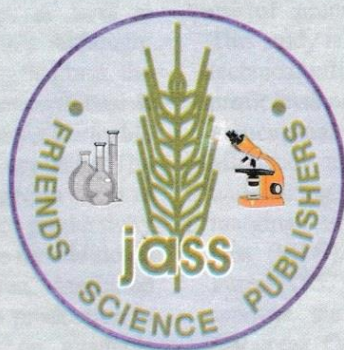


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Resource-Use Efficiency and Productivity among Farmers in Nigeria

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ABSTRACT

The stochastic production frontier function is applied to estimate output oriented technical inefficiency of crop mix of the farmers in a typical farm settlement. By means of MLE, asymptotically consistent and efficient ML estimates are obtained together with inefficiency determinants. The mean output oriented efficiency of 73%, showing that there exist room for improvement in crop production by 27% with the present technology. The farmers were operating at stage II of the production process with respect to the use of resources. The study therefore states that productivity of output on the long run must depend on improvements in technical efficiency.

Key Words: Resource use; Efficiency; Resource productivity; Stochastic function; Nigeria

INTRODUCTION

The challenge that is currently confronting Nigeria's agriculture is related to the problem of low productivity in production resulting from inefficient use of resources (Obasi & Agu, 2000). Nigeria, with a population of over 100 million people and about 93 million has of land is predominantly an agrarian country (NPC, 1992). Although, about 70% of her population is engaged in agriculture, the country is yet not self sufficient in food production (Obasi & Agu, 2000). The reality is that Nigeria has not yet been able to attain self-sufficiency in food production annually. The constraints to the rapid growth of food production seem to be mainly that of low crop yields and resource productivity (Udoh, 2005). This suggests that, there is hope for additional increases in output from cultivated land area. Attributed two-thirds ($\frac{2}{3}$) of the increase to world crop production to increase in harvested area. The pressure on available cultivated land and other resources implies that nation may have to rely on improving productivity to attain sustainable agricultural production.

An important policy issue to the Nigerian government is transforming agricultural sector and making it more competitive and market oriented. The government in this direction has taken several steps. The success of these strategies in transforming agriculture depends among other things on the production efficiency of individual farms (Bravo, 1994). It suffices to say that the knowledge of efficiency of resource use is vital to farmers in agricultural productivity. As stated by Eyoh and Igben (2002), that the utilization of land resources is closely guided by the concept of highest and best use; so is labour, capital and management resource necessary to be put to best use for maximum agricultural productivity. Resources are considered to be at its highest and best use when it is put a

use with highest comparative advantage to other uses. Efficiency of resource use can therefore be assessed from the productivity of the output. This is an important issue of the present time, because productivity growth and resource-use efficiency issues are the core elements of sustainable crop production of small-scale farming activities. Inefficient use of inputs can jeopardise food available and security. This study is therefore aimed at measuring productivity and technical efficiency of resource use and the estimate of the profit level of farmers in there farming activities.

Conceptual framework. Akpakpan (1999) refers to efficiency as the objective of getting the most from an undertaking. A resource is said to be efficiently used, if its marginal variable cost (MVC) exceeds its marginal factor cost (MFC). Noting the three components of efficiency Farrel (1957) referred to technical efficiency as the ability to produce the highest level of output given a bundle of resources. On the other hand, technical inefficiency depicts a situation in which actual and observed output from a given input mix is less than the maximum possible (Bailey, 1989).

The modern theory of efficiency dates back to the pioneering work of Farrel (1957), who drew extensively from the earlier works of Debreu (1951) and Koopmans (1951) to define a simple measure of firm efficiency, which could account for multiple inputs. Farrel identified two components of firm efficiency- technical and allocative and the combination of these two components provides a measure of economic efficiency (Udoh, 2005). Technical efficiency, the main issue in this study can be measured either as input conserving oriented technical efficiency or output expanding oriented technical efficiency. Output-expanding oriented technical efficiency is the ratio of observed to maximum feasible output, conditional on technical and observed input usage (Jondraw *et al.*, 1982; Ali, 1996; Udoh, 2005).

Efficiency measurement has given rise to specification of various estimation methods. These methods are grouped into two broad categories – parametric and non-parametric methods (Kalaizandonakes *et al.*, 1992). For the parametric, it can be deterministic, programming and stochastic (Fig. 1). Aigner *et al.* (1977) and Meeusen and Vanden Broek (1977) not found in the list independently proposed the idea of stochastic measurement.

The specification of stochastic parametric frontier recognizes component error term as major source of deviation from the production frontier. Stochastic frontier production function is given as:

$$Y_i = F(X_i; \beta) \exp(V_i - U_i) \quad i = 1, 2, \dots, N \quad (1)$$

Where

Y_i is the output of i th farm; X_i , is the corresponding ($M \times 2$) vector of inputs; β is a vector of un-known parameter to be estimated; F denotes an appropriate functional form, V_i , is the symmetric error component that accounts for random effects and exogenous shock, while $U_i, \leq 0$ is a one sided error component that measures technical inefficiency.

The major interest in efficiency study that specifies stochastic frontier is the decomposition of the component error terms ($V_i - U_i$) into mutually exclusive events. This is normally accomplished by estimating the mean of conditional distribution of U given V expressed as:

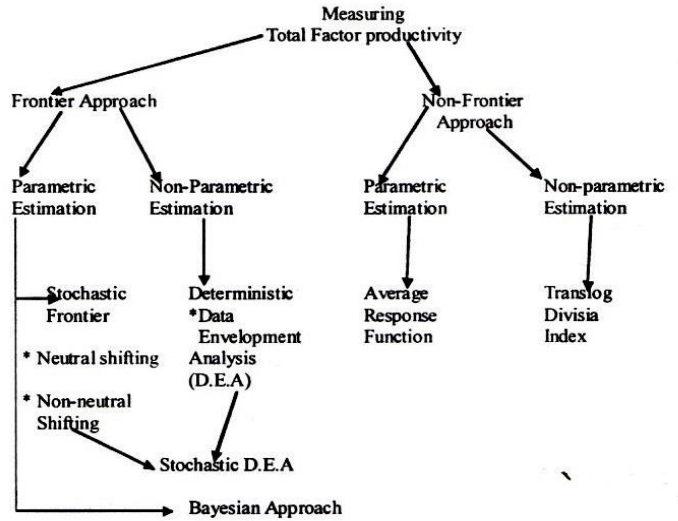
$$E(V/e_i) = \mu_i = \sigma^* \{f^* (-\mu_i/\sigma^*) [1-F(U_i/\sigma^*)]^{-1}\} \quad (2)$$

Where

$\sigma^* = (\sigma_v^2 \sigma_u^2 / \sigma^2)^{1/2}$; $\mu = (-\sigma_u^2 e_i) / \sigma^2$, f is the standard density function and F is the standard distributional assumptions. The values of unknown coefficients in (1) and (2) can be obtained jointly using the maximum likelihood (ML) method. This involves estimation of population parameters such that the probability density for obtaining the actual sample observations that have been obtained from the population is greater than the probability density obtainable with any other assumed estimates of the population parameters (Stevenson, 1980; Coelli, 1995; Draper & Smith, 1966; Olayemi, 1998; Udoh, 2005). The ML method provides estimators that are asymptotically consistent and efficient. This study however, uses a production approach to estimate technical in efficiency effects at farm levels by assuming a stochastic nature of production.

Productivity is seen as a measure of the efficiency of all resources put to use in any farming operation. It is defined as an indicator of the resource efficiency to its mean increase in optimal allocation and combination of these resources (Olayide & Heady, 1982). Productivity could as well be measured in terms of marginal physical product (MPP) in which case, the interest is in the addition to total product resulting exclusively from a unit increase in the use of that input i.e., total factor productivity growth, which is measured using the frontier and non-frontier approaches as illustrated in Fig. 1. It therefore suffices to say that

Fig. 1. Total factor productivity estimation method
Source: Mahadevan and Kalirajan (1999)



productivity can only be measure and ascertained from farm-level efficiency. Hence in this study, after estimating the technical efficiency, resource-use productivity was evaluated by estimating the marginal and average physical productivities of the inputs used by the farmers in the study area.

METHODOLOGY

The study area, sampling and data collection procedure. The study was carried out in farming intensive areas in Odukpani Local Government Area of Cross River State, Nigeria. It has boundaries with Itu L.G.A of Akwa Ibom State at the South, while at the North; it his bounded by Akamkpa Local Government Area of Cross Rivers State. The area falls within the rainforest ecological zone. The texture of the soil is predominantly deep and poorly drained, with its terrain nearly level to gently undulating plains with minor hills. This area has estimated population of 217, 706 (NPC, 1991). The area falls within the humid tropics with two distinct seasons, the dry and wet seasons. The mean annual rainfall is at least 3200 mn with maximum in July and September. The heavy rain here accounts for the accelerating erosion and plant nutrient depletion. This area is basically a farm settlement, where farming activities continue throughout the year with major crops such as cassava, plantain, yam, cucumber, fluted pumpkins, maize cultivated for both commercial and home use purposes.

Data used in the study are primary data collected directly from the farmers with the use of structured questionnaires. A cross-sectional data from a total of 120 farmers were randomly sampled from farming-intensive areas of Odukpani L.G.A. These areas include Okurikang, Usung Odot, Okpok Ikpa and Okoyong Usang Abasi. The baseline survey covers information on farm input characteristics, crop production factors, input and output

data as well as their prices.

The empirical model. The study ultimately utilizes multiple regressions based on stochastic production frontier to determine resource use efficiency, assuming a Cobb-Douglas functional form given as:

$$\ln(Qty) = \beta_0 + \beta_1 \ln(\text{land}) + \beta_2 \ln(\text{planting material}) + \beta_3 \ln(\text{Labour}) + \beta_4 \ln(\text{capital}) + \beta_5 \ln(\text{Fertilizer}) + V_i - U_i \quad (3)$$

$$e^{-vi} = \delta_0 + \delta_1 (\text{EDU}) + \delta_2 (\text{AGE}) + \delta_3 (\text{H.SZ}) + \delta_4 (\text{EXP}) + Z_i \quad (4)$$

Where

EDU is the education (years), AGE is the age of the farmers (years), H.SZ is the household size of the farmers, EXP is the experience (in years) and Z_i is an error term assumed to be randomly and normally distributed.

EMPIRICAL RESULTS AND DISCUSSION

Descriptive statistics. The variables used in this study are the socio-economic variables and farm input variables as stated in (3) and (4).

Table I shows the mean values of output and explanatory variables. Fertilizer is sparingly used in the area; as only 12% of the farmers in the study area apply fertilizer, among whom the maximum quantity is 50 kg. The farmers in the study area depend solely on the land's natural fertility that depletes with continuous cultivation. Also it was observed that in the study area all the farmers have experience in farming with the minimum value of one year and maximum of 14 years but despite their experience, they lack modern equipments. They still use their crude implements, which they don't mind purchasing costly, knowing the implements limitation. However one obvious thing among the sampled farmers is that land availability is not a problem. Every farmer has access to obtaining any size of land either by inheritance or purchase. The average farm size is 2.49 ha, minimum is 0.2 ha and maximum value 14 ha.

ML estimates result. The model specified is estimated by ML method using a computer programme FRONTIER 4.1.

Table II shows ML estimates and inefficiency determinants of the specified model. The sigma square (11.650) is statistically different from zero at $\alpha = 0.01$. This indicates a good fit and the correctness of the specified distribution assumption of the composite error term. Also, the variance ratio defined as Gamma (λ), is estimated as 0.287, meaning that the existence of technical inefficiency among the farmers accounts for about 28.7% of the variations in the output levels of the crops grown. In a nutshell, the diagnostic statistics confirm the relevance of the specified stochastic production.

Production determinants. The production function estimates indicates the relative importance of factor inputs used in farming in the study area. From Table II, land is the most important factor of production, having an elasticity of

Table I. Mean values of output and explanatory variables

Description	Unit	Mean-value	Min-value	Max-Value
Output	Grain Equivalent	14628.63	200	654,550
Labour	Mandays	147.18	2	945
Land	Hectares	2.49	0.2	14
Capital	N:K	4648.50	300	86,500
Fertilizer	Kg	2.04	1	50
Planting material	Kg	482.04	12.5	7130
Education	Years	5.72	0	14
Household size	Number	7.28	0	26
Experience	Years	22.78	1	75
Age	Years	45.03	20	90

Source: Field survey, 2005

Table II. ML estimates and inefficiency function

Variables	Coefficient	Asymptotic t-value
Production function		
Constant term (β_0)	4.503	5.8642
Land (ha) (β_1)	0.4595	4.0474
Planting material (kg) β_2	0.4290	4.5220
Labour (Mandays) β_3	0.3055	2.6648
Capital (N, k) β_4	0.1244	0.1105
Fertilizer (kg) β_5	0.0074	0.0211
Inefficiency model		
Intercept (δ_0)	-0.0760	-0.1362
Educational levels (years) δ_1	0.0184	0.2293
Age (years) δ_2	-0.0905	-1.8716
Household size δ_3	0.2084	5.4263
Years of farming Experience (years), δ_4	-0.0515	-1.8340
Diagnosis statistics		
Sigma - squared (δ_1^2)	11.650	6.8642
Gamma (λ)	0.287	1.9942
Ln (Likelihood)	176.06	
LR Lest	14.64	
Quasi - function	1.3258	
Number of observations	120	

Note: All explanatory variables are in natural logarithms. A negative sign of the parameter in the inefficiency function means that the associated variable has a positive effect on technical efficiency, and a positive sign indicates the reverse is true

Source: computer printout of frontier 4.1

0.4595. This implies that 10% increase in ha of land used would increase the total output by 4.6%. This is consistent with the observation that increase in size of land would result in increase revenue and net income of farmers in the study area. This result agrees with the findings of Adegeye and Dittoh (1985) and Eyoh and Igben (2002).

Planting material appears as the second most important factor, with an elasticity of 0.4290. This shows that planting material is positively related to the total output. A 10% increase in planting material increases output by 4.3%. The policy implication is that farmers should be provided with improved planting material to enhance output productivity of crop mix. The next important factor of production is labour, having an elasticity of 0.3055. The significance of labour to crop mix in the study area cannot be overemphasized. This is consistent with the observation that production of crop-mix in the study area is labour-intensive, rather than being capital intensive. Labour is

therefore a significant determinant of production in the study area. Therefore an increase in mandays by 10% increases total farm output by 3.1%. Production in the study area is not capital intensive. Thus explains why its elasticity is small (0.1244) and is not significant. The use of crude farming tools could be a major reason for the magnitude of the capital coefficient.

Fertilizer has little or no significance to production with an elasticity of 0.0074, this agrees with the observation that majority of the farmers in the study area neither apply organic nor inorganic fertilizer to their plots of land. This means that they rely on the land's natural fertility, which degrades with continuous cultivation. The policy implication is that, it is necessary for both inorganic and organic fertilizer to be encouraged by the government through adequate extension services, since continuous use of land, without replenishing it will not only lead to decrease in crop productivity as a result of nutrient depletion, but also in land degradation.

Inefficiency determinants. The estimated coefficients of the inefficiency function provide some explanation for the relative technical efficiency levels among individual farms (Udoh, 2005). The estimated coefficients of the inefficiency variables are highly significant, except the coefficient of educational levels. Specifically, the age of the farmers and the farming experiences positively affect the farm level technical efficiency effects. This implies that as farmers in the study area advances age, inefficiency in resource use decreases and technical efficiency increases. Advancement in age improves the farmers assimilation and understanding of relevant information more effectively; hence the farmers gets equipped and empowered gradually, which eventually leads to improved method of production, hence higher level of technical efficiency. This result agrees with the findings it Huffman (1977); Ram (1980); Parikh *et al.* (1996); Udoh, (2005).

Resource - use efficiency. The frequency distribution of efficiency as shown in Table III indicates a rather wide variation of efficiency index across the farms. The distribution spreads from left to right at different internal with the mean value being 0.73. However, larger percentage of the farms has efficiency value greater than 0.70 indicating negatively skewed distribution.

The observed distribution suggests that little marketable outputs are wasted due to inefficient use of farm resources. With a mean efficiency value of about 73%, the analysis revealed that production has not reached the frontier threshold. As such, within the context of efficient production, crop production can still be increased.

Resource - use productivity and scale of production. The evaluation of resource use productivities is done by estimating the marginal and average physical productivities of the input-use from the elasticity. Considering the nature of elasticities of the factors of production and the quasi function of 1.3258, the returns to scale for input use are increasing as the sum of factors elasticity differ significantly

Table III. Distribution of farm-specific technical efficiency

Efficiency Class	Frequency	Percentage
0.40-0.49	11	9.17
0.50-0.59	9	7.50
0.60-0.69	19	15.83
0.70-0.79	32	26.66
0.80-0.89	38	31.77
0.90-1.00	11	9.17

Mean value = 73.19

Minimum value = 0.40

Maximum value = 0.99

Source: Frontier 4.1 result

Table IV. Resource – use productivity estimates

Resource	Elasticity	MPP	APP
Land (Ha)	0.4595	2699.54	5874.95
Planting material	0.4290	0.93	2.17
Labour (mandays)	0.3055	30.36	99.39
Capital (K)	0.1244	0.36	3.15

Source: Computed from Computer printout

from unity, thus the farmers are experiencing increasing return to scale. This might be as a result of the high elasticity of land and the labour use intensity. As shown in Table IV, the return to scale for input-used are increasing, also the estimation of input productivities on the basis of elasticities of production indicates positive and high marginal physical productivities except capital and planting material. This confirms the fact that the use of modern farm tools and improved planting material is minimal in small-scale farming. It therefore can be inferred that the farmers are operating at stage II of the production process.

CONCLUSION AND RECOMMENDATIONS

This study is based on the use of survey data on inputs and aggregate crop mix (output) of farmers to measure farm –level technical efficiency and productivity terms through stochastic frontier estimation method. Cobb-Douglas production frontier was estimated by maximum likelihood estimation to obtain ML estimates and inefficiency determinants. The parameters obtained were asymptotically efficient and consistent. The diagnostic statistics confirmed the relevance of stochastic function and maximum likelihood estimation; that a classical regression model of production based on ordinary least squared would be inadequate representation of the data.

The study show the existence of increasing returns to scale on the input used, but positive and high marginal physical productivities, except for capital and planting material. The distribution of resource is efficiency revealed a rather wide variation of efficiency index across the farms, showing a maximum value of 0.99 and a minimum value 0.40. The overall mean technical efficiency of 73% shows that farmers could increase the scope of their production to narrow the existing gap and increase input use productivity. As such, more input can be used, especially capital and

improved planting material to expand production.

In line with the findings of the study, the following recommendations are made:

- The use of inorganic fertilizer should be encouraged to boost the fertility of the soil and for higher net return.
- The use of farm -level simple machine that the farmers can easily adopt should be encouraged.
- Farmers should also be provided with improved planting materials to boost productivity in the area.
- Provision of adequate extension and supportive services of government with a view of improving farming technique with technological innovations.

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