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Examining the Gender Productivity Gap among Farm Households in Mali

A. Singbo[a,b,*], E. Njuguna-Mungai[c], J.O. Yila[b], K. Sissoko[b] and R. Tabo[b]

[a]Department of Agricultural Economics and Consumer Science, Faculty of Food Science and Agriculture, Laval University, 2425 de l'Agriculture st., Bd. Paul-Comtois, Quebec, G1V0A6, Canada, [b]West & Central Africa R&D program, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), BP 320, Bamako, Mali, [c]Eastern & Southern Africa R&D program, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), PO Box 39063-00623, Nairobi, Kenya

*Corresponding author: A. Singbo. Tel: (+1)418 656-2131 ext. 403059; E-mail: alphonse.singbo@eac.ulaval.ca & alphonsesingbo@gmail.com

Abstract

AbstractThis paper decomposes the gender agricultural productivity gap and measures the factors that influence the gap between male and female agricultural plot managers in Mali. The Oaxaca–Blinder approach and the recentred influence function (RIF) decomposition methodology are applied to a nationally representative survey of Mali. The results show that the agricultural productivity of female plot managers is 20.18% lower than that of male plot managers. Additionally, while more than half (56%) of the agricultural productivity gap is influenced by female-specific structural disadvantages, 44% of the gap is due to an endowment effect. Socio-economic characteristics such as the educational level and age of the plot manager, environmental factors and agricultural production practices, i.e., the differential use of inputs (organic or inorganic fertiliser and improved seeds) and the use of hired female workers seem to affect the female-specific structural disadvantages. To reduce or close the gender productivity gap, the underlying causes of female-specific structural disadvantages must be addressed to enable female farmers to obtain the same returns as men. Traditional means of addressing the gender gap, such as providing education for women in rural areas and facilitating rural women' access to extension services and improved seeds, can mitigate the endowment deficit. This paper highlights the need to develop a better understanding of the factors influencing the structural disadvantages faced by female farmers in Mali that could feed into the development of more effective policies to address the gender gap in agricultural productivity, improving productivity and gender equity and reducing poverty.

Keywords: Oaxaca–Blinder, recentred influence function, agricultural productivity, gender gap, Mali

JEL classification: C21, J16, Q12, Q18

1. Introduction

The slow and sometimes stagnant economic growth in the decades following the independence of most countries in sub-Saharan Africa (SSA) poses a serious development challenge. Persistent social conflict, the impacts of climate change and ineffective or inexistent coordinated policies for functioning markets are some of the issues, among others, that economists have cited as factors contributing to countries' slow or lacking development. In the last decade, however, the African agricultural sector has witnessed an increase in the use of technology, access to credit facilities and research outputs (Thurow, 2010). In the face of this progress in the agricultural sector is a persistently wide yield differential between male and female farmers (Quisumbing 1996). Gender seems to be a major determinant and to play a key role in the allocation of resources and responsibilities in rural households in SSA (Doss *et al*., 2015). Rural women in SSA are overburdened by productive and reproductive tasks that are important for household well-being, but despite women's involvement in and contribution to both off- and on-farm activities, they have weak decision-making power, which affects their level of access to production capital (Udry, 1996; Doss, 2018). The implications for productivity enhancement and women's empowerment explain the need to develop efficient policies to address the underlying causes of gender inequalities.

Mali is a West African country with a population of 14.5 million people, with 77.46% of its population living in rural areas. The gender gap index[1] score for Mali is 0.578, placing it 138th out of 149 countries (INSTAT, 2014). Women's political empowerment score, 0.08 in 2014, is also very low (World Economic Forum, 2014). Although women are known to play a major role in agriculture, little is known about the differences in agricultural productivity across genders in Mali. The observed gender productivity gap in SSA has been at the core of the debate on the extent to which women are disadvantaged with respect to landownership, technology adoption, institutional support and access to various inputs such as fertiliser, water, hired labour and improved crop varieties (Quisumbing and Pandolfelli, 2010; Doss *et al*., 2015).

Recent empirical studies in other SSA countries have assessed the extent of the gender agricultural productivity gap and have made progress towards identifying its underlying causes (Kilic *et al*., 2015a). McCarthy and Kilic (2015) analysed the nexus among gender, collective action and agriculture in Malawi and found that the active participation of women and young adults in social groups improves agricultural productivity and welfare. Aguilar *et al*. (2015) indicated a 23.4% gender productivity differential among farms in Ethiopia and found that only 10.1% of this gap can be attributed to the characteristics of the plot manager and that the rest is due to household characteristics and structural disadvantages. Oseni *et al*. (2015) found that the gender productivity gap in Nigeria is primarily due to a knowledge gap in agricultural practices. In the south, asymmetric access to extension services is the main cause of the knowledge gap, while in the north, the knowledge gap is due to an endowment effect. Women have limited access to extension services, which limits the adoption of improved agricultural technology. In northern Mozambique, de Brauw (2015) found that in his data set, women control approximately 30% of all plots; of those

1 This index indicates the magnitude of the gender gap in terms of economic participation and empowerment, educational attainment, political empowerment and health and survival.

plots, they manage approximately 70%[2]. Women are more likely to manage plots when households have historic access to off-farm labour, typically male workers. When women manage plots, they tend to grow crops with less complicated production techniques and are less likely to grow cash crops. However, conditional on historic access to off-farm labour, their average farm income is similar to that of their male counterparts. In contrast, Slavchevska's (2015) household-level study of the gender agricultural productivity gap in Tanzania revealed the absence of a significant difference in productivity between male and female plot managers. However, conditional on manager characteristics, plot characteristics, inputs and crop choice, female-managed plots were found to be less productive, but female farmers were able to obtain higher yields on smaller plots by using less male labour and more female labour. Karamba and Winters (2015) investigated whether participation in an input subsidy programme helped reduce the gender gap in Malawi. Their results showed that participation in the programme improved the agricultural productivity of both male and female farmers but did not provide disproportionate help to female farmers to overcome gender disparities in agricultural productivity. Udry (1996), Akresh (2005) and Goldstein and Udry (2008) found that the gender agricultural productivity gap in Africa can be largely attributed to a sub-optimal allocation of production resources within the household. Doss *et al.* (2015) analysed the gender inequalities in ownership and control of land in Africa using statistics from a variety of nationally representative surveys on gender and plots in Africa. Their results highlight the importance of collecting sex-disaggregated data at plot level when discussing gender and development issues in Africa.

Different methods have been employed in the literature to study gender gaps in productivity. Recently, the Oaxaca–Blinder decomposition method has been used extensively to shed new light on the gender agricultural productivity gap (Aguilar *et al*., 2015; Kilic *et al*., 2015b; Oseni *et al*., 2015; Slavchevska, 2015). This decomposition method is commonly used to study labour market outcomes across groups divided in terms of gender, race or educational level because it decomposes wages in a counterfactual manner (Jann, 2008). Among households, the inequalities between male and female plot managers can be analysed using other techniques. For instance, McCarthy and Kilic (2015) used a theoretical model of public goods to examine the nexus among gender, collective action for the public good and agriculture. In addition, de Brauw (2015) developed a household decision-making model to analyse plot control and crop choice between genders in northern Mozambique.

The gender productivity gap among farm households varies across countries because each country has its own unique socio-economic profile. Therefore, analyses from neighbouring countries cannot be extrapolated. This paper applies the Oaxaca–Blinder and the recentred influence function (RIF) decomposition methods to quantify the influence of the determinants of the gender agricultural productivity gap among households in Mali. The RIF approach allows us to generate results for different percentiles, as opposed to just the mean. We use World Bank data from the Living Standards Measurement Study and the Integrated Surveys on Agriculture (LSMS-ISA) of 2014. First, we estimate the gender agricultural productivity gap using disaggregated household plot manager data and the

2 The difference between 'control' and 'manage' plot is that when women have control over their land, they own the land mostly through their parents while when women manage the land, they make specific decisions related to the management of the land, including what crops to grow.

factors underlying the gap. Second, we decompose the percentage of the gap that is due to the endowment effect (resource allocation), male structural advantages and female structural disadvantages. Third, we investigate the quantile distribution of the decomposition using RIF decomposition to ascertain how the influence of each factor changes along the distribution of agricultural productivity. Overall, the results show that the agricultural productivity of female plot managers is less than that of male plot managers. A large share of this gender gap in agricultural harvest value can be attributed to female structural disadvantages, while 44.07% of the gender gap can be attributed to an endowment effect that relates the gap to differences in input uses.

The rest of this paper is structured as follows. Section 2 describes the conceptual approach to measuring and decomposing the gender agricultural productivity gap as well as how it is empirically implemented. Section 3 presents the LSMS-ISA data for Mali, the model specification and the descriptive statistics. Section 4 presents the results regarding the distribution of the gender agricultural productivity gap and its decomposition. Section 5 concludes, emphasising the policy implications of the empirical evidence in relation to social inequalities between men and women.

2. Conceptual approach and empirical modelling

2.1. Conceptual framework

The standard method of modelling agricultural productivity involves establishing a relationship between an expected output and a set of inputs, where the technology is depicted by a production function (Peterman *et al*., 2011).

$$Y_{ia} = F(L_{ia}, Z_{ia}, V_{ia}) \tag{1}$$

where Y_{ia} is a measure of productivity for plot$i$, planted by a member of household$a$; L_{ia} is an aggregate vector of inputs such as land, labour, fertiliser, pesticide and capital; Z_{ia} is a vector of household and plot manager individual-level socio-economic characteristics; and V_{ia} is a vector of communal characteristics. Gender analyses usually focus on the explanatory variables in vector Z_{ia}. If female and male plot managers had access to the same level of production technology and planted the same crop on identical plots of land, then productivity differences would be due to managers applying different quantities of inputs. In turn, differences in input use may be due to differences in bargaining power when negotiating input prices or access to credit. Alternatively, the productivity gap may occur if the quality of inputs differs across genders because of income inequality. For example, female plot managers may be allocated lower-quality land and may receive assistance from younger family members. Female and male plot managers may also choose to grow different crops on their respective plots. These different crop choices may reflect gender differences in preferences for risk, differences in cultural norms and traditional beliefs between men and women or asymmetric access to credit. Differences in the opportunity cost of time when markets are imperfect or missing may also contribute to gender differences in agricultural productivity (Holden *et al*., 2001).

We hypothesise that lower yields on female-managed plots may be explained by the level and returns of production factors. Female-managed plots may generate lower returns for chemical inputs if women lack experience in applying such inputs. Improving women's access to inputs may not suffice to close the gender gap if they are unable to obtain the same returns as male managers. Understanding the causes of the gender gap and understanding how the incidence of different causal factors varies along the productivity distribution should help in designing policies and programmes to close the gender productivity gap and boost national income.

2.2. Empirical modelling

Previous studies have identified several potential factors to explain the productivity gap between male and female plot managers. Most of these determinants fall into the following categories: manager characteristics, plot characteristics, input use and crop choice are all necessary for modelling agricultural production outcomes. Slavchevska (2015) and Oseni *et al.* (2015) used the Oaxaca–Blinder decomposition method as described in Blinder (1973) and Oaxaca (1973)[3] to measure the influence of various factors that contribute to the gender productivity gap among household farms. This procedure is complemented by RIF decomposition to ascertain how the influence of each factor changes along the distribution of productivity. Both procedures make it possible to quantify the contribution of explanatory variables to the productivity differential between plots managed by male and female farmers. The model explains the variations in yields between plots managed by male and female farmers in terms of the variations in input endowments and socio-economic characteristics. The yield function for plot i under the management of manager j is specified as follows:

$$\ln\left(Y_{ij}\right) = \alpha + \gamma g_j + \sum_{h=1}^{H} \pi_h B_{jh} + \sum_{k=1}^{K} \varphi_k P_{ik} + \sum_{r=1}^{R} \rho_r \ln\left(I_{ir}\right) + \sum_{t=1}^{T} \theta_t T_{it} + \omega_j + \varepsilon_{ij} \quad (2)$$

where Y_{ij} is plot i's harvest value per ha obtained by manager j; α is the unknown constant term to be estimated; g_j is the manager's gender (dummy variable); B_{jh} is the set of H individual-level characteristics of manager j; P_{ik} is the set of K characteristics of plot i; I_{ir} is the set of R inputs utilised on plot i; T_{it} is the set of T different labour types used on plot i; ω_j is the regional fixed effects; and ε_{ij} is the random error term, which is assumed to be independently and identically distributed as $N(0, \sigma^2)$.

The estimation of the above model is problematic because some of the input variables are zeros. This issue pertains mainly to hired labour, fertilisers and pesticides because they are applied on some but not all plots. To prevent observations with zero quantities of inputs from being dropped from the sample when the variables are log transformed, Battese (1997) recommends creating a dummy variable that equals one for plots reporting zero for a given input and replacing the zero quantity with one. The advantage of this procedure is that the full data set is used and the estimated coefficients are efficient and unbiased.

In this model, the gender of the plot's manager is the variable of interest. In the initial multivariate examination, a progressive approach is applied to explain the gender difference in agricultural productivity. The logic of this approach is that it identifies whether and how each set of factors influences the conditional gender gap. The initial step refers to the naïve regression (Model 0), which considers only the manager's gender as the only explanatory variable. In the first step (Model 1), regional fixed effects are included in the estimation

3 For details, see Blinder (1973), Oaxaca (1973), Slavchevska (2015) and Oseni *et al.* (2015).

of Model 0 to control for regional differences between managers. The second step (Model 2) involves estimating an extended full model featuring the gender of the plot manager, individual-level characteristics of the manager, characteristics of the plot, inputs used on the plot and labour types used on the plot. Coelli and Battese (1996) found that older, more experienced plot managers tend to be more productive; over time, however, they also tend to become increasingly 'set in their ways' and sceptical of technological advances and new agricultural practices. Thus, age is expected to be positively related to productivity, while age squared is expected to have a negative coefficient. Education is included as a categorical variable. We create three dummy variables for primary education, secondary education and no formal education, which serves as a reference for comparison. It is expected that as the educational level of farmers increases (primary or secondary education), their management ability may improve. Thus, education should be positively related to productivity. However, the estimated effect of education may suffer from selection bias (Appleton and Balihuta, 1996).

Labour is disaggregated in terms of male, female and child labour inputs. The productivities of these workers are likely to differ, but economic theory suggests that they should be marginally positive. The third step (Model 3) involves estimating Model 2 based on a subsample, keeping only plots managed by female farmers. Finally, the fourth step (Model 4) requires estimating Model 2 based on a subsample of plots managed by male farmers. The results of these models make it possible to decompose the gender agricultural productivity gaps in terms of structural and endowment effects.

2.3. Gender differential decomposition

Let vector X_g be defined as the row of covariance elements associated with the estimated coefficient of gender and the estimated coefficients of other explanatory variables of the production function (Eq. 2). Then, based on Oaxaca (2007), Slavchevska (2015) and Oseni *et al.* (2015), the expected harvest value per ha for managers with gender $g = \left(m, f\right)$, where m represents male farmers and f represents female farmers, is as follows:

$$E\left[y_g\right] = \alpha_g + E\left[X_g\right]'\beta_g \tag{3}$$

The mean outcome difference between male and female managers is then the difference between the expected plot harvest values for each gender. The gender gap is calculated as follows:

$$\text{Gap} = E\left[y_m\right] - E\left[X_f\right] = \alpha_m + E[X_m]'\beta_m - \left(\alpha_f + E\left[X_f\right]'\beta_f\right) \tag{4}$$

As indicated in Oaxaca (2007), it is important to decompose the gender gap by separating the part that is explained by group differences in the explanatory variables and the unexplained part. To obtain both differences, non-discriminatory coefficients must be included in the above equation (Jann, 2008). The non-discriminatory coefficients are those obtained from the combination of the expected plot harvest value in the pooled data, which also includes the gender dummy(g) (i.e., Model 2). The pooled expected plot harvest value $\left(y_{ij}\right)$ is obtained as follows:

$$E\left[y_{ij}\right] = E\left[y\right] = \alpha + \gamma g + E[X]'\beta^* \tag{5}$$

where β^* is the vector of non-discriminatory coefficients obtained in Model (2). Following Fortin (2006), we obtain the 'two-fold' decomposition by including the above result (5) in the gap equation in (4).

$$\text{Gap} = Q + U \tag{6}$$

where Q is the part of the gender gap explained by the group differences in the explanatory variables. The explained part of the composition effect is then calculated as follows (Fortin *et al.*, 2011):

$$Q = \left\{E[X_m]' - E\left[X_f\right]'\right\} \beta^* \tag{7}$$

The 'unexplained' (U) part, which is also called the 'structural effect', is attributed to discrimination (or differences in returns) and is calculated as follows (Fortin *et al.*, 2011):

$$U = (\alpha_m - \alpha) + \left\{E\left[X_m\right]'\left(\beta_m - \beta^*\right)\right\} + \left(\alpha - \alpha_f\right) + \left\{E\left[X_f\right]'\left(\beta^* - \beta_f\right)\right\} \tag{8}$$

The subdivision of this equation into two distinct parts gives an estimate of male structural advantages (8a) and female structural disadvantages (8b):

$$U_m = (\alpha_m - \alpha) + \left\{E\left[X_m\right]'\left(\beta_m - \beta^*\right)\right\} \tag{8a}$$

&

$$U_f = \left(\alpha - \alpha_f\right) + \left\{E\left[X_f\right]'\left(\beta^* - \beta_f\right)\right\} \tag{8b}$$

A key assumption in the above decomposition methodology is overlapping support, which requires that no single value of $X = x$ or $\varepsilon = e$ can serve to identify membership in one of the two groups. This assumption rules out cases where independent variables may be different across the two productivity setting functions. Another important assumption for the identification of the decomposition terms is that of conditional independence, also known as ignorability of the treatment. The ignorability assumption has become popular in empirical research following a series of papers by Heckman *et al.* (1997a, 1997b, 1998), among others. This assumption means that the joint densities of observables and unobservables for male and female plot managers should be similar up to a ratio of conditional probabilities (for details, see Fortin *et al.*, 2011). This restriction implies that the difference between a statistic from the original distribution of productivities and the counterfactual distribution solely depends on differences in the productivity structure.

2.4. RIF decomposition

The goal of the RIF approach is to move from the assessment of mean gaps to decompositions at particular quantiles in the outcome distribution. The estimation procedure based on quantile regressions provides an explicit way of estimating the conditional distribution function. The quantile regression allows us to look beyond the average and to provide a description of the whole conditional distributional of a response variable in terms of a set of explanatory variables (Davino *et al.*, 2014). The composition effect is computed as the complement to the overall difference. These measures provide a way of distinguishing what happens at the top and bottom end of the productivity distribution. RIF regression is similar to ordinary least squares (OLS) regression, except the dependent variable is replaced by the RIF of the distributional statistic of interest (in our case, the log of harvest value per ha). The RIF is given as follows:

$$\text{RIF}\left(y;v\right) = v\left(F_y\right) + IF\left(y : v\right) \tag{9}$$

where y is the endogenous variable of interest (log harvest value per ha), $v\left(F_y\right)$ is the distributional statistics of interest or quantile, and $IF\left(y : v\right)$ is the influence function corresponding to an observed agricultural productivity y for the distributional statistics $v\left(F_y\right)$. The conditional expectations of RIF are assumed to be a linear function of X and are written as follows:

$$E\left[RIF\left(Y;v\right)|X\right] = X_{\gamma} + \varepsilon \tag{10}$$

For quantiles, RIF is $RIF\left(Y;Q_\tau\right) = Q_\tau + \dfrac{\tau - 1\left\{Y \leq Q_\tau\right\}}{f_y\left(Q_\tau\right)}$ (11)

where Q_τ is the population τ quantile of the unconditional distribution of Y, $\frac{\tau-1\left\{Y\leq Q_\tau\right\}}{f_y\left(Q_\tau\right)}$ is the influence function, $1\left\{\cdot\right\}$ is the indicator function and $f_y\left(Q_\tau\right)$ is the density of the marginal distribution of Y.

The density is obtained using the kernel methods described in (Fortin *et al*., 2011). Using the estimates $\hat{Q}_\tau$ and $f\left(\hat{Q}_\tau\right)$ and plugging them into Eq. (11), we obtain estimates of RIF for each observation. With the RIF estimates, we can implement an Oaxaca–Blinder-type decomposition using these estimates, rather than Y, as the independent variable. The estimates of RIF are regressed on the same set of explanatory variables as those in the Oaxaca–Blinder decomposition described above (Models 2, 3 and 4). Vector γ^*, obtained from a pooled regression with a group membership indicator, is used for both decompositions (the aggregate and detailed decompositions).

3. Data and variables

This study uses the nationally representative 2014 World Bank LSMS-ISA for Mali. Released by the Planning and Statistics Unit of the Ministry of Rural Development with assistance from the World Bank, this data set covers all of Mali's regions, except for the Kidal region (see Figure 1). One advantage of the data set is that it identifies the gender of the decision-maker (manager) at the plot level, which is essential for the realisation of this study. The decision-maker is the individual who decides what to plant on the plot. Information on who decides what inputs to be applied on the plot is not available; thus, we assume that the person who decides what to plant is the same as the person who decides about input use.

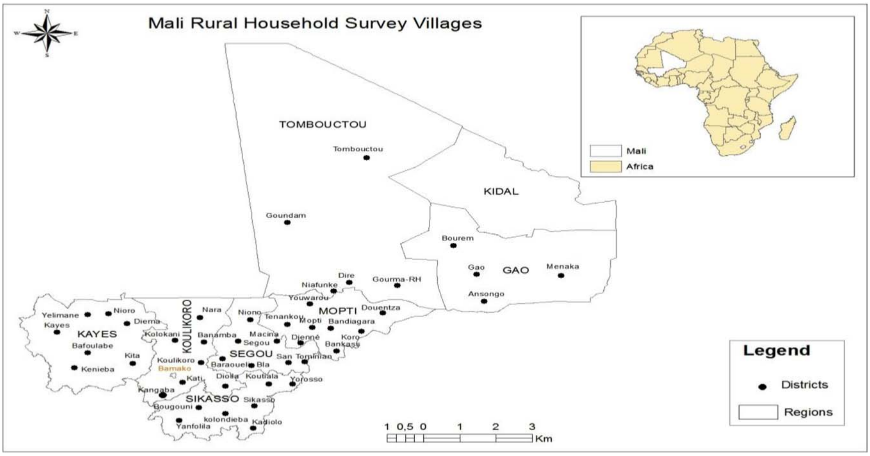

Figure 1: Location of Mali Rural Household Survey (LSMS-ISA) Villages. Source: ICRISAT-Mali

Plots not managed by a family member are dropped from the analysis because the gender of the decision-maker cannot be identified.

The data were collected from seven regions of Mali, including Bamako, the capital city. Focusing on the objectives of the study, we considered only agricultural households that cultivated plots during the rainy season. Starting with 3,992 households in the 2014 LSMS-ISA, we retained 1,437 households with 5,324 plots for our empirical analysis. Plots of at least 100 m^2 in size for which information about the plot manager's age and educational level was available were included in the data set. Out of the 2,555 households that were dropped, 1,748 were non-agricultural households (approximately 44%). The other 20% of households were dropped because there was no harvest information, they had unexploited plots, or there was inconsistent information. The remaining 36% of plots that were removed from the data set were plots less than 100 m^2 in size without the plot manager's gender, age or educational level.

Table 1 reports some basic statistics at the plot level for the full sample and by the gender of the manager. The last column reports differences in the characteristics of plots managed by female and male farmers, and an indicator is used to identify differences that are statistically significant. Productivity is measured by the harvest value (in FCFA[4]) per ha. The harvest value is calculated by summing the sale values of all crops harvested[5]. The average harvest value for the full sample is 215,935.9 FCFA, which is equivalent to 398 USD. On average, female plot managers have a lower agricultural harvest value than male managers. The harvest value for plots managed by a female manager is 186,149.7 FCFA or 343 USD, and this value is significantly lower at the 1% level than that of a male manager by 53,980.26 FCFA (100 USD). The harvest value per ha (i.e., productivity) is calculated by dividing the harvest value by the area of the plot. On average, the harvest value per ha for the full sample is 536,784.6 FCFA (990 USD), while for female farmers, the statistic is 429,778.3 FCFA or 792 USD. The

4 1 USD is equals to 542.07 FCFA on 31/12/2014.

5 The sale values are based on self-reported farmers' valuation from experience selling the crops.

Table 1: Summary Statistics and Results from Tests and Mean Differences by Gender of the Plot Manager

Variables	All	Male	Female	Difference
Productivity measures				
Harvest value (FCFA[a])	215,035.9	240,130	186,149.7	−53,980.26**
Harvest value (FCFA[a]/ha)	536,784.6	629,743.8	429,778.3	−199,965.5**
Plot manager characteristics				
Age	41.4409	42.8127	39.8618	−2.9508***
Secondary educational level	0.0058	0.0084	0.0028	−0.0056**
Basic educational level	0.1704	0.2049	0.1305	−0.0745***
Household adult size (age 15–64)	6.7475	6.6841	6.8206	0.1365
Household male adult size (age 15–64)	3.1841	3.2334	3.1272	−0.1061*
Household female adult size (age 15–64)	3.5634	3.4507	3.6933	0.2426**
Children 0–14 years old	6.9032	6.7553	7.0735	0.3181*
Child dependency ratio	1.1411	1.1305	1.1533	0.0227
Off-farm income (=1 if yes)	0.3234	0.3282	0.3179	−0.0102
Remittance value (FCFA[a])	69,049.29	77,601.45	59,204.8	−18,396.64
Main productions				
Maize (=1 if yes)	0.1669	0.1664	0.1676	0.0013
Millet (=1 if yes)	0.2554	0.2773	0.2303	−0.0469***
Sorghum (=1 if yes)	0.1962	0.2018	0.1898	−0.0119
Groundnut (=1 if yes)	0.1635	0.1389	0.1919	0.0529***
Paddy (=1 if yes)	0.1083	0.1144	0.1014	−0.0130
Cotton (=1 if yes)	0.0101	0.0105	0.0096	−0.0008
Plot's characteristics				
Area (self-reported ha)	0.8063	0.8266	0.7828	−0.0437*
Soil type (clay = compaction = 0, other =1, loam = 1)	1.1102	1.1141	1.1058	−0.0082
Plot slope (steep = 0, slight = 1, flat = 2)	1.4367	1.4348	1.4387	.0038
Family labours				
Male family labour (=1 if yes)	0.8715	0.8799	0.8618	−0.0181**
Male family labour (days)	14.4242	15.7451	12.9037	−2.8413***
Male family labour (days/ha)	40.6428	47.1962	33.0992	−14.0969**
Female family labour (=1 if yes)	0.5884	0.5735	0.6056	0.0321**
Female family labour (days)	8.6718	9.1597	8.1103	−1.0494*
Female family labour (days/ha)	9.9044	10.9246	8.7301	−2.1944**
Child family labour (=1 if yes)	0.6461	0.6454	0.6468	0.0013
Child family labour (days)	12.8426	13.4317	12.1644	−1.2672
Child family labour (days/ha)	49.6084	51.6091	47.3094	−4.2996
Hired labours				
Male hired labour (=1 if yes)	0.1211	0.1333	0.1071	−0.0263**
Male hired labour (days)	3.9229	4.5219	3.2333	−1.2886*
Male hired labour (days/ha)	4.2163	4.5802	3.7973	−0.7828
Female hired labour (=1 if yes)	0.0379	0.0453	0.0295	−0.0157**
Female hired labour (days)	0.6904	0.7964	0.5684	−0.2279
Female hired labour (days/ha)	1.2311	1.3562	1.0870	−0.2692

(Continued)

Table 1: Continued

Variables	All	Male	Female	Difference
Child hired labour (=1 if yes)	0.0293	0.0333	0.0246	−0.0086*
Child hired labour (days)	0.8264	1.2492	0.3397	−0.9094
Child hired labour (days/ha)	4.4861	7.6432	0.8518	−6.7913
Help group labours				
Male help group labour (=1 if yes)	0.9404	0.9333	0.9486	0.0153**
Male help group labour (days)	1.8001	1.9571	1.6193	−0.3377
Male help group labour (days/ha)	4.7051	5.3931	3.9131	−1.4799
Female help group labour (=1 if yes)	0.9654	0.9663	0.9644	−0.0018
Female help group labour (days)	0.6707	0.6367	0.7098	0.0731
Female help group labour (days/ha)	1.2478	1.2972	1.1909	−0.1063
Inputs				
Pesticide (=1 if yes)	0.2336	0.2330	0.2343	0.0012
Pesticide (kg)	0.5878	0.6098	0.5624	−0.0474
Pesticide (kg/ha)	1.0928	1.1383	1.0404	−0.0979
Organic fertiliser (=1 if yes)	0.9879	0.9866	0.9894	0.0028
Organic fertiliser (kg)	2,567.924	2,832.099	2,263.831	−568.268**
Organic fertiliser (kg/ha)	6,714.084	7,993.067	5,241.831	−2,751.236**
Inorganic fertiliser (=1 if yes)	0.3287	0.3447	0.3103	−0.0343**
Inorganic fertiliser (kg)	814.1238	1,040.194	553.892	−486.3019
Inorganic fertiliser (kg/ha)	1,332.166	1,494.266	1,145.572	−348.6942
Used purchased seed (=1 if yes)	0.8713	0.8641	0.8795	0.0154*
Other descriptive statistics of the sample				
Fraction of the sample with more than one plots managed by the same household but by members of different genders	94.68%			
Observations	**5,324**	**2,849**	**2,475**	**5,324**

Notes. The noted significance level for the difference in mean characteristics between sole female managed plots and male manager plots is from running the corresponding least squares regression; $***P < 0.01$. $**P < 0.05$, $*P < 0.1$. [a] $1 US equals to 542.07 in 31/12/2014.

male–female difference of 199,965.5 FCFA (369 USD) is significant at the 1% level. The mean values show that male plot managers achieve more output per ha than their female counterparts.

Female managers tend to manage smaller plots and are more likely to live in households with higher adult and child dependency than male managers. The plots managed by women are on average 5% smaller than those managed by men (0.78 ha vs 0.83). Female managers use on average 1.5% more purchased seeds per ha than male managers, as shown in Table 1.

Differences in productivity may be explained in part by differences in the utilisation of non-labour inputs. Male managers are more likely to use inorganic fertiliser and pesticide on their plots, and compared to female managers, male managers spread larger quantities of fertiliser. Labour inputs are categorised into family (men, women, and children), hired labour (men, women, and children) and help groups (men and women). Male managers generally use approximately 2 percentage points more family labour than female managers, but perhaps more importantly, they benefit from 3 percentage points more days of hired adult male labour. On the other hand, female-managed plots tend to rely on 3.21 percentage points more female family labour than male-managed plots. In contrast, male-managed plots receive more days of female family labour than female-managed plots. Furthermore, Table 1 shows that approximately 14 fewer days of male family labour per ha are applied on female plots compared to male plots. Approximately 2 fewer days of female family labour per ha are also applied on female plots than on male plots. These statistics confirm the finding of Udry (1996) that much less household male labour is devoted to a ha of land managed by a woman compared to a similar ha managed by a man in the same household. These results also show that male family labour is used on most plots (86%) managed by women and that less female labour (57%) is used on plots managed by men.

Finally, Table 1 also shows that the differences in remittance value and in securing non-farm income between male and female managers are not statistically significant. Regarding the crops that are grown, compared to male managers, female managers tend to cultivate groundnut. Approximately 20% of female-managed plots are groundnut plots compared to approximately 14% of male-managed plots, and it is confirmed that most groundnut plots in Mali belong to women (Ndjeunga *et al*., 2010). In contrast, male managers tend to grow millet crops more than female managers.

The last part of Table 1 shows that when household farms have more than two plots, approximately 73% of households have at least one plot managed by women. This finding implies that over 73% of the households in the sample have more than one plot and that these plots are managed by family members of different genders[6].

In summary, compared to the plots managed by female farmers, the plots managed by males are the largest and receive the greatest share of family resources and other productive inputs. Plots managed by males achieve more output per ha than female-managed plots. Women grow more legumes (groundnut), but male managers grow more millet.

4. Results and discussion

4.1. Estimation of the gender agricultural productivity gap

The results presented in Table 2 show varying estimates of the gender productivity gap. The results from the naïve regression (Model 0) show that the productivity of male managers is 20.18% higher than that of female managers and that this gap is statistically significant at the 1% level. The inclusion of regional fixed effects (Model 1) also indicates a significant but smaller gender agricultural productivity gap. The gender productivity gap falls to 11.29% when key factors influencing production, such as manager characteristics, labour use, plot characteristics and other inputs, are factored in, as shown in the column pertaining to Model 2. Female-managed plots still have lower productivity than male-managed plots, but it is clear that many observable factors contribute to the productivity differences across genders. This result also confirms the finding of Udry (1996) that the marginal product of land managed by a woman is less than that of similar land managed by her husband in the case of farm households in Burkina Faso[7]. Surprisingly, plot size has a negative effect on

6 To that end, we also check for within-household plot fixed effects, as suggested by a reviewer. However, the estimations do not improve our results. These results are available upon request.

7 This result is also confirmed by the estimations restricted to households that have at least one male and at least one female plot manager.

Table 2: Estimation Results. Differences in Mali (Excluding Kidal Region) Dependent Variable: Log (Value of Harvest per Hectare[1])

Variables	(Model 0)	(Model 1)	(Model 2)	Female managers (Model 3)	Male managers (Model 4)
Female manager (=1)	−0.2018***	−0.1792**	−0.1129**		
	(0.0407)	(0.0460)	(0.0257)		
Manager has secondary education (=1 if yes)			0.1668	0.4590	0.0710
			(0.1326)	(0.1887)	(0.1824)
Manager has basic education (=1 if yes)			−0.1265*	−0.1904	−0.0785*
			(0.0414)	(0.0873)	(0.0309)
Age			0.0095*	0.0040*	0.01114*
			(0.0038)	(0.0015)	(0.0043)
Age squared			−0.0001*	−0.0001*	−0.0001
			(0.0000)	(0.0000)	(0.0000)
Household male adult size (15–64)			0.0243	0.0536*	0.0058
			(0.0126)	(0.0201)	(0.0125)
Household female adult size (15–64)			0.0027	−0.0151	0.0171
			(0.0143)	(0.0184)	(0.0181)
# children under 14 years			−0.0042	0.0007	−0.0100
			(0.0109)	(0.0083)	(0.0160)
Log area (ha)			−0.4886***	−0.4689***	−0.5058***
			(0.0576)	(0.0407)	(0.0751)
Soil type (clay = compaction = 0, other = 1, loam = 2)			−0.0829	−0.0706	−0.0876
			(0.0424)	(0.0411)	(0.0500)
Plot slope (steep = 0, slight = 1, flat = 2)			0.0648	0.0727*	0.0625
			(0.0410)	(0.0234)	(0.0615)
No pesticide use (=1 if yes)			−0.3010*	−0.3998**	−0.2201*
			(0.0928)	(0.0935)	(0.0839)
Ln pesticide (kg/ha)			0.0417**	0.0536*	0.0287
			(0.0090)	(0.0174)	(0.0196)
No organic fertiliser use (=1 if yes)			0.4163*	0.3185	0.4805*
			(0.1626)	(0.2014)	(0.1341)
Ln organic fertiliser (kg/ha)			0.0885*	0.0669	0.1008**
			(0.0261)	(0.0293)	(0.0234)
No inorganic fertiliser use (=1 if yes)			−0.0048	0.0088	−0.0236
			(0.0918)	(0.1146)	(0.0826)
Ln inorganic fertiliser (kg/ha)			0.0854***	0.0826**	0.0863***
			(0.0133)	(0.0170)	(0.0107)
No male family labour (=1 if yes)			0.4858*	0.3542*	0.6010*
			(0.1397)	(0.1068)	(0.1314)
Ln male family labour (days/ha)			0.2203***	0.1782**	0.2489***
			(0.0207)	(0.0312)	(0.0135)
No female family labour (=1 if yes)			−0.1625	−0.1224	−0.2022
			(0.0723)	(0.0952)	(0.0859)
Ln female family labour (days/ha)			−0.0662	−0.0724	−0.0653
			(0.0357)	(0.0399)	(0.0407)

(Continued)

Table 2: Continued

Variables	(Model 0)	(Model 1)	(Model 2)	Female managers (Model 3)	Male managers (Model 4)
No child family labour (=1 if yes)			0.1873	0.1846	0.1859
			(0.1106)	(0.0830)	(0.1779)
Ln child family labour (days/ha)			0.1124*	0.0970*	0.1254*
			(0.0410)	(0.0293)	(0.0516)
No male hired labour (=1 if yes)			0.0491	−0.0858	0.1489
			(0.1117)	(0.1584)	(0.1417)
Ln male hired labour (days/ha)			0.1679**	0.1259*	0.1822*
			(0.0331)	(0.0430)	(0.0515)
No female hired labour (=1 if yes)			−0.6816***	−0.4839	−0.7890*
			(0.0953)	(0.3605)	(0.2172)
Ln female hired labour (days/ha)			−0.1717**	−0.1253	−0.1880*
			(0.0412)	(0.1299)	(0.0554)
No child hired labour (=1 if yes)			−0.1919	−0.1365	−0.2378
			(0.0962)	(0.2785)	(0.2619)
Ln child hired labour (days/ha)			−0.0390	−0.0474	−0.0399
			(0.0200)	(0.0771)	(0.0539)
No male help group labour (=1 if yes)			0.0659	0.4231*	−0.2424
			(0.1041)	(0.1632)	(0.2117)
Ln Male help group labour (days/ha)			0.1120*	0.1873*	0.0533
			(0.0320)	(0.0667)	(0.0380)
No female help group labour (=1 if yes)			0.1294	−0.1519	0.3910
			(0.2958)	(0.2943)	(0.2846)
Ln female help group labour (days/ha)			0.1318	0.0718	0.1809
			(0.0876)	(0.0884)	(0.0836)
Used purchased seed (=1 if yes)			0.2077*	0.1939	0.2191***
			(0.0743)	(0.1327)	(0.0330)
Maize (=1 if yes)			0.6155	0.5929	0.6270*
			(0.2812)	(0.3131)	(0.2446)
Millet (=1 if yes)			0.4232*	0.3454	0.4709**
			(0.1220)	(0.1905)	(0.1063)
Sorghum (=1 if yes)			0.2570	0.2342	0.2628*
			(0.1445)	(0.2141)	(0.0896)
Groundnut (=1 if yes)			0.4909**	0.5107*	0.4450*
			(0.1298)	(0.1719)	(0.1289)
Paddy (=1 if yes)			0.9333	0.8177	1.0235
			(0.4239)	(0.3755)	(0.4917)
Child dependency ratio			0.0227	0.0220	0.0367
			(0.0279)	(0.0440)	(0.0659)
Off-farm income (=1 if yes)			−0.0167	−0.0664***	0.0214
			(0.0222)	(0.0168)	(0.0423)
Ln remittance value			−0.0051	−0.0057	−0.0050
			(0.0048)	(0.0080)	(0.0040)

(Continued)

Table 2: Continued

Variables	(Model 0)	(Model 1)	(Model 2)	Female managers (Model 3)	Male managers (Model 4)
Constant	12.0717***	12.1683***	10.2218***	10.4365***	10.0050***
	(0.0277)	(0.0215)	(0.5100)	(0.2873)	(0.6792)
Regional fixed effect	No	Yes	Yes	Yes	Yes
Likelihood ratio	−9641.1454	−9474.5301	−8104.9112	−3763.1754	−4309.1468
R^2	0.0046	0.0650	0.4411	0.3981	0.4812
Observations	**5,324**	**5,324**	**5,324**	**2,475**	**2,849**

Notes. Robust standard errors are in parentheses for Model 1, Model 2, Model 3 and Model 4 while standard errors are in parentheses for Model 0.

The superscripts ***, ** and * denote statistical significance at the 1, 5 and 10% levels.

[1] As we are in the case of multiple cropping per year on a single plot of land and where several crops are simultaneously planted, yield measurements are less straight forward.

manager productivity, regardless of gender. The same result is found in the SSA by Oseni *et al.* (2015) for Nigeria, Aguilar *et al.* (2015) for Ethiopia and Slavchevska (2015) for Tanzania, confirming that land productivity is low due to extensive agricultural practices.

The coefficient for the basic education of plot managers is negative and statistically significant in the pooled regression (Model 2) and for male managers (Model 4), which suggests that this variable has a decreasing effect on productivity. However, the coefficient for secondary education is not significant. Male plot managers with secondary education may engage in off-farm work to earn more income, and their outside responsibilities may have a negative effect on agricultural production, just offsetting the direct positive effect of education on agricultural production. The relationship between the age and the productivity of the manager is a non-monotone relationship, with productivity increasing with age up to 45 and declining after male and female managers are pooled, as shown in Model (2). For female managers (Model 3), productivity declines with age once the plot manager reaches the age of 21. For male managers, age has a positive linear influence on production.

Household composition, plot characteristics, the usage of male and female family and hired labour, the use of purchased seeds, crop choices and remittance have a significant effect on production. The negative relationship between plot size and production corroborates the findings of Carletto *et al.* (2013) and Oseni *et al.* (2015) for Uganda and Nigeria. As seen in the mean values in Table 1, the sizes of female-managed plots are smaller than those of male-managed plots. One explanation for this difference is that the vast majority of cultivated lands in Mali (more than 99%) are procured by inheritance, by customary law, as a ‘free’ loan, or as a ‘gift’ (Smale *et al.*, 2019), placing women in a disadvantaged position (women farmers have limited direct access to land). Land is allocated between the husband and wife in the context of the marriage market, and the allocation of plots to a new wife upon marriage is a means of committing to a certain flow of utility, which in turn affects the division of outputs between the husband and wife in the marriage because both men and women in African households care more about output on their own plots (Udry, 1996). As expected, the quantities of fertiliser and pesticide used on the plot have a positive influence on the production value. Hired male family workers and help group workers have positive and significant influences on the value of production, and hence, they have a positive marginal product. Surprisingly, hired female labour has a negative and significant effect on productivity.

Columns 3 and 4 of Table 2 facilitate comparison of the effects of various factors across genders. As mentioned above, secondary education has a differential effect across genders, i.e., a positive effect for female managers and no effect for male managers. The productivity of male managers increases with age, while that of female managers decreases with age once women reach the age of 21. The number of adult males in the household has a positive and significant effect on the productivity of female-managed plots. Organic fertiliser is more productive on plots managed by men, but for inorganic fertilisers, the difference is too small to be statistically significant. Testing the intra-household efficiency of inorganic fertiliser use in Mali, Smale *et al*. (2019) find that the fertiliser allocation within households is not efficient and that lower yields cannot be attributed to lower rates of fertiliser application on women's plots compared to men's plots. Pesticide is more productive on plots managed by women, and the same can be said about most differences, as the standard errors of the coefficients tend to be large relative to the observed differences between the coefficients. The difference between the coefficients for the use of purchased seeds by male and female managers is much smaller than the standard error for the coefficient for female-managed plots (Model 3). The production of maize, millet and sorghum has positive and statistically significant influences on the productivity of plots managed by men and no significant effects on plots managed by women. However, groundnut and cotton production positively affects the productivity of both female- and male-managed plots. Access to off-farm income negatively affects the productivity of women's plots and has no significant influence on men's plots. Furthermore, the remittance value has no effect on the productivity of either female- or male-managed plots.

4.2. Decomposition of the gender agricultural productivity gap

Table 3 presents the Oaxaca–Blinder decomposition results[8] on the differential in log of harvest value (in FCFA) per ha between male and female plot managers. This decomposition (from Eqs. 7, 8a and 8b) allows a deeper understanding of the factors conditioning the gender agricultural productivity gap by linking the average differences of Table 1 and the pooled regression coefficients of Model 2 in Table 2. The disaggregated decomposition in terms of endowment and structural effects is particularly useful because it provides an order of magnitude with regard to how much of the gap can be linked to observables, with some of them being influenced by policies. The endowment effect is positive and significant at the 5% level. The structural effect of male structural advantages is not significantly different from zero, but female structural disadvantages are positive and significant at the 1% level.

The manager's age, a more intensive use of organic fertiliser, inorganic fertiliser, male family labour, hired male labour, the use of male help group labour and the planting of millet contribute to the size of the endowment effect. These factors magnify the gender gap by enlarging the endowment effect. In contrast, the basic education of plot managers, non-usage of organic fertiliser, use of more hired female labour, use of purchased seeds and the planting of groundnut have negative effects on the endowment effect. These factors reduce the

8 With Oaxaca–Blinder decomposition, the magnitude of the gender gap increases from 11.29 to 20.18%.

Table 3: Oaxaca–Blinder Decomposition of Log Value of Output per Hectare

A. Mean gender differential			
Mean male managed plot Agricultural productivity		12.0717*** (0.1686)	
Mean female managed plot Agricultural productivity		11.8699*** (0.1826)	
Mean gender differential In agricultural productivity		0.2018*** (0.0561)	
B. Aggregate decomposition	**Endowment effect**	**Male structural advantage**	**Female structural disadvantage**
Total	0.0889**	0.0000	0.1128***
	(0.0460)	(0.0123)	(0.0207)
Share of the gender differential	44.07%	0%	55.93%
C. Detailed decomposition	**Endowment effect**	**Male structural advantage**	**Female structural disadvantage**
Manager has secondary education (=1 if yes)	0.0009	−0.0008	−0.0008
	(0.0007)	(0.0006)	(0.0006)
Manager has basic education (=1 if yes)	−0.0094**	0.0098*	0.0083
	(0.0033)	(0.0055)	(0.0071)
Age	0.0282*	0.0771	0.2226**
	(0.0122)	(0.0562)	(0.1131)
Age squared	−0.0309**	−0.0178	−0.0681
	(0.0112)	(0.0409)	(0.0776)
Household male adult size (15–64)	0.0025	−0.0599**	−0.09151**
	(0.0019)	(0.0221)	(0.0318)
Household female adult size (15–64)	−0.0006	0.0497	0.0656
	(0.0034)	(0.0365)	(0.0508)
# children under 14 years	0.0013	−0.0397	−0.0346
	(0.0034)	(0.0445)	(0.0677)
Ln area (ha)	−0.0021	0.0116	0.0136
	(0.0106)	(0.0137)	(0.0175)
Soil type (clay = compaction = 0, other = 1, loam = 2)	−0.0007	−0.0027	−0.0136
	(0.0020)	(0.0164)	(0.0204)
Plot slope (steep = 0, slight = 1, flat = 2)	−0.0002	−0.0033	−0.0114
	(0.0005)	(0.0331)	(0.0411)
No pesticide use (=1 if yes)	0.0004	0.0645***	0.0790***
	(0.0019)	(0.0166)	(0.0151)
Ln pesticide (kg/ha)	0.0013	−0.0113	−0.0101
	(0.0009)	(0.0136)	(0.0142)

(Continued)

Table 3: Continued

C. Detailed decomposition	Endowment effect	Male structural advantage	Female structural disadvantage
No female family labour (=1 if yes)	−0.0052	−0.0169	−0.0157
	(0.0033)	(0.0214)	(0.0214)
Ln female family labour (days/ha)	−0.0017	0.0010	0.0067
	(0.0030)	(0.0187)	(0.0176)
No child family labour (=1 if yes)	0.0002	−0.0005	0.0009
	(0.0039)	(0.0299)	(0.0343)
Ln child family labour (days/ha)	0.0044	0.0218	0.0251
	(0.0056)	(0.0202)	(0.0234)
No male hired labour (=1 if yes)	−0.0013	0.0864	0.1205
	(0.0029)	(0.0788)	(0.1268)
Ln male hired labour (days/ha)	0.0123**	0.0044	0.0097
	(0.0056)	(0.0080)	(0.0116)
No female hired labour (=1 if yes)	0.0107**	−0.1025	−0.1919
	(0.0037)	(0.1447)	(0.3569)
Ln female hired labour (days/ha)	−0.0054**	−0.0019	−0.0040
	(0.0025)	(0.0050)	(0.0108)
No child hired labour (=1 if yes)	0.0016	−0.0443	−0.0540
	(0.0010)	(0.2006)	(0.3019)
Ln child hired labour (days/ha)	−0.0008	−0.0001	0.0005
	(0.0005)	(0.0031)	(0.0055)
No male help group labour (=1 if yes)	−0.0010	−0.2878**	−0.3388**
	(0.0016)	(0.1209)	(0.1658)
Ln male help group labour (days/ha)	0.0057*	−0.0125*	−0.0121
	(0.0035)	(0.0071)	(0.0086)
No female help group labour (=1 if yes)	0.0002	0.2528***	0.2712**
	(0.0011)	(0.0588)	(0.0893)
Ln female help group labour (days/ha)	−0.0012	0.0051	0.0068
	(0.0031)	(0.0036)	(0.0049)
Used purchased seed (=1 if yes)	−0.0032**	0.0098	0.0122
	(0.0012)	(0.0465)	(0.0540)
Maize (=1 if yes)	−0.0008	0.0019	0.0037
	(0.0133)	(0.0101)	(0.0089)
Millet (=1 if yes)	0.0198**	0.0132	0.0179
	(0.0081)	(0.0230)	(0.0217)
Sorghum (=1 if yes)	0.0031	0.0011	0.0043
	(0.0078)	(0.0185)	(0.0158)
Groundnut (=1 if yes)	−0.0259**	−0.0063	−0.0037
	(0.0100)	(0.0114)	(0.0151)
Paddy (=1 if yes)	0.0121	0.0103	0.0117
	(0.0205)	(0.0099)	(0.0102)
Cotton (=1 if yes)	0.0007	−0.0005	−0.0007
	(0.0007)	(0.0007)	(0.0006)
Child dependency ratio	−0.0005	0.0158	0.0007
	(0.0007)	(0.0463)	(0.0743)

(Continued)

Table 3: Continued

C. Detailed decomposition	Endowment effect	Male structural advantage	Female structural disadvantage
Off-farm income (=1 if yes)	−0.0002	0.0125∗	0.0157
	(0.0003)	(0.0071)	(0.0107)
Ln Remittance value	0.0000	0.0002	0.0019
	(0.0005)	(0.0094)	(0.0112)
Constant		−0.2167	−0.2147
		(0.1817)	(0.3795)
Regional fixed effect			
Koulikoro (=1 if yes)	−0.0028	0.0061	0.0073
	(0.0043)	(0.0078)	(0.0094)
Sikasso (=1 if yes)	−0.0021	0.0106	0.0127
	(0.0018)	(0.0181)	(0.0180)
Ségou (=1 if yes)	−0.0002	0.0043	0.0102
	(0.0006)	(0.074)	(0.0133)
Mopti (=1 if yes)	0.0034	0.0043	0.0083
	(0.0039)	(0.0067)	(0.0111)
Tombouctou (=1 if yes)	0.0033	−0.0030	−0.0021
	(0.0100)	(0.0038)	(0.0026)
Gao (=1 if yes)	−0.0017	−0.0018	−0.0017
	(0.0030)	(0.0022)	(0.0021)
Observations	**5,324**	**2,849**	**2,475**

Notes: Robust standard errors in parentheses.

The superscripts ∗∗∗, ∗∗ and ∗ denote statistical significance at the 1, 5 and 10% levels.

gender gap by decreasing the endowment effect. Having more adult men in the household and using more male help workers negatively and significantly impact women's structural disadvantages and hence reduce the gender gap. The age of female plot managers, whether or not a pesticide and organic fertiliser are used, male family labour, the intensity of use of organic fertiliser and the non-use of female help group labour have a positive and significant effect on female structural disadvantages and, hence, on the magnitude of the gender gap. In Mali, as in most Sahel countries in West and Central Africa, millet and sorghum are cereals that are crucial to the diets and livelihood of the rural population. However, millet is an ultra-stress-tolerant cereal, has a much shorter growing period and is mostly cultivated by male farmers.

An average gender productivity gap of 20.18% is found and can be attributed to the female structural disadvantages and the endowment effect. The majority of the gap (55.93%) remains unexplained and is due to female structural disadvantages, which suggests that designing policies meant to reduce the agricultural productivity gap between male and female plot managers will be particularly challenging. To halve the gender gap in agricultural productivity, governments should improve women's access to resources similar to those of men farmers because women farmers in Mali lag behind men farmers in endowments. To close the gender gap, more needs to be done in terms of enabling women to obtain the same returns as men from the use of agricultural inputs. As indicated by Doss (2018), key interventions for increasing women's agricultural productivity might not only lie in the

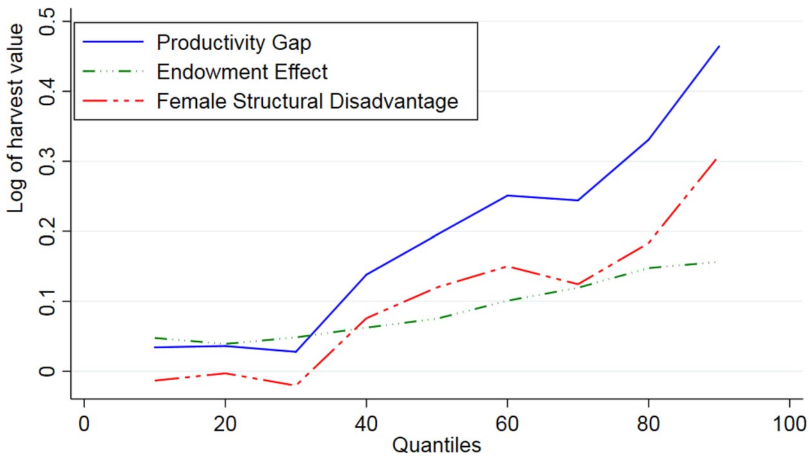

Figure 2: Gender Productivity Gap, Endowment Effect and Female Structural Disadvantage across the Quantile Distribution

agricultural sector. Interventions that reduce women farmers' drudgery, such as providing tap water or reducing the daily trek for firewood, can free up time and energy that could be more productively used in farming (Doss, 2018).

4.3. Quantile decomposition of the agricultural productivity gap

Table 4 presents the disaggregated RIF decomposition results. The results from Table 3 are also included to facilitate comparisons between results at various quantiles and at the mean. The portion of the gap due to the endowment effect significantly varies along the agricultural productivity distribution. A significant positive endowment effect is first observed at the 60th percentile and increases up to the 90th percentile. Figure 2 illustrates the evolution of the productivity gap, the endowment structural effect and female structural disadvantages at various percentiles. Between the 10th and the 40th percentiles, the results show no statistically significant of the gender gap; neither the coefficients on the aggregate endowments nor the coefficients on the female structural disadvantage or male structural advantage are statistically significant. This finding suggests that policies aimed at reducing the gap could be more potent in helping both men and women farmers who are managing plots with relatively low productivity levels. For higher percentiles, the endowment effect is smaller than female structural disadvantages. The structural effects are significant at the mean of the full sample and at all percentiles of agricultural productivity, except the first three percentiles. This result suggests that at or above the 40th percentile, female managers obtain, on average, lower returns from inputs than male managers.

The above results are noticeably different from those of Kilic *et al.* (2015b), who found that the endowment effect explains a larger share of the gender gap than the female structural disadvantage component. The results of Oseni *et al.* (2015) for Southern Nigeria reveal a dominant endowment effect, but Aguilar *et al.* (2015) found that 57% of their 23.4% productivity differential for Ethiopia remained unexplained. Clearly, the drivers of the gender

Table 4: Recentred Influence Function Estimates in Mali

	Mean	10th percentile	20th percentile	30th percentile	40th percentile	50th percentile	60th percentile	70th percentile	80th percentile	90th percentile
A. Mean gender differential										
Mean male managed plot of agricultural productivity	12.0717***	10.1729***	10.8230***	11.2342***	11.6565***	12.0271***	12.4332***	12.8259***	13.3454***	14.1839***
	(0.1686)	(0.2528)	(0.2434)	(0.2064)	(0.2010)	(0.2031)	(0.1649)	(0.1157)	(0.1202)	(0.1793)
Mean female managed plot of agricultural productivity	11.8699***	10.1387***	10.7869***	11.2064***	11.5183***	11.8321***	12.1822***	12.5819***	13.0146***	13.7194***
	(0.2017)	(0.2529)	(0.2643)	(0.2251)	(0.2150)	(0.1876)	(0.1701)	(0.1629)	(0.1133)	(0.1285)
Mean gender differential of agricultural productivity	0.2017***	0.0342	0.0361	0.0278	0.1382*	0.1950**	0.2509***	0.2440*	0.3308***	0.4645***
	(0.0561)	(0.0839)	(0.0798)	(0.0525)	(0.0621)	(0.0636)	(0.0471)	(0.0989)	(0.0956)	(0.0962)
B. Aggregate decomposition										
Endowment effect	0.0889**	0.0476	0.0391	0.0484	0.0624	0.0752	0.1009*	0.1194*	0.1476*	0.1564
	(0.0460)	(0.0422)	(0.0403)	(0.0416)	(0.0427)	(0.0478)	(0.0505)	(0.0989)	(0.0706)	(0.0878)
Male structural advantage	0	0	0	0	0	0	0	0	0	0
	(0.0124)	(0.0379)	(0.0420)	(0.0226)	(0.0212)	(0.0236)	(0.0108)	(0.0462)	(0.0386)	(0.0500)
Female structural disadvantage	0.1128***	−0.0134	−0.0030	−0.0206	0.0758*	0.1199**	0.1501***	0.1245*	0.1832***	0.3081***
	(0.0206)	(0.0422)	(0.0521)	(0.0354)	(0.0370)	(0.0354)	(0.0203)	(0.0520)	(0.0426)	(0.0649)
Share of the gender differential on endowment effect	44.07%	139%	108%	174%	45%	39%	40%	49%	45%	34%

(Continued)

Table 4: Continued

	Mean	10th percentile	20th percentile	30th percentile	40th percentile	50th percentile	60th percentile	70th percentile	80th percentile	90th percentile
Share of the gender differential on male structural advantage	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Share of the gender differential on female structural disadvantage	55.93%	−0%	−0%	−0%	55%	61%	60%	51%	55%	66%
Percent of plots managed by women	-	49.81%	47.26%	46.87%	50.72%	50.28%	47.81%	47.00%	46.14%	34.47%
Percent of households with managers of both genders	-	93.49%	95.44%	95.51%	96.49%	97.40%	97.81%	95.69%	95.29%	93.66%
Observations						**5,324**				

Notes: Robust standard errors in parentheses.
Regional fixed effects not displayed.
The superscripts ***, ** and * denote statistical significance at the 1, 5 and 10% levels.

agricultural productivity gap differ across countries and across productivity quantiles within countries.

Table 5 presents the detailed RIF decomposition results for the 10th, 50th and 90th percentiles. As expected, many of the coefficients vary along the distribution of productivity. Regarding the analysis at the mean, the endowment effect is conditioned by the manager's age, the plot size, whether or not organic fertiliser is used, whether or not hired female workers are used and the intensity with which inorganic fertiliser and male family labour are used. These factors and planting millet produce a larger endowment effect. Therefore, they tend to inflate the gender productivity gap. In addition, whether pesticide, organic fertiliser, female labour (family or hired) and purchased seeds are used increases the endowment effect to various degrees across percentiles. Basic education, which has a negative effect on the endowment effect at the mean, is significant at the 50th and 90th percentiles. Plot size does not contribute explanatory power with regard to the gender gap at the 10th, 50th or 90th percentiles, which means that the gaps for small and large plots in any given productivity group are roughly the same.

The positive and significant coefficients of female structural disadvantages at the mean of the full sample and from the 40th to 90th percentiles of the aggregate decomposition suggest that unobservable factors work against the endowment effect, widening the gender gap in agricultural productivity. However, from the 10th to 30th percentiles, the female structural disadvantage coefficients are non-significant, including those pertaining to plot size. The magnitude of the structural effects across percentiles suggests that the gender productivity gap will remain in Mali even if policies are able to equalise access to factors of production for both male and female plot managers.

The positive endowment effects in the aggregate decomposition in Table 5 indicate that differences in the levels of production factors make female managers less productive than male managers. The productivity gap is largely due to female structural disadvantages except at low percentiles, where the endowment effect accounts for most of the gap. It can be concluded that in Mali, the gender productivity differences in plots that are moderate to highly productive are largely due to female structural disadvantages. A similar conclusion was reached by Slavchevska (2015) for Tanzania and by Aguilar *et al.* (2015) for Ethiopia.

One way to make progress would be to give women more opportunities for self-support. Concretely, this means easing labour market restrictions and constraints stemming from social norms to improve female labour force participation. Another recommendation would be to reform family law to improve women's status in terms of property rights and inheritance rights, for instance, by entitling wives to a significant share of their husband's bequest regardless of the number of children. Polygamy profoundly impacts intra-household dynamics and makes comparative statics far from straightforward (Rossi, 2018).

5. Concluding remarks

This paper uses the nationally representative LSMS-ISA to investigate the gender productivity gap among farm households in Mali. The Oaxaca–Blinder approach and RIF decomposition methodology are adopted to quantify the magnitude of the gender agricultural productivity gap between male and female plot managers and to determine the factors that have a significant influence on the gender productivity gap at the mean and at different quantiles.

Table 5: Detailed Recentred Influence Function Estimates for Only the 10th,50th and 90th

A. Mean gender differential	Mean	10th percentile	50th percentile	90th percentile
Mean male managed plot of Agricultural productivity	12.0717*** (0.1686)	10.1729*** (0.2528)	12.0271*** (0.2031)	14.1839*** (0.1793)
Mean female managed plot of Agricultural productivity	11.8699*** (0.1826)	10.1387*** (0.2529)	11.8321*** (0.1876)	13.7194*** (0.1285)
Mean gender differential of agricultural productivity	0.2017*** (0.0561)	0.0342 (0.0839)	0.1950** (0.0636)	0.4645*** (0.0962)

B. Aggregate decomposition	Endowment effect				Male structural advantage				Female structural disadvantage			
	Mean	10th percentile	50th percentile	90th percentile	Mean	10th percentile	50th percentile	90th percentile	Mean	10th percentile	50th percentile	90th percentile
Total	0.0889**	0.0476	0.0752	0.1564	0	0	0	0	0.1128***	−0.0134	0.1199**	0.3043***
	(0.0460)	(0.0422)	(0.0478)	(0.0878)	(0.0123)	(0.0378)	(0.0236)	(0.0500)	(0.0206)	(0.0422)	(0.0354)	(0.0663)
Share of the gender differential	44.07%	139%	39%	34%	0%	0%	0%	0%	54.42%	−0%	61%	66%

(Continued)

Table 5: Continued

C. Detailed decomposition	Endowment effect				Male structural advantage				Female structural disadvantage			
	Mean	10th percentile	50th percentile	90th percentile	Mean	10th percentile	50th percentile	90th percentile	Mean	10th percentile	50th percentile	90th percentile
Manager has secondary education (=1 if yes)	0.0009	0.0002	0.0003	0.0002	−0.0008	−0.0017	0.0009	−0.0022	−0.0008	−0.0026	0.0014	−0.0019
	(0.0007)	(0.0021)	(0.0015)	(0.0010)	(0.0006)	(0.0018)	(0.0012)	(0.0024)	(0.0006)	(0.0019)	(0.0014)	(0.0032)
Manager has basic education (=1 if yes)	−0.0094**	−0.0050	−0.0121*	−0.0150***	0.0098*	−0.0024	0.0200***	−0.0003	0.0083	−0.0023	0.0201	0.0027
	(0.0033)	(0.0072)	(0.0060)	(0.0043)	(0.0055)	(0.0131)	(0.0059)	(0.0098)	(0.0071)	(0.0133)	(0.0141)	(0.0095)
Age	0.0282*	0.0480*	0.0127	0.0741**	0.0771	−0.0761	0.2975***	0.1233	0.2226**	−0.1410	0.4379*	0.5451
	(0.0122)	(0.0200)	(0.0105)	(0.0223)	(0.0562)	(0.4440)	(0.0802)	(0.3397)	(0.1131)	(0.6451)	(0.1701)	(0.3767)
Age squared	−0.0309**	−0.0494*	−0.0133	−0.0842***	−0.0178	0.1048	−0.1551**	−0.0902	−0.0681	0.1622	−0.2025	−0.3105*
	(0.0112)	(0.0203)	(0.0120)	(0.0237)	(0.0409)	(0.2563)	(0.0501)	(0.1416)	(0.0776)	(0.3600)	(0.1195)	(0.1541)
Household male adult size (15–64)	0.0025	−0.0006	0.0043	0.0028	−0.0599**	−0.0865	0.0219	−0.1973*	−0.09151**	−0.1197	−0.0003	−0.2330***
	(0.0019)	(0.0018)	(0.0029)	(0.0041)	(0.0221)	(0.0562)	(0.0266)	(0.0822)	(0.0318)	(0.0778)	(0.0387)	(0.0665)
Household female adult size (15–64)	−0.0006	0.0028	−0.0042	0.0017	0.0497	0.0232	0.0563	−0.0729***	0.0656	0.0173	0.0745	−0.1149**
	(0.0034)	(0.0029)	(0.0049)	(0.0049)	(0.0365)	(0.0602)	(0.0389)	(0.0178)	(0.0508)	(0.0881)	(0.0534)	(0.0437)
# children under 14 years	0.0013	0.0002	0.0034	−0.0018	−0.0397	0.0655	−0.0602	0.1089	−0.0346	0.0982	−0.0600	0.1608
	(0.0034)	(0.0054)	(0.0040)	(0.0035)	(0.0445)	(0.1315)	(0.0619)	(0.1016)	(0.0677)	(0.1806)	(0.0839)	(0.1070)

(Continued)

Table 5: Continued

C. Detailed decomposition	Endowment effect				Male structural advantage				Female structural disadvantage			
	Mean	10th percentile	50th percentile	90th percentile	Mean	10th percentile	50th percentile	90th percentile	Mean	10th percentile	50th percentile	90th percentile
Ln area (ha)	−0.0026	−0.0026	−0.0022	−0.0021	0.0116	0.0324	0.0170	−0.0279	0.0136	0.0330	0.0186	−0.0312
	(0.0106)	(0.0124)	(0.0108)	(0.0101)	(0.0137)	(0.0183)	(0.0171)	(0.0203)	(0.0175)	(0.0264)	(0.0219)	(0.0275)
Soil type (clay = compaction = 0, other = 1, loam = 2)	−0.0007	−0.0011	−0.0007	−0.0008	−0.0027	0.0775**	−0.0197	−0.0481	−0.0136	0.0753**	−0.0329	−0.0559
	(0.0020)	(0.0033)	(0.0019)	(0.0023)	(0.0164)	(0.0274)	(0.0291)	(0.0533)	(0.0204)	(0.0291)	(0.0336)	(0.0664)
Plot slope (steep = 0, slight = 1, flat = 2)	−0.0002	0.0000	−0.0002	−0.0004	−0.0033	−0.0472	0.0304	0.0040	−0.0114	−0.0431	0.0147	0.0148
	(0.0005)	(0.0002)	(0.0005)	(0.0009)	(0.0331)	(0.0252)	(0.0453)	(0.0668)	(0.0411)	(0.0364)	(0.0629)	(0.0828)
No pesticide use (=1 if yes)	0.0004	0.0005	0.0004	0.0004	0.0645***	−0.0134	0.0416	0.2111*	0.0790***	−0.0171	0.0593*	0.2610*
	(0.0019)	(0.0021)	(0.0017)	(0.0020)	(0.0166)	(0.0200)	(0.0257)	(0.0939)	(0.0151)	(0.0591)	(0.0254)	(0.1229)
Ln pesticide (kg/ha)	0.0013	−0.0008	0.0010	0.0041	−0.0113	−0.0220	0.0216	−0.0872	−0.0101	−0.0161	0.0206	−0.0857
	(0.0009)	(0.0011)	(0.0008)	(0.0033)	(0.0136)	(0.0221)	(0.0202)	(0.0556)	(0.0142)	(0.0195)	(0.0219)	(0.0600)
No organic fertiliser use	−0.0129*	−0.0089	−0.0155*	−0.0204	0.0399**	−0.0119	0.1254***	−0.0787	0.0638**	0.0169	0.1740***	−0.1407
	(0.0070)	(0.0075)	(0.0069)	(0.0119)	(0.0211)	(0.0863)	(0.0372)	(0.0600)	(0.0287)	(0.1276)	(0.0482)	(0.0910)
Ln organic fertiliser (kg/ha)	0.0274**	0.0185	0.0320**	0.0394*	0.0454***	0.0114	0.1001***	−0.0656	0.0729***	0.0463	0.1344***	−0.0929
	(0.0098)	(0.0098)	(0.0104)	(0.0167)	(0.0126)	(0.0467)	(0.0304)	(0.0698)	(0.0134)	(0.0624)	(0.0312)	(0.0881)

(Continued)

Table 5: Continued

C. Detailed decomposition	Endowment effect				Male structural advantage				Female structural disadvantage			
	Mean	10th percentile	50th percentile	90th percentile	Mean	10th percentile	50th percentile	90th percentile	Mean	10th percentile	50th percentile	90th percentile
No inorganic fertiliser use (=1 if yes)	0.0002 (0.0037)	0.0178 (0.0107)	0.0046 (0.0061)	−0.0234* (0.0109)	−0.0131 (0.0295)	−0.1169** (0.0406)	−0.0086 (0.0472)	0.0680 (0.0387)	−0.0100 (0.0387)	−0.1568** (0.0579)	0.0004 (0.0533)	0.0454 (0.0438)
Ln inorganic fertiliser (kg/ha)	0.0172*** (0.0049)	−0.0065 (0.0059)	0.0152** (0.0048)	0.0507*** (0.0145)	0.0022 (0.0163)	−0.0462* (0.0235)	0.0251 (0.0299)	−0.0063 (0.0249)	0.0065 (0.0120)	−0.0530* (0.0266)	0.0349 (0.0263)	−0.0215 (0.0369)
No male family labour (=1 if yes)	−0.0088 (0.0081)	−0.0092 (0.0093)	−0.0064 (0.0062)	−0.0037 (0.0043)	0.0138** (0.0052)	0.0053 (0.0208)	0.0013 (0.0081)	0.0493* (0.0201)	0.0181** (0.0074)	0.0130 (0.0229)	0.0000 (0.0113)	0.0603* (0.0254)
Ln male family labour (days/ha)	0.0510*** (0.0098)	0.0368*** (0.0114)	0.0402** (0.0125)	0.0543*** (0.0134)	0.0701** (0.0225)	0.0407 (0.0630)	0.0245 (0.0405)	0.1852*** (0.0509)	0.0937*** (0.0276)	0.0892 (0.0840)	0.0371 (0.0440)	0.1974** (0.0648)
No female family labour (=1 if yes)	−0.0052 (0.0033)	−0.0042 (0.0053)	−0.0063 (0.0044)	−0.0015 (0.0062)	−0.0169 (0.0214)	−0.1024 (0.0566)	0.0473* (0.0190)	0.0059 (0.0265)	−0.0157 (0.0214)	−0.1114 (0.0644)	0.0528*** (0.0200)	0.0105 (0.0365)
Ln male family labour (days/ha)	0.0510*** (0.0098)	0.0368*** (0.0114)	0.0402** (0.0125)	0.0543*** (0.0134)	0.0701** (0.0225)	0.0407 (0.0630)	0.0245 (0.0405)	0.1852*** (0.0509)	0.0937*** (0.0276)	0.0892 (0.0840)	0.0371 (0.0440)	0.1974** (0.0648)
No female family labour (=1 if yes)	−0.0052 (0.0033)	−0.0042 (0.0053)	−0.0063 (0.0044)	−0.0015 (0.0062)	−0.0169 (0.0214)	−0.1024 (0.0566)	0.0473* (0.0190)	0.0059 (0.0265)	−0.0157 (0.0214)	−0.1114 (0.0644)	0.0528*** (0.0200)	0.0105 (0.0365)
Ln female family labour (days/ha)	−0.0017 (0.0030)	−0.0033 (0.0056)	−0.0026 (0.0045)	0.0030 (0.0059)	0.0010 (0.0187)	−0.0659 (0.0507)	0.0646*** (0.0143)	0.0012 (0.0469)	0.0067 (0.0176)	−0.0851 (0.0647)	0.0878*** (0.0129)	0.0127 (0.0586)

(Continued)

Table 5: Continued

C. Detailed decomposition	Endowment effect				Male structural advantage				Female structural disadvantage			
	Mean	10th percentile	50th percentile	90th percentile	Mean	10th percentile	50th percentile	90th percentile	Mean	10th percentile	50th percentile	90th percentile
No child family labour (=1 if yes)	0.0002 (0.0039)	0.0000 (0.0007)	0.0004 (0.0057)	0.0003 (0.0048)	−0.0005 (0.0299)	−0.0499 (0.0637)	−0.0137 (0.0274)	0.0223 (0.0551)	0.0009 (0.0343)	−0.0600 (0.0783)	−0.0103 (0.0287)	0.0396 (0.0589)
Ln child family labour (days/ha)	0.0044 (0.0056)	0.0024 (0.0042)	0.0055 (0.0069)	0.0059 (0.0076)	0.0218 (0.0202)	−0.0383 (0.0253)	0.0067 (0.0140)	0.0908 (0.0645)	0.0251 (0.0234)	−0.0527 (0.0290)	0.0169 (0.0140)	0.1083 (0.0740)
No male hired labour (=1 if yes)	−0.0013 (0.0029)	−0.0118 (0.0083)	0.0054 (0.0047)	0.0043 (0.0087)	0.0864 (0.0788)	0.0000 (0.1697)	0.0598 (0.0607)	0.1476 (0.1253)	0.1205 (0.1268)	0.0122 (0.2599)	0.0806 (0.1134)	0.2457 (0.1855)
Ln male hired labour (days/ha)	0.0123** (0.0056)	0.0179 (0.0092)	0.0070* (0.0034)	0.0160 (0.0122)	0.0044 (0.0080)	0.0069 (0.0131)	0.0045 (0.0081)	0.0019 (0.0204)	0.0097 (0.0116)	0.0123 (0.0156)	0.0097 (0.0103)	0.0130 (0.0216)
No female hired labour (=1 if yes)	0.0107** (0.0037)	0.0127* (0.0054)	0.0180* (0.0077)	0.0014 (0.0094)	−0.1025 (0.1447)	0.2054 (0.2561)	−0.1561 (0.1650)	−0.3940 (0.2184)	−0.1919 (0.3569)	0.4226 (0.5304)	−0.3525 (0.4469)	−0.7699 (0.7300)
Ln female hired labour (days/ha)	−0.0054** (0.0025)	−0.0085* (0.0037)	−0.0110* (0.0054)	0.0024 (0.0051)	−0.0019 (0.0050)	0.0044 (0.0061)	−0.0058 (0.0051)	−0.0119 (0.0138)	−0.0040 (0.0108)	0.0076 (0.0118)	−0.0102 (0.0132)	−0.0197 (0.0241)
No child hired labour (=1 if yes)	0.0016 (0.0010)	0.0047* (0.0022)	−0.0008 (0.0012)	0.0034 (0.0040)	−0.0443 (0.2006)	0.1690 (0.2351)	−0.0046 (0.1931)	−0.2510 (0.3187)	−0.0540 (0.3019)	0.3046 (0.3691)	0.0232 (0.2847)	−0.5719 (0.7761)
Ln child hired labour (days/ha)	−0.0008 (0.0005)	−0.0038 (0.0022)	0.0003 (0.0008)	−0.0013 (0.0027)	−0.0001 (0.0031)	0.0057 (0.0072)	0.0025 (0.0034)	−0.0109 (0.0138)	0.0005 (0.0055)	0.0060 (0.0121)	0.0023 (0.0067)	−0.0116 (0.0212)

(Continued)

Table 5: Continued

C. Detailed decomposition	Endowment effect				Male structural advantage				Female structural disadvantage			
	Mean	10th percentile	50th percentile	90th percentile	Mean	10th percentile	50th percentile	90th percentile	Mean	10th percentile	50th percentile	90th percentile
No male help group labour (=1 if yes)	−0.0010	0.0029	0.0037	−0.0141	−0.2878**	−0.0307	−0.1975	−0.6697**	−0.3388**	−0.1168	−0.1933	−0.8396
	(0.0016)	(0.0038)	(0.0026)	(0.0089)	(0.1209)	(0.1619)	(0.1298)	(0.2347)	(0.1658)	(0.2316)	(0.1382)	(0.5106)
Ln male help group labour (days/ha)	0.0057*	−0.0012	−0.0016	0.0246	−0.0125*	0.0035	−0.0026	−0.0410	−0.0121	−0.0016	−0.0005	−0.0412
	(0.0035)	(0.0033)	(0.0012)	(0.0161)	(0.0071)	(0.0102)	(0.0070)	(0.0265)	(0.0086)	(0.0108)	(0.0070)	(0.0403)
No female help group labour (=1 if yes)	0.0002	−0.0006	−0.0005	0.0024	0.2528***	−0.1691	0.1563	0.5534	0.2712**	−0.4429	0.1981	0.8285
	(0.0011)	(0.0026)	(0.0023)	(0.0099)	(0.0588)	(0.5890)	(0.1213)	(0.3669)	(0.0893)	(1.2228)	(0.2104)	(0.7288)
Ln female help group labour (days/ha)	−0.0012	0.0006	−0.0008	−0.0040	0.0051	−0.0142	−0.0003	0.0263	0.0068	−0.0241	0.0035	0.0378
	(0.0031)	(0.0018)	(0.0027)	(0.0104)	(0.0036)	(0.0190)	(0.0035)	(0.0208)	(0.0049)	(0.0441)	(0.0071)	(0.0354)
Used purchased seed (=1 if yes)	−0.0032**	−0.0036	−0.0018	−0.0037	0.0098	0.0157	0.0255	0.0770	0.0122	0.0238	0.0374	0.0939
	(0.0012)	(0.0025)	(0.0012)	(0.0032)	(0.0465)	(0.0470)	(0.0193)	(0.1142)	(0.0540)	(0.0560)	(0.0196)	(0.1511)
Maize (=1 if yes)	−0.0008	−0.0013	−0.0010	−0.0004	0.0019	0.0342	−0.0011	0.0325	0.0037	0.0302	0.0026	0.0435*
	(0.0133)	(0.0211)	(0.0162)	(0.0061)	(0.0101)	(0.0321)	(0.0131)	(0.0234)	(0.0089)	(0.0252)	(0.0099)	(0.0191)
Millet (=1 if yes)	0.0198**	0.0472**	0.0188*	0.0029	0.0132	0.0353	0.0239	−0.0044	0.0179	0.0257	0.0279	−0.0050
	(0.0081)	(0.0162)	(0.0084)	(0.0065)	(0.0230)	(0.0482)	(0.0167)	(0.0219)	(0.0217)	(0.0405)	(0.0160)	(0.0233)
Sorghum (=1 if yes)	0.0031	0.0066	0.0034	0.0004	0.0011	0.0395	−0.0001	0.0041	0.0043	0.0351	0.0032	0.0006
	(0.0078)	(0.0165)	(0.0087)	(0.0026)	(0.0185)	(0.0327)	(0.0175)	(0.0281)	(0.0158)	(0.0277)	(0.0132)	(0.0269)
Groundnut (=1 if yes)	−0.0259**	−0.0464**	−0.0332**	−0.0067	−0.0063	0.0425	−0.0147	0.0084	−0.0037	0.0524	−0.0108	0.0129
	(0.0100)	(0.0145)	(0.0116)	(0.0103)	(0.0114)	(0.0247)	(0.0110)	(0.0132)	(0.0151)	(0.0289)	(0.0127)	(0.0203)
Paddy (=1 if yes)	0.0121	0.0160	0.0132	0.0093	0.0103	0.0373	0.0198	0.0245	0.0117	0.0326	0.0206	0.0279
	(0.0205)	(0.0263)	(0.0221)	(0.0182)	(0.0099)	(0.0261)	(0.0115)	(0.0266)	(0.0102)	(0.0218)	(0.0115)	(0.0295)

(Continued)

Table 5: Continued

C. Detailed decomposition	Endowment effect				Male structural advantage				Female structural disadvantage			
	Mean	10th percentile	50th percentile	90th percentile	Mean	10th percentile	50th percentile	90th percentile	Mean	10th percentile	50th percentile	90th percentile
Cotton (=1 if yes)	0.0007	0.0012	0.0008	0.0002	−0.0005	0.0027	0.0002	−0.0025	−0.0007	0.0021	−0.0000	−0.0015
	(0.0007)	(0.0012)	(0.0009)	(0.0005)	(0.0007)	(0.0025)	(0.0008)	(0.0035)	(0.0006)	(0.0019)	(0.0008)	(0.0034)
Child dependency ratio	−0.0005	−0.0002	−0.0009	0.0002	0.0158	−0.0656	0.0981	−0.1488***	0.0007	−0.1009	0.1020	−0.2261***
	(0.0007)	(0.0011)	(0.0017)	(0.0009)	(0.0463)	(0.1093)	(0.0590)	(0.0306)	(0.0743)	(0.1573)	(0.0875)	(0.0453)
Off-farm income (=1 if yes)	−0.0002	−0.0001	−0.0004	−0.0005	0.0125*	0.0742***	0.0083	−0.0075	0.0157	0.0779***	0.0100	−0.0037
	(0.0003)	(0.0009)	(0.0006)	(0.0009)	(0.0071)	(0.0159)	(0.0064)	(0.0295)	(0.0107)	(0.0203)	(0.0091)	(0.0339)
Ln remittance value	0.0000	−0.0000	0.0000	0.0000	0.0002	0.0027	−0.0039	0.0192	0.0019	0.0014	−0.0052	0.0225
	(0.0005)	(0.0003)	(0.0015)	(0.0004)	(0.0094)	(0.0144)	(0.0049)	(0.0204)	(0.0112)	(0.0182)	(0.0067)	(0.0246)
Constant					−0.2167	0.0209	−0.6900*	0.2187	−0.2147	0.0786	−0.7597	0.7471
					(0.1817)	(0.3659)	(0.3145)	(0.6666)	(0.3795)	(0.8025)	(0.5751)	(1.2565)
Regional fixed effect												
Koulikoro (=1 if yes)	−0.0028	−0.0048	−0.0026	−0.0009	0.0061	−0.0273	0.0038	0.0623	0.0073	−0.0398	0.0050	0.0869
	(0.0043)	(0.0072)	(0.0039)	(0.0015)	(0.0078)	(0.0275)	(0.0059)	(0.0589)	(0.0094)	(0.0395)	(0.0063)	(0.0829)
Sikasso (=1 if yes)	−0.0021	−0.0021	−0.0025	−0.0033	0.0106	−0.0401	0.0260	0.0911	0.0127	−0.0526	0.0269	0.1295
	(0.0018)	(0.0020)	(0.0024)	(0.0034)	(0.0181)	(0.0378)	(0.0299)	(0.0856)	(0.0180)	(0.0489)	(0.0319)	(0.1171)
Ségou (=1 if yes)	−0.0002	−0.0003	0.0001	−0.0007	0.0043	−0.0334	0.0030	0.0545	0.0102	−0.0443	0.0101	0.0875
	(0.0006)	(0.0008)	(0.0004)	(0.0023)	(0.074)	(0.0352)	(0.0079)	(0.0526)	(0.0133)	(0.0456)	(0.0114)	(0.0822)
Mopti (=1 if yes)	0.0034	0.0115	0.0022	−0.0045	0.0043	0.0053	0.0049	0.0342	0.0083	−0.0028	0.0120	0.0599
	(0.0039)	(0.0118)	(0.0027)	(0.0062)	(0.0067)	(0.0120)	(0.0060)	(0.0388)	(0.0111)	(0.0136)	(0.0129)	(0.0638)

(Continued)

Table 5: Continued

C. Detailed decomposition	Endowment effect				Male structural advantage				Female structural disadvantage			
	Mean	10th percentile	50th percentile	90th percentile	Mean	10th percentile	50th percentile	90th percentile	Mean	10th percentile	50th percentile	90th percentile
Tombouctou	0.0033	−0.0243	0.0025	0.0474	−0.0030	−0.0045	−0.0032	−0.0013	−0.0021	−0.0030	−0.0015	−0.0034
(=1 if yes)	(0.0100)	(0.0286)	(0.0089)	(0.0569)	(0.0038)	(0.0055)	(0.0040)	(0.0060)	(0.0026)	(0.0035)	(0.0019)	(0.0047)
Gao (=1 if yes)	−0.0017	−0.0010	0.0003	−0.0022	−0.0018	−0.0003	−0.0013	−0.0061	−0.0017	−0.0004	−0.0008	−0.0057
	(0.0030)	(0.0022)	(0.0021)	(0.0046)	(0.0022)	(0.0007)	(0.0017)	(0.0073)	(0.0021)	(0.0005)	(0.0010)	(0.0069)
Observations	**5,324**				**2,849**				**2,475**			

Notes: Robust standard errors in parentheses.

Regional fixed effects not displayed.

The superscripts ∗∗∗, ∗∗ and ∗ denote statistical significance at the 1, 5 and 10% levels.

The gender gap is estimated at the national level, but regional fixed effects are used to account for non-time-varying regional variables.

Overall, the agricultural productivity of female plot managers is 20.18% less than that of male plot managers. A large portion (55.93%) of this gender gap in agricultural harvest value can be attributed to female structural disadvantages (unexplained portion), while 44.07% of the gender gap can be attributed to an endowment effect that relates the gap to differences in input uses. This result implies that to halve the gender gap in agricultural productivity, governments should improve women's access to resources similar to those of men farmers because women farmers in Mali lag behind men farmers in endowments. However, to completely close the gender gap, more needs to be done in terms of enabling women to obtain the same returns as men from the use of agricultural inputs. This suggests that policies to close the gender gap in agricultural productivity in Mali should address social norms to enhance women's intra-household allocation of productive inputs. The endowment effect is driven by plot managers' education and age, the use and quantity of organic and inorganic fertiliser, male family and hired labour, hired female labour, the use of purchased seeds and the production of millet and groundnut crops. The female structural disadvantage effect is driven by plot managers' age, household male adult labour, pesticide use, organic fertiliser use, male family labour, male family help group labour and female help group labour.

For plots that are less productive, at the 10^{th} to 40^{th} percentiles, the gender gap is not statistically significant and female structural disadvantages do not significantly contribute to the gender gap. However, at or above the 40^{th} percentile, the agricultural harvest value of female managers is significantly lower than that of male managers. The gap widens at higher percentiles, and the importance of female structural disadvantages increases.

Closing the gender gap in agricultural production and productivity has been demonstrated to have the potential to increase food production and household nutrition benefits for society (FAO, 2013). The above results show that interventions meant to close the gender agricultural productivity gap in Mali will be most effective for plots at the lower end of the harvest value generation distribution because the endowment effects are more important at lower percentiles. At higher percentiles of the harvest value generation distribution, policies that encourage the transmission of knowledge and that improve access to improved seeds and fertilisers for female plot managers will have a lesser effect because the productivity effect is mainly due to unexplained structural effects. Female structural disadvantages are most likely impacted by cultural norms that discriminate against women. Research along these lines is particularly challenging, and there is clearly a lack of research that quantifies the effect of gender norms on the capacity to innovate among farmers. In addition, more studies are needed to understand the intra-household dynamics and how they contribute to intra-household difference in productivity.

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Conflict of Interest statement

This is an original work and is not submitted for consideration in any other journal. All the authors certify that there is no conflict of interest in publishing this paper in the Journal of African Economies (JAE).

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