TECHNICAL EFFICIENCY IN SESAME PRODUCTION IN NASARAWA DOMA LOCAL GOVERNMENT AREA OF NASSARAWA STATE, NIGERIA: AN APPLICATION OF STOCHASTIC FRONTIER MODEL

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ABSTRACT

This study assessed technical efficiency in sesame production in Nassarawa Doma Local Government Area of Nassarawa State, Nigeria using stochastic frontier model. Primary data were used. A systematic random sample of eighty farmers in the area was selected. Descriptive statistics and stochastic production frontier model were used for the analysis of data. The model was estimated by the maximum likelihood method. Results showed that elasticity of production for seeds (0.51); labour (0.71); capital (0.356); farm size (0.55) had significant effect on sesame output. The inefficiency model revealed that education and access to credit were significant at 5% probability levels and positively affects farmer's efficiency level. This suggests that a considerable sesame yield potential remains to be exploited through better use of available resources. This can be achieved through better access to improved seeds, credit, education, fertilizer and extension agent.

Keywords: Technical Efficiency, Stochastic Frontier, Sesame.

INTRODUCTION

Sesame (*Sesamum indicum*) commonly called Benniseed in Nigeria is an important oil crop believed to have originated from tropical Africa (Rahman *et al*, 2007).One of the major factors responsible for declining agricultural productivity in Nigeria is farmers limited access to production inputs which are necessary for attaining a high level of production (Palmer and Ojo,1983; Nwaru, 2004). Amaza and Olayemi (2001) observed that crop farmers mostly carry out their production under conditions involving the use of inefficient tools, unimproved seed varieties, therefore maximum efficiency is elusive to them. Efficiency can be technical and allocative (Farrel, 1957). Technical efficiency is the ability of a farm to produce maximum output with minimum input requirements and available technology. On the other hand, allocative efficiency refers to the ability of a farm to use inputs optimally given their prices (Xu and Jeffrey, 1995; Ajibefun and Daramola, 2001). Technical efficiency defines the maximum potential output that can be achieved by a farm given a mix of inputs and technology. Consequently, deviation from this maximum is ascribed to technical inefficiency and is measured for firms utilizing similar inputs in a given farm. Estimating technical efficiency involves estimating either a deterministic or stochastic frontier production function. The stochastic model is based on the assumption that the frontier production function depends on production and technology- related parameters as well as random disturbances. Technology capability comprises the skills and information to establish and operate modern machinery and the learning ability to upgrade the skills over time. These capabilities, which can be grouped into investment and production capabilities as well as learning mechanism, are veritable tools for optimizing farm level productivity. Farm productivity is broadly measured using the concept of technical efficiency (Aigner *et al*, 1977; Schmidt, 1985; Bhavani, 1991; Coelli, 1996; Young and Harris, 1999; Syri and Thijsen, 1997; Essien, 2000).

The broad objective of the study is to examine technical efficiency in sesame production in Nassarawa Doma Local Government Area of Nassarawa State, Nigeria: an application of stochastic frontier model. The specific objectives are to: (i) identify factors that determine technical efficiency in sesame production, (ii) determine efficiency levels of the sesame producers in Nassarawa Doma Local Government Area of Nassarawa State, (iii) determine the effects of some socio-economic factors on farmers efficiency level,(iv) provide information on the technical efficiency of sesame farmers in the study area.

LITERATURE REVIEW

Efficiency had been determined using the ordinary least square (OLS) estimation technique and recently, the frontier methodology that involves maximum likelihood estimation (MLE) technique has been deployed. The greatest limitation in the use of ordinary least square method (OLS) estimation technique results in the derivation of partial measures of efficiency (Ajibefun and Aderinola, 2003).To overcome this limitation, the stochastic frontier model was developed independently by Aigner *et al* (1977) and Meeusen and Van den Broeck (1977) and used in determining farm level efficiency of all farmers in a sample using cross sectional, time series and panel data. Stochastic frontier model has been used in efficiency studies in other developing countries and is gaining prominence in Nigeria's agriculture. Ajibefun (2002), Udoh and Akintola (2001). Amaza and Olayemi (2001), Nwaru (2004) and Onyenweaku *et al* (2005) had determined the level technical efficiencies of food crop farmers in Nigeria and obtained a range from 0.25 to 0.84, they also considered the effects of some farm/farmers characteristics on their efficiency and obtain results ranging from positive to negative influences depending on the variables.

CONCEPTUAL FRAMEWORK

The stochastic production frontier is an econometric method of efficiency measurement in production systems and is build around the premise that a production system is bounded by a set of smooth and continuously differentiable concave production transformation functions for which the frontier offers the limit to the range of all production possibilities (Sharma *et al*, 1999). It has the advantage of allowing simultaneous estimation of individual technical efficiency of the respondent farmers as well as the determinants of technical efficiency (Battese and Coelli, 1995). The stochastic frontier approach amounts to specifying the relationship between output and one or more input levels, using two error terms. One error is the traditional normal error term in which the mean is zero and the variance is constant. The other error term represents technical inefficiency and may be expressed as a half-normal, truncated normal, exponential or two-parameter gamma distribution. Technical efficiency is subsequently estimated via maximum likelihood estimation technique of the production function subject to the two error terms. Generally, the specification for the stochastic frontier production function involves a production function which has an error term made up of two components, one to account for random effect and another to account for technical inefficiency. In order to compute technical efficiency it is, therefore, necessary to estimate potential output, which can be done by the econometric estimation of the stochastic frontier production function. From this production function, farm specific measures of technical efficiency (TE) are derived. The formal method of doing this is well explained in Jondrow *et al* (1982). A general form of estimating this model is proposed in Baattese and Coelli (1992,1995).In this method, the average technical efficiency (ATE) is calculated as unconditional mean of TE_i, that is $E(TE_i)$.Other estimates of ATE, such as sigma square, that is $\sigma^2 = \sigma_u^2 + \sigma_v^2$ and gamma, that is $\gamma = \sigma_u^2/(\sigma_u^2 + \sigma_v^2)$, with $0<\gamma<1$ using parameterization in Batesse and Corra (1977) can also be derived.

METHODOLOGY

This study was conducted in Nassarawa Doma Local Government Area of Nassarawa State. The state is located in the middle belt zone of the country. It lies between Latitudes 7^0 and 9^0 North and Longitudes 7^0 and 10^0 East and share boundaries with Benue State to the South; Kogi State to the West; the Federal Capital Territory (FCT), Abuja to the North-East, Kaduna, Plateau and Taraba States to the South-East. The state covers an area of 27,117 Km^2 with an estimated population of 1,863,275 people (National Population census, 2006). Nassarawa Doma covered an estimated land of about

2035 Sq Km; it has a projected population of about 119,500 people (NPC, 2006). The area lies approximately between Latitudes 18^0 30^1 North and Longitudes 15^0 East. Majority of the people in the area are famers. Primary data were used for this study. Systematic random sampling technique was used to select eighty (80) farmers in the area.

Stochastic Frontier Model: Data were analyzed using the stochastic frontier function with multiplication disturbance term following Aigner *et al* (1977), Meeusen and Van den Broeck (1977) and Helfand (2003). The original specification involved a production function which had two components, one to account for random effects and another to account for technical inefficiency. The model is specified as follows:-

$$Y_i = f(X_{Ki}, \beta)\, e^{\varepsilon i}, \qquad i = 1 \ldots\ldots n;\ k=1\ldots\ldots k$$

Where,

Y_i = Output of the ith farmers

X_{ki} = Vector of k inputs by the ith farmer

f = A suitable functional form such as Cobb-Douglas or translog

β = Vector of parameters to be estimated

ε_i =The farm specific composite residual term comprising of two independent elements, error term V_i and inefficiency components u_i

$$\varepsilon_i = V_i - U_i, \quad i = 1 \ldots\ldots n$$

The symmetric component, V_i, is the two sided normally and independently distributed random term as N (O, σ_v^2) and account for random variation in output due to factors outside the farmers control such as weather and diseases. A one sided component, u_i, reflects technical inefficiency relative to the stochastic component and are often assumed to be normally distributed as truncation at zero of the normal (U, σ_u^2) distribution though it can also be assumed to be half normally distributed N(O,σ_u^2) (Dawson, 1990; Sharma *et al*, 1999). Technical efficiency (TE) = Actual output/Potential output. This specifies the ratio of observed output to frontier output. Thus:-

$$TE_i = \frac{y_i}{F(X_i, \beta)\exp(v_i)} = \exp(-u_i)$$

$$O<TE<1$$

Variables as defined before. In this study a Cobb Douglas production function was fitted to the frontier model and estimated using the maximum likelihood method. This was specified as follows:-

$$LnY = b_o + b_1LnX_1 + b_2LnX_2 + b_3LnX_3 + b_4LnX_4 + b_5LnX_5 + \varepsilon_i$$

Where,

Y = Output of sesame in Kg

X_1 = Quantity of seeds in Kg

X_2 = Fertilizer used in kg

X_3 = Labour in Mandays

X_4 = Capital input in Naira

X_5 = Farm size in Hectares

Ln = Natural logarithm

b_0 - b_5 = Coefficients to be estimated

ε_i = Composite error term

Inefficiency factors were incorporated in the model to ascertain the effects of these variables on technical efficiency

It was specified as:

$$T.E = \beta_0 + \beta_1Z_1 + \beta_2Z_2 + \beta_3Z_3 + \beta_4Z_4 + \beta_5Z_5 + \beta_6Z_6 + e$$

Where, T.E = Technical Efficiency

Z_1 = Age of farmers (Years)

Z_2 = Educational Level (Years)

Z_3 = Household Size

Z_4 = Extension Contact (1, Contact; O, Otherwise)

Z_5 = Credit Access (1, Access; O Otherwise)
Z_6 = Sex (1, Male; O Otherwise)
The maximum likelihood estimates of b and ₰ was estimated simultaneously using computer program frontier 4.1 (Coelli, 1996).

RESULTS AND DISCUSSION

Socio-Economic Characteristics of Sesame Farmers

Certain farmer's characteristics that could have bearing on sesame production in the area were considered. These include sex, farming experiences, educational level, sources of credit. The results are presented in Table 1. As shown in Table 1, 51.25 percent of sesame farmers were males. About 35.75 percent of sesame farmers had formal education. The importance of education in enhancing information acquisition and utilization and thus improving productivity cannot be over-emphasized. Education enhances the acquisition and utilization of information on improved technology by the farmers as well as their innovativeness. Furthermore, 13.75 percent of sampled farmers had less than 20 years experience in farming. About 42.50 percent of sampled sesame farmers obtained credit through personal savings. Farmer's access to credit enhances their timely acquisition of production inputs that would enhance productivity via efficiency.

Stochastic Frontier Model: - Table 2 revealed the maximum likelihood estimates of the stochastic

Productions function for sesame farmers. The coefficients of labour and farm size were significant at one percent probability level. The coefficients of seeds and capital were significant at five percent probability level. Elasticity of labour appears to be 0.74. It implies that increasing labour use by 10 percent will lead to 7.4 percent increase in output of sesame. The sum of elasticity was estimated to be 2.236 which indicate that sesame farmers were operating in the increasing return to scale region (inefficient stage). The average technical efficiency (TE) derived from the stochastic frontier model was 0.504. This is very low. There was however very wide disparities in technical efficiency (TE) estimate ranging from 0.193 for the least efficient farm to 0.807 for the very efficient ones. Of particular relevance in the analysis of technical efficiency is the variance ratio also called the gamma-value as shown in Table 2 .This is proportion of the total variance attributable to the inefficiency term (u_i). The gamma value is 0.780 which is significant at one percent probability level. It is an indication that 78 percent variation in output of sesame producers are attributed to technical inefficiency. Consequently, farm level technical efficiency and productivity can be said to account for low levels in the farms output rather than random factors. It also confirms the presence of the one sided error component in the model, thus rendering the use of the ordinary least square (OLS) estimating technique inadequate in representing the data. The sigma-square (σ^2) gave an estimated value of 0.51 which is significant at five percent probability level which indicates the correctness of the specified assumptions of the distribution of the composite error term. The maximum likelihood estimates (MLEs) of technical efficiency in sesame production systems in the area are presented in Table 3. Age, education-level, household-size, extension contact were found to have significant effect on the technical efficiency of farmers. The significant and negative coefficient of household size implies that a larger household would have sufficient family labour for farm production especially in such an area where farming is labour intensive. Farmers with more year of formal education tend to be more efficient in sesame production, probably due to their enhanced ability to acquire technical knowledge and make good use of information about production inputs .Non-availability of credit affect input availability and efficiency. The quantities of input use, the timing of input use are also important in determining yields. The farms that have access to credit may be able to arrange production at the best timing. Access to extension service enables the farmer to acquire technical knowledge as well as have access to improved production technology which will make him more efficient in production. Aged farmers are often not amenable to changes and are neither likely to adopt improved technologies nor have the physical strength to do manual work as the younger ones. This given the reason why there exist a negative relationship between age and technical efficiency. The findings are consistent with earlier results by Nwaru (2004), Ajibefun and Aderinola (2003). Furthermore, farmer's access to credit enhances their timely acquisition of production inputs that would enhance productivity via efficiency. The findings are consistent with earlier result by Bravo-Ureta and Evenson (1994); Heshmati and Mulugata (1996); Kebede (2001); Ajibefun and Aderinola (2003) and Nwaru (2004).

RECOMMENDATIONS AND CONCLUSION

This study has revealed that sesame farmers in the study area are not technically efficient and therefore there is allowance of efficiency improvement by addressing some important policy variables. It was shown that education and access to credit are positively related to technical efficiency. Policies to promote formal education, access to cheap credit facilities is advocated for and this would enable farmers make better technical decisions and allocate production inputs more efficiently in the long run. Policies to encourage relatively younger persons into sesame production and improved access to extension services are encourage and needed.

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Appendix 1

Table 1:- Socioeconomic Characteristics of Sampled Farmers

Variables	Frequency	Percentage
Sex		
Male	41	51.25
Female	39	48.75
Educational Level (Years)		
Primary	12	15.00
Secondary	14	17.50
Tertiary	6	3.75
No Formal	48	64.25
Year of Experience		
1-10	3	3.75
11-20	8	10.00
21-30	5	6.25
31-40	64	80.00
Source of Credit		
Personal Saving	34	42.50
Banks	10	12.50
Cooperative	20	15.00
Money Lenders	16	20.00
Total	**80**	**100.00**

Source: - Field Survey, 2009

Table 2 Maximum Likelihood Estimates of the Stochastic Production Function for Sesame Farmers.

Variables	Coefficient	t-values
Constant	6.75	1.82
Seeds(X_1)	0.51	2.52**
Fertilizer(X_2)	0.08	1.88
Labour(X_3)	0.74	3.05***
Capital(X_4)	0.356	2.134**
Farm Size(X_5)	0.55	2.97***
Gamma- Value (γ)	0.780	3.663***
Sigma Square (σ^2)	0.51	2.56**
Average Technical Efficiency	0.504	
Minimum Technical Efficiency	0.193	
Maximum Technical Efficiency	0.807	
Sum of Elasticities	2.236	
Log Likelihood Function	-56.69	

-Significant at 5% probability level, *- Significant at 1% probability level.
Source: - Derived from output of computer programme frontier 4.1 by Coelli (1996).

Table 3 Maximum Likelihood Estimates of Technical Efficiency in Sesame Production System

Variables	Coefficient	t-values
Constant	-0.21	0.32
Age	-0.34	2.83**
Educational Level	0.62	2.66**
Household Size	-0.13	2.61**
Extension Contact	0.12	1.04
Credit Access	2.01	2.89**
Sex	-0.14	1.21

**- Significant at 5% probability level.
Source: - Output of frontier 4.1 By Coelli (1996).