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TECHNICAL EFFICIENCY OF RICE FARMERS IN EBONYI STATE, NIGERIA

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ABSTRACT
This study was designed to measure the level of technical efficiency and its determinants in rice production in Ebonyi State, Nigeria using a stochastic frontier production function. Multi- stage random sampling technique was used to select 160 rice farmers using the cost –route approach. The estimated farm level technical efficiency ranged from 17.19% to 93. 13% with a mean of 65.06%. The wide variations in the level of technical efficiency indicates that ample opportunities exist for farmers to increase their productivity and income through improvements in technical efficiency. Credit, education, farming experience, farm size, membership of farmer's associations/cooperative society, use of improved rice varieties, extension contact, system of production, and timeliness of farm operations were found to be positively and significantly related to technical efficiency. The study found no relationship between technical efficiency and age, tenancy status and off-farm employment in the study area.
Keywords *Technical efficiency, frontier production function, rice*

INTRODUCTION
Rice (*Oryza Sativa*) is an important staple cereal in the diet of Nigerians. Domestic demand for rice out spaces domestic production resulting in massive importation of rice in the country. The rice import bill rose from N431.203 million in 1994 to N13.122 billion in 1998 (FOS, 1999).

A key feature of rice production in Nigeria is the widely dispersed small holders production base. Rice is grown on small farms using traditional manual, low input production techniques. The main inputs are land and labour; input markets to support rice production are poorly developed or non-existent. Farmers have little, if any, access to formal credit or to supplies of quality seed, fertilizers, pesticides and agricultural machinery. The resultant effect is low productivity. Increasing productivity requires continued investments in research to raise the production frontier. In addition, substantial opportunities exist to raise rice productivity in Nigeria by increasing the efficiency with which resources are used at the farm level. This is because many studies have shown that Nigerian rice farmer are inefficient in resource use (Eremie, 1986, Dittoh 1991, Olagoke 1991 Onyenweaku 1994, Onyenweaku, Agu and Obasi, 2000, Ohajianya and Onyenweaku, 2001 and 2002).

The objective of this study is to measure technical efficiency and its determinants in rice production in Ebonyi State, Nigeria using the stochastic frontier production function. Technical efficiency here refers to the ability to produce the highest level of output with a

given bundle of resources (ability to produce on the production frontier). Previous studies of the above authors on resource use efficiency in rice production in Nigeria employed the ordinary least squares (OLS) estimation technique, which provides only an average function and cannot determine farm level technical efficiency. The stochastic frontier production function overcomes this limitation of the OLS by providing numerical measures of technical efficiency of individual farmers in a sample.

MATERIALS AND METHODS

The Theoretical Model; A Stochastic Production function is defined by

$$Yi = f(X_i;B) \exp (V_i-U_i), i=1,2.....n \quad (1)$$

where Y_i is output of the i-th farm, Xi is the vector of input quantities used by the i-th farm, B is a vector of unknown parameters to be estimated, f(.) represents an appropriate function (eg. Cobb Douglas, translog etc). The term V_i is a symmetric error, which accounts for random variations in output due to factors beyond the control of the farmer e.g. weather, disease outbreaks, measurement errors etc, while the term U_i is a non negative random variable representing inefficiency in production relative to the stochastic frontier. The random error V_i is assumed to be independently and identically distributed as $N(o, ó_v^2)$ random variables independent of the U_is which are assumed to be non-negative truncations of the $N(o\ ó_u^2)$ distribution (i.e. half-normal distribution) or have exponential distribution.

The stochastic frontier model was independently proposed by Aigner, Lovell, and Schmidt (1977) and Meeusen and van den Broeck (1977). The technical efficiency of an individual farmer is defined in terms of the ratio of the observed output to the corresponding frontier output, given the available technology.

Technical efficiency (TE) = Y_i/Y_i^*

$= f(X_i;B) \exp (Vi-Ui) / f(Xi, B) \exp (Vi) = Exp (-Ui)$.....(2)

where Y_i is the observed output and Yi* is the frontier output.

The parameters of the stochastic frontier production function are estimated using the maximum likelihood method.

The Empirical Model: For this study, the production technology of rice farmers in Ebonyi State, Nigeria is assumed to be specified by the Cobb Douglas frontier production function defined as follows

$$\ln Q = b_o + b_1 \ln X_1 + b_2 \ln X_2 + b_3 \ln X_3 + b_4 \ln X_4 + b_5 \ln X_5 + V_i - U_i \quad (3)$$

where: Q is rice output in kg, X_1 is farm size in hectares, X_2 is seed/planting materials in naira, X_3 is labour input in mandays, X_4 is fertilizer input in kg, and X_5 is capital input in naira comprising depreciation of farm tools and equipment, interest on borrowed capital, repair and operating expenses of implements, b_0, b_1, ...b_5 are the regression parameters to be

estimated while Vi and Ui are as defined earlier. In addition. Ui is assumed in this study to follow a half normal distribution as is done in most applied frontier production literature.

Determinants of Technical Efficiency: In order to determine factors contributing to the observed technical efficiency the following model was formulated and estimated jointly with the stochastic frontier model in a single stage maximum likelihood estimation procedure (using the computer software frontier version 4.1) (Coelli, 1996).

$$TE_i: = a_o+a_1Z_1+a_2Z_2+a_3Z_3+a_4Z_4+a_5Z_5+a_6Z_6+a_7Z_7+a_8Z_8+a_9Z_9+a_{10}Z_{10}+a_{11}Z_{11} +a_{12}Z_{12} \quad (4)$$

where TE_i, is the technical efficiency of the i-th farmer, Z_1 is credit access, a dummy variable which takes the value of unity if the farmer has access to credit and zero otherwise, Z_2 is the farmer's age in years, Z_3 is farmer's level of education in years, Z_4 is farmer's farming experience in years, Z_5 is farm size in hectares, Z_6 is membership of farmers associations / cooperative societies, a dummy variable which take the value of unity for members and zero otherwise, Z_7 is use of improved variety of rice, a dummy variable with value of unity for improved rice varieties and zero otherwise, Z_8 is tenancy status of farmers, a dummy variable with value of unity for tenant farmers and zero otherwise, Z_9 is number of extension contacts made by the farmer in the year, Z_{10} is production system dummy variable which takes the value of unity for swamp farms and zero otherwise, Z_{11} is engagement in off farm employment a dummy variable which takes the value of unity for farmers who engage in off-farm employments and zero otherwise and Z_{12} is timeliness of farm operations, a dummy variable with value of unity for farmers who observed timeliness in their farm operations and zero otherwise, while a_0, a_1, a_2, …..,a_{12}, are parameters to be estimated. We expect a_1, a_3, a_4, a_5, a_6, a_7, a_8, a_9, a_{10}, and a_{12} to be positive and a_2 and a_{11} to be negative.

Study Area: The South Eastern zone of Nigeria comprises five states, Abia Anambra, Ebonyi, Enugu and Imo out of which Ebonyi state was purposely selected for the study based on the intensity of rice production. The state is the largest rice producing state in Southern Nigeria. The National Population Census of 1991 put the population of the state at 1,884,149 people. The state is divided into 13 administrative units called Local Government Areas (LGAs), which are grouped into 2 agricultural zones of Abakaliki and Afikpo. Agriculture is the major occupation of the people. Apart from rice, the state produces yam, cassava, cocoyam, maize, and vegetables in large quantities. **Data Collection:** A multi stage sampling technique was used in data collection. Five Local Government Areas of Abakaliki, Ezza, Ikwo, Ivo and Ohaukwu were purposely selected out of the 13 LGAs in the state based on the intensity of rice production and the availability of both swamp and upland rice production systems. Each LGA was then stratified according to the two production systems and 16 rice farmers were randomly selected from each. This gave a total sample size of 160 farmers made up of 80 swamps and 80 upland. Data were collected by means of structured

questionnaires on the socio-economic characteristics of the farmers and production activities in terms of inputs, outputs and their prices using the cost route approach from April to December 1999.

RESULTS AND DISCUSSION

Socioeconomic Features of Rice Farmers: The socio-economic characteristics of the sampled rice farms are presented in Table 1. On the average, a typical rice farmer is 45. Years old, with 4 years of education, 21.

Table 1: Average statistics of Rice Farmers in Ebonyi State, Nigeria

S/No	Variable	Mean Value
1	Farm size	3.76 hectares
2	Labour	475.61 mandays
3	Seeds	N208.21
4	Fertilizer	375.25kg
5	Capital	N5742.45
6	Age	45. Years
7	Education	4. Years
8	Farming Experience	21. Years
9	Household Size	9 people
10	No of extension contacts per year	1
11	Out put	9,144.kg

Source: Field Survey 1999.

years of farming experience and an average household size of about 9 persons. The average farmer cultivated 3.76 hectares of land, spent about N208.21 on seeds/ planting materials, N5742.45 on capital inputs, employed 475.61 mandays of labour, 375.25 kg of fertilizer made an average of one extension contact in the year and produced an output of 9144.kg of paddy rice. These results suggest that a typical rice farmers in the study area is young, highly experienced in rice farming, educated and has a large household size. However, extension services in the state are poorly developed.

Estimated Production Functions: The maximum Likelihood (ML) estimates of the stochastic frontier production function parameters for rice are presented in Table 2. The coefficients of the estimated parameters have the desired

Table 2. Estimated Stochastic Frontier Production Function for Rice, Ebonyi State, Nigeria

Variables	Parameters	Estimates	t-ratios
Constant term	b_0	0.710	3.525***
Farm Size (X_1)	b_1	0.074	3.463***
Seeds (X_2)	b_2	0.201	4.428***
Labour (X_3)	b_3	0.105	2.551**
Fertilizer (X_4)	b_4	0.096	3.173***
Capital (X_5)	b_5	0.601	2.489**
Log. Likelihood function		-189.310	
Sigma (ó)		9.714	6.508***
Lambda (λ)		1.573.	0.002
Sample Size (n)		160	

Figures in parentheses are t-ratios. ** = Significant at 5%*** =Significant at 1%

Source: Field Survey 1999

signs and are statistically significant. The ratio of the standard error of U ($ó_u$) to that of Vi (V ($ó_v$) called lambda (λ) is estimated at 1.573 and is statistically insignificant even at 10% Gamma (γ) derived at (λ^2 /1+λ^2) is equal to 0.712. This implies that 71.2% of the total variation in rice output is due to technical inefficiency.

The frequency distribution of the technical efficiency of rice farmers is presented in Table 3. Individual technical efficiency indices range between 17.19% and 93.13% with a mean of 65.06%. About 82.5% of the farmers had a technical efficiency index of above 50%. The mean technical efficiency of 65.06% obtained in this study compares favourably with the 64% obtained by Kalirajan (1981) for rice in India and the 65% obtained by Kalirajan and Shand (1986) in Malaysia. The level of technical efficiency obtained in this study suggests that opportunities exist for increasing productivity and income through increased efficiency in resource utilization by rice farmers in South Eastern Nigeria.

Sources of Technical Efficiency: The determinants of technical efficiency in rice production are presented in Table 4. Credit is positively related to technical efficiency. Improved technologies shift the production frontier upwards resulting in higher levels of technical efficiency. Credit is needed to adopt these innovations and hence the positive relationship between credit and technical efficiency. This result is consistent with those of Onyenweaku, Igwe and Mbanasor (2004) in Northern Nigeria, Bravo-Ureta and Evenson (1994) in Eastern Paraguay and Lingard, Castillo and Jayasuriya (1983) in Philippines. This result, however, differs from that of Okike (2000) who found a negative relationship between credit and technical efficiency in Northern Nigeria.

Table 3. Frequency Distribution of Technical Efficiency in Rice Production in Ebonyi State, Nigeria.

	Technical Efficiency	
Range %	**Frequency**	**Relative Frequency**
30	2	1.25
31 – 40	7	4.38
41 – 50	19	11.88
51 -- 60	36	22.50
61 --70	44	27.50
71 --80	16	10.00
81 --90	25	16.25
91 --100	10	6.25
Total	160	100
Mean technical efficiency	65.06%	
Minimum technical efficiency	17.19%	
Maximum technical efficiency	93.13%	

Source: Field Survey, 1999

Education is positively and significantly related to technical efficiency: Education enhances farmer's ability to derive, decode and evaluate useful information as well as improving labour quality. The result obtained in this study agrees with those of Onyenweaku, Igwe and Mbanasor (2004). Onu, Amaza and Okunmadewa (2000) in Nigeria, Belbase and Grabowski (1985).

Table 4: Estimated Determinants of Technical Efficiency in Rice Production in South Eastern Nigeria.

Variables	**Parameters**	**Estimates**	**t-ratios**
Constant Term	a_0	0.502	2.636***
Credit (Z_1)	a_1	0.073	2.344**
Age (Z_2)	a_2	-0.034	-1.085
Education (Z_3)	a_3	0.011	3.171***
Farming Experience (Z_4)	a_4	0.021	2.541***
Farm Size(Z_5)	a_5	0.065	2.905***
Membership of farmers Associations/Cooperative Societies (Z_6)	a_6	0.051	2.306**
Improved rice Varieties (Z_7)	a_7	0.031	2.795***
Tenancy Status (Z_8)	a_8	0.042	0.0976
Extension Contact (Z_9)	a_9	0.062	2.878***
Production System (Z_{10})	a_{10}	0.056	2.734***
Off Farm Employment (Z_{11})	a_{11}	-0.033	-1.118
Timeliness of Farm Operations (Z_{12})	a_{12}	0.072	3.312***

Figures in parentheses are t-ratios ** =Significant at 5%,***=Significant at 1%.
Source: Field Survey, 1999.

in Nepal, Kalirajan and Shand (1986) in Malaysia, and Bravo-Ureta and Pinheiro (1997) in Dominica.

Farming experience is positively and significantly related to technical efficiency. The more experienced a farmer is the more efficient his decision making processes and the more he will be willing to take risks associated with the adoption of improved agricultural technologies. This result is consistent with those of Onyenweaku, Igwe, and Mbanasor (2004), Kalirajan (1981) in India and Kalirajan and Flinn (1983) in Philippines. However, this result differs from that of Onu, Amaza and Okunmadewa (2000) whose result showed a negative relationship between farming experience and technical efficiency in cotton production in Nigeria.

Farm size is positively and significantly related to technical efficiency. Large farmers are supposed to be more educated, risk takers, to have greater assess to credit and other production inputs and to adopt agricultural technologies more than small farmers. This result is in consonance with those of Onyenweaku, Igwe and Mbanasor (2004), and Flinn and Ali (1986). However, this result contrasts from those of Kalirajan and Flinn (1983), Huang and Bagi (1984) Belbase and Grabowski (1985), Lingard, Castillo and Jayasuriya (1983), Bravo-Ureta and Evenson (1994) and Bravo-Ureta and Pinheiro (1997), which found no significant relationship between farm size and technical efficiency.

Membership of farmers associations/ cooperative societies is positively and significantly related to technical efficiency. Members of farmers associations have more access to agricultural information, credit and other production inputs as well as more enhanced ability to adopt innovations, and is consistent with the result of Okike (2000) in Northern Nigeria.

Use of improved rice varieties is positively and significantly related to technical efficiency. This result is consistent with that of Hussain (1989) in Pakistan. Improved technologies shift the production frontier upwards leading to higher technical efficiency.

Extension contact is positively and significantly related to technical efficiency in accordance with the a priori expectations that extension contact leads to more efficient transmission of information to farmers as well as enhancing the adoption of innovations. This result agrees with those of Onyenweaku Igwe and Mbanasor (2004), Kalirajan (1981), Kalirajan and Flinn (1981 and 1983).

Production system is positively and significantly related to technical efficiency. Technical efficiency is higher in the swamp system than the upland. This result agrees with those of Olagoke (1991) and Onyenweaku, Agu and Obasi (2000). Water is an important input in rice

production hence technical efficiency is expected to be higher in the swamp system than in the upland system.

Finally, timeliness of farm operations is positively and significantly related to technical efficiency, and is in consonance with the result of Flinn and Ali (1986) in Pakistan. Untimeliness of farm operations in terms of planting, weeding, fertilizer application, harvesting and selling reduces technical efficiency and may even lead to total crop failure.

However, age, tenancy status and availability of off-farm employment show no significant relationship with technical efficiency.

CONCLUSIONS

The results of this study show that technical efficiency in rice production in South Eastern Nigeria ranges from 17.19% to 93.13% with a mean of 65.06%, and suggests that there are substantial opportunities to increase productivity and income of rice farmers in the study area by increasing the efficiency with which resource are used at the farm level.

Important factors directly related to technical efficiency are credit, education, farming experience, farm size, membership of farmers associations / cooperative societies, improved rice varieties, extension contact, production system and timeliness of farm operations. Policies aimed at improving farmers access to credit, education and improve rice varieties will be useful in increasing farmers technical efficiency. This will involve establishment of sustainable micro credit schemes and greater investments in formal and informal education as well as in technology development and transfer. Policies directed at consolidating farmers holdings through the formation of farmers cooperatives, couple with the targeting of relevant policies at experienced farmers will also be useful in increasing the technical efficiency and income of rice farmers in the study area.

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