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TECHNICAL EFFICIENCY OF RICE FARMERS UNDER ANCHOR BORROWERS' PROGRAMME IN BENUE STATE, NIGERIA.

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ABSTRACT

The study examined technical efficiency of rice farmers currently receiving income supports from Anchor Borrowers' Programme in Benue State. One Hundred and Six (106) farmers were randomly sampled and structured questionnaire administered to them. Cross-Sectional data were collected and analysed using Descriptive Statistics, and Stochastic Frontier Production Function. Results show that the rice farmers achieved a technical efficiency level of 93% on average. Quantities of rice seeds planted, and fertilizer applied had statistically significant ($P < 0.01$) and positive influences on rice productivity. Farm size had positive, significant influence on productivity of rice farmers at 5% level of probability. Return to Scale of 1.17 was found, which implies that the farmers could still use more inputs to improve on the productivity. The Anchor Borrowers' programme should be sustained to support farmers with inputs particularly, seeds, and fertilizer in order to improve on rice production. The research also recommends further studies on allocative, and economic efficiency levels of the farmers receiving income supports from the programme.

Key words: Technical efficiency, Benue State, Anchor Borrower's Programme, rice farmers.

1. INTRODUCTION

Rice farming is among the primary sources of income for many farmers in Nigeria, apart from the critical importance of the commodity as a food crop. Majority (90%) of the rice farmers in Nigeria are smallholders who apply low-input technology to agriculture with minimum input requirements (Cardoni and Angelucci, 2013. Rice production in Nigeria has ,generally, trended upwards, marked by short periods of decline as experienced during increasing rice production years of between 2001 and 2006, which was followed by decreasing production from 2008 to 2010, and yet again followed by the upwards production trends from 5.5 million tonnes in 2015 to 5.8 million tonnes per annum in 2017 (Cardoni and Angelucci, 2013; Goronyo, 2017). Despite the increasing trend in local production, the yields in major producing areas such as Benue State has been estimated at 1.51 tonnes per hectare, on average, (Cardoni and Angelucci, 2013) and this yielding performance has remained below its potential. Because of low yields, supply has not match the demand for rice (Okoruwa and Ogundele, 2006). Currently, Nigeria's local demand for rice is estimated at 7million metric tonnes while its domestic production is about 3.5million tonnes (Ogbe, 2018), inspite of rice sector-specific policies such as the Presidential Initiatives on Increased Rice Production which was launched in 2002 and lasted till 2007; Nigerian National Rice Development Strategy (NRDS, 2009 – 2018), and Anchor Borrowers' Programme(2015), all with the goal of increasing domestic rice production.

The limited capacity of the Nigerian rice sector to match local demand raises an important policy question: what are the factors which explain why domestic rice production lags behind its local demand? Perhaps, the empirical answer lies in the level of Technical efficiency of rice production by farmers. Technical efficiency refers to the ability of a farmer to produce maximum output with a given set of inputs or to produce a given level of output with minimum farm inputs (Ahmed 2008). Technical efficiency (TE) in Agricultural Production has received much attention in the literature in many rural economies including Nigeria, due to its practical and policy relevance. Hence several authors have attempted empirical investigations on the issue in different agro-ecological regions of the country (Ajibefun, Daramola, and Falusi, 2006; Okoruwa and Ogundele, 2006; Okoruwa and Oyewusi, 2006; Ajibefun, Battese, and Daramola, 2002). According to Solis, Bravo-Ureta, and Quiroga, (2008), variables which may influence TE could be classified into two major groups: (i) human capital, including variables such as formal/informal education, literacy, agricultural experience, and age of farmers, and (ii) structural factors such as family income, family size, access to credit, land tenure status, gender composition of labour force, off farm employment, and environmental factors. Stefanou and Saxena (1988) in Solis *et al.*, (2008) found that education and experience have significant positive effects on the level of efficiency. Further, O"Neil and Mathew (2000) in Solis *et al.*, (2008) also in their study on the Role of agricultural extension on farm efficiency in Ireland, reported a positive relationship between these two variables. Kalirajan and Shand, (1985) in Solis *et al*., (2008) indicated that education and training have a strong and positive relationship with Technical Efficiency especially among low-income farmers. Studying the determinants of technical efficiency of farmers could assist policy makers identify and target public interventions to improve farm productivity.

1.2 Analytical Framework

Production efficiency has been measured using Parametric approach which entails econometric estimation of production functions that represent single-output technologies, and which estimates the production frontier or curve that traces out the maximum feasible output for different levels of inputs, conditional on the technology in use. To achieve this goal, the stochastic frontier production model was first, almost simultaneously, published by Meeusen and Van den Broeck(1977), and Aigner *et al*., (1977), and since then, a lot of research has tried to extend the model and explored exogenous influences on producer performance. Schmidt and Lovell, (1979 and 1980) investigating the role of exogenous variables in explaining inefficiency effects, used a two-stage formulation, which suffered serious econometric problems. More recently, Kumbhackar *et al.*, (1991), Reifschneider and Stevenson(1991), and Huang and Liu(1994) proposed a stochastic production function model that simultaneously estimates the parameters of both the stochastic frontier and the inefficiency functions using cross-sectional data. Battese and Coelli(1995) formulated a stochastic frontier production model similar to that of Huang and Liu , specifically, for panel data. The stochastic frontier production function is given as (Dhehibi, *et al*.,2012; Meeusen and Van den Broeck(1977), and Aigner *et al*., (1977)):

$Y_i = f(X_i;\beta) + V_i - \mu_i$ ………………………… (1)

$\mu_i = \sigma z_i + \varepsilon_i$ ……………………………………(2)

Where, V_i = two-sided normally distributed random error, and μ_i = one-sided efficiency component with half-normal distribution; y_i = observed output of the ith farm firm and βs are the unknown parameters to be estimated. X_i = input vector of the ith farm firm.

Subtracting V_i from both sides of equation (1) results in the following

$Y_i^* = Y_i - V_i = f(X_i;\beta) - \mu_i$ ………………………………… (3)

Where $Y_i^* =$ is the observed output of the ith farm firm adjusted for statistical nose captured by V_i . The technically efficient input vector, X_i^T, for a given level of Y_i is derived by solving simultaneously equation (3) and the input ratios, $\frac{X_1}{X_i} = K_i(i > 1)$ where K_i is the ratio of the observed inputs X_1 and X_i at output $\bar{Y}$.

The technical efficiency of the ith farm firm can be defined as (Dhehibi, *et al*., 2012):

$TE_i = \exp(-\mu_i) = \exp(-\sigma z_i - \varepsilon_i)$ …………………………………… (4)

1.3 Objectives Of The Study

The broad objective of the study was to measure technical efficiency of rice production by farmers receiving income supports from Anchor Borrowers' Programme in Benue State. The specific objectives were:

i. to determine the Socio-Economic characteristics of the rice farmers in the Study Area.
ii. to investigate the level of technical efficiency of rice production by the farmers.
iii. to investigate Input-Output relationships in rice production by the farmers.
iv. to make recommendations for policy.

1.4 Hypotheses

The following hypotheses were tested to assist in better understanding of the level of technical efficiency of the rice farmers:

i. H_0: Cobb-Douglas is the true model consistent with the data
H_1: Translog is the true model consistent with the data
ii. H_0: Inefficiencies in rice production function of the farmers are absent($\gamma = 0$)

H_1: There are inefficiencies in rice production functions of the farmers($\gamma \neq 0$)

2. RESEARCH METHODOLOGY

2.1. The Study Area.

The study area is Benue State. The State is located between longitude 6º35´E and 8º10´E, and latitude 6º 30´N and 8º 10´N of the equator (Ani *et al*., 2016), occupying a land area of about 804Km² (National Population Census,2006), with large population of about 4,219,244(Census,2006), persons who are mainly engaged in farming.

2.2. Sampling.

The population of the study was 145 rice farmers who were benefitting from the Anchor Borrowers' Programme in five local government areas of Benue State. A representative sample of 106(Table 1) rice farmers under the programme were chosen proportionately randomly from 10 communities among the five (5) out of a total of twenty three (23) Local Government Areas that make up Benue State, including Gwer West, Gwer East, Gboko, Kwande and Makurdi, where rice cultivation is predominant, and using procedure of Taro Yamane(1967) as: $n = \frac{N}{1+N(e)^2}$ Where n = the desired sample size; N= size of the population of study; e= margin of error = 5% for this study.

Table 1; Sample selection

Local Government area	Community	Population of farmers	Sampled farmers
Makurdi	Abua	37	26
	Apir	16	12
Gwer East	Taraku	16	12
	Ikpayongu	21	15
Gwer West	Aondoana	2	2
	Naka	5	4
Gboko	Amua	17	12
	Yandev	15	11
Kwande	Jato Aka	8	6
	Ikyaior	8	6
Total		145	106

Source: Bank of Agriculture, Makurdi 2018.

2.3. Data Collection.

Primary data were collected through a set of validated, structured questionnaire administered to farmers. The collection of Cross-Sectional data spanned from January to June 2018. Secondary data were gleaned from textbooks, journals and other relevant published materials.

2.4 Data Analysis.

Data analysis was carried out using descriptive statistics to describe the socioeconomic characteristics of the respondents. Stochastic Frontier Production Function was used to measure technical efficiency of the rice farmers, using Frontier 4.1.

2.4.1 Empirical model specification.

Cobb-Douglas, and Translog functional forms were applied in estimating the parameters as of the stochastic frontier production function model.

2.4.1. 1.Cobb-Douglas.

The Cobb-Douglas Stochastic frontier production function was expressed as (Ojo *et al*., 2009):

$$ln\, Y_i = \beta_0 + \beta_1 \ln(A) + \beta_2 \ln(S) + \beta_3 \ln(L) + \beta_4 \ln(H) + \beta_5 (\ln \mathrm{F}) + V_i - \mu_i \ldots(1)$$

2.4.1.2. Translog.

The translog functional form was specified to allow for more flexibility than the much restricted Cobb-Douglas model, and it incorporated Linear, and quadratic (second order) terms as well as their interactions. The Model was given as(Onyenweaku and Okoye, 2007):

$$\ln Y_i = \beta_0 + \beta_1 \ln(A) + \beta_2 \ln(S) + \beta_3 \ln(L) + \beta_4 \ln(H) + \beta_5 (\ln F) + 0.5\beta_6 (lnA)^2 + 0.5\beta_7 (lnS)^2 + 0.5\beta_8 (lnL)^2 + 0.5\beta_9 (lnH)^2 + 0.5\beta_{10} (lnF)^2 + \beta_{11} \ln(A).\ln(S) + \beta_{12} \ln(A).\ln(L) + \beta_{13} \ln(A).\ln(H) + \beta_{14} \ln(A).\ln(F) + \beta_{15} \ln(S).\ln(L) + \beta_{16} \ln(S).\ln(H) + \beta_{17} \ln(F).\ln(S) + \beta_{18} \ln(L).\ln(H) + \beta_{19} \ln(L).\ln(F) + \beta_{20} \ln(H).\ln(F) + V_i - \mu_i \quad \ldots\ldots(2)$$

Where,

ln= natural logarithm to base .

β_i = Maximum likelihood parameters to be estimated (i = 1, 2, 3… n).

Y_i = Total annual output of rice (kg) for the ith farmer

A = farm size (ha)

H = quantity of herbicides (Liters) used

L = sum of hired labour (person days)

F = quantity of fertilizer applied kg

S = quantity of seed (kg) planted.

V_i = Stochastic disturbance term

μ_i = Technical inefficiency term

0.5 = constant.

Technical inefficiency effects (μ_i) were modeled as a linear combination of their determinants as(Dhehibi, 2012):

$$\mu_i = \delta_0 + \sum_{i=0}^{n} \delta_i Z_i \quad \ldots\ldots(3)$$

Where, μ_i = Technical inefficiency term.

δ_i = parameters of the inefficiency models to be estimated (i = 1 ,2 ,3 …8)

Z_i = variables (determinants) of inefficiency of the rice farmers; such that:

Z_1= Age of farmer (in years)

Z_2 = Level of education in years

Z_3 = farming experience (years)

Z_4 = Farming experience (Rice only)

Z_5 = Household size (persons/family)

Z_6 = Number of contact with extension agent per cropping season.

$Z_{7=}$ Annual farm income per cropping season.

2.4.1.3 LogLikelihood ratio.

The loglikelihood ratio is a popular statistic used as a measure of the goodness -of -fit of models. Thus, given specifications of equations (1) and (2), the model which was more consistent with the data was identified using Loglikelihood ratio test. The Loglikelihood test statistic, LR, was expressed following Lewis *et al*., (2011) as:

$LR = 2(LL_1 - LL_0)$

Where, LL_0 = Loglikelihood function of the model with lower number of parameters (simpler model hypothesized as the true model), and LL_1 = Loglikelihood function of the much more complex model which is less restricted with more parameters. The Loglikelihood test statistic follows Chi-Square distribution with degrees of freedom equal to the difference between parameters of the two models to be compared. Choice of the loglikelihood ratio test was appropriate for model selection given that the Cobb-Douglas production function was nested within the Translog model (Lewis et al 2011). The aim was, therefore, to reject the null hypothesis (that the simpler model is consistent with data) and thus accept the alternative hypothesis if the Log likelihood test statistic exceeded the critical value of Chi-Square at 5% level of significance.

3. RESULTS AND DISCUSSION

3.1 Socioeconomic Characteristics of Rice Farmers Participating In Anchor Borrowers' Programme In Benue State.

The Socio-Economic Characteristics of Rice Farmers Participating in Anchor Borrowers' Programme in Benue State are presented in Table 2. Majority of the anchor borrowers' beneficiaries were male (79%) farmers cultivating between 0.5 to 1.5 hectares (58%) of rice farms despite that highest proportions of the households had fairly large family sizes of 7 to 12 members, and that about 88%

of the farmers were still within the active labour force age brackets. This was in agreement with Iorliam (2018) who reported mean farm size of 0.50 to less than 2 hectares amongst rice farmers in the Guinea savannas of Nigeria (Table 2).

Table2: Socioeconomic profile of Rice Farmers.

Characteristic	Frequency	Percentage %
Age (years)		
17-30	23	23.00
31-44	38	38.00
45-58	27	27.00
Above 58	12	12.00
Total	100	100.00
Sex		
Female	21	21.00
Male	79	79.00
Total	100	100.00
Characteristic	Frequency	Percentage %
Years of education		
Less than 1	11	11.00
1-6	35	35.00
7-12	38	38.00
13-18	16	16.00
Total	100	100.00
Household size		
1-6	11	11.00
7-12	35	35.00
13-18	30	30.00
19-24	15	15.00
> 24	9	9.00
Total	100	100.00
Farm size(ha)		
0.5- 1.5	58	58.00
1.6-3.10	33	33.00
3.11-4.61	7	7.00
4.62-6.12	2	2.00
Total	100	100.00

Source: field data 2018

3.2 Results of Hypotheses Testing

3.2.1 The underlying model (Model selection).

Given that the Loglikelihood test statistic was significant (LR = 87.56; Chi- Squared at 0.05 level and 14 degrees of freedom was 23.68), the null hypothesis (that the Cobb-Douglas was the true model) was rejected, and the alternative hypothesis (Translog) was accepted as the underlying model. The estimates discussed in this study are, therefore, those of the Translog model as reported in Table 4

.

3.2.2 Presence of inefficiencies.

The estimates indicated that inefficiencies were statistically absent in the production function of the farmers because the parameter, gamma (γ= 0) was statistically not different from zero at 5% level of probability. The null hypothesis was, therefore, accepted.

3.3. Technical Efficiency.

3.3.1 Distribution of technical efficiency scores.

Data in Table3 show that the farmers were technically efficient with majority (40.60%) achieving a technical efficiency score of between 95 and 97 percent. The Mean technical efficiency of the rice farmers was 93%. This was quite close but higher than those of the rice farmers under Benue State Agricultural Development Programme whose mean technical efficiency is 91% (Iorliam and Iortima 2010).

Table 3: frequency distribution of technical efficiency scores of farmers.

Technical efficiency range (%)	Frequency	Percentage (%)
0.77 - 0.79	1	1.00
0.80 - 0.82	19	18.80
0.83 – 0.85	0	0.00
0.86 – 0.88	0	0.00
0.89 -0.91	0	0.00
0.92 -0.94	39	38.60
0.95 – 0.97	41	40.60
Total	100	100.00

Source: field data analysis, 2018.

Given a mean technical efficiency of 93% as achieved by the Anchor Borrowers 'Programme rice farmers, it implies that the farmers could still gain 7% efficiency to produce at the frontier.

3.3.2. Parameter estimates of translog stochastic frontier production function.

The study found that the amount of seeds planted had positive and significant effect ($P < 0.01$) on rice productivity; increasing the amounts of seeds sown would increase productivity (Table 4).

Table 4: maximum Likelihood estimates (MLE) of parameters for rice farmers.

Variable	Parameter	Cobb-Douglas coef.	Translog coef.
Constant	β_0	3.7717(0.9150)	-0.2776(-0.2212)
Farm size	β_1	0.0981(2.6747)**	0.0306(1.2690)
Hired labour	β_2	-1.2862(-1.3179)***	11.1113(12.8602)***
Quantity of seeds	β_3	0.9767(10.9817)***	0.0087(0.4507)
Herbicides	β_4	0.7037(1.1546)	0.01746(0.7464)
Fertilizer	β_5	0.6781(18.565)***	-6.1940(-8.5702)***
(Farm size)^2	β_6		0.5398(2.1055)**
(Hired labour)^2	B_7		0.0763(0.5740)
(Quantity of seeds)^2	B_8		2.3640(9.1598)***
(Herbicides)^2	B_9		0.0948(0.4256)
(Fertilizer)^2	B_{10}		1.1752(9.8419)***
Farm size*seeds	B_{11}		0.2360(0.5836)
Farm size* Labour	β_{12}		0.1332(0.5389)
Farm size*Herbicide	β_{13}		-0.0126(-0.4338)
Farm size* Fertilizer	B_{14}		-0.2727(-0.2251)
Seeds*Labour	B_{15}		-2.3980(-8.7024)***
Seeds*Herbicide	B_{16}		0.0117(1.0574)
Seeds*Fertilzer	B_{17}		-0.0367(-2.4593)**
Labour*Herbicide	B_{18}		-0.00042(-0.04034)
Labour* Fertilizer	B_{19}		0.0049(0.3623)

Herbicide* Fertilizer	B_{20}		-0.0254(-2.0404)**
Sigma squared	δ^2	0.0145(2.9487)**	0.0040(6.7909)**
Gamma	Γ	0.5299(ns)	0.5113(0.0023)ns
Log likelihood function		90.6477	134.31

Source: field data analysis, 2018;*** Significant coefficients at 1% level of probability.

** Significant coefficients at 5% level of probability. The parameter, mu (μ) is restricted to zero

Further, the second order coefficients of quantities fertilizer, and labour were positive and highly significant ($P < 0.01$), which could be interpreted that larger quantities of fertilizer, and of labour were helping to improve productivity. In the same vein, largest farm sizes had positive significant ($P < 0.05$) influence on productivity, given that the second order coefficient of farm size was also positive.

The combine or interacting effects of *labour and seeds* was negative but statistically significant at 1% level, which implies higher quantities of seeds would reduce the labour productivity. In the same vein, a negative but significant ($P< 0.05$) relationship between productivity of rice and the interacting effect of *fertilizer* and *seeds*, and of *fertilizer* and *herbicide* were found, indicating that the more the quantity of seeds planted the less the effects of fertilizer, and the more the amounts of herbicide applied, the more negative the effect of fertilizer on productivity becomes.

4. CONCLUSION

The study finds that farmers benefiting from the support of Anchor Borrowers' Programme achieved a technical efficiency of around 93%; inputs like fertilizer, land, and seeds were the strong determinants of rice output although farmers cultivated from half to less than 2 hectares of rice farms

5. RECOMMENDATIONS

The Anchor Borrowers' programme should be sustained to support farmers with inputs particularly, seeds, and fertilizer to improve on rice production. The research recommends further studies on allocative, and economic efficiency levels of the programme farmers in the area.

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