

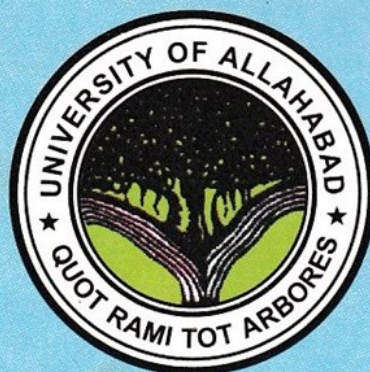
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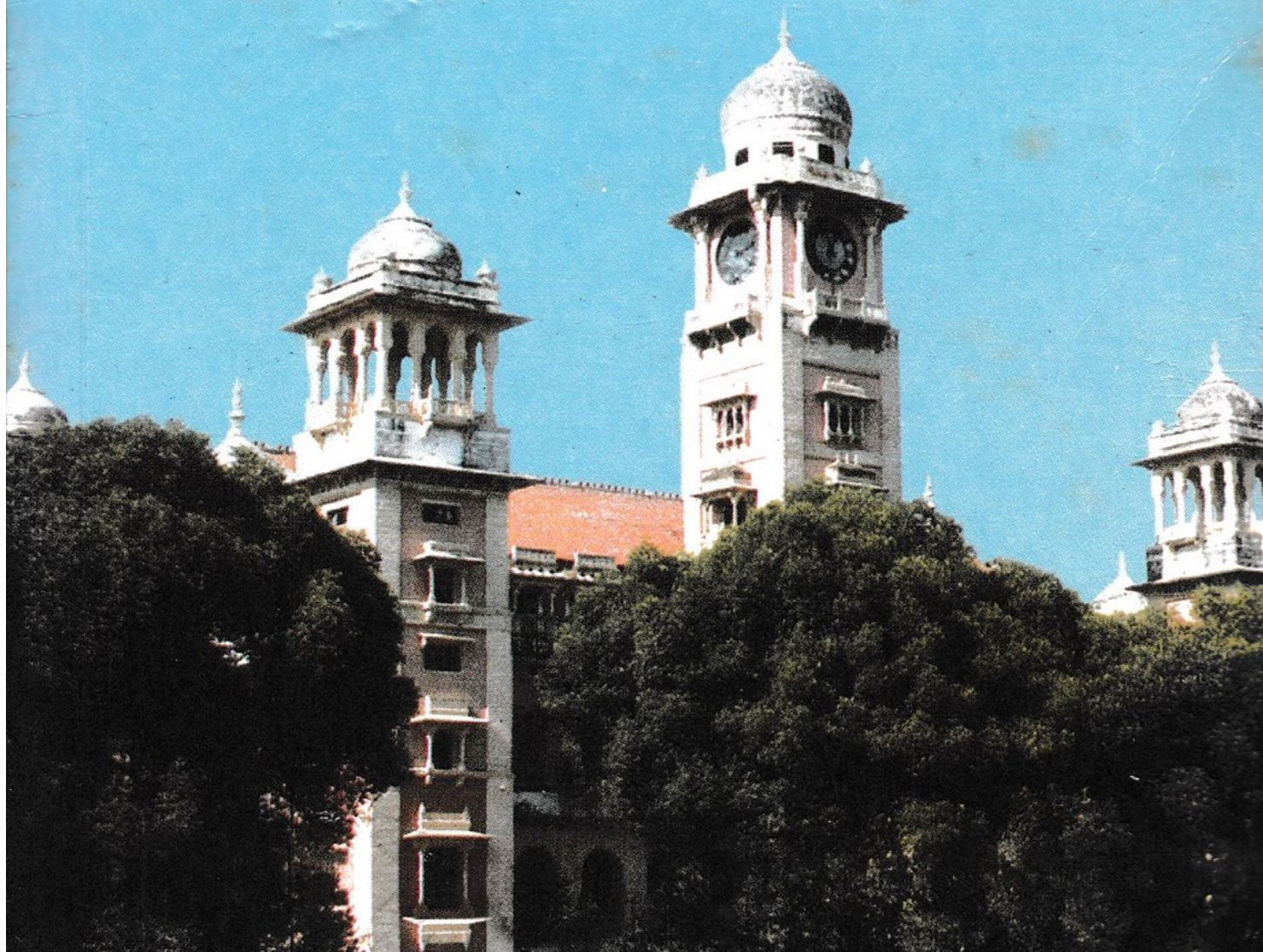
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Evaluation of Technical Efficiency and its Determinants in small Scale Rice Production in the South-South Zone of Nigeria

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Abstract

The productivity of small scale rice-farmers could be enhanced in the short run through improvement in their efficiency given their low rate of adoption improved rice technologies. In this study the level of technical efficiency and its determinants in small scale rice farming in the South-South geo-political zone of Nigeria were analysed using a Stochastic Frontier Production Function Approach. A multistage stratified random sampling technique was adopted to select ninety-six rice farmers, while a cost route method was used to obtain the required data. The mean technical efficiency of the farmers was 78 percent. The generalized likelihood ratio test indicated that, farmers are not fully technically efficient. The result further showed that, years of formal education, access to credit, membership of association and farm size, positively and significantly influenced efficiency while, age and household size significantly and negatively influenced the efficiency of rice farmers. It is therefore suggested that, policies that would attract young and educated persons into rice production as well as giving them unfettered access to credit and land should be made and implemented.

Introduction

Productivity in production will always vary as a result of differences in technology, efficiency of the producers as well as the production environment. Increase productivity can be achieved by the adoption of improved technology, enhancing efficiency and manipulating the production environment.

However, when there is lower adoption rate of improved technology, increased productivity can best be achieved in a more cost effective way by improving the efficiency of the producers (Ali and Chaudry, 1990; Kebede, 2001).

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Efficiency, which is a concept, based on the neoclassical theory of production gives an indication of a production function that would result in maximum output given in a set of resources (Khurubakar, 1994). It is a comparison between observed and optimal values of a farmer's output and input. Farrel (1957) had decomposed efficiency into two principal components (Technical and Allocative). A technically efficient farmer is one who can obtain the maximum output with his/her current resource base and available technology. On the other hand an allocatively efficient producer is one who is able to employ the correct amount of inputs to equate the marginal value product with input price (Norton & Alwang, 1993; Khumbakar, 1994). A combination of technical and allocative efficiency gives rise to economic efficiency.

Nigeria's plan to increase the rice production for self-sufficiency and export, have resulted in the setting up of a Presidential Task Force on Rice. However, to achieve this policy objective of the government, will depend principally on the level of efficiency of rice farmers especially in the short run, given the low rate of adoption of improved rice technologies by farmers in the country (Omotayo, 2001). It is therefore necessary to determine the levels of production efficiency of rice farmers as well as identifying policy variables that could be tinkered with to engender their productivity.

Much of empirical works on farmer's production efficiency in Nigeria generally and indeed the south-south geo-political zone involved in the use of the Ordinary Least Squares (OLS) estimating technique (Onyenweaku et al. 2000; Ogar et al. 2002 and Oniah 2005). This technique is limited due to its inability to provide producers level efficiency estimates and quantify factors that influence farmer's efficiency. This shortcoming of the (OLS) in efficiency studies has been overcome with the use of the Stochastic Frontier Analysis (SFA). There are a number of efficiency studies on other food crops in Nigeria (Umoh 2003; Etim et al. 2005; Nwaru, 2004; Onyenweaku et al., 2005; Udoh, 2005). They got mean technical efficiencies ranging from 0.51 to 0.48. For rice especially in other developing countries, mean estimates of technical efficiency ranged from 0.50 to 0.93 (Kalirajan, 1981; Bagi, 1982; Kalirajan and Flinn, 1983, Kalirajan, 1984; Kalirajan and Shand, 1986).

However, for Nigeria, apart from Ajibefun and Aderinola (2003) who reported a mean technical efficiency of 0.71 for rice farmers in southwest Nigeria, there is no other documented evidence. The effect of the rice production systems on farmers' efficiency has not been considered.

This paper seeks to provide empirical information on technical efficiency levels of rice farmers in the south-south zone Nigeria. Certain farm/farmers characteristics that influence their efficiency levels will also be determined.

Materials and Methods

The study was carried out in Cross River State, located in the South-South geopolitical zone of Nigeria. The state, is the most important rice growing area in

the zone, and lies within the latitude 40° 1' and 60° 3' north and between longitude 8° and 9' East of the Equator. The people are primarily farmers cultivating crops that range from cassava, yams, vegetables, rice, plantain, cocoa, rubber, and oil palm among others.

A multistage, stratified random sampling technique was adopted in selecting 96 (40 upland and 56 swamp rice) farming households from 10 communities in two Local Government Areas (Obudu and Obubra) in the State. A cost route approach, that involved, visiting the farmers on a fortnightly basis to interview and obtain the required information was used. Data collection was done between June 2004 and January 2005.

The data collected include inputs such as farm size, capital, labour, fertilizer and quantity of seeds planted. Output of paddy harvested as well as information on some socio-economic characteristics of the farmers was also obtained.

Analytical Techniques

Descriptive statistics that involved the use of percentages means and standard deviations were used in presenting data on the socio-economic characteristics of the farmers as well as summarizing information on the input and output variables. A stochastic frontier model that incorporated some inefficiency factors was used to fit the production function and estimated using Maximum Likelihood Estimating (MLE) technique.

Analytical Framework

The specification and estimation of the stochastic frontier production function accommodates two error terms that account for random effects and exogenous shocks as well as technical inefficiency (Aigner, et al., 1977; Meeusen and van den Broeck, 1977).

It can be specified as

$$Y = f(X_i ; \alpha) + \varepsilon_i \tag{1}$$

where,

Y = Output of rice

X_i = Actual input vectors

α = Vector of unknown parameters to be estimated

ε_i = Composite error term defined as V - U (2)

where,

V = Random error term that accounts for factors beyond the farmers control. It is independently and identically distributed (N (0, δ_v²))

U = Non-negative one-sided error term that accounts for technical inefficiency and assumed to be independently distributed as truncation of the normal or half normal distribution, i.e.

$$\delta_u^2 (|N(U ; \delta_u^2)|)^2$$

and

$$U_i = A_i \delta \quad (3)$$

where, A_i is a $1 \times e$ vector of farmers/farm characteristics that will influence inefficiency while, δ is vector of parameters to be estimated with the variance parameters expressed as

$$\delta^2 = \delta_v^2 = \delta_u^2 \quad (4)$$

$$\gamma = \frac{\delta_v^2}{\delta_u^2} \quad (5)$$

γ , has a value ranging from zero to one.

Empirical Model

The Stochastic frontier model for rice production in the area specified as a Cobb-Douglas frontier function is as follows :

$$\ln Y = \ln \alpha_0 + \alpha_1 \ln X_1 + \alpha_2 \ln X_2 + \alpha_3 \ln X_3 + \alpha_4 \ln X_4 + \alpha_5 \ln X_5 + \varepsilon \quad (6)$$

where

Y = output of harvested paddy rice in kg

X_1 = farm size in hectares

X_2 = labour in man-days

X_3 = fertilizer applied in kg

X_4 = capital used in naira

X_5 = quantity of seeds in kg

\ln = natural logarithm

$\alpha - \alpha_6$ = coefficients to be estimated

ε_i = composite error term as earlier defined in equation (1)

Farm/Farmers' characteristics were incorporated into the model with the belief that they have direct influence on efficiency (Battese et al. 1989; Kalirajan, 1991).

The specification was as follows :

$$U = \beta_0 + \beta_1 Z_1 + \beta_2 Z_2 + \beta_3 Z_3 + \beta_4 Z_4 + \beta_5 Z_5 + \beta_6 Z_6 + \beta_7 Z_7 + \beta_8 Z_8 + \beta_9 Z_9 + \beta_{10} Z_{10} + \varepsilon \quad (7)$$

where,

U = Technical efficiency of the rice farmer

Z_1 = Age of farmer (year)

Z_2 = Years of schooling (education level)

Z_3 = Household size (number)

Z_4 = Years in farming (experience)

Z_5 = Membership of Organization (Dummy) 1 = member, 0 = non-member

Z_6 = Farm size in hectares

Z_7 = Sex (dummy) 1 = male, 0 = female

Z_8 = Contact with extension (dummy) 1 = contact, 0 = no contact

Z_9 = Access to credit (dummy) 1 = access, 0 = no access

Z_{10} = Production system (dummy) 1 = swamp, 0 = upland

β_0 = y - intercept

$\beta_1 - \beta_{10}$ = coefficient to be estimated

Most of these variables have been consistently used in similar studies (Bravo-Ureta and Pinheiro, 1997; Ajibefun and Aderinola, 2003). The computer programme Frontier 4.1 by Coelli (1994) was used in estimating the model. A generalized likelihood test was carried out to test the hypothesis of full technical efficiency effect. The test was done at the 1 and 5 percent levels.

Results and Discussion

Socio-economic Characteristics of Rice Producers in the Zone : The table indicates that, majority (92.71%) of the farmers had one level of formal education or the other. The mean year of schooling is 7 years and a standard deviation of 2.54 years. Education helps in information acquisition and utilization and therefore, engenders the use of improved technology and thus their productivity (Amaza and Olayemi, 2000). Majority (81.25%) of the farmers was also between the age group of 30 and 45 years and a mean age of 38.7 years. This is an indication that younger persons are engaged in rice production in the area. The average farming experience of the rice farmers is 11.7 years.

Majority of the farmers are neither access to credit nor belonged to farmer's organization (Table 2), this has implication on farmer's productivity given the importance of credit and cooperatives/farmers' organization. Majority of the farmers were also swamp rice producers.

Table 1
Distribution of Rice Farmers according to Selected Socioeconomic Variables

Variable	Frequency	Percentage
Years of schooling		
0	74	7.29
6	53	55.21
12	33	34.38
15	2	2.08
>15	1	1.04
Total	96	100
Mean	7.25 (2.54)	
Household size		
2 – 4	11	11.46
5 – 7	48	50.00
8 – 10	36	37.50
>10	1	1.04
Total	96	100
Mean	7 (1.83)	
Farming experience		
<5	1	1.04
5 – 10	47	48.96
11 – 15	33	34.38
16 – 20	12	12.50
>20	3	3.12
Total	96	100
Mean	11.7 (3.85)	
Sex		
Male	67	69.79
Female	29	30.21
Total	96	100
Age		
24 – 29	2	2.08
30 – 35	25	26.04
36 – 40	27	28.13
41 – 45	26	27.08
46 – 50	9	9.38
>50	7	7.29
Total	96	100
Mean	38.7 (7.12)	

Source : Field Survey Data 2004/2005

Table 2
Distribution of Rice Farmers according to Selected Socioeconomic Variables

Variable	Frequency	Percentage
Association membership		
Member	42	43.75
Non-member	54	56.25
Total	96	100
Access to credit		
Access	34	35.42
No access	62	64.58
Total	96	100
Production system		
Swamp	56	58.33
Upland	40	41.67
Total	96	100

Source : Field Survey Data 2004/2005

Table 3 gives a summary of the output and input variables used in rice production in the area. Output per hectare in the area is about 2.25 tons, which is relatively lower than the national average of 2.65 ton/ha reported by Akpokodje, et al. (2001) especially for swamp rice produced by majority of farmers.

Table 3
Summary Statistics of variables used in estimating the Production Function

Variable	Unit	Mean	Standard deviation
Output (Y)	Kg	853.63	518.465
Farm size (X ₁)	Ha	0.38	0.15
Labour (X ₂)	Man-days	74.75	30.03
Fertilizer (X ₃)	Kg	43.04	17.95
Capital (X ₄)	₦	633.98	348.96
Seed (X ₅)	Kg	21.30	11.25

Source : Field Survey Data 2004/2005

The mean farm size in the area is about 0.38 indicating the preponderance of small nature of rice production in the area. Kebede (2001) observed a similar scenario in Nepal. Capital use in rice production is also quite small (633.98 per farmer) a pointer to the characteristic low external input usage in rice production in the zone.

Stochastic Frontier Production Function Estimates

The estimates of the production frontier function show that all the coefficients have the expected positive signs. However, only the coefficients of capital was not significant at the 5 percent level. The coefficient of labour shows that, an increase of 10 percent in labour will result in an 11 percent increase in output. This implies that rice production in the area is labour intensive. This is expected given the non-mechanization of rice production in the zone.

Table 4
*Maximum Likelihood Estimate of the Frontier
Production Function for Rice in the zone*

Variable	Coefficient	t-values
Constant	6.78	1.82
Farm size (X_1)	0.56	3.37 ^{***}
Labour (X_2)	1.10	3.74 ^{***}
Fertilizer (X_3)	0.65	2.22 ^{**}
Capital (X_4)	0.61	1.64
Seed (X_5)	0.82	2.07 ^{**}
Diagnostic statistics		
Gamma (γ)	0.89	8.87 ^{***}
Sigma square (δ^2)	0.76	3.22 ^{***}
Log likelihood function	-52.41	
LR test	23.25	

Note: *** significant at 1%; ** significant at 5%

Source Output of Frontier 4.1 by Coelli (1994).

The sum of the elasticities (3.74) indicates that the rice producers were operating in the region of increasing returns to scale (inefficient region). The gamma (γ) is 0.89 and significant at the one percent indicates that 89 percent of the variations in output of rice are caused by technical inefficiency. The value also

confirms the presence of the one-sided error component in the model suggesting that using the Ordinary Least Squares (OLS) in estimation is inadequate in representing the data. The sigma square (δ^2), which is 0.76, is significant and gives an indication of the goodness of fit and correctness of the distributional assumptions of the composite error term. This result corroborates earlier findings on rice by other authors like Xu and Jeffrey (1995), Kebede (2001) and Ajibefun and Aderinola (2003).

Estimates of Technical Efficiency

The estimates of technical efficiency of rice farmers shown in Table 5 indicate a range of 0.48 to 0.99. The mean technical efficiency obtained was 0.78. This suggests that about 22 percent chances exist for farmers to increase output with their current resource base and available technology.

Table 5
Distribution of Technical Efficiency of Rice of Farmers in the Zone

Efficiency class	No. Of Farmers	Percentage
< 0.50	3	3.13
0.5 – 0.6	6	6.25
0.61 – 0.70	11	11.46
0.71 – 0.80	26	27.08
0.81 – 0.90	22	22.93
0.91 – 100	28	29.16
Total	95	100
Mean		0.78
Standard deviation		0.22
Minimum		0.48
Maximum		0.99

Source: Derived from output of computer programme Frontier 4.1 by Coelli (1994).

This technical efficiency estimate is higher than that obtained by Kalirajan (1981) in India, Kalirajan (1984) in Philippines, Kalirajan and Shand (1986) in Malaysia, Kebede (2001) in Nepal and Ajibefun and Aderinola (2003) in South-west Nigeria.

The results further show that, for the average rice farmer to achieve the level of the most technically efficient farmer in the sample, he/she would realize about 22.1 [1-(78/99)] percent cost savings. On the other hand, the least technical efficient rice farmer would realize a cost saving of about 51.52 [1 - (48/99)] percent, to achieve the level of the most technically efficient farmer in the sample.

The distribution of efficiency levels shows that majority (80%) of the farmers attained between 0.71 and 0.99 level of efficiency. This high level of efficiency is an indication that only a small amount fraction to the output can be attributed to resource wastage. The distribution agrees with the findings of Kebede (2001).

The generalized likelihood ratio test showed that farmers were not fully technically efficient in rice production in the area. That is, the likelihood ratio ($\chi^2 = 23.35 > \chi_{0.05}^2 = 11.91$).

It is important to investigate the relationship between efficiency and some selected socio-economic characteristics of the farmers that are likely to impinge on his/her efficiency. This is done particularly for policy purposes.

Table 6
Maximum Likelihood Estimate of Determinants of Technical efficiency in Rice Production in the zone

Variables	Coefficients	t-values
Constant	0.51	1.07
Age	-0.75	2.86 ^{***}
Years of schooling	1.02	2.93 ^{***}
Household size	-0.34	2.23 ^{**}
Farming experience	0.55	1.13
Association membership	1.01	3.0 ^{***}
Farm size	0.52	2.06 ^{***}
Sex	-0.4	1.47
Extension contact	0.35	1.09
Credit access	1.47	3.19 ^{***}
Production system	-0.83	1.38

Note: *** significant at 1%, ** significant at 5%

Source: Output of Frontier 4.1 by Coelli (1994)

The results presented in Table 5 indicate that age (Z_1), household size (Z_3), sex (Z_7) and production system (Z_{10}) have negative signs. However, only sex and production systems were not significant.

The significant and negative relationship between age and efficiency implies that, older rice farmers were less efficient than younger ones. Younger farmers are able to bear risk, be innovative and possess the physical ability that is required in manual operations in rice fields than older folks. On the other hand, the older

Since education, access to credit and association membership positively and robustly influenced efficiency, policies that would encourage educated farmers to belong to cooperatives and have unfettered access to credit should be made and implemented.

It was also observed that age and household size negatively influenced efficiency of the farmers. Therefore policies that would attract young farmers into rice production should be put in place, while household members should be encouraged to take up off-farm employment to forestall farm family labour saturation on the small size farms.

An enabling policy that would guarantee free markets for land be promulgated and enforced to enable land consolidation.

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