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Technical Efficiency Analysis of Small-holder Farmers in Rural and Peri-urban Areas of Nigeria

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KEYWORDS Technical Efficiency Analysis**.** Stochastic Frontier Model. Production Function. Small-holder Farmers. Benue State

ABSTRACT This study analysed technical efficiency of small-holder farmers in rural and peri-urban areas of Nigeria using 224 rural farmers and 393 peri-urban farmers in Benue State. The stochastic frontier production function was used to analyse data. The study showed technical efficiency among the respondents in the rural areas varied substantially ranging between 0.00 and 1.00, with a mean technical efficiency of 0.11. In the peri-urban areas, technical efficiency among the respondents varied widely ranging between 0.00 and 0.83, with a mean technical efficiency of 0.30. High levels of technical inefficiency are highly attributable to the low availability of extension services and information about technical aspects of crop technologies. Revamping the productivity of smallholder farmers therefore requires a sustained effort to improve farmers' access to technological information, quality productive farm labour and product markets and to lower the risks they face.

INTRODUCTION

It is generally accepted that the small scale farmer is poor, with low productivity in rural areas and depends mainly on agriculture (Ajibefun 2002; Ater 2003; Federal Republic of Nigeria 2007). Ajibefun (2000b) 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 (1975), should generate high productivity and the productivity should be transformed into an improvement in the quality of life of targeted Nigerians.

According to Desli et al. (2002), two otherwise identical firms never produce the same output, and costs and profit are not the same. This difference in output, cost, and profit can be explained in terms of efficiency, and some unforeseen exogenous shocks. According to Csaki and Lerman (1997a), artificially low food prices and subsidies left farm producers with little motivation for improving efficiency and competitiveness. Prices for purchased inputs grew much faster than farm gate prices for agricultural product. Decreased farm income in the presence of high nominal interest rates, in turn, reduced farm investment. Standard measures of agricultural productivity clearly deteriorated (Kurkalova and Jensen 1998). Farm-specific variables, such as characteristics of the farm manager and farm management system, experience of managers and distance from supply and distribution points, can enhance the understanding of farm production efficiency (Battese and Coelli 1995; Brock 1994).

Given agriculture's prominence in Nigeria's economy, productivity in the sector should be of great concern to policy makers. Nigeria's agricultural productivity, particularly among the majority of the smallholder farmers, has fallen a long way below its potential given the available technology. Poor households are more in agricultural occupation and participation in agriculture is found to be more predominant in rural areas and peri-urban areas where majority are small-holder farmers. To maintain high productivity in the face of declining land holding sizes, there is a particular need to improve the efficiency of the smallholder sub-sector, which is by far the largest.

The main objective of this paper is to analyse technical efficiency of small-holder farmers in rural and peri-urban areas of Nigeria. The specific objectives are to:

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(i) assess farm-level technical efficiency indicators;
(ii) ascertain the determinants of such levels of efficiency;

The following hypotheses were stated and tested:

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;
iv. inefficiency effects are not stochastic; and
v. the farmers are not technically inefficient.

METHODOLOGY

Study Area

For this study, farm level data were collected on 224 rural farmers and 393 peri-urban farmers in Benue State, Nigeria. 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 6^0 35'E and 10^0E and between Latitudes 6^0 30'N and 8^0 10'N. The State has abundant land estimated to be 5.09 million hectares. This represents 5.4 percent of the national land mass. Arable land in the State is estimated to be 3.8 million hectares (BENKAD 1998). Benue State is predominantly rural with an estimated 75 percent of the population engaged in rainfed 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 spp*.

Sampling Technique

In this study, the multi-stage random sampling technique was used for sample selection. 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 percent, three local government areas were randomly selected from Zone A and Zone B while four local government areas were randomly selected from zone C under the guide of Benue ADP workers in BNARDA. From each of the selected local government areas, one rural community and one peri-urban community were 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 percent in order to make the sampling design to be self-weighting thereby avoiding sampling bias (Eboh 2009). Based on the foregoing, 224 and 393 small-holder farmers were randomly selected from rural and peri-urban communities respectively, giving a total of 617 small-holder farmers 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, copies of which were administered to the selected 617 small-holder farmers in Benue State.

Analytical Techniques

The Stochastic Frontier production function model was used for the analysis of data collected for the achievement of the specific objectives. The generalized likelihood-ratio tests were adopted for testing hypothesis i-iv whereas hypothesis v was tepted using t-test.

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 defined by Seyoum et al. (1998):

$$LnY_i = \beta_0 + \beta_1 Ln\, X_{1i} + \beta_2 Ln\, X_{2i} + \beta_3 Ln\, X_{3i} + \beta_4 Ln\, X_{4i} + \beta_5 Ln\, X_{5i} + V_i - U_i \quad (1)$$

Where:

Ln = natural logarithm
Y_i = output of the ith farmer (kg)
X_i = Farm size (ha)
X_2 = Seed (kg)

X_3 = Fertilizer (kg)
X_4 = Agrochemical (litre)
X_5 = Labour (man-days)
βs = Parameters to be estimated
V_i = random error that is assumed to be normally distributed with zeromean 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:

$$U_i = \delta_0 + \delta_1 Z_1 + \delta_2 Z_2 + \delta_3 Z_3 + \delta_4 Z_4 + \delta_5 Z_5 + \delta_6 Z_6 + \delta_7 Z_7 + \delta_8 Z_8 + \delta_9 Z_9 + \delta_{10} Z_{10} \quad \text{.......................................(2)}$$

Where:
Z_1 = age of farmers (years)
Z_2 = educational level of farmers (years)
Z_3 = Farming experience (years)
Z_4 = Household size (number)
Z_5 = dependency ratio
Z_6 = Access to extension (yes = 1, no = 0)
Z_7 = Household distance to the nearest city (km)
Z_8 = household head membership of farmer association (yes = 1, no = 0)
Z_9 = Household distance to urban market (km)
Z_{10} = Household distance to tarred road (km)
δs = Parameters to be estimated

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

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 develop inefficient production routines and practices. However, a negative effect of age on technical inefficiency effects is expected as an indication of the impact of experience on productivity.

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, increases the technical efficiency of the farming operation.

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.

Household size is expected to have negative effects on technical inefficiency. This is mainly through availability of labour and its productivity. 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.

Dependency ratio is expected to have a negative effect on technical inefficiency effects as an indication of the positive effect of having higher proportion of productive non-dependents than non-productive dependents on availability of labour and its productivity.

Access to extension is expected to have a negative effect on the technical inefficiency effects because it provides the incentive and means for farmers to access improved crop technology.

Household distance to the nearest city is expected to have a negative effect on technical inefficiency effects as the further the farm is located from the alternative sources of employment, the better are the chances of keeping the most productive labour on the farm.

Household head membership of farmer association is expected to have a negative effect on the technical inefficiency effects as an indication of the impact of added advantage derivable from such organization in farm resources acquisition and utilization.

Household distance to urban market is expected to positive effect on technical inefficiency effects because the farther away from an urban market, the higher the loss of time, energy and resources used in going to the market and consequently reduction in the farmers' access to market and hence reduction in the farmers' liquidity and the affordability of the inputs required for production.

Household distance to the nearest tarred road is expected to have positive effect on technical inefficiency effects as an indication that the further away the farm is located from the road by which farm produce can be evacuated, the lower the efficiency of production.

The model defined by equations 1 and 2 was proposed by Battese and Coelli (1995). The parameters of the model: the β's, the δ's and the variance parameters:

$$\sigma^2 = \sigma^2_u + \sigma^2_v \quad \text{.................................. ... (3) and}$$

$$\gamma = \sigma^2_u / (\sigma^2_u + \sigma^2_v) \quad \text{..(4)}$$

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 (1 – 2) is zero, and the model reduces to a traditional production function with the variables: age, educational level, 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 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 equation (1). The function is a modified version of a Cobb-Douglas model. It permits different levels of productivity associated with different proportions of farm size, seed, fertilizer, agrochemical and labour.

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:

$$\lambda = -2 \log [(L(H_0) / L(H_1)] \quad \text{OR}$$
$$\lambda = -2[\log L(H_0) - \log L(H_1)]$$

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. The measure of technical efficiency relative to the production frontier (1) is defined as:

$$EFF_i = E(Y_i^*/U_i, X_i,)/ E(Y_i^*/U_i, = 0, X_i), \quad \text{.........} (5)$$

where Y_i^* is the production 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.

RESULTS AND DISCUSSION

Maximum Likelihood Estimates

For the rural area, the estimated standard errors of some of the coefficients in the stochastic frontier models (Table 1) 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 (first null) hypothesis that the variables in the Cobb-Douglas model are zero (Table 2). 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, agrochemicals and labour were estimated at the means of the input variables to be 1.01, 0.12, -0.02, -0.09 and 0.14 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 a decreasing function of fertilizer and a decreasing function of agrochemicals. 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 1.38, implying increasing returns-to-scale for production among the small-holder 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

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

Variable	*Parameter*	*Estimate*	*Standard error*	*t-ratio*
Stochastic Frontier				
Constant	β_0	5.02	0.06	87.68
Ln (Farm size)	β_1	1.01	0.05	2.20**
Ln (Seed)	β_2	0.12	0.003	38.74**
Ln (Fertilizer)	β_3	-0.02	0.03	-0.65
Ln (Agrochemical)	β_4	-0.09	0.002	-44.00**
Ln (Labour)	β_5	0.14	0.002	54.52**
Inefficiency Model				
Constant	δ_0	-60.11	27.93	-2.15
Age	δ_1	-0.35	0.15	-2-.40**
Education	δ_2	-0.87	0.42	-2.08**
Farming experience	δ_3	-0.12	0.18	-0.65
Household size	δ_4	-2.33	0.85	-2.73**
Dependency ratio	δ_5	-6.59	1.85	-3.55**
Access to extension	δ_6	-9.50	2.93	-3.24**
Household distance	δ_7	-7.54	2.71	-2.78**
to the nearest city	δ_8	-4.25	1.40	-3.04**
Household membership of farmer association				
Household distance to urban market	δ_9	3.06	0.83	3.68**
Household distance to tarred road	δ_{10}	0.26	0.19	1.36
Variance Parameters				
Sigma squared	σ^2	170.01	52.81	3.22**
Gamma	λ	0.9999999	0.000001	840447.86**
Ln likelihood function		-561.73		

Source: Field Survey 2009
λ t-ratio is significant at 1% level of significance.
** t-ratio is significant at 1% level of significance.

policy that will help to increase technical efficiency among the farmers would bring about an increase in farm output of the smallholder farmers in rural areas of Nigeria.

For the peri-urban area, the estimated standard errors of some of the coefficients in the stochastic frontier models (Table 3) 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 (first null) hypothesis that the variables in the Cobb-Douglas model are zero (Table 4). 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 3), 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 0.90, 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, an increasing function of fertilizer and an increasing function of labour. The elasticity of mean value of farm output was estimated to be a decreasing function of agrochemicals. The high land elasticity suggests that expansion in production among the farmers was mainly due to increase in farm

Table 2: Generalized-likelihood ratio tests of hypotheses involving the parameters of the stochastic frontier and inefficiency model for rural farmers in Nigeria

S.No.	*Null hypothesis*	*ln (H_0)*	*λ*	*Degree of freedom*	*Critical*	*Decision value*
	Stochastic Frontier					
1	H_0: $\beta_{ij} = 0$	-570.29	17.12	5	15.09	Reject H_0
	Inefficiency Model					
2	H_0: $\gamma = \delta_0 = \delta_1 = \delta_2 = \delta_3 = \delta_4 = \delta_5 = \delta_6 = \delta_7 = \delta_8 = \delta_9 = \delta_{10} = 0$	-605.44	87.42	12	26.22	Reject H_0
3	H_0: $\delta_1 = \delta_2 = \delta_3 = \delta_4 = \delta_5 = \delta_6 = \delta_7 = \delta_8 = \delta_9 = \delta_{10} = 0$	-593.47	63.48	10	23.21	Reject H_0
4	H_0: $\gamma = 0$	-602.91	82.36	2	9.21	Reject H_0

Source: Field Survey 2009
*Critical value is significant at 1% level of significance.

Table 3: Maximum likelihood estimates for parameters of the stochastic frontier production model for peri-urban farmers in Nigeria

Variable	*Parameter*	*Estimate*	*Standard error*	*t-ratio*
Stochastic Frontier				
Constant	β_0	3.03	0.17	18.27
Ln (Farm size)	$\beta 1$	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	17.36	13.15**
Gamma	γ	0.99794352	0.0003	2872.85**
Ln likelihood function		-931.41		

Source: Field Survey 2009
*t-ratio is significant at 5% level of significance.
**t-ratio is significant at 1% level of significance.

Table 4: Generalized-likelihood ratio tests of hypotheses involving the parameters of the stochastic frontier and inefficiency model for peri-urban farmers in Nigeria

S. No.	*Null hypothesis*	*ln (H_0)*	*λ*	*Degree of freedom*	**Critical value*	*Decision*
	Stochastic Frontier					
1	H_0: $\beta_{ij} = 0$	-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 2009
*Critical value is significant at 1% level of significance.

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 farmers. 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 Benue State, 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 farmers.

Contrary to the expectation, herbicide quantity had negative and significant coefficient in both rural and peri-urban areas. High cost of herbicides accounts for the negative relationship between output and herbicide use among the respondents.

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 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.

Factors that Determine the Levels of Farmers' Production Efficiency

The analysis of the determinants of (in) efficiency is very important as a basis for informing agricultural policy on what needs to be done to improve farmers' productivity. The marginal effects or partial elasticities show the percentage change in the technical efficiency that result from a unit change in each variable.

For the rural area, 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 2). The third null hypothesis which specifies that the explanatory variables in the model for the inefficiency effects have zero coefficients is rejected at 5 percent level of significance by the result of the generalized likelihood ratio tests (Table 2). 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, household size, dependency ratio, access to extension, household membership of farmer association and household distance to the nearest city are negative and significant at 5 percent level of significance while the estimated coefficient for household distance to the nearest urban market is positive and significant at 5 percent level of significance (Table 1). This implies that age, education, household size, dependency ratio, access to extension, household membership of farmer association, household distance to the nearest city and household distance to the nearest urban market are significant determinants of technical inefficiency at 5 percent level of significance among the respondents. The negative coefficients of age, education, household size, dependency ratio, access to extension, household membership of farmer association and household distance to the nearest city imply that an increase in any of or in all of these variables 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.

For the peri-urban area, the second null hypothesis which specifies that inefficiency effects are absent from the model is strongly rejected at 5 percent level of significance (Table 4). The third null hypothesis which specifies that the explanatory variables in the model for the inefficiency effects have zero coefficients is rejected at 5 percent level of significance (Table 4). 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 5 percent level of significance while the estimated coefficient for household distance to the nearest urban market is positive and significant at 5 percent level of significance (Table 3). 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 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 would lead to decline in the level of technical inefficiency. The positive coefficients of household distance to the nearest urban market imply that an in increase in this variable would lead to increase in the level of technical 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 and household distance to the nearest urban market.

This is consistent with the findings of Bravo-Ureta and Pinheiro (1997) that formal education is likely to increase farm-level efficiency. *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 and peri-urban 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 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 and peri-urban areas permanently.

In the absence of adequate market environment, the agricultural production units that are relatively in close proximity to urban market achieve higher levels of efficiency in agricultural production as they have relatively easy access to urban markets. Investment into development of markets among the farming households is likely to increase quality of available farm labour resources directly. Tchale (2009) had noted that access to markets is an important policy and institutional variable that positively influence efficiency because 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 among the small-holder farmers.

Tchale (2009) had noted that extension is an important policy and institutional variable that positively influence efficiency because they provide the incentive and means for farmers to access improved crop technology. Availability of extension services and information about technical aspects of crop technologies plays 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/market/credit related organizations exhibit higher levels of efficiency. This probably explains why access to extension had the greatest significant coefficients in both rural and peri-urban areas. For instance, a marginal increase in access to extension of the households resulted in 9.5% and 22.23% decline in technical inefficiency in the rural area and peri-urban areas respectively. The implication of these results is that high levels of technical inefficiency are highly attributable to the low availability of extension services and information about technical aspects of crop technologies.

The policy implication of the foregoing finding is that improvement of efficiency hinges largely on improving the policy and institutional environment. Increasing the productivity of small-holder farmers therefore requires a sustained effort to improve farmers' access to technological information, quality productive farm labour and product markets and to lower the risks they face. In the light of the above, it is pertinent to encourage the development of institutional innovations such as contract farming, to provide technology, inputs and extension support all in one package.

The estimate for the variance parameter, γ, is estimated to be close to one in both rural and peri-urban areas. If this parameter is zero, then σ_u^2 in (1) is zero, and the model reduces to a traditional production 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 the nearest urban market and household distance to tarred road all included in the production function meaning that inefficiency effects are not stochastic. The fourth null hypothesis which specifies that the explanatory variables in the model for the technical inefficiency effects are not stochastic is rejected (Tables 2 and 4). This implies that the traditional average response 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 1 and 2 respectively.

The estimated sigma squared was significantly different from zero at the 1 percent level of significance in both rural (170.01) and peri-urban (228.31) areas. 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 function are the dominant sources of errors. This means that 99.99 percent of the variation in output among the farms is due to differences in technical efficiency in the rural area. Similarly, in the peri-urban area, this means that 99.79 percent of the variation in output among the farms is due to differences in technical efficiency. This confirms the relevance of stochastic frontier production function, using the Maximum Likelihood Estimator (MLE).

Efficiency Estimates from the Stochastic Frontier Models

The results of the t-tests in Table 5 show that the null hypothesis that the small-holder farmers in rural and peri-urban areas of Nigeria are not technically inefficient in the use of resources for production is rejected at 5 percent level of significance. This result implies that the predicted mean technical efficiency is significantly different from the frontier technical efficiency level, suggesting that the farmers are technically inefficient in the use of resources for production.

In the rural areas, majority of the respondents (89.29%) operated within a technical efficiency range of less than 0.20 (Table 6). In the peri-urban areas, majority of the respondents (89.82%) operated within a technical efficiency range of less than 0.20 (Table 6).

Table 5: Test of the hypothesis that the predicted mean technical efficiency is not significantly different from the frontier efficiency level among the respondents

Null Hypothesis	*Rural*	*Peri-urban*
	The farmers are not technically inefficient	*The farmers are not technically inefficient*
Mean	0.11	0.30
t-statistics	-73.95	-68.83
Degree of Freedom	446	784
Critical Value*	1.97	1.96
Decision	Reject H_0	Reject H_0

Source: Field Survey 2009
*Critical value is significant at 1% level of significance.

Table 6: Distribution of the respondents by technical efficiency estimates

Technical efficiency range	*Rural*		*Peri-urban*	
	Frequency	*Percentage*	*Frequency*	*Percentage*
0.0 < 0.20	200	89.29	353	89.82
0.20 < 0.40	9	4.02	16	4.07
0.40 < 0.60	7	3.13	10	2.54
0.60 <0.80	2	0.89	3	0.76
0.80 < 1.00	6	2.68	11	2.80
Total	224	100	393	100
Minimum efficiency	0.00		0.00	
Maximum efficiency	1.00		0.83	
Mean efficiency	0.11		0.30	

Source: Field Survey 2009

The wide range of values indicates large variations in performance across farms. The implication of these results is that the respondents were not efficient in the use of resources for production. The farmers were operating far away from the efficiency frontier. This finding validates the assertion of Desli et al. (2002) that in reality, small scale producers are not always efficient. Furthermore, technical efficiency among the respondents in the rural areas varied substantially ranging between 0.00 and 1.00, with a mean technical efficiency of 0.11 (Table 6). In the peri-urban areas, technical efficiency among the respondent varied widely ranging between 0.00 and 0.83, with a mean technical efficiency of 0.30 (Table 6). This result suggests that the farmers were not utilizing their production resources efficiently, indicating that they obtained less than maximum output from their given quantum of inputs. In other words, technical efficiency among the respondents could be increased by 89 percent and 70 percent in the rural and peri-urban areas respectively 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.

CONCLUSION

High levels of technical inefficiency are highly attributable to the low availability of extension services and information about technical aspects of crop technologies. Increasing the productivity of small-holder farmers therefore requires a sustained effort to improve farmers' access to technological information, quality productive farm labour and product markets and to lower the risks they face.

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