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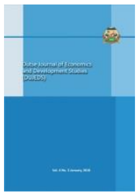

DETERMINANTS OF TECHNICAL EFFICIENCY AMONG SMALL SCALE MAIZE FARMERS IN KADUNA STATE

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Abstract

This study attempts to examine the determinants and levels of efficiency of some selected small scale maize farmers in Kaduna state. Technical efficiency estimates were obtained using the Stochastic Frontier Model, the Maximum Likelihood Estimate (MLE) and Cobb-Douglass production function; stratified random sampling was employed; both primary and secondary data were used for the study. The lambda value of 1.267 and gamma value of 1.417 both of which are significantly different from zero indicates that the model is a good fit. Also a 2.622 return to scale value implies increasing returns to scale such that any additional input will lead to more than proportionate change in the output (excess capacity). Farm land, quantity of seeds and fertilizer were found to be significant at 5% level of significance meaning that increasing these factors by 1% will lead to an increase in output by 66%, 21% and 13% respectively. Based on the findings the study recommends that the N-Power (agro) federal government programme should be sustained and improved upon as it could be a platform to raise the current level of efficiency in maize farming.

Keywords: Maize, Production, Small Scale Farming. Technical Efficiency
JEL Classification

Introduction

Globally, small scale farmers are the key food producers. There are approximately 2.5 billion people involved in agriculture both full and part time, small holder farmers manages an estimated 500 million small farms, provide about 80 percent of food consumed in a large part of under-developed countries (IFAD, 2013). In the colonial and post-colonial era, Nigeria was food secured with enough for export as one of the world leading producers of crops like cocoa, maize, rubber, palm oil, ground nut etc. and the surpluses were used for developmental projects, this was made possible by small scale farmers. Nigeria has about 93.3 million hectares of land available for agriculture, it is however unfortunate that it has not used even halve of its capacity to reduce the incidence of unemployment, poverty and hunger (Opara, 2011).

Small scale farmers provide food for the large proportion of Nigerians yet small farmers live in remote and environmentally fragile location, marginalised and disenfranchised population who often than not are the poorest. Small scale farming is characterised by low productivity as a result of poor and in-efficient use of resources as a backdrop of poor technical knowhow, input cost etc. (Duniya and Joseph, 2013). Thus, impairing their ability to afford good health, education, hired labour, technology etc. these factors in turn affect efficiency and output hence creating a vicious circle of poverty.

Despite the enormous potentials in vast arable land, conducive climate, varieties of crops and animals, forest resources, fertile soils, cheap and available labour, ready market, Kaduna state and indeed Nigeria is experiencing acute food scarcity exacerbated by high food prices where supply cannot keep pace with demand (Abba, 2012). So many programmes of government towards revamping the agricultural sector especially small scale farming leads to little or no visible results as farm output cannot keep pace with population growth resulting to shortage of food crops, high prices, input cost among others.
A strong and efficient agricultural sector leads to a multiplier effect on any nation's socio-economic

life. Technical efficiency which has to do with obtaining the maximum output from a given set of inputs is pivotal to the enhancement of farmers' productive capacities (Shehu, 2013).

Thus the in-efficiency in the agricultural sector especially among small scale farmers resulting in poor quality and quantity of outputs, poverty and food insecurity are issues facing the agricultural sector. Therefore, this study is directed towards examining the determinants and measures of technical efficiency in the production of maize in order to chatter the way forward for small scale farmers to improve their productivity. This paper is apt considering the diversification drive of the Nigerian economy. It will provide researchers in this area resources, provides policy makers with recommendations in respect to policy formulation for the growth and development of the agricultural sector.

Literature Review

The optimal production and distribution of scarce resources is known as efficiency. Farrel (1957) referred to technical efficiency as the ability to produce the highest level of output given a bundle of resources. On the other hand, technical inefficiency depicts a situation in which actual and observed output from a given input mix is less than the maximum possible (Bailey, 1989). A firm is said to be technically efficient if the firm is producing the maximum output from the minimum quantity of inputs such as labour, and technology.

Corn (maize) belongs to the family of grasses (graminaeae) and botanically it is called *Zea mays.* Maize is high-yielding, easy to process, readily digested and costs less than other cereals (IITA, 2001). Maize grain production in Nigeria was estimated to have doubled from seven million metric tons in 2004 to fourteen thousand metric tons in 2013 and this had enhanced income generation, wealth creation, poverty alleviation and improved food security yet there is great room for improvement.

The Food and Agriculture Organization of the United Nations (FAO) adopted a 2-hectare (ha) threshold as a broad measure of a small farm. The concept of small scale farming is a natural outgrowth of sustainable agriculture which is essentially agriculture that produces abundant food without depleting the earth's resources or polluting its environment.

The Physiocrates, for instance, viewed the agricultural sector as the only area that can generate economic surpluses or net products over cost of production in order to initiate economic growth, and that the rate of growth of other sectors is dependent on the growth of the agricultural system. (Dunmoye 1987).Classical text book exposition views an efficient firm as producing on the isoquant production possibility frontier, while a technically inefficient firm operates outside or inside its production possibility frontier (McGuire, 1987). Eicher (1994) argues that small holder farmers should be "viewed as a positive force in 'getting agriculture moving'. He suggests that African governments should give priority to the development of both smallholder and middle farmers. With the necessary support, smallholder farmers have the potential to produce a marketable surplus.

Aigner, Lovell and Schmidt(1992) and Meeusen and Broeck(1997) independently proposed the stochastic frontier production function model of the form:

$$\ln q_i = X_i\beta + V_i - U_i \quad \ldots\ldots (1)$$

Which has asymmetric random error $V_i$which account for statistical noise, which arises from unintentional removal of relevant variables from the explanatory (independent) variables as well as from measurement errors and approximation errors associated with the choice of the functional form. The above function is known as the stochastic frontier production function because the values of outputs are bounded from above by the stochastic variable exp (X_i β+ V_i). V_i Which can be positive or negative, thus, the stochastic frontier outputs vary about the deterministic part of the model exp ($X_i\beta$).

James (2010), in a study "factors influencing technical efficiency among selected wheat farmers in Uasin Gishu district, Kenya" where the stochastic frontier production function was used observed that technology, education, access to credit, and capital are factors that influences technical efficiency. The above studies however did not indicate the degree of efficiencies in productivity so the extent of inefficiency becomes difficult to ascertain.

Nandi, Yurkush, and Ashiko, (2011) conducted a study on 'Resource use efficiency among ginger farmers in Kaduna state, using Multi stage random sampling, descriptive; stochastic frontier analysis was used; it was discovered that there was a variations in technical, allocative and economic efficiencies indicating great potentials to improve efficiency. Sani (2015) conducted a study on the 'analysis of guava (Psidiunguajava) production among small holders' farmers in selected local government areas of Kaduna state'. The study uses Multi-stage random sampling, descriptive statistics, net farm income, stochastic frontier analysis. Variables of seeds, fertilizer and labour were significant at 5percent, 10 percent and 1 percent respectively. The mean technical efficiency is 82 percent guava contributes about 68 percent of household income, pest and diseases, in adequate capital, high cost of input, high cost of transportation and poor access to market are among the constraints to guava production.

Orefi Abu (2013) conducted a study on maize productivity and rural poverty reduction in liberalised fertilizer using data envelop analysis (DEA) it was found out that a direct relationship exist between agricultural productivity and poverty reduction with total factor productivity of 5.4%. The liberalised period lead to raised agricultural production and raised income of small holder farmers.

Joseph, Umeh, and Adejo (2015) in a study 'Technical efficiency analysis of pig production: a sustainable animal protein augmentation for Nigeria' using Simple random sampling, descriptive statistics and stochastic frontier production function found out that Feed and labour has a positive and significant effect on production output. Education has a negative impact and significant effect on technical efficiency. The mean efficiency was 0.77, which implies that there still exists an excess capacity of about 0.23 to be utilised to enhance the production of pigs in order to ensure the augmentation of animal protein. Education seems to be detrimental to efficiency, this is unlikely as education based on a priori should improve the understanding of farming procedures and enhances productivity.

Danladi, Akinola, Banta, Makarau and Ali (2017) in a study 'Socio-economic assessment of ginger production in Jaba Local Government area of Kaduna state' using purposive sampling, descriptive statistics, multiple regression analysis, gross margin and productivity for data analysis; found out that education, credit, and farm size are the dominant variables influencing ginger production. Inadequate input, poor transport facilities, high cost of labour and inadequate credit are constraints of ginger production in the study area. The literature reviewed indicated different mean technical efficiencies of the farmers on different study areas. The factors affecting the technical efficiency of farmers were revealed in the literature review. However, the study discovered that; enough studies have not been made on the measures, determinant/sources of technical efficiencies in the study areas.

Methodology

The study is conducted in Kaduna state. Both secondary and primary data were used in this paper through the use of questionnaire and from the Kaduna Agricultural Development Programme (KADP) of the state ministry of agriculture as well as other literatures reviewed. Three local governments were selected which are Kaura local government, Chikun and Zaria local government areas through; a stratified random sampling.

The sample size was calculated using the adjusted Taro Yamane formulae, thus;

$$n = \frac{N}{3 + N(\alpha)^2}$$

$$n = \frac{71548}{3 + 71548(0.05)^2} = 390$$

Where;

n= Sample size

N= Population

3= Adjusted constant value

α = Confidence level (significant level) which is usually set at 0.05

390 respondents were randomly selected from the sample frame of 71548 farmers' family figure based on the data collected from Kaduna State Agriculture Development Programme (KADP, 2007). This forms the sample size of the study as given below

Table 1: Distribution of respondents based on farming family figures

S/N	Local Government Area	Farmers Family Figure	Ratio	Sample Size	Per Ward	No. of Wards Selected
1	Chukun	18096	2.5	98	33	3
2	Kaura	34192	4.8	187	62	3
3	Zaria	19260	2.7	105	35	3
	Total		10	**390**		9

Source: Farming Family Figures Survey (KADP, 2007); Reprinted in 2013.

From table 1 the sample size for each local government is to the ratio of the size of the population of the local government to the total population of farming families according to the data collected from the Kaduna Agricultural Development Programme.

Stochastic Frontier Estimation

Thus the model is specified as follows.

$$Y = f(X_i \beta)e^{v-u}$$

Logarithmically; $LnY_i = \ln f(X_i \beta) + V_i - U_i$

Y=output,

X=input vector

V_i= random error term which is independently identically and normally distributed with 0 mean and a constant variance {iid N (0, σ^2)}; U_i=inefficiency term distributed independently of V_i which is a function of a set of explanatory variables which may include some input in the stochastic frontier function. This is specified as follows:

$$Y = F(X_1, X_2, X_3, X_4,)$$

Operationally

$$LnY = \beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + U_i$$

Where;

In = the natural logarithm; Y= output; X_1= capital; X_2= labour; X_3= land; X_4=fertilizers; X_5= manure; X_6= seeds; and X_7=pesticides. U_i= error term $=V_i - E_i$ where V_i is the statistical error term and $E_i$is the error term measuring the level of in-efficiency in production β_0-β_4= parameters

Whereby,

$$Ui = a_0 + a_1 C_1 + a_2C_2 + a_3 C_3 + a_4 C_4 + a_5 C_5 + a_6 C_6 + a_7 C_7 + a_8 C_8 + e_i$$

Where

C_1 =farm size (ha); C_2 =marital status; C_3 = Household size (numbers); C_4 = Age (years), C_5 = Number of years spent in formal education; C_6 =access to credit (N) C_7 = Number of extension contact; C_8= Farming experience (years); e_0= Error term; a_0= intercept or constant; a_1 –a_8 = parameters to be estimated.

(Coelli, 1995, Coelli, 1996, Coelli and Battesse, 1996)

For technical efficiency; TE= $\frac{lny_i}{lny^*} = \left[\frac{f(X_i\beta)exp(V_i - U_i)}{f(X_i\beta)exp(V_i)}\right]$

TE=$exp(-e_i) = u_i^{-e}$, Such that 0≤TE≥1

Thus, the in-efficiency index is given as: [1-$exp(-e_i)$]

Therefore, where;

e_i=0, the agricultural production lies on the stochastic frontier and production is technically efficient.

e_i>0 implies agricultural production lies below the frontier and is in-efficient.

The model thus, will be estimated using the method of the maximum likelihood (ML).

Analysis and Discussion of Result

The stochastic production frontier estimates

The Cobb Douglass maximum likelihood production function results are presented in table 4.1. From the table, the lambda value of 1.267 and gamma value of 1.417 both of which are significantly different from zero meaning that the model is a good of fit. Also a 2.622 return to scale value implies increasing returns to scale such that any additional input will lead to more than proportionate change in the output (excess capacity).

$$\text{Ln } Y = 1.326 - 0.051X_1 + 0.071X_2 + 0.661X_3 + 0.42X_4 + 0.211X_5 + 0.321X_6 + 0.043X_7$$

(2.79) (-0.412) (0.054) (6.331) *** (0.043) (2.44) *** (3.412) (0.563)

The above equation represents the coefficients of each of the variables from the maximum likelihood estimate result in table 4.1. The three significant variables at 5% level of significance in this model are farm land, quantity of seeds and fertilizer. The coefficient of farm land (0.661), meaning that increasing the farm size by one hectare will lead to about 66% increases in output of the maize farmers in the area; planting seeds (0.211) showing a positive relation with output thus, a change in the quantity of planting seed by 1% will lead to a change in output by about 21%. Also, fertilizer shows a positive relationship with output with a coefficient of (0.131) representing about 13% change in output resulting from a 1% change in fertilizer application.

$$\gamma = 1.335 - 0.005C_1 + 0.005C_2 - 0.007C_3 - 0.002C4 - 0.031C_5 + 0.004C_6 - 0.025C_7 + 0.04C_8 - 0.052C_9$$

(5.638) (3.023)*(1.398) (-2.866)*(-1.659)*(-2.431)*(1.862)* (-3.210) (-1.224) (1.876)

From the inefficiency estimates on the basis of farmers characteristics, age, cost of fertilizer, cost of herbicide, membership of cooperatives, farming experience, access to credit and educational level are significant at 5%, 1%, 1%, 5%, 1%, 5% and 1% respectively only extension service shows insignificance. Only age and farming experience are positive meaning that they contribute to technical inefficiency in maize production in the area. This could be that the respondents are fairly old. Such people may not easily adopt improved technology that can enhance their efficiency. Cost of fertilizer, cost of herbicides, membership of cooperatives and educational level, access to credit are negative and contribute to efficiency in maize production.

Table 2: The maximum likelihood estimates of parameters of the Cobb Douglas frontier function

Variable	Estimate
General model	
Constant	1.326*** (2.79)
Capital	-0.051 (-0.412)
Labour (Man-days)	0.071 (0.054)
Farm land	0.661*** (6.331)
Organic Manure	0.042 (0.043)
Seeds	0.211*** (2.44)
Fertilizer	0.321 (3.412)
Pesticide	0.043 (0.563)
Inefficiency model	
Constant	1.335*** (5.638)
Age	-0.005** (3.023)
Household size	0.005 (1.398)
Cost of fertilizer	-0.007*** (-2.866)
Cost of herbicides	-0.002* (-1.659)
Cooperative	-0.031** (-2.431)
Farming experience	0.004* (1.862)
Educational level	-0.025*** (-3.210)
Extension	-0.04 (-1.224)
Credit	-0.05 (1.876)
Variances parameter	
Sigma-square σ2u	0.010
Gamma	1.417 (2.874)
Lambda	1.267 (3.501)
Log likelihood LLR	121.010
Return to scale	3.533

Source:
Significant at 10, 5 and 1% levels respectively; Source: Data analysis, 2018.

Technical Efficiency Estimates

The technical efficiency level of each production unit covered by the study has been computed. The results indicates a great difference in efficiency levels among production units thus, some producers can achieve relatively high efficiency whilst others are technically less efficient. The study found out that the average technical efficiency of the sample farms is 0.652, with a minimum level of 0.219 and a maximum level of 0.952. This means that for the average farmer in the sample to achieve the technical efficient level of the most efficient farmer in the sample, then, the average farmer could realised about 34% increase in output through improved technology. Farms with efficiency values of about 95% could be considered as efficient because in reality, there cannot be perfect efficiency or 100% efficiency although there still exist an excess capacity of about 5% for the most efficient farmers to improve their productivity.

Conclusion and Recommendations

By estimating a stochastic frontier for maize farmers, the results show that efficiency levels are significantly different across all production units. While some production units were efficient others were not. The uneven distribution of efficiency scores revealed that there are important factors that reduce efficiency which are related to particular farm lands. Though majority i.e. 52.5 per cent of the farmers achieved higher efficiencies, there is still excess capacity and thus room for improvement.

The frontier model used in this study reveals the current levels of efficiency of the production units, which could change with time. It was found that there is inefficiency in the production system. This suggests that a significant proportion of the error term in the estimated production function is explained by inefficiency effects. It is also observed that improvement in efficiency via the factors will enhance improvement in output in terms of quantity and quality of output.

In line with the findings the study therefore recommended that government policy should be focused on attracting the youth who are more agile and aggressive to go into maize production. The N-Power (agro) federal government programme should be sustained and improved upon as it could be a platform to raise the current level of efficiency in maize farming.

The government should have the prime responsibility of providing basic education in these areas and facilitates the necessary materials so that farmers can understand agricultural instructions easily and have better access to product information and use the available inputs more efficiently. Furthermore, education on agriculture should be holistic and practical, it should be taught as early as in the primary school, secondary school students should be able to earn from agriculture while in school in order to encourage them and to make the venture more attractive. Informal/none formal education is also appropriate to enhance the knowledge of rural small scale farmers in order to adapt to current trend in the agricultural sector.

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