PRODUCTION EFFICIENCY AMONG GROWERS OF NEW RICE FOR AFRICA IN THE SAVANNA ZONE OF NIGERIA

TIAMIYU S.A.[1], AKINTOLA J.O.[2], RAHJI M.A.Y.[3]

[1]National Cereals Research Institute, Badeggi, PMB 8, Bida, Niger State, Nigeria
[2]Department of Agricultural Economics, Bowen University, Iwo, Osun State, Nigeria
[3]Department of Agricultural Economics, University of Ibadan, Oyo State, Nigeria

Abstract

The technical, allocative and economic efficiencies of farmers who grow the New Rice for Africa (NERICA) were examined empirically in this study. The probabilistic frontier production function was used to predict the farm level technical efficiency which serves as basis for estimating the economic efficiency. Results showed that rice output is inelastic with respect to herbicide (0.04), land (0.25), fertilizer (0.31), seed (0.33), labour (0.46) and statistically significant ($P < 0.01$). Rice farms in the study area exhibits increasing positive return to scale (1.3), indicating that farmers were not efficient in allocating their resources. The average technical, allocative and economic efficiency indices of 0.65 (±0.059), 0.59 (±0.111) and 0.39 (±0.094) respectively, indicate considerable room for increase productivity of rice farmers through improvement in their production efficiencies. Efficiency indices were significantly ($P < 0.05$) affected by age of farmer, farming experience, extension contact and credit use. Improvement of those factors that significantly affect efficiency indices is recommended.

Key words: upland rice productivity, New Rice for Africa, efficiency indices, probabilistic frontier approach, Savanna zone, Nigeria

INTRODUCTION

The inability of Nigeria agricultural sector to meet up with the demand for rice as evidenced from a substantial amount of foreign exchange committed to rice importation has made self-sufficiency in rice production a major part of policy goal of Nigeria government. In response to this goal, upland production system which is the most accessible but least productive when compared with the lowland and irrigated systems (Olagoke, 1991, is being exploited for rice production (Longtau, 2003). The increase in upland rice area has contributed to increasing trend of rice output over the years (CBN, 2005), however, annual growth rate has continue to decline (Hussein, 2004). The declining growth rate could be attributed to low productivity of upland system (Akande, 1994). As an attempt to increase productivity of upland rice, Nigeria government has been promoting the use of NERICA varieties by farmers since 2003 when it was officially released. The New Rice for Africa (NERICA) was specifically bred by scientist of Africa Rice Center (WARDA) to address the problem of low productivity of upland rice in sub-Sahara Africa. Although recent studies showed evidence of adoption of NERICA varieties by Nigeria farmers (Spencer et al., 2006, Tiamiyu et al., 2006), there is no empirical study yet that actually evaluate the potential of NERICA in addressing the problem of low productivity in Nigeria. Given the fact that efficiency of production is directly related to the overall productivity, this study aims at exploring how upland rice productivity can be increased through examination of the levels and determinants of production efficiency of farmers who grow NERICA.

Measurement of efficiency began with the work of Farrell (1957) who gave definitions for both technical and allocation efficiencies, starting from the deterministic frontiers concept. The major weakness of deterministic frontier lies in its susceptibility to extreme observations and measurement errors. In order to circumvent the problem of outlier observations which usually affect the estimated coefficients under a deterministic approach Aigner and Chu (1968) proposed probabilistic frontier function which was implemented by Timmer (1971). Application of probabilistic frontier function is very scanty in efficiency literature (Ali and Chaudhry, 1990; Kipkoechi, 2007). In this study, probabilistic frontier production function was used to estimate technical efficiency. Most of the previous studies in Nigeria (Ajibefun et al., 2002; Ogundele and Okoruwa, 2004; Amaza, et al. 2006; Ogundari and Ojo, 2006) used stochastic frontier approach. Hence this study is expected to make contribution to efficiency literatures in the Nigerian context. To be useful for policy intervention, efficiency measurements in this study were disaggregated into technical, allocative and economic efficiencies.

MATERIALS AND METHODS

Using multistage sampling technique, a total of 227 farmers selected from 25 villages in Kaduna and Nasarawa states in the savanna zone of Nigeria provided data for this study. Information pertaining to production activities for 2006 was obtained through structured questionnaires that were administered on farmers who grow NERICA varieties. Data were analyzed using ordinary least square (OLS) regression and probabilistic frontier model (Timmer, 1971). The logarithmic form of the estimated Cobb-Douglas production function for the purpose of estimating technical efficiency indices is specified as:

$$\ln Y = \ln\beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta_5 \ln X_5 + \varepsilon \quad (1)$$

where:

Q = total rice output (kg)
X_1 = rice farm size (ha)
X_2 = total labour used in rice production (mandays)
X_3 = quantity of seeds used in planting (kg)
X_4 = total quantity of fertilizer (kg)
X_5 = volume of herbicide (litres)
βi = parameters to be estimated (i = 0, 1, 2, 3, 4, 5)
u = error terms
ln = the natural logarithm (i.e. to base e).

Following procedure used by Ali and Chaudhry, 1990, equation (1) was transformed into a probabilistic frontier function that was used to predict the technical efficiency which serves as basis for estimating the allocative and economic efficiency indices of farmers. Relationship between efficiency indices and socioeconomic variables was investigated separately for technical, allocative and economic efficiency indices using OLS regression models as specified below:

$$EI = b_0 + b_1 S_{1i} + b_2 S_{2i} + b_3 S_{3i} + b_4 S_{4i} + b_5 S_{5i} + b_{6i} S_{6i} + b_{9i} S_{9i} \quad (2)$$

Where:

EI = efficiency indices
S_1 = age of rice farmer in years
S_2 = number of years of schooling completed by rice farmer
S_3 = land tenure status, dummy, 1 for owner-operator, 0 otherwise
S_4 = rice farming experience in years
S_5 = farm income, in thousand naira
S_6 = number of people in the household
S_7 = number of contact with extension agent per cropping season
S_8 = membership of farming association, dummy, 1 for member, 0 otherwise
S_9 = credit use, dummy, 1 for farmers that reported receiving credit, 0 otherwise.

RESULTS AND DISCUSSION

Probabilistic frontier production function

The estimated coefficients of the average and frontier production functions for the sample farmers are presented in Table 1. The signs on the coefficients of the probabilistic frontier are as expected. The estimated output elasticities of the frontier production function are positive and significant for all the inputs, meaning that output increases by the value of each coefficient as the quantity of each variable increase by unity. Based on the coefficient of each input, the important factors of production are labour, seeds, fertilizer, land and herbicide in order of impact on output of paddy. The elasticity of rice output with respect to herbicide was the least among the input considered in the production function fitted. The low value of coefficient for herbicide could be attributed to low rate of herbicide applied by farmers in the area. Land also has low coefficient (0.25) reflecting the small scale nature of Nigeria agricultural production. Labour has the largest coefficient (0.46), meaning that the largest impact on output on average would be experienced if additional labour was imputed on the farms. This is expected in a situation where the resource-poor small farmers depend largely on labour for production. The sum of estimated coefficients of the explanatory variables of the general models is 1.3, showing that all the variables have positive increasing function to the factors (the stage of inefficient factor usage). This shows that more of the variable inputs could be employed to achieve more output.

Analysis of efficiency indices

Distribution of the rice farmers' efficiency indices is presented in Table 2. The technical efficiency of all the sampled farmers is less than one (or 100%) indicating that all the rice farmers sampled were operating below the frontier. The best performing farm has a technical efficiency of 0.84 (or 84%), while the least performing farm has a technical efficiency of 0.43 (43%). The average technical efficiency of the rice farmers is 0.65 (or 65%). This means that there exists a 35% potential for increasing farmers output at the existing level of their resources if they were to operate at the frontier or by 19 percent if all farmers would adopt the technology and production techniques currently used by the most technically efficient farmer. The high production gap that exists between the 'best-practice' farmers and 'average' farmers suggests the need to strengthen the existing agricultural development structure to exploit the above mentioned potential.

The distribution of allocative efficiency indices of the rice farmers revealed an average of 0.59. This means that rice farmers were able to obtain only 59% of optimal output for a given set of production input prices. The best performing farm had allocative efficiency index of 0.76, while the least performing farm had allocative efficiency index of 0.25. The mean allocative efficiency of 0.59 suggest that there is scope for increasing rice production in the study area by 41% if they are to operate at the frontier or by 39% if all rice farmers would operate at the level currently used by the most allocatively efficient farmer.

The economic efficiency indices derived from the product of technical and allocative efficiencies showed that the sampled farmers were generally economically inefficient. The average economic efficiency level for the

Tab. 1: Parameter estimates from probabilistic production frontier

Variable	Average		Frontier	
	coefficients	t-statistics	coefficients	t-statistics
Intercept	1.90223a (0.648558)	2.933015	2.3239a (0.4987)	4.660062
Land	0.236201b (0.12146)	1.944673	0.2501a (0.0932	2.683881
Labour	0.605428a (0.127782)	4.737987	0.4656a (0.0987)	4.718521
Seeds	0.38599a (0.102315)	3.772578	0.3293 (0.0786)a	4.187822
Fertilizer	0.207036a (0.01603)	12.9157	0.3059a (0.0146)	20.90682
Herbicide	0.059177a (0.010575)	5.595889	0.0439a (0.0082)	5.348788
F-ratio	1 453		2 471	
Adjusted R	0.97		0.98	
Observation	227		226	

a = significant at the 1% level, b = significant at the 5% level; standard errors are in parenthesis
Source: Extracted from results of data analysis

Tab. 2: Frequency distribution of efficiency indices

Efficiency indices	Technical efficiency		Allocative efficiency		Economic efficiency	
	frequency	%	frequency	%	frequency	%
90 <100	0	0	0	0	0	0
80 < 90	3	1.3	0	0	0	0
70 < 80	42	18.6	33	14.6	0	0
60 < 70	146	64.6	83	36.7	1	0.4
50 < 60	33	14.6	54	23.9	22	9.7
40 < 50	2	0.9	45	19.9	95	42.0
30 < 40	0	0	9	4.0	64	28.3
20 < 30	0	0	2	0.9	38	16.8
10 < 20	0	0	0	0	6	2.7
Mean	0.653891		0.588139		0.388132	
Minimum	0.431196		0.254098		0.11413	
Maximum	0.843455		0.768854		0.610115	

Source: Computed from result of data analysis sample is 39% with a minimum of 11% and a maximum of 61%. The mean economic efficiency of 39% indicated that the rice farmers were able to obtain only about 39 of optimal output from a given set of production inputs. This implies that there exists a potential for increasing the economic efficiency of the farmers.

Factors affecting efficiency indices

The summary statistics of socioeconomic variables of respondents and the results of OLS regression estimation of the variables and efficiency indices are presented in Table 3 and Table 4 respectively. Age of rice farmers has a negative and significant effect on all efficiency indices, which suggest that, on average, younger farmers operate at higher efficiency levels than older farmers. Age of farmer is expected to influence efficiency in any direction depending on the education level and experience. Age contribute positively if the level of farmer's education and experience in farming is high, and negatively, if the level of education and experience of farmers is low. There is significant ($P \leq 0.01$) but negative relationship between age and efficiency indices. This is expected where younger farmers are more educated, and thus more successful in gathering information about new technology, which in turn will improve their efficiency.

Education enhances a farmer's ability to seek and make good use of information about production inputs, and therefore, expected to influence efficiency positively. The relationship between allocative and economic efficiency indices and education was positive and statistically significant ($P \leq 0.10$). This could be attributed to the exposure of the educated farmers to complementary production technology.

Land tenure arrangement may influence the extent to which a given crop could be cultivated. Land ownership status of farmer is expected to influence efficiency in any direction; hence the sign of the coefficient of this variable cannot be predicted a priori. Land ownership status is expected to be positively related to efficiency if it is assumed that the ownership of farmland will encourage individual operator to pay attention to the maintenance of soil quality and take greater risk to try improved production technique on his farm. On the other hand, tenant farmers are likely to be more efficient so as to be able to pay rent and make reasonable profit to keep him in business. In this study, allocative and economic efficiency indices are positively influenced by land ownership status, while there is negative but insignificant relationship between land ownership status and technical efficiency indices. However, only allocative efficiency indices are statistically significant ($P \leq 0.10$), indicating that owner operators are more allocatively efficient than tenants.

Farming experience could take on either negative or positive sign, depending on the length of period and farmer's education level. Increased farming experience coupled with higher level of educational achievement may lead to better assessment of the importance and complexities of good farming decision. Results revealed a positive and significant coefficient for rice farming experience in

Tab. 3: Summary of descriptive statistics of socio-demographic variables of respondents

Variables	Minimum	Maximum	Mean	Standard deviation
Age of farmer (years)	23	23	44	8.07
Education (school year)	0	0	3.5	4.12
Tenure status (dummy)	0	0	0.76	0.42
Rice farming experience(year)	12	12	24	3.43
Farm income (N'000)	100	23	299	88.17
Family size	3	0	9	2.47
Family labour	1	0	6	2.04
Extension contact per season	0	12	3.2	3.39
Membership of association	0	590	0.45	0.49
Credit use	0	15	0.19	0.39
Commercialization level	0.25	12	0.64	0.14
		10		
		1		
		1		
		0.90		

Source: Computed from field data, 2006

Tab. 4: Regression estimates of the efficiency indices and socioeconomic variables

Variable	Technical		Allocative		Economic	
	coefficients	t-statistics	coefficients	t-statistics	coefficients	t-statistics
Constant	0.734409 (0.046109)	15.92779	0.577234 (0.05463)	10.56623	0.425475 (0.055102)	7.721656
X_1 = age	–0.00336 (0.000737)	–4.56265	–0.00577 (0.000873)	–6.60941	–0.005580 (0.00088)	–6.33403
X_2 = education	0.00021 (0.001291)	0.162717	0.004144 (0.00153)	2.70853	0.002818 (0.001543)	1.825836
X_3 = landownersp	–0.00028 (0.009276)	–0.0299	0.020876 (0.01099)	1.899536	0.01149 (0.011085)	1.036492
X_4 = farm expr.	0.002059 (0.00144)	1.429732	0.007608 (0.001706)	4.459243	0.006149 (0.001721)	3.57327
X_5 = income	–2.3E-05 (4.48E-05)	–0.51184	–3.4E-05 (5.3E-05)	–0.64692	–3.5E-05 (5.35E-05)	–0.66113
X_6 = famlysize	0.003361 (1.984893)	1.801319	0.004092 (0.00221)	1.85122	0.004425 (0.002229)	1.984893
X_7 = ext. visit	0.004234 (0.001944)	2.177908	0.007663 (0.002323)	3.326647	0.007982 (0.002303)	3.43567
X_8 = associatn	–0.01294 (0.008402)	–1.54071	0.005902 (0.009955)	0.592876	–0.00554 (0.01004)	–0.55135
X_9 = credit use	–0.07044 (0.012232)	–5.75895	–0.0136 (0.014493)	–0.93821	–0.05615 (0.014618)	–3.84124
F	8.366786		58.00927		32.97186	
R-Square	0.258499		0.70735		0.578739	
Adjusted R^2	0.227603		0.695156		0.561187	

Note: Standard errors are in parenthesis
Source: Computed from results of data analysis (2006)

allocative and economic efficiency indices implies that farmers with more years of experience tend to be more efficient.

Access to extension agents is expected to increase the efficiency of rice farmers, if farmers learn from the services provide by extension agents. Positive and significant ($P \leq 0.05$) coefficient of access to extension agents in this study implies that access to extension agent increase the efficiency of rice farmers.

Credit use is expected to assist farmers purchase necessary inputs for crop production. It also provides farmers with additional source of investment in new ideas and therefore expected to be positively related to efficiency. The coefficients of regressors in the technical and economic equations are negative and significant. This implies that credit use significantly reduce rice farmers' technical and economic efficiencies. The reason may be due to wrong use of credit.

CONCLUSION

It is evident from the results of efficiency estimation that the sampled farmers were yet to be on the production frontier, indicating that there is room for improvement in technical, allocative and economic efficiencies. The sampled farmers have higher ability to produce larger quantities of output from the same quantities of measurable inputs (more technically efficient) than their ability to maximize profit (less allocatively efficient). The implication is that allocative inefficiency constitutes a more serious problem than technical inefficiency in the economic inefficiency of the sampled farmers. The variable inputs allocation was in stage I of production surface (the stage of inefficient factor usage). This shows that efforts should be made to expand the present scope of production to actualize the potential in it, that is, more of the variable inputs such as fertilizer and herbicide could be employed to achieve more output.

Analysis of relationship between efficiency indices and socioeconomic variables revealed that age of farmer, farmers education, farmers experience, extension contact and credit use are the significant factors affecting efficiency of the sampled rice farmers. These significant factors need to be improved if efficiency improvement is to be the policy focus in increasing upland rice productivity. In these regards the following recommendations are made:

- More use of productive inputs like fertilizer should be encouraged among older farmers who are less efficient, since age is negatively related to efficiency indices.
- Since education and extension contact affect efficiency indices positively and significantly, more farmers should be focused in extension and training activities. This entails adequate funding of research, training and extension activities.
- As credit use was found to be negatively related to efficiency indices, farmers should be prevented from using credit wrongly by monitoring and ensure that credit obtained are used for the right purposes.

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Corresponding author:

Saliu Akinlabi Tiamiyu
National Cereals Research Institute
Badeggi, PMB 8, Bida
Niger State, Nigeria
e-mail: satiamiyu@yahoo.com