DETERMINANT OF TECHNICAL EFFICIENCY OF NEW RICE FOR AFRICA (NERICA) PRODUCTION: A GENDER APPROACH

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Abstract

The study estimated the determinants of technical efficiency of new rice for Africa (NERICA) in Ekiti State of Nigeria. It specifically estimated technical efficiency of NERICA production among the female and male farmers. Seven villages where NERICA diffusion activities trials were conducted were chosen through purposive sampling and data for the study were obtained from a total of 315 respondents who provided useful information through face-face interview using structured pre-tested questionnaires. Data analysis was done using Cobb – Douglas Stochastic parametric frontier model to elicit the technical efficiency. The results for all the rice farmers indicated that positive coefficient of farm size, family labour, hired labour quantity of fertilizer and herbicide used indicates that as each of these variables are increased, rice output increases. The negative sign of the seeds implies that seed is being over utilized suggesting an inefficient use of planting material in the production of rice in the study area. The mean technical efficiency is 75 % which implies that on the average, the respondents were able to obtain only 75 % of the optimal output from a given mix of production inputs. The study also showed that the mean technical efficiencies for female and male farmers were 71 % and 84% respectively. Therefore, it is recommended that more female farmers should be encouraged to plant NERICA varieties and they should be provided with credit and land tenure security. Also, concerted effort should be made to increase farmers' farm size and they should be encouraged to use more fertilizer irrespective of their gender.

Key words: *Variables, Technical, Efficiency, NERICA, Rice, Farmers and Africa.*

Introduction

Nigeria has a potential 5 million hectares of land that spread across all the ecological zones, suitable for rice cultivation. Yet Nigeria still imports rice. The major reason for the importation was the inability of the local farmers to meet domestic demand due to low productivity. The West Africa Rice Development Association released a new variety called New Rice for Africa (NERICA) to boost rice production. NERICA varieties yield about 5 tons Ha^{-1}, suppresses weeds, have short duration, allowing for double cropping; they are also resistant to abiotic and biotic constraints (Jones *et.al*. 1997; Dingkuhn et al, 1998; Audebert *et al*., 1998; Johnson *et al*., 1998). NERICA is well suited to the low-input conditions of rainfed rice farming (Dingkuhn *et al*., 1998; Johnson et al., 1998) because they out yielded other varieties under poor management condition. In Uganda, NERICA is grown without fertilizer by most farmers and the average yield obtained is 2.3 tons per hectare; this is more than twice as high as the average upland rice yield in Sub Saharan Africa (Kijima *et al*., 2006). The NERICA variety an Africa miracle seed is drought tolerant, insensitive to weed, high yielding and well suited to the low-input and poor management condition of rainfed rice farming (Osiname, 2002).

Although much has been said about the agronomic superiority of NERICA over other rice cultivars, but the importance of efficiency considerations in the adoption decision regarding NERICA at the farm level is uncertain; the knowledge of the technical efficiency of NERICA production would be important and useful.

The position of individual farms relative to the frontier (whether on the frontier or below the frontier) could be influenced by environmental and farm characteristics. Ajibefun (2003) estimated technical efficiency among the farmers in the Ondo using a Tobit regression analysis and found that extension visit, higher education, land input and membership of farm associations were significant factors influencing technical efficiency. He suggested that education, input supply, and public awareness should be considered when making policy.

Onyenweaku and Effiong (2005) however, found no significant relationship between technical efficiency and credit, age, education and household size in their study. The study was

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dgned to measure the level of technical efficiency and its determinants in pig production in Akwa Ibom State, Nigeria using a stochastic frontier production function. Important determinant of technical efficiency were farming experience, farm size, membership of farmers association/cooperative society, extension contact and gender.

Awoyemi and Adekanye (1993) undertook a gender analysis of economic efficiency of cassava based farming in Oyo and Osun States. The study employed a stochastic parametric decomposition functional form to measure technical, allocative and economic efficiency of small scale cassava producers. The results indicated that the overall productive efficiency in the sample was 78.69% which implies that small scale cassava farmers in the sample could reduce total variable cost by 21.31% if they reduce labour, fertilizer, land and capital applications to levels observed in changing input mix (technical efficiency) and then obtain optimal input mix for the given input prices and technology. The empirical analysis of the data from the male respondents showed that the average economic, technical and allocative efficiency indexes were 78.07%, 87.4% and 89.33% respectively while the same, when computed for the female sample were 76.12%, 95% and 80.13% respectively. This indicates that the technical efficiency for of women was greater than that of men.

On the contrary, Udry *et al.*, (1995) showed that output per hectare was lower on plots controlled by women and that the gender yield differential was lower on the plots controlled by women and that the gender yield differential, appeared to be caused by the difference in the intensity with which measured inputs are applied rather than by differences in the efficiency with which these inputs are used. However, Adesina and Djato (1996) observed that the technical efficiency of both men and women rice farmers are similar. Labour was the most limiting factors in cassava production suggesting that the technologies that enhance the productivity of labour are likely to achieve significant positive effects on cassava production.

While there are studies that have examined adoption and production of improved rice varieties in Nigeria (Onyenweaku and Nwaru 2005; Rahji 2005) limited study is known to have examined the technical efficiency of NERICA production on gender basis in Nigeria. This study intends to bridge this gap. The objective of this study is to examine the technical efficiency of the NERICA NERICA production and among the female NERICA and male NERICA farmers.

Methodology

Study Area

Ekiti State was selected for this study because it was the first State to embrace the cultivation of NERICA in Nigeria. The state was formed in 1996 from the former old Ondo State. The state lies between Longitude 7^0N and 8^0N and Latitude 5^0E and 6^0E of the equator. The target population for this study is the small scale farmers in the State. Primary data was collected in 2007 through a survey with the aid of structured questionnaire administered by trained enumerators.

Sampling Procedure

A three stage sampling technique was employed to obtain the cross sectional data used in the study. In the first stage, the seven villages where NERICA diffusion activities trials were conducted were chosen through purposive sampling. The state lies between Longitude 7^0N and 8^0N and Latitude 5^0E and 6^0E of the equator. The climate is tropical rain forest with distinct wet and dry season. The raining (wet) season starts from middle March and ends in early November. The dry season is from November to early March. The mean annual rainfall ranges between 1,000 mm to 1,500 with high humidity of about 75%. The mean annual temperature is about 27^0C, which ranges from 21^0C – 28^0C. The population is about 1.6 million according to the 1991 census.

They are Epe, Oye, Igbole, Agbado, Iworoko, Eringiyan and Oke Ado located in seven Local Government Areas of Ekiti State. (Ekiti ADP, 2005). All these seven villages were therefore used for this study.

In the second stage, two non NERICA villages within a fifteen – kilometer radius were randomly selected. Fifteen farmers were randomly chosen from each of the selected 21 villages in the third stage making a total sample size of 315 rice farmers. The survey was restricted to rice farmers only. Non-rice farmers were randomly replaced whenever present in the first random draw.

Analytical Technique

This study employed the stochastic parametric frontier model to estimate the technical efficiency of NERICA and non NERICA rice producers and the female and male rice farmers in the study area.

$A_i = B_i\beta_+ (V_i - U_i)$, i = 1... 6

For male NERICA farmers

B_i is a k x 1 vector of (transformations of the) input quantities of the i-th firm (all respondent);

β is a vector of unknown parameters to be estimated;

V_I are random variables two sided ($-\infty < v_i <$) normally distributed random error $N \sim (0, \sigma_v^2)$.

U_i is a one sided ($U_i \geq 0$) efficiency component that captures the technical inefficiency of the farmers. In other words, u measures the shortfall in ouput Y_r and Y_s from its maximum value given by the stochastic frontier $(B_{i;}\beta) + V_i$.

The technical efficiency of the farms, assuming the Cobb-Douglas production function is expressed as:

Technical efficiency (TE) = Y_i / Y_i^*..

Where Y_i is the observed output and Y_i^* is frontier output.

TE = Y_i / Y_i^* which is obtained by the use of frontier 4.1(Coelli, 1995). Based on the individual farm's technical efficiency, the mean technical efficiency for the sample is obtained (Yao and Lui, 1998).

Description of Variables used in the Technical Efficiency Model

Q = Output is the total quantity of rice harvested using the new NERICA technology and the non NERICA technology and it is standardized in grain equivalent tonnes. This output includes the portion consumed and given away as gift. The output was measured in kilogram

B_1 = Farm Size; B_2 = Family labour is expressed in man days equivalent; B_3 = Hired labour in man day; B_4 = the quantity of fertilizer used in Kilogram. The apriori expectation of fertilizer is positive; B_5 = Herbicide; B_6 = seed. This is the quantity of seed in kilogram. The apriori expectation is $\delta Q/\delta x_6 > 0$. That is the variable is expected to a positive significant effect on the farmers efficiency.

Determinant of Efficiency

To identify the determinant of efficiencies or inefficiencies, a second step of estimation procedure was used, Rahji, (2005). In this procedure the technical efficiencies empirically identified were regressed against the farm and farmers characteristics that were hypothesized to influence it (Rahji, 2005). The efficiency index was transformed into the natural logarithm of the ratio of efficiency to inefficiency (TEI). This transformation makes it possible for the ratio to assume any value. The dependent variable of the estimating equation thus becomes:

TEI = ln(TE/1-TE)

The independent variables hypothesized to determine the productive efficiency as follows: Z_1 = Age of farmers measured in years (years); Z_2 = Education of respondent. Z_3 = Gender in this study is used to measured the sex of farmer where dummy 1 is for male and zero for female, Z_4 = Family size (number); Z_5 = land ownership; Z_6 = Amount of Credit in Naira. The farmers in the study have access to credit; Z_7 = Land constraint captures the farmers access to as much land as needed to rice cultivation. Z_8 = Land tenure (dummy: have security of tenure =1, otherwise = 0)

Results and Discussion

Analysis of Stochastic Frontier Estimation

Table 1 shows the likelihood parameters of the stochastic production frontier for all the respondents combined. It also presents the expected parameters and the related statistical test results obtained from the analysis of the maximum likelihood estimates (MLE) of the Cobb-Douglas based stochastic frontier production function for rice farmers.

The output of rice is influenced by farm size, family labour, hired labour quantity of fertilizer quantity of herbicide and quantity of seed for all the respondents. These variables except quantity of seeds used have positive signs which conformed to the a priori expectation. The positive coefficient of farm size, family labour, hired labour quantity of fertilizer and herbicide used indicates that as each of these variables are increased, ceteris paribus rice output increases. The negative sign of the seeds implies that seed is being over utilized suggesting an inefficient use of planting material in the production of rice in the study area. The non – conformity of the seeds coefficient to a priori expectation could be due to the planting method. In the study area the farmers plant rice by dribbling. Also, most farmers recycle their old seeds, in order to have good emergence count thus farmers may use more seeds than required to make allowance for non-viable seeds. This implies that as more quantity of seeds are used the output of rice decreased. This variable is however not significant. The coefficient of fertilizer is not significant and this does not agree with Awoyinka (2005). The coefficient of farm size is significant at one percent level of significance. This is the major factor influencing rice production in the area. The coefficients of the variable associated with family labour, hired labour and herbicide are not statistically significant.

The variance parameters of production function which is represented by sigma-squared (δ^2) and gamma (γ) are significant at 1 %. The Lambda, which is the estimated ratio of the standard error of (U_i) to that of v_i is greater than one (λ = 3.8). This means that the one sided error term (u_i) dominates the symmetric error (v_i). The statistically significance of Lambda indicates that there is sufficient evidence to suggest technical inefficiencies are present in the data. This implies a good fit for the estimated model and the correctness of the distributional assumptions for the u_i and the v_i and shows that a great part of the residual variation in output is associated with technical inefficiency rather than with measurement error which is associated with uncontrollable factors related to the production process (Habibullah and Ismail,1994). The gamma is 0.94 and significant at 1% this also implies a good fit for the model. The estimated gamma reveals that the amount of the variation in rice outputs which results from technical efficiency of the sample farmers.

Table 1 Estimated Stochastic Production Frontier Function for all the Farmers

Variable	Parameters	Coefficients	Standard Error	t-value
Constant	a_0	7.413*	0.2610	28.41
Farm size (B1)	a_1	0.784*	0.0520	15.08
Family labour (B2)	a_2	0.000	0.0280	0.00
Hired labour (B3)	a_3	0.068	0.0378	1.18
Fertilizer (b4)	a_4	0.067	0.0133	1.51
Herbicide (B5)	a_5	0.009	0.0473	0.19
Seed (B6)	a_6	-0.104	0.0549	-1.18
Variance Parameter				
Log-likelihood function	-20.2471			
sigma-squared (σ^2)	$\sigma u^2 + \sigma v^2$	2.090	1.1181	1.76
gamma(γ)	$\sigma u^2/\sigma^2$	0.941*	0.0338	27.80
Lambda(λ)	$\sigma u/ \sigma v$	3.8		
σu^2		1.96		
σv^2		0.13		
σu		1.4		
σv		0.36		
Sample size (n)		315		
Mean technical efficiency		75		

*, **, *** Estimates are significant at 1%, 5% and 5% level of significance respectively.

The technical efficiency indices of the farmers are derived from the analysis of the stochastic frontier production function in equation 33. The level of predicted technical efficiency revealed that the technical efficiency indices range from 22 to 94% for the farms in the sample. This implies that the best farm has a technical efficiency of 94% while the worst farm has a technical efficiency of 22%. The predicted technical efficiency analysis of rice producers in the study area showed that technical inefficiency effects existed in rice production in the study area as indicated by the gamma value of 0.94 that was significant at 1% level of significance. The mean technical efficiency is 75% which implies that on the average, the respondents were able to obtain only 75% of the optimal output from a given mix of production inputs (Habibullah and Ismail, 1994).The results also mean that, if the average farmer in the sample was to achieve the technical efficiency level of its most efficient counterpart, then the average farmer could make a 20 % cost savings [that is 1 – (75/94) x 100]. The calculation for the most technically inefficient farmer reveals a cost saving of 76 percent [that is 1 – (22/94) x 100] (Bravo-Ureta and Pinhero, 1997).

Tables 2a and 2b present the expected parameters and the related statistical test results obtained from the analysis of the maximum likelihood estimates (MLE) of the Cobb-Douglas based stochastic frontier production function for female and male NERICA farmers.

Table 2a Estimated Stochastic Production Frontier Function for the Female Farmers

Variable	Parameters	Coefficient	Standard Error	t-value
Constant	g_0	7.324*	0.5298	13.8238
Farm size (H_1)	g_1	0 .7974*	0.110	7.2292
Family labour(H_2)	g_2	-0.0860	0.0614	-1.3997
Hired labour(H_3)	g_3	0.106	0.0999	1.070
Fertilizer(H_4)	g_4	0.085 *	0.0264	3.2468
Herbicide(H_5)	g_5	- 0.078	0.1066	-0.7390
Seed(H_6)	g_6	-0.038	0.1181	-0.324
Variance Parameter				
Log-likelihood function	-80.2895			
sigma-squared (σ^2)	$\sigma u^2 + \sigma v^2$	1.053	1.0506	1.0024
gamma(ɣ)	$\sigma u^2/\sigma^2$	0.848*	0.1577	5.3810
Lambda(λ)	$\sigma u/ \sigma v$	2.353		
σu^2		0.892		
σv^2		0.161		
σu		0.944		
σv		0.4012		
Sample size (n)		103		
Mean efficiency		0.7099		

*, **, *** Estimates are significant at 1%, 5% and 5% level of significance, respectively.

Table 2a shows that the output of female NERICA farmers is influenced by farm size, family labour, hired labour, quantity of fertilizer, herbicide and seeds. Farm size, hired labour and fertilizer have the expected signs. Their increase will improve the output of NERICA**.** However, hired labour is not significant but farm size and fertilizer are significant at one percent significant level. These are the major factor influencing NERICA output among the female. The coefficients family labour, herbicide and seeds have negative sign which implies that if these inputs are increased, output of NERICA among the female will decreased. It also showed that the farmers are over utilizing these variables although these variables are not significant.

The variance parameters of production function (gamma (ɣ)) are not significant even at 10 percent significant level. The Lambda (is 4.2) which is the estimated ratio of the standard error of (U_i) to that of ($v_{i)}$ is greater than one. This means that the one sided error term (u_i) dominates the symmetric error (v_i). The statistically significance of Lambda indicates that there is sufficient evidence to suggest technical inefficiencies are present in the data. This implies a good fit for the estimated model and the correctness of the distributional assumptions for the u_i and the v_i and shows that a great part of the residual variation in output is associated with technical inefficiency rather than with measurement error which is associated with uncontrollable factors related to the production process.

The gamma is 0.87 and significant at one (1) percent, this also implies a good fit for the model. The estimated gamma reveals that the amount of the variation in NERICA outputs which results from technical inefficiency of the sampled female farmers. In other word 87 % of the deviation from the production frontier is a result inefficiency of the farmers. The mean technical efficiency is 71 % which implies that on the average, the respondents were able to obtain only 71 % of the optimal output from a given mix of production inputs.

Table 2b Estimated Stochastic Production Frontier Function for the Male Farmers

Variable	Parameters	Coefficient	Standard Error	t-value
Constant	i_0	1.757 *	0.3135	24.1561
Farm size(J_1)	i_1	0 .798*	1.5788	13.496
Family labour(J_2)	i_2	0.019	0.3192	0.6138
Hired labour(J_3)	i_3	0.0364	0.0414	0.8800
Fertilizer(J_4)	i_4	0.0642*	0.0141	4.538
Herbicide(J_5)	i_5	0.33	0.0513	0.0658
Seed(J_6)	i_6	-0.126**	0.0620	-2.032
Variance Parameter				
Log-likelihood function	-110.99			
sigma-squared (σ^2)	$\sigma u^2 + \sigma v^2$	0.843	0.5542	1.5222
gamma(ɣ)	$\sigma u^2/\sigma^2$	0.876 *	0.0813	10.7839
Lambda(λ)	$\sigma u/ \sigma v$	4.213		
σu^2		0.738		
σv^2		0.042		
σu		0.859		
σv		0.204		
Sample size (n)		212		
Mean efficiency		0.7099		

*, **, *** Estimates are significant at 1%, 5% and 5% level of significance, respectively.

The results of the male NERICA farmers on table 2b revealed that farm size, family labour, hired labour, quantity of fertilizer and quantity of herbicide have the expected signs except the quantity of seeds. The increase in these variables (except quantity of seeds) will increase output of NERICA among the male. The negative signs of the coefficient of seeds imply that the output of NERICA will decline will with additional use of seeds. This is significant at one percent significant level. The explanation for the non-conformity of the coefficient of seeds to a priori expectation has been given earlier. The coefficients of farm size and fertilizer are significant at one percent level of significant. Farm size, fertilizer and seeds are the major factors influencing NERICA output in the study area.

The gamma (ɣ) which represents the variance parameters of production function is significant even at one percent significant level. The Lambda, which is the estimated ratio of the standard error of (U_i) to that of v_i is greater than one. This means that the one sided error term (u_i) dominates the symmetric error (v_i). The statistically significance of Lambda indicates that there is sufficient evidence to suggest technical inefficiencies are present in the data. This implies a good fit for the estimated model and the correctness of the distributional assumptions for the u_i and the v_i and shows that a great part of the residual variation in output is associated with technical inefficiency rather than with measurement error which is associated with uncontrollable factors related to the production process (Habibullah and Ismail,1994).

The gamma is 0.84 and significant at one (1) percent, this also implies a good fit for the model. The estimated gamma reveals that the amount of the variation in NERICA outputs which results from technical inefficiency of the sampled male farmers. In other word 84 percent of the deviation from the production frontier is a result inefficiency of the farmers. The mean technical efficiency is 71 percent which implies that on the average, the respondents were able to obtain only 71 percent of the optimal output from a given mix of production inputs.

Conclusion and Recommendation

The technical efficiency of New Rice for Africa (NERICA) production was assessed among the female and male farmers. It explored the factors that were responsible for the technical inefficiency of NERICA and non NERICA production and female and male farms.

The results obtained in this study revealed that the female farmers are technically inefficient compared to the male farmers and the following policy measures are recommended: more female farmers should be encouraged to plant NERICA varieties. The study revealed that there is resource inequality among female and male farmers and so the female rice farmers should be provided with credit, land tenure security and land of their own since these variables significantly increase the technical efficiency among female farmers. Finally, to increase rice production in Nigeria concerted effort should be made to increase farmers' farm size and all farmers should be encouraged to use more fertilizers.

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