MEASUREMENT OF TECHNICAL EFFICIENCY AND ITS DETERMINANTS AMONG INLAND VALLEY RICE FARMERS IN OHAFIA AGRICULTURAL ZONE OF ABIA STATE, NIGERIA

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Abstract

Despite her great potentials for increased rice production, Nigeria still relies a lot on imported rice in order to provide for her teeming population. Given the deleterious consequences of imports of this magnitude to the scarce foreign exchange, there is need to ensure that yield potentials are fully achieved on rice farms. One way of doing this is harnessing on a sustainable basis the rich and abundant rice growing environments in the country such as inland valleys. Therefore, this study was designed to assess the technical efficiency of inland valley rice production in Abia State of Nigeria. It employed the translog stochastic frontier production function technique to analyse primary data collected by the cost route approach from a random sample of 60 inland valley rice farmers. The estimated farm level technical efficiency in rice production ranges from 0.1681 to 0.9991. The mean technical efficiency was 0.5780 percent. The significant determinants of technical efficiency were age of the farmer, years of education, years of farming experience, extension contact, farm size and famers' access to credit. It was recommended that policies encouraging greater investments in education as well as technology transfer; establishing sustainable micro-credit schemes and increasing farmers' scale of operation through improved access to production inputs like land should be put in place.

Key words: Technical Efficiency, Inland Valley, Rice Production

Introduction

Rice growing environments in Nigeria are usually classified into five rice ecosystems: rainfed upland; rainfed lowland, irrigated lowland, deep water and swamp (Cobley, 1976; WARDA, 1999). Around 9 percent of these rice growing environments are generally estimated to fall under deep-water environment, although this figure is most likely over estimated given the physical limits to area expansion within this environment. Irrigated environments account for 16 percent of total rice area; rainfed upland systems account for 25 percent and rainfed lowlands accounts for the remaining 50 percent (FAO, 2003). The rainfed lowland systems, which include the broad inland valley bottoms referred to as Fadama in Northern Nigeria and the flood plains along the Niger and Benue River systems, appear to have been a major source for rapid improvement in paddy production in recent years. Continued increase in rice production will be possible through continued expansion into high potential areas, especially the inland valley bottoms in the Midwest and Southeast and the alluvial lowlands along the Niger and Benue Rivers (Carsky, 1992). Additional gains may be achieved through investment in water control, particularly low-cost small-scale systems in inland valleys. Iheke and Nwaru (2008) reported that inland valleys present the most profitable picture of rice production as shown by their higher profit margins over other rice production systems.

Andersen (1993) noted that although food production increased at an impressive rate in developing countries during the 1980s, it failed to keep pace with population growth in two-thirds of the developing African countries. The situation has not only contributed to food insecurity but has led to adoption of inappropriate land use practices which has resulted to soil degradation and loss of fertility (Tantawi, 2000) and reliance on imports. These scenarios seem true for Nigeria. WARDA (2003) noted that Nigeria is the world's second largest importer of rice, spending over US $300 million annually on rice imports alone. It stated that the country imported 1.7 million tons of rice in 2001 and 1.5 million tons in 2002 (WARDA, 2003).

Imports of these magnitudes represent a major drain to scarce foreign exchange and a hindrance to broader developmental efforts.

Yet, Nigeria has the potential to greatly increase its own rice production. The Nigerian rice sector has a lot of potentials for increased productivity as the country is blessed with rich and abundant rice growing environments. However, according to WARDA (2002), rice policy in Nigeria is characterized by inconsistency, shifting between open and protectionist trade policy and such changes hinder the ability of stakeholders to develop long term strategies. WARDA (2002) also noted that the key issues for the domestic sector improvement are the availability of inputs and credit, as it is the best crop for the flood prone low lands (fadamas). IITA (1988) reported that severe scarcity of resources and poor crop management are the greatest constraints to rice production in Africa. As a result, yield potentials are not fully achieved on rice farms, although high yielding varieties and the associated technologies exist and are already being used by some of the farmers. The result is that Nigeria has depended heavily on imported rice to meet her consumption needs and, according to (WARDA, 2003), has become the world's second largest importer of rice. The deleterious consequences have reinforced the vicious cycle of poverty that still ravages the country.

IITA (1988), in its strategic plan, noted that the greatest increases in rice production in the region would come from inland valley bottoms and associated hydromorphic uplands. Carsky (1992) described inland valleys as small valleys, which are located near the coast and do not have long flood plains. They are in the upper reaches of watersheds having no large flood plain, typical of large rivers or salinity and sulphur problems, typical of coastal valleys (Carsky and Masajo, 1992). According to Andriesse (1986), an inland valley starts at a water source as a stream flow valley, which further downstream becomes a river over flow valley. Carsky (1992) noted that though a substantial amount of research has been conducted on rice, there has been less study of rice production in inland valleys (IVs). The WARDA Technical Bulletin of 1978 placed rice research efforts in inland valleys at less than 10 percent while between 14 – 22 percent was concentrated on each of the other rice ecosystem, despite the fact that IVs have great potentials for increased rice production.

Given the present world food crisis, it has become pertinent to exploit the opportunities offered by this rice growing environment and this has made it necessary for an investigation in to the farm level technical efficiency of farmers in this production system. While most studies have focused on upland and swamp rice, little has been done in inland valleys with its great potential of increasing rice production and productivity especially in the study area. In the area of technical efficiency, there is limited empirical evidence on the efficiency of rice farmers in inland valleys. Therefore, this study was designed to measure the technical efficiency of inland valley rice farmers in Abia State, Nigeria. Technical efficiency refers to the ability of production units to produce maximum outputs from a given set of inputs. It indicates all the undisputed gains obtainable by simply gingering up the management (Farrel, 1957; Iheke, 2006). Differentials in technical efficiency might attributed to the differences in managerial ability, employment of different levels of technology as indicated by the quality and type of resources used, differences in environmental conditions such as soil quality, rainfall, temperature, solar radiations and precipitation or non technical and non economic factors such as sicknesses which may prevent the user of the resources from working hard enough, thus failing to achieve the best level of output (Nwaru, 1993). It is believed that the productivity of the farmers in general and rice farmers in particular could be enhanced through enhancing their technical and allocative efficiency in response to better information and education (Idiong, 2006). With the difficulties encountered by farmers in developing countries for developing and adopting improved technologies due to resource poverty, efficiency has become a very significant factor in increasing productivity (Ali and Chandry, 1990).

Methodology

Study Area: This study was conducted in Abia State of Nigeria. The State has a land mass of 6,320 square kilometers, a population of 4,222,476 people and a gross domestic product (GDP) of $8.69 billion and per capita of $3,003 (C-GIDD, 2008).The State lies approximately between latitudes 4^{o} 40^{I} and 6^{o} 14^{I} North and longitudes 7^{o} 10^{I} and $8^{o}O^{1}$ East. It shares common boundaries to the north with Ebonyi State; to the south and southwest with Rivers State; and to the east and southeast with Cross River and Akwa Ibom States respectively. To the west is Imo State and to the northwest is Anambara State. Abia State is divided into three agricultural zones namely: Ohafia, Umuahia and Aba Agricultural Zones. The predominant soil of the area is sandy loam while the natural vegetation is the tropical rainforest. Being located in the tropical rainforest zone of the country, it is characterized by two distinct seasons - the dry season and the wet season. The dry season lasts from November to March while the wet season lasts from April to October. Farming is the predominant occupation of the inhabitants. Almost all the families in the zone farm either as a primary occupation or as a secondary occupation. The region is blessed with favourable warm climate and sufficient moisture ideal for the growing of tree crops, root and tuber crops, cereals, vegetables, nuts and food crops including rice.

Data Collection Technique: A multi-stage sampling technique was used in choosing the sample. Ohafia Agricultural Zone was purposively selected because it is in this Zone that the inland valleys such as the Ubibia Awallo inland valley are found. Two Local Government Areas in the Zone, based on performance in rice production, were purposively selected for the study. From each of the chosen LGAs, 3 blocks were randomly selected from which 6 ADP cycles were randomly chosen. Five villages in each cycle were randomly selected. A rapid appraisal of the study area was undertaken and questions posed to village heads, resident agricultural extension agents and key informants helped in preparing the list of rice farmers in each chosen village. This list formed the sampling frame from which a sample 60 inland valley rice farmers was selected using simple random sampling procedure.

Preliminary visits were made to the study locations before the commencement of actual data collection. The visits helped the researchers familiarize themselves with the study locations and establish helpful public relations with village heads, resident agricultural extension agents, key informants and field guides. At this stage, field enumerators were recruited, trained and assigned to the study locations. Also data collection instruments consisting of well-structured questionnaire and interview schedule were pre-tested to standardize them and to give the enumerators adequate orientation. This made for easy understanding by the respondents and easy administration by the field enumerators.

The cost route approach was used in data collection for the entire production period from April to December 2007. By this method, contacts were made with the respondents forth nightly to determine and record relevant pieces of information from them. The research instruments found useful at the end of the fieldwork were used for further analysis. Data collected were those on socio-economic characteristics of the respondents such as age, sex, household size, educational background and farming experience. Others were on farm inputs like fertilizer, labour use, farm size, capital assets, paddy prices, credit and extension services, costs and returns (input and output) arising from rice production in the production systems.

Analytical technique:

The theoretical model: A stochastic frontier production function is given as:

$$Y_i = f(X_i; \beta) \exp. (V_i - U_i), \quad i = 1, 2, \dots, n \qquad (1)$$

Where Y_i is the output of the i-th farm, X_i is the vector of input quantities used by the i-th farm, β is a vector of unknown parameters to be estimated, f( ) represent an appropriate function such as Cobb-Douglas, translog, etc; V_i is a symmetric error accounting for the effect of random variations in output due to factors beyond the control of the farmer e.g. weather, diseases outbreaks, measurement errors, etc. V_i is assumed to be independently and identically distributed as $N(O, \delta_v^2)$ random variable independent of the U_is. It is a non-negative random variable representing inefficiency in production relative to the stochastic frontier. The U_is are assumed to be non-negative truncations of the $N(O, \delta_v^2)$ distribution, that is, i.e. half normal distribution.
The stochastic frontier model was independently proposed by Aigner *et al* (1977) and Meeusen and Van den Broeck (1977). Its major advantage is that it provides numerical measures of technical efficiency. 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.

$$\text{Technical efficiency (TE)} = Y_i/Y_i^* = f(X_i;\beta)\exp.(V_i - U_i)/ f(X_i;\beta)\exp.(V_i) = \exp(-U_i) \qquad (2)$$

Where Y_i is the observed output and Y_i^* is the frontier output and other parameters remain as defined in equation (1). The parameters of the stochastic frontier models are estimated using the maximum likelihood techniques (Aigner *et al*, 1977).

The empirical model: The production function of the rice farmers was assumed to be represented by a translog stochastic frontier production function and was specified as follows:

$$InY = Inb_0 + b_1InX_1 + b_2InX_2 + b_3InX_3 + b_4InX_4 + b_5InX_5 + 0.5b_6InX_1^2 + 0.5b_7InX_2^2 + 0.5b_8InX_3^2 + 0.5b_9InX_4^2 + 0.5b_{10}InX_5^2 + b_{11}InX_1InX_2 + b_{12}InX_1InX_3 + b_{13}InX_1InX_4 + b_{14}InX_1InX_5 + b_{15}InX_2InX_3 + b_{16}InX_2InX_4 + b_{17}InX_2InX_5 + b_{18}InX_3InX_4 + b_{19}InX_3InX_5 + b_{20}InX_4InX_5 + V_j - U_i \qquad (3)$$

Where In is the natural logarithm, b_0 is the intercept, b_1 to b_{20} are the parameters estimated, X_1 is farm size in hectares, X_2 is labour in mandays, X_3 is cost of seed, X_4 is fertilizer and other agrochemicals (naira), X_5 is capital (naira) and other variables were as previously defined in equations (1) and (2).

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

$$TE_i = a_0 = a_1Z_1 + a_2Z_2 + a_3Z_3 + a_4Z_4 + a_5Z_5 + a_6Z_6 + a_7Z_7 + a_8Z_8 + a_9Z_9 \qquad (4)$$

Where: TE_i is the technical efficiency of the i^{th} farmer, Z_1 is the age of the farmer (in years), Z_2 is household size, Z_3 is farmer's level of education in years, Z_4 is years of farming experience, Z_5 is number of extension contact made by the farmer in the cropping year, Z_6 is farm size (in hectares), Z_7 is membership of farmers association or cooperative society (a dummy which takes the value of unity for members and zero if otherwise), Z_8 is access to credit (a dummy which takes the value of unity for access and zero if otherwise), Z_9 is use of improved rice variety (a dummy which takes the value of unity for use and zero if otherwise), and a_1, a_2, a_3, ..., a_9 are regression parameters estimated. It was expected *a priori* that a_1 and a_2 would be negative while the others would be positive.

Results and Discussion

Summary statistics of the farmers' use of inputs

The summary statistics of the farmers' use of inputs is presented in Table 1. From the Table, the mean hectarage cultivated by the farmers was 1.35 hectares while the average amount of labour spent was 99.09 mandays. The average expenditure on seed was ₦2061.50. The average expenditures on fertilizer and agrochemical and capital inputs were ₦11005.35 and ₦1286.95 respectively.

Table 1: Summary statistics of the farmers' use of farm inputs

Variable	Minimum	Maximum	Mean	Standard deviation
Farmland	0.5	3.5	1.35	1.13
Labour	88.33	156	99.09	17.36
Cost of seed	1920	3550	2061.50	121.25
Fertilizer/agrochemical	10425	18900	11005.35	397.55
Capital inputs	965.05	3780	1286.95	511

Source: Survey data, 2008

Estimated translog stochastic frontier production function

The maximum likelihood estimates of the translog stochastic frontier production function of the inland valley rice farmers were summarized and presented in Table 2. The coefficients of farm size, labour and fertilizer and other agrochemicals were positively signed and significantly related to rice output. These imply, *ceteris paribus,* that the output of rice increases with an increase in these variables. Labour and entrepreneurship are the most important resources next to land in traditional agriculture because it is in them that the decision making power in the production process resides

(Olayide and Heady, 1982; Upton, 1997; Ojo and Ajibefun, 2000). Labour here refers to the available human effort for use in agricultural production. Moreover, farm operations in Nigeria have remained labour intensive (Nwaru, 2004). The use of fertilizer and other agrochemicals have been described as a proxy for technology; that is, technology is said to be improving if fertilizer and other agrochemicals were being used optimally because according to Nwaru (2004), fertilizer has been described as a major and common soil augmenting input in the sense that it improves productivity by increasing crop yields per hectare.

Table 2: Estimated Translog stochastic production function

Production factor	Parameter	Coefficient	t-ratio
Constant term	α_0	-158.497	-1.576*
Farm size	α_1	26.383	2.642***
Labour	α_2	20.918	1.511*
Seed	α_3	151.254	1.446
Fertilizer and other agrochemicals	α_4	2.333	2.008**
Capital	α_5	0.207	1.415
Farm size^2	α_6	-1.364	-0.429
Labour^2	α_7	-2.671	-2.699***
Seed^2	α_8	-2.967	-1.483
Fertilizer and other agrochemicals^2	α_9	-5.450	-0.335
Capital^2	α_{10}	-0.746	-0.969
Farm size X labour	α_{11}	2.557	1.945*
Farm size X seed	α_{12}	0.701	2.334**
Farm size X Fertilizer and other agrochemicals	α_{13}	1.872	1.778*
Farm size X capital	α_{14}	-0.942	-0.531
Labour X seed	α_{15}	-1.979	-2.139**
Labour X Fertilizer and other agrochemicals	α_{16}	2.612	2.936***
Labour X capital	α_{17}	-1.345	-0.799
Seed X Fertilizer and other agrochemicals	α_{18}	-0.438	-0.661
Seed X capital	α_{19}	2.333	1.680*

Fertilizer and other agrochemicals X capital	α_{20}	-1.169	-1.096
Diagnostic statistics			
Log likelihood function		-25.397	
Total variance	δ^2	0.713	5.478***
Variance ratio	Γ	0.871	4.989***
LR test		27.530***	

Source: Computed from Frontier 4.1 MLE/ survey data, 2008

Among the second order terms, the coefficient of the square of labour was significant at 1 percent and negatively related to rice output. The coefficients of the interactions of farm size and labour, farm size and seed, farm size and fertilizer and other agrochemicals, and seed and capital were positively related to rice output and significant while those of labour and seed and labour and fertilizer and agrochemicals were negatively related to output of rice and were significant. The estimated variance is statistically significant at 1 percent indicating goodness of fit and the correctness of the specified distribution assumptions of the composite error terms for the inland valley rice farmers. However, the variance of the non-negative farm effects is a non-significant proportion of the total variance of farm outputs. Gamma (γ), given by ($\lambda^2/1 + \lambda^2$) was estimated at 0.871 indicating that 87.1 percent of the total variations in rice output are due to technical inefficiency.

Sources of technical efficiency

The estimated determinants of technical efficiency in inland valley rice production were summarized and presented in Table 3. From the Table, age, years of education, years of farming experience, extension contact, farm size and access to credit were the significant determinants of technical efficiency. Apart from age, all the other factors were directly related to technical efficiency of the farmers. Age was significant at 1 percent. This result is consistent with *a priori* expectation and agrees with Idiong (2005), Onyenweaku and Ohajianya (2007), Okoye and Onyenweaku (2007). Idiong (2005) stated that the older a farmer becomes, the more he is unable to combine his resources in an optimal manner given the available technology. Nwaru (2004) posited that the risk bearing abilities and innovativeness of a farmer, his mental capacity to cope with the daily challenges and demands of farm production activities and his ability to do manual work decrease with advancing age.

Table 3: Determinants of technical efficiencies of the farmers

Variable	Parameter	Coefficients	t-ratio
Constant	a_0	0.1732	0.087
Age	a_1	-0.054	-4.273***
household size	a_2	0.129	1.243
Years of education	a_3	0.878E-02	3.516***
Farming experience	a_4	0.107E-01	1.594*
Extension contact	a_5	0.161	2.191**
Farm size	a_6	0.020	2.425**
Farmers' association	a_7	-0.015	-0.479
Access to credit	a_8	0.328	2.358**
Improved variety	a_9	0.043	0.942

Source: Computed from Frontier 4.1 MLE/ survey data, 2008

Education was significant at 1 percent and positively related with technical efficiency. This implies that the higher the level of education acquired by the farmer, the greater his efficiency. This conforms to *a priori* expectations and the report from Nwaru (2004). Education increases the ability of farmers to adopt agricultural innovation and hence improve on their efficiency. In line with this Obasi (1991) stated that the level of education of a farmer not only increases his farm productivity but also enhances his ability to understand and evaluate new production techniques. Meanwhile, Jaja *et al.* (1998) and Nwaru (2001) opined that the Nigerian agricultural landscape is charcterised among other things by numerous isolated small holder farm operators, the overwhelming majority of who cannot read or write. Therefore, policies and programmes to enhance the educational status of the farmers especially through adult literacy programmes are necessary.

Farming experience was significant at 10 percent and positively related with technical efficiency. This agrees with Kalirajan (1981), Kalirajan and Flinn

(1983), Onyenweaku, Igwe and Mbanasor (2004), Onyenweaku and Ohajianya (2007), Okoye and Onyenweaku (2007) but differs from Onu *et al*, (2000) whose result shows a negative relationship. It has been noted that farmers would count a lot more on their farming experience for increased productivity and efficiency (Olomola 1988; Obasi, 1991 and Nwaru, 1993). Thus the result has some positive implications for increased efficiency and productivity because according to Nwaru (2004), as the number of years a farmer has spent in the farming business may give an indication of the practical knowledge he has acquired on how he can overcome certain inherent farm production problems.

Land and labour have been described as the most critical inputs in traditional agriculture. The coefficient for farm size was significant at 5 percent and positive. This result with agrees with *a priori* expectations and the reports from Onyenweaku and Effiong (2005), Onyenweaku and Nwaru (2005), Onywnweaku and Okoye (2007).However, itdiffers from Lau and Yotopoulus (1971), Kilirajan (1991), Bravo-Ureta and Evenson (1994) who noted that smaller farms were more economically efficient than larger farms within the range of output studied. Result of the present study implies that policies for increased access to farmland through land reform policies that make for redistribution and consolidation should be encouraged.

Extension contact was significant at 5 percent and positively related to technical efficiency. This is in accordance with *a priori* expectation and to the reports from Kalirajan and Flinn (1983), Onyenweaku, Igwe and Mbanasor (2004), Onyenweaku and Effiong (2005), and Onyenweaku and Ohajianya (2007). According to Onyenweaku and Ohajianya (2007), extension contact leads to a more efficient transmission of information to farmers which enhances the adoption of innovations. It is hoped that interactions with extension system would help the farmer to receive and synthesise new information on economic activities in his locality and even beyond.

Access to credit was significant at 5 percent and positively related to technical efficiency. This is consistent with *a priori* expectation and the report from Nwaru (2004) who explained that it could be deduced that credit enabled the farmers to hire more labour and that, *ceteris paribus*, the input of credit would lead to significant shifts in which farmers can afford more purchased inputs. Krause *et al.* (1990) and Immink and Alarcon (1993) noted that lack of access to credit prohibits smallholder farmers from assuming risks of financial leverage associated with the adoption of new technology. Access to credit offers liquidity and adoption of new technology was also found to be sensitive to the amount of equity capital (Krause *et al.*, 1990). The implication is that policies and programmes for making key into optimal use of available credit facilities in the economy should be put in place.

Distribution of technical efficiency

The frequency distributions of the farm level technical efficiency indices of the inland valley rice farmers are presented in Table 4. Individual technical efficiency indices range

Table 4: Distribution of technical efficiency indices

Technical efficiency	Frequency	Relative frequency
0.01 – 0.20	1	1.67
0.21 – 0.40	11	18.33
0.41 – 0.60	27	45.00
0.61 – 0.80	12	20.00
0.81 – 1.00	9	15.00
Total	60	100.00
Maximum technical efficiency	0.9991	
Minimum technical efficiency	0.1681	
Mean technical efficiency	0.5718	

Source: Computed from Frontier 4.1 MLE/ survey data, 2008

From 0.1681 to 0.9991 for the rice farmers with a mean of 0.5781. About 48 percent of the inland valley rice farmers have an efficiency index of above 0.60 or 60 percent. The result shows that none of the farmers achieved optimum efficiency. The level of technical efficiency obtained in this study suggests that ample opportunities exist for the farmers attain optimality in the efficiency of their farm operations. This would lead to increased productivity and income through increased efficiency in resource employment in their farm operations.

Conclusion and Recommendations

This study was designed to assess the technical efficiency of inland valley rice production in Abia State of Nigeria. Results of this study revealed that farm level technical efficiency in rice production ranges from 0.1681 to 0.9991 with a mean of 0.5781. The estimated farm level technical efficiency indices suggest that opportunities exist for the farmers to increase their efficiency and hence, productivity and income. The significant determinants of technical efficiency were age of the farmer, years of education, years of farming experience, extension contact, farm size and access to credit. All the factors were positively related to technical efficiency except age. This implies that increase in the values of these variables would increase the technical efficiency of the rice farmers. These results call for policies and programmes aimed at improving access to education, farm land, extension contact and credit. In this regard, policies encouraging greater investments in education as well as technology transfer; establishing sustainable micro-credit schemes and increasing farmers' scale of operation through improved access to production inputs like land should be put in place. Specifically, the agricultural extension system should be strengthened to provide farmers with the informal training they require for enhancing their knowledge and understanding innovations for improved efficiency and productivity. Also, the Bank of Agriculture and other allied institutions should be strengthened to provide farmers with credit needed for on-farm investments.

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