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ANALYSIS OF TECHNICAL, ALLOCATIVE AND ECONOMIC EFFICIENCY OF RICE FARMERS IN EBONYI STATE, NIGERIA

**Nwahia O.C.¹, Balogun O.S.^{2*}, Balogun O.L.³, Emeghara U.U.²,
Onwegbunam N.E.², Bala U.J.²**

¹Department of Agricultural Economics, Ahmadu Bello University, Zaria, Nigeria

²Federal College of Forestry Mechanization, Afaka Kaduna, Nigeria

³Department of Agricultural Economics & Extension, Babcock University, Ilishan Remo, Nigeria

*E-mail: baaseg2006@yahoo.com

ABSTRACT

Major obstacles to food security in Nigeria, is the low productivity of most staple food crops and the efficiency with which the farmers use the limited available inputs. These have threatened the effort of the Nigerian government towards food security. Therefore, this research work focused on the analysis of the technical, allocative and economic efficiency of rice farmers in Ebonyi state, Nigeria. Multi-stage sampling procedure was employed to select 476 respondents for the study. Data were collected from primary source with the aid of structured questionnaire and field observations. Data collected were analyzed using descriptive statistics and stochastic frontier production function model. Results revealed that Ebonyi rice farmers were 86% technical efficiency, 63% allocative efficiency and 54% economic efficiency. The study concluded that there is room for improvement in the Ebonyi rice farmer's technical, allocative and economic efficiency and recommended that Agricultural Development Programme (ADP) of Ebonyi States and other agricultural based capacity development organizations that have the mandate of training the farmers should intensify effort in rice farmers training especially in the areas of how herbicides are used against abused or waste as herbicide negatively affect their production efficiency.

KEY WORDS

Food security, low productivity, stochastic frontier.

The role agriculture sector as a source of food consume by more than 7 billion people worldwide cannot be overemphasized and the sector shares more than 50% in revenue of the world's population (Abdullah et al 2005, Rizwan et al 2020). Rice (*Oryza sativa*) has always been an important staple in many African countries including Nigeria. It has been the most rapidly growing food source across the continent (Norman and Kebe, 2010; Aliou, Didier, Marco and Kazuki, 2012, International Food Policy Research Institute (IFPRI), 2016a). The crop serves as a main source of calories for rural and urban population (Igboji and Anozie, 2015). In Nigeria, large gap exists between supply and demand of food especially rice due to increasing population in major cities (Okon et al. 2010). Currently, rice production is in the hands of small-scale resource poor farmers making the local production largely insufficient to meet the consumers' needs (Aliou, *et al.*, 2012). Between 2001 and 2003 Nigeria rice production was estimated at 2.03 million tonnes while consumption was 3.90 million tonnes. The balance of 1.90 million tonnes was obtained by importation (Food and Agricultural Organization Statistics Division (FAOSTAT), 2007). In 2003, Nigeria the highest rice producer produced about 21.2% of total production of paddy rice (about 15.08 million tons) in the continent (Osanyinlusi and Adenegan, 2016). According to Udemezue, (2018), Production and importation of rice between 2012 and 2016, stood at 17.96 million tons and 29.30 million tons respectively with a deficit of 11. 34 million tons a scenario capable of plunging the country into food insecurity.

The problem of food security in Nigeria centres on poor technical efficiency among others (Oyetunde-Usman and Olagunju (2019). A low level of improved farm inputs usage among the small-scale farmers may result from high cost of inputs, bad production practices, poor resource management, inadequate extension agents, market failures and insufficient technical-know-how among others (Osanyinlusi and Adenegan, 2016).

Technical efficiency is the ability to produce a given level of output with a minimum quantity of inputs and can be measured either as input conserving oriented technical efficiency or output-expanding oriented technical efficiency (Okon et al. 2010). The study aimed at estimating the technical, allocative and economic efficiency of Ebonyi rice farmers.

LITERATURE REVIEW

This study is anchored on the theory of production as postulated by Farrel (1957). The theory of production is concerned with the process of transforming production factors or inputs into outputs (Baumol, 1977). It represents a particular process, techniques or technology adopted in the transformation of production inputs into outputs Olayemi (2004). However, there is nothing in the definition of production which suggests that a particular process, techniques or technology used is efficient, therefore it may be efficient or inefficient. Usually, a farmer is faced with the problems of what to produce and how much to produce, what production inputs to use for production and how to combine inputs to maximize profit. In considering the numbers of ways to use to produce output, the varying combination of inputs, as defined by a particular technology used and which give rise to varying quantities of output constitute the input-output relationship described by a production function Debertin (2012). It is generally written in the form $Y = f(X_i)$, where Y is an output and X_i are the inputs.

Production function's general preposition is that, provided technologies and managerial decision making skills are the same, farmers who have identical access to identical factors (both quantity and quality) may produce identical outputs of a given crop. Therefore, following presentations by Aigner, Lovell and Schmidt (1977), we assume that rice farmers utilize a vector of conventional inputs, X_i to produce a single output Y . The household incurs production risk because rice yield is affected by uncertain climatic conditions. This risk is captured by a random variable, v_i , whose distribution is exogenous to the rice farmers action and other risks that might occurred as a result of the rice farmers inefficiency, which is captured by u_i and its distribution is endogenous to the rice farmers action. Let β be the corresponding parameter of the conventional inputs and e_i be the composite error term i.e, $v_i + u_i$, then the stochastic production function is given by $Y = f(X_i; \beta) + e_i$ where Y is output, X_i are standard inputs and β are the parameters. Therefore the technical efficiency of production is given as $TE_i = \exp(-u_i) = Y/Y^*$. Where Y is the observed output and Y^* is the maximum feasible output. Allocative efficient implies that the firm was able to equate the marginal value product (MVP_x) of each resources employed to its unit cost (P_x). MVP_x is obtained, when slope of production function (marginal product (MP_x)) is equal to the slope of the =Iso-Profit line which is the ratio of the price of the factor inputs to the price of output (P_x/P_y) as derived below: $MP_x = P_x/P_y = MP_x \times P_y = P_x$. Therefore, $MVP_x = P_x$. where: $MVP_x = MP_x \times P_y$. MVP_x is the marginal value product of the input.

$MP_x = \partial Q / \partial X_i$, and based on the double log functional form is given by $MPP = b(Y/X_i)$. Where b is the coefficient of the variable, Y_i is the geometric mean of output and X_i is the geometric mean of the inputs. Hence, for an optimum input utilization MVP_x must equals P_x . Then, if $MVP_x > P_x$ or $MVP_x < P_x$, there is disequilibrium in the use of inputs, that is under-utilization (over utilization), hence the use of such input must be increased (decreased) in order to improve the allocative efficiency of the input by the farmer. Economic efficiency is concerned with maximum profit and it is the product of technical efficiency and allocative efficiency.

In most of the literatures technical studies (Ajayi and Olutumise 2018; Oluwatayo and Adedeji 2019) with single equation for their predictors. With their emphasis on a single crop, the estimated mean technical efficiency of rice and cassava farmers were 86.6 percent and 83 percent, respectively in Nigeria. Oyetunde-Usman and Olagunju (2019) examined the determinants of food security and technical efficiency among agricultural households in Nigeria using a stochastic frontier framework. The result revealed that the households had a mean technical efficiency of 52%, suggesting that agricultural households have the tendency of improving their technical efficiency by 48% using the available resource more efficiently. Bui et al (2018) indicated that there is a strong consistency in the directional impact of seed rate, quantity of urea, organic fertilizer, and labor for optional work (i.e. time to eliminate competing weeds and control harmful insects) on productivity for the selected ecologies and overall sampling. Also showed that on average rice producers at the research site obtained a technical efficiency score of 86.9%, with lowland growers having a higher score than up landers at 88.3% and 85.5%, respectively, suggesting an increase rice output is possible through better farming practices at the farm level. Singh and Chand (2011) revealed that the mean of technical, allocative and economic efficiency was 69%, 66% and 54% respectively for Delhi's farmers. The study indicates that efficient and optimum use of inputs is necessary to sustainable cultivation of rice.

MATERIALS AND METHODS OF RESEARCH

The study was conducted Ebonyi State, Nigeria. The state was created in 1996, making it one of the youngest states in Nigeria. Farming is one of the major economic activities in the state with an estimated 85% of the population earning their living from one form of agriculture. The state has a total land area of about 5,935 km² (Obasi, Agbo and Onyenekwe, 2015). Ebonyi State is located within latitude 7° 30E, and 8° 30 E and longitude 6° 40N and 6° 45N of South East zone of Nigeria. The State is made up of thirteen Local Government Areas (LGAs) with a total population projected with an estimated growth rate of 3% to be 3.1 million people in 2020.

Table 1 – Description of Sampled Respondents

Local Government Area	No of Respondents
Afikpo South	103
Abakaliki	63
Ohaozara	76
Ohaukwu	56
Ezza North	178
Total	476

Source: Field Survey 2018; Ebonyi State ADP, 2018.

As presented in the table above, the study used cross-sectional data collected from 476 rice farmers from the state using multi-stage sampling technique. In the first stage of the sampling, five (5) Local Government Areas (LGAs) were randomly selected from the state. Second stage involved random selection of three villages from each of the LGA. In the next selection, rice farmers were chosen from village using the Yemen Taro (1967) scientific formula for calculating sample size. Yemen Taro (1967) scientific formula that was adopted in this study is given as $n = \frac{N}{1+N(\alpha^2)}$, 5% room for error was given and 95 percent confidence level in selecting the sample size. Where n is the sample size, N is the sample frame and α^2 is the precision level (0.05). Data were collected from primary source with the aid of structured questionnaire and field observations. The cost route survey approach was used in collecting the required data in three stages – after planting, weeding and after harvesting of rice for 2018

season. Data collected were analyzed using descriptive statistics and stochastic frontier production function model.

Stochastic Frontier Production Function model was developed by Aigner, Lovell and Schmidt, (1977) and it is specified as $Y = f(X_i, \beta) + \varepsilon_i$ (1).

Stochastic Frontier Production Function model was used to estimate technical, economical and allocative efficiency of rice farmers).

The technical efficiency of production is given as $TE_i = \exp(-u_i) = \frac{Y_i}{Y^*}$ (2). Where Y_i is the observed output and Y^* is the maximum possible output.

$Y^* = f(X_{ij}, \beta) + v$ (3). Where Y^* is the firm's observed output adjusted for the statistical noise captured by v .

$Y_i = f(X_{ij}; \beta) + \varepsilon_i$ (4), $\varepsilon_i = v_i + u_i$ (5). Where Y_i = output of the farm, X_i = Vector of inputs, β = vector of the parameter estimated, v_i = Random error outside farmer's controlled, u_i = Technical inefficiency effects.

Cobb Douglas production function is fitted into the stochastic frontier model and the empirical stochastic frontier production model is specified thus: $\ln Y_i = \beta_0 + \beta_1 \ln X_{1i} + \beta_2 \ln X_{2i} + \beta_3 \ln X_{3i} + \beta_4 \ln X_{4i} + \beta_5 \ln X_{5i} + v_i - u_i$ (6). Where $\ln$ = logarithm to base e, Y_i = output of rice (kg/ha), β_0 = constant, $\beta_1 - \beta_5$ = parameters estimated, X_1 = farm size (ha), X_2 = fertilizer (kg), X_3 = labour (man-days/ha), X_4 = herbicide (litre/ha), X_5 = rice seed (kg/ha). The inefficiency effect is non-negative with half normal distribution. It is assumed that it is truncated at zero and thus it is specified as: $U_i = \delta_0 + \delta_1 \ln Z_{1i} + \delta_2 \ln Z_{2i} + \delta_3 \ln Z_{3i} + \delta_4 \ln Z_{4i} + \delta_5 \ln Z_{5i} + \delta_6 \ln Z_{6i}$ (7). Where U_i = Technical inefficiency, δ_0 = constant, $\delta_1 - \delta_6$ = Parameters estimated, Z_{1i} = age (years), Z_{2i} = education (years spent in formal education), Z_{3i} = household size (number), Z_{4i} = years spent in cooperative society (years), Z_{5i} = years of farming experience in rice production (years), Z_{6i} = number of visit with extension agent (number of visit in a month).

The cost efficiency (CE) of the rice farmers is defined in terms of the ratio of observed cost (Cb) to the corresponding minimum cost (Cmin) under a given technology: $CE = \exp(U_i)$ (8). Where: CE = Cost efficiency, Cb = the observed cost and represents the actual total production cost; Cmin = the minimum cost and represents the frontier total production cost.

Allocative efficiency is given by $\frac{1}{CE}$ (9).

The corresponding cost frontier derived analytically from the stochastic frontier production function is given as: $\ln C_i = \alpha_0 + \alpha_1 \ln P_{1i} + \alpha_2 \ln P_{2i} + \alpha_3 \ln P_{3i} + \alpha_4 \ln P_{4i} + \alpha_5 \ln P_{5i} + v_i + u_i$ (10). Where: C_i = Total cost of production (naira), $\ln$ = logarithm to base e, α_0 = constant, $\alpha_1 - \alpha_5$ = parameter estimated, P_{1i} = Rent on land per hectare (₦), P_{2i} = Cost of fertilizer (₦), P_{3i} = Cost of labour (₦), P_{4i} = Cost of herbicide (₦), P_{5i} = Cost of rice seed (₦).

The cost inefficiency effects are defined as in equation 7 above. The economic efficiency is the product of technical and allocative efficiency which can be given by $\exp(-u_i) \times \frac{1}{CE} = \frac{Y_i}{Y^*} \cdot \frac{1}{CE}$.

RESULTS AND DISCUSSION

Estimate of Stochastic Frontier Models of Technical Efficiency in Rice Production.
The maximum likelihood estimate (MLE) of the Cobb-Douglas stochastic frontier model of technical efficiency of Ebonyi rice farmers is presented in Table 2.

The estimated sigma-squared (σ^2) (0.28) was significantly different from zero at 1% level indicating a goodness of fit and correctness of the distribution of the assumed composite error term. The gamma estimate of 61% was significantly different from zero at 1% level of probability implying that 61% of discrepancies between observed output and the frontier output are due to technical inefficiency of the rice farmers.

The estimate of the parameter of the stochastic production frontier analysis in Table 2 revealed that the estimated elasticity of output with respect to area of rice cultivated was 0.82

and this is positive and statistically significant at 1% level of probability. This implies that as the area cultivated to rice increases, output will increase as well and vice versa. The result showed that holding other variable constant, 1% increase in the area cultivated to rice by rice farming households will increase rice output by 0.82%.

Table 2 – Maximum Likelihood Estimate of Technical Efficiency of Rice Production

Variables	Coefficients	Standard error	T-ratio
Constant	7.37008	0.26956	27.341***
Rice farm size	0.81984	0.05589	14.666***
Fertilizer	0.07379	0.02042	3.614***
Labour	0.11564	0.04925	2.348**
herbicide	-0.01591	0.00432	-3.688***
Rice Seed	0.01861	0.02665	0.698
Inefficiency variables			
Constant	-0.02190	0.65832	-0.033
Age	0.00125	0.00978	0.026
Yrs in formal edu	-0.10112	0.02867	-3.531***
Household size	-0.10779	0.04117	-2.618***
Yrs in cooperative	-0.08554	0.02261	-3.784***
Yrs of experience	-0.06643	0.01958	-3.393***
Extension visit	-0.04737	0.08557	-0.554
Sigma-squared	0.28681	0.03050	9.405***
Gamma	0.61306	0.05971	10.267***
Log likelihood	-210.577		
LR test	55.894		
No of obs	476		

Source: Field Survey, 2018. Note: ***, ** is significant at 1% and 5% respectively.

The estimated elasticity of output with respect to fertilizer is 0.07. The coefficient was positive and statistically significant at 1% which implies that as the amount of fertilizer used in the rice production increases by 1%, rice output will increase by 0.07%. The estimated elasticity of output with respect to labour inputs is 0.12 and statistically significant at 5%. This means that a unit increase in labour (mandays) used in rice production by rice farming households will increase rice output by 0.12 unit. This is in line with the work of Ajoma, Ezihe and Odoemenem, (2016). Also, against the *a priori* expectation, the estimated elasticities of mean output with respect to herbicides - 0.02 and significant at 1% level. This means that for a 1% increase in herbicide used in rice production, rice output will decrease by 0.02%. This could be wrong use of these chemical or that the soil is not compatible with the chemical. It could be as a result of fake chemical being sold to the farmers at the open market as reported by the farmers during the field work. Using the coefficients of the all the production variables, the returns-to-scale parameter is estimated to be 1.012, implying increasing returns to scale in the rice enterprise. This means that Ebonyi rice farmers are at the stage 1 of production function. This is not a rational or economic production region. At this stage, a given increase in variable factor leads to a more than proportionate increase in the output. The producer is not making the best possible use of the fixed factor; a particular portion of fixed factor remains unutilized.

The Maximum Likelihood Estimate of Technical Inefficiency Model. Socio-economic variables were considered and estimated in the model and the result is presented in Table 2. The result showed that the estimated coefficient for years in formal education was negative and statistically significant at 1% level of probability. This implies that rice farmers who spent more years in formal education tend to be more technically efficient in rice production than those who spend less. Taphe, Agbo and Okorji, (2015), noted that farmers with higher education have privileged ability to read, write and understand rice market and farming situation more than the less educated ones. Household size had a negative and significantly influenced inefficiency at 1%

level of probability implying that rice farmer with more members in his household tend to be more technically efficient in rice production than those with few members. This could be due to the fact that large household size enhances labour availability as most of the members are involved in the farming business. Likewise, the coefficient of years in cooperative was found to be negative and statistically significant at 1% level of probability. This indicates that rice farmers who spent more years in cooperative tend to be more technically efficient than others. This could be due to experience and knowledge being shared among members of cooperative societies; furthermore, trainings are usually organized and conducted for members of cooperative societies which subsequently boost their efficiencies. Also, the coefficient of years of experience in rice farming was found to be negative and statistically significant at 1% level of probability. This shows that rice farmers with more experience tends to be technically efficient than those with less experience. According to Yusuf and Nwachukwu (2015), highly experienced farmers have better ability to obtain and process information relating to prices and new technology.

Estimate of Stochastic Frontier Cost Function (allocative efficiency) of Ebonyi rice farmers. The Maximum Likelihood (ML) estimate of the stochastic frontier cost parameters for the respondents is presented in Table 3. The sigma square value of (100) and significant at 1% indicate the goodness of fit and correctness of the specified assumption of the composite error terms distribution. The gamma ($\gamma = 0.94$) shows that 94% of the variability in the total rice production cost of the Ebonyi rice farming households results from the existence of allocative inefficiency.

Table 3 – Estimate of stochastic frontier cost function (allocative efficiency) of rice farmers

Variables	Coefficients	Standard error	t-ratio
Constant	-0.02195	0.31029	-7.061***
Rice land rent	0.08210	0.04620	1.777*
Fertilizer cost	-0.3255	0.04047	-0.805
Labour cost	0.21795	0.05584	3.905***
herbicide cost	-0.00182	0.00186	0.980
Rice Seed cost	0.05101	0.05818	0.872
Inefficiency variables			
Constant	5.10097	0.84944	6.005***
Age	-0.12599	0.03930	-3.208***
Yrs in formal edu	-0.06692	0.03967	-1.687*
Household size	-0.19005	0.10950	-1.736*
Yrs in cooperative	0.94947	0.07401	12.830***
Yrs of experience	-0.22414	0.03087	-7.260***
Extension visit	-0.03389	0.19149	-17.697***
Sigma-squared	0.10058	0.00953	10.549***
Gamma	0.93999	0.33752	2.785***
Log likelihood	-92.921		
LR test	10.389		
No of obs	476		

Source: Field Survey, 2018. Note: ***, * is significant at 1% and 10% respectively.

The estimated parameter of cost function presented in Table 3 revealed that the coefficients of rent on land, cost of labour were statistically significant at 10% and 1% level of probability respectively. This indicates that these variables mostly determine the total cost of production of the rice farmers. Thus, an increase in these inputs may lead to an increase in the total cost of rice production. In the inefficiency cost model, the coefficient of age was statistically significant (1%) and negatively related to cost efficiency of non-participants. This implies that older farmers tend to be cost efficient than the younger farmers. Years in formal education were statistically significant (10%) and positively related to cost efficiency of the rice farmers implying

that the more educated rice farmers are likely to take cost decisions that will lead to cost efficiency compared to others who had little or no education. This is in line with the work of Taphe, Agbo and Okorji, (2015). Also, household size was statistically significant (at 10%) and positively related to cost efficiency of the rice farmers indicating that relatively larger household sizes are likely to use more of family labour to reduce the high cost of hired labour thereby enhancing cost efficiency. Extension visit is significant at 1%. This means that increase in extension visit to rice farmers, will reduce cost inefficiency of the rice farmers. This could be because of input price information usually passed to the rice farming households in the course of the visit by extension agents. Against the *a priori* expectation, years in a cooperative society were found to be statistically significant (at 1%) and negatively related to cost efficiency. The monthly dues being paid in these cooperative before and after each farming season which farmers usually include as part of the farming cost may be responsible for this.

Frequency Distribution of Technical, Allocative and Economic Efficiency (TE) of Ebonyi rice farmers. The frequency distribution of technical, allocative and economic efficiency levels for rice farmer in the study area are presented in Table 4.

Table 4 – Frequency Distribution of Technical, Allocative and Economic Efficiency of Ebonyi rice farmers

Efficiency Index	Technical Frequency	Efficiency Percent	Allocative frequency	Efficiency Percent	Economic frequency	efficiency percent
0.10 – 0.24	0	0	27	5.67	41	8.61
0.25 -0.49	2	0.42	93	19.54	101	21.22
0.50 – 0.74	28	5.88	97	20.38	304	63.87
0.75 -1.00	446	93.7	259	54.41	30	6.30
Total	476	100	476	100	476	100
Min	0.32		0.11		0.10	
Max	0.96		0.99		0.95	
Ave.	0.86		0.63		0.54	

Source: Field survey, 2018.

The result revealed that the mean technical efficiency was 0.86, which suggested that an average rice farmer is 14% less than the maximum possible level due to their technical inefficiency. This also implies that if the average farmers in the sample was to achieve the TE level of its most efficient counterpart, then the average farmer could realize a 11% cost saving i.e. $(1-86/96 \times 100)$, a similar calculation for most technically inefficient farmers reveals cost saving of 67%. This is in line with work of Abba and Abu (2015) and Girei, Maurice and Onuk (2016a). Furthermore, results in table 4 revealed that the mean allocative efficiency was 0.63, which suggested that on the average, the observed cost was 37% less than the optimum minimum cost implying that there is room for improvement in the rice farmer's allocative efficiency. Therefore, if the average farmers in the Study area was to achieve the AE level of its most efficient counterpart, then the average farmer could realize a 36% cost saving i.e. $(1-63/99 \times 100)$, a similar analysis for most allocative inefficient farmers reveals cost saving of 89%. This finding is in line with the work of Tijjani and Bakari (2014). Also, the result showed an estimated mean economic efficiency of 0.54 indicating that if an average farmer in the study area was to achieve the EE level of its most efficient counterpart, then he could realize a 43% cost saving, i.e. $(1-54/95 \times 100)$, a similar calculation for most economic inefficient farmers reveals cost saving of 89%.

CONCLUSION

The study concludes that there is room for improvement in the Ebonyi rice farmer's technical, allocative and economic efficiency and therefore recommend that Agricultural

Development Programme (ADP) of Ebonyi States and other agricultural based capacity development organizations that have the mandate of training the famers should intensify effort in rice farmers training especially in the areas of how herbicides should be used against abused or waste as herbicide negatively affect their production efficiency.

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