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Technical and Allocative Efficiency Analysis of Nigerian Rural Farmers: Implication for Poverty Reduction

[1]B.C. Asogwa, [2]J.C. Ihemeje and [3]J.A.C. Ezihe
[1, 3]Department of Agricultural Economics, [2]Department of Agricultural Management,
University of Agriculture, P.M.B. 2373, Makurdi, Benue State, Nigeria

Abstract: The stochastic frontier models were used to analyse technical and allocative efficiency of Nigerian rural farmers. Farm level data from Benue state of Nigeria was used for the study. The study showed that technical and allocative efficiency in farm production among the farmers could be increased by 68 and 65%, respectively through better use of available resources. This could be achieved through improved farmer-specific factors which include improved farmer education, improved farmer experience, attraction of young and male farmers into farm productions. In addition, there should be policies that encourage the supply of sufficient and affordable labour for farm production.

Key words: Efficiency analysis, stochastic frontier models, rural farmers, poverty reduction, Benue state, farmer education, Nigeria

INTRODUCTION

According to IFAD, about three quarters of the poor in sub-Saharan Africa lack the capacity to obtain measurable output value that generates income sufficient for decent food, shelter, clothing and life quality generally; they live and work in the rural areas and depend mainly on farming or farm labour for their sustenance. Umeh *et al*. (1996) observed that >99.9% storage volume of grain production are stored at the on-farm level where fragile and clearly inefficient storage out-fits are in use. They concluded that the food security of Nigeria is in jeopardy.

Hoekman *et al.* (2001) argued that growth in incomes of the poor is strongly correlated with overall growth of the economy especially growth in the agricultural sector and this fact has been demonstrated in cross-country and individual country studies. Chirwa (2005) therefore, argued that macroeconomic policies that promote growth in income are likely to lead to poverty reduction. For instance with respect to agriculture, changes in price will provide incentives for agricultural production and specialization which in turn may lead into growth and distribution of income through employment generation and revenue enhancement and consequently poverty reduction (Chirwa, 2005).

The extent to which a given rate of growth translates into poverty reduction will depend on how distribution of income changes with growth and on initial inequalities in incomes, assets and access to opportunities that allow poor people to participate in generating growth. Hoekman *et al.* (2001) argued that for growth to have some meaningful impact on poverty that growth must occur in sectors in which a large proportion of the poor derive their livelihood. Agricultural sector remains the important sector for livelihood especially in rural Nigeria which accounts for >70% of the population.

Ravallion and Datt (2002) in a study of growth and poverty in India found that initial inequality in income, literacy, farm productivity and asset distribution affect the relationship between growth and poverty. Ater observed that productivity improvement for the Nigerian small scale farmers is the ultimate if development is to take place and be sustained. This is because it is generally accepted that the small scale farmer is poor with low productivity in rural areas and depends mainly on agriculture. Ajibefun (2000) opined that if the farmer is to be alleviated from poverty, the productivity and efficiency should be improved to support increased income, better standard of living and a check on environmental degradation. The resources committed to agriculture, according to Norman, should generate high productivity and the productivity should be transformed into an improvement in the quality of life of targeted Nigerians.

According to Ajibefun and Daramola (2003) to achieve prosperity and overcome stagnation, there is a need to increase growth in all sectors of the economy for such growth is the most efficient means of

Corresponding Author: Benjamin C. Asogwa, Department of Agricultural Economics, University of Agriculture, P.M.B. 2373, Makurdi, Benue State, Nigeria

alleviating poverty and generating long-term sustainable development. Resources must be used much more efficiently with more attention paid to eliminating waste. This will lead to an increase in productivity and incomes. The success in achieving broad-based economic growth will depend largely on the ability to efficiently utilize the available resources. Others observed that efficient resource use enhanced farm output, farm income and reduce annual farm cost of the cassava farmers in Nigeria (Umeh and Asogwa, 2005; Asogwa *et al.*, 2007).

There is crucial need to raise agricultural growth as such growth is the most efficient means of alleviating poverty. For Nigeria, raising productivity per area of land is the key to effectively addressing the challenges of achieving food security, as most cultivable land has already been brought under cultivation and in areas where wide expanse of cultivable land is still available, physical and technological constraints prevent large-scale conversion of potentially cultivable land (Ajibefun, 2002). Although, the importance of efficient use of resources has long been recognized, more often than not it is assumed that producers in an economy always operate efficiently. Nevertheless, the producers are not always efficient.

This is because two otherwise identical farmers never produce the same output and costs and profit are not the same and hence, difference in welfare and standard of living. This difference in output, costs and profit and consequently welfare and standard of living can be explained in terms of efficiency and other unforeseen exogenous shocks. Technical efficiency reflects the ability of a farmer to obtain maximum possible output from a given set of resources (inputs).

Allocative efficiency on the other hand, reflects the ability of a farmer to use the inputs in optimal proportions given their respective prices. Only few studies have been carried out on technical and allocative efficiency of farmers in the African setting.

However, there is relatively little empirical work to guide the development of agricultural policies aimed at reversing the decline in productivity among rural farmers and improve their farm efficiency and income thereby reducing poverty.

Objectives of the study: The broad objective of the study is to analyse, the technical and allocative efficiency of Nigerian rural farmers. The specific objectives of the study are to:

- Determine the effect of resource use on the output and production cost of rural farmers in Nigeria
- Estimate the technical and allocative efficiency levels of rural farmers in Nigeria
- Identify the determinants of technical and allocative inefficiency of rural farmers in Nigeria

Statement of the hypotheses: In order to achieve the specific objectives the hypotheses to be examined in the study are:

- Frontier is not of Cobb-Douglas form
- Inefficiency effects are absent from the model
- Inefficiency effects are not a linear function of the explanatory variables
- Inefficiency effects are not stochastic

Approaches to measuring efficiency: Farrell (1957)'s researches have led to the development of several techniques for the measurement of production. These techniques can be broadly categorized into two approaches: parametric and non-parametric. These approaches include parametric Stochastic frontier production function approach and the non-parametric mathematical programming approach commonly referred to as Data Envelopment Analysis (DEA). The two are most popular techniques used in efficiency analysis. The main strengths of the Stochastic frontier approach is that it deals with Stochastic noise and permits statistical tests of hypotheses pertaining to production structure and degree of inefficiency. The explicit parametric form for the underlying technology and an explicit distributional assumption for the inefficiency term are the main weaknesses of the parametric approach.

The main advantages of the DEA approach are that it avoids parametric specification of technology as well as the distributional assumption for the inefficiency. However, DEA is deterministic and attributes all the deviations from the frontier to inefficiencies. A frontier estimated by DEA is likely to be sensitive to measurement errors or other noise in the data. Various studies have used the different approaches of measuring efficiency (Seyoum *et al.*, 1998; Ajibefun and Daramola, 2003; Asogwa *et al.*, 2007; Gorman and Ruggiero, 2008; Kuah *et al.*, 2010).

MATERIALS AND METHODS

The study area: For this study, farm level data were collected on 224 rural farmers in Benue state. Benue state is one of the 36 states of Nigeria located in the North-Central part of Nigeria. The state has 23 local government areas and its headquarters is Makurdi. Located between longitudes 6°35'E and 10°E and between Latitudes 6°30'N and 8°10'N. The state has abundant land estimated to be 5.09 million ha. This represents 5.4% of the national land mass. Arable land in the state is estimated to be 3.8 million ha (BENKAD, 1998). This state is predominantly rural with an estimated 75% of the population engaged in rain-fed subsistence agriculture. The state is made up of 413,159 farm families (BNARDA, 1998). These farm families are mainly rural. Farming is the major occupation of Benue state indigenes. Popularly known as the food basket of the nation, the state has a lot of land resources. For example cereal crops like rice, sorghum and millet are produced in abundance. Roots and tubers produced include yams, cassava, cocoyam and sweet potato. Oil seed crops include pigeon pea, soybeans and groundnuts while tree crops include citrus, mango, oil palm, guava, cashew, cocoa and *Avengia* sp.

Sampling technique: In this study, the multi-stage random sampling technique was used for sample selection. Benue state is divided into three agricultural zones viz: zone A-C. Zone A and B are made up of seven local government areas each while zone C is made up of nine local government areas. Using a constant sampling fraction of 45%, three local government areas were randomly selected from zone A and B while four local government areas were randomly selected from zone C under the guide of Benue state Agricultural development programme workers. From each of the selected local government areas, one rural community was randomly selected. Finally from each community, households were randomly selected on the basis of the community's population size using a constant sampling fraction of 1% in order to make the sampling design to be self-weighting thereby avoiding sampling bias (Eboh, 1998). Based on the foregoing, 224 farm households were randomly selected for the study.

Data collection: Data were collected mainly from primary sources. The primary data were obtained through the use of structured questionnaires that were administered to the selected 224 farm households in Benue state.

Analytical technique: The Stochastic frontier production and cost function models were used for the analysis of data collected for the achievement of the specific objectives. The generalized Likelihood-ratio tests were adopted for the testing of the null hypotheses.

Model specification

Stochastic frontier model: In order to determine. The resource use efficiency of the respondents, the stochastic frontier production and cost functions models were used.

Stochastic frontier production function model: In this study, Cobb-Douglas stochastic frontier production function is assumed to be the appropriate model for the analysis of the technical efficiency of the respondents. The model to be estimated is as defined by (Seyoum *et al*., 1998):

$$\text{Log } Y_i = \beta_0+\beta_1\log X_{1i}+\beta_2\log X_{2i}+\beta_3\log X_3 i+ \beta_4 \log X_{4i}+\beta_5\log X_{5i}+V_i-U_i \quad (1)$$

Where:

Y_i = Output of the ith farmer (kg)
X_i = Farm size (ha)
X_2 = Seed (kg)
X_3 = Fertilizer (kg)
X_4 = Agrochemical (L)
X_5 = Labour (man-days)
V_i = Random error that is assumed to be normally distributed with zero mean and constant variance (σ^2_{Vi})
U_i = Technical inefficiency effects independent of V_i and have half normal distribution with mean zero and constant variance (σ^2_{ui})

Following Battese and Coelli (1995) model, the mean of farm-specific technical inefficiency U_i is defined as:

$$U_i = \delta_0+\delta_1 Z_1+\delta_2 Z_2+\delta_3 Z_3+\delta_4 Z_4+\delta_5 Z+\delta_6 Z \quad (2)$$

Where:

Z_1 = Farming experience (years)
Z_2 = Educational level of farmers (years)
Z_3 = Age of farmers (years)
Z_4 = Household size (number)
Z_5 = Sex (female = 1, male = 2)

Farm output is expected to be influenced positively by farm size, seed quantity, fertilizer quantity, agrochemical and labour.

Farming experience of farmer is expected to have negative effects on technical inefficiency. This because farming experience improves the rate of adoption of improved techniques. This would lead to effective utilization of inputs which in turn increases the technical efficiency of the farming operation.

Educational level of farmers is expected to have a negative effect on technical inefficiency. This is because education improves understanding and receptiveness to agricultural innovations. The result of this would be effective utilization of inputs which in turn in creases the technical efficiency of the farming operation.

Age of farmers is expected to have a positive effect on technical inefficiency effects. This is because old people are less energetic and less receptive to agricultural innovations and hence develops inefficient production routines and practices. Household size is expected to have negative effects on technical inefficiency as household size is proxy for family labour. The larger the households size, the more the family labour and the more the labour the more the utilization of inputs. Sex is expected to have a negative effect on the technical inefficiency effects as an indication that male farmers are more effective in the utilization of farm resources than their female counterpart.

Stochastic frontier cost function model: In this study, Cobb-Douglas stochastic frontier cost function is assumed to be the appropriate model for the analysis of the allocative efficiency of the respondents. The corresponding cost function is derived analytically and defined as follows:

$$\text{Ln } C_i = \beta_0+\beta_1 \text{ Ln } (Y_i^*)+\beta_2 \text{ Ln } (P_{1i})+\beta_3 \text{ Ln } (P_{2i})+ \beta_4 \text{ Ln } (P_{3i})+ \beta_5\text{Ln } (P_{4i})+\beta_6\text{Ln } (P_{5i})+V_i+ U_i \quad (3)$$

Where:

- C_i = The total cost of production per unit farm measured in Naira
- Y_i^* = The total farm output per unit farm measured in Naira
- P_{1i} = Seed cost in naira
- P_{2i} = Fertilizer cost in naira
- P_{3i} = Agrochemical cost in naira
- P_{4i} = Labour cost in naira
- P_{5i} = Land cost in naira

The model for allocative inefficiency is given as:

$$U_i = \delta_0+\delta_1Z_1+\delta_2Z_2+\delta_3Z_3+\delta_4Z_4+\delta_5Z+\delta_5Z \quad (4)$$

Where:

- Z_1 = Farming experience (years)
- Z_2 = Educational level of farmers (years)
- Z_3 = Age of farmers (years)
- Z_4 = Household size (number)
- Z_5 = Sex (female = 1, male = 2)

Total farm production cost is expected to be influenced positively by output and input costs. This suggests that an increase in output and seed cost, fertilizer cost, agrochemical cost, labour cost and land cost would increase total cost of production.

Farming experience of farmer is expected to have a negative effect on allocative inefficiency effects because cost minimizing input combination and revenue maximizing output requires information about technology and market prices. The more experienced the farmer the better the ability of the farmer as a decision maker to obtain and process information about prices and technology. Educational attainment of farmer is expected to have a negative effect on allocative inefficiency effects because education improves the ability of the farmer as a decision maker to obtain and process information about prices and technology which in turn in crease allocative efficiency of the farming operations.

Age of farmers is expected to have a negative effect on allocative inefficiency effects. This is because older farmer may have developed managerial routines and practices by experience that would help them to improve their ability in making input choices in a cost minimizing way.

Household size is expected to influence allocative inefficiency negatively because the larger the household size the less the hired labour that would be used in the production of output and the less the total cost of production. This in turn would increase allocative efficiency.

Sex is expected to have a negative effect on the technical inefficiency effects as an indication that male farmers are more effective in the utilization of farm resources than their female counterpart.

The model defined by Eq. 1-4 was proposed by Battese and Coelli (1995). The parameters of the model, the β's, the δ's and the variance parameters:

$$\sigma^2 = \sigma^2_u+\sigma^2_v \quad (5)$$

and;

$$\gamma = \sigma^2_u/ (\sigma^2_u+\sigma^2_v) \quad (6)$$

are simultaneously estimated using the method of maximum likelihood. The computer programme frontier 4.1 developed by Coelli (1994) that computes the parameters estimates by iteratively maximizing a nonlinear function of the unknown parameters in the model subject to the constraints was used. The value of the γ indicates the relative magnitude of the variance associated with the distribution of inefficiency effects, U_i. If U_i in the stochastic frontier are not present or alternately, if the variance parameter, γ associated with the distribution of U_i has value zero, then σ^2_u in Eq. 1-4 is zero and the model reduces to a traditional production function with the variables: farming experience, educational level, age, household size and sex all included in the production function meaning that inefficiency effects are not stochastic.

The functional form for the technical efficiency (stochastic frontier production function) is defined by Eq. 1 while that of allocative efficiency (Stochastic frontier cost function) is defined by Eq 3. The function is a modified version of a Cobb-Douglas model. It permits different levels of productivity associated with different proportions of farm size (or land cost), seed (or seed cost), fertilizer (or fertilizer cost), agrochemical (or agrochemical cost) and labour (or labour cost). Several generalized

Likelihood-ratio tests pertaining to Stochastic frontier coefficients Inefficiency model and variance parameters were carried out. The generalized Likelihood-ratio test statistic is computed as:

$$\lambda = -2 \log [(L(H_0)/L(H_1)]$$

or;

$$\lambda = -2[\log L(H_0)-\log L(H_1)]$$

where, $L(H_0)$ and $L(H_1)$ are the likelihood functions evaluated at the restricted and unrestricted maximum-likelihood estimator for the parameters of the model. If the null hypothesis, H_0 is true then the statistic has approximately Chi-square (χ^2) distribution with parameter equal to the number of restrictions imposed by H_0. The test statistic (λ) has a χ^2 or a mixed χ^2 distribution with degrees of freedom equal to the difference between the parameters involved in H_0 and H_1.

Efficiency predictions: The computer program (frontier 4.1) calculates predictions of individual firm technical efficiencies from estimated Stochastic production frontiers and predictions of individual firm cost efficiencies from estimated Stochastic cost frontiers. The measures of technical efficiency relative to the production frontier 1 and of cost efficiency relative to the cost frontier 3 are both defined as:

$$EFF_i = E(Y_i^*/U_i, X_i)/E(Y_i^*/U_i, = 0, X_i) \qquad (7)$$

where, Y_i^* is the production (or cost) of the i-th firm which will be equal to Y_i when the dependent variable is in original units and will be equal to exp (Y_i) when the dependent variable is in logs. In the case of a production frontier, EFF_i will take a value between zero and one while it will take a value between one and infinity in the cost function case.

RESULTS AND DISCUSSION

Maximum likelihood estimates: The estimated standard errors of some of the coefficients in the Stochastic frontier models (Table 1 and 2) are large relative to their estimates which indicate that the individual coefficients may not be statistically significant. However, the generalized Likelihood-ratio test rejects the composite hypothesis that the variables in the Cobb-Douglas model are zero (Table 3). That means that given the assumption of Cobb-Douglas specification, a Cobb-Douglas function is an adequate representation of the Stochastic frontier function. Using the maximum-likelihood estimates for the parameters of the production frontier (Table 1), the elasticities of frontier output with respect to land, seed, fertilizer, herbicide and labour were estimated at the means of the input variables to be 0.32, 0.31, 0.18, -0.10 and -0.12, respectively. Given the specification of the Cobb-Douglas frontier models the results show that the elasticity of

Table 1: Maximum likelihood estimates for parameters of the Stochastic frontier production model for farms in rural Nigeria

Variables	Parameters	Estimate	SE	t-ratio
Stochastic frontier				
Constant	β_o	3.110	0.197	15.77**
Ln (farm size)	β_1	0.320	0.117	2.76**
Ln (seed)	β_2	0.310	0.036	8.74**
Ln (fertilizer)	β_3	0.180	0.058	3.11**
Ln (herbicide)	β_4	-0.100	0.036	-2.79**
Ln (labour)	β_5	-0.120	0.045	-2.58**
Inefficiency model				
Constant	δ_o	40.850	7.292	5.60**
Farming experience	δ_1	-0.550	0.213	-2.61**
Education	δ_2	-1.170	0.259	4.54**
Age	δ_3	0.530	0.127	-4.19**
Household size	δ_4	-1.320	0.776	-1.71*
Sex	δ_5	-49.600	5.632	-8.81**
Variance parameters				
Sigma square (σ^2)	σ^2	152.720	16.74	9.12**
Gamma (γ)	γ	0.997	0.0008	1190.64**
Ln likelihood function	-	-520.060	-	-

Table 2: Maximum likelihood estimates for parameters of the Stochastic frontier cost model for farms in rural Nigeria

Variables	Parameters	Estimate	SE	t-ratio
Stochastic frontier				
Constant	P_0	1.1300	0.023	48.69**
Ln (output)	P_1	0.0006	0.003	0.16
Ln (seed cost)	P_2	0.2500	0.022	11.67**
Ln (fertilizer cost)	P_3	0.5500	0.023	2.35**
Ln (herbicide cost)	P_4	-0.0010	0.005	-0.33
Ln (labour cost)	P_5	0.2900	0.019	15.05**
Ln (land cost)	P_6	0.0200	0.003	6.30**
Inefficiency model				
Constant	δ_0	-2.7800	0.109	-2.56**
Farming experience	δ_1	-0.0040	0.011	-0.41
Education	δ_2	-0.0600	0.024	-2.60**
Age	δ_3	0.0050	0.007	0.76
Household size	δ_4	-0.1900	0.070	-2.75**
Sex	δ_5	-3.1800	0.910	-3.50**
Variance parameters				
Sigma square (σ^2)	σ^2	2.0700	0.607	3.42**
Gamma (γ)	γ	0.9940	0.002	482.55**
Ln likelihood function	-	-6.6700	-	-

*t-ratio is significant at 5% level of significance. **t-ratio is significant at 1% level of significance

Table 3: Generalized Likelihood ratio tests of hypotheses involving the parameters of the Stochastic frontier and Inefficiency model for farms in rural Nigeria

Null hypothesis	ln (H_0)	λ	df	*Critical value	Decision
Stochastic frontier					
H_0: $\beta_{ij} = 0$	-560.29	80.46	5	15.09	Reject H_0
Inefficiency model					
H_0: $\gamma = \delta_0 = \delta_1 = \delta_2 = \delta_3 = \delta_4 = \delta_5 = 0$	-582.52	124.92	7	18.48	Reject H_0
H_0: $\delta_1 = \delta_2 = \delta_3 = \delta_4 = \delta_5 = 0$	-571.02	101.92	5	15.09	Reject H_0
H_0: $\gamma = 0$	-582.52	124.92	2	9.21	Reject H_0

*Critical value is significant at 1% level of significance, Field Survey (2008) mean value of farm output is estimated to be an increasing function of land, an increasing function of seed and an increasing function of fertilizer.

The elasticity of mean value of farm output was estimated to be a decreasing function of herbicide and a decreasing function of labour. The high land elasticity suggests that expansion in production among the farmers was mainly due to increase in farm size rather than increase in technical efficiency. The returns-to-scale parameter was found to be 1.03, implying increasing return-to-scale for production among the rural farmers in Nigeria. This suggests that a proportionate increase in all the inputs would result to more than proportionate increase in the output of the farmers.

The increasing return-to-scale in this study implies increasing productivity per unit of input, suggesting that the farmers are not using their resources efficiently. This means that the farmers can still increase their level of output at the current level of resources. This implies that production efficiency among the farmers would result to higher farm output in Nigeria. The implication is that policy that encourages technical efficiency among the farmers would bring about an increase in farm output in Nigeria.

Contrary to the expectation, labour and herbicide had negative and significant coefficients. According to Olayide *et al*. (1980), a negative relationship do exist between family labour and hired labour among the resource-poor rural farmers because the consumption of additional hired labour is meant to supplement available family labour such that as the availability of family labour decreases, additional hired labour is consumed at the limit of the lean resources of the farmers. Due to the high cost of hired labour if additional hired labour must be consumed then additional cost must be incurred. This implies that to maintain the cost of production at the limit of their lean resources when additional hired labour is to be consumed, the resource-poor rural farmers must cut down the level of their cassava production.

This explains the negative influence of labour on output as observed among the respondents. This finding is in consonance with the observation of Nweke (2004) that farmers who plant improved cassava varieties have sometimes have to suspend planting because they were unable to hire sufficient labour to harvest previously planted cassava fields because of rising wages. Similarly, high cost of herbicides accounts for the negative relationship between output and herbicide use among the respondents. The elasticity of mean values of cost with respect to the output and input prices is estimated at the values of the means of the costs of resources. Using the maximum-likelihood estimates for the parameters of the cost frontier (Table 2), the elasticities of frontier cost with respect to output, seed price, fertilizer price, herbicide price, labour price and land price were estimated at the means of the input price variables to be 0.0006, 0.25, 0.55, -0.001, 0.29 and 0.020, respectively.

Given the specification of the Cobb-Douglas frontier models, the results show that the elasticity of mean value of farm production cost is estimated to be an increasing function of output, an increasing function of seed price, an increasing function of fertilizer price and a decreasing function of herbicide price. The elasticity of mean value of farm production cost was estimated to be an increasing function of labour price and an increasing function of land price. The low land price elasticity suggests that decrease in production cost among the farmers was mainly due to land acquisition by inheritance rather than increase in allocative efficiency.

The returns-to-scale parameter was found to be 1.11, implying increasing return-to-scale for production cost among the rural farmers in Nigeria. This suggests that a proportionate increase in all the inputs given their respective prices would result to more than proportionate increase in the production cost of the farmers. The increasing return-to-scale in this study implies increasing cost per unit of output, suggesting that the farmers are not using their inputs in optimal proportions given their respective prices. This means that the farmers can still minimize their production cost at the current level of resources by using their inputs in optimal proportions given the input prices.

This implies that allocative (cost) efficiency among the farmers would result to higher farm profit in Nigeria. The implication is that policy that encourages allocative (cost) efficiency in production among the farmers would bring about an increase in farm profit in Nigeria.

The major interest of the study is concerned with the coefficients for the Inefficiency model. The 2nd null hypothesis which specifies that inefficiency effects are absent from the model is strongly rejected at the 5% level of significance (Table 3). The 3rd null hypothesis which specifies that the explanatory variables in the model for the inefficiency effects have zero coefficients is rejected at the 5% level of significance (Table 3). Thus, it can be concluded that the explanatory variables in the inefficiency effects contribute significantly to the explanation of inefficiency in production among the respondents. The estimated coefficients of farming experience, education, household size and sex are negative and significant at the 5% level of significance while the estimated coefficient for age is positive and significant at the 5% level of significance (Table 1). This implies that farming experience, education, household size, age and sex are significant determinants of technical inefficiency at the 5% level of significance among the respondents. The negative coefficients of farming experience, level of education and household size imply that an increase in any of or in all of these variables would lead to decline in the level of technical inefficiency. Furthermore, the negative coefficient of sex implies that the male farmers are more technically efficient than their female counterpart. The positive coefficient of age implies that an in increase in age would lead to increase in the level of technical inefficiency.

Similarly, education, household size and sex are significant determinants of allocative inefficiency at the 5% level of significance among the respondents (Table 2). The negative coefficients of level of education and household size imply that an increase in any of or in all of these variables would lead to decline in the level of allocative inefficiency. Furthermore, the negative coefficient of sex implies that the male farmers are more allocatively efficient than their female counterpart.

The implication of the foregoing analyses is that any policy that would attract people with high level of education especially male farmers into farming as well as encourage relatively young and experienced farmers into farming and provide affordable farm labour for the farmers would lead to increase in the level of technical and allocative efficiency of the farmers and hence the level of productivity in the Nigerian agricultural sector. This would improve the profitability of farm production as the farmers through the expansion of input use would be able to move from the production phase of increasing return to scale to the phase of decreasing return to scale where profit would be maximized.

The estimate for the variance parameter, γ is estimated to be close to one. If this parameter is zero, then σ_u^2 in Eq. 1-3 is zero and the model reduces to a traditional production (or cost) function with the variables farming experience, education, household size, age and sex all included in the production (or cost) function meaning that inefficiency effects are not stochastic. The last null hypothesis which specifies that the explanatory variables in the model for the technical (or allocative) inefficiency effects are not stochastic is rejected (Table 3). This implies that the traditional average response (or cost) function is not an adequate representation for farm production among the respondents, given the specification of the stochastic frontier and inefficiency effects defined by Eq. 1-4.

The estimated sigma squared was significantly different from zero at the 1% level of significance. This indicates a good fit and the correctness of the specified distributional assumption of the composite error term. In addition, the magnitude of the variance ratio, λ was estimated to be high and close to one, suggesting that the systematic influences that are unexplained by the production function (or cost) are the dominant sources of errors. This means that 99.74% of the variation in output among the farms is due to differences in technical efficiency while 99.38% of the variation in cost among the farms is due to differences in allocative efficiency. This confirms the relevance of Stochastic frontier production and cost functions, using the Maximum Likelihood Estimator (MLE). Given the specification of the Cobb-Douglas stochastic frontier production function in Eq. 1 and 2, the predicted technical efficiency vary widely among the sample farmers, with minimum and maximum values of 0.0000006 and 0.84, respectively and a mean technical efficiency value of 0.32 (Table 4). The distribution of technical efficiency in Table 4 shows that the technical efficiency skewed heavily in the 0.3 and 0.5 range, representing 38.39% of the sample farmers.

The wide variation in technical efficiency estimates is an indication that most of the farmers are still using their resources inefficiently in the production process and there still exists opportunities for improving on their current level of technical efficiency. This result suggests that the farmers were not utilizing their production resources efficiently in dicating that they were not obtaining maximum output from their given quantum of inputs. In other words, technical efficiency among the respondents could be increased by 68% through better use of available production resources given the current state of technology.

This would enable the farmers obtain maximum output from their given quantum of inputs and hence increase their farm incomes thereby reducing poverty. Similarly, given the specification of the Cobb-Douglas stochastic frontier cost function in Eq. 3 and 4, the predicted allocative efficiency vary widely among the sample farmers, with minimum and maximum values of 1.04 and 42.91, respectively and a mean allocative efficiency value of 1.65 (Table 5). The distribution of allocative efficiency in Table 5 shows that the allocative efficiency skewed heavily in the 1.04 and 1.40 range, representing 74.11% of the sample farmers. The wide variation in

Table 4: Distribution of respondents by technical efficiency estimates

Technical efficiency	Frequency	Percentage
0.0000006<0.10	43	19.20
0.10<0.30	52	23.21
0.30<0.50	86	38.39
0.50<0.70	37	16.52
0.70<0.90	6	2.68
Total	224	100.00
Minimum efficiency	0.0000006	-
Maximum efficiency	0.84	-
Mean efficiency	0.32	-

Field Survey (2008)

Table 5: Distribution of respondents by allocative efficiency estimates

Technical efficiency	Frequency	Percentage
1.04<1.40	166.00	74.11
1.40<1.60	34.00	15.18
1.60<1.80	9.00	4.02
1.80<2.00	10.00	4.46
2.00<43.00	5.00	2.23
Total	224.00	100.00
Minimum efficiency	1.04	-
Maximum efficiency	42.91	-
Mean efficiency	1.65	-

Field Survey (2008)

allocative efficiency estimates is an indication that most of the farmers have not yet achieved optimal resource mix in their production process and there still exists opportunities for improving on their current level of allocative efficiency.

This result suggests that the farmers were not minimizing production costs in dicating that they were utilizing the inputs in the wrong proportions given the input prices. In other words, 65% of resources were inefficiently allocated relative to the best-practiced farms producing the same output and facing the same technology. This implies that allocative efficiency among the respondents could be increased by 65% through better utilization of resources in optimal proportions given their respective prices and given the current state of technology.

This would enable the farmers equate the Marginal Revenue Product (MRP) of input to the marginal cost of the input thereby improving farm income and consequently reduction of poverty.

CONCLUSION

The implication of the study is that technical and allocative efficiency in farm production among the farmers could be increased by 68 and 65%, respectively through better use of available resources given the current state of technology. This can be achieved through improved farmer-specific factors which includes improved farmer education, improved farmer experience, attraction of young and male farmers into farm productions. In addition, there should be policies that encourage the supply of sufficient and affordable labour for farm production.

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