PRINT: ISSN 0976-5239 ONLINE: ISSN 2456-6594
J Economics, 2(2): 89-98 (2011)
DOI: 10.31901/24566594.2011/02.02.03

Analysis of Economic Efficiency of Nigerian Small Scale Farmers: A Parametric Frontier Approach

Benjamin C. Asogwa, Joseph C. Umeh and Simon T. Penda

Department of Agricultural Economics, University of Agriculture, P. M. B. 2373, Makurdi, Benue State, Nigeria

KEYWORDS Technical Efficiency. Allocative Efficiency. Economic Efficiency. Parametric Frontier Models. Small Scale Farmers

ABSTRACT This study analysed the economic efficiency of Nigerian small scale farmers using the parametric frontier approach. Farm level data were collected from randomly sampled 393 small scale farmers in Benue State, Nigeria. The average level of technical, allocative and economic efficiency was estimated at 30%, 12% and 36% respectively. The study showed that technical inefficiency was higher than allocative inefficiency. Also, the low economic efficiency level can largely be explained by the low level of technical efficiency relative to allocative efficiency. High level of technical inefficiency was highly attributable to the low availability of extension services and information about technical aspects of crop technologies. On the other hand, high level of cost inefficiency was highly attributable to the low profitability that results from inadequate organization of farmers into collective farmers' institutions that can provide opportunities for risk sharing and improved bargaining power.

INTRODUCTION

Since independence, agriculture has continued to play a critical role in the Nigerian rural livelihoods. It employs over 80 percent of the rural population and also contributes to Nigeria's foreign exchange earnings. Agriculture, therefore, determines the pace and direction of overall economic growth for Nigeria. Nigerian's agricultural sector is dominated by the small scale farmers in rural areas. How the country's economy performs thus depends largely on its small scale farmers' performance. Given agriculture's prominence in Nigeria's economy, performance of small scale farmers in the sector should be of great concern to policy makers.

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 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. Agricultural growth is, therefore, a catalyst for broad based economic growth and development in most low-income countries and that economic growth is strongly linked to poverty reduction (Amalu 2005).

Previous efficiency studies in Nigeria have looked mainly at technical efficiency and its shortfalls (Ajibefun 2002; Ater and Umeh 2003; Asogwa et al. 2007). Technical efficiency (the relative position of the farmer on the frontier) derives from agronomic view and it is possible that the farmer could achieve this kind of efficiency, though at a much higher cost. An economic view, on the other hand, considers the use of inputs in optimal quantities while keeping their cost in proportion to the price the farmer receives for the outputs. It is, therefore, useful to examine the factors that affect overall economic efficiency. This paper builds on the previous studies by examining the levels and determinants of overall economic efficiency among small scale farmers in Nigeria.

The broad objective of the study is to analyse the economic efficiency of Nigerian scale farmers. The specific objectives of the study are to:

i. determine the effect of resource use on the output and production cost of small scale farmers in Nigeria;
ii. estimate the technical, allocative and economic efficiency levels of small scale farmers in Nigeria; and

Corresponding Author:
Benjamin C. Asogwa
Department of Agricultural Economics,
University of Agriculture,
Makurdi, P. M. B. 2373,
Makurdi, Benue State, Nigeria.
Telephone: +234-08065550122
E-mail: bcasogwa@yahoo.com

iii. identify the determinants of technical, allocative and economic inefficiency of small scale farmers in Nigeria.

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

i. frontier is not of Cobb-Douglas form;
ii. inefficiency effects are absent from the model;
iii. inefficiency effects are not a linear function of the explanatory variables; and
iv. inefficiency effects are not stochastic.

METHODOLOGY

For this study, farm level data were collected from small scale farmers in Benue State, Nigeria. Benue State is located between Longitudes 6^0 35'E and 10^0E and between Latitudes 6^0 30'N and 8^0 10'N. Arable land in the State is estimated to be 3.8 million hectares. This State is predominantly rural with an estimated 75 percent of the population engaged in rain-fed subsistence agriculture.

Benue State is divided into three (3) agricultural zones viz. Zone A, Zone B and Zone C. Zone A and Zone 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 Zone B while four Local Government Areas were randomly selected from Zone C. From each of the selected Local Government Areas, one farming 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 2009). Based on the foregoing, 393 small scale farmers were randomly selected for the study.

Data were collected mainly from primary sources. The primary data were obtained through the use of structured questionnaires that were administered to the selected 393 small scale farmers in Benue State. The parametric frontier models were used to analyse the economic efficiency of the small scale farmers in Nigeria.

Model Specification

The parametric frontier approach was chosen because of the many variations that underlie small scale production in developing countries. The stochastic frontier attributes part of the deviation to random errors (reflecting measurement errors and statistical noise) and farm specific inefficiency (Forsund et al. 1980; Battese and Coelli 1995; Coelli et al. 1998). Thus, the stochastic frontier decomposes the error term into a two-sided random error that captures the inefficiency component and the effects of factors beyond the control of the farmer.

To begin with, one assumes a deterministic production frontier generally given by the equation:

$$Q_f = g\ (X_{tfi}\ \beta), \quad \ldots\ldots (1)$$

where Q_f is the total output of the f^{th} farm (household) using input from a set of different but complementary inputs denoted X_{tf}. β denotes the vector of parameters to be estimated. From equation (1), it is possible to derive technically efficient output level Q for any given level of inputs by solving equation (1) substituting the X_{tf} with the technically efficient input quantities. Next, if we assume that the production frontier given in equation (1) is self-dual (Cobb Douglas or stochastic frontier), the corresponding cost frontier can be given as:

$$K = h(P,Q;\ \gamma) \quad \ldots\ldots (2)$$

where K is the minimum cost to produce output level Q, with P denoting the vector of input prices and γ a vector of the parameters to be estimated (unknowns). From this, the system of minimum cost input demand equations can be recovered by differentiating the equation in (2), which is referred to as the cost frontier, with respect to each by applying Shephard's lemma. This may be given as:

$$\partial K/\partial P_t = X_{tf} = l\ (P,\ Q,\ \theta), \quad \ldots\ldots (3)$$

where θ denotes the vector of unknown parameters. If we substitute the input prices and the technically efficient output level Q into equation (3), we can obtain economically efficient input quantities X_e . Given these technically and economically efficient input bundles, it is now possible to calculate the actual cost of these observed input levels by their respective prices as $X_t.P_t$ in the case of *technical efficiency* (TE) and $X_e.P_e$ in the case of *economic efficiency* (EE). From these, we can easily deduce that:

$$TE = X_t.P_t\ /\Sigma(X_t.P_t) \quad \ldots\ldots (4)$$

$$EE = X_t.P_t\ /\Sigma(X_e.P_e) \quad \ldots\ldots (5)$$

As given by Farrell (1957) and Bravo-Ureta and Pinheiro (1997), economic efficiency is the product of *technical efficiency* (TE) and *allo-*

cative efficiency (AE). Hence, by definition, it is possible to compute AE using equations (4) and (5) as:

$$AE = EE/TE = X_t.P_t / \Sigma(X_e.P_e) / X_t.P_t / \Sigma(X_t.P_t) \quad (6)$$

Technical efficiency is the ability of the firm or farm to maximize output for a given set of resource inputs. Allocative efficiency is its ability to use the inputs at its disposal in optimal proportions given their respective prices and the available production technology. Thus, TE is the farmer's ability to produce on the maximum possible frontier, AE is the farmer's ability to produce a given level of output using the cost minimizing input ratios, and EE is the farmer's ability to produce a predetermined quantity of output at minimum cost given the available technology.

To obtain the parametric measure of efficiency, a functional form for the stochastic production frontier is chosen. Ideally, the functional form should be flexible and computationally straightforward. To satisfy these properties, most empirical studies use the Cobb-Douglas production function. Following Seyoum et al. (1998), the Cobb-Douglas specification is mathematically expressed as:

$$\ln Y_i = \beta_0 + \beta_{ij} \ln X_{ij} + V_i - U_i \quad (7)$$

where Y_i is the total crop output obtained by the farm household per given season, X_{ij} are the inputs, $\beta_0 \ldots \beta_{ij}$ are the parameters to be estimated, V_i is a two-sided random error and is assumed to be identically and independently distributed with zero mean and constant variance and is independent of the one-sided error, U_i. Furthermore, to obtain estimates for the cost frontier, we estimate a stochastic cost frontier where the natural log of total cost K is regressed against the natural log of output and the natural log of specific input prices (seed, fertilizer, hired labour, agrochemical and land). We then specify the one-sided technical efficiency effect as being related to the exogenous factors, z that influence crop production:

$$u_j = f(z) + \varepsilon \quad (8)$$

where *z* is a vector of determinants of technical efficiency and ε is the error assumed to be iid (independent and identically distributed). The determinants are specified as household socioeconomic characteristics and some selected policy and institutional variables that are known to influence farm-level efficiency (For this study, these include age, education, farming experience, household size, dependency ratio, access to extension, household distance to the nearest city, household membership of farmer association, household distance to urban market and household distance to tarred road). Some variables that have been given prominence in the literature are farmer's education, access to extension, farming experience, age, farmer's access to improved technologies through the market or public policy interventions and land holding size. Most studies find that household variables such as household size, gender and education positively influence farm-level efficiency mainly through availability of labour and its productivity, although in some cases these relationships are not supported by other empirical studies (for example, Mochobelele and Winter-Nelson 2000, in the case of Lesotho). Extension and access to markets are important policy and institutional variables that positively influence efficiency, because on the one hand they provide the incentive and means for farmers to access improved crop technology and on the other they improve farmers' liquidity and the affordability of the inputs required for production.

The estimation for the efficiency model is conducted in the computer programme FRONTIER 4.1 developed by Coelli (1994) that computes the parameters estimates by iteratively maximizing a non-linear function of the unknown parameters in the model subject to the constraints. 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 asso-ciated with the distribution of U_i has value zero, then σ^2_u in (7 – 8) is zero, and the model reduces to a traditional production function with the variables: age, education, farming experience, household size, dependency ratio, access to ex-tension, household distance to the nearest city, household membership of farmer association, household distance to urban market and household distance to tarred road all included in the production function meaning that inefficiency effects are not stochastic.

Generalized Likelihood-Ratio Tests

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-squared 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 and of cost efficiency relative to the cost frontier are both defined as:

$$EFF_i = E(Y_i^*/U_i, X_i)/E(Y_i^*/U_i = 0, X_i), \quad \text{.....................} (9)$$

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. Economic efficiency estimate is the product of the technical efficiency and the allocative efficiency estimates.

RESULTS AND DISCUSSION

Maximum Likelihood Estimates

The estimated standard errors of some of the coefficients in the stochastic frontier models (Tables 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, agrochemical and labour were estimated at the means of the input variables to be 0.90, 0.45, 0.11, -0.08 and 0.04 respectively. Given the specification of the Cobb-Douglas frontier models the results show that the elasticity of mean value of farm output is estimated to be an increasing function of land, an increasing function of seed and an increasing function of labour. The elasticity of mean value of farm output was estimated to be an increasing function of fertilizer and a decreasing function of herbicide. 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 1.58, implying increasing return-to-scale for production among the small scale 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 will help to increase technical efficiency among the farmers would bring about an increase in farm output of the small scale farmers in Nigeria.

Contrary to the expectation, agrochemical had negative and significant coefficient. High cost of herbicides accounts for the negative relationship between output and agrochemical 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 0.0004, 0.25, 0.53, 0.0002, 0.32 and 0.02 respectively. Given the specification of the Cobb-Douglas frontier models the results show

Table 1: Maximum likelihood estimates for parameters of the stochastic frontier production model for small scale farmers in Nigeria

Variable	*Parameter*	*Estimate*	*Standard error*	*t-ratio*
Stochastic Frontier				
Constant	β_0	3.03	0.17	18.27
Ln (Farm size)	β_1	0.90	0.03	30.57**
Ln (Seed)	β_2	0.45	0.10	4.57**
Ln (Fertilizer)	β_3	0.11	0.04	2.48**
Ln (Herbicide)	β_4	-0.08	0.02	-3.37**
Ln (Labour)	β_5	0.04	0.02	2.71**
Inefficiency Model				
Constant	δ_0	-105.59	10.73	-9.84
Age	δ_1	-1.23	0.14	-8.92**
Education	δ_2	-0.36	0.23	-1.59**
Farming experience	δ_3	-0.35	0.18	-1.93*
Household size	δ_4	-2.67	0.36	-7.51**
Dependency ratio	δ_5	-7.30	1.35	-5.40**
Access to extension	δ_6	-22.23	1.48	-14.98**
Household distance to the nearest city	δ_7	-15.92	1.24	-12.80**
Household membership of farmer association	δ_8	-0.94	1.07	-0.89
Household distance to urban market	δ_9	4.60	0.41	11.12**
Household distance to tarred road	δ_{10}	0.16	0.15	1.04
Variance Parameters				
Sigma squared	σ^2	228.31.01	17.36	13.15**
Gamma	γ	0.99794352	0.0003	2872.85**
Ln likelihood function		-931.41		

Source: Field Survey 2010
*t-ratio is significant at 5% level of significance.
**t-ratio is significant at 1% level of significance.

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 an increasing function of agrochemical 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 1.12, implying increasing return-to-scale for production cost among the small scale farmers in Nigeria. This suggests that a proportionate increase in all the inputs given their respective prices would result in 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 technology by using their inputs in optimal proportions given the input prices. This implies that allocative efficiency among the farmers would result to higher farm profit in Nigeria. The implication is that policy that will help to increase allocative efficiency in production among the farmers would bring about an increase in farm profit of the small scale farmers in Nigeria.

The implication of the foregoing finding is that any policy that would provide affordable land, planting materials, fertilizer, agrochemical and labour would improve the profitability of farm production, as farmers through the expansion of input use would be able to move from the production phase of increasing returns to scale to the phase of decreasing returns to scale where profit would be maximized.

Factors that Determine the Levels of Small Scale Farmers' Production Efficiency

The study is majorly concerned with the coefficients for the inefficiency model. The second null hypothesis which specifies that inefficiency effects are absent from the model is strongly rejected at 5 percent level of significance by the result of the generalized likelihood ratio tests (Table 3). The third null hypothesis which specifies that the explanatory variables in the model

Table 2: Maximum likelihood estimates for parameters of the stochastic frontier cost model for small scale farmers in Nigeria

Variable	*Parameter*	*Estimate*	*Standard error*	*t-ratio*
Stochastic Frontier				
Constant	P_0	1.18	0.01	101.23
Ln (Output)	P_1	0.0004	0.002	0.18
Ln (Seed cost)	P_2	0.25	0.02	15.50^{**}
Ln (Fertilizer cost)	P_3	-0.53	0.02	28.66^{**}
Ln (Agrochemical cost)	P_4	0.0002	0.004	0.04
Ln (Labour cost)	P_5	0.32	0.01	22.96^{**}
Ln (Land cost)	P_6	0.02	0.002	11.50^{**}
Inefficiency Model				
Constant	δ_0	0.34	0.46	0.74
Age	δ_1	-0.17	0.02	-8.47^{**}
Education	δ_2	-0.08	0.02	-4.23^{*}
Farming experience	δ_3	-0.09	0.03	-3.55^{*}
Household size	δ_4	-0.12	0.04	-3.48^{**}
Dependency ratio	δ_5	0.34	0.07	5.10^{**}
Access to extension	δ_6	-1.40	0.12	-11.91^{**}
Household distance to the nearest city	δ_7	-0.46	0.07	-6.74^{**}
Household membership of farmer association	δ_8	-1.95	0.18	-10.84^{**}
Household distance to urban market	δ_9	0.09	0.02	5.77^{*}
Household distance to tarred road	δ_{10}	0.16	0.01	15.81^{**}
Variance Parameters				
Sigma squared	σ^2	1.05		16.92^{**}
Gamma	γ	0.97841721		466.64^{**}
Ln likelihood function		12.66		

Source: Field Survey 2010
*t-ratio is significant at 5% level of significance.
**t-ratio is significant at 1% level.

for the inefficiency effects have zero coefficients is rejected at the 5 percent 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 age, education, farming experience, household size, dependency ratio, access to extension and household distance to the nearest city are negative and significant at the 5 percent level of significance while the estimated coefficient for household distance to the nearest urban market is positive and significant at the 5 percent level of significance (Table 1). This implies that age, education, farming experience, household size, dependency ratio, access to extension, household distance to the nearest city and household distance to the nearest urban market are significant determinants of technical inefficiency at the 5 percent level of significance among the respondents. The negative coefficients of age, education, farming experience, household size, dependency ratio, access to extension and household distance to the nearest city imply that an increase in any of or all of these variables

Table 3: Generalized-likelihood ratio tests of hypotheses involving the parameters of the stochastic frontier and inefficiency model for small scale farmers in Nigeria

S. No.	*Null hypothesis*	*ln (H_0)*	*λ*	*Degree of freedom*	**Critical value*	*Decision*
	Stochastic Frontier					
1	H_0: $\hat{a}_{ij} = 0$	-999.25	135.68	5	15.09	Reject H_0
	Inefficiency Model					
2	H_0: $\gamma = \delta_0 = \delta_1 = \delta_2 = \delta_3 = \delta_4 = \delta_5 = \delta_6 = \delta_7 = \delta_8 = \delta_9 = \delta_{10} = 0$	-1055.66	248.50	12	26.22	Reject H_0
3	H_0: $\delta_1 = \delta_2 = \delta_3 = \delta_4 = \delta_5 = \delta_6 = \delta_7 = \delta_8 = \delta_9 = \delta_{10} = 0$	-1058.46	254.10	10	23.21	Reject H_0
4	H_0: $\gamma = 0$	-1035.76	208.70	2	9.21	Reject H_0

Source: Field Survey 2010
*Critical value is significant at 1% level of significance.

would lead to decline in the level of technical inefficiency. The positive coefficient of household distance to the nearest urban market implies that an in increase in this variable would lead to increase in the level of technical inefficiency.

Similarly, age, education, farming experience, household size, dependency ratio, access to extension, household distance to the nearest city, household membership of farmer association, household distance to the nearest urban market and household distance to the nearest tarred road are significant determinants of allocative inefficiency at the 5 percent level of significance among the respondents (Table 2). The negative coefficients of age, education, farming experience, household size, dependency ratio, access to extension, household distance to the nearest city and household head membership of farmer association imply that an increase in any of or all of these variables would lead to decline in the level of allocative inefficiency. The positive coefficients of household distance to the nearest urban market and household distance to the nearest tarred road imply that an increase in any of or in all of these variables would lead to increase in the level of allocative inefficiency.

The determinants of farm-level efficiency among the respondents were identified to be age, education, farming experience, household size, dependency ratio, access to extension, household distance to the nearest city, household membership of farmer association, household distance to the nearest urban market and household distance to the nearest tarred road.

This is consistent with findings reported in previous studies. For example, Bravo-Ureta and Pinheiro (1997), among others, have reported that formal education is likely to increase farm-level efficiency. Educated farmers are able to gather, understand and use information from research and extension more easily than illiterate farmers can. Moreover, educated farmers are very likely to be less risk-averse and therefore more willing to try out modern technologies.

Ceteris paribus, the farms located further from the cities are less inefficient in resource use. This result can be attributed to its productive labour-keeping effect. The advantage in location may have allowed the farms to compete better with cities for workers. More energetic workers from rural farms located closer to cities could commute to jobs in these cities, thus lowering the average skill/effort level of the available labour on the farms. In addition, the farms located closer to cities had easier access to the less productive (in agricultural task) city workers and students recruited for harvest time. In this way, relative efficiency would be related to the distance to city through its effect on the quality of the farm's productive labour even if workers do not leave the rural areas permanently.

In the absence of adequate market environment, the agricultural production units that are relatively in close proximity to tarred road and urban market achieve higher levels of efficiency in agricultural production as they have relatively easy access to their farms and urban markets. Investment into development of markets and improvement in road networks among the farming households are likely to increase quality of available farm labour resources directly. Tchale (2009) had noted that extension and access to markets are important policy and institutional variables that positively influence efficiency, because on the one hand they provide the incentive and means for farmers to access improved crop technology and on the other they improve farmers' liquidity and the affordability of the inputs required for production. Tchale (2009) also pointed out that the institutional and policy issues such as markets and other public provisions are just as important as technological factors in improving overall efficiency in the small scale subsector. The results may reflect the declining value/cost ratios that are caused by input costs increasing faster than output prices. This has invariably resulted in a low level of investment among small scale farmers, thereby further depressing crop yields and profitability. Thus, investment into farm social infrastructure might be a valuable tool that can be used to improve productivity in agricultural production.

Availability of extension services and information about technical aspects of crop technologies play an important role in increasing farm-level efficiency. The availability of an extension worker in the community and the usefulness of the extension messages (as perceived by the respondents) are significant determinants of technical efficiency. Furthermore, farmers who are members of extension related organizations exhibit higher levels of efficiency. This probably explains why access to extension had the greatest significant coefficients and followed by household membership of farmer association among the respondents. For instance, a marginal increase in access to extension of the households resulted in 22.23% decline in technical inefficiency among the respondents. Similarly, a marginal increase in the enrolment of household heads in farmer association resulted in 1.95% decline in allocative inefficiency among the respondents. The implication of these results is that high level of technical inefficiency is highly attributable to low availability of extension services and information about technical aspects of crop technologies. On the other hand, high level of cost inefficiency is highly attributable to the low profitability that results from inadequate organization of farmers into collective farmers' institutions that can provide opportunities for risk sharing and improved bargaining power.

The policy implication of the foregoing finding is that improvement of efficiency hinges largely on improving the policy and institutional environment so that farmers' net profitability will be enhanced. Revamping the productivity of small scale farmers, therefore, requires a sustained effort to improve farmers' access to technological information and product markets and to lower the risks they face.

Furthermore, collective farmers' institutions provide opportunities for risk sharing and improved bargaining power that are not available to individual farmers. It is, thus, important to encourage the development of institutional innovations such as contract farming, to provide technology, inputs and extension support all in one package. Efforts must be made to promote private market development.

The estimate for the variance parameter, γ, is estimated to be close to one. If this parameter is zero, then σ_u^2 in (7) is zero, and the model reduces to a traditional production (or cost) function with the variables age, education, farming experience, household size, dependency ratio, access to extension, household distance to the nearest city, household membership of farmer association, household distance to urban market, and household distance to tarred road 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 equations 7 and 8.

The estimated sigma squared was significantly different from zero at the 1 percent 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, γ, was estimated to be high and close to one, suggesting that the systematic influences that are unexplained by the production (or cost) function are the dominant sources of errors. This means that 99.97 percent of the variation in output among the farms is due to differences in technical efficiency while 97.85 percent of the variation in production 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).

Predicted Efficiency

Given the specification of the Cobb-Douglas stochastic frontier in equation 7, the predicted technical efficiency varied widely among the sample farmers, with minimum and maximum values of 0.00000006 and 0.83 respectively and a mean technical efficiency value of 0.30 (Table 4). 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, indicating that they were not obtaining maximum output from their given quantum of inputs.

Table 4: Average technical, allocative and economic efficiency of Nigerian small scale farmers

Total farm-level	*Mean efficiency estimate*	*Minimum efficiency estimate*	*Maximum efficiency estimate*	*Average efficiency (%)*
Technical efficiency	0.30	0.00000006	0.83	30
Allocative efficiency	1.88	1.05	67.10	12
Economic efficiency	0.36	0.00000006	1.11	36

Source: Field Survey 2010

On the other hand, the predicted allocative efficiency varied widely among the sample farmers, with minimum and maximum values of 1.05 and 67.10 respectively and a mean allocative efficiency estimate of 1.88 (Table 4). The wide variation in allocative efficiency estimates is an indication that most of the farmers are still allocating their resources inefficiently in the 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, indicating that they were utilizing the inputs in the wrong proportions, given the input prices.

Similarly, the economic efficiency varied widely among the sample farmers, with minimum and maximum values of 0.00000006 and 1.11 respectively and a mean economic efficiency value of 0.36 (Table 4). The wide variation in economic efficiency estimates is an indication that most of the farmers are still economically inefficient in the use of resources for production and there still exists opportunities for improving on their current level of economic efficiency. This result suggests that the farmers in the study area were not maximizing profit.

In general, the study indicates that land, planting materials and fertilizer are the key factors in the production of the major crops grown by the majority of the farmers. Labour is also a key variable, especially among farmers who grow labour intensive crops. The average level of technical, allocative and economic efficiency is estimated at 30%, 12% and 36% respectively. The wide range of values indicates large variations in performance across farms. The results generally highlight the relative inefficiency that characterizes small scale agricultural production in Nigeria. Reddy et al. (2004) observed that greater efficiencies in the use of resources are associated with the large farms than the small farms. They pointed out that the smallness of holdings deters the use of mechanization and does not allow the use of modern inputs due to lack of purchasing power in the hands of small farmers. This finding validates the assertion of Desli et al. (2002) that in reality, small scale producers are not always efficient. This can result in low productivity and low income, and consequently incidence of poverty among the farmers. Furthermore, Todaro and Smith (2009) reported that extreme income inequality leads to economic inefficiency. This is partly because at any given average income, the higher the inequality, the smaller the fraction of the population that qualifies for a loan or other credit. When low-income individuals cannot borrow money, they generally cannot adequately educate their children or start and expand a business. Asogwa et al. (2010) found that high degree of inequality exists in the distribution of farm income and non-farm income among the rural and peri-urban farming households in Nigeria.

The results further indicate that allocative inefficiency is worse than technical inefficiency, which implies that the low level of overall economic efficiency is the result of higher cost inefficiency. This suggests that solving the allocation problems may be more critical for improving small scale farmers' efficiency than solving technical problems. These results imply that if the average farmer in the sample was to achieve the technical efficiency level of his or her most efficient counterpart in Nigeria, he or she would be 63.86% more productive and the allocative efficiency of the average farmer would increase by 97.20% (where the percentage increase in efficiency is obtained by using the formula: [1 – (average efficiency/maximum efficiency)]* 100).

The distribution of efficiency estimates among the respondents suggests that the scope for efficiency gains is fairly large. Technical efficiency of the small scale farmers could be increased by up to 64% on average, using the current production technology. By simple analogy, this implies that the productivity of the small scale farmers could be more than doubled using current production technology, if key factors that currently constrain overall efficiency are adequately addressed.

On a national scale, therefore, the effect of a marginal increase in both technical and allocative efficiency could be substantial. The corresponding economic efficiency of the average farmer would increase by 67.57% using the current production technology. Hence, the improvement in agricultural productivity would correspond to at least a doubling of returns to the household from agricultural activity. Such an increase in household incomes would lead to rapid poverty reduction. Improving the productivity of small scale farmers, therefore, should play a key role in a broad-based economic growth strategy and poverty reduction for Nigeria.

The policy implication of the foregoing finding is that the overall picture of Nigeria's small scale farmers' farming system, consistent with the findings of other studies in developing countries, is of low to moderate efficiency levels. However, even with the available technology there are prospects for achieving significant efficiency gains. The results show that small scale farmers can improve their efficiency if the key factors that affect their efficiency are addressed.

The main focus of agricultural policy should be on how to realize these efficiency gains as a basis for improving productivity and profitability and hence poverty reduction for these farmers, since they constitute the bulk of the country's agricultural sector.

CONCLUSION

The results of the study showed that allocative inefficiency is higher than technical inefficiency, and that the low economic efficiency level can largely be explained by the low level of allocative efficiency relative to technical efficiency. High levels of cost inefficiency are highly attributable to the low profitability that results from inadequate organization of farmers into collective farmers' institutions that can provide opportunities for risk sharing and improved bargaining power. Thus, improvement of overall economic efficiency hinges largely on improving the policy and institutional environment so that farmers' net profitability will be enhanced. Efforts must be made to promote access of small scale farmers to agricultural extension services in Nigeria as a basis for further improving their technical efficiency and hence overall economic efficiency. The main focus of agricultural policy should be on how to realize these efficiency gains as a basis for improving productivity and profitability and hence poverty reduction for these farmers.

REFERENCES

Ajibefun IA 2002. Analysis of Policy Issues in Technical Efficiency of Small Scale Farmers Using the Stochastic Frontier Production Function: With Application to Nigerian Farmers. *Paper Prepared for Presentation at the International Farm Management Association Congress, Wageningen,* The Netherlands, July 2002, P. 8.

Ajibefun IA, Daramola AG 2003. Determinants of technical and allocative efficiency of micro-enterprises: Firm-level evidence from Nigeria. *African Development Bank*, 353-395.

Amalu UC 2005. Poverty alleviation and agriculture in sub-Saharan Africa: The Nigerian experience. *Journal of Food, Agriculture and Environment*, 3(2): 230-236.

Asogwa BC, Umeh JC, Ater PI 2007. Technical Efficiency Analysis of Nigerian Cassava Farmers: A Guide for Food Security Policy. In: Consolidation of Growth and Development of Agricultural Sector. *Proceedings of the 9th Annual National Conference of the Nigerian Association of Agricultural Economists (NAAE) held at 100 Seater Theatre, Abubakar Tafawa Balewa University, Bauchi*, 5 – 8 November, 2007, pp. 2-10.

Asogwa BC, Umeh JC, Uza DV 2010. Household Income Distribution Among the Farming Households in Nigeria: Implication for Poverty Reduction. In: Academic Science Research. *Proceedings of the 6th International Conference of the World Academy of Science, Engineering and Technology, Singapore*, August 25 – 27, 2010, Issue 69, pp. 147-152.

Ater PI, Umeh JC 2003. A stochastic frontier production function for poverty reduction analysis: The World Bank Assisted Dry Season Fadama Enterprises in Benue State, Nigeria. *Journal of Economic and Social Research*, 3(3): 7-15.

Bankers RD, Charnes A, Cooper WW 1984. Some models for estimating technical and scale inefficiencies in data envelopment analysis. *Management Science,* 30: 1078-1092.

Battese GE, Coelli TJ 1995. A model of technical inefficiency effects in a stochastic production function for panel data. *Empirical Economics*, 20: 325–332.

Bravo-Ureta BE, Pinheiro AE 1997. Technical, economic and allocative efficiency in peasant farming: Evidence from the Dominican Republic. *The Developing Economies*, 35(1): 48–67.

Coelli TJ 1994. *A Guide to FRONTIER Version 4.1: A Computer Program for Stochastic Frontier Production and Cost Function Estimation*. Department of Econometrics, University of New England, Armidale, Australia.

Coelli TR, Prasada RDS, Battese N 1998. *An Introduction to Efficiency and Productivity Analysis*. Boston: Kluwer Academic.

Desli E, Ray SC, Kumbhakar SC 2002. A Dynamic Stochastic Frontier Production Model with Time-Varying Efficiency. *Working Paper Series- Working Paper 2003-15*, Department of Economics, University of Connecticut, P.10.

Eboh EC 2009. *Social and Economic Research: Principles and Methods.* 2nd Edition. Enugu, Nigeria: African Institute for Applied Economics. P. 262.

Farrell MJ 1957. The measurement of productive efficiency. *Journal of the Royal Statistical Society*, Series A, 120 (3): 253 – 290.

Forsund FR, Lovell CAK, Schmidt P 1980. A survey of frontier production functions and of their relationship to efficiency measurement. *Journal of Econometrics*, 13: 5–25.

Mochobelele MT, Winter-Nelson A 2000. Migrant labor and farm technical efficiency in Lesotho. *World Development*, 28(1): 143–153.

Reddy SS, Ram PR, Sastry TVN, Devi IB 2004. *Agricultural Economics*. New Delhi: Oxford and IBH Publishing Co. Pvt. Ltd.

Seyoum ET, Battese GE, Fleming EM, 1998. Technical efficiency and productivity of maize producers in Eastern Ethiopia: A study of farmers within and outside the Sasakawa-Global 2000 project. *Agricultural Economics*, 19: 341-348.

Tchale H 2009. The efficiency of smallholder agriculture in Malawi. *Anglophone-Francophone Journal of Agricultural Resource Economics*, 3(2): 101-121.

Todaro MP, Smith SC 2009. *Economic Development.* 10th Edition. England: Pearson Education Limited. P. 861.