ANALYSIS OF TECHINICAL EFFICIENCY OF NATIONAL FADAMA II FACILITY ON ARABLE CROP FARMERS IN IMO STATE, NIGERIA

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ABSTRACT

This study measured the level of technical efficiency and its determinants in Fadama II Arable Crops farmers in Imo State, Nigeria using a stochastic Frontier Production Function. Multi-stage random sampling technique was used to select 120 arable crop farmers from which input-output data were collected. Instrument of data collection was via well-structured and pre-tested questionnaire. The estimated farm level technical efficiency ranged between 83.0% and 98.0% with a mean of 93.0%. Determinants of technical efficiency of Fadama II arable crop farmers were age of farmers, educational level, household size, membership of cooperative societies, access to credit and frequency of extension contact. Higher yield and technical efficiency could be attained by efficient allocation of the employed resources which is vital to the sustainability of the Nigeria Fadama programme.

Key words: Technical Efficiency, Frontier, Fadama II, Arable Crop Farming.

INTRODUCTION

Low production and productivity have continued to characterize Nigeria agricultural sector thereby limiting the ability of the sector to perform its traditional role in economic development (Akpa, 2007). In order to break this cycle and improve the performance of agricultural sector the Nigerian government, over the years, introduced and implemented several policies and programmes aimed at revamping the sector (Ajibefun and Aderinola, 2004). A more recent effort towards boosting production and enhancement of farmers' welfare is the introduction of the second National Fadama Development Project (NFDFP II). This Fadama II project is a follow-up to the phase I equally funded by the World Bank between 1993 and 1999, which built on the success of pump and wash bore farming which the ADPs supervised (Blench and Ingawa, 2004).

Imo State is among the 12 World Bank assisted states implementing the second National Fadama Development Project, which aimed at sustainably increasing the income of all users of Fadama resources and to reduce conflict amongst them. The Fadama expansion program was considered to be an instrument for technical transformation in agriculture which would empower the smallholder farmer to get out of the poverty trap (Ingawa, 2001).

More importantly, achieving Nigeria's agricultural policy objective of sustainable food production and food security requires that resources be used much more efficiently with more attention paid to eliminating waste-productive efficiency goal (Ingawa, 2001).

Because of these developments, irrigation water application to agricultural crops is becoming increasingly important especially during the dry season. Considering the economic returns of Fadama land and its scarcity in relation to demand in Imo State especially during the dry season, the importance of using it most efficiently and productively becomes very imperative. It has become obvious that efforts to increase crop production through Fadama land may have to concentrate on increasing their productivity rather than increase in areas (Mbanasor and Obioha, 2003). Efficiency analysis aids the identity of the possibilities for increasing output while the resources are conserved. The role of increased technical efficiency was examined as a viable complement to any set policies to stimulate Fadama cropping system and/or promote resource conservation.

The objectives of the study are to determine the level of technical efficiency of the Fadama II arable crop farmers in the state and estimate elasticity as well as returns to state.

METHODOLOGY

The study area was Imo State. The State was purposively chosen because it was the only state in the south-eastern political zone of Nigeria to benefit from the Fadama II project. The state lies between latitude 5° 10' and 6° 35' north of the equator as well as between longitude 6° 35' and 7° 35' each of the Greenwich meridian (NAERLS, 1995). All the three agricultural zones (Orlu, Okigwe and Owerri) were involved in the study. Multi-stage random sampling technique was used in the selection of samples. First, one Local Government Area (LGA) was selected at random from each agricultural zone. The selected Local Government Areas were

Onuimo (Okigwe zone); Aboh-Mbaise (Owerri zone) and Oguta (Orlu zone). Second, 4 Fadama practising communities were selected from each Local Government Area thus giving a total of 12 communities. Third, 10 Fadama II arable crop farmers were randomly selected from each community thus giving total sample size of 120 respondents. The data for this study were collected with cost route technique, which is simply described as collecting of data at the time the farmer is performing each operation and with the aid of detailed pre-tested and structured questionnaire administered on the selected Fadama farmers in the areas.

Data for objectives were analyzed using stochastic frontier production function model. The theoretical framework of the stochastic frontier production function is specified as follows:
$Y_i = f(X_i, \beta) \exp(V_i - U_i)$, I = 1, 2 n… (1)
Where Y_i = Output of the i-th farm, X_i = the vector of input quantities used by the i-th farm, β is a vector of unknown parameters to be estimated, $f(\ )$ represents an appropriate function (e.g. 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, 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 $(0, \sigma_u^2)$ random, variables independent of the U_is which are assumed to be non negative truncation of the N $(0, \sigma_u^2)$ distribution (i.e. half-normal distribution) or have exponential distribution.

The stochastic frontier was independently proposed by Aigner *et al*. (1977) and Meeusen and Van der 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 (Onyenweaku and Effiong, 2006).
Technical Efficiency (TE) = Y/Y_i^*
$= f(X_i, \beta) \exp(V_i - U_i) / f(X_i, \beta) \exp(V_i) = \exp(-U_i)$ … (2)
Where Y = observed output and Y_i^* = 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 the arable crop Fadama II farmers in Imo State Nigeria is assumed to be specified by the Cobb Douglas frontier production function defined as follows:
$\text{In } Q = \beta_0 + \beta_1 \text{ In } X_1 + \beta_2 \text{ In } X_2 + \beta_3 \text{ In } X_3 + \beta_4 \text{ In } X_4 + \beta_5 \text{ In } X_5 + V_i - U_i$. (3)
Where Q = gross income in arable crop production per Fadama II farmer, X_1 = planting materials (kg); X_2 = fertilizer use (kg); X_3 = labour input (man days); X_4 = farm size (ha); X_5 = depreciation; V_i = random error and U_i = technical efficiency. In addition, U_i is assumed in this study to follow a half normal distribution as is done in most applied frontier production literature.

a. Determinants of Technical Efficiency: In order to determine factors contributing to the observed technical efficiency, the following model was formulated and estimated jointly with stochastic frontier model in a single stage maximum likelihood estimation procedure using the computer software Frontier Version 4.1 (Coelli, 1996).
$TE = a_0 + a_1 Z_1 + a_2 Z_2 + a_3 Z_3 + a_4 Z_4 + a_5 Z_5 + a_6 Z_6 + a_7 Z_7$ …… (4)
Where TE = Technical Efficiency of the i-th farmer
Z_1 = age of farmer (years); Z_2 = educational level; Z_3 + household size; Z_4 = farming experience (years); Z_5 = membership of cooperative society (dummy); Z_6 = credit access (₦); Z_7 = frequency of contact with extension agent. While
a_0 ….aij are parameters to be estimated.

RESULTS AND DISCUSSION

Mean statistics of Fadama II arable crop farmers are displayed in Table 1. On the average, a typical Fadama II arable crop farmer is 44.22 years old with 8.23 years of education, 14 years of Fadama farming experience and average farm size of 0.86 ha. The mean household size was 6 persons with an average annual farm income of ₦60, 333.83 and a mean output of 7538.63 kg per annum.

Table 1: Mean Socio-economic Statistics of Fadama II Arable Crop Farmers in Imo State Nigeria

Variable	Mean value
Age of Fadama II farmers (years)	44.22
Educational level (years)	8.23
Farming experience (years)	14.00
Farm size	0.86
Household size	06.00
Farm income (₦)	60,333.83
Farm output (₦)	7,538.63

Source: Field survey data, 2007

b. Estimated Production Function: The maximum likelihood estimates (MLE) of the stochastic frontier production parameters for Fadama II arable crop farmers are presented in Table 2.

The coefficients of planting materials, fertilizer used and labour inputs had the desired positive signs and are statistically significant except for the coefficient of farm size. The coefficient (0.3279) of planting materials was positive and statistically significant at 1.0% probability level. This implies that the more planting materials are used, the more the quantity of output accrued to the Fadama II farmers.

Labour input had a positive coefficient (0.3781) and statistically significant at 1.0% risk level. Its implication is such that a one percent increase in labour input would cause the revenue of the Fadama II arable crop farmer to increase by 0.3781%. The estimated coefficient (1.0672) of fertilizer was positive and statistically significant at 1.0% risk level. This implies that one percent increase in fertilizer use led to 1.0672 percent increase in total farm income.

Table 2: Estimated Stochastic Frontier Production Function for Arable Crop Farmers in Imo Sate, Nigeria

Production Factor	*Parameter*	*Coefficient*	*Standard Error*	*t-ratio*
Constant term	β_0	*13.9667*	*0.6408*	*21.7958****
Planting materials	β_1	*0.3279*	*0.0317*	*10.3345****
Fertilizer use	B_2	*1.0672*	*0.1172*	*9.1014****
Labour input	β_3	*0.3781*	*0.0568*	*6.6538****
Farm size	β_4	*-0.0992*	*0.957*	*-1.0373*
Depreciation	β_5	*0.0086*	*0.0123*	*0.7024*
Diagnostic Statistics				
Total variance	Σ^2	*1.5528*	*0.3081*	*5.0398****
Variance ratio	Y	*0.9949*	*0.0016*	*608.2822*
Likelihood ratio test	-	*218.1618*	-	-
Log Likelihood function	-	*3.7533*	-	-

Source: Computed from field survey data, 2007
****Significant at 1% risk level*
***Significant at 5% risk level*
**Significant at 10% risk level*

b. Determinants of Technical Efficiency

The determinants of technical efficiency in Fadama II arable crop farmers are shown in Table 3.
Farmers' age had negative sign (-0.2303). This result is in consonance with Ajibefun and Daramola (2004), Okike (2000) and Onu *et al*. (2000), that increasing age would lead to decrease in technical efficiency since an ageing farmer would be less energetic to work in the farm. But this result is inconsistent with those of Kalirajan and Shand (1985), Belbase and Grabowski (1985), Bravo-Ureta and Pinheiro (1997) whose results showed age to be positively and significantly related to technical efficiency.

Educational level was positively signed and statistically significant at 5.0% level. The result is inconsistent with Onyeweaku and Nwaru (2005), Onyenweaklu *et al*. (2004), Onu *et al*. (2000), Amaza and Olayemi (2000) whose results showed education and technical efficiency to be positively related. This implies that the more educated the Fadama II farmer is, the more the likelihood of his achieving increased technical efficiency.

Household size showed a negative relationship with technical efficiency and is statistically at 1.0% risk level. The result is consistent with those of Onyenweaku and Nwaru (2005) and Bravo and Pinheiro (1997), which showed household size and technical efficiency to be negatively and significantly related.

Membership of farmer's association/cooperative societies is positive and significantly related to technical efficiency. Members of farmers association have access to agricultural information, training, credit and other production inputs as well as more enhanced ability to adopt innovation (Onyenweaku and Effiong, 2000). This result is consistent with that of Okike (2000).
Credit access showed a positive relationship with technical efficiency and is statistically significant at 5.0% risk level. This result agrees with those of Onyenweaku and Nwaru (2005). Onyenweaku *et al.* (2004), and Brave-Ureta and Evenson (1994) whose results showed credit access to be positively related to technical efficiency and disagrees with Okike (2000) who found a negative relationship between credit access and technical efficiency.

Frequency of extension contact is negatively and significantly related to technical efficiency which is against a priori expectations. Inefficient transmissions of information to farmers as well as bottlenecks that militate against enhancing the adoption of innovation are critical reasons for the behavior of this variable in the analysis. This result disagrees with those of Onyenweaku *et al.* (2004), Amaza and Olayemi (2000) and Kalirajan (1981).

Table 4: Estimated Determinant of Technical Efficiency in Fadama II Arable Crop Farmers in Imo State Nigeria

Determinants	Parameter	Coefficient	Standard Error	t-ratio
Constant term	a_0	-0.0710	1.3926	-5.0991***
Age of farmers	a_1	-0.2303	0.114	-2.067**
Educational level	a_2	1.8596	0.2579	7.59***
Household size	a_3	-6.9820	0.6770	-10.31***
Farm experience	a_4	0.2123	0.6591	0.37
Membership of cooperatives	a_5	1.1189	0.3750	2.98**
Credit access	a_6	2.9577	0.4013	7.36***
Extension contact	a_7	-0.7509	0.2507	-2.99**

Source: Computed from field survey data, 2007
***Statistical significance at 1% level
**Statistical significance at 5% level
*Statistical significance at 10% level

Distribution of Technical Efficiency

The distribution of the efficiency estimates obtained from the stochastic frontier is presented in Table 5. The table showed that all the Fadama II arable crop farmers (100%) operated at efficiency level greater than 80%. The average technical efficiency for the sample is 93%. This figure compares favourably with 84% and 89% obtained by Battese *et al*. (1989) and 83%.^% obtained by Onyenweaku and Effiong (2006). In the short run, there is opportunity for increasing Fadama II arable crops production by 7%, by adopting the techniques and technology employed by the best practice in Fadama farms. However, the maximum technical efficiency is 98%. The result of the mean technical efficiency showed that most farmers operated much near to frontier. The level of technical efficiency obtained in this study suggests that opportunities still exist for increasing productivity and income through increased efficiency in resource utilization by Fadama II arable crop farmers in the state.

The implication of the mean technical efficiency (93%) is such that the average Fadama II arable crops farmers require 5.1% cost savings to attain the status of the most efficient Fadama II arable crop farmer among the sampled best 10 category while the least performing farmer would need 13.27% cost saving to become the most efficient Fadama II arable crops farmer among the worst 10 sampled farmers.

Table 5: Distribution of Technical Efficiency Indices of Fadama II Arable Crops Farmers in Imo State

Technical Efficiency Index	Frequency	Percentage
0.00 – 0.20	0	0
0.21 – 0.40	0	0
0.41 – 0.60	0	0
0.61 – 0.80	0	0
0.81 – 1.00	120	100.00
Total	120	100.00
Maximum Technical Efficiency 0.98		
Minimum Technical Efficiency 0.83		
Mean Technical Efficiency 0.93		
Mean of Best 10 farmers 0.03		
Mean of worst 10 farmers 0.85		

Source Computed from field survey data, 2007

Elasticity of Production and Returns to Scale

The regression coefficients in the Cobb-Douglas stochastic production frontier function are the elasticities and their sums indicate the returns to scale (Hazarika and Subramanian, 1999). The production elasticities are shown in Table 6. The production elasticities have a function coefficient of 1.6826. This means that Fadama II arable crops farmers' production plan is elastic and thus the farmers are in stage II of production function phase (i.e. the rational stage of production). This was necessitated by the high and positive coefficient of fertilizer with low and positive coefficient of depreciation. Therefore it means that the Fadama II arable crops farmers in Imo State optimally utilized and allocated most of their production inputs especially fertilizer judiciously.

Table 6: Elasticity and Returns to Scale for Fadama II Arable Crops Production in Imo State

Production Inputs	Elasticity
Planting materials	0.3279
Fertilizer	1.0672
Labour	0.3781
Farm size	-0.0992
Depreciation	0.0086
Returns to scale	1.6826

Source: Computed from field survey data, 2007

CONCLUSION AND RECOMMENDATION

The results of this study show that technical efficiency in Fadama II arable crops farmers in Imo State is relatively high. Individual levels of technical efficiency ranged between 83.0% and 98.0% with a mean of 93.0%, suggesting that opportunities still exist for increasing productivity and income of Fadama II arable crops farmers in the state by increasing the efficiency with which resources are used at the farm level.

Age of farmers, educational level, household size, membership of cooperative societies/association, access to credit and frequency of extension contact were important factors directly related to technical efficiency. To address some inefficiency, the following policy options are suggested:

i. Evidence had shown that large household size had negative influence on a farmer. The encouragement and enforcement of the current family planning program of the Federal Government and UNICEF should be intensified while policy on birth control suggested.
ii. Since large farm size has a positive influence on technical efficiency, it is imperative that the land use act of 1990 be reviewed to eliminate difficulties associated with land acquisition for agricultural purposes. This will facilitate increased agricultural expansion and growth.
iii. Policy that encourages the formation of combines and cooperative societies should be encouraged. This is due to the importance of cooperatives in capacity building, acquisition of credit and production inputs at low costs.
iv. The positive influence of fertilizer on yield of crops has been noted. In this direction, increased subsidy policy should be imposed on fertilizer to not only make the availability of this input but its affordability by resources of poor farmers at all levels thereby enhancing their efficiency levels.

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