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Gender decomposition in smallholder agricultural performance in rural Nigeria

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ABSTRACT

Although women are actively involved in a wide array of agricultural production activities, they have limited access to farm productive resources and their influence in decision-making is also restricted compared with men. These limitations have the potential to affect women performance in agriculture. This study assesses gender-based farm performance (proxy by productivity) differences and identified sources of performance differentials amongst rice farmers in rural Nigeria using the Blinder-Oaxaca gender decomposition framework. The results revealed a disparity between men and women with a gender performance gap of about 11% in favour of men, of which 77.66% of the gap remained unexplained after accounting for gender differences in household characteristics, access to supply-driven factors, and farm productive resources. A more detailed analysis suggests that factors such as the use of improved rice varieties, membership of farmer-based organisations, extension services, and quantity of seeds sown could contribute to the gender performance gap. As a result, the study concludes that focusing on these productivity gaps and the factors that contribute to them is critical for developing policy interventions aimed at empowering women.

Introduction

In many countries in the Sub-Saharan African (SSA) region, women form a substantial part of the agricultural labour force. They constitute about 30 to 80% of the rural agrarian labour force and contribute to about 60% - 80% of the total food production [[3],[17],[26],[31]]. Agricultural productivity in SSA is low, partly because women who play a central role have limited control over productive inputs such as land, water, and improved technologies [26]. Patrilineal laws and cultural norms have limited women's access to profitable assets in the agricultural sector and even hinder their inheritance of farm

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properties [[30],[46]]. Aside from the social and administrative bias against women, they are also denied equal access to education, training, extension contacts, and information, which in turn, worsen their plights as women [[14],[17],[39]]. The limited access to these vital inputs by female gender has resulted in a decrease in their productivity to aggregate crop production, including rice output over the years. According to Merab [28], if women have direct access or right to land, there will be an increase in the food supply, which will reduce poverty, improve health, and enhance the economy of the country. The gender gap not only diminishes women's efficiency and decreases their commitments to the agriculture sector, but also imposes a burden on the economy through productivity losses [18]. This 'gap' refers to the difference in productivity between men and women on 'best practice' in farm operations with comparable resources and under similar conditions [1].

Although gender disparity may exist in agricultural production to the disadvantage of women in many African economies, many empirical studies [[2],[27],[38]] claimed that women are almost as efficient as men whenever given the opportunity. The debate on whether women are productive as men have motivated many empirical studies on evaluating and explaining men-women differentials in agricultural productivity and the results have been mixed. A study conducted by Saito et al. [44] in Nigeria revealed no statistically significant differences in productivity between men and women in household analysis. Nevertheless, the plot-level analysis revealed that men are more productive than women. While a study by Bindlish et al. [7] in Burkina Faso show that women are less efficient than their men counterparts, Udry et al. [45] found no productivity differentials between men and women. In Ethiopia, Agulair et al. [3] estimated a gender gap of 23% to the disadvantage of women smallholder farmers, with 10.1 percentage points ascribed to contrasts in characteristics by gender. Employing the Uganda National Panel Survey (UNPS), Ali et al. [5] estimated the gender productivity gap of 18%, of which 12 percentage points are attributed to differences in gender characteristics. A study conducted by Danso-Abbeam et al. [13] in Ghanaian cocoa farms also indicated that men are more technically efficient in managing their cocoa farms than their women counterparts. In Nigeria, conventionally, men have dominated the agricultural sector. However, women have joined the sector in recent years. About 70% of rural female-headed households in Nigeria derived their primary source of livelihoods from agriculture. Women involved in Nigerian agricultural production are equally faced with production constraints such as limited access to land, inputs, and extension services. Women are involved in several crop production activities, spanning from land preparation to marketing. One of the main crops that women usually engage in its production activities is rice.

Rice (*Oryza sativa*) is an indispensable food crop that is mostly consumed in majority of the urban and rural households in Nigeria. According to FAO [19], the consumption rate of rice in Africa is highest in Nigeria; also, the country is one of the largest producers of rice on the continent and simultaneously one of the largest rice importers in the world. In 2011, Nigeria imported 3.4 million tonnes of rice, putting the country in the first ranking of the largest rice importer that year [37]. The high importation may be attributed to the inconsistency and variability in the production of rice in Nigeria. For example, production increased from 2.92 million tonnes in 1995 to 4.18 million tonnes of paddy rice in 2008, but reduced to 3.22 million tonnes in 2010 [25]. FAO [20] reported that there is a 4% slight increase of 4.95million tonnes in rice production in 2016 compared to 4.75 million tonnes output in 2015. The upsurge in rice output is not because of the rise in productivity of the farmers but due to more farmers engaging in rice production, which invariably led to the expansion of land area under rice cultivation. Despite the increase in rice production, yields are still low. The rice yield in irrigated land is 3.0–3.5 metric tonnes/ha (mt/ha) compared with the potential of 7–9 mt/ha, while in the rainfed lowland environment, rice yield is 1.5–3.0 mt/ha compared to a potential of 3.0–6.0 mt/ha. Also, in the upland areas, yields range from 1.0 to 1.7 mt/ha compared with a potential of 2.0–4.0 mt/ha [25].

Aside from the challenges of low productivity emanating from limited access to improved technologies and supply-side access variables such as credit, and extension services amongst others, one of the significant yet unnoticed is gender disparity. Gender disparity in the Nigerian agricultural sector is an essential constraint to the productivity of rice farmers, but has remained under-researched. This has left a knowledge gap in the gender literature, which this study aims to fill. The need to correct gender disparity in agricultural production, particularly in Sub-Saharan Africa, has been recognised in many empirical works [[3],[5],[24]]. However, the situation of women in agricultural production differs even within the borders of a country. Thus, farm-level policies that may work in one country may not be the best alternative in another country. Hence, analysing farmers' performance and identifying the sources of gender differentials (if any) in performance is critical to improving the livelihoods of women in Nigeria. The results of this study will highlight the recent situation in Nigeria concerning women in agriculture and will serve as a guide to informed farm-level policy aimed at closing the gender gap in agricultural productivity. The results can also be applied to other agriculture-dependent economies experiencing similar situations in their agricultural sector. This will help in reducing low productivity, food insecurity, and poverty in many agrarian-dependent economies, particularly in Sub-Saharan Africa.

The present study uses household-level data from smallholder rice farmers in Ogun state, Nigeria to estimate gender differentials in farm performance[1] (proxy productivity) and identify factors explaining the differentials. The use of productivity as a measure of performance provides a better estimate of how productive a farmer may be. The study employed the Blinder-Oaxaca (B-O) econometric gender decomposition procedure to decompose the mean outcome differences between the two groups into endowment (the explained component) and structural (the unexplained component) effects. The endowment effect is a portion of the differential in the group outcomes that can be ascribed to the group differences in independent variables, whereas the structural effects are as a result of discrimination or omitted factors [33].

[1] The details on the measurement of farm performance in the context of this study is discussed in Section "*Data and methods*".

The B-O decomposition method, since its development, has been widely employed in labour economics (see [[9],[12],[35]]). However, recently, the B-O decomposition procedure has been applied in the analysis of gender differentials in agricultural productivity, where Kilic et al. [26] have been credited as the first authors to measure gender productivity differential using the B-O decomposition method. Since then, authors such as Aguilar et al. [3], Oseni et al. [39], Ali et al. [5], and Backiny-Yetna and McGee [6] have employed this method to assess gender differentials with regards to agricultural productivity in Sub-Saharan Africa.

Gender and agricultural productivity in Sub-Saharan Africa

Agricultural productivity is generally low in most developing countries, particularly Sub-Saharan African countries, where farmers are mostly smallholders, and even lower for women compared with their men counterparts [[3],[23],[24]]. Consequently, the gender gap in agricultural productivity has been an issue of public discourse in most developing nations across the world [16]. Kilic et al. [26] indicated that gender differences in agricultural productivity across SSA varies extensively from 4% to 40%. This observed gender gap could be ascribed to differences in the utilisation of farm inputs, physical, social and human capital, credit and markets access, investments in land tenure security and improved technologies and institutional constraints. In most multicultural countries such as Nigeria, gender roles and division of labour in agriculture and its related activities vary with regards to farming systems, cultural settings, and locations [36]. For example, agricultural activities such as fishing, palm wine tapping, livestock (beef) farming and tree felling are done by men only in a typical Nigerian rural community.

Aside from the gender division of labour, other gender dimensions such as ownership of asset, landholdings, agricultural extension services access, and social networks (e.g., membership of farmer groups) are major constraints that inhibit women's decisions over agricultural input management [47]. For instance, households headed by females operate lesser farmlands area compare to male-headed households due to combinations of these constraints. Hence, women tend to harvest lower yields compared with their men counterparts [29]. The widened gender gap in productivity is disadvantageous to the empowerment of women in developing countries. It enforces burdens on societies in terms of unexploited potential in farm output, food security, and economic development [42]. Diiro et al. [15] indicated that if female farmers had similar opportunity as men to farm inputs, such as seed and agrochemicals, and other supply services such as credit and agricultural extension, maize output would increase by as much as about 19% in western Kenya, 17% in Ghana and 16% in Malawi. Kinkingninhoun-Mêdagbé et al., [27] observed that the higher productivity of male farmers than their female counterparts could be ascribed to the possession of larger landholding allocated to men for rice farming in Benin. However, empirical studies in developing countries disclosed that income managed by female-headed households has more positive impact than men's income on nutrition, calorie intake, wellbeing, and education of individuals in the household [41].

Data and methods

Study area and data collection techniques

The study was conducted in South West Nigeria, Ogun state precisely, which is one of the states that produces a considerable proportion of rice in the region. The state vegetation comprises of tropical rain forest and has wooded savanna in the northwest. Crop farming serve as the primary sources of livelihood with food crops such as rice, maize, cassava, yam, and banana as the principal crops produced in the area.

A multistage random sampling technique was used to select 250 rice farm plot managers in the study area. In the first stage, five major rice producing local government areas (LGAs) was selected based on a list obtained from the Ogun State Ministry of Agriculture. In the second stage, five rice-growing communities were randomly selected in each of the five LGAs. Lastly, 8– 12 farming households were chosen from each of the communities. A total of 250 sample size comprising of 145 male-headed rice farming households and 105 female-headed rice farming households were included in the study. The study defined a female-headed household as a household where the woman is single (never married, divorce or widow) or married, but the husband has been away for at least six months (i.e., migrant husband). In this case, women who were household heads were also the rice farm managers. It is worthy to note that in a typical rural African setting, particularly in Nigeria, the man is always the household head in the presence of both the man and the woman; hence, the man is usually the general overseer of all farm plots managed by the households. This was the case for this study, where in the presence of both the woman and the man, the man was considered and interviewed as the household head. An informative and pre-tested questionnaire was used for the data collection.

Conceptual framework and estimation techniques

This section discusses the three estimation procedures employed to achieve the study objectives. First, the study applied the ordinary least squares (OLS) estimator to model the determinants of farm performance for male-headed households, female-headed households, and the pooled sample. Second, the Blinder-Oaxaca decomposition framework was applied to disaggregate the mean performance between men and women[2]. Finally, we complemented the Blinder-Oaxaca analysis with Recentered Influence Function (RIF) to assess the differences across the rice performance distribution. Productivity was used as a proxy to measure smallholder farmers' performance in rice production in Southwest Nigeria. Performance in productivity is measured as the output per unit area of land (kg/ha). Productivity is considered to be a good estimator of farmers' performance because it captures the efficient management of productive resources such as land, labour, fertilizer, and seeds, amongst others. The performance of the farm households can be expressed as

$$P_i = \eta_0 + \eta_1 G + \alpha Z_i + \chi X_i + \xi_i \quad (1)$$

where P_i denotes the farmers' performance indicator proxy by productivity. $G_i, Z_i,$ and X_i are gender, a vector of input variables, and a vector of farmers' socioeconomic factors, respectively. ξ_i is an error term, and $\eta_i, \alpha,$ and χ are parameters to be estimated. The study then applies the OLS estimator to the performance equation (Eq. (1)), where P_i is regressed on a set of observable characteristics of a pooled sample of male and female-headed households, including gender (G) to measure the effects of gender on farm performance. However, the OLS procedure does not decompose the gender gaps in productivity, as well the gaps in endowment and returns.

The study, therefore, applies Blinder-Oaxaca decomposition to measure the gender differential in productivity of rice production in the study area, and the extent to which the differentials are explained by observed and unobserved covariates.

The Blinder-Oaxaca decomposition approach

The primary focus of the application of B-O is to partition the overall differences in performance between the two groups. Since Eq. (1) is a pooled equation, separate equations are estimated distinctly for the two groups, male-headed rice farming households and female-headed rice farming households. The separate equations for the two groups can be specified as;

$$P_m = E(\eta_0^m + \sum_{i=1}^{1} \eta_i^m K^m + \xi_i^m) \quad (2)$$

$$P_f = E\left(\eta_0^f + \sum_{i=1}^{1} \eta_i^f K^f + \xi_i^f\right) \quad (3)$$

where m and f denote male and female-headed households, while Kcontain the i^{th}predictors. The error terms are assumed to be $E(\xi_i^m) = E(\xi_i^f) = 0$; hence, Eqs. (2) and (3) can be reformulated as;

$$P_m = \eta_0^m + \sum_{i=1}^{1} E(K^m)\eta_i^m \quad (4)$$

$$P_f = \eta_0^f + \sum_{i=1}^{1} E\left(K^f\right)\eta_i^f \quad (5)$$

The overall difference in the outcome variable measured as the average gap between the two groups; P_m and P_f is specified as;

$$\bar{P}_m - \bar{P}_f = \left(\bar{X}_m - \bar{X}_f\right)\hat{\eta}_m + \left(\hat{\eta}_m - \hat{\eta}_f\right)\bar{X}_f \quad (6)$$

From Eq. (6), the mean gap in P is the addition of both the coefficient and characteristic effects. $(\bar{X}_m - \bar{X}_f)\hat{\eta}_m$ is the differences attributed to the endowment effect (observable characteristics), whereas $(\hat{\eta}_m - \hat{\eta}_f)\bar{X}_f$ relates to the differences ascribed to the structural effect.

As opined by Oaxaca and Ransom [34], $\bar{P}_m - \bar{P}_f$ can be decomposed using a matrix of weights, which can be expressed as follows;

$$\bar{P}_m - \bar{P}_f = \left(\bar{X}_m - \bar{X}_f\right)\eta^* + \bar{X}_m(\eta_m - \eta^*) + \bar{X}_f\left(\eta^* - \eta_f\right)\eta^* = \Omega\eta_m + (\mathrm{I} - \Omega)\eta_f \quad (7)$$

In Eq. (7), Ω and I are the matrix of weight and identity, respectively. Blinder [8] and Oaxaca [33] proposed a generalised equation which denotes a precise case in which $\Omega = I$ or Ω is a null matrix, respectively. Nevertheless, different other states of Ω have been recommended. For example, Reimers [43] proposed the "weighting matrix" $\Omega = (0.5)\mathrm{I}$, whereas Cotton [10] suggested $\Omega = \varsigma \mathrm{I}$ as "weighting matrix". where ς denotes the majority group sample size. Also, Neumark [32] and Oaxaca and Ransom [34] proposed the derivation of a counterfactual coefficient vector by estimating the pooled model.

Furthermore, in a study by Daymont and Andrisani (1984) a threefold option to the conventional B-O model was proposed. This allows decomposing the average differential in the outcome variable into three components. The extension proposed by Daymont and Andrisani (1984) can be expressed as;

$$\bar{P}_m - \bar{P}_f = \left(\bar{X}_m - \bar{X}_f\right)\eta_m + \bar{X}_m\left(\eta_m - \eta_f\right) + \left(\bar{X}_m - \bar{X}_f\right)\left(\eta_m - \eta_f\right) = \varpi + \Psi + \varpi\Psi \quad (8)$$

where ϖ represents the portion of the raw differences that is attributed to endowment differences, Ψ denotes the portion due to coefficient differential, and $\varpi\Psi$ represents the portion which explains the interaction between ϖ and Ψ.

[2] It is important to note here that in the study men and women, and male-headed and female-headed households are used interchangeably.

Table 1
Definition of variables used in the model.

Variable	Definition
Rice output	Output of harvested rice (kg)
Explanatory variables	
Gender	1 if male-headed rice farming household; 0 otherwise
Educational attainment	Years of education of farmer
Experience in rice farming	Number of years in rice farming
Crop farming as a full time	1 if crop farming is the primary occupation, 0 otherwise
Access to improved variety	1 if farmer has access to improved rice variety/seeds, 0 otherwise
Membership of FBOs	1 if farmer belongs to a Farmer-based organisations, 0 otherwise
Access to credit	1 if farmer has access to credit, 0 otherwise
Access to extension service	1 if farmer has access to extension service, 0 otherwise
Quantity of seeds	The quantity of rice seeds cultivated (kilogram)
Quantity of pesticides	The quantity of pesticides used (litres)
Quantity of fertilizer	The quantity of fertilizers used (kilogram)
Quantity of hired labour	The quantity of hired labour employed (person-day)
Farm size	Area of farmland (hectares)

Recentered Influence Function technique

Complementing the B-O model, we employ the Recentered Influence Function (RIF) technique to determine the rice farmers' performance gaps across different distribution points other than the mean (i.e. average performance/productivity). The RIF technique was proposed by Firpo et al. [21] and recently incorporated in Stata software by Rios-Avila (2020). The RIF method is an unconditional quantile regression that provides the detailed B-O decomposition estimates at each specified decile of the rice performance distribution [21]. This method is similar to a standard OLS regression except the difference in the dependent variable (The RIF of the distributional statistics of interest (i.e. percentiles) is used to replace P). According to Firpo et al. [22] and Cowell and Flachaire [11], the RIF method in a B-O decomposition offers a linear approximation of extremely non-linear functional and estimations of the robustness of distributional statistics to small data disturbances. Thus, this will play a major role in highlighting the difference in overall and specific endowment and structural limitations that contribute to the gender rice performance gap at each percentile.

Following Firpo et al. [21] the RIF model is expressed as follows:

$$\mathrm{RIF}(P;\upsilon) = \upsilon(F_P) + \mathrm{IF}(P;\upsilon) \tag{9}$$

where $\mathrm{RIF}(P;\upsilon)$is the estimated RIF to be substituted for P dependent variable. $\upsilon(F_P)$ is the main distributional statistics to be used (i.e., quantiles q_τ) for the density of marginal distribution F_P of P and $q_\tau = Q_\tau(P)$ is the population τ-quantile of the unconditional distribution of P. $\mathrm{IF}(P;\upsilon)$ is the influence function for υ for whose q_τ distributional statistic is given as;

$$\mathrm{IF}(P;q_\tau) = \frac{\tau - 1\{P \le \upsilon(F_P)\}}{F_P(\upsilon(F_P))} \tag{10}$$

where $1\{P \le \upsilon(F_P)\}$ is an indicator function which equals to 1 if the condition inside the bracket is satisfied but 0 if otherwise. Furthermore, the q_τ based RIF is defined as;

$$\mathrm{RIF}(P;q_\tau) = q_\tau + IF(P;q_\tau) \tag{11}$$

The RIF[3] is computed using the Eq. (11) of which each observation of P, quantile τ and density F_P are estimated using the kernel density technique. After estimating the RIF, the values are used as the dependent variable in replacement of P in the application of the B-O decomposition model. Thus, this gives a quantile-based gender gap decomposition across the performance distribution of the rice farmers.

Results and discussion

Summary of descriptive statistics

The definition of variables is presented in Table 1 while the descriptive statistics for the sampled farm managers and by gender disaggregation of demographic, farm-specific, and institutional variables included in the models is presented in Table 2. The *t-statistic* in the last column of Table 2 indicates whether there are statistically significant differences in mean characteristics between male and female plot managers.[4]

Table 2 indicated that the mean output for the sampled household is 865.65 kg. However, male-headed households had a significantly higher output of harvested rice (952.93 kg) than rice plots managed by female-headed households (745.12 kg).

[3] Stata 15 software is used to compute the RIF for this study.
[4] Unequal variance of two-sample t-test was employed.

Table 2
Farm managers' descriptive statistics by gender.

Variables	Male		Female		Full sample		
	Mean	SD	Mean	SD	Mean	SD	*t*-value
Output of harvested rice (kg)	952.93	455.36	745.12	307.38	865.65	412.24	4.31[a]
Quantity of hired labour (person-days)	35.88	9.41	34.69	10.06	35.39	9.68	0.95
Quantity of fertilizer (kg)	238.62	47.05	229.05	55.81	234.60	51.02	1.43
Quantity of pesticides (litres)	7.35	2.94	7.26	3.34	7.32	3.09	0.24
Quantity of seeds (kg)	155.3	40.58	145.28	41.32	151.09	41.11	1.91[c]
Demographic factors							
Gender (Male =1, Female=0)					0.58	-	
Educational attainment (years)	6.61	6.53	3.61	4.56	5.35	5.96	4.27[a]
Experience in rice farming (years)	14.71	4.66	16.07	5.62	15.28	5.12	2.02[b]
Crop farming as a full time (Yes =1)	0.46		0.62	0.49	0.53	0.500	2.48[b]
Farm-specific factors							
Farm size (hectares)	2.26	0.56	2.17	0.61	2.23	0.58	1.37[a]
Institutional/policy factors							
Access to extension services (Yes = 1)	0.27	0.04	0.15	0.04	0.22	0.03	2.28[b]
Access to credit (Yes = 1)	0.4	-	0.31	-	0.36	-	1.40
Membership of FBOs (Yes = 1)	0.72	0.45	0.61	0.49	0.67	0.47	1.78[c]
Access to improved variety (Yes = 1)	0.81	-	0.67	-	0.76	-	2.45[b]

a, *b* and *c* denote significance levels at 1%, 5% and 10%. SD denotes standard deviation.

Many studies (e.g., [[26],[39]]) in Sub-Saharan Africa have reported that plots managed by male-headed households tend to have a higher output than plots managed by female-headed households. With regards to the use of inputs, no statistically significant differences exist between male and female-headed households, although men tend to employ more of the inputs than women. Thus, the study shows little or no evidence that men access and use more farm productive resources than women in the study area. This study has shown a changing trend if women used to have access to less productive resources compared with men. Alene et al. [4] analysed the supply response of female farm managers and reported that women use farm resources as intensively as men. However, men allocate a considerably large hectare of land compared with their female counterparts, although it is only significant at 10%. Thus, females manage fewer hectares of land than males.

This confirms many pieces of literature [[17],[40]] that reported that women access to land is one of the critical concerns for agricultural development in Sub-Saharan Africa. Moreover, men in the sample population have more years in rice farming than women in the sampled population.

More men are actively engaged in crop farming as their primary source of livelihood as compared to women. This did not come as a surprise, as women are usually engaged in marketing of agricultural products and other petty trading than men do. The descriptive statistics further show that male-headed households have higher access to supply-driven factors such as agricultural extension services and farmer-based organisations than female-headed households. Similarly, men have more access to agricultural credit than women, though not significant. These result is in line with the previous study conducted by [[49]], who reported that inadequate access to these policy instruments have undermined the productivity of women in Sub-Saharan Africa.

The base determinants of farm productivity

In this section, the study followed a yield-based approach, where productivity (measured as output per unit of land) is expressed as a function of households' characteristics, institutional variables, and farm inputs. It is important to mention here that the productivity function estimated by the OLS estimator may face an endogeneity problem. However, the objective of the study is not to infer causality but to assess the extent to which differences in observed factors explain gender productivity gap and inform policy of appropriate areas of intervention. The results of the OLS estimates, which include covariates assumed to explain the differences in productivity between men and women is reported in Table 3.

The study estimated the full and separate samples for male and female-headed households. In the full sample, we included the gender variable to predict the gender coefficient in productivity. In this estimation, the coefficient of the gender variable represents the conditional gender productivity gap of about 11%, and it is statistically significant at 5%. The coefficient of the gender reflects the difference in return to a given productive input, a critical element in the structural effect. Aside from the gender variable, the other covariates explaining the productivity differences include membership of FBOs, experience in crop farming, access to credit and extension services. Farm inputs that explain productivity include quantity of seeds, quantity of fertilizer used, and quantity of hired labour.

Aggregate decomposition in farm performance: the B – O approach

The aggregate results from the B-O decomposition approach used in estimating the proportion of the gender performance differences that could be attributed to: (i) differences in average characteristics of productivity-generating factors (endowment effects), and (ii) gender differences in their returns (structural effects) is presented in Table 4. The table contains the

Table 3
Base OLS regression for mean gender decomposition.

Variables	Full sample Coeff	RSE	Male managers Coeff.	RSE	Female managers Coeff.	RSE
Gender	0.1068^{b}	0.0449				
Educational attainment	0.0037	0.0023	0.0032	0.0026	0.0040	0.0044
Experience in rice farming	0.0034	0.0023	0.0088^{a}	0.0029	-0.0008	0.0039
Crop farming as a full time	0.0016	0.0237	0.0147	0.0326	0.0027	0.0345
Access to improved variety	0.0596	0.0447	0.0599	0.0614	0.0504	0.0739
Membership of FBO	0.0995^{b}	0.0214	0.0886^{a}	0.0292	0.1016^{a}	0.0337
Access to credit	0.0461^{b}	0.0228	0.0530	0.0339	0.0644^{b}	0.0330
Access to extension service	-0.0945^{a}	0.0316	-0.1082^{a}	0.0411	-0.0681	0.0460
Quantity of seeds	0.0031^{a}	0.0004	-0.0025^{a}	0.0006	0.0039^{a}	0.0007
Quantity of pesticides	-0.0012	0.0036	-0.0034	0.0048	-0.0008	0.0051
Quantity of fertilizer	0.0005^{c}	0.0003	0.0004	0.0004	0.0006	0.0004
Quantity of hired labour	0.0032^{c}	0.0017	0.0030	0.0038	0.0016	0.0021
Constant	1.9607	0.1273	2.1084	0.1198	1.9269	0.2191
R-squared	0.5317		0.441		0.6268	
Variance inflation factor (VIF)	1.32		1.32		1.59	

a, b and *c* denote significance levels at 1%, 5% and 10%. RSE denotes the robust standard error.

Table 4
Blinder-Oaxaca aggregate decomposition of the rice performance gap.

Results	Ω = Neumark Coeff.	%	Ω = 0.5 (Reimers) Coeff.	%	Ω = 0.58 (Cotton) Coeff.	%	Ω = (Daymont and Andrisani) Coeff.	%
Endowment-Effects	0.075 (0.032)^{b}	70.44	0.003 (0.046)	2.69	-0.001 (0.046)	- 1.30	0.024 (0.067)	22.24
Male Structural-Advantage	0.013 (0.006)^{b}	12.41	0.039 (0.031)	36.19	0.033 (0.026)	30.40	0.000 (0.000)	0.00
Female Structural-Disadvantage	0.018 (0.009)^{b}	17.14	0.065 (0.033)^{b}	61.12	0.075 (0.038)^{b}	70.90	0.131 (0.066)^{b}	77.66
Raw Differential	0.107 (0.033)^{a}	100	0.107 (0.033)^{a}	100	0.107 (0.033)^{a}	100	0.107 (0.033)^{a}	100

a, *b*, and *c* represent significant levels at 1%, 5%, and 10%, respectively. Ω denotes omega. Standard errors are reported in parenthesis.

results from the extended version of the B-O estimation technique by Reimers [43], Daymont and Andrisani [[48]], Neumark [32] and Cotton [10].

As indicated in the last row of Table 4 (the raw differential), there is a gender productivity gap of about 11%, which is statistically significant and positive at 1%, suggesting that male-headed rice farming households outperform female-headed rice farming households marginally by 11%. The 11% mean gender gap is then fragmented into the endowment and structural effect. The endowment effect, as explained earlier, is the explained part of the gender productivity gap. The structural effect (unexplained part) is sub-divided into male advantage and female disadvantage. The male advantage component of the structural effect is the advantage experienced by male farm managers with respect to observable characteristics, while the female disadvantage part measures how disadvantage women are compared with their male counterparts. The results from the Daymont and Andrisani [[48]] estimates showed that about 22% (2.4 percentage points) of the farm performance gap is explained by the gender differences in the productive resources endowment.

However, the female structure disadvantage, which is because of the contrasts in return to productive resources accounted for the remaining 78% representing about 13 percentage points. Reimers [43] contended the weighting matrix of $\Omega = I$, and proposed a weighting matrix of $\Omega = 0.5(I)$. With regards to Reimer's approach, only 2.69% of the difference in productivity between male and female respondents could be ascribed to the endowment effects, while the male structural advantage and the female structural disadvantage accounted for approximately 36.19 and 61.12%, respectively. Cotton [10] protracted the conception of no-discrimination by Reimers [43] and established the weighting matrix based on the share of the sampled majority group. Cotton [10], therefore, formulated the weighting matrix to be $\Omega = \varsigma I$, where ς denotes the comparative percentage of the majority group in the sample [[50]].[5] This formulation had a significant influence on the structure of the decomposition, as indicated in the table (columns 6 and 7). From Cotton's formulation, the male advantage contributed to about 30.40% (i.e., 3.3 percentage points), while the female disadvantage accounted for about 71% (i.e., 7.5 percentage points) of the structural effects. The endowment effects accounted for only 1.30%, representing about 4.6 percentage points.

Lastly, Oaxaca and Ransom [34] and Neumark [32] suggested that the counterfactual vector could be derived from the estimation of the combined or the pooled model. This approach is more difficult and comprehensive than the other methods

[5] The sample size of male farm managers in the study was 145, which represents about 58% of the sample. Thus, the $\varsigma = 0.58$.

Table 5
B-O detailed decomposition.

Variables	Endowment effects				Male Advantage		Female Disadvantage	
	Coeff	Std. error	% (EF)	% (GPG)	Coeff.	Std. error	Coeff.	Std. error
Educational attainment	0.021	0.016	1.22	0.95	0.040[b]	0.019	-0.025	0.031
Experience in rice farming	0.019	0.018	2.72	2.18	0.054	0.026	-0.022	0.025
Crop farming as a full time	0.514[a]	0.177	79.79	62.40	0.452	0.245	0.666[c]	0.260
Access to improved seeds	-0.577[a]	0.177	90.94	71.11	0.240	0.423	-0.339	0.439
Membership of FBO	-0.418[b]	0.191	87.11	68.12	0.546	0.277	0.399[c]	0.272
Access to credit	-0.152	0.177	4.70	3.67	0.172	0.246	-0.048	0.259
Access to extension service	0.543[b]	0.218	127.18	99.45	-0.702	0.285	-0.695[b]	0.348
Quantity of seeds	-1.829[a]	0.798	333.78	2.61	-4.672	1.687	-0.655[c]	0.966
Quantity of pesticides	-0.184	0.198	39.55	30.93	-0.068	0.290	-0.194	0.268
Quantity of fertilizer	-0.232	0.348	28.40	22.21	0.264	0.597	-0.055	0.411
Quantity of hired labour	0.565	0.483	95.47	74.65	0.647	0.663	0.760	0.733
Constant	-8.517	3.287			17.926	7.617	5.806	3.551

a, b, and *c* denote significance levels at 1%, 5%, and 10%, respectively. EF and GPG indicate percentage contribution to endowment effect and gender performance gap, respectively.

suggested by Daymont and Andrisani [[48]], Reimers [43], and Cotton [10][6]. The findings from the Neumark methodology revealed that the endowment factor accounted for 70.44% of the productivity gap, which represents about 7.5 percentage points. The male structure advantage and female structure disadvantage contributed approximately 12.41 and 17.14%, respectively.

The detailed aggregate decomposition by gender using B-O approach

In Table 5, we report a detailed decomposition using the methodology proposed by Neumark [32] for a given set of socioeconomic, institutional, and input factors. In interpreting the results, a positive coefficient of a factor tends to widen the gender farm performance gap, while a negative coefficient of factor narrows the gap.

The percentage contributions of each predictor or explanatory variable to the endowment effect are calculated by the ratio of the coefficient of each predictor to that of the coefficient of the endowment effect. Also, the contribution of each variable to the overall gender performance gap is found by dividing the coefficient of the variable by the performance gap. These percentage contributions are indicated in columns 4 and 5 in Table 5.

The results from Table 5 indicate that farmers' engagement in crop production as full-time employment widens the gender performance gap. Full time crop farming explains about 80% of the endowment effect and about 62% of the gender performance gap. In the female structural disadvantage results, full-time crop farming is positive and statistically significant, indicating that it widens the gap in performance. High performance requires more time and a high level of managerial skills to ensure high productivity, and subsequently, better margins. Women, especially those with children, have more household responsibility concerns such as household chores, child care, amongst others, and therefore, devote less time for farming activities, this may lead to lower farm productivity, and hence, lower performance compared to men with fewer household responsibilities.

One of the critical factors that improve farm productivity, and subsequently, performance is productivity-enhancing technologies such as the use of an improved variety of crops. The results indicate that the use of improved varieties of rice has a negative and statistically significant effect on the explained portion (endowment effect) of the gender gap. Thus, the factor has the potential of closing the gender gap. With respect to the contributions, 90% and 71% of the differences in the endowment effect and gender performance gap were predicted by the improved rice varieties. Table 4 further revealed that policy-driven variables (access to agricultural extension services and membership of FBOs) have significant effects on gender productivity gaps. While membership of FBOs displays a negative effect on endowment, access to extension is positive with a statistically significant effect on the explained part (structural effect) of the decomposition model.

The negative coefficient of FBO membership suggests that the policy variable helps to close the gender gap in farm performance. These findings could be ascribed to the current gender-sensitive intervention programmes being executed in rural farming areas in Nigeria. Women in groups can easily access agricultural credit, do collective marketing through cooperatives, and negotiate for better output prices. However, the positive coefficient of the extension variable connotes a positive contribution of the variable to widening the gender performance gap in favour of men. This could be a reflection of inadequate extension services that addresses women needs for information or possibly due to time constraint/restriction for women in obtaining full training on farm management practices. In rural community settings such as the study area, women are responsible for child care and are full-time administrators of the house, hence, they are limited by time, especially when time for attending extension service training (e.g., evenings) coincides with time for performing household chores. The negative effects of extension services on women performance, as also indicated by the female structural disadvantage,

[6] The results in Table 4 was generated using the Neumark methodology.

Table 6
Decomposition of gender differentials at the selected points of rice productivity distribution.

	Mean	25th	50th	75th
Gender differentials				
Male managers (log of yield/ha)	0.045 (0.019)[b]	0.045 (0.026)[c]	0.033 (0.019)[c]	0.154 (0.020)[a]
Female managers (log of yield/ha)	0.062 (0.025)[b]	0.158 (0.049)[a]	0.013 (0.023)	0.068 (0.019)[a]
Differences	0.107 (0.032)[a]	0.111 (0.055)[b]	0.146 (0.030)[a]	0.086 (0.028)[a]
Aggregate decomposition				
Endowment effects (explained part)	0.042 (0.056)	0.022 (0.156)	0.045 (0.069)	0.039 (0.059)
Share of the endowment effects	39.25%	19.82%	97.83%	45.35%
Structural effects (unexplained part)	0.065 (0.055)	0.089 (0.158)	0.001 (0.072)	0.047 (0.065)
Share of the structural effects	60.75%	80.18%	2.17%	54.65%

a, *b*, and *c* represent significant levels at 1%, 5%, and 10%, respectively. Standard errors are reported in parenthesis.

could possibly be that the targeted women are weak and more likely to receive the extension services. The results on productive farm inputs revealed that women are taking advantage of the use of productive resources such as seeds, as it is statistically significant. This is probably because women are endowed in the use seeds and that contribute to closing the gender gap.

Distributional results-RIF decomposition approach

The RIF decomposition method was used to determine the gender performance gap (endowment, structural, and overall) along the chosen point of rice productivity distribution. The aggregate decomposition of gender differences in rice yields is shown in Table 6. The estimated mean and median (50th percentile) gender difference in rice yields is 10.7% and 14.6%, respectively, while the 25th and 75th percentile differences are 11.1% and 8.6%, respectively. Endowment and structural effects are generally insignificant across rice productivity distributions. It is important to note, however, that the share of structural effects (the unexplained part of the gap) is high (around 80%) at the 25th percentile and 61% at the mean. However, at the median (50th percentile), endowment effects account for approximately 98% of the performance gap, while structural effects account for only about 2%.

Table 7 shows the RIF detailed decomposition at the mean, 25th, 50th, and 75th percentiles. Educational attainment, rice farming experience, full-time crop farming, FBO membership, access to extension service, seed and fertilizer quantity are the significant variables for endowment effects. The quantity of seeds contributes positively to the endowment effect at the 25th decile. Access to extension services and the amount of fertilizer used contribute positively to the endowment effect at the median distribution point, while educational attainment contributes negatively. Full-time crop farming and FBO membership, respectively contribute negatively and positively to the endowment effect at the top (75th) decile of the rice productivity distribution. Experience in rice farming and FBO membership, on the other hand, have a positive and negative impact on the structural effect at the bottom (25th) decile. Education attainment and credit access are statistically significant on the median percentile and contribute positively to the structural effect. Finally, we discovered that quantity of seeds and pesticides contribute negatively to the structural effects of the gender gap in rice yields at the top decile of the productivity distribution.

Conclusions and policy recommendations

Gender differences influence agricultural productivity in different ways, sometimes determined by culturally defined roles, and labour divisions. Other covariates such as access to farm productive inputs and socio-economic and other supply-driven policy instruments also play vital roles in gender productivity gaps. The study aimed to contribute to the discourse on gender performance differential in agricultural sector by estimating the productivity gaps between male-headed households and female-headed households in South-western Nigeria. Employing the Oaxaca-Blinder gender decomposition framework, the results from the study revealed a gender performance (productivity) gap of about 11% between male and female-headed households. Thus, yields of rice farms managed by male-headed households are about 11% more productive than yields of farms of female-headed households. Using the matrix proposed by Neumark, the endowment effects, measured by the proportion of the gaps ascribed to differences in observed household characteristics accounted for about 22%, while the structural effects (decomposed into male advantage and female disadvantage) accounted for the remaining 78%. Thus, the structural component of the gap is larger than the endowment component. This result suggests that even if women possess the same characteristics as men and have equal access to productive resources as well as policy factors, performance differences will still persist. Nevertheless, more opportunities for women concerning resources and training would be of benefit and subsequently enhance their performance. Using the Oaxaca-Blinder decomposition method, the study also identified some factors contributing to the performance gap. The study indicated that engagement in crop production as a full-time work as the primary source of livelihoods tends to widen the gender performance gap, while the use of improved rice variety tends to close the gap.

Table 7
Detailed decomposition of gender differentials at the selected points of rice productivity distribution.

	Endowment effects				Structural effects			
	Mean	25th	50th	75th	Mean	25th	50th	75th
Educational attainment	-0.001 (0.010)	-0.020 (0.029)	-0.040 (0.016)^{b}	0.008 (0.013)	0.021 (0.003)	0.075 (0.069)	0.092 (0.035)^{b}	0.012 (0.033)
Experience in rice farming	0.014 (0.004)^{a}	0.021 (0.016)	0.011 (0.008)	0.006 (0.005)	0.156 (0.006)^{b}	0.422 (0.141)^{a}	0.243 (0.083)	0.069 (0.072)
Crop farming as a full time	-0.005 (0.005)	0.008 (0.013)	-0.007 (0.007)	-0.015 (0.008)^{c}	-0.005 (0.021)	-0.003 (0.042)	0.002 (0.025)	0.021 (0.026)
Use of improved variety	-0.007 (0.049)	-0.056 (0.139)	0.056 (0.062)	0.032 (0.055)	-0.005 (0.008)	0.009 (0.017)	0.008 (0.009)	-0.000 (0.008)
Membership of FBO	0.012(0.007)^{c}	0.035 (0.022)	0.013 (0.009)	0.019 (0.007)^{b}	0.008 (0.001)	-0.166 (0.076)^{b}	0.027 (0.044)	0.029 (0.036)
Access to credit	0.003 (0.003)	0.001 (0.007)	0.001 (0.004)	0.004 (0.005)	0.003 (0.017)	0.021 (0.039)	0.006 (0.002)^{a}	0.011 (0.023)
Access to extension service	0.010 (0.006)	-0.017 (0.145)	0.016 (0.009)^{c}	-0.006 (0.007)	-0.006 (0.015)	0.003 (0.033)	0.007 (0.019)	0.004 (0.002)
Quantity of seeds	0.039 (0.021)^{c}	0.067 (0.040)^{c}	0.013 (0.012)	-0.015 (0.013)	-0.007 (0.007)	-0.011 (0.013)	0.001 (0.006)	-0.011 (0.001)^{a}
Quantity of pesticides	0.001 (0.002)	-0.005 (0.006)	-0.001 (0.003)	0.002 (0.004)	-0.003 (0.001)	0.002 (0.004)	0.001 (0.002)	-0.005 (0.002)^{b}
Quantity of fertilizer	0.008 (0.009)	0.012 (0.019)	0.015 (0.009)^{c}	0.002 (0.007)	0.004 (0.005)	0.008 (0.011)	0.005 (0.006)	0.009 (0.007)
Quantity of hired labour	0.001 (0.003)	0.001 (0.001)	0.002 (0.005)	0.000 (0.005)	0.002 (0.004)	-0.001 (0.004)	0.001 (0.003)	0.006 (0.008)

a, b, and *c* represent significant levels at 1%, 5%, and 10%, respectively. Ω denotes omega. Standard errors are reported in parenthesis.

Access to agricultural extension services contributes to widening the gap, suggesting that less attention may be given to women in agricultural extension programs. To close the gap in the productivity of rice farmers in South West Nigeria, policy makers should address in priority the following constraints: use and quality of extension services by women, and quantity of inputs used. However, membership of FBOs has a higher potential to close the performance gap. It is, therefore, essential for the extension directorate of the state agricultural department to consider re-orienting extension programmes by considering, for instance, the timing for training programmes to favour women or have separate extension training programmes for men and women. Finally, women use less quantity of productive resources such as the quantity of seeds compared with men. This calls for urgent policy intervention to promote the use of these resources amongst women farmers.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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