COMPARATIVE TECHNICAL EFFICIENCY OF PARTICIPANTS AND NON-PARTICIPANTS IN THE KOGI ACCELERATED RICE PRODUCTION PROGRAMME, KOGI STATE, NIGERIA

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Abstract: In this paper a stochastic frontier was applied to cross-sectional data randomly collected from 162 participants and 162 non-participants of the Kogi Accelerated Rice Production Programme in order to compare their technical efficiencies. Our results revealed that both participants and non-participants of the programme are technically efficient with mean technical efficiency of 0.959 (95.6%) and 0.826(82.6%) respectively. These results indicate that the technical efficiency of the participants is higher than the technical efficiency of non-participants. A log-likelihood ratio (LR) test statistic of 38.504 (15df) means that the technical efficiency of participants and non-participants are significantly different. We recommend that measures should be taken to improve farmers' access to education, credit facilities, land and extension contact as these would make them to be more efficient.

Keywords: Technical Efficiency, Irrigation, Rice, Participants, Non-participants.

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INTRODUCTION

Rice is a major staple food for millions of people in West Africa and the fastest growing commodity in Nigeria's food basket. According to Ibrahim *et al.* (2008) rice production has a great potential to play a crucial role in contributing to food and nutritional security, income generation, poverty alleviation and socio-economic growth of Nigerians. Although total rice production in Nigeria has increased in recent years, such increases could not meet the increasing demand from the rapidly growing population. Available statistics show that Nigeria is currently the highest rice producer in West Africa with about 3.2 million tonnes of paddy rice, paradoxically, is also Africa's largest importer of rice and the world's second largest importer (USAID, 2009; Cadoni and Angelucci, 2013). This implies that there is a prevailing demand-supply gap for in Nigeria. Similarly, Nigeria's rice consumption is projected to reach 35 million tonnes by 2050, from five million tonnes currently, rising at the rate of 7% yearly, due to population growth (Ayanwale and Amusan, 2012).

The productivity of Nigeria rice is among the lowest within neighbouring countries with average yields of 1.51t/ha. Although average yields of irrigated rice is between 3and 3.5t/ha and generally higher than yields obtained in other rice production systems, it is much lower than the potential yields estimated at between 7 and 9 t/ha (Bamba et al., 2010). The National Bureau of Statistics (NBS, 2012) reported an average yield of rice in Kogi State to be 2.05 t/ha. Although this yield is higher than the national yield of 1.51 t/ha, it is much lower than the average yields of 3 – 3.5 t/ha recorded in irrigated rice systems. This means that rice farmers in Kogi State are not getting maximum yield from their resources. Moreover, rice farmers in the state lack the necessary farm inputs to increase their production.

The major objective of the Kogi Accelerated Rice Production Programme (KARPP) is to produce sufficient rice that will fill the gap in Nigeria Rice Need Demand (NIRND) through irrigation, create wealth for farmers and poverty reduction. However, self-sufficiency in food production can only be attained by increases in farm efficiency and productivity driven by recent advances in agricultural technology. For this reason, efficiency has remained an important subject of empirical investigation particularly in developing economies where majority of the farmers are resource-poor. This is because the scope of agricultural production can be expanded and sustained by farmers through efficient use of resources (Udoh, 2000). It has been suggested that strategies towards improving productivity and efficiency must include, among others, accelerated adoption of improved crop varieties, increased restoration of soil nutrients through the use of organic and inorganic fertilizers and adoption of improved soil and water conservation technologies in order to reduce erosion and improve soil moisture content (Oduol et al., 2011). One of the key ways to improve soil moisture content is through irrigation. Irrigation is believed to increase the productivity of and efficiency of rice production because it provides opportunity for growing multiple crops per season, produces highest yield of rice per hectare and is very reliable especially now that natural rainfall can no longer be guaranteed.

Empirical studies on rice production in Kogi State focused attention primarily on profitability and technical efficiency (Onoja and Herbert, 2012; Ataboh *et al.*, 2014) while a few others (Onoja and Achike, 2010) compared resource use efficiency in irrigation and rain-fed production systems. These studies revealed that rice production in Kogi State is technically efficient but there is gap for improvement. The technical efficiency of irrigated rice farmers under the Kogi Accelerated Rice Production Programme (KARPP) has not been examined especially the comparative technical efficiency of programme's participants and non-participants. Against this background, this study is carried out to examine the comparative technical efficiency of KARPP's participants and non-participants.

Analytical Framework

The stochastic frontier production function independently proposed by Aigner et al., (1977) Meeusen and Van Den Broeck (1977) assume maximum output may not be obtained from a given input or a set of inputs because of the inefficiency effects. The production frontier model without random component can be written as:

$Y_i = f(x_i;\beta_i)$ exp $(V_i - U_i)$ $i = 1, \ldots n$ 1

Where Y_i is the observed scalar output of the producer i , x_i is a vector of N inputs used by the producer i , $f(x_i;\beta_i)$ is the production frontier, and β_i is a vector of technology parameters to be estimated. The two components V_i and U_i are assumed to be independent of each other, where V_i is a two-sided , normally distributed random error ($v_i \sim$N (0, σ_v^2) and it accounts for pure random factors on production which are outside the farmer's control such as weather , disease, etc. U_i are non-negative, one-sided efficiency component with half-normal distribution ($u_i \sim$ N(0, σ_u^2|) which captures the effect of inefficiency and hence measures the shortfall in output. The parameters of the frontier model are estimated such that Gamma (γ) = σ_u^2 / $\sigma_u^2+\sigma_v^2$, so that $0 \leq \gamma \leq 1$ and represents the total variation in output from the frontier attributable to technical efficiency. Sigma squared, $\sigma^2 = \sigma_u^2+\sigma_v^2$.The technical efficiency of an individual firm is defined in terms of the observed output(Y_i) to the corresponding frontier output (Y_i^*) given the available technology is expressed as:

$TE = \frac{Y_i}{Y_i^*}$ 2

$= f(x_i;\beta_i)$ exp $(V_i - U_i)$ / $f(x_i;\beta_i)$ exp (V_i)

$= exp(-U_i)$..3

Where: $0 \leq TE \leq 1$

The inefficiency effects model is specified as:

$U_i = \delta_0 + \sum_{d=1}^{n} \delta_d W_d + \varepsilon_i$..4

Where: U_i is farm specific inefficiency; W_d is a set of explanatory variables associated with the inefficiency effect of the farm; δ_0 and δ_d are parameters to be estimated; ε_i is the error term. Assume that $f(x_i;\beta_i)$ takes the log-linear Cobb-Douglas form, the model can be written as:

$lnY_i = \beta_0 + \sum_n \beta_n \, lnx_{ni} + v_i - u_i$……………………………………5

Tests of several null hypotheses for the parameters in the frontier production function can be performed using the generalized likelihood ratio test statistic defined by:

$\lambda = -2\{\ln [L(H_0)/ L(H_1)]\}$…………………………………..……….6

Where: $L(H_0)$ and $L(H_1)$ denote the values of the likelihood function under the null (H_0) and alternative (H_1) respectively.

If the null hypothesis is true, the test statistic has approximately a chi-squared or a mixed chi-squared distribution with degrees of freedom equal to the difference between the numbers of the parameters involved in the alternative and null hypotheses. If the inefficiency effects are absent from the model, as specified by the null hypothesis, $H_0 = \gamma = 0$, where γ and sigma-squared (σ^2) are as specified above, then λ is approximately distributed according to a mixed chi-squared distribution with at least 10 degrees of freedom. In this case, critical values for the generalized likelihood ratio test are obtained from Table1 of Kodde and Palm (1986). The Cobb-Douglas functional form was used for this study because the coefficients estimated directly represent elasticity of production and has been widely applied in estimating farm efficiencies (See Ogundari and Ojo, 2007; Hussain *et al.*,2012; Omondi and Shikuku, 2013).

The stochastic frontier production function as an econometric method of measuring efficiency has the advantage of allowing simultaneous estimation of individual technical efficiency of the respondent farmers as well as determinants of technical efficiency

(Battese and Coelli, 1995).The main strengths of the stochastic frontier approach are in its ability to deal with stochastic noise and permits statistical tests of hypotheses pertaining to production and the degree of inefficiency.

METHODOLOGY

Data

This study employed a multi-stage sampling technique in the selection of respondents for primary data collection. A total of six (6) local governments were purposively selected (Two local governments each) from Zone B, Zone C and Zone D on the basis of natural ecology, comparative advantage in rice production and where irrigated rice production took place under the Kogi Accelerated Rice Production Programme. On the basis of these, a total of 162 irrigated rice farmers were randomly selected from eleven (11) communities/villages using the ballot method and interviewed as participants in the KARPP from a list obtained from the State ADP. The selection of the participants was proportional to the number of irrigated rice farmers. An equal number of 162 irrigated rice farmers who are not participants in the programme were randomly selected as comparative or control group from purposively selected eleven (11) communities/villages based on the intensity /volume of irrigated rice production. This selection was also done using the ballot method and the sample size was proportional to size. Thus a total of 324 irrigated rice farmers were sampled as the total respondents for the study.

The main instrument used for data collection is the structured questionnaire. Data were collected in the months of May and June, 2015 from the respondents for the 2014/2015 cropping season beginning from December to April. In order to achieve accurate data collection trained enumerators were used. The enumerators were properly trained on the questionnaire and carefully supervised for proper entries. Data collected with the aid of the questionnaire were on (a) socio-economic/demographic characteristics of the respondents and (b) cultivated land size, rice output, quantity of inputs such as seed, agrochemical, fertilizer, labour, among others. In order to obtain a valid comparison group and to reduce spill-over effects, farmers located in areas where the participants are were excluded. It was also discovered that no special seed variety was given by the government and that the variety used are available in the market and is accessible by all the farmers. The support is in the provision of some free inputs, so spill-over effects is negligible.

Empirical Model

The Cobb-Douglas functional form of the stochastic frontier production function is defined as:

$lnY_i = \beta_0 + \beta_1 lnX_1 + \beta_2 lnX_2 + \beta_3 lnX_3 + \beta_4 lnX_4 + \beta_5 lnX_5 + V_i - U_i$...........7

Where:

Y_i = output (kg), X_i= labour (man-day), X_i= land (ha), X_i= seed (kg) , X_i= fertilizer (kg), X_i = agrochemical (litres), ln =natural logarithm , β_0 = intercept, $\beta_1 - \beta_5$ = output elasticity with respect to the *i*th input, V_i = two-sided stochastic noise term which accounts for the random variation in output by factors beyond the farmer's control and is independent of the U_i , U_i = one-sided non-negative error term which captures inefficiency effects in production.

The determinants of technical efficiency of farmers were estimated by:

$U_i = \delta_0 + \delta_1 Z_1 + \delta_2 Z_2 + \delta_3 Z_3 + \delta_4 Z_4 + \delta_5 Z_5 + \delta_6 Z_6 + \delta_7 Z_7 + \delta_8 Z_8 + \delta_9 Z_9 + \varepsilon_i$...8

Where:

U_i= technical inefficiency of the *i*th farmer, Z_1= education(years of formal education completed), Z_2= sex (dummy:1= male; female=0), Z_3= farming experience (years of rice farming), Z_4 = extension contact (number of visits made by extension officer to the farmer in a cropping season), Z_5= access to credit (dummy: Yes=1 ;otherwise= 0), Z_6= membership of farmers association(dummy: Yes=1;otherwise=0), Z_7= household size (number of people living under one roof and eating from the same pot), Z_8=distance covered to farm (kilometers), Z_9= participation in non-farm activities (dummy: Yes=1;otherwise= 0), δ_0- δ_9 = parameters to be estimated, ε_i= error term.

The maximum likelihood estimates (MLE) of the parameters of the stochastic frontier production function defined by equation (7), given the specifications for the inefficiency effects defined by equation (8) were determined using FRONTIER 4.1c (Battese and Coelli, 1995).

RESULT AND DISCUSSION

Technical Efficiency of Participants

The maximum likelihood estimates of the stochastic frontier production function for the participants are presented in Table 1.
As indicated in Table 1 the estimated sigma-squared value is 0.016, this represents the random error term which account for random variation in the farmers yield due to factors outside the farmer's control. These include natural factors such as nature of soil, natural weather or climatic condition of the farm sites, managerial abilities, pests and diseases etc. The value of sigma is statistically significant at 1% level of probability. The generalized likelihood ratio statistic of 19.39 exceeds the critical chi-squared value at 1% level of probability. This indicates a good fit and the correctness of the specified distributional assumption of the component error term. Thus the Cobb-Douglas functional form used in this estimation is an adequate representation of the data. The log likelihood value of gamma statistic of 0.476 is statistically significant at 1% probability level. This means that technical inefficiency effects were present in irrigated rice production in the study area Therefore, the null hypothesis which states that the parameter estimate of gamma equals zero is rejected. This finding is consistent with the findings of Okoruwa and Ogundele (2006) and Idiong (2007) who established that rice production in Nigeria is characterized by significant presence of technical

inefficiency effects. The value of gamma means that 47.6% change in the output of irrigated rice production are attributed to farmers inefficiency factors in their respective site and not as a result of random variability.

Since these factors are under the control of the farm, reducing the influence of the effect of γ will greatly enhance the technical efficiency of the farmers and improve their yield. The mean technical efficiency of the participants in KARPP is 95.9% thus leaving a gap of 4.2% for improvement. This result is similar to other results. For instance, Okoruwa and Ogundele (2006) recorded a technical efficiency of values slightly greater than 0.90 from the rice farms studied. Similarly, Ahmadu and Alufohia (2012) reported a mean TE of 92% for irrigated rice in Niger State. However, Omondi and Shikuku (2013) estimated mean technical efficiency of irrigated rice production to be 82% while Onoja and Achike (2010) estimated mean technical efficiency of the farmers managed irrigation scheme to be 73%.The result imply that there is still room for farmers to improve their output. The return to scale (computed as the sum of the estimated output elasticities of all inputs at their mean values) for the participants is 0.239.This implies that production is in stage two, the stage of positive decreasing returns to variable inputs. This is a rational (optimal) stage of production. At this stage the TE of fixed resources increases. In this stage the variable resources are abundant relative to fixed resources. Omondi and Shikuku(2013) reported a return to scale of 0.35 while Onoja and Achike (2010) recorded a decreasing return to scale of 0.813 on farmers managed irrigation scheme in Kogi State.

All estimated first-order coefficients in the production function fall between zero and one except that of land and seed. This negative estimate contradicts the monotonicity condition that all marginal products are positive at the mean input levels. All other variables of the model have expected a priori signs. The estimated elasticities of mean output with respect to labour, land, seed, fertilizer and agrochemical are 0.215,-0.158,-0.054, 0.075 and 0.318 respectively. Labour, seed and fertilizer were significant at 1% respectively while agrochemical was significant at 5% probability level. The variables with positive elasticities imply that as such variables are increased, irrigated rice output increases. For instance a 1% increase in the quantity of fertilizer used increases rice output by 0.075. This means that fertilizer increases soil fertility thereby leading to higher yields. The positive coefficient and significance of labour input usage affirmed that labour is a significant factor that positive influences change in output. The implication here is that irrigated rice production is labour-intensive arising from land preparation, water application, weeding and harvesting. Agrochemical was significant and has the highest elasticity with respect to output which means that a 1% increase in quantity of agrochemical used increases output by 0.138. Although the quantity of seed used is significant at 1%, its coefficient is negative which means that increasing the quantity of seed planted by 1% decreases output by 0.054. The coefficient of land was insignificant and negatively related to output. This is contrary to the result reported in other studies. Majority of the participant are small-scale rice farmers since they cultivated an average of 1 hectare of land. This size limits the use of other variable factors in their full capacities. These results are consistent with previous findings. For instance, Myint and Kyi (2005) found that family labour and urea fertilizer would significantly lead to increase in the yield of small farmers in irrigated rice production system in Myanmar. This is also similar to the result obtained by Ahmadu and Alufohai (2012) who reported that family labour, seed and agrochemical significantly influence rice output.

The result of the inefficiency model showed that all the socio-economic variables entered have their a priori expectation except farming experience. Access to credit is significant at 1% probability level while participation in non-farm activity is significant at 5% level of probability. The variables with negative signs reduce farmers' inefficiency while those with positive signs increases farmers' inefficiency. Thus, education, extension contact, access to credit, membership of farmers' association and participation in non-farm activities reduces farmers' inefficiency. This implies that these variables have positive effect on efficiency. Farming experience, household size and farm distance increase farmers' inefficiency, that is, they have negative effect on farmers' efficiency. Expectedly, membership of farmers' association affords a farmer the opportunity of sharing information on modern rice practices by interacting with other farmers. In addition, farmers' association may be an avenue for acquiring improved inputs and for marketing their farm products at more remunerative prices. Access to credit enables farmers to purchase assets and adopt modern farm techniques which increase farmers' efficiency. This underlines the need for improved farm credit access as emphasized by so many policy advocates in developing countries like Nigeria where farmers find it very difficult to raise start-up capital for their farm business (Onoja and Herbert, 2012). Non-farm activities provide additional source of income to farmers. Farmers who are engaged in non-farm activities have additional income which enables them to expand their farm business thereby increasing their efficiency.

The maximum likelihood estimates of the stochastic frontier production function for the non-participants are presented in Table 2. As shown in Table 2, the estimated sigma- squared value of 0.025 is statistically significant at 1% probability level, indicating a good fit and the correctness of the specified distributional assumption of the component error term. The generalized likelihood ratio statistic of 129.614 exceeds the critical chi-squared value at 1% probability level. The log-likelihood value represents the value that maximizes the joint densities in the estimated model. Thus the Cobb-Douglas functional form used in this estimation is an adequate representation of the data. The value of gamma statistic of 0.990 implies that 99% changes in the output of irrigated rice production are attributable to farmers' inefficiency factors and is significant at 1% probability level. The result revealed that technical inefficiency effects were present in irrigated rice production among the non-participants in the study area. Therefore the hypothesis which states that the parameter estimates of gamma equals zero is rejected.

The mean technical efficiency of the non-participants is 83% giving room for farmers to improve their output by 17%.This result is similar to previous studies on efficiency in irrigated rice production. For example, Omondi and Shikuku (2013) estimated TE of irrigated rice production to be 82%, Okoruwa *et al.* (2005) reported a mean TE of 83.1% for upland rice in North-Central Nigeria while Amaza and Maurice (2005) reported a mean TE of 80% for rice in Adamawa, Nigeria. The return to scale for the non-participants is 0.493.This implies production is in stage two the stage of positive decreasing returns to scale. That is, the farmers were at a stage where the marginal returns to variable input are decreasing. The results in Table 2 also revealed that only the elasticities of the quantity of labour, agrochemical and fertilizer used have expected a priori signs in the production model. The positive sign of labour, agrochemical and fertilizer implies that as such variables are increased, rice output increases. For instance, 1% increases in the use of fertilizer increases rice output by 0.052. This means that irrigated rice farmers can increase their output by using more agrochemical and adding more fertilizer. The variable with negative sign implies that the quantities of the variable input decreases as output increases. The non-conformity of the coefficients of land and seed to a priori expectations although statistically significant, may be as a result of improper use of the input by farmers in the study area at the recommended rate given the relatively small size of land irrigated. These results are consistent with studies on irrigated rice production. For instance, Myint and Kyi (2005) found that family labour and urea fertilizer would significantly increase the yield level of small scale farmers in irrigated rice production system in Myanmar while Omondi and Shikuku(2013) reported that fertilizer and labour would positively influence paddy productivity while that of chemical negatively influence paddy productivity.

The inefficiency model revealed that sex, farm distance and participation in non-farm activities are significant socio-economic factors affecting farmers' efficiency. The coefficient of education, years of farming experience, farm distance and participation in non-farm activities have expected a priori signs. Education, years of farming experience and participation in non-farm activities are negatively related to farmers' inefficiency. This implies that these factors reduce farmers' inefficiency while farm distance, household size, access to credit, extension contact and sex are the factors which increase farmers' inefficiency.

The implication of the negative sign of education is that farmers with more years of formal schooling tend to be more efficient in rice production due to their enhance ability to acquire technical knowledge which makes them move close to the frontier output. As argued by Amaza and Maurice (2005) farmers with education respond readily to the use of improved technology such as application of fertilizers, pesticides, seed, etc. and move closer to the frontier. Although contact with extension agents reduces farmers' inefficiencies as reported by various researchers, the positive sign of the coefficient here implies that non-participants are not having the required number of contacts with extension agents. It is expected that large household size provide larger work force thus a saving in labour expenditure, however, as argued by Abdullahi *et al.* (2012) what matters is not size of the family per se, but the composition and quality of those capable of working on the farm.

Test of Differences in Technical Efficiency of Participants and Non-participants

We performed a log-likelihood ratio (LR) test whether the two technical efficiency of the participants and non-participants estimated are significantly different, that is, a test to determine whether the two models (frontiers) are significantly different from each other. If the two models are the same we would have used a single model (pooled) to estimate their technical efficiency. The value of LR statistic is 38.504 (df 15).This implies that the null hypothesis is strongly rejected. This result suggests that the technical efficiency of participants and non-participants are significantly different that they do not share a single frontier (pooled).

CONCLUSION AND RECOMMENDATION

This study compared technical efficiency of participants and non-participants of KARPP using cross-sectional data collected from 162 participants and 162 non-participants. A stochastic frontier production function was used to estimate their technical efficiency. The results revealed that both participants and non-participants are technically efficient with mean technical efficiency of 0.959 (95.6%) and 0.826(82.6%) respectively, although there is still room for improvement. These results indicate revealed that the technical efficiency of participants is higher than the technical efficiency of non-participants. A log-likelihood ratio (LR) test statistic of 38.504 means that the technical efficiency of participants and non-participants are significantly different. Based on these results we conclude that the participants of the Programme are technical efficient compared to non-participants. We recommend that measures should be taken to improve farmers' access to education, credit facilities, land and extension contact as these would make them to be more efficient.

TABLES

Table 1:Maximum likelihood estimates of the stochastic frontier production function for the participants

Variables	Coeff.	Std.Error	T-value
Production Model			
Constant	-0.158	0.711	-0.221
Labour	0.215	0.063	3.415***
Land	-0.158	0.711	-0.221
Seed	-0.054	0.02	-2.647***
Fertilizer	0.075	0.022	3.373***
Agrochemical	0.318	0.129	2.472**
Inefficiency Model			
Constant	8.575	0.613	13.994***
Education	-0.026	0.077	-0.342
Farm. Exp	0.047	0.052	0.913
Ext. Contact	-0.02	0.133	-0.151
Access To Credit	-0.093	0.029	-3.179***
Mem. of Farm Ass.	-0.068	0.044	-1.565
Household Size	0.001	0.002	0.408
Farm Distance	0.013	0.01	1.333
Non-Farm Activity	-0.042	0.02	-2.127***
Goodness of Fit			
Sigma-Squared	0.016	0.003	5.344***
Gamma	0.476	0.144	3.302***
Log likelihood		148.866	
LR Test		19.396***	
RTS		0.239	
Mean Eff.		0.959	
No. of Observations		162	

***p < 0.01

** p < 0.05

* p < 0.1

Table 2:Maximum likelihood estimates of the stochastic frontier production function for the non-participants

Variables	Coeff.	Std.Error	T-value
Production Model			
Constant	0.447	0.127	3.511***
Labour	0.102	0.051	1.99**
Land	-0.083	0.052	-1.595
Seed	-0.093	0.019	-4.987***
Fertilizer	0.052	0.031	1.669*
Agrochemical	0.067	0.055	1.216
Inefficiency Model			
Constant	8.36	0.786	10.642***
Education	-0.047	0.136	-0.345
Sex	0.272	0.079	3.442***
Farm. Exp	-0.018	0.08	-0.227
Ext. Contact	0.004	0.038	0.106
Access To Credit	0.092	0.06	1.519
Household Size	0.002	0.002	0.833
Farm Distance	0.061	0.026	2.364**
Non-Farm Activity	-0.008	0.005	-1.714*
Goodness of Fit			
Sigma-Squared	0.025	0.003	7.328***
Gamma	0.99	0.015	66.892***
Log likelihood		129.614	
LR Test		39.388***	
RTS		0.493	
Mean Eff.		0.826	
No. of Observations		162	

***$p < 0.01$
** $p < 0.05$
* $p < 0.1$

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