Profit efficiency of small scale cowpea farmers in Niger state, Nigeria

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Abstract: The study examined the estimation of profit efficiency of small scale cowpea farmers in Niger State, Nigeria: A stochastic profit frontier approach. Data used for the study were obtained using structured questionnaire administered to 100 randomly selected cowpea farmers from Paiko and Gurara Local Government Areas of the State. The study showed that the levels of profit efficiency ranged from 11.62% to91.90% with mean of 77.75% suggesting that an estimated 22.25% of the profit was lost due to a combination of both technical and allocative inefficiency in cowpea production. From the results obtained, although farmers were generally relatively efficient, they still have room to increase the profit efficiency in their farming activities as about 23 percent efficiency gap from optimum (100%) remains yet to be attained by all farmers. The result further showed that, age, farmers' educational level, and years of farming experience significantly influenced the farmers' efficiency positively. It is recommended that investments in rural education through effective extension delivery program in the current political and economic environment in Nigeria should be provided

Keywords: Stochastic profit frontier, profit efficiency and cowpea production, Niger state

INTRODUCTION

The rapid increase in the country's population from about 60 million in 1963, to a recent figure of about 140 million in 2006 coupled with increase in the standard of living and other economic and political factors have greatly raised the demand for food. The importance of legume crops is becoming clearer to most of farmers and citizenry in the recent years. For most of the major food crops of the world, a lot of information is already available, however, legumes such as cowpeas, Soya bean, bean and groundnut which are widely used as a good source of plant protein in the diet of both man and livestock, have been largely neglected. The growth in cowpea production has been primarily due to rapid population growth, large internal market demand complemented by the availability of high yielding improved varieties of cowpea, relatively well developed market access infrastructure, then existence of improved processing technology and an international movement structure (Rowland 1993).

Almost all the vegetable cowpea and seed are valuable food and source of vitamins and protein. This provides household food security, compared to other grains; cowpea is more tolerant to soil fertility and thrives well in warm climate with moderate and evenly distributed rainfall. Cowpea provides income and employment opportunities for most people in the rural communities, particularly women who are entirely responsible for its processing and marketing. It provides them additional earning opportunity to contribute to the household food security.

Resource allocation and productivity is an important aspect of increased food production which is also associated with the management of the farmers who employ these resources in production. Furthermore, efficiency in the use of available resources is a major pivot for a profitable farm enterprise. Therefore, inefficiency in the use of resources, wrong choice of enterprise combination and cropping systems constitute the major constraints to increased food production in Nigeria (Okorji and Obiechina, 1985).

The subject of economic analysis of cowpea production in Nigeria has received considerable attention in the literature, however few of such studies from the study area had estimated profit efficiency as well as determined economic efficiency in cowpea production. Also, little attention has been given to measuring profit efficiency of farmers even when the prices of output and input are known in an attempt to examine the allocative efficiency of the farmers. The physical productivity considerations are important improvement in production efficiency, but profit efficiency will lead to greater benefits to agricultural producer in the country. Given this backdrop this study sets out to analyse profit efficiency of small scale cowpea farmers in Niger State, Nigeria using a stochastic profit frontier approach and to identify farm-specific characteristics that explain variation in the efficiency of individual farmers.

Conceptual Framework

Production inefficiency is usually analysed by its two components – technical and allocative efficiency. In a production context, technical efficiency relates to the degree to which a farmer produces the maximum feasible output from a given bundle of inputs (an output oriented measure), or uses the minimum feasible level of inputs to produce a given level of output (an input oriented measure). Allocative efficiency, on the other hand, relates to the degree to which a farmer utilises inputs in optimal proportions, given the observed input prices (Coelli *et al*., 2002). The popular approach to measure efficiency, the technical efficiency component, is the use of frontier production function (e.g. Battese and Coelli, 1995 and Battese, 1992). However, Yotopoulos *et al* (1973) and others argue that a production function approach to measure efficiency may not be appropriate when farmers face different prices and have different factor endowments (Ali and Flinn, 1989). This led to the application of stochastic profit function models to estimate farm specific efficiency directly (e.g., Ali and Flinn, 1989; Sanzidur, 2003 and Ogundari, 2006).

Coelli, (1996); Battese and Coelli (1995) extended the stochastic production frontier model by suggesting that the inefficiency effects can be expressed as a linear function of explanatory variables, reflecting farm-specific characteristics. The advantage of Battesse and Coelli (1995) model is that it allows estimation of the farm specific efficiency scores and the factors explaining efficiency differentials among farmers in a single stage estimation procedure. The present paper utilises Battesse and Coelli (1995) model by postulating a profit function, which is assumed to behave in a manner consistent with the stochastic frontier concept. Profit efficiency is a broader concept since it takes into account the effects of the choice of vector of production on both costs and revenues.

The stochastic profit function is defined as

$$\pi = f\left(P_{ij}, Z_{ik}\right) \bullet \exp\left(\varepsilon\right)$$

The error term ε_i is assumed to behave in a manner consistent with the frontier concept (Ali and Flinn, 1989), i.e. $\varepsilon_i = V_i + U_i$

where π_i is normalised profit of the ith farm defined as gross revenue less variable cost, divided by farm specific output price; P_{ij} is the price of j^{th} variable input faced by the i^{th} farm divided by output price; Z_{ik} is level of the k^{th} fixed factor on the i^{th} farm. V_i's are assumed to be identically and normally distributed with mean zero and constant variance as $N(0,\delta^2 v)$. U_i is the one-sided disturbance form used to represent profit inefficiency and it is independent of V_i; and i = 1,2 ….., n, is the number of farms in the sample.

The production/profit efficiency of farm *i* in the context of the stochastic frontier profit function is defined as

$$EFF = E\left[\exp\left(U \right)\right] / \varepsilon_i = E \exp \left(\delta_0 \sum_{d=1}^{D} \delta_d W_{di} \right) / \varepsilon_i$$

where W_{di} is the d^{th} explanatory variable associated with inefficiencies on farm *i*, δ_0 and δ_d are the unknown parameters and E is the expectation operator. This is achieved by obtaining the expressions for the conditional expectation U_i upon the observed value of ε_i. The method of maximum likelihood is used to estimate the unknown parameters, with the stochastic frontier and the inefficiency effects functions estimated simultaneously. The likelihood function is expressed in term of the variance parameters, $\sigma^2 = \sigma v^2 + \sigma u^2$ and $\gamma = \sigma u^2 / \sigma^2$ (Battesse and Coelli, 1995). .The parameter γ represents the share of inefficiency in the overall residual variance with values in interval 0 and 1. A value of 1 suggests the existence of a deterministic frontier, whereas a value of 0 can be seen as evidence in the favour of OLS estimation.

METHODOLOGY

Study Area: The study was conducted in Niger State of Nigeria. The state is located within latitudes 8° – 10° north and longitudes 3° – 8° east of the prime meridian with land area of 76,363 square kilometers and a population of 4,082,558 people (Wikipedia, 2008). The state is agrarian and well suited for production of arable crops such as cowpea, yam, cassava and maize because of favourable climatic conditions. The annual rainfall is between 1100mm – 1600mm with average monthly temperature ranges from 23°C and 37°C (NSADP, 1994). The vegetation consist mainly of short grasses, shrubs and scattered trees.

Sampling Techniques: The data mainly from primary sources were collected from two Local Government Areas (LGAs) which were purposively selected because of prevalence of the crop in the area using multistage sampling technique. The LGAs include Paiko and Gurara LGAs. The second stage involved a simple random selection of 50 farmers from each of the two LGAs, thus, making 100 respondents. Data were collected with the use of structured questionnaire administered in the sampled farms to collect data relating to yield, a unit cost of labour per man day, land area under cultivation (ha), inputs prices such as price per kg of fertiliser, price per kg of seeds, average price of agro-chemical per litre and average price of farm implements/tools. Data were also collected on the socioeconomic variables such as age, educational level (year of schooling), farming experience, number of extension contact and household size. The data collected (on quantity of cowpea harvested and output price) were used to compute farm total revenue as **P×Q**, where **P** is the price of the output and **Q** is the quantity produced while the farm level profit (π) was computed as difference between the total revenue and total variable cost expended on producing the cowpea i.e. [Gross Margin (π) = TR - WX].

Stochastic Profit Frontier Model Specification:

Profit efficiency in this study is defined as profit gain from operating on the profit frontier, taking into consideration farm-specific prices and factors. Given a farm that maximises profit subject to perfectly competitive input and output markets and a singular output technology that is quasi-concave in the (n x 1) vector of variable inputs, and the (m x 1) vector of fixed factors, Z the actual normalised profit function which is assumed to be well behaved can be derived as follows:

Farm profit is measured in term of Gross Margin (GM) which equals the difference between the Total Revenue (TR) and Total Variable Cost (TVC).That is:

$$GM(\pi) = \ddagger''(TR \quad TVC) = \ddagger''(PQ \quad WX_i)$$

To normalise the profit function, gross margin (π) is divided on the both side of the equation above by P which is the market price of the output (cowpea).That is:

$$\frac{\pi(p,z)}{P} = \frac{\ddagger''(PQ \quad WX_i)}{P} = \frac{Q \quad WX_i}{P} = f(X_i, Z) \quad \ddagger'' p_i X_i$$

Where: TR represents total revenue, TVC represents total variable cost, P represents price of output (Q), X represents the quantity of optimised input used, Z represents price of fixed inputs used, $p_i = W/P$ which represents normalised price of input Xi while f(Xi, Z) represents production function.

The Cobb-Douglas profit function in implicit form which specifies production efficiency of the farmers is expressed as follows:

$$\pi = f(P_{ij}, Z_{ik}) \bullet \exp(V_i \quad U_i), \quad i = 1, 2, \ldots\ldots n$$

.Where, π , pi , z, V_i and U_i are as defined above.

The profit efficiency is expressed as the ratio of predicted actual profit to the predicted maximum profit for a best-practiced cowpea farmer and this is represented as follows:

Profit Efficiency

$$(E\pi) = \frac{\pi}{\pi^{\max}} = \frac{\exp[\pi(p,z)]\exp(\ln V)\exp(\quad \ln U) \quad \theta}{\exp[\pi(p,z)]\exp(\ln V) \quad \theta}$$

Firms specific profit efficiency is again the mean of the conditional distribution of U_i given by $E\pi$ and is defined as: $E\pi = E[\exp(\quad U_i)/E_i]$

$E\pi$ takes the value between 0 and 1. If $U_i = 0$ i.e. on the frontier, obtaining potential maximum profit given the price it faces and the level of fixed factors. If Ui > 0, the firm/farm is inefficient and losses profit as a result of inefficiency.

However, for this study, Coelli (1996) model was used to specify the stochastic frontier function with behaviour inefficiency components and to estimate all parameters together in one step maximum likelihood estimation. The explicit Cobb-Douglas functional form for the cowpea farmers in the study area is therefore specified as follows:

$$\ln\pi = \ln\beta_0 + \ln\beta_1 Z_{1i} + \ln\beta_{2i} P_{1i} + \ln\beta_{3i} P_{2i} + \ln\beta_{4i} P_{3i} + \ln\beta_{5i} P_{4i} + \ln\beta_{6i} Z_{2i} + (V_i \quad U_i)$$

Where: Π represents normalised profit computed as total revenue less variable cost divided by farm specific cowpea price; Z_1 represents Farm size (ha); P_1 represents average price per man day of labour; P_2 represents average price per kg of fertiliser; P_3 represents average price per kg of seed; P_4 represents price per litre of agro-chemical; Z_2 represents average price of farm tools.

The inefficiency model (Ui) is defined by:

$$U_i = \delta_0 + \delta_1 L_{1i} + \delta_2 L_{2i} + \delta_3 L_{3i} + \delta_4 L_{4i} + \delta_5 L_{5i}$$

Where L_1, L_2, L_3, L_4 and L_5 represent age, educational level, farming experience, household size and number of extension contact respectively. These socio-economic variables are included in the model to indicate their possible influence on the profit efficiencies of the cowpea farmers (determinant of profit efficiency)

The estimate for all parameters of the stochastic frontier profit function and the inefficiency model are simultaneously obtained using the program FRONTIER VERSION 4.1c (Coelli, 1996).

RESULTS AND DICUSSION

The summary statistics of the variables used appears in Table 1. The mean yield of 2,403.02 kg per ha of cowpea was recorded over the sampled area with a standard deviation of 1231.20kg/ha. Also an average of N 115.75 per kg of cowpea was recorded in the sampled area as price of output. Table 1 also showed the mean gross margin of ₦38, 879.30 with standard deviation of ₦24, 263.75. The average level of education of the farmers is less than eight years and the average years of experience in cowpea production are approximately 11 years.

Table1: Summary Statistics of the Variables in Stochastic Frontier Model

Variables	Minimum	Maximum	Mean	Standard Deviation
Cowpea Output (kg)	500.00	6,100.00	2,403.02	1,231.20
Gross Margin (₦)	3,059.59	113,365.20	38,879.3	263.74
Farm Size (ha)	0.75	4.00	2.13	0.91
Labour wage(₦/Man-days)	124.38	663.39	395.62	131.05
Fertiliser Price (₦/kg)	50.00	90.00	66.12	8.45
Agrochemical Price (₦ /Litres)	266.67	800.00	487.89	95.18
Seed Price (₦/kg)	115.57	200.00	141.69	23.72
Average Farm tools (₦)	600.00	1,300.00	1,057.79	146.14
Age (years)	20.00	70.00	35.77	9.06
Household Size	1.00	6.00	2.66	1.30
Education Level (years)	0.00	19.00	7.88	6.58
Years of Experience	2.00	40.00	11.34	7.80
Number of Extension Contact	0.00	4.00	2.28	0.71

Source: Field Survey, 2008

The result of the generalised likelihood ratio which is defined by the chi square distribution is presented in Table 2. The null hypothesis in the Table is Ho: $\gamma = 0$, which specifies that the inefficiency effects in the stochastic profit frontier are not stochastic. The null hypothesis is rejected. This implies that the traditional response function (OLS) is not an adequate representation of the data

Test of Hypotheses and Diagnostic Statistics

Table 2: Generalised likelihood ratio test of hypothesis for parameters of the stochastic profit frontier for small scale cowpea production in Niger State.

Null Hypothesis	Log likelihood	No. of Restrictions	χ^2 Statistics	Critical value	Decision
Ho: $\gamma = 0$	-71.78	7	14.12	14.07	Rejected

Source: Computed from MLE Results

The stochastic profit frontier function estimates of cowpea producers in Niger State are presented in Table 3. The Table showed that the estimated coefficients of the parameters of the normalised profit function are positive except the cost of labour. This indicated that a unit increase in prices of these inputs will lead to increase in the gross margin of cowpea.

Furthermore, the estimated gamma parameter (γ) of model 2 of 0.8222 in Table 2 was highly significant at 1 percent level of significance. This implies that one-sided random inefficiency component strongly dominates the measurements error and other random disturbance indicating that about 82 percent of the variation in actual profit from maximum profit (profit frontier) between farms mainly arose from differences in farmers' practices rather than random variability.

The parameters estimates for determinants of profit efficiency were reported in the lower part of Table 2. However, the analysis of inefficiency models shows that the signs and significance of the estimated coefficient in the inefficiency model have important implication on the profit efficiency of the farmer. And based on this, age, educational level and farming experience in the inefficiency model have negative coefficients, meaning that as these variables increase the profit inefficiency of the farmer decreases.

Table 3: Maximum Likelihood Estimates of the Stochastic Profit Frontier Function for Cowpea Production in Niger State.

Variables	Parameters	Coefficients	t-ratio
General Model			
Constant	$ß_0$	3.241	2.370**
Farm Size (ha) (Z_1)	$ß_1$	5.609	4.693***
Average Price per man-day of labour (P_1)	$ß_2$	-0.170	$-1.130^{N.S}$
Average Price of Fertiliser (kg) (P_2)	$ß_3$	0.249	1.773*
Average Price of Herbicide (Litres) (P_3)	$ß_4$	0.560	2.116**
Average Price of Seeds (kg) (P_4)	$ß_5$	0.493	2.205**
Average Price of Farm tools (kg) (Z_2)	$ß_6$	0.212	$0.746^{N.S}$
Inefficiency Functions			
Constant	δ_0	0.532	$0.305^{N.S}$
Age (years)	δ_1	-131	-1.904*
Household Size	δ_2	0.101	1.798*
Education Level (years)	δ_3	-0.306	-1.924*
Farming Experience (years)	δ_4	-0.190	-1.960*
Extension Contact	δ_5	0.745	$1.225^{N.S}$
Diagnosis Statistics			
Sigma-square σ^2		0.5762	1.799*

Gamma γ	$\sigma^2 = \sigma_u^2 + \sigma_v^2$ $\gamma = \frac{\sigma_u^2}{\sigma_u^2 + \sigma_v^2}$	0.8222	11.907***
Log likelihood function	-71.78		
LR Test	14.12		

Source: Computed from MLE Results
* = Significant at 10% level; ** = Significant at 5% level; *** = Significant at 1% level.
NS = Not significant

Profit Efficiency Estimates of the Farmers

The distribution of profit efficiency of cowpea production is presented in Table 4. The average profit efficiency score is 0.7775 implying that the average farm producing cowpea could increase profits by 22.25% by improving their technical and allocative efficiency. Some farmers demonstrated a range of profit efficiency of 0.9190 (91.90%) while the worst farmer had a profit efficiency of 0.1162 (11.62%). Despite wide variation in efficiency, about 83% of modern cowpea farmers seem to be skewed towards profit efficiency level of 71% and above. Nevertheless, the results imply that a considerable amount of profit can be obtained by improving technical and allocative efficiency in cowpea production in the area.

Table 4: Distribution of Profit Efficiency Indices among Farmers in the Study Area

Efficiency Class Index	Frequency	Percentage
0.00 - 0.10	0	0
0.11 – 0.20	1	1
0.21 – 0.30	1	1
0.31 – 0.40	1	1
0.41 – 0.50	0	0
0.51 – 0.60	3	3
0.61 – 0.70	11	11
0.71 – 0.80	33	33
0.81 – 0.90	47	47
0.91 – 1.00	3	3
Total	100	100
Mean	0.7775	
Maximum value	0.9190	
Minimum value	0.1162	
Standard Deviation	0.1268	

Source: Computed from MLE Results

SUMMARY AND CONLUSION

This empirical study is on estimation of profit efficiency among small scale cowpea farmers in Niger State, Nigeria: A stochastic profit frontier approach. . A Cobb-Douglas profit frontier was estimated by maximum likelihood estimation method to obtain ML estimates and inefficiency determinants. The MLE results revealed that profit efficiency of small scale cowpea farmers varied due to the presence of profit inefficiency effects in cowpea production. The results further revealed all the inputs have positive sign on the profitability of cowpea production in the study area except the unit cost of labour per man-day.

The distribution of the profit efficiency indices as shown that cowpea farmers were fairly efficient in their resources allocation, judged by the fact that more than half of the farmers having profit efficiency of 0.71 and above with an average profit efficiency of 0.77 suggesting that considerable amount of profit is gained due to the relative level efficiency of observed in the sample area. The results of the inefficiency model showed that the age, years of education and farming experience significantly increased the farmers' profit efficiency.

This study showed that small scale cowpea farmers were not fully efficient in their resource allocation and therefore there is allowance of efficiency improvement by addressing some important policy variables that could negatively and positively influence farmers' levels of profit efficiency in the area.

In conclusion, the investments in rural education through effective extension delivery program in the current political and economic environment in Nigeria will provide farmers with skills essential to increasing efficiency.

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