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Full Length Research Paper

Application of stochastic frontier function in measuring profit efficiency of small-scale maize farmers in Niger State, Nigeria

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The study employed Cobb-Douglas stochastic profit frontier function to measure profit efficiency among maize farmers' in Niger State, Nigeria. A multistage sampling technique was used to select 120 respondents. The results showed that profit efficiencies of the farmers varied widely between 12% and 95% with a mean of 71%. The mean level of efficiency indicates that there exists room to increase profit by improving the technical and allocative efficiency. Least profit efficient farmer needs an efficiency gain of 87% to attain the profit efficiency of the best farmer in the region, an average efficient farmer need an efficiency gain of 25% to attain the level of the most profit efficient farmer, while the most profit efficient farmer needs about 5% gains in profit efficiency to be on the frontier. All the parameters included in the inefficiency model have significant impacts on profit efficiency. This implies that profit inefficiency in maize production can be reduced significantly with improvement in the level of education of sampled farmers.

Keywords: Profit efficiency, factors explaining inefficiency, profit loss, Maize farmers, Small-scale, Nigeria

INTRODUCTION

Despite Nigeria's physical and human resources, there had been progressively worsening welfare conditions of it nationals (Etim et al., 2010). Majority of the poor in Nigeria live in rural areas as over 70% of them derive their livelihood from farming (Etim, 2007). Since most of the poor who engage in agriculture reside in rural communities, the increase in agricultural production is necessary for economic stability. One of such viable crops that would stimulate growth in the economy and redirect agricultural production for the rural poor is maize.

Maize (*Zea mays L.*) is the most important cereal crops in sub-Saharan Africa and is the world's most widely grown cereal crop as well as essential food source for millions of the world's poor. Farmers grow conventional maize on an estimated 100 million hectares (250 million acres) throughout the developing world (Nsikak and Sunday, 2013). Maize is an important food in Africa, and main ingredient in several well-known national dishes. Examples are *tuwon-masara* and *akamu* in northern Nigeria, *koga* in Cameroon, *injera* in Ethiopia and *ugali* in Kenya (IITA, 2008). In sub-Saharan Africa, maize is a staple food for an estimated 50% of the population and an important source of carbohydrate, protein, iron, vitamin B, and minerals. Current production of maize is about 8 million tonnes and its average yield is 1.5 tonnes per hectare. The average yield is lower as compared to the world average of 4.3 tonnes/ha and other African countries such as South Africa with 2.5 tonnes/ha (FAO, 2009), thus, there exist a wide gap between the demand for maize and its supply. Nsikak and Sunday (2013) noted that the strong force of demand for maize relative to supply is evidenced in frequent rise in price of maize and therefore, greatly implied for the food security situation and development of the economy. To reduce the problem of the current food challenge, government at different levels have embarked on various programmes aimed at stimulating maize production particularly among the resource poor farmers. Furthermore, considerable efforts have been directed at examining productive efficiency of farmers that is exclusively focused on technical efficiency of the farmers in Nigeria (Ajibefun *et al*, 2002; Ojo, 2004; Ogundari and Ojo 2005), with little attention being given to measuring profit efficiency of farmers even when the prices of output and input are known in an attempt to examine the profit efficiency of the farmers.

Chirwa (2005), argued that macroeconomic policies that promote growth in income are likely to lead into poverty reduction. For instance, with respect to agriculture, changes in price will provide incentives for agricultural production and specialization, which in turn may lead to growth and distribution of income through employment generation and revenue enhancement, and consequently poverty reduction. Similarly, at the micro level, enterprises

that promote income growth and distribution and enhance the revenue of the poor households are most likely to lead to poverty reduction among the poor households. For instance, improvement in farmers' productivity and output would lead to income growth (all things being equal) and consequently poverty reduction (Ajibefun and Daramola 2003). According to Ajibefun (2002), for Nigeria, raising productivity per area of land is the key to effectively addressing the challenges of achieving food security, as most cultivable land has already been brought under cultivation, and in areas where wide expanse of cultivable land is still available, physical and technological constraints prevent large-scale conversion of potentially cultivable land. Ater (2003) stated that productivity improvement for the Nigerian small scale farmers is the ultimate if development is to take place and be sustained. This is because it is generally accepted that the small scale farmer is poor, with low productivity in rural areas and depends mainly on agriculture.

Kurt (2011) 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 Daniel et al. (2010), should generate high productivity and the productivity should be transformed into an improvement in the quality of life of targeted Nigerians. According to Ajibefun and Daramola (2003), to achieve prosperity and overcome stagnation, there is a need to increase growth in all sectors of the economy, for such growth is the most efficient means of 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.

Hoekman et al. (2001) argued that for growth to have some meaningful impact on poverty, that growth must occur in sectors in which a large proportion of the poor derive their livelihood. It is worth noting that the agricultural sector remains the important sector for livelihood especially in rural Nigeria, which accounts for more than 70 percent of the population. 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. Low productivity in maize production has led to increase in the price of maize. According to Ogunniyi (2011), if resources are properly managed the yield of maize should range from 1, 120 to 2, 240 kg/ha for early crop and 670 to 1, 123 kg/ha for late crop. However, it appears that maize farmers in Nigeria are not getting maximum return from the resources committed to the enterprise. It is therefore necessary to examine the factors that reduce profit from maize production.

These resource-poor smallholder farmers who contribute more than 90% of agricultural output in Nigeria in particular and Sub-Saharan Africa in general, must be assisted to raise beyond the level of subsistence to higher levels of profitability through more efficient use of their production resources. A considerable scope to expand output and also productivity by increasing production efficiency at the relatively inefficient farms and sustaining the efficiency of those operating at or closer to the frontier is an alternative to attaining this. Computing profit efficiency therefore, constitutes a more important source of information for policy makers than the partial vision offered by analysing allocative efficiency. The estimation of a frontier profit function capture firm level production specialization, thus allowing the higher revenues reserved by the firms that produce differentiated or higher quality output to compensate for the higher cost incurred.

In view of this, profit efficiency of small holder farms has important implications for development strategies adopted in most developing countries where the primary sector is still dominant. An improvement in the understanding of the levels of profit efficiency and its relationship with a host of farm level factors can greatly aid policy makers in creating efficiency enhancing policies as well as in judging the efficacy of present and past reforms. Furthermore, this study is necessary so as to contribute to literature on profit efficiency studies on food crops and especially maize production with the attendant aim of improving the welfare of maize farmers in Nigeria.

Conceptual Information on Stochastic Profit Function

Theoretical concept of stochastic profit frontier function

The analysis of efficiency dates back to Knight (1933), Debrew (1951) and Koopmans (1951). Koopmans (1951) provided a definition of technical efficiency while Debrew (1951) introduced its first measure of the 'coefficient or resource utilization'. Following Debrew (1951) in a seminal paper Farrell (1957), provided a definition of frontier production functions, which embodied the idea of maximality. In his pioneering study he defined efficiency as the ability to produce a given level of output at lowest cost. Farrell (1957) distinguished three types of efficiency: (1) technical efficiency, (2) price or allocative efficiency and (3) economic efficiency which are the combination of the first two. Technical efficiency is an engineering concept referring to the input-output relationship. A firm is said to be efficient if it is operating on the production frontier (Ali and Byerlee, 1991). On the other hand, a firm is said to be technically inefficient when it fails to achieve the maximum output from the given inputs, or fails to operate on the production frontier. Mbowa (1996) in his study on the sugarcane industry in South Africa defined an efficient farm as that which utilizes fewer resources than other farms to generate a given quantity of output. Yilma (1996) while studying efficiency among the smallholder coffee producers in Uganda defined an efficient farm as that which produces more output from the same measurable inputs than that one which produces less. Fan (1999) referred to technical inefficiency as a state in which actual or observed output from a given input mix is less than the maximum possible.

Allocative efficiency deals with the extent to which farmers make efficient decisions by using inputs up to the level at which their marginal contribution to production value is equal to the factor cost. According to Rahman (2003), allocative efficiency relates to the degree to which a farmer utilizes inputs in optimal proportions, given the observed input prices. These components have been measured by the use of frontier production function which can be deterministic or stochastic. Deterministic frontier production function explains that all deviations from the frontier are attributed to inefficiency where as in stochastic frontier production function it is possible to discriminate between random errors and differences in efficiency. Yotopoulos et al. (1970) argued 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). Thus, this led to the application of stochastic profit function models to estimate farm specific efficiency directly (Rahman, 2003; Ogundari, 2006).

According to Ali and Flinn (1989), profit efficiency, within a profit function context, is defined as the ability of a farm to achieve the highest possible profit, given the prices and levels of fixed factors of that farm and profit inefficiency is defined as profit loss from not operating on the profit frontier given farm specific prices and resource base. Ali et al. (1994) stated that profit function approach combines the concepts of technical and allocative efficiency in the profit relationship and any error in the production decision is assumed to be translated into lower profits or revenue for the producer. As pointed out by a number of researchers including Ogunniyi (2011) a profit function is much superior to production function because first it permits straight forward derivation of own-price and cross-price elasticities and output supply and input demand functions, second, the indirect elasticity estimates via profit function have a distinct advantage of statistical consistency, third, it avoids problems of simultaneity bias because input prices are exogenously determined. Furthermore, he confirms that "problems of endogeneity can be avoided by estimating the profit or cost function instead of the production function".

Besides, the profit function is extensively used in literature (Akinwumi and Djato, 1997; Abdulai and Huffman, 2000). A number of functional forms exist in literature for estimating the profit function which includes the Cobb- Douglas and flexible functional forms, such as normalized quadratic, normalized translog and generalized Leontif. The Cobb-Douglas functional form is popular and is frequently used to estimate farm efficiency despite its known weaknesses (Ogundari, 2006; Sunday et al., 2012; Oladeebo and Oluwaranti, 2012). The translog model has its own weaknesses as well but it has also been used widely (Hyuha, 2006; Nwachukwu et al., 2007; Ogunniyi, 2011). The main drawbacks of the translog model are its susceptibility to multicollinearity and potential problems of insufficient degrees of freedom due to the presence of interaction terms. The interaction terms of the translog also don't have economic meaning (Ogunniyi, 2011). It should be noted that Battese and Coelli (1995) had 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 their 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. However many studies used Battese and Coelli (1995) model by postulating a profit function, which is assumed to behave in a manner consistence with the stochastic frontier concept.

Profit efficiency shows success of a given farm enterprise, as it indicates the ability of a farm to obtain a maximum profit given a level of input and output prices including the level of fixed factors of production in the farm. From Farrel analysis, a farm is profit efficient in resource use when it operates on the profit efficiency frontier. On the other hand, profit inefficient farms operate below the efficiency frontier. The functional form of the stochastic profit frontier was determined by testing the adequacy of the Cobb–Douglas (highly restrictive) by fitting in the less restrictive translog.

According to Sunday et al. (2012), the profit function model for the profit efficiency analysis was given as follows:

$\pi = \pi/\rho = f\,(q_i;\, Z)\ exp\ (V_i - U_i)$ ………………………..……(1)

Where;

π = normalized profit of ith farmer

qi = vector of variable inputs

Z = vector of fixed inputs

ρ = output price

$exp\ Vi - UI$ = composite error term

The stochastic error term consist of two independent elements "V" and "U". The element V account for random variations in profit attributed to factors outside the farmer's control. A one sided component U ≤ 0 reflects economic efficiency relatives to the frontier. Thus, when U = 0, it implies that farm profit lies on the efficiency frontier (i.e. 100% profit efficiency) and when U < 0, it implies that the farm profit lies below the efficiency frontier. Both V and U are assumed to be independently and normally distributed with zero means and constant variances. Thus economic efficiency of an individual farmer is derived in terms of the ratio of the observed profit to the corresponding frontier profit given the price of variable inputs and the level of fixed factors of production of farmers.

$$EE = \frac{observed\ farm\ profit\ for\ ith\ farmerfrontier}{farm\ profit\ for\ ith\ farmer} =$$

$$\frac{f(qi;\,Z)\ \exp\,(Vi - Ui)}{f\,(qi;\,Z)\ \exp\ Vi} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(2)}$$

$$EE = \frac{\exp\,(Vi - Ui)}{\exp\,(V_i)} = exp\,(-Ui) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(3)}$$

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

$$\text{Profit Efficiency } (E\pi) = \frac{\pi}{\pi^{max}} = \frac{\exp\,[\pi\,(P, Z)]\,\exp\,(\ln V)\,\exp\,(-\ln U) \cdot \theta}{\exp\,[\pi\,(P, Z)]\,\exp\,(\ln V) \cdot \theta} \quad \ldots\ldots\ldots \text{(4)}$$

Firms specific profit efficiency is again the mean of the conditional distribution of Ui given by Eπ and is defined as:

$E\pi = E\ [\exp\,(-U_i)/E_i]$ .... (5)

E π 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 $U_i > 0$, the farm is inefficient and losses profit as a result of inefficiency.

Literature Review

Following Farrell's (1957) work there has been a proliferation of studies in the field of measuring efficiencies in all fields. But in the field of agriculture, the modeling and estimation of stochastic function, originally proposed by Aigner et al., (1977) and Meeusen and van den Broeck (1977) has proved to be invaluable. A critical narrative of the frontier literature dealing with farm level efficiency in developing countries conducted by Battese (1992), Bravo-Ureta and Pinheiro (1993), Coelli (1995) and Thiam et al., (2001) indicated that there were wide ranging theoretical issues that had to be dealt with in measuring efficiency in the context of frontiers and these included selection of functional forms and relevant approaches (parametric as opposed to non-parametric).

Abdulai and Huffman (1998) examined the profit inefficiency of rice farmers in northern Ghana. The empirical results show that farmers' human capital represented by the level of schooling contributes positively to production efficiency, suggesting that investment in farmers' education improves their allocative performance. Rahman (2003) estimated a stochastic profit function for Bangladesh rice farmers. The results showed that there existed a high level of inefficiency in rice farming because γ was close to one. The average profit efficiency scores were 60%, which implied that the farmers could improve their profitability by as much as 40%. The farmers also exhibited a lot of profit inefficiency. The farm-specific factors responsible were poor access to input markets, unfavorable tenancy arrangements, and off farm employment. Pius and Inoni, (2006) used Cobb-Douglas stochastic profit function to estimate economic efficiency of yam farmers in south eastern Nigeria. An average economic efficiency of 41% was discovered. The study also shows that farmer's experience and accessed to credit are factors significantly affecting economic inefficiency of yam farmers.

Ogundari (2006) investigated factors that determine the profit efficiency among small scale rice farmers in Nigeria using Cobb-Douglas stochastic profit function. The results showed that their profit efficiency where positively influence by age, educational level, farming experience and household size. Oladeebo and Oluwaranti (2012), used cobb-Douglas stochastic profit function to examined the profit efficiency among cassava producers, in Southwestern Nigeria. The result indicated that the mean profit efficiency of the farmers was 79% which suggested that an estimated 21% loss in profit was due to a combination of both technical and allocative inefficiencies. Furthermore, the result showed that household size and farm size were the major significant factors which influenced profit efficiency positively. Sunday et al. (2012) used Cobb-Douglas stochastic profit function to measure Profit Efficiency of Homestead based Cassava Farmers in Southern Nigeria. The result showed an average economic efficiency of 61.22%. furthermore, it was found that farmer's education, experience, household size, level of farming involvement, extension agent visit, soil management method adopted by farmers and farm size are significant factors affecting profit efficiency in resource use among homestead based cassava farmers.

Hyuha (2006) investigated profit efficiency among rice producers in eastern and northern Uganda using normalized translog functional form. The results showed area under rice and capital had a positive influence on profit levels while cost of family labor and "other inputs" had a negative effect. The analysis also showed that all farmers were not operating on the profit frontier and scored a mean profit efficiency of 66 percent with about 70 percent of the farmers scoring at least 61 percent. The efficiency levels at the district level were 75, 70 and 65 percent, respectively for Pallisa, Lira and Tororo, respectively. Nwachukwu and Onyenweaku (2007) applied translog stochastic profit function to measure efficiency of Fadama Telfairia production in Imo State, Nigeria. Their empirical results reveal that age, farming experience, farm size, membership of cooperative society and house hold size are significant determinants of economic efficiency of the farmers. An average profit efficiency of 0.57 was discovered for the sample farmers.

Ogunniyi, (2008) used translog stochastic profit function to examine profit efficiency of cocoyam production in Osun State, western Nigeria. The result of the analysis revealed an average profit efficiency of 12%. The results further reveal accessibility to credit, family size, farm size and mulching as significant determinants of profit efficiency of cocoyam farmers in the region. Ogunniyi (2011) used translog stochastic profit function to measure profit efficiency among maize producers in Oyo State, Nigeria. The results showed that mean profit efficiency of the farmers was 41.4% suggesting that an estimated 58.6% of the profit is lost due to a combination of both technical and allocative inefficiencies in maize production. From the inefficiency model, it was found that education, experience, extension and non-farm employment were significant factors influencing profit efficiency.

METHODOLOGY

The data used in this study were based on the farm level research of maize farmers in Niger State of Nigeria. Niger State is located between latitudes 8°20'N and 11°30'N of equator and longitude 3°30'E and 7°20'E of the Greenwich meridian. Niger State covers an area of 76,363 square kilometre with varying physical features like hills, lowland and rivers (Nigerstate.gov.ng, 2011), which makes the state the largest in the country in terms of landmass, with a population of 4,082,558 (Official Gazette, 2007; Tanko et al., 2011).The state has two distinct ecological zones - the Northern Guinea savanna to the North and the Southern Guinea savanna to the south. The state is divided into three agricultural zones, namely, Bida, Kuta and Kontagora Agricultural zones respectively. Agriculture is the main occupation of the people and small scale traditional farming system predominates in the area. Multi-stage sampling technique was employed for the study. Firstly, one out of the three Agricultural zones, namely, Kuta zone was purposively selected given its conspicuous importance in maize crop production. Secondly, three LGAs, namely, Shiroro, Bosso and Paikoro LGAs, respectively were purposively selected based on the preponderance of small-scale maize farmers' in the areas. Thirdly, four villages were randomly selected from each LGA. Lastly, ten farmers from each of the villages were randomly selected, thus making a total of 120 respondents. Pre-tested questionnaire was used to elicit information on input-output data defined within cost and returns content. Both descriptive and Cobb-Douglas frontier profit function model were used to analyze the data collected.

Empirical model

Profit efficiency in this study is defined as profit gain from operating on the profit frontier, taking into consideration farm-specific prices and factors. And, considering a farm that maximizes 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. The actual normalized 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:

$$GM\ (\pi) = \sum(TR - TVC) = \sum(P_yQ - W_iX_i) \quad \text{........................} \ (6)$$

To normalize the profit function, gross margin (π) is divided on both sides of the equation above by P_y which is the market price of the output. That is:

$$\pi = \frac{\sum(P_yQ - W_iX_i)}{P_y} = Q - \frac{W_iX_i}{P_y} = \frac{f(X_i, Z)}{P_y} - \sum P_iX_i \quad \text{..........................} \ (7)$$

Where:

TR = Total revenue (Naira);

TVC = Total variable cost (Naira);

P_y = Unit price of output (Naira/kg);

X_i = Variable input quantity (kg);

Z = Price of fixed inputs (Naira);

$P_i = W/P_y$ which represents normalized price of input X_i,

While $f(X_i, Z)$ represents production function.

Table 1: Summary statistics of the variables in stochastic profit frontier model

Variables	Mean	Standard deviation
Gross margin (₦)	70,441.03	13,043.25
Labour cost (₦)	18,300.00	9,340.25
Seed cost (₦)	1,821.26	1,107.20
Fertilizer cost (₦)	6,692.86	3,435.71
Herbicides cost (₦)	4,973.11	3,437.59
Farm size (ha)	2.1	1.2
Capital depreciation cost (₦)	3,308.52	1,567.77
Age of farmers (years)	42.44	6.78
Educational level (years)	9.1	7.6
Farming experience (years)	7.27	3.26
Household size (number)	5	1.92

Source: Field survey, 2014

The Cobb-Douglas profit function in implicit form which specifies production efficiency of the farmers is expressed as follows (Sunday et al., 2012);

$\pi_i = \pi_i / P_y = f(X_i, Z) \exp(Vi - U_i)$ .... (8)

Where,

π = normalized profit of ith farmer (Naira);

X_i = vector of variable inputs (Naira);

Z = vector of fixed inputs (Naira);

P_y = output price (Naira); and,

$\exp(V_i - U_i)$ = composite error term

However, for this study, Coelli (1996) model will be 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 maize farmers in the study area, is therefore, specified as follows:

$\ln\pi = \alpha_0 + \alpha_1 \ln P_{1i} + \alpha_2 \ln P_{2i} + \alpha_3 \ln P_{3i} + \alpha_4 \ln P_{4i} + \alpha_5 \ln X_{1i} + \alpha_6 \ln X_{2i} + (V_i - U_i)$ .... (9)

Where:

π = Restricted normalized profit computed for *jth* farm which is defined as gross revenue less variable costs divided by farm specific maize output price P_y;

ln = Natural log

P_i = Price of variable inputs normalized by price of output where (for i =1, 2, 3 and 4),

So that:

P_1= Costs of labour normalized by price of Maize (P_y)

P_2 = Costs of seed normalized by price of Maize (P_y)

P_3 = Costs of fertilizer normalized by price of Maize (P_y)

P_4 = Costs of herbicides normalized by the price of maize (P_y)

X_i = Quantity of fixed inputs (i = 1, 2)

Where,

X_1= land under maize (hectares under maize) for each farm j_{th}

X_2 = Depreciation on capital used in farm j_{th}.

α_0 = Constant parameter

α_{1-n} = Co-efficients of parameters to be estimated

The inefficiency model (U_i) is defined by:

$U_i = \delta_0 + \delta_1 Z_{1i} + \delta_2 Z_{2i} + \delta_3 Z_{3i} + \delta_4 Z_{4i} + \vartheta$ .... (10)

Where;

U_i = Inefficiency effects

Z_i = Variables explaining inefficiency effects and are defined as follows:

Z_1 = Age (years);

Z_2 = Education (Formal =1, otherwise= 0);

Z_3 = Household size (numbers);

Z_4= Farming experience (years);

Z_5= Non-farm employment (yes=1, otherwise= 0);

Z_6 = Extension contact (yes= 1, otherwise= 0);

ϑ = Truncated random variable.

δ_0 and δ_{1-n} are scalar parameters to be estimated.

These socio-economic variables are included in the model to indicate their possible influence on the profit efficiencies of the maize farmers (determinant of profit efficiency).

Profit loss due to inefficiency will be calculated as maximum profit at farm - specific prices, fixed factors, and soil dummies multiplied by farm- specific profit inefficiency. Profit loss is defined as the amount that has been lost due to inefficiency in production given prices and fixed factor endowments and is calculated by multiplying maximum profit by (1-Pe). Maximum profit per hectare is computed by dividing the actual profit per hectare of individual farms by its efficiency score.

PL = maximum profit (1-PE) .... (11)

Where:

PL = profit loss

PE = profit efficiency

RESULTS AND DISCUSSION

Summary statistics of the variables in stochastic profit frontier function

Table 1 shows the summary statistics of the variables used. The mean yield of 1,389.49 kg per cropping season was recorded over the sampled area with a standard deviation of 679.44kg. Also an average of ₦75 per kg of maize was recorded in the sampled area as price of output. It further showed the mean profit margin of ₦70441.03k with standard deviation of ₦46254.67k. The average level of education of the farmers is 9.1 years and the average years of experience in maize production are approximately 7.3 years.

Cobb-Douglas empirical stochastic frontier profit function estimates and factors explaining inefficiency

The maximum likelihood estimates of the parameters of the stochastic profit frontier model are presented in Table 2. The dependent variable was restricted profit from an output of one season. All the estimated coefficients of the estimated parameters of the normalized profit function based on the assumption of competitive markets carry the theoretically expected signs in the MLE model and are statistically significant, except herbicides price which is not significant. The reason for the herbicides price being insignificant factor might be due to its lesser contribution to the profit of maize production. This implies that all the variables are influential variables in maize production. Furthermore, a unit increase in the prices of inputs with positive coefficient will lead to increase in the normalized profit of maize and vice versa.

The estimated function reveals that wage rate, seed price, fertilizer price, herbicides price, depreciation on capital and farm area significantly affected the farm level profit of maize farmers in the study area. The coefficient of wage rate (-0.20), seed price (-0.31), fertilizer price (-0.307) and capital depreciation (-0.11) has negative significant relationship with farm profit, except herbicides price which is negative but not significant (-0.06). One naira increase in these factor prices will bring about a marginal decrease in farm profit of 20kobo, 31kobo, 31kobo and 11kobo respectively. Area under maize affects profit efficiency positively, that is, the slope coefficient of farm size (1.196) shows that the variable has a positive significant relationship with the farm profit. This implies that a unit increase in farm size will also increase farm-level profit by N1.20kobo. The estimated value of γ is close to 1 and is significantly different from zero thereby establishing the fact that a high level of inefficiencies exists in maize production. The estimated gamma parameter (γ) of 0.981 was highly significant at 1 percent level of significance. This implies that 98.1 percent of variation in actual profit from maximum profit (profit frontier) between farms mainly arose from differences in farmers' practices rather than random variability. The estimated Sigma-Squared (σ^2) is 0.165 and is statistically significant at 5% probability level. Since the figure is significantly different from zero, it indicates a good fit and correctness of specified distribution assumption of the composite error term. The results corroborate the findings of the previous works on similar issues done by Ogundari (2006); Nwachukwu et al., (2007); Ogunniyi, (2008) and Oladeebo and Oluwaranti, (2012) in other parts of Nigeria.

The estimated coefficient in the explanatory variables for the inefficiency model is presented in the lower part of Table 2. The purpose was to determine factors that explain profit inefficiency. The variables included in the model were in line with theory. These are education, experience, household size, non-farm employment and extension services. The results revealed that the estimated coefficient on education is negative and statistically significant at 5% level, indicating reduction in profit inefficiency. This implies that to an extent more education brings about decrease inefficiency (increase in efficiency) in maize production. This also indicates that farmers with more years of schooling incur significantly higher profit efficiency than farmers with less years of schooling. These results are consistent with Nganga et al. (2010), Ogunniyi (2011), Oladeebo and Oluwaranti (2012). The estimated coefficient associated with experience, carries the expected negative sign and is statistically significant at 5 percent level. The result implies that those with experience are better performers than those without. In other words, maize farmers with more years of experience tend to operate at significantly higher level of profit efficiency. The estimated coefficient associated with the extension services is significant in the study area. This result reveals that farmers who have access to extension services perform significantly better in operating at higher level of efficiency. This result is also consistent with findings obtained by other researchers (Rahman, 2002; Hyuha, 2006; Ogunniyi, 2011). This result therefore serves to emphasize the role of extension services in reducing profit inefficiency in maize production. The estimated coefficient associated with household size, carries the expected positive sign and statistically significant at 5 percent level. The result implies that those with increase household size could increase the quantity of farm produce consume by the family in addition to increase family consumption expenditure. All these factors tend to reduce farmer's income, farm investment and eventually economic efficiency in farm resource utilization. Also, an increase in the farmer's household size could exert considerable pressure on the relatively finite land area meant for maize cultivation, as part or whole might be converted to alternative land uses (Ogunniyi, 2008; Sunday et al. 2012). This would reduce available land for maize cultivation. Hence economic efficiency of the farmer will be reduced as good proportion of revenue will be lost. The estimated coefficient associated with farmer's age,

Table 2: Maximum-likelihood estimates of parameters of the Cobb-Douglas stochastic profit frontier function and profit inefficiency in small scale maize production in Niger state, Nigeria

Variable	Parameters	Coefficients	Standard error	t-ratios
General model				
Constant	β_0	0.915***	0.076	12.025
Price of labour (₦)	β_1	-0.200***	0.061	-3.307
Price of seed Price (₦)	β_2	-0.310***	0.117	-2.661
Price of fertilizer (₦)	β_3	-0.307***	0.070	-4.416
Price of herbicides (₦)	β_4	-0.061^{NS}	0.050	-1.214
Farm size (ha)	β_5	1.196***	0.130	9.195
Capital Depreciation cost (₦)	β_6	0.114*	0.081	-1.416
Inefficiency model				
Constant	δ_0	0.145***	0.050	2.891
Age (years)	δ_1	0.431***	0.164	2.625
Educational level	δ_2	-0.185**	0.103	-1.796
Household size	δ_3	0.190**	0.102	1.863
Farming experience (years)	δ_4	-0.735***	0.096	-7.659
Non-farm employment	δ_5	0.230**	0.126	1.834
Extension contact	δ_6	-0.151*	0.092	-1.639
Diagnostic statistic				
Sigma-square $\sigma^2 = \sigma^2 v + \sigma^2 u$		0.165**	0.072	2.291
Gamma $\gamma = \sigma^2 u/\sigma^2 v + \sigma^2 u$		0.981***	0.012	91.582
Log likelihood function (llf)		-54.097		

Source: Computer print-out of FRONTIER 4.1
Note: ***,**,* Implies significance at 0.01, 0.05 and 0.10 probability levels respectively.
NS: Non-significant

Table 3: Deciles Frequency Distribution of Profit Efficiencies of Maize Farmers.

Efficiency level	Frequency	Relative Efficiency (%)
< 0.50	23	19.2
0.51-0.60	4	3.3
0.61-0.70	13	10.8
0.71-0.80	23	19.2
0.81-0.90	45	37.5
0.91-1.00	12	10.0
Total	**120**	
Minimum	**0.123**	
Maximum	**0.950**	
Mode	**0.893**	
Mean	**0.707**	
Standard deviation	**0.21**	

Source: Computed from MLE Results

carries positive sign and statistically significant at 5 percent level. This is due to the fact that aged farmer's are risk averse when compared to their contemporary young ones. This result is contrary to the findings of Sunday et al. (2012). The positive and significant coefficient of the non-farm employment variable indicates that farmers who engaged in non-farm activities operate at significantly lower levels of efficiency. The effect of off-farm income activity on farming could be negative if farmers have higher chances of obtaining off-farm and non-farm employment, ultimately, reducing profit efficiency. Ogunniyi (2012) reported similar result for maize farmers in Oyo state, Nigeria.

Profit efficiency score estimates

The frequency distribution of farm- specific efficiency scores for the maize farmers is shown in Table 3. The maize farmers exhibit a wide range of profit inefficiency ranging from 12% to 95%. It is worth noting, however, that this wide variation is not unique to Nigeria, similar results have been reported by other researchers

Table 4: Frequency Distribution of Profit Loss in Maize Production

Profit loss	Frequency	Relative efficiency (%)
1-10000	64	53.3
10001-20000	34	28.3
20001-30000	12	10.0
30001-40000	6	5.0
40001-50000	3	2.6
>50000	1	0.8
Total	**120**	100
Minimum	**571.05**	
Maximum	**79,989.81**	
Mode	**13,786.67**	
Mean	**13,076.07**	
Standard deviation	**11,303.67**	

Source: Computed from MLE Results

Table 5: Generalized likelihood ratio test of hypothesis for parameters of the stochastic cost function for small scale maize farmers in Niger State, Nigeria.

Null hypothesis	Log likelihood	No. of Restrictions	χ^2-statistics	Critical value	Decision
H_0: $\gamma = 0$	-54.10	8	10.83	10.64	Rejected

Source: Computed from MLE Results

elsewhere Ali and Flinn (1989) obtained a minimum of 13 percent and a maximum of 95 percent for rice farmers of Gujranwala district, Pakistan. Wang et al., (1996) reported efficiency levels ranging from 6 percent with a mean of 62 percent for rural farm households in China. The findings showed that maize farmers achieved on average 71 percent level of efficiency. This implies that the average farmer in the study area could increase profit by 29%to attain frontier by improving their technical and allocative efficiency. This result conformed to the findings of Rahman [2003], Ojo et al. [2009], Fadil and Mitsuyasu (2012), and, Oladeedo and Oluwaranti (2012) who reported mean profit efficiency levels of 0.77 for Bangladeshi rice farmers, 0.78 for Nigerian cowpea farmers, 0.81 for Brunei Darussalam rice production and 0.79 for Nigeria cassava farmers respectively. It could be seen that despite the variation in efficiency, about 66.7% of the farmers seemed to be skewed towards efficiency level of 0.71 and above, while the worst of these farmers obtained a profit efficiency score of 0.12. However, the least profit efficient farmer needs an efficiency gain of 87% [i.e. (1.00 – 0.12/0.95)*100] in the use of specified farm resources if such farmer is to attain the profit efficiency of the best farmer in the region. Likewise for an average efficient farmer, he will need an efficiency gain of 25% (i.e., 1.00 – 0.71/0.95)100 to attain the level of the most profit efficient farmer. Also, the most profit efficient farmer needs about 5% gains in profit efficiency to be on the frontier. In spite of this, the results implied that a considerable amount of profit can be obtained by improving their technical and allocative efficiency in the study area.

Profit loss in maize production

The inefficiency translated into a profit loss ranging from ₦571.05k to ₦79, 989.81k with a mean of ₦13,076.07k. This could be recovered by eliminating technical and allocative inefficiency (Table 4).

Test of Hypothesis and Diagnostic Statistics

Table 5 shows the result of the generalised likelihood ratio which is defined by the chi square distribution. The null hypothesis which specifies that the inefficiency effects in the stochastic profit frontier are not stochastic is rejected. This implies that the traditional response function (OLS) is not an adequate representation of the data.

CONCLUSION AND RECOMMENDATION

This research employed Cobb-Douglas stochastic profit frontier model to examine profit efficiency among maize farmers in Niger State, Nigeria using farm level data obtained from 120 maize farmers'. The study showed that profit efficiency varied widely among the sampled farmers with it ranging from 12% to 95% with a mean of 71%. The mean level of efficiency indicates that there exists room to increase profit by improving the technical and allocative efficiency. Least profit efficient farmer needs an efficiency gain of 87% to attain the profit efficiency of the best farmer in the region, an average efficient farmer need an efficiency gain of 25% to attain the level of the most profit efficient farmer, while the most profit efficient farmer needs about 5% gains in profit efficiency to be on the frontier. All the parameters included in the inefficiency model have significant impacts on profit efficiency. The policy implication in maize production is that inefficiency in maize production can be reduced significantly by improving the level of education among the farmers and awareness by extension agents. Most important are the extension services and the existing technological packages that need to be critically examined. Furthermore, the study will go a long way to help other researchers and research institutions in further research for more effective combinations of resources for better efficiencies as well as increase output and productivity in the farming business, it would also help the government, policy makers and other donor agencies in planning, designing and formulations of agricultural programmes that would tends towards increase resource, resource availability as well as affordability.

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