Trends in
Agricultural Sciences

OPEN ACCESS

Effect of Entrepreneurial Competencies on Technical Efficiency of Gender Disaggregated Maize Farmers in Southwest, Nigeria

[1]*Edamisan Stephen Ikuemonisan*, [2]*Taiwo Ejiola Mafimisebi and* [2]*Igbekele Amos Ajibefun*

[1]*Department of Agricultural Economics, Faculty of Agriculture, Adekunle Ajasin University, PMB 001, Akungba Akoko, Nigeria*

[2]*Department of Agricultural and Resource Economics, School of Agriculture and Agricultural Technology, Federal University of Technology, PMB 704, Akure, Nigeria*

ABSTRACT

Background and Objective: This study focuses on the critical issues of sustainable agriculture and social justice, emphasizing the pivotal role of agriculture in reshaping global development towards sustainability. It specifically highlights the inadequate compensation faced by African women farmers in policy development, despite their vital contributions to food production. The study aims to address the gender disparities in maize production efficiency in Ondo State, Nigeria, by incorporating entrepreneurial competencies into the analysis. **Materials and Methods:** A multi-stage sampling technique was employed to gather data for this study. A total of 372 maize farmers in Ondo State were selected as the sample size. The study collected comprehensive data on gender-specific influences on production efficiency through this sampling method. **Results:** The analysis of the gathered data revealed significant inefficiencies in maize production in Ondo State. Both male and female-owned farms were found to be sensitive to input variables, showcasing gender-specific nuances. The findings highlight the need to promote improved maize varieties and optimize agrochemical usage to enhance production efficiency. Furthermore, it is imperative to tackle gender-related barriers in obtaining land for sustainable maize farming. **Conclusion:** To sum up, this research not only adds to academic discussions but also offers practical guidance for policymakers, extension services and development professionals.

KEYWORDS

Sustainable agriculture, social justice, gender-disaggregated, maize production efficiency, entrepreneurial competencies, agricultural education

INTRODUCTION

The global maize industry is valued at USD 139.42 billion in 2023 and is projected to grow to USD 161.70 billion by 2028 with a consistent compounded annual growth rate of 3.0%. Several factors are expected to shape the trajectory of the maize industry, including the rising demand for maize as a biofuel and ongoing experiments to fortify maize flour with micronutrients, particularly in regions where micronutrient deficiencies are prevalent public health issues[1,2].

ISSN: 2957-9449 (Online)
ISSN: 2957-9430 (Print)
https://doi.org/10.17311/tas.2024.180.193

Received: 01 Apr. 2024
Accepted: 29 May, 2024
Published: 30 Jun. 2024

Maize holds significant importance in Nigeria as a major cereal and a crucial staple crop. Its genetic adaptability allows for widespread cultivation across various ecological regions, ranging from the wet evergreen climate of the forest zone to the dry conditions of the Sudan savanna. Unlike other crops, maize is not influenced by day length, enabling farmers to grow it throughout the year and easily incorporate it into different cropping systems. As a result, maize plays a prominent role as one of the leading cereal crops in Nigeria. The surge in demand for maize in Nigeria has sparked debates on its economic significance. In 2021, the annual demand for maize stood at 10 million metric tonnes (10 MMT), creating a yearly deficit of 2 MMT[3,4].

However, by 2023, the demand increased to 15 MMT, with domestic production ranging between 10-12 MMT, resulting in an average deficit of 3 MMT[5]. Based on Food and Agriculture Organisation maize production statistics for 2020, Nigeria emerged as the second-largest maize producer in Africa. Additionally, it holds the top position as the leading maize producer in West Africa, contributing over 48% of the overall maize production in the region from 2015 to 2020. Emerging innovations in maize utilization are anticipated to further drive demand in the coming years, making it a crucial economic tool to address socio-economic challenges, especially in rural areas of sub-Saharan Africa.

Maize finds diverse applications, serving as food for human consumption, livestock feed and raw material for various industries[1,6,7]. Its role in the pharmaceutical industry, where maize starch is employed in dosage forms, adds to its versatility. Despite its growing importance, the gap between domestic production and demand in Nigeria remains a concern. The current average yield of 2 tonnes per hectare on 7 million hectares is significantly below the global average of 5.8 ton/ha, hindering the potential for agricultural growth and rural economic transformation[3,8]. Scholars advocate for enabling policies to promote innovation and increase maize productivity, emphasizing the need for inclusive research and development (R&D) investments targeting women, marginalized communities and the resource poor[9,10].

In the context of Nigeria and sub-Saharan Africa, women's involvement in agriculture, particularly at the production level, is considerable. Despite their higher participation in both agricultural and household activities, women's contributions are often not fully recognized in the sector[11]. Scholars have examined gender-disaggregated roles in crop seed selection, processing, production strategies and marketing decisions, but the role of women in maize production in Nigeria is underreported[3]. Gender-disaggregated production decisions are crucial for understanding efficiencies and production outputs. This knowledge is essential for designing equitable policies, programmes and strategies for poverty reduction, hunger and malnutrition elimination and addressing gender inequalities. Moreover, it provides an opportunity to enhance resilience, interventions and gender-related statistics in a maize production-dominated economy.

Previous studies have highlighted the importance of inclusive policies and R&D investments for women, marginalized communities and the resource-poor in agriculture[11]. Women's significant but often unrecognized role in production necessitates focusing on gender-disaggregated data to design equitable policies and programs. While gender roles in various agricultural aspects have been studied, the specific role of women in maize production in Nigeria is underreported.

Ensuring a steady supply of maize becomes crucial given its multifaceted applications and growing global demand. The efficiency of maize production plays a pivotal role in meeting this demand. Evidence suggests that the entrepreneurial competence of farmers is a key factor influencing production efficiency. Agricultural entrepreneurs, by demonstrating competencies such as diversification, shape their entrepreneurial actions, fostering creativity and innovation. These competencies, as highlighted by Hennon[12], contribute to the adoption of new management practices that enhance the overall well-being of farmers. Recognizing the significance of improving farmers' entrepreneurial competencies, Balogun *et al.*[13] stress that enhanced competencies are essential for achieving increased agricultural production outcomes.

MATERIALS AND METHODS

The study used a survey and cross-sectional research design. The survey involved collecting data from a sample of individuals through structured questionnaires and interviews between the period, April-June, 2023. This design is useful for gathering information on attitudes, beliefs, behaviours and demographics. Similarly, in this study, data was collected at a specific point in time from different individuals. This design helps in understanding relationships and characteristics across different populations.

Study area: The study was carried out in Southwest, where over 60% of the population resides in rural areas and about 75% of those in the rural areas are majorly involved in agrarian activities. Six states make up the Southwestern Region and the region is characterized by lush vegetation, including rainforests in the south and sub-savannah forests in the north. The Region experiences a tropical climate with distinct rainy and dry seasons, favorable for agriculture.

Sampling and data collection: The study targeted all maize farmers in Southwest, Nigeria. A multi-stage approach was adopted to select the respondents. In the first stage, one (Ondo State) out of the 6 states was randomly selected. The study carried out a preliminary investigation from the Agricultural Development Project (ADP) and found that there were 6,972 maize farmers supervised by state extension agents in Ondo State. Employing the Slovin's formula as used in the literature by Adesunkanmi and Nurain[14],

$$n_o = \frac{N}{1+N\,(e^2)}$$

where, n_0 is sample size, e is 0.05, N is total number of observations (6972), a sample size of 378 respondents was determined, considering a 5% margin of error, 95% confidence and applying a finite correction factor. The farmers were sorted across five ADP zones (Akoko, Akure, Okitipupa, Ondo and Owo) using proportional sampling to ensure diverse representation of maize production practices across the state. The proportional sample, as applied by Jude and Iheagwara[15], was obtained using the formula below:

$$\frac{\text{Members of maize farmers in each ADP zone}}{\text{Total members of maize farmers in the 5 ADP zone}} \times n_o$$

Summing up the sub-samples, a total of 378 farmers were obtained (Table 1). Farmers for this study were randomly chosen from each ADP zone. The study team, in collaboration with extension agents, gathered data from selected maize farmers between April and June 2023. Notably, data were collected exclusively from farms practicing sole maize cropping to minimize interference from extraneous variables. Following questionnaire review, only 372 properly filled questionnaires were deemed suitable for critical analysis.

Data for this study were collected using a well-structured questionnaire administered to respondents. The questionnaire covered socio-economic information and details of farm production activities, including maize output, quantities and costs of production factors. Additionally, respondents self-assessed their entrepreneurial competencies using a 5-point Likert scale, responding to statements adapted from various sources. The study focused on constructs identified in section 2.2. Self-assessment was chosen to capture respondents' perspectives on their entrepreneurial competencies, considering the subjective nature of these skills, as they are not directly observable[16]. This approach aligns with the understanding that individuals are best placed to assess their competencies.

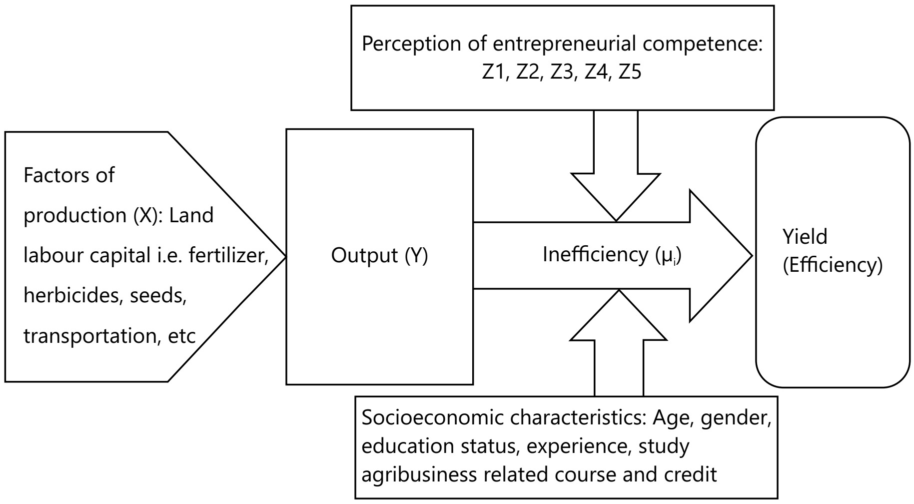

Fig. 1: Conceptual framework linking the explanatory variables to the TEL

Table 1: Distribution of respondents by ADP zones

ADP zones	Frequency	Percent	Cumulative percent
Akoko	62	16.6	16.6
Akure	84	22.2	38.8
Okitipupa	81	21.3	60.1
Ondo	74	19.7	79.8
Owo	76	20.2	100.0
	378	100.0	

Source: Field Survey, 2023

Analytical technique

Linkage between entrepreneurial competencies and technical efficiency: In the current study, the hypothesis revolves around entrepreneurial competencies affecting the technical efficiency of maize production in Nigeria. The specific competencies considered are the competence to identify opportunities in the maize industry (Z1), creativity and conceptual competence, competence to organize production resources (Z2), valuing ideas and relationships with labour to achieve organizational goals (Z3), competence for self-development and learning (Z4) and commitment to ethical and sustainable business strategies organizational competence (Z5). These conceptual fields, along with the use of a self-assessment approach, were developed by modifying existing studies in the literature[13,17-19], guided by previous research[19-21]. Figure 1 illustrates the link between entrepreneurial competencies and the technical efficiency of maize production in Nigeria.

In the conceptual diagram, the output of maize (Y) is regressed on the factors of production (X). The μi component of the composite random shock provides information on the technical inefficiency level (TIL), a critical determinant of deviation from the production frontier[22]. Furthermore, this TIL is regressed on the socioeconomic characteristics of the farmers and their perception of entrepreneurial competencies, following the approach of Balogun *et al.*[13] and Adeyonu *et al.*[17]. The explanatory variables of the TIL aim to elucidate the factors contributing to the TIL and can also be used to explain the technical efficiency level (TEL) of maize production in the study area. The ultimate goal for every organization, in this case, maize producers, is to acquire entrepreneurial competencies that help in making the best possible combination of factor inputs with the expectation of achieving maximum output[23,24]. For maize producers in the study area, the desired outcome is the maximum maize yield derived from the combination of these direct and indirect factors of production.

Descriptive and principal component analysis: To determine the level of entrepreneurial competencies among maize farmers, Principal Component Analysis (PCA) was conducted, guided by the methodology outlined by Morgan *et al.*[25]. The calculation of the ith principal component value followed the expression specified by Mensah and Dadzie[26] and adopted by Greenacre *et al.*[27]. The model is specified as Equations shown below:

$$PCI_i = \sum_{j=1}^{P} K_j X_j$$

$$PCI_i = K_{i1}X_1 + K_{i2}X_2 + K_{i3}X_3 .... + K_{ip}X_p$$

where, PC1 is the first principal component and are the first, second and third independent variables of PC1 in the linear additive model needed to derive the principal component and the K_{i1}, K_{i2} and K_{i3} are coefficient (component loadings) associated with the X_1, X_2 and X_3 variables.

Stochastic frontier analysis: The stochastic frontier analysis in this study assumes the existence of technical inefficiency in maize production. A Cobb-Douglas production function was utilized to construct the stochastic frontier. The typical Cobb-Douglas production function can be represented as follows:

$$Y_i = \beta_0 X_1^{\beta_1} X_2^{\beta_2} .... X_n^{\beta_n} Y$$

The Cobb-Douglas production function is log-linearized and employed in stochastic frontier analysis, where Y represents maize output and Xn is a vector of farm resources used for production. These resources include Maize harvested area (X1), quantity of urea used (X2), type of seed planted (X3), cost of agrochemicals (X4), cost of land preparation (X5), cost of farm tools (depreciation of tools used for maize production in the season) and machinery rentals (X6) and cost of labour (X7).

The stochastic frontier model, following Yankah and Dadzie[28] is utilized to estimate the technical efficiency of maize production.

$$InY_i = \beta_0 + \sum_{i=1}^{7} \beta_i\, InX_i + (v_i - u_i)$$

In the specified stochastic frontier model, In represents the natural logarithm, Y_i is the maize output of each respondent, X_i is the input variables, β_i are production coefficients, v_i is a random error associated with uncontrollable factors (such as weather, natural disasters and luck), measurement errors and statistical noise, while u_i is the technical inefficiency measure. The error term (v_i-u_i) is considered "composite," and v_i is a two-sided ($-\infty < v_i < \infty$) normally distributed random error [$v_i \approx N(0,\sigma v^2)$]. The term u_i is a one-sided inefficiency measuring the shortfall in output Y_i from its maximum value given by the stochastic frontier f (X_i; β_i)+v_i. It is assumed to have a half or exponential distribution [$u_i \approx N(0,\sigma u^2)$]. The components v_i and u_i are assumed to be independent. The impact of farmers' entrepreneurial competencies on technical inefficiency is simultaneously estimated to address unbiasedness and inconsistency in the estimator. The second equation is defined as follows:

$$u_i = f(Z_i)$$

Where: T.E = technical inefficiency scores; (Z_i) is a vector of explanatory variables which include: Entrepreneurial competencies: competence to spot opportunities in maize industry (Z1), creativity and conceptual competence (competence to organize production resources = Z2), valuing ideas and relationship with labour to achieve organizational goals (Z3), competence for self-development and learning (Z4) and commitment to ethical and sustainable business strategies organizational competence (Z5). In addition to the entrepreneurial competencies, the influence of socioeconomic characteristics of farmers was also tested on the technical inefficiency level of farmers. The Z6 = age of household head, Z7 = Extension visits (number/production cycle), Z8 = household size, Z9 = Years spent in schooling, Z10=study agriculture, Z11= farming experience (years) and Z12 = membership of cooperative.

RESULTS

Summary statistics of variables of Interest: The findings in Table 2 provide a detailed analysis of variables related to maize production and the cost structure of male-owned and female-owned farms. Notably, the study reveals that 49% of respondents opted for improved maize varieties, while 51% continued with traditional varieties. The cost of seeds significantly influences yield performance, constituting approximately 5% of the total cost of maize production per hectare in the study area.

The average expenditure on agrochemicals during the production cycle and the cost of land preparation collectively represent about 19% of the overall cost of maize production in Ondo State.

In terms of cost dynamics, female-owned farms incur higher expenses on farm tools and labour during the production cycle. In view of the higher cost of labour, farmers tend to minimize its usage, opting for increased reliance on agrochemical control in maize production, raising concerns among pro-organic food advocates.

Demographic insights highlight differences between male and female respondents. The demographic insights indicate that male respondents have an average age of 62, while females average 46. Gender distribution shows 56% male and 44% female respondents. Average household size is 9 for male-headed households and 7 for female-headed households. In education, males spend an average of 14 years in schooling and females 12 years. Only 26% of respondents with education beyond primary school pursue Agriculture or a related course. Male farmers have an average farming experience of 28 years, while females average 21 years. It implies, that male respondents are older, have larger household sizes, spend more years in schooling and have more farming experience on average.

The t-statistics presented in Table 2 provide a comprehensive comparative analysis of male and female-owned farms' socioeconomic characteristics and cost structures related to maize production. The statistical tests reveal noteworthy differences between the two groups.

Firstly, female-owned farms exhibit statistically lower average maize output (3.085 ton) compared to male-owned farms (3.421 ton) at a 5% significance level. Similarly, the harvested area in female-owned farms (1.406 ha) is significantly smaller than that in male-owned farms (1.772 ha) at a 5% significance level.

Further analyses highlight significant differences in the use of urea fertilizer, with female-owned farms employing a significantly lower quantity compared to their male counterparts at a 5% significance level. Additionally, the cost and quantity of seeds used in female-owned farms differ significantly from those in male-owned farms, with statistical evidence at 1 and 5% significance levels, respectively. Examining various cost factors, the results indicate that extension visits, costs of land preparation and rent are significantly higher in female-owned farms compared to male-owned farms, with statistical evidence at a 1% significance level. This implies that female farmers incur higher expenses in these aspects, potentially influencing overall production costs and farm management.

Additionally, the analysis reveals and farming experience between male and female respondents. These findings underscore the importance of gender-specific considerations in understanding the nuances of socioeconomic characteristics and cost structures within statistically significant differences at a 1% significance level in the means of age, household size, years spent in schooling the context of maize production in the study area. The observed variations in output, resource use and cost factors emphasize the need for targeted interventions and policies to address gender-specific challenges in maize farming and enhance overall agricultural productivity.

Table 2: Summary of statistics of variables of interest

Variable code	Variable name	Mean	Standard deviation	Minimum	Maximum	T-statistics (p value)
Y	Maize output (tonnes)	3.155	1.238	0.22	12.331	
Male	Male	3.421	1.391	0.338	14.175	-2.525
Female	Female	3.085	1.109	0.082	10.211	(0.012)
X1	Maize harvested area (ha)	1.528	1.414	0.371	4.182	
Male	Male	1.772	1.118	0.448	6.028	2.501
Female	Female	1.406	1.694	0.272	3.828	(0.013)
X2	Fertilizer					
	Quantity of (NPK) fertilizers used (kg)	101.272	12.511	0	163.08	
Male	Male	102.232	12.624	0	164.629	-0.707
Female	Female	101.341	11.341	0	163.274	(0.4803)
	Quantity of urea fertilizer used	264.25	25.072	0	785.082	
Male	Male	266.603	24.31	0	792.954	-2.352
Female	Female	260.461	25.869	0	688.683	(0.019)
X3	Seed (1st Filia=1; 2nd or 3rd Filia=0)	1st Filia=104 (28%): 2nd or 3rd Filia= 268 (72%)				
	Improved breed (IB) = 1; Traditional breed (TB) = 0	Improved Breed IB = 182 (49%); Traditional Breed (TB) = 190 (51%)				
X4	Cost of agrochemical (Herbicides, Pesticides, etc)	102,150.18	15,533.27	1,931.68	281,047.13	
Male	Male	103120.57	15680.83	2,168.52	283716.98	-0.307
Female	Female	102618.33	15604.45	1,645.94	282335.15	(0.7587)
X5	Land					
X6	Cost of farm tools and machinery rentals	40,381.98	6,581.78	1,881.05	107,521.18	
Male	Male	40,765.60	6,644.30	2,302.72	111,571.09	-0.306
Female	Female	40,567.05	5,611.94	1,291.50	101,027.69	(0.7597)
X7	Labour cost for 4 months of production period	61,955.75	74,825.53	7,883.22	990,640.50	
Male	Male	65,394.21	78,536.35	12,718.08	1000051.3	0.614
Female	Female	53,614.58	75,168.45	8,055.99	995180.57	(0.5399)
Z6	Age of household head	54.362	12.026	24	76	
Male	Male	62.114	10.208	24	76	-15.604
Female	Female	46.831	8.287	32	64	(0.000)
Z7	Extension visits to farmers during production cycle	7.16	1.52	1	14	
Male	Visits to male farmers	6.58	1.09	0	12	19.081
Female	Visits to female farmers	8.36	0.55	0	14	(0.0001)
Z8	Household size	7.23 ≈ 7.00	1.11	1	11	
Male	Male headed household	8.52 ≈ 9.00	1.21	2	11	-16.573
Female	Female headed household	6.55≈ 7.00	1.04	1	6	(0.000)
Z9	Years spent in schooling	11.72	2.308	0	22	
Male	Years spent in schooling by male	14.36	3.142	0	22	
Female	Years spent in schooling by female	12.44	4.422	0	18	0
Z10	Study agriculture or related course (Yes = 1; No = 0)[Among 316 who have education beyond pry level]	Yes = 25.94%: No = 74.05% of 316 (Yes = 82) % of Male farmers/agriculture related course = 60% of 82 % of Male farmers/agriculture related course = 40% of 82				
Z11	Farming experience	15.446	6.259	3	42	
Male	Male	28.328	6.801	5	42	-11.791
Female	Female	21.242	4.055	3	25	(0.000)
Z12	Membership of cooperative (Yes = 1 and No=0)	Yes = 60.32% and No = 39.68%				
Male	Male	65 (47%)				
Female	Female	73 (53%)				

Source: Field survey, 2023

Table 3: Output of adequacy and bartlett's test of sphericity

Symbol	Entrepreneurial competence		Number of items	Number of extracted items	KMO	Bartlett's Chi square	Sigma
Z1	Competence to spot opportunities	M	8	3	0.83	2055.15	0.000
		F	8	2	0.71	789.28	0.000
Z2	Creativity and conceptual competence (competence to organize production resources)	M	13	5	0.66	2160.26	0.000
		F	13	3	0.75	1837.40	0.000
Z3	Valuing ideas and relationship with labour to achieve organizational goals	M	7	3	0.74	1297.75	0.000
		F	7	3	0.85	1450.93	0.000
Z4	Competence for self-development and learning	M	5	2	0.68	2185.93	0.000
		F	5	1	0.64	763.81	0.000
Z5	Commitment to ethical and sustainable business strategies organizational competence	M	7	2	0.72	603.39	0.000
		F	7	3	0.78	1686.00	0.000

Source: Data analysis, 2023

Adequacy and bartlett's test of sphericity for entrepreneurial competencies of maize farmers: Table 3 presents the Kaiser-Meyer-Olkin measure of sampling adequacy (KMO) and Bartlett's test of sphericity. The criterion employed for factor extraction in the study was the significant loading of items onto specific factors. Consequently, when examining competence in identifying opportunities, out of the initial 8 listed items, only 3 factors were extracted for male respondents and 2 factors for female respondents. Similarly, for the domains of creativity and conceptual competence (specifically, competence in organizing production resources), where 13 items were originally listed for each gender group, only 5 factors were extracted for males and 3 for females. In the context of competence in valuing ideas and managing relationships with labour to achieve organizational goals, despite having 7 items listed for each group, only 3 factors were extracted for both males and females. Exploring competence in self-development and learning, while 5 items were initially listed, only 2 factors were extracted for males and 1 for females. Lastly, focusing on commitment to ethical and sustainable business strategies and organizational competence, with 7 items listed for each group, only 2 factors were extracted for males and 3 for females. To ensure the appropriateness of the extracted variables, each underwent statistical significance testing, justifying their inclusion in subsequent analyses. The Kaiser-Meyer-Olkin measure of sampling adequacy (KMO) values ranged from 0.64 to 0.85 and the Bartlett test values were all found to be significant at a 1% level of significance, affirming the adequacy of the dataset for factor analysis.

Stochastic frontier production function of maize farms: Table 4 presents the maximum likelihood parameter estimates of the stochastic frontier production function for maize farms, offering insights into the production process. The sigma squared (δ^2) parameter, representing inefficiency or deviations from the ideal production frontier, is statistically significant at the 1% level, indicating notable inefficiency in maize production that requires attention to enhance overall efficiency and productivity.

Analyzing the impact of input variables on maize output for both male and female-owned farms, the size of the land has a positive and significant effect on output at a 1% significance level for both groups. A unit increase in the cultivated area leads to a 121% increase in maize output for male-owned farms and a 151% increase for female-owned farms. Other inputs significantly influencing maize output for male-owned farms include urea quantity, planting first filial generation seeds, cost of agrochemicals and labour cost. For female-owned farms, significant influences come from the area harvested, the cost of agrochemicals, the cost of tools and machinery rentals and labour costs.

Table 4: Maximum Likelihood parameter estimates of stochastic frontier production function of maize farms

	Male			Female		
Variable	Coefficient	Stander. error	p-value	Coefficient	Stander. error	p-value
Constant	0.026***	0.005	0.0001	0.312***	0.101	0.0022
X1	1.218***	0.163	0.0001	1.505***	0.359	0.0001
X2 (urea)	0.552***	0.127	0.0001	0.151	1.844	0.9347
X3 (F1 = 1)	1.185**	0.502	0.0192	1.314	0.882	0.1382
X4	0.311*	0.188	0.0996	0.081**	0.035	0.0219
X5	0.125	0.694	0.8573	0.186	1.021	0.8558
X6	-1.528	1.151	0.1856	-0.834***	0.225	0.0003
X7	0.105**	0.046	0.0234	0.225***	0.082	0.0067
RTS	1.346		1.746			
Inefficiency						
Constant	12.188***	1.601	0.0001	52.291***	18.355	0.0046
Z1	-0.221***	0.053	0.0001	-0.428***	0.108	0.0001
Z2	-0.144*	0.075	0.0566	-0.173*	0.102	0.0918
Z3	-0.462	0.288	0.1095	-0.625**	0.301	0.0385
Z4	-0.007	0.005	0.1623	-0.018	0.011	0.1026
Z5	-0.001	0.002	0.6894	-0.102	0.081	0.2087
Z6	0.208*	0.115	0.072	-0.266	0.181	0.1436
Z7	0.396	0.288	0.1706	0.552	1.833	0.7637
Z8	-0.119***	0.026	0.0001	-0.103	0.208	0.6211
Z9	-0.024	0.015	0.1111	-0.499***	0.083	0.0001
Z10	-0.136**	0.082	0.0483	-0.047*	0.025	0.0609
Z11	-0.261**	0.122	0.0331	-0.306**	0.152	0.0448
Z12	-0.327	0.288	0.2569	-0.219**	0.102	0.0324
Sigma-squared	0.303***	0.084	0.001	0.401***	0.012	0.0001
Gamma	0.524***	0.045	0.000	0.684*	0.361	0.0589
Log-likelihood	-142.28					
Pseudo-R^2	0.318					

Source: Data analysis, 2023. ***, ** and * represent 1, 5 and 10% level of significance

Examining the efficiency factors, male farmers' efficiency is positively influenced by competence to spot opportunities, creativity, conceptual competence, household size, farming experience and studying agriculture-related courses. Each unit increase in these factors leads to efficiency gains of 22, 14, 12, 26 and 14%, respectively. However, the age of male maize farmers has a negative and significant impact, with a unit increase resulting in a 21% decrease in efficiency.

Similarly, female farmers' efficiency is positively influenced by competence to spot opportunities, creativity, conceptual competence, competence in valuing ideas, managing relationships with labour for organizational goals, years spent in school, studying agricultural-related courses, farming experience and membership in cooperatives. Each unit increase in these variables significantly enhances female farmers' efficiency by 43, 17, 63, 50, 5, 31, 22 and 40%.

These findings underscore the complexity of factors influencing maize production efficiency, with variations between male and female-owned farms. Addressing inefficiencies and considering gender-specific factors is crucial for devising effective strategies to improve overall maize farming operations.

Distribution of production efficiency scores: Table 5 provides an overview of the distribution of production efficiency scores across gender categories. The production efficiency scores for male maize farmers in the study area range from 0.115 to 0.922, while female maize farmers' scores range from 0.109 to 0.961. The mean technical efficiency scores for male and female farmers are 0.592 and 0.533, with standard deviations of 0.106 and 0.092, respectively.

Table 5: Efficiency distribution of gender disaggregated maize farmers

	Male		Female	
Range	Frequency	Percentage	Frequency	Percentage
0.00-0.300	47	22.6	52	31.7
0.301-0.600	74	35.6	55	33.5
0.601-0.900	68	32.7	36	22.0
0.901-1.000	19	9.1	21	12.8
Total	208	100.0	164	100.0
Range	0.115-0.922		0.109-0.961	
Mean	0.592		0.533	
SD	0.106		0.092	
t-statistics (p value)	-5.646 (0.0001)			

Source: Data analysis, 2023

In this study, the t-statistics result of -5.646 indicates that the difference between the mean technical efficiencies of male and female farmers is statistically significant and not due to chance. Consequently, the results imply that adopting techniques employed by the best practice maize producers could enhance maize production.

DISCUSSION

This study delves into the gender-specific intricacies within the stochastic frontiers of maize production, offering significant insights into a region characterized by diverse ecosystems mirroring those found across Nigeria. Ondo State's varied landscapes, including mangrove-swamp forests, tropical rainforests and wooded savannas, provide a unique backdrop for understanding the multifaceted factors influencing maize production.

The study identifies key variables shaping maize output, encompassing harvested area, urea fertilizer usage, planting of first filia generation maize seeds, agrochemical application and associated costs such as farm tools, machinery rentals and labour. The study finds that the average expenditure on agrochemicals during the production cycle and the cost of land preparation collectively represent about 19% of the overall cost of maize production in Ondo State. This contrasts with the 25% recorded for the same purpose in Adamawa State, as reported by Gwandi *et al.*[29] and Olayinka *et al.*[30] documented a lower proportion of approximately 10% for pesticides in the total cost of production in Kwara State.

The utilization of agrochemicals in maize cultivation has demonstrated a positive impact on yield productivity, consistent with findings from Mabe *et al.*[31]. The study sheds light on gender dynamics in land acquisition, revealing that the average rent paid for land by female respondents is higher than that paid by males. This reflects existing literature emphasizing the predominantly male-dominated access to land as a production resource, limiting females' ability to acquire and retain land[32,33]. These findings underscore the importance of gender-specific considerations in understanding the nuances of socioeconomic characteristics and cost structures within the context of maize production in the study area. The demographic distribution of respondents in this study was similar to that of Abubakar and Onwujiobi[34].

This study finds that there is a positive influence of harvested area on maize output. Notably, the elasticity observed in this study (1.22) contrasted with Ayinde *et al.*[35] (0.41), suggesting a more pronounced impact of harvested area on maize production in the current context. This highlights a nuanced efficiency in land resource utilization among farmers in the study area, emphasizing the necessity for tailored interventions based on specific local conditions.

An essential focus of this study is the investigation into the use of organic fertilizer, specifically urea, shedding light on its significant effects on maize production. The study finds that urea application on maize farm significantly improve the production of male owned maize farms contrary to the female owned ma farms. This disparity would require further investigation to acertain the fact behind such an outcome. Despite the limited adoption of organic fertilizers in the study area, the research emphasizes a commitment to sustainable and context-specific agricultural practices that can enhance productivity while contributing to environmental sustainability based on its findings.

The significance of planting first filia generation maize seeds in increasing maize production output aligned with existing literature[36,37], emphasizing the importance of seed quality and variety selection. The adoption of herbicides for weed control, influenced by the increasing cost of farm labour and changing climatic conditions, is revealed to be a prevalent and positively correlated practice with maize production output. The finding aligned with the evidence from Mabe *et al.*[31]. Analyzing the impact of input variables on maize output for both male and female-owned farms, the size of the land has a positive and significant effect on output at a 1% significance level for both groups. A unit increase in the cultivated area leads to a 121% increase in maize output for male-owned farms and a 151% increase for female-owned farms. The massive output caused some curiosity because there was no such close to it in the literature except where Abate *et al.*[24] found a similar impact in rice production in Laguna (Phillipines). Other inputs significantly influencing maize output for male-owned farms include urea quantity, planting first filial generation seeds, cost of agrochemicals and labour cost. For female-owned farms, significant influences come from the area harvested, the cost of agrochemicals, cost of tools and machinery rentals and labour costs. These findings were similar to the findings of Chigbu[32]. Similarly, Abate *et al.*[24] averred that a unit increase in size of land positively yields a high significant increase in crop production output.

However, the study's identification of labour cost as a significant predictor of maize production output introduces a discrepancy with some studies, such as Balogun *et al.*[13], who observed a negative impact of labour cost on maize output production. This discrepancy may be attributed to variations in regional agricultural practices, climate conditions or other contextual factors, underlining the need for region-specific considerations.

Efficiency determinants among male-owned maize farmers aligned with existing literature, emphasizing age, household size, educational status and cooperative membership. Diverging from Balogun *et al.*[13], this study reveals a broader set of determinants, reflecting crop-specific dynamics and regional agricultural practices. Entrepreneurial competencies, including spotting opportunities, creative and conceptual competence and valuing ideas, prove significant in shaping farmers' efficiency, supporting Rahman *et al.*[38] and Fani *et al.*[39] advocacy for entrepreneurial business success.

The positive impact of experience on production efficiency resonates with previous studies, emphasizing practical knowledge's contribution to enhanced efficiency. Recognizing age, household size, educational status, cooperative membership and experience as significant determinants underscores the need for holistic approaches to enhance agricultural efficiency among male maize farmers. These findings contribute to the discourse on factors influencing farmers' performance, offering insights for targeted interventions and policy considerations.

These findings contribute valuable insights into the nuanced dynamics of maize production determinants, challenging existing trends in the literature. The positive impacts of urea fertilizer, improved seed varieties and the strategic use of agrochemicals underscore opportunities for farmers to optimize their production practices. The comprehensive exploration of production efficiency determinants among male-owned maize farmers aligns with existing literature, emphasizing the multifaceted nature of agricultural productivity. The inclusion of entrepreneurial competencies adds a novel dimension, suggesting that a nuanced understanding of various competencies, including entrepreneurial and social skills, is essential in comprehensively analyzing agricultural productivity. The recognition of age, household size, educational status, cooperative membership and experience as significant determinants provides a foundation for targeted interventions and policy considerations, contributing to the ongoing discourse on factors influencing the performance of male maize farmers.

CONCLUSION AND RECOMMENDATIONS

This study delves into the intricate dynamics of gender-disaggregated maize production in the diverse ecosystems of Ondo State, Southwest Nigeria. The research sheds light on the stochastic frontiers of production, revealing key determinants of maize output. Notably, variables such as harvested area, urea fertilizer use, first filial generation seed planting, agrochemical application and associated costs significantly influence maize production across the genders. The positive impact of urea fertilizer on production challenges prevailing trends, providing inspiration for farmers seeking to enhance maize yield sustainably. Additionally, the significance of first filial generation seed planting mirrors other studies advocating for improved seed varieties. As climate change and increasing labor costs shape agricultural practices, the study unveils the positive correlation between agrochemical use and maize production. Contrary to some literature, this study finds that labour costs positively impact production, highlighting the region-specific nature of these determinants.

Beyond the evidence that there is a significant difference between the mean technical efficiency score of male and female farmers, the study unveils a multifaceted landscape of determinants influencing the production efficiency of male and female-owned maize farms. Aligning with existing literature, factors such as age, household size, educational status, cooperative membership and experience emerge as significant contributors to production efficiency. The findings challenge previous studies by revealing a broader set of determinants beyond organizing competence. The inclusion of competence to spot opportunities, creativity and conceptual competence (competence to organize production resources) and the competence to value ideas and relationships with labour to achieve organizational goals underscore the importance of holistic skill sets in enhancing agricultural productivity. Practical knowledge gained through experience stands out as a robust determinant, emphasizing the cumulative learning process in optimizing farming practices. The study does not only align with existing literature but enriches our understanding by incorporating diverse factors. The recognized determinants emphasize the need for holistic approaches to enhance agricultural efficiency and productivity among male-owned maize farmers.

The following recommendations arise from the findings of this study are:

- Government should ensure tailored extension services to address gender-specific challenges, promoting efficient practices among male and female farmers
- Government should implement awareness campaigns, subsidies and educational programs to encourage the adoption of sustainable practices, especially urea fertilizer
- Farmers should prioritize investments in tools, machinery and efficient land preparation methods to alleviate cost burdens and enhance production efficiency
- The government should design policies recognizing gender differentials, focusing on improving access to land, farm inputs like seeds, agrochemicals, etc as well as education to enhance female farmers' innovativeness and their entrepreneurial competence

SIGNIFICANCE STATEMENT

This study delves into gender-specific maize production in Ondo State, Nigeria, emphasizing sustainable farming and societal fairness. It recognizes the crucial role of African women farmers in food cultivation but notes their often inadequate compensation in policy. By integrating entrepreneurial competencies, the research assesses gender-based production efficiency. Results unveil notable efficiency differences among male and female maize farmers, identifying factors like opportunity spotting, creativity, education, experience and cooperative membership as efficiency influencers, particularly for women. These insights are vital for policymakers, extension services and development practitioners, aiding agricultural sustainability and gender equity efforts in Ondo State. Addressing these factors and enhancing compensation policies can foster equitable and sustainable agricultural development, aligning with global goals and advancing discourse on sustainable agriculture.

REFERENCES

1. Onyediako, P.O. and J.G. Adiele, 2022. Enhanced cassava production for food security and economic development in Nigeria: A review. Nigeria Agric. J., 53: 204-211.
2. Job, A., I.O. Iseghohi, M.T. Igyuve, R. Olayiwola and R. Akinwale *et al*., 2024. Performance of early-maturing topcross maize hybrids across multi-environments. J. Plant Breed. Crop Sci., 16: 15-26.
3. Wossen, T., A. Menkir, A. Alene, T. Abdoulaye and S. Ajala *et al*., 2023. Drivers of transformation of the maize sector in Nigeria. Global Food Secur., Vol. 38. 10.1016/j.gfs.2023.100713.
4. Sadiq, M.S., I.P. Singh and M.M. Ahmad, 2020. A paradigm shift from area-led to productivity-led production of maize in Nigeria. J. Agric. Environ. Sci., 5: 27-43.
5. Klopfenstein, T.J., G.E. Erickson and L.L. Berger, 2013. Maize is a critically important source of food, feed, energy and forage in the USA. Field Crops Res., 153: 5-11.
6. Ranum, P., J.P. Pena-Rosas and M.N. Garcia-Casal, 2014. Global maize production, utilization, and consumption. Ann. N.Y. Acad. Sci., 1312: 105-112.
7. Wossen, T., T. Abdoulaye, A. Alene, S. Feleke, A. Menkir and V. Manyong, 2017. Measuring the impacts of adaptation strategies to drought stress: The case of drought tolerant maize varieties. J. Environ. Manage., 203: 106-113.
8. Olaniyan, A.B., 2015. Maize: Panacea for hunger in Nigeria. Afr. J. Plant Sci., 9: 155-174.
9. Erenstein, O., M. Jaleta, K. Sonder, K. Mottaleb and B.M. Prasanna, 2022. Global maize production, consumption and trade: Trends and R&D implications. Food Sec., 14: 1295-1319.
10. Grote, U., A. Fasse, T.T. Nguyen and O. Erenstein, 2020. Food security and the dynamics of wheat and maize value chains in Africa and Asia. Front. Sustainable Food Syst., Vol. 4. 10.3389/fsufs.2020.617009.
11. Ibrahim, H.I., N.D. Saingbe and Z.A. Abdulkadir, 2012. Gender participation in economic activities and decision making in Keffi area of Nigeria. Asian J. Agric. Rural Dev., 2: 10-16.
12. Hennon, C.B., 2012. Entrepreneurship, Farming, and Identity: A Phenomenological Inquiry. In: Entrepreneurship-Gender, Geographies and Social Context, Burger-Helmchen, T. (Ed.), IntechOpen, London, United Kingdom, ISBN: 978-953-51-0206-9, pp: 249-294.
13. Balogun, O.L., A.G. Adeyonu and K. Ayantoye, 2021. Farmers entrepreneurial competencies and technical efficiency of rice farms. Rev. Agric. Appl. Econ., 24: 12-19.
14. Adesunkanmi, S.O. and S.A. Nurain, 2022. Empirical study of logistics outsourcing practices and firm productivity of selected manufacturing companies in Nigeria. Open J. Bus. Manage., 10: 3327-3341.
15. Jude, O. and A.I. Iheagwara, 2016. Application of word length using three discrete distributions (a case study of students' research projects). Int. J. Res. Math. Stat., 2: 35-44.
16. Lans, T., V. Blok and R. Wesselink, 2014. Learning apart and together: Towards an integrated competence framework for sustainable entrepreneurship in higher education. J. Cleaner Prod., 62: 37-47.
17. Adeyonu, A.G., O.L. Balogun, I.O. Amao and T.O. Agboola, 2022. Does farmers' entrepreneurial competencies explain their household poverty status? Evidence from rural areas of Kwara State, Nigeria. Cogent Econ. Finance, Vol. 10. 10.1080/23322039.2022.2071384.
18. Mamun, A.A., R. Thurasamy and S.A. Fazal, 2021. Entrepreneurial index for low-income households in Malaysia. Socio-Econ. Plann. Sci., Vol. 77. 10.1016/j.seps.2021.101013.
19. Chell, E., 2013. Review of skill and the entrepreneurial process. Int. J. Entrepreneurial Behav. Res., 19: 6-31.
20. Lizote, S.A. and M.A. Verdinelli, 2014. Entrepreneurial skills: A study with administrative employees of a food company. Contemp. Thought Adm. Mag., 8: 164-182.

21. Gianesini, G., S. Cubico, G. Favretto and J. Leitão, 2018. Entrepreneurial Competences: Comparing and Contrasting Models and Taxonomies. In: Entrepreneurship and the Industry Life Cycle: The Changing Role of Human Capital and Competences, Cubico, S., G. Favretto, J. Leitão and U. Cantner (Eds.), Springer International Publishing, Cham, Switzerland, ISBN: 978-3-319-89336-5, pp: 13-32.
22. Aigner, D., C.A.K. Lovell and P. Schmidt, 1977. Formulation and estimation of stochastic frontier production function models. J. Econom., 6: 21-37.
23. Al Mamun, A., S.A. Fazal and R. Muniady, 2019. Entrepreneurial knowledge, skills, competencies and performance: A study of micro-enterprises in Kelantan, Malaysia. Asia Pac. J. Innovation Entrepreneurship, 13: 29-48.
24. Abate, T., B. Shiferaw, A. Menkir, D. Wegary and Y. Kebede *et al*., 2015. Factors that transformed maize productivity in Ethiopia. Food Secur., 7: 965-981.
25. Morgan, S.L., T. Marsden, M. Miele and A. Morley, 2010. Agricultural multifunctionality and farmers' entrepreneurial skills: A study of Tuscan and Welsh farmers. J. Rural Stud., 26: 116-129.
26. Mensah, A.C. and J. Dadzie, 2020. Application of principal component analysis on perceived barriers to youth entrepreneurship. Am. J. Theor. Appl. Stat., 9: 201-209.
27. Greenacre, M., P.J.F. Groenen, T. Hastie, A.I. D’Enza, A. Markos and E. Tuzhilina, 2023. Publisher correction: Principal component analysis. Nat. Rev. Methods Primers, Vol. 3. 10.1038/s43586-023-00209-y.
28. Yankah, J.E. and D.K. Dadzie, 2015. Push and pull factors of innovation performance in quantity surveying firms. J. Econ. Sustainable Dev., 6: 188-196.
29. Gwandi, O., Y.Z. Dia and V. Kamalvanshi, 2023. Comparative assessment of farmers’ livelihood strategies by optimizing resource use in farming areas of Adamawa State, Nigeria and Eastern Uttar Pradesh, India. Curr. Perspect. Agric. Food Sci., 4: 39-50.
30. Olayinka, A.S., A.F. Lawal, M.A. Bwala, U.H. Mohammed and A.I. Sulaiman, 2019. Economic analysis and pattern of agrochemicals use among smallholder crop farmers in Edu Local Government Area of Kwara State. J. Agribus. Rural Dev., 52: 157-163.
31. Mabe, F.N., K. Talabi and G. Danso-Abbeam, 2017. Awareness of health implications of agrochemical use: Effects on maize production in Ejura-Sekyedumase municipality, Ghana. Adv. Agric., Vol. 2017. 10.1155/2017/7960964.
32. Chigbu, U.E., 2019. Anatomy of women’s landlessness in the patrilineal customary land tenure systems of sub-Saharan Africa and a policy pathway. Land Use Policy, 86: 126-135.
33. Adiaha, M.S., 2017. Economic value of Maize (*Zea mays*L.) in Nigeria and its impacts on the global food production. Int. J. Sci. World, 6: 27-30.
34. Abubakar, M.I. and A.C. Onwujiobi, 2023. Analysis of maize production efficiency in selected communities of Orlu Local Government Area of Imo State, Nigeria. J. Agric. Environ., 19: 11-21.
35. Ayinde, Y.O., V.E. Epunam and O.B. Oyesola, 2015. Gender differential in livestock production within agro-pastoral households in Ido Local Government Area of Oyo State, Nigeria. Niger. J. Rural Sociol., 16: 29-34.
36. Pandit, M., M. Chakraborty, R.K. Yadav, K. Prasad, R.P. Sah and U. Soti, 2019. Association study in different generations of Maize (*Zea mays*L.). Cogent Food Agric., Vol. 5. 10.1080/23311932.2019.1592062.
37. Saleem, U., N. Akhtar, S. Saleem, S. Kaukab, M. Yaseen, H.M. Asadullah and E.U. Hassan, 2024. Generation mean analysis for different morpho-physiological parameters of maize seedling under different regimes of water. J. Anim. Plant Sci., 34: 415-424.
38. Abidur Rahman, S., A. Amran, N.H. Ahmad and S.K. Taghizadeh, 2015. Supporting entrepreneurial business success at the base of pyramid through entrepreneurial competencies. Manage. Decis., 53: 1203-1223.
39. Fani, D.C.R., U.U. Henrietta, E.N. Oben, D.D. Dzever and O.H. Obekpa *et al*., 2021. Assessing the performance and participation among young male and female entrepreneurs in agribusiness: A case study of the rice and maize subsectors in Cameroon. Sustainability, Vol. 13. 10.3390/su13052690.