Economics and Technical Efficiency of Maize Production Among Small Scale Farmers in Abuja, Nigeria: Stochastic Frontier Model Approach

E. S. Ebukiba, L. Anthony, and S. M. Adamu

Abstract — This study evaluated Economics and Technical Efficiency of Maize Production Among Small Scale Farmers in Abuja, Nigeria; Stochastic Frontier Model Approach; Multi-stage sampling technique was adopted and used. Primary data were collected through the use of well-structured questionnaire from one hundred and fifty (150) sampled respondents in the study area. Data were analyzed to achieve the specified objectives using the following tools of analysis, Descriptive Statistics, Stochastic Frontier, Gross Margin Analysis, Financial Analysis, Five Point Likert Scale, and Principal Components Analysis. The results show that majority 40.47% of the sampled respondents were among the age range of 41-50 years of age and 25.33% were within the age bracket of 31-40 years of age. The mean age of the sampled farmers is 44 years. Which indicated that Young and energetic farmers are able to withstand stress and adopt new innovations. Most 88.67% of the farmers were male. Majority 72.67% were married. The mean household size of the sampled respondents is 6 members per family. Majority (67%) of the small-scale maize farmers had 1-2 ha of land and the average farm size cultivated by the farmers was 2.576 ha. The factors influencing total output of maize were seed input (P<0.01), Farm Size (P<0.05), quantity of fertilizer (P<0.05), and labour input (P<0.01) were statistically significant variables. The results of the inefficiency components show that the factors influencing technical inefficiency includes: age (P<0.01), education (P<0.01), access to credit (P<0.05), farming experience, and household size (P<0.05) and were statistically significant. The total revenue realized by the sampled small-scale maize farmers was ₦238,317 on average. While the total variable costs on average basis was ₦109,702.93. The gross margin realized was ₦128,667.07. The gross margin ratio was 0.54 while operating ratio calculated was 0.857 and the rate of return on investment (RORI) was 1.17. The retained component from the constraint’s analysis include Lack of Improve Seed, Lack of Transportation, Poor Storage Facilities, Inadequate Capital, and Cattle Herdsman. The retained components explained 60% of the variation of the component included in the model. The study therefore, recommends that affordable loans and adequate capital should be made available to the small-scale maize farmers, farmers should be properly trained and educated by the non-governmental organizations and extension agents on chemical application, fertilizer use and pests and diseases control measures especially on integrated pest management (IPM). Inputs like improve seeds, fertilizer, and chemicals should be made available to farmers at subsidized rates and at appropriate time coinciding with production periods for proper usage. Provisions should be made for transportation and storage facilities for farmers, the issue of conflict between farmers and herdsmen should be brought to book and resolved amicably for peaceful coexistence.

Index Terms — cost and returns, Technical efficiency, small scale maize farmers, stochastic frontier.

I. INTRODUCTION

Agricultural is one of the leading sectors in Nigeria and in terms of its contributions to income, employment, foreign exchange earnings and domestic food supply [26]. Agriculture in Nigeria is majorly dominated by small-scale farmers who are involved in the production of food for the country. Maize (Zea mays L.) which is considered as one of the most abundant food crops in Nigeria is the most important staple food in Nigeria and it has grown to be local ‘cash crop’ [14]. Maize is one of the most versatile emerging crops having wider adaptability under varied agro climatic conditions. Globally, maize is known as queen of cereals because it has the highest genetic yield potential among the cereals [4]. Today the crop is one of the most important sources of the world’s food supply. It is the most heavily cultivated cereal crop globally, and one of the main cereals crops of West Africa and the most important cereal food in Nigeria [29]. About 80% is consumed by man and animals, while 20% is utilized in variety of industries processes for production of starch, oil high fructose, corn sweetener, and ethanol, cereal and alkaline. Maize consists of 71% starch, 9% protein and 4% oil on a dry weight basis. Maize is very good source of minerals, carbohydrate, vitamin B and protein for people of sub-Saharan Africa. After sorghum, and millet, maize came third as an important cereal and Nigerian staple food crop. Maize is used in the following areas: corn syrup, starch, for feeding livestock, protein and oil, food sweeteners, beverages, fuel, sugars, corn flakes, biscuits, dextrose, baking and brewing, used in industries. The major industries using maize includes livestock industries, pharmaceutical industries, food and confectionary industries, and beverages industries [3]. Maize is increasingly used as feedstock for the ethanol fuel production. Ethanol is mixed with gasoline to decrease the amount of pollutants emitted when used to fuel motor vehicles, what is nowadays known as biofuels [33]. About 90% of Nigerian farmers are subsistence in nature, their production is mainly for family consumption and sale some, they are also referred to smallholder farmers, marginal, and peasant or small-scale. They are characteristics by low

Published on November 21, 2020.
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DOI: http://dx.doi.org/10.24018/ejfood.2020.2.6.145
Vol 2 | Issue 6 | November 2020
capital base, they use crude implements with low level of technology, they are mostly poor, and the yield obtained per hectare of land is very low [24]. The demands for maize outweigh the supply of maize. The demand for agricultural produce is continuously rising due to the geometric rise in population; this has resulted in the intensification of cultivable land in an attempt to increase agricultural productivity [1].

Research shows that Nigeria is the tenth largest producer of maize in the world, and the largest maize producer in Africa, followed by South Africa. While maize is grown in the entirety of the country, the north central region is the main producing area. Maize production in Nigeria stood at 10.7 million metric tons in 2015 [9] and 10.5 million metric tons in 2017 [19]. Following the ban of maize imports by Central bank of Nigeria 2020, Nigeria projects 12.5 million metric tons of maize Production [7]. It is usually intercropped, with yam, cassava, guinea corn, rice, cowpea, groundnut, and soybeans [34]. As a result of competition for maize by both man and animal, the significance of increasing productivity may not be taken too lightly, higher maize productivity will lead to quicker economic growth, rural jobs and resources for industrial progress along with food supply to ever-increasing population. There is a clear evidence of production sustainability rate of maize in Nigeria [19], [9]-[14].

Therefore, effective economic development strategy depends critically on promoting productivity and output growth in the agricultural sector, particularly among smallholder producers which dominate the sector. With the ban on importation of maize into Nigeria small-scale farmers has comparative advantage and better opportunity for enlarging or increasing maize production output to make significant profit. Therefore, increasing efficiency in maize production is paramount and timely that result in higher returns. Technical efficiency (TE) is the ability of a firm to achieve maximum output from a given set of inputs under a given technology. [21] defined technical efficiency as the ability to derive the greatest amount of output possible from a fixed quantity of inputs. Allocative efficiency (AE) is the ability of a firm to operate at optimum input levels given their respective factor prices in production process. The product of TE and AE is economic efficiency (EE). Maize production mainly depends on farmer’s level of efficiency which is a function of their socioeconomic factors and their farm characteristics [31]. A number of studies have been conducted on technical efficiency it is very imperative to note that studies on efficiency has to do with time, location of the study and the type of crop. Hence there is need to look deeper into efficiency of maize production among small-scale maize farmers in order to come up with policy that will facilitate its production.

The major problems and some of the factors hindering agricultural development in Nigeria include inadequate investment in agriculture, limited access to credit by smallholder farmers, high cost and unavailability of inputs such as fertilizers and improved seeds, inadequate use of modern technologies, inefficient agricultural input markets, and the absence of a conducive policy environment [17]. Small-scale farmers are further faced with price instability or fluctuations, pest and diseases infestations, lack of storage facilities, and resources they have are not efficiently used, this makes the production of maize to be low [3]. Most common characteristic of Nigeria is an agrarian economy with 70% of its people dependent on agriculture [20]. Agriculture is dominated by peasant farmers relying mainly on traditional method and crude implements [23]. The Government of Nigeria has been trying to achieve food security at both household and national level through its mechanized approach. It is however surprising that, with all her potentials for agricultural progress can hardly meet its food requirements. Some of the challenges of food Production in Nigeria according to [13], have been attributed to several factors such as; small land area cultivated by farmer of less than 2 hectares for cropping; sub-optimal supply of agricultural inputs such as fertilizer, limited access to credit. The widening gap between food demand and supply in the country which necessitated massive food imports continued to swell Nigeria’s agricultural import bills despite all remedial measures to assuage the problem.

According to [22], this lopsided relationship between food demand and supply had earlier compelled the Food and Agricultural Organization of United Nations to opine that as the world population is increasing by approximately 1 million every four hours, we may have more than 3000 million people to feed by the year 2025. If they are to be fed adequately, the present food production level will have to be doubled and other strategies/approaches revised and/or encouraged. The result of the study would provide an indication relative to inputs use and input prices by small scale farmers which will provide information that would guide policy makers on how to increase the use of productive resources to alleviate food insecurity and poverty to achieve sustainability. This study provides answers to the following research questions:

(i) What are the socioeconomic characteristics of the small-scale maize farmers in Abuja, Nigeria?
(ii) What is the technical efficiency of maize production and the determinants of technical efficiency among small scale farmers?
(iii) What is the profitability of maize production among small scale maize farmers?
(iv) What are the constraints of maize production in the study area?

II. LITERATURE REVIEW

Alabi et al [3] investigated economic market decisions among marginal maize farmers in Abuja, Nigeria: applications of double hurdle model and factor analysis. The results Cobb Douglas production show that the factors influencing output of maize production by marginal farmers were: farm size (< 0.01), family labour (P < 0.05), hired labour (P < 0.05), fertilizers (P < 0.01), seed input (P < 0.05), and volume of pesticide used (P < 0.10). [32], carried out a research on Analysis of Resource Use Efficiency in Small-Scale Maize Production in Tafawa-Balewa Local Government of Bauchi State Nigeria using double-log function and marginal value productivity analysis the result revealed that, the double-log function gave the best fit with Adjusted R$^2$ of 81.16%. Production inputs such as seed, fertilizer, labour affected output significantly. Maize
production in the study area has an increasing return to scale from the sum of elasticity of production (1.747). Seed and fertilizer were underutilized in maize production, whereas labour was overused. [28], evaluated Farmers Resource – Use and Technical Efficiency in Cowpea Production in Osun state southwest Nigeria, using the stochastic production frontier, budgetary and resource-use efficiency analyses. The marginal value products of all the resources used are less than their prices (MVP<MFC), indicating underutilization of resources. The enterprise economic efficiency is 1.17. The farmers’ average technical efficiency is 87%, which suggest an appreciable use of inputs in productivity. Analysis efficiency using stochastic production frontier shows that farm size, seed, hired labour, family labour, fertilizer and pesticides are significant at 1% and some socio-economic variables using tobit regression model is found to be significantly different from zero at 1% for cooperative farming and membership experience.

[27] applied a Cobb-Douglas stochastic frontier production function in the analysis of technical efficiency in sesame production system in Jigawa State. The empirical result indicated that the technical efficiencies of the farmers varied widely ranging from 0.25 to 0.86 but with a mean technical efficiency of 0.57. The inefficiency model indicated that age of farmer, years of farming experience and extension contact significantly affected farmers’ efficiency level.

[36] analyzed the determinants of cost efficiency in cowpea production in Adamawa State, Nigeria using stochastic cost frontier. The mean allocative efficiency was estimated at 0.66, indicating that farmers operate at 34% below the cost frontier. The inefficiency models revealed that socio-economic variables, namely family size, farming experience, gender and extension contact have significantly reduced cost inefficiency among the farmers.

[30] analyzed the cost efficiency of maize production in the Chitwan district, Nepal with a view to predicting economic efficiencies using stochastic frontier cost function. The maximum likelihood estimates of the parameters revealed that estimated coefficients of cost of tractor, animal power, labour, fertilizer, manure, seed, and maize output gave positive coefficients and were statistically significant at 5% level. The quantitative estimates obtained from the cost function revealed that an average maize farm from the study incurred about 63% costs above the cost frontier, an indication of inefficiency.

A. Objectives of the Study

The broad objective of this study is to analyze the of economics and technical efficiency of maize production among small-scale farmers in Abuja, Nigeria, Stochastic frontier model approach. The specific objective was to:

(i) Determine the socioeconomic characteristics of small-scale maize farmers in Abuja, Nigeria.

(ii) Evaluate the technical efficiency of maize production and the determinants of technical efficiency among small scale farmers.

(iii) Evaluate the profitability of maize production among small farmers.

(iv) Identify the constraints militating against maize production in the study area.

III. MATERIALS AND METHODS

A. Study Area

This study was conducted in Kuje and Kwali Area Councils Abuja, Nigeria. Abuja was created and carved out in 1976 from the Kaduna, Niger, Kwara and Plateau States. Abuja has a boundary with Kaduna State to North and Kogi State to the South. It is also bordered to the East and West by Nasarawa and Niger States respectively. There are six Area Councils in Abuja, namely: Abaji, Bwari, Gwagwalada, Kuje, Kwali and Abuja Municipal Area Councils. Abuja is located within Latitudes 700 20’’ North of Equator and Longitudes 600 45’’ and 700 39’’. It lies on 416 m above sea level, the city has a tropical climate in winter there is much less rainfall than in summer. The average annual temperature is 26.1 °C. In a year, the average rainfall is 1331 mm and average humidity of 34%. Abuja has total land area of about 8,000 Sq Kilometers with a total population of 776,298 people as at the 2006 census [12]. It is predominantly a grassy savannah region, thus has potentials to produce both root crops and tubers such as yam and cassava. It also sustains legumes (groundnut & cowpea); grains (maize, sorghum & rice); seeds and nuts (melon seeds & benniseed); fruits and vegetable. Beside crop production, the rural communities also rear livestock such as sheep, goat, cattle, and poultry birds at subsistence level. The main vegetation of the study area is Guinea-savannah [8].

B. Sampling Technique and Sample Size

The sampling technique of the area involved purposive selection of Abuja, due to the concentration of maize farming in the area. Multi-stage sampling technique was used. First stage, two (2) area councils were selected using simple random sampling technique, the six (6) area councils were written on a piece of paper placed in a ballot-box, the papers were well shackled and shuffled, out of the six (6), two (2) area councils were selected. The area councils selected were: Kuje and Kwali. In the second stage, a simple random sampling technique was used to select four (4) from ten (10) wards from each area council. Third stage, a simple random and proportionate sampling technique was used. The simple random sample was accomplished using a table of random numbers. A total sample size of 150 respondents were selected for interview using simple random sampling 80 and 70 respondents from the two area councils respectively.

C. Method of Data Collection

Primary data were used for this study. Data were collected through the use of questionnaires. The questionnaire was designed to capture the important variables such as socioeconomic characteristics of the small-scale maize farmers. In each of the Area Council, two (2) Agricultural Extension Agents who are familiar with the geographic and socio-economic characteristics of the people was recruited, trained and mobilized as enumerators for data collection. Thereafter, Primary data were collected through the administration of structured questionnaire by a team of trained enumerators to 150 sampled small-scale maize farmers in the study area.
D. Method of Data Analysis

(i) Descriptive Statistics.

(ii) Stochastic Frontier.

(iii) Gross Margin Analysis.

(iv) Financial Analysis.

(v) Five Point Likert Scale.

(vi) Principal Components Analysis.

E. Descriptive Statistics

This involves the use of percentages, frequency distribution, means, minimum and maximum values, standard deviation, and variances. The descriptive statistics was used to summarize the collected data and describe the socioeconomic characteristics of the small-scale maize farmers. This was used to achieve the specific objective one (1) and part of specific objective four (4).

F. Stochastic Frontier Model

This study applied stochastic frontier production function model developed by [2]; [4] which is stated as follows:

\[ Y_i = f(X_i, \beta) \epsilon_i, \epsilon_i = \gamma + \epsilon_i \]  

where:

\( Y_i \) is the total output produced by \( i^{th} \) maize farmer, \( X_i \) is the vector of inputs used by \( i^{th} \) maize farmer, and \( \beta \) is coefficients or vector of parameters estimated, where \( \epsilon \) is the stochastic error term, which is decomposed into:

\[ \epsilon = v_i - u_i \]  

where:

\( v_i \) is the random component of the factors which are beyond the control of the small scale maize farmer, \( X_i \) is the vector of inputs used by \( i^{th} \) maize farmer, and \( \beta \) is a coefficients or vector of parameters estimated, where \( \epsilon \) is the stochastic error term, which is decomposed into:

\[ \epsilon = v_i - u_i \]  

\[ \epsilon \] is normally distributed \( N(0, \sigma^2) \) and independent of \( u_i \), and \( u_i \) is the random variable that represent technical inefficiency in the production function model which is assumed to be independently distributed, and normally distributed with mean \( u_i \) and variance \( (J/N(u_i, \sigma^2)) / f \).

Technical efficiency is stated thus:

\[ TE = \frac{Y_i}{Y_i^*} \]  

\[ TE = \frac{\log Y_i - \sum_{i=1}^{5} \beta_i \log X_i + V - U_i}{\log Y_i - \sum_{i=1}^{5} \beta_i \log X_i + V} \]  

where:

TE=Technical efficiency.

\( Y_i \)= Yield of maize observed.

\( Y_i^* \)= Frontiers yield of maize.

The inefficiency effects suggested by [4] is stated as thus:

\[ u_i = z_i \delta + w_i \]  

\( TI_i = 1 - TE_i \)

\( TI_i = 1 - \frac{Y_i}{Y_i^*} \)

where:

\( z_i \) is the vector of exogenous or explanatory variables included in the technical inefficiency model, \( \delta \) represent the vector of unknown parameters to be estimated, and \( w_i \) refers to unobserved random variables, and are assumed to be identically distributed [13]. \( TI_i \), is technical inefficiency of the \( i^{th} \) small-scale maize farmer and it ranges from 0 and 1.

The variance parameters can be estimated as follows:

\[ \delta_i^2 = \delta_e^2 + \delta_s^2 \] and \[ \gamma = \frac{\delta_e^2}{\delta_s^2} \]  

where, \( 0 \leq \gamma \leq 1 \) the value of \( \gamma \) lies between 0 and 1. Which represent the level of technical inefficiency. \( \gamma=0 \) signifies no technical inefficiency in the production model [15].

The Stochastic Frontier (Cobb Douglas Production Function) Mode is stated thus:

\[ Y_i = F(X_i, \beta) + \epsilon_i \]  

\[ Y = f(X_1, X_2, X_3, X_4, X_5, V - U_i) \]  

\[ LN Y_i = \beta_0 + \sum_{i=1}^{5} \beta_i \log X_i + V - U_i \]  

The explicit function is stated thus:

\[ LN Y_i = \beta_0 + \beta_1 \log X_1 + \beta_2 \log X_2 + \beta_3 \log X_3 + \beta_4 \log X_4 + \beta_5 \log X_5 + V_i - U_i \]  

where:

\( LN Y_i \) = Output of Maize (Kg).

\( X_1 \) = Seed Input (Kg).

\( X_2 \) = Farm Size (Hectares).

\( X_3 \) = Quantity of Fertilizer (Kg).

\( X_4 \) = Chemical Input (Litres).

\( X_5 \) = Labour Input (Man-days).

The Technical Inefficiency Component of the Stochastic Frontier Model is stated thus:

\[ U_i = a_0 + a_1 Z_1 + a_2 Z_2 + a_3 Z_3 + a_4 Z_4 + a_5 Z_5 + a_6 Z_6 + a_7 Z_7 \]  

where:

\( U_i \) = Technical Inefficiency Component.

\( Z_1 \) = Sex (1, Male; 0, Otherwise).

\( Z_2 \) = Age of Farmers (Years).

\( Z_3 \) = Education Level of Farmers (Years Spent Schooling).

\( Z_4 \) = Access to Credit (1, Access; 0, Otherwise).

\( Z_5 \) = Extension Contact (Number of Contact per Month).

\( Z_6 \) = Farming Experience (Years).

\( Z_7 \) = Household Size (Number).

\( a_0 \) = Constant Term.

\( a_1 - a_6 \) = Regression Coefficients.

This was used to achieve specific objective (ii).

G. Gross Margin Analysis

Gross Margin Analysis is defined as the difference between the gross farm income (GFI) and the Total Variable Cost (TVC) this tool is mostly used to estimate the profitability or cost and returns of farm enterprise among small-scale maize farmers. This was used to achieve the specific objective three (iii).
Gross margin Model (GM) is stated thus:

\[ GM = TR - TVC \]
\[ GM = \sum_{i=1}^{n} P_i Q_i - \sum_{j=1}^{n} P_j X_j \]

where: GM = Gross Margin (₦/ha); TR= Total Revenue from the Sales of Maize Output (₦); TVC= Total Variable Cost (₦).

\[ P_i = \text{Price of Maize Out Produced (₦/Kg)} \]
\[ Q_i = \text{Quantity of Maize Output Produced (kg/ha)} \]
\[ P_j = \text{Price of Input (₦/kg)} \]
\[ X_j = \text{Quantity of Input Used (kg/ha)} \]

This was used to achieve part of specific objective three (iii):

\[ \text{Operating ratio and rate of return per naira invested in maize production were estimated following [3], and [25]. The operating ratio (OR) is stated thus:} \]

\[ OR = \frac{TVC}{Gi} \]

where, OR= Operating Ratio (Units); TVC= Total Variable Cost (Naira); Gi= Gross Income (Naira).

Any Operating Ratio that is less than one (1) according to [2] signifies that the total revenue realized from maize production was unable to cover the cost of variable inputs utilized in the production cycle. The rate of return invested per naira is stated thus:

\[ RORI = \frac{NI}{TC} \]

where, RORI= Rate of Return per Naira Invested (Units); NI= Net income from Maize Production (Naira); TC= Total Cost (Naira). (Fixed cost is negligible on a short run). This was used to achieve part of specific objective three (iii).

1. **Financial Analysis**

The following financial ratios was used in this study in order to determine the profitability of maize production by small scale farmers as used by [6] in [3]. This was used to achieve part of specific objective three (iii):

\[ \text{Gross Margin Ratio} = \frac{\text{Gross Margin}}{\text{Total Revenue}} \]

\[ \text{Operating ratio and rate of return per naira invested in maize production} \]

\[ \text{were estimated following [3], and [25]. The operating ratio (OR) is stated thus:} \]

\[ OR = \frac{TVC}{Gi} \]

Subject to:

\[ \alpha_k \alpha_K = 1 \]

\[ \text{cov} [\alpha_k^2 X - \alpha_K^2 X] = 0 \]

This was used to achieve specific objective (iv).

IV. RESULTS AND DISCUSSION

A. **Socioeconomic Characteristics of the Sampled Small-scale Maize Farmers**

The socio-economic characteristics of the small scale farmers in the study area show that, the majority 40.47% of the sampled respondents were within the age of productivity this result is consistent with [13] who reported that the farmers were young and are expected to have more energy with high vigour to practice maize farming, the results is also in line with [3] which indicated that young and energetic farmers are able to withstand stress and adopt new innovations. Most 88.67% of the farmers were male while 11.33% of the sample respondents were female. Majority 72.67% were married while 18.67% were single. The results further revealed that 23.33% of the sampled respondents attained primary school
level of education and 13.33% attained secondary and primary school level of education respectively and majority (50%) of the sampled respondents has no formal education. This agrees with the findings of [3] who reported that education is an important factor that can influence small-scale farmers to adopt new innovations and research findings related to their area of production. When a farmer is educated, there is high probability that he will take advantages of innovations and new technologies easily.

The mean household size of the sampled respondents is 6 members per family. 58% of the sampled respondents had 1-5 years of experience in maize production while 39.33% had 6-10 years of farming experience and the average farming experience of the small-scale maize farmers is 7 years. Majority (67%) of the small-scale maize farmers had 1-2 ha of land and the average farm size cultivated by the farmers was 2.576 ha. This result is consistent with [18] who reported that the mean farm size of the sampled respondents was about 2 hectares of land indicating that food crop production is undertaken on a small scale by small-scale farmers. The average non-farm income from other sources among the small-scale farmers in the study area was ₦50,745.33.

**TABLE 1: SOCIOECONOMIC CHARACTERISTICS OF SMALL-SCALE MAIZE FARMERS IN THE STUDY AREA**

| Characteristics                  | Frequency | Percentage | Mean   |
|----------------------------------|-----------|------------|--------|
| **Age**                          |           |            | 43.7   |
| 18-20                            | 5         | 3.33       |        |
| 21-30                            | 14        | 9.33       |        |
| 31-40                            | 38        | 25.33      |        |
| 41-50                            | 61        | 40.67      |        |
| 51 and above                     | 32        | 21.33      |        |
| **Gender**                       |           |            |        |
| Male                             | 133       | 88.67      |        |
| Female                           | 17        | 11.33      |        |
| **Marital Status**               |           |            |        |
| Single                           | 28        | 18.67      |        |
| Married                          | 109       | 72.67      |        |
| Divorced                         | 3         | 2          |        |
| Widow                            | 5         | 3.33       |        |
| Widower                          | 5         | 3.33       |        |
| **Education Level**              |           |            |        |
| Primary School                   | 35        | 23.33      |        |
| Secondary School                 | 20        | 13.33      |        |
| Tertiary Institution             | 20        | 13.33      |        |
| **Household Size**               | 75        | 50         |        |
| 1-5                              | 78        | 52.00      | 6.03   |
| 6-10                             | 59        | 39.33      |        |
| 11-15                            | 8         | 5.33       |        |
| 16 and above                     | 5         | 3.33       |        |
| **Farming Experience**           |           |            | 7.04   |
| 1-5                              | 87        | 58.00      |        |
| 6-10                             | 34        | 22.67      |        |
| 11-15                            | 15        | 10.00      |        |
| 16-20                            | 10        | 6.67       |        |
| 21 and above                     | 4         | 2.67       |        |
| **Farm Size**                    |           |            | 2.576  |
| <2                               | 101       | 67.33      |        |
| 3-4                              | 31        | 20.67      |        |
| 5-6                              | 10        | 6.67       |        |
| 7 and above                      | 8         | 5.33       |        |
| **Non-Farm Income**              |           |            | 50,745.33 |
| ≤50000                           | 93        | 62.00      |        |
| 51000-100000                     | 32        | 21.33      |        |
| 101000-150000                    | 16        | 10.67      |        |
| 151000-200000                    | 5         | 3.33       |        |
| 201000 and above                 | 4         | 2.67       |        |

Source: Authors (2020).

**B. Estimates of the Technical Efficiency of Small-scale Maize Farmers in the Study Area**

The results of the maximum likelihood (MLE) of the parameters of the stochastic frontier production function and inefficiency were estimated for small-scale maize farmers using Stata software version 12. The MLEs of the Cobb-Douglas stochastic frontier model with half-normal distributional assumptions on the efficiency error term were estimated. The estimate of gamma is a measure of the level of the inefficiency in the various parameters and ranges from 0 to 1. Gamma estimate was 1.168043. Indicating the amount of technical inefficiency of the small-scale maize farmers in the study area. This result can be interpreted that 1.168% of the random variation in the output of maize farmers was due to differences in technical efficiency. The parameter of sigma square was (0.1654387). The mean value of technical efficiencies for small-scale maize farmers was 0.95. Implying that, on average the sampled respondents on individual basis were able to obtain 95% of potential output from a given mixture of production inputs, therefore in a short run, there is a shortfall of 5% of increasing the efficiency of maize production among small-scale maize farmers, by adopting the technology and techniques used by best small-scale maize farmers. This result shows that small-scale maize farmers are efficient in maize production in the study area.

The estimated coefficient of seed input for small-scale maize farmers was (0.3604115) and it was statistically significant at (P<0.01) probability level. The magnitude of the coefficient of seed 0.360 implies that a unit increase in the quantity of seed input in maize production results in 36% increase in the total output of maize among the small-scale maize farmers in the study area. The estimated coefficients for farm size was (0.291096) and significant at (P<0.05). The positive sign of the coefficient of farm size indicates that a unit increase in the farm size as a result of more expansion by small-scale maize farmers will result in increase of output of maize by 29% among maize farmers, this is in line with [35] which indicated that farm size has a positive and significant relationship with technical efficiency. The estimated coefficient of the quantity of fertilizer input used by the small-scale maize farmers was (-0.055879) and was statistically significant at (P<0.05) Probability level. A unit increase in the coefficient of the quantity of fertilizer as a result of more usage will result in the decrease of maize output due to the negativity of the sign of the coefficient. The estimated coefficient of labour was (0.4964175) and was positive and statistically significant at (P<0.01), this implies that a unit increase in labour supply by small-scale maize farmer results in 50% increase in the total output of maize. This agreed with the findings of [13] who observed that the magnitude of the coefficient of labour would induce an increase in the output of crop, and vice versa.

The inefficiency component model estimates are shown in Table 2 for small-scale maize farmers. The negative sign of the estimated parameters means that the variable reduces technical inefficiency (increases technical efficiency). The positive signs increase inefficiency (decreases technical efficiency). The coefficient of age (0.467188) was positive and statistically significant at (P<0.01) probability level the positive sign implies that age increases technical inefficiency, a unit increase in age results in 47% increase in technical efficiency.
inefficiency and decreases technical efficiency in maize production among small-scale farmers. This could be as a result of old age which could make the farmers unproductive as they advance in age.

| TABLE 2: MAXIMUM LIKELIHOOD ESTIMATES OF THE STOCHASTIC FRONTIER PRODUCTION FUNCTION FOR SMALL-SCALE MAIZE FARMERS |
|---------------------------------------------------------------|
| Variables     | Parameter | Coefficients | Standard Error | Z-score |
| Stochastic frontier | Constant | $\beta_0$ | 1.92113 | 0.2319 | 8.28* |
| Seed Input ($X_1$) | $\beta_1$ | 0.3604115 | 0.1179 | 3.06* |
| Farm Size ($X_2$) | $\beta_2$ | 0.2910966 | 0.1279 | 2.27** |
| Quantity of Fertilizer ($X_3$) | $\beta_3$ | -0.05857 | 0.0337 | -1.7*** |
| Agro-Chemical Input ($X_4$) | $\beta_4$ | 0.083377 | 0.0747 | 1.12 |
| Labour Input ($X_5$) | $\beta_5$ | 0.4964175 | 0.0820 | 6.05* |
| Inefficiency Model | $\alpha_1$ | -0.0633074 | 0.0495 | -1.28 |
| | $\alpha_2$ | 0.467188 | 0.0769 | 6.07* |
| | $\alpha_3$ | -0.3866881 | 0.0542 | -7.14* |
| | $\alpha_4$ | -0.4596595 | 0.0840 | -5.47* |
| | $\alpha_5$ | 0.007086 | 0.0011 | 63 |
| | $\alpha_6$ | -0.0041506 | 0.0019 | -2.11** |
| | $\alpha_7$ | -0.3693116 | 0.0477 | -7.7** |
| | $\alpha_8$ | -0.0012995 | 0.0025 | -0.52 |
| | $\sigma_1$ | 0.1654387 | 0.0460 |
| | $\gamma$ | 1.168043 | 0.1415 |
| Log likelihood | & -43.142996 & |
| Number of Observation | N | 150 |
| Mean Tech efficiency | TE | 0.95 |

Source: Authors (2020) *, **, ***. Significant at 1%, 5% and 10% Respectively.

Education level of sampled small-scale maize farmers was negatively and statistically significant (P<0.01). The magnitude of the coefficient of education level was (-0.3866881). A unit increase in the level of education of the small-scale maize farmer’s results in 38.7% decrease in the level of technical inefficiency as the small-scale maize farmers level of education increases their efficiency in maize production also increases. This indicates that the literacy level of farmers increases technical efficiency, this could be as a result by the fact that education exposes and encourages the farmers to adopt new technologies, the farmers could also use their education in the use of available resources and they were more exposed to new methods of farming and were able to adopt new innovations. Access to credit was negatively and statistically significant at (P<0.01), the coefficient of access to credit was (-0.4596595) the negative sign signifies decrease in inefficiency, a unit change in the access to credit results in 45.9% decrease in inefficiency in maize production by the small-scale farmers. As farmers has more access to credit will lead to accessibility of input easily, which could increase output of maize production thereby increasing technical efficiency among small-scale maize farmers.

Farming experience has negative sign and statistically significant at (P<0.05). The coefficient of farming experience was (-0.0041506). A unit change in farming experience of the small-scale maize farmers results in 0.42% decrease in inefficiency in maize production. Farming experience increases the level of efficiency as the farmers accumulated experience results in increase in maize productivity. Household size of the sampled small-scale maize farmers was negative and statistically significant at (P<0.05) probability level. The estimated coefficient for household size was (-0.3693116). This implies that a unit increase in household size results in 36.9% decrease in technical inefficiency in maize production by small-scale farmers. This indicates that household size of the small-scale maize farmers’ technical efficiency, this could be due to the fact that small scale farming is characterized by family labour which is mostly supplied by the household members. These findings are in agreement with the findings of [16].

C. Technical Efficiency Score among Small-scale Maize Farmers

The estimate of the technical efficiency revealed that 1.33% of the sampled respondents fall within the range of ≤ 0.85 and 0.86-0.90 level of technical efficiency respectively while 30% of the small-scale farmer attained 0.91-0.95% level technical efficiency. Majority 67.33% attained 0.96-1.00 level of technical efficiency. The minimum technical efficiency value attained by individual small-scale maize farmer was 0.5469 while the maximum technical efficiency attained was 0.9905. This result revealed that, the small-scale maize farmers were technically efficient in maize production but had a shortfall of 5% below perfection technically.

| TABLE 3: DISTRIBUTION OF TECHNICALLY EFFICIENCY SCORE AMONG SMALL-SCALE MAIZE FARMERS |
|-----------------------------------------------|
| Technical Efficiency Score | Frequency | Percentage |
| ≤0.85 | 2 | 1.33 |
| 0.86-0.90 | 2 | 1.33 |
| 0.91-0.95 | 45 | 30.00 |
| 0.96-1.00 | 101 | 67.33 |
| Total | 150 | 100 |
| Minimum | 0.5469 |
| Maximum | 0.9905 |
| Mean TE | 0.95 |

Source: Authors (2020).

D. Average Costs of Maize Production Among Small-scale Farmers

The total revenue realized by the sampled small-scale maize farmers was ø238,317 on average. While the total variable costs on average basis was ø109,702.93. The gross margin realized was ø128667.07. The gross margin ratio was 0.54 while operating ratio calculated was 0.857 and the rate of return on investment (ROI) was 1.17. This study shows that maize production was a profitable venture for investment among the small-scale maize farmers. This result is in agreement with [13] who reported that maize production is a profitable venture.
V. CONCLUSION AND RECOMMENDATIONS

Based on the findings emanating from this study, maize production is a profitable venture to invest in for increased income and provide food for the family and also provide food security and eradicate poverty among small-scale maize farmers, most of the sampled farmers were technically efficient therefore, the study recommends that affordable loans and adequate capital should be made available to the small-scale maize farmers so that they can expand their business enterprise and take advantage of large scale production, in order for them to make more profit, provide food for the family and eradicate poverty, this can only be achieved and sustained by developing a unique credit facilities administrations system for smallholder maize farmers in rural areas. Farmers should be properly trained and educated by the non-governmental organizations and extension agents on chemical application, fertilizer use, pests and diseases control measures especially integrated pest management (IPM). Inputs like improve seeds, fertilizer, and chemicals should be made available to farmers at subsidized rates and at appropriate time coinciding with production periods for proper usage. Provisions should be made for transportation and storage facilities for farmers, the issue of conflict between farmers and herdsmen should be resolved amicably for peaceful coexistence.

TABLE 4: AVERAGE COSTS AND RETURNS OF MAIZE PRODUCTION AMONG SMALL-SCALE MAIZE FARMERS

| Variables (Per Year) | Average Amount (₦) |
|----------------------|---------------------|
| (A) Total Revenue    | 238,317             |
| Variable Cost        |                     |
| Cost of Seed         | 15,317              |
| Cost of Fertilizer   | 21,414              |
| Cost of Agrochemical | 14,308.73           |
| Cost of Labour       | 58,663.2            |
| (B) Total Variable Cost | 109,702.93         |
| (C) Gross Margin = (A-B) | 128,669.07         |
| GMR                  | 0.54                |
| OR                   | 0.852               |
| ROR                  | 1.17                |

Source: Authors (2020).

E. Principal Component Analysis of Constraints Facing Smallholder Maize Farmers in the Study Area

Table 5 shows the results of the constraints faced by small scale maize farmers, PCA is a statistical technique that transform interrelated data with many variables into few numbers of uncorrelated variables. From the result the number of principal components retained using the Kaiser Meyer criterion are five based on the Eigen value greater than 1. The retained components explained 60% of the variation of the component included in the model. The Kaiser-Meyer-Olkin measures of sampling adequacy (KMO) of 0.5822 and Bartlett test of sphericity of 313.719 was significant at 1 % level of probability and demonstrated the feasibility of using the data set for principal component analysis. Lack of improved seed had an Eigen value of 2.28192 and it was ranked 1st in the order of importance based on perception of the small-scale maize farmers. Lack of Transportation and Poor Storage Facilities with Eigen value of 1.7173 and 1.42222 was ranked 2nd and 3rd respectively in the order of occurrence based on the perception of the small scale maize farmers as the major constraints militating against maize production in the study area. Inadequate capital and cattle herdsmen, with Eigen values of 1.42222 and 1.04115, which follows in order of their occurrence and importance respectively based on the perception of small-scale maize farmers as other challenges faced in maize production in the study area.

TABLE 5: RESULTS OF THE PRINCIPAL COMPONENT ANALYSIS OF CONSTRAINTS FACING SMALLHOLDER MAIZE FARMERS IN THE STUDY AREA

| Component Mean (Std Dev) | Eigen Value | Difference | Proportion | Cumulative |
|--------------------------|-------------|------------|------------|------------|
| Lack of Improve Seed     | 2.28192     | 0.564622   | 0.1755     | 0.1755     |
| Lack of Transportation   | 1.7173      | 0.295084   | 0.1321     | 0.3076     |
| Poor Storage Facilities  | 1.42222     | 0.18155    | 0.1094     | 0.4170     |
| Inadequate Capital Cattle | 1.24067   | 0.199515   | 0.0954     | 0.5125     |
| Herdsmen                | 1.04115     | 0.077268   | 0.0801     | 0.5926     |
| Bartlett Test of Sphericity | 313.719*** | 1.0000    | 0.5822     |            |

Source: Authors (2020).

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