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Parametric and Cost-Benefit Determination of Maize Production Technology among Micro-Farmers in Igabi Agro-Ecological Zone of Kaduna State, Nigeria

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Abstract

The research was conducted to ascertain maize production technology among farmers in Igabi agro- ecological Zone of Kaduna State, Nigeria using parametric approach. The specific objective of the study was to determine the socio-economic traits of farmer (age, gender, marital status, educational attainment, household size among others) technical efficiency and challenges to maize production were investigated using Stochastic Frontier Production Function. Multi-stage random sampling technique was used to select, sixty (60) farmers that were used for the study. Descriptive statistical and stochastic frontier production function were applied to analyze the data. The study observed that, average age of the farmers was thirty-eight (38) years, large household size, farming experience averaged eight (8) years and monthly income was ₦120,518.92. The coefficients of the following variables were found to be positive: seed cost (0.008), labor cost (0.433), fertilizer cost (0.348), and chemical cost (0.017). This suggested that the variables were positive determinants of maize output. The coefficient of farm size (-0.222) was found to be a negative but statistically significant determinant of efficiency. Age (0.341), education (0.621), household size (0.036), farming experience (0.102), and extension contact (0.271) were all positively related to technical efficiency, supporting the conclusion that the variables were significant determinants of output. Among the constraints identified were insecurity (97%), inadequate finance (88%), high labor costs (78%), and the use of crude implements (78%). Some of the suggestions included encouraging farmers to spend more money on better and higher-quality maize seeds and instituting and organizing formal education outside of the classroom. It is expected that if the observed recommendations are taken into serious consideration, inefficiency will be reduced among farmers in the study area.

Keywords: Parametric Assessment, Maize Production Technology, Cost-Benefit Determinants, Micro-Farmers, Nigeria.

Introduction

One of Nigeria's most significant crops, maize (Zea mays L.) is widely farmed in both rural and urban regions. It is typically grown as a horticultural crop in some metropolitan settings, where it is tended to in the garden and surrounding grounds. Micro-agro farmers with dispersed land holdings currently dominate Nigeria's bulk maize production. According to

Girei et al. (2018) and Mgbenka and Mbah (2016), these farmers make up roughly 80% of the farming population and supply between 80% and 90% of Nigeria's food production. Ebukibia et al. (2020), opined that maize is the most versatile, plentiful, and significant food crop cultivated in Nigeria. The crop may be produced under a variety of agro-ecological circumstances, the author stated.

Studies have demonstrated the importance of maize as a food crop in both developed and emerging nations, such as Nigeria (Alabi and Abdlazeez, 2018). Ebukibia et al. (2020), stated that, it is one of the most widely grown crops worldwide and has the largest food supply in the current economy. Both humans and animals use the crop because it includes protein, vitamin B, and much-needed energy. It is a reliable source of foreign exchange, income, and jobs. Humans can utilize it to make starch, corn flour, protein, oil, food sweeteners, fuel, sugar, biscuits, corn flasks, syrups, baking powder, and alcohol. The pharmaceutical industry can potentially benefit from maize. The crop can be fed to animals and consumed by humans as a snack.

Consequent to its principle, agricultural production allows for the combination of specific limited resources in order to achieve the highest possible yield. How effectively these resources are combined determines how much of these inputs are obtained to meet the needs of a country in terms of food, fiber, agro-chemicals, raw materials, farmer income, and foreign exchange earnings, among other things (Rana et al., 2024, Kaine, 2021, Ume and Kaine, 2021). The production process involves a number of linkages and elements, including productivity, technical efficiency, farm and output expansion, and others.

When a certain quantity of resources is employed to produce the most output feasible, a farm is considered to be efficient. The productive utilization of resources is referred to as efficiency. It demonstrates the functional and technological connection between input and output. Hence, the degree to which a specific quantity of input is utilized to generate the greatest amount of product is known as technical efficiency (Simpa et al., 2014 and Kumbhakar and Lovell 2000).

Efficiency, according to Maligina et al. (2015), is the measurement of the techniques utilized to convert a specific quantity of input into output. By making the most use of limited resources to create a specific quantity of product, efficiency is attained. It is the capacity to maximize an input vector's outcome. Therefore, maximum efficiency is reached during production when resource reallocation is impossible without lowering the total value of output (Kumbhakar et al., 2001). Efficiency, to Ogundari (2014) and Asogwa et al. (2011), is the ratio of output to a specific quantity of input. However, when the output from a particular combination of resources falls short of the anticipated potential production, technical inefficiency may occur. Alabi and Osifo (2005), ascertained that socioeconomic, demographic, and subsistence demands may be the cause of agricultural inefficiency.

Depending on whether they impose a parametric functional form or not, slants toward technological efficiency can be classified as parametric (Stochastic Frontier Production Function) (SFPF) or non-parametric (Data Envelopment Analysis) (DEA). Whereas the SFPF calls for econometric methods, the DEA demands linear programming techniques. Both

deterministic and stochastic parametric approaches are possible. It is considered stochastic when there is a significant improvement since it is feasible to distinguish between random errors and variations in inefficiency, but deterministic when all deviations from the frontier are ascribed to inefficiency (Kaine, 2008).

The parametric SFPF models are extremely vulnerable to inaccuracies in the model definition. They do, however, make it possible to obtain estimators with statistical characteristics that enable one to do inference investigations. In addition to deviations from frontiers caused by inefficiency, stochastic approaches also allow deviations from frontiers that result from random causes. Additionally, they make it easier to construct consistent estimators of individual efficiency of sample observations.

The SFPF theory depicts a typical production scenario with many factors, some of which may be outside the producer's or farmer's control. In this instance, there may be certain stochastic components to the overall production process that are unrelated to inefficiency. Efficiency is influenced by a number of factors, including weather and measurement mistakes in both dependent and independent variables. All of these could lead to the creation of a stochastic error term, which indicates a number of established faults and raises the producer's inefficiency (Mohammed and Tamer, 2016).

The primary focus of the study was a parametric assessment of maize production technique among micro-farmers in Igabi agro-ecological zone of Kaduna State, Nigeria. Various studies have been conducted in different aspects of maize production in the study area, it not certain that enough study has been conducted with particular reference to a parametric determination of maize production technology among micro-farmers in Igabi agro-ecological Zone of Kaduna State, Nigeria. It is on this backdrop that the research was carried out. In particular, it determined the socioeconomic traits, farmers' technical proficiency, and barriers to maize production in the research region.

Methodology

The Study Area

The study was carried out in the Igabi Local Government Area, which corresponds to the Igabi agro-ecological zone of Kaduna State, Nigeria. Two hundred seventeen thousand, four hundred and fourteen (217,414) men and two hundred thirteen thousand, three hundred and thirty-nine (213,339) women make up the zone's total population of 403,753 (NPC, 2006). In 2023, the estimated total population, assuming a 3.2% growth rate, was 715,050. From the anticipated population figures, the male demographic stands at three hundred sixty thousand, nine hundred seven (360,907), whereas the female demographic was recorded at three hundred fifty-four thousand, one hundred forty-three (354,143). The primary economic activity in the region is agriculture, with a variety of crops cultivated, including maize, millet, rice, groundnut, and beans, among others. The predominant livestock raised includes goats, sheep, and cattle, while fish farming and poultry production represent the smaller-scale livestock enterprises practiced in the area.

Sampling Technique

The farmers employed in the survey were selected using a multistage random sampling technique. The selection of communities was the initial step. For the study, five (5) communities were chosen at random. The selection of farmers was the second step. With a sample size of sixty (60) farmers used for the study, twelve (12) farmers were chosen at random from the five (5) villages that were first chosen. This was due to cost and convenience purpose. All of the information needed for the study was gathered using a well-designed questionnaire that addressed every goal of the investigation (primary source).

Method of Data Analysis

Data pertaining to the study's goals was gathered, coded, and examined using parametric modeling (stochastic frontier production function) and descriptive statistics.

Empirical Model

The Stochastic Frontier (Cobb Douglas Production Function) Model was used stated below:

$Yi = F(Xi\ ,\ \beta) + \epsilon i$

$Y = (X_1, X_2, X_3, X_4, X_5, V - Ui)$

$LnYi = \beta 0 + \sum \beta i{=}1\ LnXi + \cdots \beta n\ LnXn + V - Ui$

The explicit function is stated as:

$LnYi = \beta 0 + \beta_1 LnX_1 + \beta_2 LnX_2 + \beta_3 LnX_3 + \beta_4 lX_4 + \beta_5 LnX_5 + Vi - Ui.$

Where:

$LnYi$ = Output of maize (Kg).

X_1= Seed cost of maize (₦).

X_2 = Labour cost (Man-days).

X_3 = Quantity of fertilizer (Kg).

X_4 = Chemical input cost (Litres).

X_5 = Farm size (Ha).

The Technical Inefficiency Component of the Stochastic

Frontier Model is stated thus:

$Ui = \alpha_0 + \alpha_1 Z_1 + \alpha_2 Z_2 + \alpha_3 Z_3 + \alpha_4 Z_4 + \alpha_5 Z_5 + \alpha_6 Z_6 + \alpha_7 Z_7$

Where:

Ui = Technical Inefficiency Component.

Z_1= Age (Years)

Z_2= Educational attainment (Years)

Z_3= Household size (Number).

Z_4= Farming Experience (Years).

Z_5= Extension Contact (Number of contacts per month).

α_0 = Constant Term.

$\alpha_1 - \alpha_6$ = Regression Coefficients.

Results and Discussion

Maize producers' socio-economic status

The socio-economic traits of the farmers were examined, and Table 1 shows the findings. The average age of the farmers in the sample was thirty-eight (38) years old, according to the variable: age of the farmers. This suggested that the research area's farmers were comparatively young. Kaine et al. (2021) found that the average age of maize farmers in Igabi Local Government Area, Kaduna State, Nigeria, was thirty-nine (39) years old, while Alabi and Abdlazeez (2018) found that the average age was 37.2 years old. This contradicts the findings of this study, which suggested that the farmers were youthful and engaged. The average age of the farmers was forty-two (42) years old, according to Kaine and Abojei (2024), who also reported average age of forty-two (42) years and noted that the farmers were economically viable and engaged at that age. A mean age of 42.5 years was also noted by Adedepo (2008) in research on the technical efficiency of maize farmers in Ogbomosho, Nigeria. According to the gender observed results, twenty-two (22) (37%) of the respondents were female, while thirty-eight (38) (63%) were male. It suggested that in the research area, maize production involved both sexes.

Forty-three (43) (72%) of the farmers were married, based on analysis of the variable marital status. It further revealed that only seventeen (17) (28%) of the farmers were single. It suggested that maritally limited maize production did not exist in the research area. The study on educational attainment, the majority of farmers, 36 (60%) had no formal schooling. This finding contradicts the findings of Oladunni et al. (2013) and Adedepo (2008), who found that smallholder maize farmers in the Ogbomosho Agricultural Zone, Nigeria, had high literacy levels.

An average of seven (7) people per household was reported in this study indicating that household sizes were high. The farmers' average farming experience as observed in the study's findings, was eight (8) years. With an average farm size of four hectares and a mean monthly income of ₦120,518.92, the results of the farm size study showed that the farmers were micro maize farmers.

Table 1. Maize producers' socio-economic status

Variables	Frequency	Percentage	Mean
Age			
30 – 35	19	32	
36 – 40	28	47	
41 – 45	08	13	
46 – 50	05	08	**38**
Gender			
Male	38	63	
Female	22	37	

Marital Status			
Married	43	72	
Single	17	28	
Educational Attainment			
Informal	36	60	
Formal	24	40	
Household Size			
Less than 5	20	33	
6 – 9	33	55	
10 – 14	05	8	
15 and above	02	3	**7**
Farming Experience			
5 – 10	28	47	
11 – 15	18	30	
16 – 20	06	10	
20 and above	08	13	**8**
Farm Size			
≤ 2	38	63	
3 – 4	11	18	
5 – 6	08	13	
7 and above	03	5	**4**
Farm income			
50,000 – 100,000	19	32	
151,000 – 200,000	27	45	
210,000 – 250,000	06	10	
251,000 – 300,000	04	6	
300,000 and above	04	6	**₦120,518.92**

Source: Computed from field, 2024.

Estimates of the farmers' technical efficiency

Table 2 shows the maximum likelihood estimates (MLE) of the parameters of the stochastic frontier production model technique that was used to identify the technology of maize production among micro-farmers in the research area. With a coefficient of sigma squared of 0.204 (critical t = 1.8430), the results showed that the composite error term assumption was true and that the fit was good. The gamma coefficient (0.994) explained the variance in output levels among micro maize producers in the research area and demonstrated the presence of technical inefficiency. This implied that the relatively insignificant factors left out of the model were the cause of the unexplained variation.

The coefficients of the estimated parameters of the variables: chemical cost (0.017), fertilizer cost (0.348), labor cost (0.433), and seed cost (0.008) were positive. This suggested that the variables positively influenced the amount of maize produced. It also implied that a unit increase in these variables will lead to a corresponding increase in the output of

maize. The result is in line with the a priori expectations. A similar result was observed by Usman (2017) and Idris et al., (2015).

The variable (seed cost) was found to be statistically significant. An increase in seed cost therefore, will significantly increase technical efficiency and reduce inefficiency. The estimated parameter of the variable seed cost 0.008 (t – ratio 4.032) was positively related to technical efficiency, suggesting that farmers with improved seeds had higher productivity or output and that the use of improved seeds will lead to improved productivity.

A strong correlation between the variable labor cost (0.433) (21.751) and technical efficiency was observed. Ume et al. (2020) achieved a similar outcome. This finding suggested that farmers who invested more in labour or who had greater labour costs were more technically efficient. The t-ratio (21.751) showed that labor costs had a highly significant effect on technical efficiency. It also suggested that a strong determination of technological efficiency, rather than chance, was responsible for the outcome.

The cost of fertilizer had a coefficient of 0.348, indicating a positive, strong, and significant relationship with technical efficiency. The t-ratio result (13.734) suggested that the variable had a meaningful impact on efficiency, suggesting that farmers who applied more of the variable were likely to obtain more yield and thereby improve efficiency. This is consistent with economic a priori expectations. Food and Agricultural Organization (FAO) (2020) and Usman et al. (2015), suggested that fertilizer use can increase net agricultural revenue, productivity, and efficiency. The study's results contradict the findings of Simpa et al. (2014), who found a positive but non-significant relationship between fertilizer cost and technical efficiency.

The cost of chemicals was another significant factor taken into account in this investigation. An increase in chemical costs had a slight but favorable impact on technical efficiency and maize production, based on the analysis of the variable's coefficient (0.017). The variable demonstrated a high and significant link with the technical efficiency of maize production in the research area, as indicated by the positive sign of the t-ratio (7.918).

In this study, the coefficient of farm size (-0.222) was found to be a statistically significant negative driver of technical efficiency. A unit increase in farm size will result in a unit fall in the dependent variable, which will then result in a decrease in productivity or output, ceteris paribus, based on the inverse connection between the variable and technical efficiency. The t-ratio (3.802) yielded a good outcome. This suggested that, at the 5% level of significance, the variable was statistically

significant. However, Idris et al. (2015) and Kaine et al. (2025) found a favorable correlation between technological efficiency and farm size.

Technical inefficiency estimates of the farmer

Technical inefficiency of the farmers was determined and the result provided in Table 2. Age, education, household size, agricultural experience and extension contact were

evaluated as key variables for this study. All of the variables' coefficients and corresponding t-ratios showed favorable indications. Age, education, and household size were found to be positively correlated. A similar result was observed by Kaine et al. (2025). At the 5% level of significance, the results showed that the coefficient of age (0.341) and t-ratio = 2.010 were statistically significant, positive and determinants of technical efficiency. This suggested that as people age, their level of inefficiency will rise. Additionally, it suggested that elderly farmers were typically less productive than younger ones. This outcome is consistent with the findings of Rana et al. (2024). A positive coefficient (0.621) was found for the variable education (t-ratio = 1.414). This suggested that inefficiency decreases with age. The outcome also suggested that inefficiency decreased with farmers' level of education.

The study observed a t-ratio of 1.597 and a household size coefficient of 0.036 indicating that as household size increases, efficiency will rise and inefficiency will decrease. The coefficient of farming experience (0.102) indicated that the variable decreased inefficiencies, maize output and was positively correlated with efficiency. It meant that farmers who were more experienced were probably more productive. It also suggested that inefficiency decreased by 0.102 units for each extra year of agricultural expertise. Kaine et al. (2025), however, found efficiency and the variable agricultural experience to be negatively correlated. As shown in Table 2, extension contacts (0.271) (t – ratio = 1.564) demonstrated that an increase in extension contacts boosts efficiency and decreases inefficiency.

Table 2: Maximum likelihood estimates of the stochastic frontier production function

Variables	Parameter	Coefficient	Standard error	t – ratio
Constant	β_0	1.909	0.355	5.375
Seed cost	β_0	0.008	0.002	4.032
Labour cost	β_0	0.433	0.020	21.751
Cost of fertilizer	β_0	0.348	0.025	13.734
Chemical cost	β_0	0.017	0.002	7.918
Farm size	β_0	-0.222	-0.228	3.802
Inefficiency models				
Constant	β_0	0.119	0.037	3.206
Age	β_0	0.341	0.169	2.010
Education	β_0	0.621	0.439	1.414
Household size	β_0	0.036	0.022	1.597
Farming experience	β_0	0.102	0.067	1.530
Extension contact	β_0	0.271	0.173	1.564
Sigma – squared		0.204	0.111	1.843
Gamma		0.994	0.004	242. 451

Source: Computed from field survey, 2024.

Log likelihood function = 0.11867079E+03 **ie. 118.67**

Likelihood Ratio (LR) 0.49202372E+02 **ie 49.20**

Limitations on the production of maize

Numerous obstacles faced by maize farmers in the research area tended to limit their capacity to enhance production activities and participation levels, which in turn delayed investment expansion. Table 3 showed the main obstacles that the research area's maize producers had identified. According to fifty-eight (58) (97%) of the interviewees, the greatest obstacle preventing maize production was insecurity. One of the main obstacles to maize production, as was indicated by fifty-three (53) (88%) of the farmers, was a lack of funding. Forty-seven (47) (78%), thirty-nine (39) (65%), and thirty-four (34) (57%) of the respondents, respectively, cited high labor costs, the use of crude implements, and a lack of capital as issues impeding maize output. Thirty-four (34) (57%) of the farmers in the research area cited the high cost of herbicides as a barrier to maize cultivation. Twenty-nine (29) (48%) and seventeen (17) (28%) of the respondents cited inadequate storage facilities and the high cost of fertilizers as two of the barriers that hindered greater maize output in the research area.

Table 3: Constraints to maize production

Variables	Frequency	Percentage
Insecurity	58	97
Inadequate finance	53	88
High cost of labour	47	78
Use of crude implements	39	65
Inadequate capital	34	57
High cost of herbicides	34	57
Poor storage facilities	29	48
High cost of fertilizer	17	28

*Multiple responses by respondents

Source: Computed from field survey, 2024.

Conclusions and Recommendations

The result of the study established that the average age of farmers was thirty-eight (38) years old, literacy level was low, household size was large, and they had an average of eight (8) years of farming experience. The results also demonstrated that the farmers were low-income earners, with a mean farm size of four hectares and a monthly income of ₦120,518.92. Positive indications were shown by the coefficients of the calculated parameters of the variables: chemical cost (0.017), fertilizer cost (0.348), labor cost (0.433), and seed cost (0.008). This suggested that the variables positively determined the output of maize produced. The coefficient of the variable farm size (-0.222) was established to be negative but statistically significant predictor of technical efficiency. Technical efficiency was positively correlated with the coefficient of the following variables and their t-ratios: age (0.341) (t-ratio = 2.010), education (0.621) (t-ratio = 1.414), household size (0.036) (t-ratio = 1.597), farming experience (0.102) (t-ratio = 1.530), and extension contact (0.271) (t-

ratio = 1.564). This supported the notion that these factors significantly influenced the amount of maize produced.

A number of constraints were identified as obstacles to maize production in the study area. Notable among these is insecurity, inadequate finance, high labor costs and the use of crude implement. Given the findings of this investigation, it was suggested that:

i. Given the low literacy rate in the study area, farmers should receive formal education outside of the classroom;
ii. Since the variable cost of seeds was found to be a positive predictor of technical efficiency and maize yield, farmers should be encouraged to purchase high yielding and improved maize seeds. The multiplier effect of this will be increased efficiency, output and social welfare.
iii. It was recommended that public and private partnerships should provide farmers with high-quality seeds;
iv. All levels of government should adopt and carry out policies that will promote and improve farmers' access to high-quality seeds;
v. It was suggested that the adoption of better labour-saving equipment (mechanization) be promoted since labour costs were a positive determinant of efficiency and maize production output. In order to minimize inefficiencies, farmers should also ensure that labour allocation was optimized.
vi. Since the result showed that the variable chemical cost was a positive determinant of technical efficiency and output of maize produced it was important to optimize the use of chemicals (pesticides and herbicides) in the production process.
vii. It was suggested that older farmers be trained and retained in order to decrease farmer inefficiencies. It is hoped that if recommendations given inn this study are taken seriously, maize producers in the study area will not only improve their technical efficiency will also enhance output and standard of living.

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