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Production Efficiency of Rice Production in Kwara State, Nigeria

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ABSTRACT: This study was carried out to analyze the efficiency of rice production in Kwara State of Nigeria. The study made use of a cross-sectional data to obtain information from 120 rice farmers in the four agricultural zones of Kwara State. The result indicates that, the rice farmers were not technically efficient. The mean efficiency was 0.548 and 0.681 under CRS and VRS specification respectively indicating that there was 45.2% and 31.9% allowance for improving efficiency. The result also shows that majority (82.5%) of the farmers were operating with increasing return to scale while 17.5% were under constant return to scale. The result further reveals that age, education, experience and farm size significantly influence the farmers' efficiency.
Key words: *Rice, Input oriented DEA, VRS, CRS*

INTRODUCTION

The importance of Agriculture in developing countries like Nigeria cannot be overemphasized because it is the main thrust of employment opportunities, food production, national survival and foreign earnings. The climate condition of Nigeria is favorable for agricultural production (Adebayo and Okuneye, 2005).

One of the main crops in Nigeria is Rice. It is grown on over 1.5 million hectares of land. In Nigeria, rice is cultivated in almost all the ago-ecological zones. The production of rice in the country in 1994 was 2.4 million metric tonnes and it rose to 3.9 million metric tonnes in 2005(FAO, 2003: CBN, 2006). In spite of the increase, its demand far exceeds domestic production. Importation of rice is high because government efforts to making the country self- sufficient in rice production have proved abortive (Idiong, 2007).

The minimum food security requirement is 2400 calories per person per day and rice can provide the nation population with it (FAO, 2002). Rice is mostly eaten as food crop for household food security (Bamidele *et al*., 2010). The average Nigeria consumes 24.8kg of rice per year, representing 9 percent of annually caloric intake (IRRI, 2001). The per capita consumption of rice has been rising at an average of 7.3 percent annually due to changing consumer's preference from traditional staple (Yams, Garri, Cocoyam etc.) increasing population and urbanization among others (Akpokodje *et al*., 2001).

Small scale farmers who still engage in subsistence farming techniques are those who majorly engage in production of rice in Nigeria. Low resource productivity has been attributed to the significant difference between the actual yields and potential yields (Federal Ministry of Agriculture and Rural Development, 2001).

Efficiency is an act of harnessing materials and achieving management goals. It is the act of using minimal effort to produce result. Efficiency is everything done to uphold and better productivity capacity of the farm. Ali and Chaudry (1990) observed that measurement of efficiency has remained an area of important research to both the developed and developing countries especially in developing agricultural economics where resources are meager and opportunities for developing and adopting better technologies are dwindling.

The concept of efficiency is at the core of economic theory. Optimization which implies efficiency is the most concerned in the theory of production economics. Researchers and policy makers have identified the importance of efficiency in increasing agricultural output. Therefore, a considerable effort has been devoted to the analysis of farm level efficiency in the developing countries. An underlying premise behind much works on this is that, if farmers are not making efficient use of the existing technology, their efforts designed to improve efficiency would be more cost-effective than introducing new technologies as a means of increasing agricultural output (Bravo-Ureta and Evenson, 1994).

There have been many studies on efficiency in agriculture in developing countries in which a majority used stochastic frontier studies. Ogundari (2008) used production function to estimate resource productivity, technical efficiency and allocative efficiency of rain-fed rice farmers in Nigeria. His results show that herbicide has the highest elasticities, then seeds, followed by fertilizer and land while labour has the least contribution to output. The result also shows that none of the respondents optimally allocated the inputs. He reported a mean technical efficiency index of 0.75. Shehu and Mshelia (2007) investigate the productivity and technical efficiency of small-scale rice farmers in Adamawa State of Nigeria using stochastic frontier production function. Their study revealed that predicted technical efficiencies for the farmers ranged from 74% to 98.9% with a mean of 95.7%. Okoruwa and Ogundele (2005) examined technical efficiency differentials between farmers planting two varieties of rice using stochastic frontier production function. Their results show that the estimated average technical efficiency for the two groups was high which indicates that there is little opportunity for increased efficiency given the present state of technology.

However, the application of Data Envelopment Analysis (DEA) method too has gradually increased. Recent application of DEA method of agriculture efficiency in developing countries includes the study by Dhungana *et al*., (2004). They used DEA to analyse 76 Nepalese rice farmers efficiency and it reveals average relative economic, allocative, technical, pure technical and scale inefficiencies as 34, 13, 24, 18 and 7 percent respectively.

Ogisi *et al*., (2012) investigated the technical and scale efficiencies in rice production in Ebonyi State of Nigeria using DEA. Their result shows that majority of the rice farmers were operating with increasing return to scale (77.2%), 18.99% with decreasing returns to scale and only 3.9% with constant return to scale. Their results further indicated that only 5.56% of the farmers were 100% technically efficient in resource utilization under variable return to scale specification. Other studies that use DEA are Krasachat (2003) on Thailand rice farms and Okeke *et al*., (2012) on Nigeria rice farms.

This study demonstrates an approach to determining the farm efficiency using DEA technique. The estimate of resource-use efficiency obtained will be useful in providing insights to assess the potential for and sources of improvements in rice farms production. DEA is a non-parametric technique that measures the efficiency of Decision-Making Units (DMU) relative to production possibility or input requirement set. Seiford and Thrall (1990) further describe it in terms of floating piece-wise linear surface to rest on top of the observations. According to Charnes *et al.,* (1985), the key constructs of a DEA model are the envelopment surface and the efficient projection path to the envelopment surface.

Fare *et al*., (1994) posit that the efficient projection path and envelopment surface rely on the scale assumption that underlined the model and the optimisation assumption respectively. The optimisation production process could be output or input-oriented model. The input-oriented model shows how much the input could be proportionally reduced without changing the quantity of the output produced while the output-oriented shows how much the output quantity could be proportionally expanded without altering the input quantity. Output-oriented model gives credence to neo-classical production function defined as the maximum output given input quantity. In this study, the input-oriented model approach was used to estimate various efficiency indices.

MATERIALS AND METHODS

The study was carried out in Kwara State of Nigeria. Population of the study is made up of all rice farmers in the study area. A multi-stage random sampling technique was employed in selecting the sample. The four agricultural zones were taken as the sampling units at the first stage of sampling. At the second stage, two local government areas were randomly selected to represent the zone making a total of eight LGAs. The last stage involved random selection of 120 rice farmers from the selected LGAs.

DEA is non-parametric method which involves the use of linear programming to construct a piecewise linear envelopment frontier over the data points such that all observed points lie on or below the production frontier. Let X be a K * N matrix of inputs, which is constructed by placing the input vectors x_i, of all N firms side by side and Y denotes the M * N output matrix which is formed in analogous manner.

The input – oriented VRS DEA frontier is defined by the solution to N linear programs of the farm.

$$\min_{\ell, T} \ell$$

Subject to $- y_i + YT \geq 0$ ……………………………………………(1)

$$x_i / \ell - XT \geq 0$$

$$N/T = 1$$

$$T \geq 0$$

Where ℓ is the input distance measure. Also note that $1 \leq \ell \leq \infty$ and that 1/ ℓ is the proportional reduction in inputs that could be achieved by the i+e firm, with output quantities held constant.

The technical efficiency measure under CRS, also called the "overall" technical efficiency measure, is obtained by solving N linear programs of the form.

Min Φ^{CRS}

Φ_i^{CRS}

Subject to $-YT + Y_i \geq 0$ ……………………………………………….(2)

$\Phi_i^{CRS} x_i - XT \geq 0$

$T \geq 0$

Where Φ_i^{CRS} is a technical efficiency measure of the ith firm under CRS and 0 α Φ_i^{CRS} α 1.

The output and input oriented models will estimate exactly the same frontier surface and therefore, by definition, identify the same set of firms as being efficient. The efficiency measures may, however, differ between the input and output orientations. Under the assumption of CRS, the estimated frontier and the efficiency measures remain unaffected by the choice of orientation (Coelli and Perelman, 1999).

One output and five inputs were used in the models. The only output is the rice yield. The inputs are farm size, labour, seed, fertilizer and herbicide.

Determinants of Efficiency Model

A second step regression model was applied to determine the farm specific attributes in explaining efficiency in this study. Alternatively, the factors can be incorporated directly into the model. The pros and cons of these approaches are provided in Kumbhaka *et al.,* (1991). This study applied second step approach by using a Tobit regression.

The model assume

$$y^* = \beta, + \beta_1 Z_i + \beta_2 Z_2 + \beta_3 Z_3 + \beta_4 Z_4 + e \quad \text{----------------------------------} (3)$$

Where y is a DEA efficiency model and used as a dependent variable.

$$y = \begin{cases} y^* & if \ y^* < 100 \\ 100 & otherwise \end{cases}$$

Z_1 = age (years)

Z_2 =education (years)

Z_3 =experience (years)

Z_4 = household size (number)

Z_5 = farm size (hectare)

β is the unknown parameter vector associated with the farm specific attributes and e is an independently distributed error term assumed to be normally distributed with zero mean and constant variance, δ^2.

Therefore, the model assumed that there is underlying, stochastic index equal to (Zβ + e) which is observed only when it is less than 100 and qualified as an unobserved latent variable. The dependent variable, which is efficiency index, cannot be normally distributed but censored distribution because it has a value between 0 and 1. OLS will yield an inconsistent estimate, hence this study used Tobit regression model using maximum likelihood estimate (MLE) approach (Tobin, 1958).

The expected value becomes

$$E(y/z) = 1 - \phi\ (b)\ x\ 100 + \phi\ (b)\ Z\beta - \delta\ \phi\ (b)$$

$$where\ b = \frac{(100 - z\beta)}{\delta} \qquad - \qquad - \qquad - \qquad - \qquad (4)$$

RESULTS AND DISCUSSION

Summary Statistics

The summary statistics of variables for the production of rice is presented in Table 1. The table revealed that the average output is 478.67kg with a standard deviation of 154.25kg. The large variability by the standard deviation implies that the farmers operated at different levels of farm size which tends to affect their output levels. The mean farm size was 0.60ha with a standard deviation of 0.26ha. The variability is due to change in hectares of rice under the production seasons. The mean farm size of 0.60ha implies that rice producers are small-scale farmers. The mean total labour used was 37.84 man-days with a standard deviation of 17.10man-days. This is an indication that rice production is labour intensive considering the large variability recorded. The mean age of the respondents was 48.3 years. This indicates that rice production in Kwara State was in the hands of active producers who are tending towards the declining productivity class of greater than 50 years (Ogundele and Okoruwa, 2006). The implication of this is that except the occupation witnessed the injection of young able men, in the next one decade, many of these farmers would have reached the declining productivity level and rice farming will suffer a setback.

The mean years of education were 4.63 years with a standard deviation of 3.12years. This is an indication that majority of rice farmers in study area did not finish primary school education. This low level of education might likely affect their level of technology adoption and skill acquisition.

The mean years of experience in rice production was 19.94years with a standard deviation of 15.98 years. In essence, majority of the farmers have had long number of years in the production of rice and could be said to be well experienced in the business. This implies that farming experience varied significantly among the farmers.

Table 1. Summary statistics of socio-economic characteristics of rice producers

Variable	Mean	Standard Deviation	Minimum value	Maximum value
Output (kg)	478.67	154.25	64.49	1547.69
Farm size (Ha)	0.60	0.26	0.41	1.63
Total labour (Man-days)	37.84	17.10	2.08	60.67
Seed (kg)	7.34	5.98	1.25	30
Fertilizer(kg)	10.46	8.92	0	50
Herbicide(litre)	9.88	5.47	0	35
Age (years)	48.28	10.76	25	80
Education (years)	4.63	3.12	0	12
Farming experience (years)	19.94	15.98	2	65
Household size (number)	12.33	5.16	4	27

Source: Field survey, 2012

Technical Efficiency

Table 2 gives the frequency distribution of CRS and VRS efficiency estimates obtained by the multi-stage method. The average overall technical efficiencies are 0.548 and 0.681 for CRS and VRS respectively. This scores are low when compared with 76% obtained by Dhungana *et al*., (2004) in the analysis of Nepalese rice farms. Inefficiency occurred in the farming operation of the sampled farm households in the study area. In essence, 45.2% and 31.9% of rice output is forgone to inefficiency. Under the prevailing conditions, about 4% and 27% of farms were identified as fully technically efficient under the CRS and VRS specification respectively. This percent under VRS is higher than that reported by Ogisi *et al*., (2012). They reported that 5.6% of the farms were fully efficient. The observed difference between the CRS and VRS measures further indicated that some of the farmers did not operate at an efficient scale and improvement in the overall efficiencies could be achieved if the farmers adjusted their scales of operation. The lowest percentage of technical efficiency score falls within 0.8-0.89 under CRS scale specification while that of VRS falls within 0.4-0.49. This shows that TE scores under the VRS were higher than those obtain under the CRS specification. This study is in line with the earlier findings by Alemdar and Oren (2006).

Table 2. Frequency Distribution of Technical Efficiency

Efficiency Scores	CRSTE	VRSTE	SE
< 0.2	14(11.7)	12(10.0)	01(0.8)
0.2-0.29	10(8.3)	09(7.5)	02(1.7)
0.3-0.39	15(12.5)	10(8.3)	02(1.7)
0.4-0.49	04(3.3)	03(2.5)	01(0.8)
0.5-0.59	15(12.5)	06(5.0)	06(5.0)
0.6-0.69	32(26.7)	13(10.8)	19(15.8)
0.7-0.79	14(11.7)	19(15.8)	04(3.3)
0.8-0.89	02(1.7)	08(6.7)	17(14.2)
0.9-0.99	09(7.5)	08(6.7)	48(40.0)
1.00	0.5(4.2)	32(26.7)	20(16.7)
Total	120(100)	12(100)	120(100)
Mean	0.548	0.681	0.844
Minimum	0.089	0.104	0.118
Maximum	1.000	1.000	1.000
Std dev	0.247	0.293	0.190

Source: Data Analysis, 2012.
*Figures in parentheses are percentages

Return to Scale

Mean scale efficiency of the rice farm is 0.844 (table 2). The result shows that there is substantial scale inefficiency in the study area. This implies that most of the farms should be larger than their present size in order to achieve higher production.

Table 3 shows that of the 120 rice farms, 21 shows constant return to scale and 99 show increasing return to scale. The mean farm size and mean output are 0.63ha and 521.94 kg respectively for fully efficient farms. The mean output of optimal scale is larger than that of sub-optimal scale. The result indicates that the optimal output level overlap a substantial portion of sub-optimal.

Table 3. Characteristics of Farms with respects to return to scale

Scale	No of farms (%)	Mean farm size (ha)	Mean output (kg)
Sub-optimal	99(82.5)	0.48	468.01
Optimal	21(17.5)	0.63	521.94
Super –optimal	-	-	-

Source: Filed survey, 2012

Input Slacks

Table 4 gives the summary of input slacks under the VRS specification. The land slack was 0.06 hectare. The result indicates that land used in rice production exhibits substantial level of infertility. The same level of output that was realized from this land area could still be obtained if the farm size were reduced by 0.06ha. The labour slack is 11.38 man days. This amount is the excess Man-days of labour used in the production process.

Fertilizer slack is 0.90kg. This amount of fertilizer was a waste in the production process. According to these results, sample farms could reduce labour use by 55.7% staying at the same production level. Number of farms using excess labour is low while that of seed is high. The greatest input excess is labour working man-days, seed and herbicide follow this.

Table 4. Distribution of input slacks

Slacks (Input)	No of Farms	Mean Slack	Mean Input use	Excess Input Use (%)
Land	22	0.056	0.89	6.29
Labour	15	11.38	20.44	55.68
Seed	69	2.85	9.51	29.97
Fertilizer	17	0.90	22.82	3.94
Herbicide	49	1.34	13.12	10.21

Source: Data Analysis¸ 2012.

Variable Affecting Technical Efficiency

Table 5 indicates the estimates of the Tobit regression under CRS and VRS specification in the study area. Under the CRS, four variables had significant effects on the technical efficiency. These are age, education, experience and farm size. There is a negative and significant relationship between technical efficiency and age. This implies that aged farmers are technically inefficient than the younger farmers. Also there is a negative and significant relationship between technical efficiency and education. In essence, educated farmers tend to be less technically efficient than the uneducated farmers.

Experience and farm size has a positive and significant relationship with technical efficiency under CRS. This implies that experienced farmers and farmers with more farm size are technically efficient than inexperienced and farmers with small farm size.

Under the VRS specification, two variables were significant. These are Age and Farm size.

Table 5. Factors Affecting Technical Efficiency

Variable	CRS Coefficient	t-value	VRS Coefficient	t-value
Constant	0.591	4.223	0.798	4.476
Age	-0.006**	-2.195	-0.006*	-1.940
Education	-0.012*	-1.672	-0.005	-0.543
Experience	0.007***	3.806	0.003	1.430
Household size	0.005	1.328	0.003	0.615
Farm size	0.055*	1.653	0.073*	1.711
Sigma	0.221	5.492	0.282	15.492
Adjusted R^2			0.152	0.028
F			5.28***	1.70
Log Likelihood function		10.612		-18.240

Source: Field survey, 2012.

CONCLUSION

The study concluded that there exists more potential that remained untapped in rice production in the study area. There is scope for increasing rice production by about 45.2% and 31.9% for technical efficiency under CRS and VRS specification respectively with the present technology in Kwara State. The determinants of efficiency are age, education, experience and farm size. Majority of the farmers were experiencing increasing return to scale. By operating on an optimal scale, input wastage could be reduced.

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