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Measuring the Production Efficiency of Food crop farmers in Rivers State, Nigeria: Data Envelopment Analysis (DEA) Approach.

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Abstract

This study examines the technical efficiency (TE) of food crop farmers in River state, Nigeria using data envelopment approach (DEA) and ordinary least square (OLS) regression. A multi-stage sampling procedure was used to select respondents for the study. The data for the study were collected using structured questionnaires from crop farmers. One hundred and forty (140 farmers comprising of 67 male and 73 females) were sampled for the study. Majority of the farmers were not technically efficient with mean technical efficiency being 0.94. The mean input slack for farm size, fertilizer, hired labour, capital, planting stock and family labour 3.1 %, 2.7 %, 19.2 %, 1.2 %, 5.3 % and 3.8 %, respectively. Gender was significant and had positive effect on TE at 5% while membership of association and year of schooling negatively affected efficiency at 5 % and 10 %, respectively. The study concluded that majority of the farmers are not technically efficient and should be assisted with resources and relevant education that will help them to increase their efficiency.

Keywords: *Data envelopment analysis, food crop farmers, resource use, technical efficiency.*

1.0 Introduction

In spite of the overwhelming dominance of the oil sector in foreign exchange earnings and government revenue, and the rapid industrial drive embarked upon by successive governments, Nigeria remains an agrarian country (Federal Ministry of Agriculture and Rural Development (FMARD), 2012). Like most non-industrialized countries, agriculture is the dominant sector of the Nigerian economy employing about 65 percent of the population as at 2010 (National Bureau of Statistics (NBS), 2012; Central Bank of Nigeria (CBN), 2012). Food production is a major preoccupation of the rural populace in the developing countries and despite the number of people involved in farming, food production cannot meet the need of the people; hence there is large importation of food to bridge the gap between demand and supply. To date, agricultural production in most developing nations, Nigeria inclusive, has not only failed to provide adequate food requirement for the fast growing population but also drastically falls short of the domestic and industrial needs (Falusi, 1999). Thus, in-spite of the potentialities and prospects of producing food for home consumption and export, producing enough food to meet the needs of the teeming population appears elusive.

Food production in Nigeria has not increased at the rate that can meet the increasing population. While food production increases at the rate of 2.5 %, food demand increases at a rate of more than 3.5 % due to high rate of population growth of 2.83 % (CBN, 2012). The apparent disparity between the rate of food production and demand for food in Nigeria has led to increasing resort to food importation and high rates of increase in food prices.Failure to achieve the objective of increased food production could be traced to such problems as faulty planning and implementation, non-availability or inadequacy of inputs, which have truncated the goals of various food production programmes. Food production in Nigeria is faced with a lot of challenges among which are limited and inadequate farm resources (inputs). Unlike in the developed countries, farming is still carried out with crude implements coupled with limited farm resources leading to poor yield and returns. This has largely affected the production efficiency of most farmers (Idumah, 2006).

Efficiency is concerned with relative performance of the processes used in transforming given inputs into output (Ohajianya & Onyenweaku, 2001) Production efficiency means attainment of production goal without waste (Ajibefun & Daramola, 2003). An increase in efficiency would lead to an improvement of the welfare of the farmers and consequently a reduction in their poverty level and food insecurity (Effiong, 2004). To increase the efficiency of the farm, owners require a good knowledge of the variation of the current level of efficiency in various farm enterprises. This will provide success indicators and performance measure for the rapid growth in food production. More so, the ability to quantify efficiency and its joint determinants provide the decision makers with a control mechanism that will help to monitor the performance of the farm enterprise (Ojo *et al*., 2012). It also provides the means and ideas of improving the performance of the farm enterprise.

The study of efficiency is a significant area of research especially in developing economies like Nigeria where resources are meager and opportunities for developing and adopting better technology are dwindling (Udoh, 2000). Measurement of efficient use of technology otherwise called technical efficiency is very important for the study and analysis of productivity growth. Such studies ascertain the extent to which it is possible to increase productivity by improving efficiency with the present resource base and the available technology. Thiswould also assist them to decide whether to improve efficiency first or develop a new technology in the short run.

Various studies such as Ogundari & Ojo, (2007) and Oredipe & Akinwumi, (2000) have reported that there are shortfalls in the efficiency of resource use in this country. This means that output can be increased without new technology. There is therefore, the need to determine the level of the efficiency shortfall so as to determine the magnitude of the gains that could be obtained by improving performance in agricultural production with a given technology. To do this, it is necessary to investigate the socio-economic factors of the farmers that affect the efficiency of food production and determine the opportunities for increasing farm outputs. This study is aimed at examining the production efficiency of food crop farmers in River state, Nigeria and to provide answers to the following questions:

i. Are food crop farmers efficient in the use of farm resources?

ii. What are the factors influencing the TE of food crop farmers in the study area?

iii. What are the socio-economic characteristics of farmers in the area?

The objectives of this study therefore are to examine the socioeconomic characteristics of farmers in the study; estimate the efficiency score of the decision making units (DMUs) and to classify them into efficient and inefficient categories; determine the efficiency of the farmers as well as investigate the factors influencing the efficiency of farmers in the study area.

1.1 Theoretical framework

Several techniques have been developed for the measurement of efficiency of production. These techniques can be broadly categorized into two approaches: parametric and non parametric. Under the parametric technique we have deterministic parametric frontier (Afriat, 1972) and stochastic parametric frontier (Aigner, *et al*., 1977). Under the non-parametric approach, data envelopment analysis (DEA) is used to derive technical, scale, allocative and economic efficiency measures (Charnes, *et al*.; 1978, Fare *et al*., 1985, 1994).

1.2 Concept of DEA

This is a non- parametric method of measuring efficiency initiated by Charnes, *et al*., (1978). Data Envelopment Analysis [DEA] is an alternative non- parametric method of measuring efficiency that uses mathematical programming rather than regression. Here, one circumvents the problem of specifying an explicit form of the production function and makes only a minimum number of assumptions about the underlying technology (Yusuf & Malomo, 2007). According to Ojo, *et al*.,(2013), DEA uses mathematical programming techniques to find the set of weight for each firm X_1, X_2, X_K that maximizes its efficiency score greater than 100 % at those weight. DEA builds an `envelop' of observations that are most efficient at each sets of weights. A firm can be shown to be inefficient if it is less than another firm at the set of weights that maximize its relative efficiency. For an efficient firm at least one other firm will be more efficient (Ojo, *et al*., 2013).

A DEA model not only allows the weights attached to each performance indicator to vary across firm, it is also able to accommodate non-linear relationship between cost and outputs i.e. variable return to scale (VRS).

1.3 DEA Estimation

The theoretical definition of a production function has been based on expressing the maximum amount of output obtainable from given bundles of inputs. This definition assumes that technical efficiency is absent from the production function. Following Sharma, *et al*., (1999), consider the situation with *n* firms or decision-making units (DMUs) each producing a single output by using m different inputs. Here *Yi* is the output produced and *Xi* is the (M x1) vector of output and *Xi* is the (m x n) matrix of input of all DMUs in the sample. *Wi* is the (m x 1) vector of input prices for the i^{th} DMU. The technical efficiency (TE) measure under constant return to scale (CRS) also called the `overall' TE measure is obtained by solving the following DEA model.

$$\min_{\theta i CR\lambda} \theta i^{CRS} \qquad (1)$$

Subject to $Yi < Y\lambda$

$$\theta i^{CRS} Xi > X\lambda$$

$$\lambda > 0$$

where θi^{CRS} is a TE measure of the i^{th} DMU under CRS and λ is an n x 1 vector of weights attached to each efficient DMU.

A separate linear programming (LP) problem is solved to obtain the TE for each of the n DMU in the sample. If θi^{CRS} =1, the DMU is on the frontier and is technically efficient under CRS. If θi^{CRS} <1, then the DMU lies below the frontier and is technically inefficient.

2.0 Materials and Methodology

2.1 Area of study

The study was conducted in River State of Nigeria. Rivers State occupies an area of 19416km and lies between latitude 4°.17'S and 5°.45'N and longitude 5°22'W to 7°.35'E. It is bounded in the North by Imo State, Bayelsa and Delta State in the West and Akwa-Ibom in the East. Its shores form part of the West African coastlines with one-thirds of its lying within the Niger Delta Basin. The 1992 population census figure was put at 2.0 million (NPC, 2000). Three major vegetation types characterize the area: mangrove and swamp forests to the south and to the north are a thick forest with arable lands. Rainfall is heavy throughout the year but decreases towards the north. Agriculture and fishing dominate the local economy of the Rivers people. Crops commonly grown include yam, cocoyam, maize, cassava, plantain, banana, oil palm, and vegetables. Administratively, the state consists of 23 Local Government Areas (LGAs). The state contains a large deposit of crude oil where major exploration takes place (Ashimolowo, 2012). Oil exploration activities in the area have made the area vulnerable to incessant oil spills which pose threats to land and water resources.

2.2 Sampling procedure and data

A multi stage sampling procedure was used to draw respondents for the study. In the first stage, 2 LGAs were purposively selected from the upland area of the state based on their involvement on food crops production. These were Ahoada and Gokana. In the second stage, 12 and 10 villages were selected from Ahoada and Gokana using proportionate sampling technique. In the final stage, 10 farmers were selected from each village using a simple random sampling technique making a total of 220 respondents. A total of 220 questionnaires were administered out of which 140 were found suitable for the final analysis. Data were collected on the socioeconomic characteristics of the respondents such as age, farm size, year of schooling and inputs-output variables as well as the major crops produced.

2.3Analytical techniques

Data collected were subjected to both descriptive, Data Envelopment Analysis and inferential statistics. The descriptive statistics used included percentages, mean and standard deviation.

2.3.1 Empirical Model Estimation

Data Envelopment Analysis (DEA) is a relative measure of efficiency where the general problem is given as

$$Max\ TE = \frac{\sum_{r=1}^{n} \alpha r y i}{\sum_{r=1}^{s} \beta i x i} = \frac{q}{q*} \qquad 2$$

$$\frac{\sum_{r=i}^{s} a r Y r j}{\sum_{r=i}^{m} \beta i X i j} \leq 1,\ j = 1\text{-----}n$$

αr, $\beta i \geq 0$; r=1,------,s; I =1,----,m

where Xij and Yrj are the quantities of the i^{th} input and r^{th} output respectively of the jth firm

αr, $\beta i \geq 0$ are the variable weights to be determined. The variables of Data Envelopment Analysis (DEA) model include:-

Yrj = Vector of output including yams, cassava and maize

$Xijs$ = Vector of inputs - these include:-

X_1 = Farm size (Ha)

X_2 = Family labour (man-days)

X_3 = Hired labour (man-days)

X_4 = Planting materials (Kg)

X_5 = Fertilizer (kg)

2.3.2 Regression Analysis

Farmers' specific characteristics including household size, years of schooling, farming experience, membership of an association and gender were modeled as determinants of efficiency to understand how these characteristics influence the level of efficiency of the farmers. The Regression model used is as follows:-

$\mu = f(Z_1\ Z_2\ Z_3\ Z_4\ Z_5)$. 3

where

μ = TE (derived from DEA model)

Z_1 = Household size

Z_2 = Farming experience

Z_3 = Years of schooling (Years)

Z_4= Membership of Association (Dummy variable, Yes =1, otherwise =0)

Z_5 = Gender (Dummy Variable, male = 1, female = 0)

Descriptions of variables and their expected signs: To explain the influence of some variables on efficiency level of farmers, their expected signs in their coefficients were predicted ‘a priori’.

Household size: This is the total number of people living together in a house, feeding from the same pot. It is expected to have a negative influence on efficiency. Okike (2000) confirmed the negative influence of household size on farmers’ efficiency. Large family size having economic inefficiency is plausible considering the value of farm products that could have been sold but are consumed directly by the household. In a situation where the family size is large and only a small proportion of farm labour is derived from it, then the inefficiency effects are expected to be greater.

Farming experience: Studies on farming experience on efficiency have given mixed results. Farming experience could have negative or positive effect on the efficiency of the farmer. Parikh et al., (1995) reported a positive relationship between the age of the farmers (which is positively correlated with farming experience) and the efficiency of farmers in Pakistan and Ethiopia respectively. These findings stem from the fact that farmers with more years of experience and are older are likely to be more conservative and, therefore less willing to adopt new practices, thus leading to low efficiencies in production. Coelli & Battese (1996) reported negative production elasticity with respect to farming experience for farmers in two villages in India, thus suggesting that older farmers are relatively more efficient and vice-versa.

Years of schooling: Studies have shown that farmers with formal education have a great ability to adopt new technology and innovation (Bamire, *et al*., 2002). This is expected to have a positive influence on their level of efficiency. Coelli & Battese (1996) have confirmed the positive influence of education on farmers' production efficiency.

Membership of association: Studies have indicated thatmembership of an association tend to be more efficient in food crop production presumably due to their enhanced ability to acquire technical knowledge and other useful information at association level which also tend to improve their technical knowhow on food production.

Gender: Dummy variable was used to represent sex taking on the value of 1 if the farmer is a male and 0, if otherwise. This could have either a negative or positive influence as the case may be. Ajani (2000) reported a negative coefficient for gender in her normalized profit function analysis for maize and yam enterprise while Awoyemi (2000) in his gender analysis of economic efficiency reported a positive coefficient in cassava based farm holdings.

3.0 Results and Discussion

The socioeconomic characteristics of respondents in the study area are presented in Table 1. The demographic and socio economic variables considered include age, gender of farmers, household size, farm size, years of farming, level of education and marital status. The table shows that the mean age of the farmers is 48.25 ± 11.55 years showing that the farmers are relatively young, energetic and in their active age. About 63.3 % of the sampled farmers were between the age bracket of 20 -50 years. This shows that the farmers were still in their economic active age which could result in a positive effect on production. This result agrees with the findings of Ibrahim, *et al*. (2014) who observed that farmer's age has great influence on the technical efficiency of farmers in Ogun state with younger farmers producing more than the older ones plausibly because of their flexibility to new ideas and risk.
Furthermore, 82.1 % of the sampled respondents had one form of formal education or the other. This finding is in agreement with Sofoluwe, *et a*l., (2011) observed that formal education has positive influence on the acquisition and utilization of information on improved technology by the farmers as well as their adoption of innovations. Over 88 % of the respondents had above five years of farming experience thus making them to be familiar with all the challenges and opportunities associated with farming in the area.

Table 1: Socio-economic characteristics of the respondents

Variables	Frequency	Percentage (%)	Mean
Age			
0-20	0	0	
21-40	44	31.4	48.25 ± 11.55
41-60	71	50.7	
61 and above	25	17.8	
Household size			
1-5	74	52.9	5 ± 2.3
6-10	66	47.1	
11 and above	0		
Years of schooling			
0	25	17.9	
6	27	19.3	
11	33	23.6	9.07 ± 5.08
13	38	27.1	
14 and above	17	12.1	
Years of Farming			
1-5	16	11.4	
6-10	22	15.8	
11-15	30	21.4	17.62 ± 9.94
16 and above	72	51.4	
Membership of Association			
Yes	25	17.9	
No	115	82.1	
Farm size			
0-1	27	19.3	
1.1-1.5	42	30.0	1.51 ± 0.86
1.6-2.0	46	32.8	
2.1 and above	25	17.9	

Source: Field survey, 2010

3.1 Classification of farmers

Data Envelopment Analysis (DEA) result on the classification of the farmers into efficient and inefficient farmers is shown in Table 2. The result in the table showed that 10.7 % of the sampled crop farmers in the study area are operating at frontier and optimal level of production with mean TE of 1.00. This shows that 89.3 % of the farmers in the study area can still improve on their level of efficiency through allocation and utilization of available resources.

Table 2. Data Envelopment Analysis Summary of results

Classification	Sample(No of farms)	%	Mean TE
Category 1	15	10.7	1.0
Category II	125	89.3	0.896
Total	140	100	0.907

Source: Field survey: 2010

3.2 Distribution of Technical Efficiency

The distribution of the technical efficiency (see Table 3) scores shows that majority (95 %) of the farmers fall within the TE of 0.81 and 1.00. The table shows that about 48 % of the farmers are closer to the production frontier. The variation in the technical efficiency from the frontier level as revealed by the analysis implies that most farmers are not fully technically efficient in resource use. This result further suggested that there are still opportunities to increase productivity and income for the farmers through increased efficiency in resources utilization in the study area.

Table 3: Technical Efficiency Scores

Class internal of efficiency indices	Frequency	Percentage
0.00-0.70	0	
0.71-0.80	7	5
0.81-0.90	66	47.14
0.91-1.00	67	47.86

Source: Field survey, 2010

Results of inputs slacks

Slacks arise when it becomes necessary to determine whether a farm is on efficient point on the frontier so as to reduce the amount of input used and still be able to produce the same output. This is commonly referred to as input slack. Table 4 below shows the summary of inputs slacks generated from analyzed data. On the average, the input slacks for farm size, fertilizer, hired labour, capital, planting stock and family labour are 3.1 %, 2.7 %, 19.2 %, 1.2 %, 5.4 % and 3.8 % respectively. This implied that the inputs could be reduced by those units and still produces the same level of output. This implies that farmers are said to be radially inefficient in input usage of the said factors. Farmers are under-utilizing their resources. With input slack it means that more output would be produced. The farmers are not optimizing their output. From the result, capital has the least input slack meaning that capital is more efficiently utilized than other inputs while hired labour is the most under-utilized input.

Output slacks: The value for the output slack is zero showing that there are no slacks in the output, hence the outputs are optimized.

Table 4: Summary of Inputs Slacks

INPUTS	Means slacks(%)
Farm size	3.1
Fertilizer	2.7
Hired labour	19.2
Capital	1.2
Planting stock	5.4
Family labour	3.8

Source: DEA results of computed data

3.3 Factors affecting Technical Efficiency of the farmers

Some selected farmers' socioeconomic characteristics were investigated to identify the sources of technical efficiency (TE) among the farmers in the study area. These include farming experience expressed in the number of years of farming, membership of association, educational qualification, gender, household size. The results of the TE model showed that three of the variables have significant impact on the farmers' efficiency (see Table 4).

The coefficient of gender was positively signed and significant as expected. However, the coefficients of farming experience and membership of association though significant were negatively signed. The implication of the positive coefficient of gender is that men tend to be more efficient in food production than their female counterpart presumably due to the fact that farming is labour intensive and that the male farmers have access to resources than their female counterparts. This finding is also supported by Yusuf & Malomo (2007).

The coefficient of farming experience is negative. The implication is that farmers who have been farming for many years are older and conservative and so not readily willing to adopt new technologies thus resulting in low efficiency in production. This finding is supported by Parikh *et al*., (1995) who reported a negative relationship between farming experience of farmers and technical efficiency of farmers in Ethiopia and Pakistan respectively. This is also supported by Yusuf & Adenegan (2009) also reported a negative influence of farming experience by women farmers in Kwara State, Nigeria. The coefficient of membership of association is surprisingly negatively signed and significant. That means that membership of association by the farmers in the study area does not have any positive impact on their production and so does not improve their technical efficiency.

Table 4. Determinants of Farmers Technical Efficiency in Food CropProduction

Variable	Double log	t-value
Household size	0.0107425	1.39
Farming experience	0.0052079	0.87
Years of schooling	-0.0137552	-1.67***
Membership of association	-0.0685503	-3.68**
Gender	0.0140768	2.95**
Constant	1.974831	153.28*

Source: Field survey, 2010. Note: ***significant at 10 %, **significant at 5 %, * significant at 1 %

4.0 Conclusion

The study highlighted the technical efficiency of food crop farmers in Rivers state, Nigeria using the data envelopment approach. It was found that majority of the farmers (89.3 %) are not technically efficient. The study further showed that gender has positive effect on the technical efficiency of the farmers while membership of association and year of schooling had negative effect. However, the level could still be increased if farmers have equal access to farm resources e.g. labour, fertilizer and maximally utilize them. It is hereby suggested that resources like fertilizers should be provided by the government at affordable prices to the farmers to increase their productivity. Moreover, young and able body men should be encouraged to go into farming as this will go a long way to reduce youth unemployment and increase food production.

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