Journal of Sustainable Agriculture And the Environment

A translog stochastic frontier analyses of technical, economic and allocative efficiencies in yam production in Ebonyi State, Nigeria

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Abstract

This study estimated technical, economic, allocative efficiencies and determinants of allocative efficiency of yam farmers in Ebonyi State, Nigeria using translog stochastic frontier production function. Data were collected with structured questionnaire from 160 proportionately and randomly selected yam farmers. Data were analyzed using descriptive statistics such as mean, standard deviation, frequency distribution and percentages, as well as econometric tool of translog stochastic frontier production function. Results show that the mean age, level of education, farm size farming experience, extension contact, household size and anuual farm income were 48.2 years, 9.3 years, 1.02 hectares, 18.7 years, 0.53 visit, 8 persons and N431603 respectively. The mean technical, economic and allocative efficiencies were 72.12%, 67.55%, and 86.31% respectively. Yam farmers are allocative inefficient in resource utilization. The sources of allocative inefficiency were age, level of education, farming experience, farm size, marital status, extension contact, credit access, household size, and off-farm employment. Yam farmers should endeavor to properly allocate resource inputs to achieve improvement in allocative efficiency.

Keywords: Technical, Economic, Allocative, Efficiency, yam farmers, Ebonyi State

Introduction

Agriculture is the growth foundation of the Nigerian economy, and has remained the main driver of growth for some decades (World Bank, 2018). Agriculture holds the key to rural development, poverty alleviation and overall economic development (Egbuna, 2008; Oluwafemi, 2010). The sector accounted for about 33 – 45% of Gross Domestic Product (GDP) between the year 2010 and 2015(Central Bank of Nigeria (CBN), 2015). It also provided paid and self-employment for over 75% of the nation's population (Food and Agriculture Organization (FAO), 2014). The food crop sub-sector of which yam is one contributed about 29% to GDP (CBN, 2015).

Yams constitute a critical source of food and income and play a major role in the socio-cultural life of a varied range of farm households. Yam is a major source of energy in diet of Nigeria. It can be eaten when boiled, roasted, baked or fried. It can also be processed into crude flour by drying thin slices in the sun and then pound or ground into flour. Yam peels serve as feed for livestock and as a good component of organic manure. Yam also plays vital roles in traditional culture, rituals and religion, as well as local commerce of the producers (Izekor and Olumese, 2010). Although, Nigeria is a global leader in yam production, most of the yams produced are also consumed within Nigeria with little or no exportation at all. In Ebonyi State, yam production is of high economic benefit to the people due to amount of resources committed to its production and the proportion of their income which it represents. Resources are considered to be at its highest and best use when it is put into use with highest comparative advantage to other uses. The study of efficiency in agriculture is based on certain economic theories, which serve as the framework for this study. The production function stipulates the technical relationship between inputs and output in the production process (Ohajianya, 2006). The modern theory of efficiency identified two components of farm efficiency as technical and allocative efficiencies and the combination of these two components provides a measure of economic efficiency (Toluse and Sekumade, 2017).

Technical efficiency is based on expressing the maximum amount of output obtainable from given bundles of production resources with fixed technology. It is the attainment of production goods without wastage (Onyenweaku and Okoye, 2007). Allocative efficiency, the main issue in this study relates to the degree to which a farmer utilizes inputs in optimal proportions, given the observed input prices (Ogundari *et al*., 2006). According to Effiong and Idiong, 2008), economic efficiency occurs when a farmer chooses resources and enterprises in such a way as to attain economic optimum.

Measurement of farm efficiency via frontier approach has been widely utilized and studied. The term frontier involves the concept of maximality in which the function sets a limit to the range of possible observations (Reuben and Barau, 2012). The observations of points below the production frontier for farms producing below the maximum possible output can occur, but there cannot be any point above the production frontier given the available technology. Deviations from the frontier are attributed to inefficiency. Despite the importance of yams to the people of Ebonyi State, the research attention to its production with respect to allocative efficiency is still questionable. Most of the previous studies in Nigeria dwelt on resource use efficiency (Reuben and Barau, 2012; Toluwase and Sekumade, 2017), economic efficiency (Onyenweaku and Okoye, 2007; Ohajianya, 2006) profit efficiency (Ogundari, 2006; Tanko and Alidu, 2017), and technical efficiency (Izekor and Olumese, 2010; Amaza, 2000; Onyenweaku and Nwaru). There have been limited studies on efficiency of resource use in yam production in Ebonyi State. There have also been recent studies in Nigeria to assess the allocative efficiency of farmers (Toluwase and Sekumade, 2017; Rahman, 2002; Wadud and White, 2000; Tzonvelekas *et al*., 2001), and none of these studies analyzed allocative efficiency using translog stochastic frontier production function approach in Ebonyi State, the gap this study intends to fill, because allocative efficiency issues are some of the core elements of sustainable yam production activities. Yam farmers in Ebonyi State have little access to improved production resources, and the resultant effect is inefficient resource allocation and low productivity. Increasing productivity and allocative efficiency requires continued investments in resource to raise the production frontier. Inefficient allocation of resources can jeopardize food production, availability and its security. It is therefore imperative to know whether resources are allocative efficiently utilized in yam production in Ebonyi State. The aim of this study is to use translog stochastic frontier production function to analyze technical, economic and allocative efficiency of yam farmers in Ebonyi State, Nigeria. It is hypothesized that yam farmers in Ebonyi State are allocative inefficient in resource use.

Materials and Methods

This study was conducted in Ebonyi State of Nigeria. The State lies in the humid tropical agro-ecological zone of Nigeria within, latitudes 5^0 40^1 N and 6^0 45^1 N and Longitudes 7^0 30^1E and 8^0 30^1E (Ebonyi State Fadama III, 2012).

It has a land area of 5,935 km^2 with a projected population of 2,253, 140 persons in 2016 using a growth rate of 3.5% (National Population Commission (NPC), 2016).

The state shares boundaries on the North with Benue State, on the West by Enugu State, on the East by Cross River state and on the South with Imo State and Abia States (Ebonyi State Government, 2017). It is delineated into three agricultural zones of Ebonyi North, Ebonyi Central and Ebonyi South. There are 13 Local Government Areas (LGAs) in the State, namely; Abakaliki, Ebonyi, Ishielu, Ivo, Izii, Ikwo, Ohaukwu, Ezza North, Ezza South, Atikpo North, Afikpo South, Ohaozara and Onicha LGAs.

The climate of Ebonyi State is that of humid tropical climatic region, with two seasons which are rainy season between April and October, and dry season which is between November and March. The main occupation of the people are farming and trading. The state is a leading producer of rice, yam, potatoes, maize, beans and cassava. It also has several solid mineral resources and huge salt deposit at the Okposi and Uburu Salt lakes.

A multistage sampling technique was used to select sample. In the first stage, two LGAs were purposively selected from each agricultural zone to get six LGAs with the highest record of yam production in the state (Ebonyi State Agricultural Development Project, 2015). In the second stage two communities were randomly selected from each LGA to get 12 communities. In the third stage, the list of yam farmers in the selected communities was compiled with the assistance of field extension agents. From this sampling frame totaling 618, proportionate and simple random sampling techniques were used to select 160 yam farmers for the study. The data used for this study were essentially from primary sources. The data were collected through the use of well-structured questionnaire. The data collected were subjected to descriptive statistical analysis such as mean, standard deviation, frequency distribution and percentages. The translog Stochastic Frontier Production Function was used to estimate technical, economic and allocative efficiencies of yam farmers, while the determinants of allocative efficiency was ascertained using the Maximum Likelihood Estimates (MLE).

Analytical Framework of Efficiency Measures

Following the pioneering but independent work by Aigner *et al* (1977) serious consideration has been given to the possibility of estimating the frontier production, in an effort to bridge the gap between theory and empirical work. A stochastic frontier production function is defined by;

$Yi = f(X_i B_i) \exp (V_i U_i)$, I = 1,2 ….., n …………………..2.1

Where Y_i is output of the ith farm, X_i, is the vector of input quantities used by the i^{th} farm, B_i is a vector of unknown parameters to be estimated, $F(_i)$ represents an appropriate function (e.g,, Cobb-Douglas, Translog, etc), V_i is a random variable which is assumed to be $N(O, \sigma V^2)$ and independent of the U_i; which are non-negative random variables assumed to account for Technical efficiency in production. Allocative or price efficiency traditionally rests on an index of marginal product of opportunity costs. If among all inputs, the ratios of marginal factors to opportunity costs are equal to one, a firm is price or allocative efficient. This efficiency measure has to do with the extent to which farmers make efficient decision by using inputs up to the level at which their marginal contribution to production value is equal to the factor. If a firm is allocative inefficient, it operates off its least cost path (Ajanfi and Olayem i, 2001).

The allocative efficiency can be derived from the stochastic frontier cost function and thus defined by;

$C= F (W_i, Y_i, a) \exp e_i$, i = 1, 2,......,n.............................. 2.2

Where,

C = Minimum cost associated with yam production

W = vector of input prices

Y = yam output

a = vector of parameters

e = composite error term $(V_i – U_i)$

Applying Lemma Sheppard, we obtain.

$C/\delta P_i = X_i (W,Y,a)$..2.3

Substituting a firm's input prices and quantity of output in equation 2.3 yields the economically efficient input vector, X_i. With observed levels of outputs given, the corresponding technically and economically efficient cost of production will be equal to X_i, P and X_{ie}, respectively while actual operating input combination of the farm is X_iP. The three cost measures according to Okoye (2006) and Rahman and Yakubu (2005) can then be used to compute the technical efficiency (TE) and Economic Efficiency (EE) indices as follows:

$TE = (X_{ii}P)/ (X_iP)$ …………………………. 2.4

$EE = (X_{ie}P)/ (X_iP)$ ………………………… 2.5

The combinations of equation 2.4 and 2.5 are employed to obtain the allocative efficiency (AE) index which is consistent with Farrell (1957).

$AE = EE/TE = (X_{ie}P)/ (X_iP)$ ……………… 2.6

Allocative efficiency value, K ranges can be 1, less than 1 or greater than 1. The input is over utilized if $K < 1$, and underutilized if $K > 1$. Absolute allocative efficiency requires that $K = 1$ for all inputs.

In this study, the production technology of yam farmers in Ebonyi State Nigeria is specified by the translog stochastic frontier production function shown in equation 2.7

Estimation of Technical Efficiency

This was achieved using stochastic frontier production function for yam production. The functional form is specified as follows:

$$LnY_i = b_0 + b_1lnX_1 + b_2lnX_2 + b_3lnX_3 + b_4lnX_4 + b_5lnX_5 + b_6lnX_6 + b_7lnX_7 + ½b_8lnX_1^2 + ½b_9lnX_2^2 + ½b_{10}lnX_3^2 + ½b_{11}lnX_4^2 + ½b_{12}lnX_5^2 + ½b_{13}lnX_6^2 + ½b_{14}lnX_7^2 + b_{15}lnX_1lnX_2 + b_{16}lnX_1lnX_3 + b_{17}lnX_1lnX_4 + b_{18}lnX_1lnX_5 + b_{19}lnX_1lnX_6 + b_{20}lnX_1lnX_7 + b_{21}lnX_2lnX_3 + b_{22}lnX_2lnX_4 + b_{23}lnX_2lnX_5 + b_{24}lnX_2lnX_6 + b_{25}lnX_2lnX_7 + b_{26}lnX_3lnX_4 + b_{27}lnX_3lnX_5 + b_{28}lnX_3lnX_6 + b_{29}lnX_3lnX_7 + b_{30}lnX_4lnX_5 + b_{31}lnX_4lnX_6 + b_{32}lnX_4lnX_7 + b_{33}lnX_5lnX_6 + b_{34}lnX_5lnX_7 + b_{35}lnX_6lnX_7 + V_i - U_i \quad \ldots\ldots\ldots\ldots\ldots 2.7$$

Where,

Y_i = Yam output of the i^{th} farmer (tonne)

X_1 = Land area cultivated (Ha)

X_2 = Expenditure on yam seeds (₦)

X_3 = Labour input (Mandays)

X_4 = Expenditure on staking material (₦)

X_5 = quantity of chemical fertilizer (kg)

X_6 = Expenditure on organic manure (₦)

X_7 = Capital inputs (depreciation on implements in naira)

b_0 = Intercept

b_1 = b_{35} are parameters estimated, and

V_i and U_i are as earlier defined

Estimation of Economic Efficiency

Economic efficiency was measured using a translog stochastic frontier cost function specified as;

$$LnC = a_0 + a_1lnq_1 + a_2lnq_2 \; a_3lnq_3 + a_4lnq_4 + a_5lnq_5 + a_6lnq_6 + ½a_7lnq_1^2 + ½a_8lnq_2^2 + ½\,a_9lnq_3^2 + ½a_{10}lnq_4^2 + ½a_{11}lnq_5^2 + ½\,a_{12}lnq_6^2 + a_{13}lnq_1lnq_2 + a_{14}lnq_1lnq_3 + a_{15}lnq_1lnq_4 + a_{16}lnq_1lnq_5 + a_{17}lnq_1lnq_6 + a_{18}lnq_2lnq_3 + a_{19}lnq_2lnq_4 + a_{20}lnq_2lnq_5 + a_{21}lnq_2lnq_6 + a_{22}lnq_3lnq_4 + a_{23}lnq_3lnq_5 + a_{24}lnq_3lnq_6 + a_{25}lnq_4lnq_5 + a_{26}lnq_4lnq_6 + a_{27}lnq_5lnq_6 + V_i - U_i \quad \ldots\ldots\ldots\ldots\ldots 2.8$$

Where,
C_i = total input cost of the ith farmer (Naira/tonne)
q_1 = expenditure on yam seeds (Naira)
q_2 = expenditure on fertilizer in naira per kg
q_3 = average wage rate in naira per Manday
q_4 = expenditure on staking materials (Naira)
q_5 = Land rent in naira
q_6 = capital (depreciation on implements in naira)
a_0 = intercept
a_1 = a_{27} = parameters estimated
Vi = is error term not under the control of the farmers, while U_i is error term under the control of the farmers.

Estimation of Allocative Efficiency

The estimated individual economic efficiencies were divided by the estimated individual technical efficiencies of the farmers to derive the allocative efficiency indices for the individual farmers (Rahman and Yakubu, 2005). Mathematically, it is specified as follows;

$AE_i = EE_i/TE_i$ ……………………………………………… 2.9

AE_i = Allocative efficiency of i^{th} yam farmer
EE_i = Economic efficiency of i^{th} yam farmer
EE_i = Technical efficiency of i^{th} yam farmer

If the allocative efficiency value is one, the yam farmer is allocative efficient in resource use. If the allocative efficiency value is less than one, the yam farmer over utilizes resource inputs, while if the allocative efficiency value is greater than one, the yam farmer underutilizes the resource inputs.

The allocative efficiency scores of the individual farmers as derived were regressed against the farm specific factors to obtain the determinants of allocative efficiency following Kalirajam and Flinn (1991). The model is specified as follows;

$AE_i = b_0 + b_1Z_1 + b_2Z_2 + b_3Z_3 + b_4Z_4 + b_5Z_5 + b_6Z_6 + b_7Z_6 + b_7Z_7 + b_8Z_8 + b_9Z_9 + b_{10}Z_{10} + b_{11}Z_{11} + e_i$ …………………… 2.10

Where,
AE_i = allocative efficiency of the i^{th} farmer
Z_1 = age of the farmer (years)
Z_2 = level of education (years)
Z_3 = gender (dummy variable, 1 for male, zero for female)
Z_4 = farm experience (years)
Z_5 = farming size (Ha)
Z_6 = Marital status (Dummy variable, 1 for married, 0 for single)

Z_7 = extension contact (no. of visit)
Z_8 = credit access (dummy variable, 1 if farmer has access, zero if otherwise)
Z9= Cooperative membership (Dummy variable, 1 for member. 0 if otherwise)
Z_9 = household size (No. of persons)
X_{11} = Non-engagement in off-farm employment (dummy variable , 1 for non-engagement, 0 otherwise)
e_i = error term
b_0 = intercept
$b_1 – b_{11}$ = regression parameters estimated
The expectation is that b_2, b_3, b_4, b_5, b_6, b_7, b_8, b_9, b_{11} would be positive, while b_1, b_{10} would be negative.
The estimation was by the method of maximum likelihood using the computer programme LIMDEP (Coelli, 1996).
The hypothesis was tested using the results obtained for allocative efficiency of yam farmers in Ebonyi State.

RESULTS AND DISCUSSION

Average Characteristics of Yam Farmers

The average characteristics of yam farmers in the study area are presented in Table 1. The mean age

Table 1. Average Characteristics of Yam Farmers

Variable	Mean	Standard Deviation	Minimum	Maximum
Age (years)	48.2	16.3	26	72
Level of education (years)	9.3	2.4	0	13.4
Farming experience (years)	18.7	7.6	8.3	34.4
Household size (Number)	8	3	4	12
Farm size (Ha)	1.02	0.46	0.68	3.42
Extension contact (No. of visits)	0.53	0.13	0	2.04
Annual farm income (₦)	431603	182155	206549	671446
Labour (Mandays)	182.7	42.4	90.5	306.4

Source: Summarized from computed printout of results, 2018

of farmers was 48.2 years with standard deviation of 16.3 years. This implies that the farmers were within their productive age and can still engage efficiently in yam production. The mean level of education was 9.3 years with standard deviation of 2.4 years, which implies that most of the farmers attended at least primary school. The mean farm size was 1.02 hectares with standard deviation of 0.46 hectare. This implies that most of the farmers are smallholders. The mean extension contact was 0.53 visit, which implies that extension contact was very poor for the yam farmers.

Estimated Production Function and Technical Efficiency of Individual Yam Farmers

The maximum likelihood (ML) estimates of the Translog Stochastic Frontier Production parameters for yam farmers are presented in Table 2. The coefficients for land area cultivated, expenditure on yam seeds, labour, expenditure on staking materials, fertilizer, organic manure and capital have the desire positive signs and are statistically significant at 5% showing direct relationship with yam output. This finding on direct relationship is similar to those of Ogundari and Ojo (2007) on resource inputs on cassava farmers in Osun State, Idiong et al (2005) on rice farms in Niger Delta region, and Tanko and Olowogbayi (2007) in Niger State.

Among the second order terms, the coefficients of the square for land area cultivated ($1/2\ln X_1^2$), yam seeds ($1/2\ln X_2^2$), staking material ($1/2\ln X_4^2$), organic manure ($1/2\ln X_6^2$), and capital $1/2\ln X_7^2$), (and those of the interactions of land area cultivated and yam seeds ($\ln X_1 \ln X_6$), land area and capital ($\ln X_1 \ln X_7$), yam seeds and staking material ($\ln X_2 \ln X_4$), yam seeds and manure ($\ln X_2 \ln X_6$), yam seeds and capital ($\ln X_2 \ln X_7$), staking material and manure ($\ln X_4 \ln X_6$), staking material and capital ($\ln X_4 \ln X_7$), fertilizer and capital ($\ln X_5 \ln X_7$), and manure and capital ($\ln X_6 \ln X_7$) are positive and statistically significant at 5% showing direct relationship with yam output. The coefficients of all other second order terms are statistically insignificant at 5% level indicating no significant relationship with yam output. This finding on second order terms is consistent with those of Onyenweaku and Nwaru (2005) in food crop production in Imo State and those of Ohajianya et al (2007) in cocoyam production in Enugu State.

A statistical test was carried out to confirm that the translog function adequately represents the production rather than the Cobb-Douglas. For the production function to be Cobb-Douglas, the coefficients of all the second order terms should be zero (Onyenweaku and Okoye, 2007). The rejection of this hypothesis in the confirmation of the fact that the translog function is more suitable model specification for data than the Cobb-Douglas.

Table 2. Estimated Translog Stochastic Frontier Production Function for Yam Farmers' in Ebonyi State

Variable	Parameter	Estimate	t-ratio
Constant	b_0	11.068	7.1103***
Land area cultivated ($\ln x_1$)	b_1	0.2115	4.1062***
Yam seeds ($\ln x_2$)	b_2	0.0713	3.0715***
Labour ($\ln X_3$)	b_3	0.0882	2.1902*
Staking material ($\ln X_4$)	b_4	0.0914	2.2814*
Fertilizer ($\ln X_5$)	b_5	0.0568	3.1887***
Organic manure ($\ln X_6$)	b_6	0.0343	3.0426***
Capital ($\ln X_7$)	b_7	0.0692	3.3097***
½ $\ln X_1^2$	b_8	0.0413	3.1604***
½ $\ln X_2^2$	b_9	0.0725	3.2753***
½ $\ln X_3^2$	b_{10}	0.0609	1.1602
½ $\ln X_4^2$	b_{11}	0.0704	3.0974***
½ $\ln X_5^2$	b_{12}	0.0922	1.5563
½ $\ln X_6^2$	b_{13}	0.0618	3.5414***
½ $\ln X_7^2$	b_{14}	0.0543	3.7473***
$\ln X_1 \ln X_2$	b_{15}	0.0928	3.6042***
$\ln X_1 \ln X_3$	b_{16}	0.0742	1.8133*
$\ln X_1 \ln X_4$	b_{17}	0.0446	3.5296***
$\ln X_1 \ln X_5$	b_{18}	0.0941	1.6134
$\ln X_1 \ln X_6$	b_{19}	0.0453	3.0555***
$\ln X_1 \ln X_7$	b_{20}	0.0826	3.1696***
$\ln X_2 \ln X_3$	b_{21}	0.0468	1.5149
$\ln X_2 \ln X_4$	b_{22}	0.0713	3.5445***
$\ln X_2 \ln X_5$	b_{23}	0.0836	1.8712*
$\ln X_2 \ln X_6$	b_{24}	0.0527	3.7034***
$\ln X_2 \ln X_7$	b_{25}	0.0488	3.5215***
$\ln X_3 \ln X_4$	b_{26}	0.0712	1.6022
$\ln X_3 \ln X_5$	b_{27}	0.0568	1.4917
$\ln X_3 \ln X_6$	b_{28}	0.0843	1.7025
$\ln X_3 \ln X_7$	b_{29}	0.0316	1.4902
$\ln X_4 \ln X_5$	b_{30}	0.0429	1.7133
$\ln X_4 \ln X_6$	b_{31}	0.0718	3.0642***
$\ln X_4 \ln X_7$	b_{32}	0.0659	3.4125***
$\ln X_5 \ln X_6$	b_{33}	0.0209	1.6882
$\ln X_5 \ln X_7$	b_{34}	0.0316	3.9214***
$\ln X_6 \ln X_7$	b_{35}	0.0812	4.0254***
Log Likelihood Function =		-107.4022	

Sigma Square (σ^2)	6.3921	4.3109***
Lambda (λ)	1.7206	4.2608***
Gamma (y)	0.7512	3.8215***

** = Significant at 5% level *** =1%, * = 10%

Source: Computed from survey data, 2018

The estimated variance (σ^2) is statistically significant at 1% indicating goodness of fit and the correctness of the specified distribution assumptions of the composite error term. Besides, the variance *of* the non-negative farm effects is a small proportion of the total variance of yam output. Gamma (y), derived as ($\lambda^2/1+\lambda^2$) is estimated at 0.7512 and it is statistically significant at 1% indicating that only 75.12% of the total variation in yam output is due to technical inefficiency.

The variance ratio parameter (λ)=($\lambda_u^2/\lambda^2 v$) is estimated at 1.7206 and it is statistically significant at 1% level, implying that variation in actual yam output from maximum yam output between yam farmers mainly arose from differences in farmer practices rather than random variability.

Technical Efficiency of Individual Yam farmers

The technical efficiency of individual yam farmers are presented in Table 3. The table shows that the individual technical efficiency indices range

Table 3. Frequency Distribution of Technical Efficiency of yam Farmers in Ebonyi State

Technical Efficiency Range (%)	Frequency	Relative Frequency
≤ 50	3	1.88
51 – 60	14	8.75
61 – 70	38	23.74
71 – 80	23	14.36
81 – 90	73	45.63
91 – 100	9	5.63
Total	160	100

Mean value	72.12%
Minimum value	47.29%
Maximum value	97.23%

Source: Estimated from survey data, 2008 between 47.29% and 97.23% with a mean of 72.12%. Result showed that about 98.12% of the farmers had a technical efficiency index of above 50%. The mean technical efficiency of 72.12% obtained in this study implies high level of technical efficiency in resource use and is consistent with the low variance of the farm effects in Ebonyi State. The mean technical efficiency of 72.12% obtained in this study compares favourably with the 81% obtained by Tanko and Olouogbayi (2009) for yam in Niger State, the 77% obtained by Idiong et al (2005) for rice in Niger Delta, Nigeira, the 88% obtained by Tanko (2003) for Arable crop production in Kebbi State of Nigeria, but is at variance with the results on technical efficiency of 57.00% obtained by Onyenweaku and Nwaru (2005) for food crops production in Imo State, Nigeria and the 93.00% obtained by Onyenweaku and Okoye (2007) for cocoyam in Anambra State, Nigeria.

Estimation of Economic Efficiency of Individual Yam Farmers

The Maximum Likelihood (ML) estimates of the Translog Stochastic frontier model for economic efficiency of yam farmers are presented in Table 4. All the coefficients have the expected theoretical signs. As is theoretically consistent, the coefficients of the expenditure on yam seeds, fertilizer, labour, staking material and land rent as well as capital are positively signed as expected and statistically significant at 1% level, implying a direct relationship with cost of yam production. Among the second order terms, the coefficients of the square for expenditure on fertilizer ($1/2\ln q_2^2$), expenditure on staking material ($1/2\ln q_4^2$), land rent ($1/2\ln q_5^2$) and capital ($1/2\ln q_6^2$), and those of the interactions of expenditure on yam seeds and expenditure on staking material ($1/2\ln q_1 \ln q_4$), expenditure on yam and land rent ($l/2\ln q_1 \ln q_5$), expenditure on yam seeds and capital ($1/2\ln q_1 \ln q_6$), expenditure on fertilizer and expenditure on staking material ($1/2\ln q_2 \ln q_4$), expenditure on fertilizer and land rent ($l/2\ln q_2 \ln q_5$), expenditure on fertilizer and capital ($1/2\ln q_2 \ln q_6$), expenditure on staking material and land rent ($1/2\ln q4\ln q5_5$), expenditure on staking material and capital ($1/2\ln q_4 \ln q_6$), and land rent and capital ($1/2\ln q_5 \ln q_6$), are positive and statistically significant at 1% level showing direct relationship with Total cost of yam production. The coefficients of all other second order terms are statistically insignificant at 5% level Indicating no significant relationship with Total cost of yam production.

A statistical test was performed to confirm that the translog model adequately represents the cost rather than the Cobb-Douglas. For the cost frontier to be Cobb-Douglas, the coefficients of all the second order terms should be zero. The rejection of this hypothesis in the Translog model is a confirmation of the fact that the translog model is more suitable for data and model specification than the Cobb-Douglas. The sigma square (σ^2) estimate was 7.1902 and it is significant at 1%level of probability. This result indicates a good fit and the correctness of the specified distributional assumption of the composite error term, the Gamma estimate was 0.6914 which was relatively high. Its value implies that only 69.14% of the total variation in Total Cost of yam production was as a result of economic inefficiency. The variance ratio parameter Lambda (λ) is estimated at 1.5216 and it is statistically significant at 1% level, implying that variation in actual total cost of yam production from maximum total cost of yam production between yam farmers mainly arose from differences in farmer practices rather than random variability.

Table 4. Estimated Translog Stochastic Cost Frontier for Yam Farmers in Ebonyi State

Variable	Parameter	Estimate	t-ratio
Constant Term	a_0	10,0391	8.2103***
Expenditure on yam seeds ($\ln q_1$)	a_1	0.0524	4.1116***
Expenditure on fertilizer ($\ln q_2$)	a_2	0.0618	3.6526***
Wage rate ($\ln X_3$)	a_3	0.0664	2.9412**
Expenditure on staking material ($\ln X_4$)	a_4	0.0732	3.8703***
Land rent ($\ln q_5$)	a_5	0.0714	4.0432***
Capital ($\ln q_6$)	a_6	0.0891	4.1256***
½ $\ln q_1^2$	a_7	0.0526	1.5902
½ $\ln q_2^2$	a_8	0.0413	3.0644***
½ $\ln q_3^2$	a_9	0.0609	1.6529
½ $\ln q_4^2$	a_{10}	0.0392	3.4813***
½ $\ln q_5^2$	a_{11}	0.0618	3.0992***
½ $\ln q_6^2$	a_{12}	0.0592	3.5216***
½ $\ln q_7^2$	a_{13}	0.0443	1.5926
$\ln q_1 \ln q_2$	a_{14}	0.0609	1.6836
$\ln q_1 \ln q_3$	a_{15}	0.0843	3.0544***
$\ln q_1 \ln q_5$	a_{16}	0.0743	4.0943***
$\ln q_1 \ln q_6$	a_{17}	0.0629	3.7126***
$\ln q_2 \ln q_3$	a_{18}	0.0254	1.6112
$\ln q_2 \ln q_4$	a_{19}	0.0392	3.0942***
$\ln q_2 \ln q_5$	a_{20}	0.0538	4.6591***
$\ln q_2 \ln q_6$	a_{21}	0.0339	3.6033***
$\ln q_3 \ln q_4$	a_{22}	0.0428	1.5216
$\ln q_3 \ln q_5$	a_{23}	0.0713	1.9033*
$\ln q_3 \ln q_6$	a_{24}	0.0644	1.3042
$\ln q_4 \ln q_5$	a_{25}	0.0839	3.8429***
$\ln q_4 \ln q_6$	a_{26}	0.0653	4.1344***

$\ln q_5 \ln q_6$	a_{27}	0.0716	3.7102***
Log Likelihood Function =		-108.4126	
Sigma Square (σ^2)		7.1902	4.1155***
Lambda (λ)		1.5216	4.1033***
Gamma (y)		0.6914	3.9618***

** = Significant at 5% level * = 10% *** = 1%

Source: Computed from survey data, 2018

Economic Efficiency of Individual Farmers.

The estimated economic efficiency of individual farmers is presented in Table 5. The table shows that individual economic efficiency indices

Table 5. Frequency Distribution of Economic Efficiency of Yam Farmers in Ebonyi State.

Economic Efficiency Range (%)	Frequency	Relative Frequency
≤ 50	5	3.13
51 – 60	36	22.50
61 – 70	72	45.00
71 – 80	12	7.50
81 – 90	28	17.50
91 – 100	7	4.37
Total	160	100

Mean value 67.55%
Minimum value 37.13%
Maximum value 97.04%

Source: Estimated from survey data, 2018

ranged between 37.13% and 97.04% with a mean of 67.55%. About 96.87% of the farmers had an economic efficiency index of above 50.00%. The mean economic efficiency of the yam farmers is 67.55% which is an indication of moderate economic efficiency in resource use by the yam farmers. Also there exists a wide variation between the efficiency of best economically efficient farmer and that of the average farmer. This type of wide variation in farmer specific efficiency levels is a common phenomenon in developing countries (Amaza, 2000).

This result further shows that the average best farmer from the sample would require a cost saving of (1-0.67/0.68) x 100 which equals 29.88% to become the best economically efficient farmer in the sample while the worst farmer in the sample would need a cost saving of (1-0.37/0.97)x100 which equals 61.23% to become the best economically efficient farmer in the sample. The results however are in line with those of Ohajinya (2006) who found that the economic efficiencies of poultry farmers in Imo State, Nigeria differs substantially ranging between 16.00% and 89.00% with a mean economic efficiency of 43.00%; those of Effiong and Idiong (2008) who found that the economic efficiencies of rabbit farmers in Akwa Ibom State, Nigeria differs substantially ranging between 14.00% and 91.00% with a mean economic efficiency of 67.00%, and those of Onu *et al.*, (2000) who found that the economic efficiencies of cotton farmers in Nigeria differs substantially ranging between 7.00% and 85.00% with a mean of 41.00%.

Estimation of Allocative Efficiency

The estimated allocative efficiency of individual farmers is presented in Table 6. The table shows that the individual allocative efficiency indices range between 46.28% and 99.97% with a mean of 86.31%. Results also show that about 98.75% of the farmers had an allocative efficiency index of above 50.00%. Thus result on overall allocative efficiency of yam farmers implies that the yam farmers are allocative inefficient in resource utilization since the overall allocative efficiency index was less than 1.00.or 100%.

Table 6. Frequency Distribution of Allocative Efficiency of Yam Farmers in Ebonyi State

Economic Efficiency Range (%)	Frequency	Relative Frequency
≤ 50	2	1.25
51 – 60	3	1.88
61 – 70	9	5.63
71 – 80	29	18.13
81 – 90	36	22.50
91 – 100	81	50.61
Total	160	100

Mean value 86.31%
Minimum value 45.37%
Maximum value 98.58%

Source: Estimated from survey data, 2018

Therefore, hypothesis 1 which states that yam farmers in Ebonyi State are allocative inefficient in resource use is hereby accepted. This result means that there is a probability to increase farmers gross revenue by allocating resources properly. The result is similar to those of Ohajianya et al (2007) who found that the allocative efficiency of cocoyam farmers in EnuguState of Nigeria ranged between 34% and 92% with a mean of 67% and those of Ogundari (2009) who found that the allocative efficiency of upland rice farmers in their study ranged between 38% and 91% with a mean of 63%.

Determinants of Allocative Efficiency

The estimated determinants of Allocative Efficiency among yam farmers in Ebonyi State is presented in Table 7. The coefficients of education (Z_2), experience (Z_4), farm size (Z_5), marital status (Z_6), extension (Z_7), credit (Z_8), and employment (Z_{11}) are positive and significant at 1% level of probability, indicating a direct relationship with allocative efficiency, while the coefficients of age (Z_1) and household size (Z_{10}) are negative and significant at 1% level of probability, indicating an inverse relationship with allocative efficiency. The findings on direct relationship agrees with those of Ohajianya et al (2007) for cocoyam production in Enugu State, and Ogunadri (2006) for rice production systems in Nigeria, while the findings on inverse relationship is consistent with those of Awoke (2002) for multiple cropping system in Ebony State, and Eze (2003) for cocoyam production in Enugu State of Nigeria. The coefficients of gender (Z_3) and cooperative (Z_9) are not significant at 1% level of probability, indicating non-significant relationship with allocative efficiency. The coefficient of age (Z_1) was negative and significant, implying that the older the farmer becomes the less his allocative efficiency in yam production. The coefficient of education (Z_2) is positive and significant, implying that higher education leads to improvements in allocative efficiency of yam farmers.

Table 7. Maximum Likelihood Estimates of the Determinants in Ebonyi State

Variable	Parameter	Estimate	t-ratio
Constant Term	b_0	10.0026	8.5412***
Age (Z_1)	b_1	-3.0422	4.0926***
Education (Z_2)	b_2	0.2918	3.5813***
Gender (Z_3)	b_3	0.0342	1.5318
Experience (Z_4)	b_4	2.3116	3.1744***
Farm size (Z_5)	b_5	1.9038	3.0724***
Marital status (Z_6)	b_6	0.7314	3.1165***
Extension (Z_7)	b_7	0.0655	4.261***
Credit (Z_8)	b_8	0.0429	3.9413***
Cooperative (Z_9)	b_9	0.0738	1.6039
Household size (Z_{10})	b_{10}	0.8312	-4.914***
Employment (Z_{11})	b_{11}	0.0539	2.9813***

** = Significant at 5% level, *** 1 % * =10%
Source: Computed from survey data, 2018

The coefficient of farming experience (Z_4) was positive and significant at1%, implying that increases in farming experience leads to improvements in allocative efficiency in yam production. The coefficient of farm size (Z_5) was positive and significant at1%, indicating that large farm sizes result to allocative efficiency of yam farmers. The coefficient of marital status (Z_6) was positive and significant at1%, implying that married yam farmers have more commitments and responsibility which lead to improvement in their allocative efficiency. The coefficient of extension contact (Z_7) was positive and significant, indicating that increase in number of extension visits leads to improvement in allocative efficiency of yam farmers. The coefficient of credit access (Z_8) was positive and significant, indicating that access to production credit leads to improvement in allocative efficiency of yam farmers. The coefficient of household size (Z_{10}) was negative and significant at1%, implying that increase in household size leads to reduction in allocative efficiency of yam farmers. The coefficient of off-farm employment (Z_{11}) was positive and significant, suggesting that non-engagement in off-farm employment leads to marked improvement in allocative efficiency of yam farmers.

CONCLUSION AND RECOMMENDATIONS

The study estimated technical, economic and allocative efficiencies of yam farmers in Ebonyi State of Nigeria using the Translog stochastic Frontier Production Function. The yam farmers are majorly smallholders. The farmers had high level of technical efficiency and moderate level of economic efficiency in resource use. The yam farmers are allocative inefficient in resource utilization. Sources of allocative inefficiency were age, level of education, farming experience, farm size, marital status, extension contact, credit access, household size and off farm employment.

Yam farmers are encouraged to properly allocate the resources of land, yam seeds, labour, staking material, fertilizer, organic manure, and capital to achieve improvements in allocative efficiency since overall allocative efficiency index showed allocative inefficiency.

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