

**ANALYSIS OF TECHNICAL EFFICIENCY AMONG RICE FARMERS IN EBONYI
STATE OF NIGERIA: A STOCHASTIC FRONTIER APPROACH**

**CHIKEZIE, C., BENCHENDO, G. N., IBEAGWA, O. B., OSHAJI, I. O. AND O.A.
ONUZULU**

*Department of Agricultural Economics, Federal University of Technology Owerri, Imo State,
Nigeria*

Corresponding author: chykecoms@gmail.com

ABSTRACT

This paper analysed the technical efficiency of rice farmers in Ebonyi State, Nigeria. It specifically analysed the levels and determinants of technical efficiency. A multistage sampling technique was adopted for sample selection. A total of 150 well-structured questionnaires were distributed but only 91 were returned. The Cobb-Douglas production function model was used to predict the farm level technical efficiency. Results from the Cobb-Douglas Regression showed a sigma square (σ^2) of 0.06584 which was statistically significant at 1 percent. The technical efficiency scores among the rice farmers ranged from 0.012 to 1.000 with a mean of 0.350. Farm size, quantity of rice seedlings, quantity of fertilizer and quantity of agrochemical all were showed positive correlation with coefficients of 0.93511, 0.08310, 0.11200 and 0.14345 respectively while farm labour showed a negative correlation with technical efficiency. The determinants of technical inefficiency were age, household size and extension visits. This paper advocates the strengthening of existing extension system for timely sourcing of highly improved rice varieties and subsidized fertilizer. There is the need to enhance farmers' technical efficiency through adequate training on optimum input mix.

Keywords: Rice production, technical efficiency, cobb-douglas production function

<https://doi.org/10.4314/jafs.v18i1.4>

INTRODUCTION

Food is necessary for wellbeing and sustenance of life. Of all the popular crops cultivated by man, rice stands out as the most preferred food crop. It is a staple food consumed by a good number of people and nationalities across the world (Tashikalma Giroh and Ugbeshe, 2014). In the early 50s, consumer preference of many Nigerians tilted toward food crops such as cassava and cocoyam and away from rice (Project Coordinating Unit, 2001). During this period, Nigeria had the lowest per-capita annual consumption of rice in the West-African Sub-region. But from the mid-1960s, preference for rice consumption in Nigeria rose immensely (Imolehin and Wada, 2000). This was such that domestic production of rice could not meet up with the demand for the crop leading to a heightened importation which stood at 3 million metric tons as at 2008 and in the year 2018, it dropped to 1,8 million metric tons (World Atlas, 2019). In the year 2000, out of about 25 million hectares of land cultivated to various food crops, only about 6.37% was cultivated to rice. During this period, the average

national yield was 1.47 tons per hectare creating a serious gap between the supply and demand for rice (Akande, 2003).

Sequel to this, rice is of high demand in Nigeria as well as in other parts of the world especially in Asia, where it serves as the major staple food. The Federal Government of Nigeria has made numerous efforts to beef up rice production in the bid to ensure food security, improve the socio-economic welfare of small- and large-scale farmers, since rice is one of the most widely eaten staple. The Federal Government over the years introduced some programs to ensure sustained rice production and these include; the Federal Rice Research Station (FRRS), National Cereals Research Institute (NCRI), National Accelerated Food Production Program (NAFPP), Abakaliki Rice Project, Agricultural Development Program (ADP) the Presidential Rice Initiative and rural development financial/credit institutions such as the Bank of Agriculture (Longtau, (2003); Udumeze, 2018). Following these special interventions, the annual rice production in Nigeria increased from 5.5 million tons in 2015 to 7.5 million tons in 2016 (Udumeze, 2018) but still leaves significant gap of 3.8 million metric tons (United States Department of Agriculture, 2018). This seems to suggest a missing link towards achieving enhanced rice production.

Ebonyi State is one of the eight top producers of rice in Nigeria. Although the State has recorded remarkable results in rice production over the years; it is still faced with a lot of challenges. These include: reduction in water level at the end of the dry season, high cost of agrochemicals, unavailability of improved varieties, crude mode of production, cultivation of marginal of land, high cost of labor and low productivity. Salau (2013) and Ehirim *et al.*, (2016) in their studies showed a very strong relationship between productivity and level of output. According to Ehirim *et al.*, (2016), when the rate of investment in agricultural technology increases there is a corresponding increase in the rate of returns with a high production efficiency.

The efficiency of production is extremely important for output growth. It involves using existing resources in the best possible manner to produce the highest possible output for the given technological constraints (Shanmugam and Atheendar, 2006). Therefore, increasing the production efficiency of the farmers will amount not only to incremental output and profitability but also to food security in the country. Efficiency is that missing link which has remained an important subject of empirical investigation particularly in developing economies where majority of farmers are resource poor (Biam, Okorie and Nwibo, 2015). Farmers' indisposition towards the right input's combination is a very hard nut that needs to be cracked. The efficiency of a farm production unit can be measured in terms of allocative, technical and production efficiency. This paper used the stochastic frontier function approach to estimate technical efficiency and its determinants among rice farmers in Ebonyi State. The devastation caused by climate change in form of erosion and floods limits the number of plots available for cultivation. But with the technology of employing the right input combinations, efficiency can be enhanced without necessarily increasing the farm size. The justification of this study therefore is that it will guide policy makers in designing frameworks that will improve technical efficiency without increasing the land resource base.

MATERIALS AND METHODS

The study was conducted in Ebonyi State of Nigeria which lies on latitude 6.15°N and longitude 8.05°E (Okereke, 2012). The State shares boundaries with Benue State to the North, Enugu State to the West, Imo State and Abia State to the South and Cross River State to the east. According to the National Population Commission of Nigeria (2006) the population of the state sits at 2,176,947 people, with a land area of about 5,935 sq. km (National Bureau of Statistics, 2010). The main crops produced in the state are maize, rice, beans, yam, sweet potato, cassava, melon, plantain and cocoyam. The mainstay of her economy is agriculture, although it is endowed with a diverse array of solid mineral resources such as glass sand, limestone, salt lead, zinc, gypsum and granite.

A multistage sampling technique was adopted for sample selection. In the first stage, of the three agricultural zones, four Local Government Areas (LGAs) were purposively selected on the basis of their comparative advantage in rice farming. The LGAs selected were Afikpo South, Izzi and Onicha. The second stage involved the random selection of two communities from each of the LGAs giving a total of six communities. The final stage was a random selection of 40% of rice farmers from the agricultural development programme list of registered farmers. The selection produced 51 respondents from Afikpo-South LGA, 47 respondents from Izzi LGA and 52 respondents from Onicha LGA. A total of 105 of questionnaire were administered out of which 91 were returned. Data collected included those on the socio-economic characteristics of the rice farmers as well as the factors that affect their efficiency in the study area which include quantity of rice seed, fertilizer and agrochemicals, the quantity and unit prices of other farming inputs and output of rice produced.

Descriptive statistics was used to examine farmers' level of technical efficiency and factors affecting technical efficiency and technical inefficiency were analysed using the stochastic production frontier. Technical efficiency (TE) of an individual farmer is defined in terms of the ratio of the observed output (Y_i^*) to the corresponding frontier output (Y_i), conditioned on the level of inputs used by the farmer and it is shown as:

$$TE = \frac{Y_i}{Y_i^*} = \frac{f(X_i; \beta) \exp(V_i - U_i)}{f(X_i; \beta) \exp(V_i)} = \exp(-U_i)$$

Following Usman (2015); Ehirim *et al.*, (2016), stochastic production function is given by

$$Y_i = f(X_{ij}) \exp(V_i - U_j), \quad i = 1, 2, \dots, n$$

where Y_i is output of the i -th farm, X_i is the vector of input quantities used by the i -th farm, β is vector of unknown parameters to be estimated; f represents an appropriate function. The term V_i is assumed to be independent and identically distributed as $N(0, \sigma^2)$. Being asymmetric in nature it accounts for measurement errors as well as variations in outputs due to factors beyond the control of the farmer. The term U_j is a non-negative random variable

representing inefficiency in production relative to the stochastic frontier and it follows a non-negative truncated normal distribution.

The production frontier function is estimated through maximum likelihood methods. For this study, the computer programme FRONTIER version 4.1c (Coeli, 1996) was used.

The Cobb-Douglas frontier production function is specified as follows:

$$\ln Y_i = \alpha_0 + \alpha_1 \ln X_{1i} + \alpha_2 \ln X_{2i} + \alpha_3 \ln X_{3i} + \alpha_4 \ln X_{4i} + \alpha_5 \ln X_{5i} + \alpha_6 \ln X_{6i} + V_i - U_i$$

Where:

The subscript *i* indicates the *i*th farmer in the sample,

\ln = natural logarithm

Y_i = Observed individual *i*th farmer's yield of rice (kg per hectare)

X_1 = Farm Size Cultivated to Rice (hectare)

X_2 = Labor input (man-days per hectare)

X_3 = Quantity of Rice (kg per hectare)

X_4 = Quantity of fertilizers (kg per hectare)

X_5 = Quantity of other Agrochemicals (litres)

X_6 = Interest on Borrowed Capital (naira)

α_i = Parameters to be Estimated

It is expected that all the included explanatory variables, apart from cost of borrowed capital, will have a positive sign. The *a priori* expectation is stated mathematically as follows

$$X_1, X_2, X_3, X_4, X_5 > 0; X_6 < 0$$

The determinants of technical inefficiency in rice production are estimated jointly with the stochastic frontier using the specialized computer software already specified above (Frontier Version 4.1(Coelli, 1996)). The technical inefficiency is expressed as:

$$U_i = b_0 + b_1 Z_1 + b_2 Z_2 + b_3 Z_3 + b_4 Z_4 + b_5 Z_5 + b_6 Z_6 + b_7 Z_7$$

Where

U_i = Technical inefficiency as previously defined

Z_1 = Age of household head (Years)

Z_2 = Farming experience (Years)

Z_3 = Level of education (Years)

Z_4 = Access to credit (Naira)

Z_5 = Sex (dummy; 1 for Male, 2 for Female)

Z_6 = Household size (Number)

Z_7 = Extension visits (Number)

RESULTS AND DISCUSSION

3.1 Determinants of technical efficiency of rice production in Ebonyi State

Presented in Table 1 are the estimated parameters for the production function. The Table shows an estimate of the sigma square (σ^2) value of 0.06584 which is statistically significant

at 1 %. The variance ratio (Gamma) is estimated as 1.0000. However, estimates of the parameters of the stochastic frontier production model revealed that all the estimated coefficients of the variables of the production function were positive except for farm labor. The positive coefficients of farm size, quantity of rice seedlings, quantity of fertilizer and quantity of agrochemical were in line with the *a priori* expectations. While farm size and labour were significant at 1 %, quantity of fertilizer and agroforestry were significant at 5%. The result further shows that as farm size and quantity of fertilizer increased by 1 unit each, the output of rice increased by 0.93511 and 0.11200 units respectively. As additional unit of agrochemical were applied, the rice output increased by 0.14345 units. This finding on the quantity of fertilizer applied is in consonance with Usman (2015) who found a strong positive correlation between fertilizer used and output of rice. This is true because fertilizers play a catalyst role in food production as suggested by Ehirim *et al.*, (2016). This result on the less proportionate increase of rice output by 0.11200 units also suggest the need to include organic manure in order to reduce cost of production and abate environmental hazards. Agrochemical on the other hand suppresses weeds and pests thereby boosting rice production. Against the *a priori* expectation, labour was negatively signed. The negative coefficients of farm labor (-0.24370) shows that as farmers labor is increased by one unit, output decreases by the above stated value.

3.2 Levels of technical efficiency in Rice production in Ebonyi State

The result of the frequency distribution of Technical efficiency estimates is presented in Table 2. The table shows that the technical efficiency of the rice farmers ranges from 0.012 to 1.000 with mean value of 0.350. This implies that the average farm producing rice could increase its technical efficiency by 65% through the adoption of improved technology. Approximately, 14.29% of the farmers had technical efficiency greater than 0.2 but below 0.29. A total of 38.47% is below the average technical efficiency. This implies that this group of farmers was not using their resources in the best possible manner and was thus unable to produce maximally. However, only 4.40% of them were within the range of 0.3 and 0.37 and a total of 42.86% were said to be technically inefficient. This percentage is however not strong enough to ensure expanded rice production and guarantee food security in the study area.

3.3 Determinants of Technical Inefficiency in Rice Production in Ebonyi State

The estimated determinants of technical inefficiency in rice production are presented in Table 3. The coefficient of age shows a positive and significant correlation with technical inefficiency and this is consistent with findings of Khai and Yabe (2011) who found that age had positive relationship with technical inefficiency. The coefficient of access to credit (-0.143619) was negatively signed, implying that access to credit reduces technical inefficiency. This is because rice farming is highly labour intensive, substantial part of available credit is used to hire labour. This agrees with Umar (2012) who reported that access to credit reduces technical inefficiency. Extension contact (-0.152733), in line with *a priori* expectation, was negatively correlated with inefficiency as the coefficient indicated. Extension contact helps to boost farmers' adoption of improved technologies and techniques

as well as provision of technical assistance to the farmers in order to reduce their inefficiencies for higher output (Ifeanyichukwu, Ike, Akubuike and Felix 2016). The coefficient of household size was positively signed and this indicates ready availability of labour through large household size. According to the findings, larger household size could lead to a decrease in inefficiency. Nevertheless, Nwaru (2004) argued that large household size may not necessarily ease the burden of farm labour availability. He added that this is mostly the case where most of the household members are schooling and do not live with the head of the household or where most of the household members have not attained the age of offering labour on the farm. The coefficient of age of the farmers (0.008554) was positively signed implying that as age increases technical inefficiency. This could be due to the fact that aging is associated with weariness and thus reduces the vigour of the farmer and makes him incapable of carrying out farming operations which are characteristically labour intensive. Similarly, the coefficients of years of experience and level of education (0.011867 and 0.024065) were positively signed, indicating a positive relationship between the variables and inefficiency. This result on level of education is in line with the findings of Okorji (2013).

CONCLUSION

This paper used a Cobb Douglas stochastic frontier production function to analyse technical efficiency among rice farmers in Ebonyi State of Nigeria. The analysis reveals an average level of technical efficiency ranging from 0.012 to 1.000 with an average value of 0.350. The study therefore concludes that the rice farmers were technically inefficient in the use of farm resources. The determinant factors of technical efficiency in the study are farm size, quantity of rice seedlings, quantity of fertilizer, farm labour and quantity of agrochemical while technical inefficiency was determined by age, household size and extension visits. This study therefore recommends for the strengthening of extension system to enable farmers acquire adequate training for enhanced output. Policies designed to educate rice farmers especially the more experience one could have a great impact in increasing the level of efficiency and productivity and so should be encouraged. There is the need to reduce farmers' technical inefficiency by providing soft loans to rice farmers.

REFERENCES

- Akande, T. (2003). An overview of the Nigerian rice economy, agriculture and rural development Department. The Nigerian Institute of Social and Economic Research (NISER).
- Biam, C. K., Okorie, A., Nwibo S. U. (2015). Economic efficiency of small scale soybean farmers in central agricultural zone, Nigeria: A Cobb-Douglas stochastic frontier cost function approach. *Journal of Development and Agricultural Economics*. 8(3), 52-58.
- Coelli, V. J. (1996). Guide to Frontier Version 4.1: A computer program for stochastic frontier production and cost function estimation. Department of Economics, University of New England, Armidale, Australia.
- .Ehirim, N, Onyeagocha, S., Ben-ChenDO, G., Essien, U., Osuji. E. and Okwara, M. (2016). Farming techniques, environmental challenges, and technical efficiency of sweet potato production in Abia State, Nigeria *International Journal of Agricultural Management and Development (IJAMAD)* 6(4), 409-420.
- Ifeanyichukwu, E. C. I., Eluwa, A. N. and Ebe F. (2016). Analysis of technical inefficiency in rice production among farmers in Ezza South LGA of Ebonyi State of Nigeria (Application of Stochastic Frontier Production) *Archives of Current Research International* 5(2): 1-12, *SCIENCEDOMAIN international*
- Imolehin, E. D and Wada, A. C. (2000). Meeting the rice production and consumption demands of Nigeria with improved technologies. *International Rice Commission Newsletter. FAO*, (49), 33-41.
- Khai, H. V. and Yabe, M. (2011). Technical efficiency analysis of rice production in Vietnam. *Journal of International Society for South-East Asian Agricultural Sciences*, 17 (1),135-146.
- Longtau, S. R. (2003). Multi-agency partnerships in West African agriculture: A Review and description of rice production systems in Nigeria. Eco-Sys Dev Org, Nigeria 1-36
- National Bureau of Statistics, (NBS) (2010). Annual Abstracts of Statistics, Federal Republic of Nigeria. 1-611.
- National Population Commission,(NPC) (2006). Office of the National Population Commission, Abakaliki, Ebonyi State.
- Nwaru, J .C. (2004). Determinants of information credit demand and supply among food crop farmers in Akwa Ibom Sate Nigeria. *Journal of Rural and Community Development* 6(1), 129-139.
- Okorji, E. C. Appropriate technology generation for small scale farmers in Nigeria. Processing of the national farming system research network workshop held at Calabar, Cross River State, Nigeria. 125-127.
- Project Coordinating Unit (PCU). (2001). Crop area yield survey (CAY). Federal Ministry of Agriculture and Rural Development, Abuja

- Salau, S. A. (2013). Cropping intensification and technical inefficiency of Maize-Based farming households in Southern-Guinea Savanna (SGS) of Nigeria, Fourth International Conference, September 22-25, 2013, Hammamet, Tunisia 161643, African Association of Agricultural Economists (AAAE).
- Shanmugam K. R. and Atheendar V. (2006). Technical efficiency in agricultural production and its determinants: An exploratory study at the district level *International Journal of Agricultural Economics*. 61 (2), 171-180
- Tashikalma, A.K., Giroh. D. Y. and Ugbeshe, V.A. (2014). Swamp rice production in Ogoja Local Government Area of Cross River State, Nigeria: An imperative for rice value chain of the agricultural transformation agenda. *International Journal of Agricultural Policy and Research*, 2 (8), 281-287.
- Udemezue, J.C. (2018). Analysis of rice production and consumption trends in Nigeria. *Journal of Plant Sciences and Crop Protection* 1(3), 1-6
- Umar, M. (2012). Economic analysis of poultry-egg production in Bauchi Local Government Area, Bauchi State, NIGERIA. Unpublished Thesis Department of Agricultural Economics and Rural Sociology Faculty of Agriculture Ahmadu Bello University, Zaria
- United States Department of Agriculture (2018). Rice imports and consumption trends in Nigeria from 1980-2016
- World Data Atlas (2019). World and Regional Statistics. Nigeria - Rice imports quantity.

APPENDIX

Table 1: Maximum Likelihood Estimates of Stochastic Frontier Production Model

Variables	Coefficient	Standard-error	t-ratio
Constant	9.60771	0.42913	22.38897***
lnFarm Size (X ₁)	0.93511	0.03906	23.93942***
lnFarm Labor (X ₂)	-0.24370	0.05281	-4.61437***
lnQty of Rice Seed (X ₃)	0.08310	0.05447	1.52556
lnQty of Fertilizer (X ₄)	0.11200	0.05322	2.10471**
lnQty of Agrochemical (X ₅)	0.14345	0.05635	2.54572**
lnInterest on B. Capital (X ₆)	-0.01224	0.02169	-0.56408
Diagnostic statistics			
Sigma-squared	0.06584***	0.00848	7.76493
Gamma	1.00000***	0.00002	58778.13000
Log likelihood	-0.401213		

Source: Field Survey Data, 2018

p<0.05, *p<0.01

Table 2: Technical Efficiency Levels of Rice Farmers in Ebonyi State

Efficiency Level	Frequency	Percentage (%)
0.01-0.09	22	24.18
0.10-0.19	17	18.68
0.20-0.29	13	14.29
0.30-0.39	4	4.40
0.40-0.49	10	10.99
0.50-0.59	4	4.40
0.60-0.69	5	5.49
0.70-0.79	6	6.59
0.80-0.89	5	5.49
0.90-0.99	3	3.30
1.00-1.09	2	2.20
Total	91	100.00
Mean	0.350	
Standard Deviation	0.293	
Minimum	0.012	
Maximum	1.000	

Source: Field Survey Data, 2018

Table 3: Estimates of Technical Inefficiency in Rice Production

Variable	Coefficient	standard Error	t-ratio
Constant	0.54686	0.397797	1.37472
Age (Z ₁)	0.008554	0.00416	2.05625**
Years of Experience (Z ₂)	0.011867	0.006543	1.81369*
Level of Education (Z ₃)	0.024065	0.012069	1.99395*
Access to Credit (Z ₄)	-0.143619	0.138834	-1.03447
Sex (Z ₅)	-0.032406	0.07568	-0.42820
Household Size (Z ₆)	0.044108	0.01309	3.36960***
Number of Extension Visits (Z ₇)	-0.152733	0.069858	-2.18634**

Source: Field Survey Data, 2018

p<0.05, *p<0.01