ANALYSIS OF THE TECHNICAL EFFICIENCY IN MAIZE AND SORGHUM PRODUCTION IN KADUNA STATE, NIGERIA USING THE PARAMETRIC AND NON-PARAMETRIC MODELS

Ogaji, A.; Tanko, L.; Nmadu, J.N and Olaleye, R.S.
Department of Agricultural Economics and Farm Management,
Federal University of Technology Minna Niger State.
Corresponding Author's e-mail: abuogaji@yahoo.co.uk

ABSTRACT
The study analyzed the technical efficiency of maize and sorghum production in Kaduna State using the parametric and non-parametric models. Data were collected from primary sources and was obtained using the multistage random sampling technique. A total of 303 respondents were sampled. Analytical tools employed were descriptive statistics (means and percentages), stochastics frontier model and data envelopment analysis. Results showed that 65% of the respondents were between the ages of 31-50, 86.8% were males and 74.3% were married. Result also showed a mean technical efficiency of 0.72 and 0.86 for the SFA and DEA models respectively. it was recommended that both models should be used in determining efficiency giving the importance of accurate production efficiency estimates in policy decision making.

KEYWORDS:
Stochastics frontier, data envelopment analysis, efficiency

Introduction

Maize has a great potential and plays a crucial role in contributing to food and nutritional security, income generation, poverty alleviation and socio economic characteristics of farmers in Nigeria. The significance of maize to modern society is first and foremost clearly reflected in the importance of the crop in the diet of man and animals throughout the world (FAO, 2001). All over Nigeria, the selling of roasted and boiled maize is a thriving business that provides employment for hundreds of thousands of young girls and women, though the nature of employment is part time and seasonal (Samson, 2000). In addition, maize is traditionally used as animal feed and for the production of maize meal, flour, gut, starch, sweeteners as well as alcoholic beverages.
Sorghum on the other hand is an annual cereal crop that belongs to the family of grasses called *graminaecea* with good vegetative growth and some characteristic features that enable them to withstand grazing and drought to some extent (Mohammad, 2006). Sorghum is commonly called guinea corn in Nigeria. It is the fourth most important cereal crop after wheat, rice and maize respectively (FAO, 2003).it is traditionally used as animal feed and for the production of flour, guts and starches as porridge.

However, the production of maize and sorghum in Nigeria is dominated by the poor and uneducated farmers who grow crops on small and scattered farm holdings (Abubakar, 2000). These farmers operate mainly within the limit of their limited resources which tend to hamper their capacity to employ the most recommended production techniques, thereby leaving them with the options of either applying ineffective methods based on their indigenous knowledge or leaving their farm operations at the mercy of natural risk factors (Rahman, 2013). Such factors can greatly affect technical efficiency (Shehu, 2013).

In view of the potential of maize and sorghum as staple food crops and their economic significance in agro-allied and feed industries in Nigeria, it is very necessary to find ways of increasing the production of these crops. Studies have been conducted to determine the production efficiency of arable crop farmers in Nigeria using the ordinary least squares estimation (OLS) technique (Onoja, 2001; Joe, 2005; Omia, 2005 and Musa, 2012), the stochastic frontier model (Ogaji, Tanko and Omolehin 2012; Aji 2012), and the Data Envelopment Analysis model (Ojo, 2013; Okonkwo, 2015). These methods however, have their various limitations. The OLS estimation technique makes it difficult to determine farm level efficiency as it provides only an average function (Bravo-ureta and Ruheiro, 1997). On the other hand, both the stochastic frontier production function (SFPF) and the Data Envelopment Analysis (DEA) model can be used to determine farm level efficiencies of farmers. However, while SFPF has a limitation of not bringing out the efficiency score of individual farmers (Ojo, 2013). DEA also has the limitation of not bringing out the estimates of the parameters like the SFPE (Ojo, 2013; Okonkwo, 2015). To overcome these short comings, both the SFPF and the DEA methods will be used in the study so as to complement each-others deficiencies. It is against this background that the following objectives were formulated.

The aim of the study is to analyze the *technical* efficiency of maize and sorghum production in Kaduna State. The specific objectives are to:

1. describe the socio-economic characteristics of maize and sorghum farmers,
2. analyze the determinants of technical, efficiency in maize and sorghum production.

Hypothesis

Ho_1: There is no significant difference in the efficiency score using stochastic frontier production function (SFPF) and data envelopment analysis (DEA) methods

METHODOLOGY

Study area

The study was conducted in Kaduna State, Nigeria. Kaduna State is in the North-Western part of Nigeria. It lies between Latitudes 7°00'N and 10°87'N and Longitudes 06°43'E and 10°52'E. It shares boundaries with Kastina and Kano States respectively to the North, Plateau State to the North-East, Nassarawa and Abuja respectively to the South and Niger and Zamfara States to the West. (KADP, 2014). The State occupies an area of approximately 48,473.2 square kilometers with a projected population of 6.67 million based on annual population growth index of 3.2% (National population Commission, 2014).

Sampling Techniques

Multistage sampling technique was employed to select respondents for the study. The first stage was the purposive selection of Kaduna State because of the prevalence of Maize and Sorghum production enterprises in the area (KAPD, 2014). Kaduna State is stratified into four agricultural zones. Out of the four zones, namely: Samaru, Lere, Birnin-Gwari and Maigana zones, two agricultural zones namely: Samaru and Maigana zones were randomly selected.. This formed the second stage. The third stage involved the random selection of two Local Government Areas from each of the selected Zones to give a total of four Local Government Areas (LGAs) using the proportion allocation technique following Paul, (2008). The fourth stage involved the random selection of 2 farming communities in each of the selected LGAs. The final stage involved the random selection of 303 respondents from the study areas using the proportion allocation technique (Paul, 2008).The formula is given as:

$$S_h = \frac{n \times N_h}{N}$$

S_h = Number of small scale farmers to be selected,
n = Total number of small scale farmers for the survey,
N_h = Farming households in a LGA and
N_T = Sum of farming households in the 4 LGA.

Using the formula above, the actual number of farmers sampled from Kachia, Sanga, Giwa, Soba, LGAs are: 82, 86, 64, 71, respondents respectively. This gave a total of 303 respondents to be used for this study.

Method of Data Collection

The study utilized primary data that were obtained by survey method using a structured questionnaire to collect all relevant information from maize and sorghum farmers in the study area. The researcher was assisted by well-trained enumerators as well as resident extension agents in data collection. Data were collected from 2016 to 2017.

Validity and Reliability Test

The validity and reliability test was carried out before data collection. According to Gliem and Gliem (2003), the questionnaire for a field survey need to be tested to ensure all necessary information needed for the study are captured. The Cronbach alpha model was used to test the reliability of the instrument used in collecting the data. The formula for the Cronbach alpha model is given as: =

$$\alpha = {}^{NC}/_{V} + (N - 1)c$$

Where:
=Cronbach alpha
N=Number of items
C=Average inner item similar to other items
V=Average variance
Note that when =1, implies absence of error, while, =0, implies full error.

Methods of Data Analysis

The tools used in achieving the set objectives include: descriptive statistics, stochastic frontier production function and data envelopment Analysis (DEA) models.

Descriptive Statistics

Descriptive statistics such as means, percentages and frequency distribution tables were used to achieve objective 1.

MEASUREMENT OF TECHNICAL EFFICIENCY

Empirical Transcendental Logarithmic (Translog) Stochastic Frontier Production function

Following Tanko and Jirgi (2008), and Ogaji *et al.*;(2012), the implicit form of the translog stochastic frontier production function model to be used in measuring technical efficiency in maize and sorghum production enterprises is specified as:

$$\ln Y_i = \beta_0 + \sum_{k=1}^{6} \beta_k InX_{ki} + {}^{1}/_{2} \sum_{k=1}^{6}\sum_{k=1}^{6} \beta_{k1} InX_{ki}\, InX_{i1} + V_i - U_i$$

Where
In=Natural Logarithm,
i=ith farmer,
Y_i=Farm output for the ith farmer,
X's=input variables,
β = input co-efficient for resources used in production,
U_i = farmer's specific characteristics related to production efficiency and
V_i = Normal random errors (disturbance term).

Following Onus, Amaza and Okunmadewa (2000), and Tanko and Jirgi (2008), the explicit form of the Translog stochastic frontier production function is specified as

$$\ln Y = \beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta_5 \ln X_5 + \beta_6 \ln X_6 + {}^{1}/_{2}\beta_{11} \ln X_1^2 + {}^{1}/_{2}\beta_{22} \ln X_2^2 + {}^{1}/_{2}\beta_{33} \ln X_3^2 + {}^{1}/_{2}\beta_{44} \ln X_4^2 + {}^{1}/_{2}\beta_{55} \ln X_5^2 + {}^{1}/_{2}\beta_{66} \ln X_6^2 + \beta_{12} InX_1 InX_2 + \beta_{13} InX_1 InX_3 + \beta_{14} InX_1 InX_4 + \beta_{15} InX_1 InX_5 + \beta_{16} In X_i\, In X_6 + \beta_{23} I_n X_2 InX_3 + \beta_{24} I_n X_2 InX_4 + \beta_{25} I_n X_2 In X_5 + \beta_{26} X_2\, In X_2 + \beta_{34} InX_3 InX_4 + \beta_{35} InX_3 InX_5 + \beta_{36} X_6 InX_6 \beta_{45} InX_4 InX_5 + \beta_{46} InX_6 InX_6 + \beta_{56} InX_5 InX_6 + V_i - U_i$$

Where:
In=Natural logarithm,
Y = Output of maize and sorghum (Grain equivalent conversions),
X_1=Farm size (in hectares),
X_2=Seed (Grain equivalent conversions),
X_3=Agro Chemicals (N),
X_4=Fertilizer (kg),
X_5=Labour (mandays),

X_6 = Other costs (These include depreciation charges on machineries, equipment, rent on land and interest charges on borrowed capital in Naira),
X_1^2 = Farm size squared,
X_2^2 = Seed squared,
X_3^2 = Agrochemical squared,
X_4^2 = Fertilizer squared,
X_5^2 = Labour squared,
X_6^2 = Other costs squared,
X_1X_2 = interaction between inputs X_1 and X_2,
X_1X_3 = interaction between inputs X_1 and X_3,
X_1X_4 = interaction between inputs X_1 and X_4,
X_1X_5 = interaction between inputs X_1 and X_5,
X_1X_6 = interaction between inputs X_1 and X_6,
X_2X_3 = interaction between inputs X_2 and X_3,
X_2X_4 = interaction between inputs X_2 and X_4,
X_2X_5 = interaction between inputs X_2 and X_5,
X_2X_6 = interaction between inputs X_2 and X_6,
X_3X_4 = interaction between inputs X_3 and X_4,
X_3X_5 = interaction between inputs X_3 and X_5
X_3X_6 = interaction between inputs X_3 and X_6,
X_4X_5 = interaction between inputs X_4 and X_5,
X_4X_6 = interaction between inputs X_4 and X_6,
X_5X_6 = interaction between inputsX_5 and X_6,
β_0= Intercept/constant term,
β_1 - β_6= inputs parameters to be estimated,
V_i = Normal random errors assumed to be independently and identically distributed having $N \sim (0, \delta^2)$ and U_i = Non-negative (zero mean and constants variance) random variables called technical inefficiency effect associated with technical efficiency of the i[th] farmer Uij's are the technical inefficiency effects which are assumed to be independent of V_{ij}'s such that U_{ij}'s is the non-negative truncation (at zero) of the normal distribution with mean U_i and variance $\delta^2 v$ where U_i is defined as:

$$-U_i = \delta_0 + \delta_{1i}Z_1 + \delta_{2i}Z_2 + \delta_{3i}Z_3 + \delta_{4i}Z_4 + \delta_{5i}Z_5 + \delta_{6i}Z_6 + \delta_{7i}Z_7 + \delta_{8i}Z_8 + \delta_{9i}Z_9 + \delta_{10i}Z_{10} + \delta_{11i}Z_{11} + \delta_{12i}Z_{12}$$

$-U_i$ = Technical inefficiency of the i[th] farmer,
Z_1 = Age of the farmer (in years),
Z_2 = Level of education (in years),
Z_3 = Household size (number),
Z_4 = Farming experience (in years),
Z_5 = Extension contact (Number of times visited by extension agents during the cropping season),
Z_6 = Gender (male = 1, female = 0),
Z_7 = Access to credit (Amount of credit received in Naira),
Z_8 = Membership of co-operation society (1 if farmer is a member of any Co-operative Society, 0 if otherwise),
Z_9 = Risk attitude (risk averse coefficients),
Z_{10} = Herbicide usage (quantity in liters),
Z_{11} = Level of involvement of the farmer (1 if full time; 0 if otherwise),
Z_{12} = Distance from house stead to the farm (Km) and
δ_1 - δ_{11} = Unknown parameters to be estimated.

The parameters of the translog stochastic frontier production function were estimated by the method of maximum likelihood using the computer Programme FRONTIER version 4.1 (Coelli, 1995).

The effect of technical inefficiency in the variation of output were determined by drawing a relationship for the inefficiency index to that of general error as follows:

$$\gamma = \frac{\lambda^2}{1+\lambda^2}$$

Where γ = Inefficiency index and has a value between 0 and 1.
λ = General error

Data Envelopment Analysis

Unlike the SFPF, the DEA model can breakdown or decompose the total technical efficiency (TE) into two, namely: pure technical efficiency and scale technical efficiency. To obtain the TE scores, data are fitted to a constant returns to scale (CRS) DEA and a variables returns to scale (VRS) DEA. The TE scores obtained from CRS, DEA are called total technical efficiency while those from VRS DEA are referred to as pure TE.

Scale efficiency (SE) for the individual

Decision Making Unit (DMU's), can be computed using the formula:

$$SE = \frac{TECRS}{TEVRS}$$

Whereby, if SE = 1 it stipulates scale efficiency or constant returns to scale while if SE < 1 it indicates scale inefficiency.

The general problem is specified as:

$$Max\ TE = \sum_r U_r Y_{ro} / \sum_i V_i X_{io}$$

Subject to:

$$\sum_r U_r Y_{rj} / \sum_i V_i X_{ij} \leq 1 \text{ for } i = 1, 2, \ldots,$$

$$m, J = 1, 2, \ldots, n \text{ and } r = 1, 2, \ldots, s$$

$$U_r, V_i \geq 0 \text{ for all } i \text{ and } r$$

Where:

X_{ij} and Y_{rj} are the quantities of the i[th] input and r[th] output of the j[th] firm

Y_{rj} = Vector of output of farmers (kg)

To isolate the determinants of TE, the scale efficiencies obtained from the ratio of the TECRS and TECVRS will be regressed against the vector of inefficiency factors. The DEA model to be specified is adopted as

$$Max\ TE = \frac{\sum_{r=1}^{s} \alpha_r Y_{ro}}{\sum_{r=1}^{m} \beta_i X_{io}} = \frac{q}{q^*}$$

Subject to:

$$\frac{\sum_{r=1}^{s} \alpha_r Y_{rj}}{\sum_{r=1}^{m} \beta_i X_{ij}} \leq i, j = 1, \ldots, n, \ldots;$$

$$\alpha_r, \beta_i \geq 0, r = 1, \ldots, s, i - 1, \ldots, m$$

Where X_{ij} and Y_{rj} are are the quantities of i[th] input and r[th] output respectively of the j[th] firm and $\beta_i \geq 0$ are the variable weights to be determined by the solution to this problem. Thus, if TE = 1, then it is perfectly efficient. The vector X_{ij}'s, are explicitly presented as

Y = Output of maize and sorghum (Grain equivalent conversions),

X_1 = Farm size (in hectares),

X_2 = Seed (Grain equivalent conversions),

X_3 = Agro Chemicals (N),

X_4 = Fertilizer (kg),

X_5 = Labour (mandays) and

X_6 = Other costs (These include depreciation charges on machineries, equipment's rent on land and interest charges on borrowed capital in Naira).

RESULTS AND DISCUSSION

Results in Table 1 show that a large proportion of the respondents in Kaduna State (65%) were between the ages of 31-50years with a mean age of 38. This result agrees with the findings of Abang *et. al* (2001), Chukwuji *et al.*, (2007), Tanko and Jirgi (2008) Nmadu *et al.*,(2012) and Ojo (2013), which all indicated that famers within this age bracket are more amenable to new ideas and are risk bearing. In addition, they are strong enough to carry out the rigorous nature of farming activities.

Famers above 50years constituted about 10.5% for Kaduna State. These categories of famers are not strong enough to carry out tasking farm operations. In addition, older farmers are usually more risk-averse especially as it appertains investment decisions.

Results in Table 1 also show that 86.8% are males while only 13.2% are females. These results conform with *a -priori* expectation that males tend to be far more than females in any agricultural production enterprise due to the tedious nature of farming activities. On the other hand, the low percentage of females involved in farming could be due to the nature of faming activities that women hardly cope with. Women are however, responsible for processing most of the farm produce, and in some cases, were involved in other farming activities like planting, harvesting and fertilizer application which is assumed to be less tedious. According to Dhehibi *et al* (2007), male farmers are more risk-bearing than their female counterpart especially in the adoption of new technology due to their level of involvement and experience in farming with could go a long way in increasing their production efficiency

Table 1 also show the distribution of respondents according to their marital status. The results indicate that majority of the respondents sampled in Kaduna State (74.3%) were married. This may be one of the reasons why respondents had large household sizes with a mean household size of 7 persons. The preponderance of married farmers in the study area could translate into availability of family labour as opposed to other respondents who are either single, divorced or separated. In addition, marriage comes with responsibilities hence, the respondents that are married will be more willing to take risk that comes with adopting new technology and management strategies in other to increase their yield.

Table 1: Socio-economic characteristics of respondents

Variables	Kaduna State (n=303) Frequency & Percentage
Age (years)	
Less than 31	74(24.4)
31-40	116(38.3)
41-50	81(26.7)
51-60	28(9.3)
Greater than 60	4(1.3)
Total	303 (100.0)
Mean	38
Gender	
Male	263(86.8)
Female	40(13.2)
Total	303 (100.0)
Marital Statues	
Single	44(14.5)
Married	225(74.3)
Divorced	14(4.6)
Separated	4(1.3)
Widow (er)	16.(5.3)
Total	303 (100.0)

Source: field survey, 2017 (Numbers in parenthesis represents the corresponding percentages)

Summary Statistics of the Variables Included in the SFA and DEA Models in the Study Area

The summary statistics of the variables included in the econometric models to analyze efficiency are presented in Tables 2. Results show that the mean output of a typical farmer in Kaduna, were 3008.13, grain equivalent. The outputs of maize and sorghum which were measured in physical terms were combined using the grain equivalent conversion table to bring their weights at par. The average farm size for the respondents was 3.57ha, usually on several plots in scattered locations. An average farmer utilized 240.92, mandays of labour per annum indicating that the respondents in the study area relied heavily on human labour to accomplish most of their farm operations.

A typical farmer utilized 131.4kg of fertilizer. These findings seem to exemplify the nature of small scale farming which dominates production in Nigeria. (Tanko, 2003; Shehu and Mshelia, 2007)

Table 2: Summary statistics of the variables included in the SFA and DEA in Kaduna state

Variables	Minimum	Maximum	Mean	Standard deviation
Output (grain equivalent)	300.00	14760.00	3008.13	1980.80
Farm size	0.70	16.00	3.57.00	4.53
Seeds	0.98	121.00	23.08	17.09
Agro chemical	1500.00	31500.00	5671.21	1421.10
Fertilizers	25.00	7001.00	131.40	402.09
Labour	16.50	462.00	240.92	82.84
Depreciation	1000.00	18466.67	4444.54	2766.38
Age	20.00	62.00	38.52	8.63
Formal education	0.00	16.00	8.89	5.38
Household size	1.00	28.00	6.23	4.08
Farming experience	3.00	40.00	15.84	8.07
Extension contact	0.00	12.00	0.47	1.18

Source: Computer Printout of Frontier Version 4.1/Field Survey, 2017

Transcendental Logarithmic Stochastic Frontier Estimation for Technical Efficiency

Results in Table 3 show that the estimated sigma square was 0.26, and was significant at 0.01 probability levels. This indicates a good fit and correctness of the specified distributional assumptions of composite error term. Results further shows that the variance ratio defined as $\gamma = \delta\ u^2 / (\delta u^2 + \delta_v^2)$) that is gamma is estimated to be as high as 97.7%,. This suggest that systematic influence that are unexplained by the production function are the dominant sources of random errors. In other words, 97.7% of the variations in the output off the farmers in Kaduna State, were due to differences in their technical inefficiencies.

Table 3 further show the maximum likelihood estimates for the factors affecting maize and sorghum in the study area. The result shows that farm size and seed were both positive and statistically significant at 0.01 probability levels. This implies that an increase in these inputs led to a proportionate increase in the output level. In addition, the squared term for seed was statistical significant at 0.01 probability level but has a negative sign, meaning that if seeds used are in turn squared it will lead to a decrease in output. The joint effect of farm size and seeds was negatively significant at 0.01 probability level. This implies that there will be a decrease in output level when farm size and seeds used are increase by 1 unit.

Sources of technical inefficiency in the study area

The sources of inefficiency were examined using the estimated coefficient associated with the inefficiency factors in Table 4. The estimated coefficient of the inefficiency function provides some explanation for the efficiency levels among individual farmers. According to Omotosho*et.al* (2008), Ojo*et.al* (2009) and Nganga *et al.,* (2010), since the dependent variable of the inefficiency function represents the mode of inefficiency, a positive sign of an estimated parameter implies that the associated variable has a negative effect on efficiency and a negative sign indicates the opposite.

Table 4 show that level of education, farming experience, gender and membership of cooperative society carried negative signs of -0.146, -0.149, -0.428 and -0.781 respectively and were all significant at 0.01 probability levels. The negative sign of the level of education implies that farmer who had one form of formal education or the other tend to be more efficient in maize and sorghum production due to enhanced technical competence which enables them to produce close to the frontier level. Farming experience was also negatively related to technical inefficiency. This is in conformity with *a-priori* expectation that the more experience a farmer has, the more technically efficient he becomes. Chinwa (2007), Omotosho*et.al* (2008), Tanko and Jirgi (2008), Wautabouna (2012) all found a positive relationship between farming experience and efficiency. The coefficient of membership of cooperative society was found to be negative and significant at 1% level. This implies that farmer's membership of association affords them the opportunity to interact with others thereby exchanging information on improved technology in maize and sorghum production. Cooperative societies provide benefits to members. They also serve as vehicles via which implementation of agricultural policies are made more effective.

Estimated elasticities of factor inputs and returns to scale

Results in Table 5 show a return to scale of 0.555, for Maize and sorghum production in Kaduna. This implies that the Maize and Sorghum farmers across location of study were operating at decreasing positive return to scale level. In other words, they are operating at stage II of the production region.

Frequency distribution of technical efficiency scores obtained with SFA model for maize and sorghum production in the study area

Table 6 indicates the technical efficiency of maize and sorghum farmers in the study area which ranges from 0.17 - 0.95 indicating that a wide gap exists between the efficiency of the best technically efficient farmers and that of average ones. The mean technical efficiency is 0.72. This implies that an average farmer in Kaduna State, were able to obtain about 72%, of potential output from a given mix of productive inputs. The results therefore indicated that, although farmers were generally relatively efficient, they still produced below the frontier levels. They however, still have room to increase the efficiency in their farming activities as about 28%, efficiency gap from optimum (100%) was yet to be attained by a typical farmer in the study area.

Table 3: Maximum likelihood estimates obtained in the estimation of technical efficiency using stochastic frontier translog model.

Variables	Kaduna State (N=303) Coefficients	T-Values
Constant	7.39	23.88***
Farm Size	0.56	4.59***
Seed	0.001	8.13***
Agro Chemical	-0.008	-0.44
Fertilizer	3.51e-04	0.41
Labour	0.002	0.88
Other cost	-1.10e-04	-0.67
Farm Size Squared	-0.052	-0.56
Seed Squared	-1.3e-07	-3.68***
Agro Chemical Squared	8.30e-04	0.95
Fertilizer Squared	-3.40e-07	-0.14
Labour Squared	-5.00e-06	-0.86
Other cost Squared	8.80e-08	1.14
Farm Size x Seed	-8.00e-04	-2.93***
Farm Size x Agrochemical	-4.70e-03	-1.47
Farm Size x Fertilizer	7.60e-05	0.43
Farm Size x Labour	-9.60e-05	-0.30
Farm Size x Other Cost	1.90e-06	0.05
Seed x Agrochemical	-4.50e-06	-1.23
Seed x Fertiliser	-7.00e-08	-0.45
Seed x Labour	-2.00e-07	-0.67
Seed x Other cost	2.90e-08	0.71
Agrochemical x Fertilizer	2.20e-05	0.88
Agrochemical x Labour	1.00e-05	0.21
Agrochemical x Other cost	-5.10e-06	-1.04
Fertilizer x Labour	4.30e-07	0.20
Fertilizer x Other cost	-1.80e-07	-0.87

Table 4: Determinants of technical inefficiency from the translog stochastic frontier

Variables	Parameters	Kaduna State Coefficients	T-Values
Constant	??$_0$	-5.68	-0.55
Age of farmer	??$_1$	7.34	0.80
Level of education	??$_2$	0.15	7.33***
Household size	??$_3$	3.78	0.40
Farming experience	??$_4$	-0.15	-7.79***
Extension contact	??$_5$	0.34	0.66
Gender	??$_6$	-0.42	-3.42***
Access to credit	??$_7$	1056.95	0.69
Membership of cooperative	??$_8$	-0.78	-7.27***
Risk attitude	??$_9$	-8.51	-0.39
Herbicide usage	??$_{10}$	35.50	0.04
Level of involvement	??$_{11}$	1.42	0.69
Distance to farm	??$_{12}$	-0.14	-0.59

Source: Computer Printout of Frontier Version 4.1/Field Survey, 2017

*, **, *** are significant levels at 10%, 5% and 1% respectively.

Table 5: Estimated elasticities of factor inputs and return to scale

Valuables	Kaduna
Farm Size	0.56
Seed	1.00e-03
Agro Chemical	-7.80e-03
Fertilizer	3.50e-04
Labour	1.60e-03
Other cost	-1.10e-04
Total	0.56

Source: Computer Printout of Frontier Version 4.1/Field Survey, 2017

Table 6: Frequency distribution of technical efficiency scores obtained with SFA model for maize and sorghum production in the study area

	Kaduna State (N=303)	
Efficiency Class Index	Frequency and Percentages	T-Values
0.10-0.20	2	0.67
0.21-0.30	12	3.96
0.31-0.40	10	3.30
0.41-0.50	14	4.62
0.51-0.60	26	8.58
0.61-0.70	41	13.53
0.71-0.80	66	21.78
0.81-0.90	118	38.94
0.91-0.100	14	4.62
Mean	0.72	
Minimum	0.17	
Maximum	0.95	

Source: Computer Printout of Frontier Version 4.1/Field Survey, 2017

Distribution of respondents according to their level of technical efficiency using the DEA

Results in Table 7 show that the distribution of technical efficiency using DEA was 0.38-1.00. This implies that a wide gap exists between the efficiency of the best technically efficient farmers and that of an average farmer. The average technical efficiency was 0.86. This is quite higher than that obtained using the SFA models. This may be due to absent of the inefficiency factors in the DEA model which do not take care of the error terms.

Table 7: Frequency distribution of technical efficiency scores obtained using the DEA model for maize and sorghum production in the study area

	Kaduna State (N=303)	
Efficiency Class Index	**Frequency and Percentages**	**T-Values**
0.31-0.40	3	0.99
0.41-0.50	17	5.61
0.51-0.60	26	8.58
0.61-0.70	28	9.24
0.71-0.80	29	9.57
0.81-0.90	17	5.61
0.91-0.100	183	60.40
Mean	0.86	
Minimum	0.38	
Maximum	1.00	

Source: Computer Printout of Frontier Version 4.1/Field Survey, 2017

Distribution of respondents according to CRS, VRS and SE obtained from the DEA model

Results in Table 8 show that the mean total technical efficiency is 0.78, implying that the farmers would have to reduce their level of inputs by 22%, if they were to operate at frontier level. Decomposing the total technical efficiency reveled that on average, the sampled farmers were more scaled efficient than they are technical efficient with the mean scale efficiency of 0.82, The mean pure technical efficiency are 0.95, which has the lowest score of 0.59, and a highest score of 1.00

Table 8: Distribution of respondents according to CRS, VRS and SE

	Mean	Maximum	Minimum
Kaduna State			
Constant returns to scale	0.78	1.00	0.26
Variable returns to scale	0.95	1.00	0.59
Scale efficiency	0.82	1.00	0.35

Source: Computer Printout of Frontier Version 4.1/Field Survey, 2017

Hypothesis

The Z-test results for the comparison of means for technical, efficiency of maize and sorghum production between the DEA and the SFA models are presented in Table 9.

Results show that there was a significant difference at 0.01 probability levels for the technical efficiency scores obtained from the two models used. The null hypothesis is hereby rejected. From the results obtained, it can be concluded that the parametric and non-parametric methods of determining efficiency show some level of variation in the distribution pattern of technical economic and allocative efficiency.

Table 9: comparison of means for technical, allocative and profit efficiency

Efficiency	Variable	Obs	Means	Std Err	Std Dev.	(95% Conf. Interval)	
Technical	DEA	398	0.673	0.009	0.188	0.654	0.691
	SFA	398	0.883	0.009	0.177	0.866	0.900
	Diff.	398	0.210	0.121	0.242	0.234	0.186
	Mean Diff.		0.00	0.00	0.00	0.00	11.177***

Source: Field Survey, 2017. *** = 1% significant level

Conclusion and recommendations

The study showed that the respondents in Kaduna State were small scale farmers. In addition, the study revealed that maize and sorghum farmers were not fully technically efficient. There is a scope for raising the level of technical efficiency of the maize and sorghum farmers in the study area in particular and Nigeria in general to attain its full potential.

In light of the findings from this study, the following recommendations have been put forward;

1. Since education is one of the important variables that positively influenced technical efficiency, farmers should be encouraged to acquire some level of formal education by enrolling for adult education. This will go a long way to improve their farm production efficiency, profitability and awareness about production risk.
2. Membership of cooperative societies was also found to be positively significant to technical efficiency in this study. Hence, in other to expand scale of production and also get regular useful information on modern global best practices in maize and sorghum production, farmers in the study area should be encouraged to form/join cooperative societies.
3. The two methods of determining production efficiency used showed some level of variations in the distribution pattern of technical, economic and allocative efficiency in this study, it is therefore recommended that both SFA and DEA should be used in determining efficiency scores, giving the importance of accurate production efficiency estimates in policy decision making.

REFERENCES

Abubakar, H (2000). "Maize as Source of Starch for Food and Phamaceutical". In: Valencia, J.A; Falaki, A.M.; Miko, S, and Ado, S.G. (eds). Sustainable Maize Production in Nigeria: The Challenges in the Coming Millennium. *Proceedings of the National Maize Production Workshop.* 22nd -24th July, 2000. Held at Ahmadu Bello University, Zaria, Kaduna State. Pp 152-188.

Aji, D.A (2012). Profitability and Efficiency of Broiler and Layer Production Enterprises in Niger State, Nigeria. Unpublished MS.c Thesis, Department of Agricultural Economics and Extension Technology, Federal University of Technology Minna, Niger State Nigeria. Pp 37-40

Bravo-Ureta, B.E & A.E, Pinheiro (1997). Technical Economic and Allocative Efficiency in Present Farming. *Evidence from the Dominical Republic the Developing Economy. 35(1):48-67.*

Chukwuji, C.O.; Inoni, O.E.; Ogisi, O.D &Oyaide W.J. (2006).A Quantitative Determination of Allocative Efficiency in Broiler Production in Delta State, Nigeria.*Agriculture Conspectus Scientificus*. 71:21-26

Dhehibi, B., Lachaal, L. Elloumil, M. & E.B. Messaoudi (2007). Measurement and Science of Technical Inefficiency in Tunisian Citrus Growing Sector. Paper Prepared for Presentation at the Mediterranean Conference of Agro-Food Sequel Scientist 103rd EAAE Seminar "Adding Value to the Agro-Food Supply Chain in the Future Euro-Mediterranean Space, Bacelona Spain April 23rd – 25th, 2007.

Joe, S.W (2005). Empirical Analysis of Swamp Rice Production Function in Ini

Local Government Area of Akwa-Ibom State, Nigeria.Unpublished Ph.D Dissertation, Department of Agricultural Economics and Extension Technology, University of Calabar, Nigeria. Pp. 82

Musa, Y.H.I.; I.I Onu.; J.I, Vasanka& A.I, Anoguku (2011) Production Efficiency of yam in zing Local Government Area of Taraba State, Nigeria.*January Agriculture and Forestry. 31 (2):372-378.*

National Population Commission (2006). Nigeria News, Census 2006.Retrieved 16th April 2015. www.nigenonnews.com/letter/htm

Nmadu, J.N.; Ogidan, I.O.&R.A.Omolehin (2014). Profitability and Resources use Efficiency of Poultry Egg Production in Abuja, Nigeria. *Kasetsart Journal (Social Science) 35:134-146.*

Ogaji, A.; Tanko, L & R.A.Omolehin (2012) Analysis of Farm Level Technical Efficiency in Maize Production inKogi State Nigeria. A Stochastic Frontier Approach. Journal of Agriculture and Agricultural Technology 3 (1):1-6

Ojo, M.A. (2013). Analysis of Production Efficiencyamong Small Scale yam and cassava farmers in Niger State and Kogi States, Nigerian.Unpublished Ph.D thesis, Department of Agricultural Economic and Extension Technology, federal University of Technology Minna, Niger State. Nigeria Pp60-75.

Okonkwo, N.C (2015). Analysis of the Production Efficiency of Small Scale Broiler Production in the Federal Capital Territory, Abuja, Nigeria. Unpublished M. Tech thesis, Department of Agricultural Economics and Extension Technology, Federal University of Technology Minna. Pp 26-30.

Onia, M.O. (2005). Economics of Small Scale Rice farming in Obubra Local Government Area of Cross River State. Unpublished M.sc Thesis, Department of Agricultural Economics and Extension, University of Calabar. Pp. 54-55

Onoja, M.M, (2001). Resource Use Efficiency of Small Scale Maize Production in Idah Local Government Area of Kogi State.Unpublished B.Sc Thesis, Department of Agricultural Economic and Extension, Kogi State University Anyigba, Kogi State, Nigeria.Pp 19-22.

Onus, J. J.; Amaza, P.S & F.Y Okunmadewa (2000) Determinants of Cotton Production in Nigeria. *Journal of Economic Efficiency in business and Economic Research* 1 (2): 35- 40

Shehu, J.F.& S.I.Mshelia (2007). Productivity and Technical Efficiency of Small Scale Rice Farmers in Adamawa State. *Journal of Agricultural and Social Science.* 3(4): 117-120.

Tanko, L & A.J. Jirgi (2008). Agricultural Credit and Relative Production Efficiency inSoghum Based Cropping Enterprise InKebbi State, Nigeria *Journal of Research on Agricultural* 2: 39-45

Tanko, L (2003): Technical Efficiency in Arable Crop Production in Kebbi State. *Nigeria Journal of Agriculture and Food Science 3(2):165-174*