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ISSN: 1598 - 9960

## ECONOMIC EFFICIENCY AMONG SMALL HOLDER ARABLE CROP FARMERS IN KEBBI STATE NIGERIA

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### ABSTRACT

The economic efficiency, determinants of production and the sources of inefficiency in arable crop production in Kebbi State are investigated using a stochastic frontier profit function which incorporates a model for inefficiency effects. Data were generated using the cost route approach from a sample of 96 farm households selected from the four agricultural zones of the state during the 2004 cropping season using the multi-stage stratified random sampling techniques. Results show that size of land holding (hectares) and capital inputs are the major factors associated with changes in the output of arable crops. Of the farmer's specific socioeconomic variables, only three, namely: level of education, extension contact and cooperativeness were found to be the significant factors accounting for the variation in efficiency among small holder arable crop farmers. It recommends policies that would encourage land consolidation, attainment of basic formal education by the farmers and strengthening the existing extension services in the state.

**KEY WORDS:** Economic efficiency, Technical efficiency, Stochastic frontier, Arable crops, Farmer.

### INTRODUCTION

The current concern of stakeholders in agricultural development in Nigeria is the onerous task of feeding over hundred million people in the nation. The continual increase in the nation's population without a corresponding increase in food production rather signals a scenario of widespread hunger, malnutrition and poverty.

The contribution of Gross Domestic Products (GDP) (CBN,1999) observed, progressively declined from 60% in 1974 to less than 10% in the 1990's following the discovery of petroleum in the early seventies. This situation has been attributed to the relative neglect of agriculture as policy makers shifted emphasis from the farms to the oil wells. Yields are low owing to inefficient production techniques, shortage of capital for agricultural investment, use of in-appropriate and labor-intensive agricultural technology, rapidly declining soil productivity and poor extension services (Tanko,2004) among others. The obvious consequence is the slow growth and inadequate capacity of the agricultural sector to provide sufficient food for the fast growing population. With the 3 per cent per annum rapid growth rate of the national population (CBN,1999), there has been much more pressure on food availability with concurrent effects of increased food importation and a deepening foreign debt status. For instance, the Central Bank of Nigeria (1999) reported that the value of annual food imports in Nigeria increased from N441.7 million in 1976 to N7,595.6 million in 1996.

Quite a number of strategies that attempt to bring about significant increases in food production have been advocated, one of which is the effective combination of measures aimed at increasing the level of farm resources, making efficient use of the resources already committed to the food subsector and combining the enterprises in an optimal manner (Alam et al 1995, Tanko, 2004).

Increasing the level of efficiency in food crop production among smallholder farmers who operate optimally along their production function/frontier while being much less successful in shifting from a production function to a higher one could help in the resolution of the food crisis and improving the welfare of farmers. Lending credence to this, Bagi (1982) affirms that it is ideal to lay emphasis on allocating and distributing adequate resource inputs investment in research and eliminating the bottle necks to efficient resource utilization at the farm level. This study examined the economic factors that determine production efficiency and the sources of inefficiency of small holder arable crop farmers in Kebbi State.

a) Hypotheses:

H<sub>1</sub>: Arable crop farmers in Kebbi State are economically efficient in production.

H<sub>2</sub>: The explanatory variables in the model for the inefficiency factors have zero coefficients (i.e H<sub>0</sub>:  $\delta_1 + \delta_2 + \dots + \delta_n = 0$ )

b. Theoretical framework

Efficiency is the ability to produce a given level of output at lowest cost (Farrel, 1957). Economic efficiency is the ability of a farm to achieve the highest possible profit, given the prices and levels of resources of that farm (Bagi, 1982). The economic theory of production provides the analytical framework for most empirical research on productivity and efficiency. As a result of the pioneering but independent works by Aiger et al (1977), Bagi and Huang (1983) Kalirajan and Flinn (1983), Amaza and Olayemi (2001) consideration has been given to the possibility of estimating the stochastic frontier production function. In most of the studies, it was found that the Cobb-Douglas stochastic frontier does not provide an adequate representation for describing the data given the specification of a translog model (Tanko, 2004).

Following Ajibefun (2002), considering a farmer using inputs  $X_1, X_2, \dots, X_n$  to produce output  $Y$ , efficient transformation of inputs into output is characterized by the production function  $f(X)$ , which shows the maximum output obtainable from various input vectors. The stochastic frontier production is defined as

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

where,

$Y_i$  = production of the  $i^{\text{th}}$  farm

$X_i$  = vector of input quantities of the  $i^{\text{th}}$  farm

$\beta$  = vector of unknown parameters of the  $i^{\text{th}}$  farm

$V_i$  = random error associated with random factors not under the control of the farm  
e.g weather.

$U_i$  = inefficiency effects (one-sided error with  $U_i \geq 0$ ) i.e  $U_i$ s are non-negative with technical inefficiency in production.

$(V_i - U_i)$  = composite error term

The symmetric component,  $V$ , account for factors outside the farmer's control such as weather and diseases. It is assumed to be independent and identically distributed as  $N \sim (0, \delta^2 V)$ . A one-sided component  $V = 0$  reflects technical inefficiency relative to the stochastic frontier,  $f(X_i; \beta) \exp(V_i - U_i)$ . Thus  $V = 0$  for a farm output which lies on the frontier and  $V < 0$  for one whose output is below the frontier as  $N \sim (0, \delta^2 U)$ , i.e the distribution of  $V$  is half-normal. Thus, the stochastic production frontier model can be used to analyze cross-sectional data. The model simultaneously estimates the individual technical efficiency of the respondents as well as determinants of technical efficiency (Battese and Coelli 1995).

The estimation of stochastic frontier production makes it possible to find out whether the deviation in technical efficiencies from the frontier output is due to firm specific factors or due to external random factors. It provides estimates for the technical efficiency by specifying composite error formulations to the conventional production functions (Khumbakar, 1990; Coelli, 1995; Battese and Coelli, 1995).

Technical efficiency of an individual farmer is defined as the ratio of the observed output to the corresponding frontier output, conditional on the levels of inputs used by the farmer. The technical efficiency of farmer (i) in the context of the stochastic production function in equation (1) is

$$TE = Y_i / Y_i^* \quad \text{--- (2)}$$

$$= f(X_i; \beta) \exp(V_i - U_i) / f(X_i; \beta) \exp V_i \quad \text{--- (3)}$$

$$= \exp(-U_i) \quad \text{--- (4)}$$

where

$Y_i$  = observed value of output  
 $Y_i^*$  = frontier output (or potential output).

Given the density function of  $U_i$  and  $V_i$ , the frontier production function can be estimated by the maximum likelihood technique. The value of the technical efficiency lies between zero and one. The most efficient farmer will have value one, whereas the least efficient farmer will have value lying between zero and one. The stochastic frontier of the translog type was specified for this study. The maximum likelihood technique is used to estimate the parameters of the stochastic frontier and the predicated technical efficiency/ inefficiency of the farmers.

Even though empirical estimation of the translog has come under theoretical criticism on the basis that estimates obtained may be invalid because of violation of regularity conditions at extreme sample values to the inclusion of the second-order term, especially in small samples (Amaza, 2000), however, the problem becomes partially solved with large samples with better degree of freedom.

## METHODOLOGY

- a) The Data and Model
- i. The Data

This study was conducted in Kebbi State. It is located in North Western part of Nigeria which lies between latitude:  $10^{\circ}$  and  $13^{\circ}$  N and longitudes  $3^{\circ}$  and  $6^{\circ}$  W. The area falls within the dry Savanna agro ecological zone of Nigeria with an average annual rainfall of between 650mm and 1100mm, with distinct wet (May- October) and dry (November April) seasons. Over two thirds of the estimated population of about 2,051,831 people are engaged in agriculture production, mainly on arable crops, alongside few cash crops with aspects of animal husbandry (Tanko, 2004). There are four agricultural zones in the state, namely, Argungu, Bunza Yauri and Zuru. Kebbi State was chosen for the study because the state is strategic in terms of food production in Nigeria.

A multi-stage stratified random sampling technique was used to select 96 representative arable crop farm households. The agricultural development project zones formed the first-stage of sampling. The second stage involved listing all the blocks in each of the zones to form separate sampling frames. The third stage was circle level. Four circles each were chosen from selected blocks. From each circle, a village was purposively selected. Purposive selection of villages was to ensure that only farming communities were chosen. The last stage was the farm household level. A list of smallholder arable crop farmers was compiled by the resident extension agents with the assistance of village heads. The sampled villages include Ribah, Amanawa, Fakai, Danko, Kaoje, Bagudo, Bess Aliero, Bunza, Ngaski, Agwara, Gungun Sarki, Yelwa, Arewa, Kangiwa, Gulma, and Gwandu from the four agricultural zones. Data were collected from the farm households with a structured and validated questionnaire. Data were collected on the socio-economic characteristics of the farmer, cropping patterns, production activities in terms of inputs, outputs and their prices using the cost-route approach from July 2004 to January 2005 after all the crops have been harvested. The yield plot method was used to obtain the yield of crops and conversions were later made using the grain equivalent table.

### ii) The Model

The stochastic frontier production function used by Parikh and Shah (1994) and Onus et al (2000) which in turn derive from the pioneering work of the composed error model of Aigner, et al (1977) was used in analyzing the data. The explicit form of the translog empirical stochastic frontier profit function model was used, which allows analysis of interactions among variables is specified as follows:

$$\ln \pi^* = \beta_0 + \beta_1 \ln x_1 + \beta_2 \ln x_2 + \beta_3 \ln x_3 + \beta_4 \ln x_4 + \beta_5 \ln x_5 + \frac{1}{2} \beta_6 \ln x_1^2 + \frac{1}{2} \beta_7 \ln x_2^2 + \frac{1}{2} \beta_8 \ln x_3^2 + \frac{1}{2} \beta_9 \ln x_4^2 + \frac{1}{2} \beta_{10} \ln x_5^2 + \beta_{11} \ln x_1 \ln x_2 + \beta_{12} \ln x_1 \ln x_3 + \beta_{13} \ln x_1 \ln x_4 + \beta_{14} \ln x_1 \ln x_5 + \beta_{15} \ln x_2 \ln x_3 + \beta_{16} \ln x_2 \ln x_4 + \beta_{17} \ln x_2 \ln x_5 + \beta_{18} \ln x_3 \ln x_4 + \beta_{19} \ln x_3 \ln x_5 + \beta_{20} \ln x_4 \ln x_5 + V_i \quad (6)$$

Where,

$\ln$  = logarithm to base e

- $\pi^*$  = Normalized profit in Naira of the farm defined as gross revenue less variable cost normalized by price of crop output per farmer
- $\beta_0$  = intercept / constant term
- $\beta_1, \beta_{20}$  = parameters estimated
- $X_1$  = farm size measured in hectares
- $X_2$  = capital inputs measured in Naira. These include: depreciation charges on machinery, equipment, implements, tools, repair and operating expenses, interest charges on borrowed capital, rent on land, tractor hiring costs and irrigation charges
- $X_3$  = Daily wage rate (N) normalized by price of crop output per farmer
- $X_4$  = Price of fertilizer (N) normalized by price of crop output per farmer
- $X_5$  = Price of planting material (N) normalized by price of crop output per farmer.
- $V_i$  = Normal random errors which are assumed to be independent and identically distributed having zero mean and constant variance.
- $U_i$  = Technical inefficiency effects, assumed to be independent of  $V_i$ 's and are non-negative random variables associated with the economic efficiency of the enterprise involved. It is under the farmer's control and accounts for inefficiency.

The total number of interactions is fifteen.

It is assumed that the technical inefficiency effects are independently distributed and arise by truncation (at zero) the normal distribution with mean  $U_i$  and variance  $\delta^2$ , where  $U_i$  is specified as;

$$U_i = \delta_0 + \delta_1 Z_{1i} + \delta_2 Z_{2i} + \delta_3 Z_{3i} + \delta_4 Z_{4i} + \delta_5 Z_{5i} + \delta_6 Z_{6i} + \delta_7 Z_{7i} + \delta_8 Z_{8i} + \delta_9 Z_{9i} \quad \text{--- (7)}$$

Where,

- $U_i$  = economic efficiency of the  $i$ th farmer
  - $Z_1$  = Age of the farmer in years
  - $Z_2$  = Level of education in no. of years spent in school.
  - $Z_3$  = Farming experience in years
  - $Z_4$  = Household size
  - $Z_5$  = Farm size
  - $Z_6$  = Number of meetings with extension agents during the production season
  - $Z_7$  = Dummy variable for credit status (1 for access to credit, 0 otherwise)
  - $Z_8$  = Dummy variable for membership of co-operative (1 for membership, 0 otherwise)
  - $Z_9$  = Sex, (1 for male, 0 otherwise)
- $\delta_1 - \delta_9$  = unknown parameters estimated.

The parameters of the stochastic frontier function are estimated by the method of maximum likelihood using computer program FRONTIER version 4.1 (Coelli, 1994).

The effect of technical inefficiency in the variation of output was determined following Jondrow et al' (198) drawing a relationship for the inefficiency index to that of general error as follows:

$$\gamma = (\lambda^2 / 1 + \lambda^2) \quad \text{--- (8)}$$

## RESULTS AND DISCUSSION

### (a). Socio-economic Profile of Respondent Farm Household Heads.

The average farm household surveyed had seven family members, headed by male, married and had attained at Quaranic level education. Farm size per household averaged 3.50 hectares of cultivated land in scattered localities.

Farm operations relied primarily on household labour and traditional farming practices. Mean years of farming experience was 18. Operating capital averaged N14,200.

b) Stochastic Frontier Estimation

The frontier function was estimated using maximum likelihood estimation approach (MLE) through the FRONTIER 4.1 programme developed and licensed by Coelli (1994). The results of MLE are given in Table 1.

Table 1: Maximum Likelihood Estimates of the Determinants of Economic Efficiency in Arable Crop Production in Kebbi State, 2004.

Variable	Parameter	Coefficient	t-ratio
Production factors	B	2.474	0.956
Intercept	B <sub>0</sub>	1.457***	3.203
Farm size (X <sub>1</sub> )	B <sub>1</sub>	1.432***	3.551
Capital inputs(X <sub>2</sub> )	B <sub>2</sub>	0.911	0.173
Labour (X <sub>3</sub> )	B <sub>3</sub>	0.294	0.563
Fertilizer (X <sub>4</sub> )	B <sub>4</sub>	-0.180	-0.323
Planting Material (X <sub>5</sub> )	B <sub>5</sub>		
Squared Terms	B <sub>6</sub>	-0.007	-0.893
Farm size X farm size	B <sub>7</sub>	0.001	0.803
Capital X Capital	B <sub>8</sub>	-0.001	-0.631
Labour X Labour	B <sub>9</sub>	0.002**	2.135
Fertilizer X fertilizer	B <sub>10</sub>	-0.002	-1.107
Material X Material			
Interaction Among Inputs	B <sub>11</sub>	-0.073	-0.791
Farm size X Capital	B <sub>12</sub>	0.025	0.432
Farm size X Labour	B <sub>13</sub>	-0.029	-0.699
Farm size X Fertilizer	B <sub>14</sub>	-0.096	-1.299
Farm size X Material	B <sub>15</sub>	0.003	0.055
Capital X Labour	B <sub>16</sub>	0.124*	1.865
Capital X Fertilizer	B <sub>17</sub>	-0.039	-0.619
Capital X Material	B <sub>18</sub>	0.004	0.079
Labour X fertilizer	B <sub>19</sub>	-0.018	-0.555
Labour X Material	B <sub>20</sub>	0.100**	2.126
Fertilizer X Material			
Inefficiency Factors	Z <sub>0</sub>	0.710**	1.307
Intercept	Z <sub>1</sub>	-0.016	-1.222
Age	Z <sub>2</sub>	0.040**	2.295
Level of Education	Z <sub>3</sub>	0.022	1.587
Farming Experience	Z <sub>4</sub>	-0.001	-0.002
Household size	Z <sub>5</sub>	-0.008	-0.329
Farm size	Z <sub>6</sub>	0.242**	1.987
Extension contact	Z <sub>7</sub>	0.254	0.744
Credit	Z <sub>8</sub>	0.869**	2.194
Co-operativeness	Z <sub>9</sub>	0.145	0.406
Sex		-62.60	
Diagnostic Statistics		33.00	
Likelihood ratio		0.507***	(5.997)
LR test	( $\delta^2$ )	0.619***	(6.010)
Sigma-Squared	( $\gamma$ )		
Gamma			

Asterisks \*\*\*, \*\* and \* imply significance at the 0.01, 0.05 and 0.10 levels respectively  
 Source: Computer printout of Frontier 4.1.

Table 1 shows the maximum likelihood parameter estimates of the translog stochastic frontier profit function for arable crop farmers in the survey area. Results in the table show that the estimate of  $\delta^2$  (0.507), that is sigma-squared is relatively large, statistically significant and different from zero at 0.01 level. This indicates a good fit and the

correctness of the specified distributional assumption of the composite error term. Xu and Jeffrey (1995), Kebede (2001) and Ajibefun and Aderinola (2003) in their various investigations obtained similar results.

More so, the variance ratio, defined as  $\gamma = \delta u^2 / (\delta u^2 + \delta v^2)$  that is gamma, is estimated to be as high as 61.99% percent, suggesting that systematic influences that are unexplained by the production function are the dominant source of random errors. In other words, the presence of technical inefficiency among the sample farms explains about 62 percent of the variation in the output level of the crops grown. This confirms that in the specified model, there is the presence of one-sided error component. This also implies that the effect of technical inefficiency is significant and that a classical regression model of production function based on ordinary least squares estimation would be an inadequate representation of the data. The results of the diagnostic statistics therefore confirm the relevance of stochastic parametric production frontier and maximum likelihood estimation.

The frontier function was estimated using maximum likelihood estimation (MLE) approach through the FRONTIER. 4.1 Program developed by coelli (1994).

c) Production Elasticities

The results in Table 1 show that the coefficients of farm size and capital inputs carried the expected positive signs and were significant at the one percent level. Their output elasticities indicated that an increase of 1 percent in farm size (hectare) and capital inputs will lead to 1.457 and 1.432 per cent increase in output of arable crops respectively. The sum of the elasticities indicated that the farmers were operating in the increasing returns to scale stage of production in the short run. Increasing returns portray a case whereby an additional unit of input results in a larger increase in production than the preceding unit. In this scenario, optimum efficiency of production or resource use has not been attained and resources are mis-allocated or underutilized below the point of economic efficiency. Farm size and capital inputs were thus found to be important factors in explaining output. However, Tanko (2004) observed that in traditional agriculture, capital investment on fixed assets is negligible.

d) Interactions of physical inputs

Capital and Fertilizer: This interaction term has a positive effect on output level and is significant at 1 percent level. It implies that a unit increase in capital with a corresponding unit increase in fertilizer would lead to less than proportionate increase in output level by 0.124 margin.  
Fertilizer and Material: The estimated coefficient of the joint effect of fertilizer and cost of planting material which is 0.100 is statistically significant at 5 percent level and is positively related to output level attained. This also shows a less than proportionate increase in the output level when fertilizer is increased by 1 unit, given a unit increase in the cost of planting material.

e) Sources of Inefficiency

The sources of inefficiency are examined by using the estimated  $\delta$ -coefficients in Table 1 associated with the efficiency variables in equation 7. The coefficient of level of education variable is estimated to be positive and statistically significant at the 5 percent level. This finding is in consonance with previous findings (Battese et al (1996); Coelli and Battese (1996); Seyoum et al (1998) and Amaza and Olayemi (2001). Farmers with formal education tend to be more efficient in food crop production, due presumably to their enhanced technical competence, which enables them to produce close to the frontier output. Also, farmers with education respond readily to the use of improved technology and tend to cope more with complexities associated with improved technology.

The coefficient of extension variable is estimated to be positive as expected and statistically significant at the 5 percent level. This implies that farmers who had more extension visits and teachings, tend to be more efficient in arable crop production. Extension visits afford the farmer the opportunity to learn improved technologies and to acquire needed inputs and services.

The coefficient of membership of co-operative was found to be positive and significant as expected at the 5 percent level. The result corroborates the findings of Effiong (2005), Tanko (2004) and Nwaru (2004). Farmers' membership of associations affords them the opportunity of interacting with others and thereby exchanging information on improved technology in arable crop production.

The distribution of respondents according to levels of attainment of economic efficiency is presented in Table 2

Results in Table 2 indicate that economic efficiency of arable crop farmers in the survey area ranged from 0.21 to 0.95, indicating that a wide gap exists between the efficiency of best economically efficient farmers and that of the average farmers. The mean economic efficiency of the farmers is 0.59. The estimates reveal that for the average arable crop farmer

Table 2. Frequency distribution of Economic Inefficiency of Arable crop farmers in Kebbi State, 2004.

Efficiency class	No. of Farmers	Percentage
0.21-0.30	12	12.50
0.31-0.40	15	15.62
0.41-0.50	10	10.42
0.51-0.60	10	10.42
>0.60	49	51.04
Total	96	100.00
Mean	0.59	
Standard deviation	0.12	
Minimum	0.21	
Maximum	0.95	

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

to attain the level of the most economically efficient in the sample, he/she would experience a cost saving of 39 percent [i.e. (1-59/96)]. The least economically efficient farmer will however, experience efficiency gain of about 79 percent that is [ (1-21/96) ] to be able to attain the level of the most economically efficient farmer in the sample. This shows that farmers in the survey area are economically inefficient. Amaza (2000) observed that a wide variation in farmer-specific efficiency level is a common phenomenon in developing countries. In the same vein, Onu et al (2000) found that the economic efficiencies of Cotton farmers in Nigeria differ substantially, ranging between 0.07 and 0.85 with a mean efficiency of 0.41.

f) Test of hypotheses.

Table 3 shows the tests of hypotheses for the parameters of the translog empirical stochastic frontier profit function.

Table 3. Test of Hypotheses of the Parameters of the Translog Stochastic Frontier Profit Function for Arable Crop Producers in Kebbi State, 2004.

Hypotheses	Likelihood ratio	Critical $X^2$ 0.05	Decision
1	33.00	11.91	Reject
2	-62.60	11.91	Reject

Source: MLE Diagnostic Statistics Critical  $X^2$  were obtained from Dey et al, (2000).

The results of the generalized likelihood ratio test indicate that hypothesis 1 which states that arable crop farmers are fully economically efficient is hereby rejected. This implies that there is economic inefficiency in arable crop production in the survey area. Hypothesis 2, which specifies that the explanatory variables in the model for the inefficiency factors have zero coefficients is also hereby rejected. This implies that the explanatory variables in the model contributed significantly in the explanation of efficiency in arable crop production in Kebbi State.

CONCLUSION AND POLICY RECOMMENDATIONS

The study has shown that arable crop farmers in the area were not economically efficient and economic efficiency in arable crop production could be increased. Farm resources were not optimally allocated suggesting a scope for improvement. Size of land holding was positive and significantly influenced farmers' efficiency. The need for emphasizing the expansion of area under cultivation becomes imminent as there are advantages of having large sized farms. There was apparent increasing returns to size in arable crop production and farmers with large farm sizes have access to production inputs and extension services. Policies that would encourage land consolidation are advocated. The Land Use Act of 1978 should be abolished and a policy that will allow for establishment of land markets be introduced or reactivated to engender acquisition and expansion of cultivable land.

The coefficient for capital inputs is positive and significant at the 5 percent level. The amount of capital inputs per farm determines the level of investment in such a farm and ultimately the level of output. Adequate supply of modern inputs at terms and times convenient and at fairly competitive price should be targeted at practicing farmers. Since education is an important variable that positively influenced efficiency, farmers should be encouraged to acquire formal education. The Universal Basic Education (UBE) should be strengthened. Results also reveal that extension contact and membership of farmer in organization were positive and significant. The role of these variables in improving productivity vis-a-vis acquisition and use of information on modern arable crop production techniques cannot be over emphasized. The Extension Department of the State Ministry of Agriculture and the ADPs should be properly funded and strengthened to enhance their outreach to farmers.

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Received for Publication: 19/02/2008

Accepted for Publication: 04/04/2008

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