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Technical efficiency analysis of yam production in Edo state: A stochastic frontier approach

S.I. Orewa [1], O.B. Izekor [*2]

[1] *Department of Agriculture, Benson Idahosa University, Benin City, Nigeria*
[2] *Department of Agricultural Economics and Extension Services, University of Benin, Benin*

Abstract

The technical efficiency of yam farmers in Edo State was analysed in this study using the Stochastic Frontier Production Model. A multistage sampling technique was employed to select the 180 yam farmers used for the study. A set of questionnaire was used to collect data from the respondents. Data collected were analysed using descriptive statistics and stochastic frontier production function. The result of the study revealed that the technical efficiency of the farmers range from 0.001 – 96.50% with a mean of 69.32%. This indicates ample opportunity for the farmers to increase their productivity through improvement in their technical efficiency. Farm size, yam sett, fertilizer and labour were found to be statistically significant and positively related to farmers output while educational level, household size and farming experience of the respondents negatively influenced farmers' technical inefficiency. The farmers therefore need to increase their output through more intensive use of land, yam sett and fertilizer input.

Keywords: Technical efficiency, Stochastic frontier production function, Yam production

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[*] Corresponding author. *E-mail address:* ododoizekor@ yahoo.com

1. Introduction

Yam is an important food crop produced in Nigeria. The crop is grown throughout Africa with West Africa producing over 90% of the total world production of yam (Hahn et al., 1993). Nigeria is the world largest producer of yam. It contributed over 65% of the world production in 2008 (FAO, 2010). The nation's yam production is estimated at about 38.92 million metric million tonnes annually (FAO, 2008). The crop constitutes a major staple food for the Nigerian population contributing about 20% of the daily calorie intake of the people (Nweke et al., 1991). Despite this, there has been a decline in yam production in Nigeria over the years (IITA, 2002) with the area under cultivation and total yam output declining (IITA, 2002 and Ayanwuyi, 2011). Previous studies carried out on food crop production in Nigeria have shown that food crop farmers have low productivity because of inefficiency in resource use (Idiong et al., 2002). It is believed that inefficiency in the use of resources, wrong choice of enterprise combination and cropping system constitute the major constraint to increased food production in Nigeria (Okorji and Obiechina, 1985).

The modern theory of efficiency dates back to the pioneering work of Farrell (1957), who proposed that the efficiency of a firm consist of technical and allocative component and the combination of these two components provides a means of economic efficiency. Technical efficiency as used in this study means a farmers success in producing maximum output from a given set of inputs. An important assumption relating to efficiency measurement is that firms operating on the outer bound production function that is on the efficiency frontier are said to be technically efficient while firms that fail to operate on the outer bound production function are technically inefficient. Productivity is reduced in the presence of technical inefficiency whereas the more efficient the firm, the higher its productivity, ceteris paribus (Kumbhakar, 2004). One way farmers can raise productivity is improving the efficiency within the limit of the existing resource base and technology (Udoh, 2005). Boosting yam production could lead to an improvement in the food production level of the nation. This however, requires that resources be use efficiently since efficiency in the use of the production input is essential for optimum farm production. To achieve efficient resource use in yam production a sound knowledge of this is required. Therefore, there is the need to assess the level of efficiency of resources used in agricultural production in general and yam production in particular. This study specifically seeks to estimate the technical efficiency of yam farmers in Edo State and the factors that determine their levels of efficiency in the production. It is expected that the finding would help in providing information and solution to the declining productivity and yield of yam per hectare thereby leading to improvement in yam production.

2. Material and methods

2.1. Study area

The study area for this study is Edo State. The State lies roughly between longitude 06^0 04^I E and 06^0 43^IE and latitude 05^0 44^IN and $07^0 34^I$N. It is bound in the south by Delta State, in the West by Ondo State, in the North by Kogi State and in the East by Kogi and Anambra States.

2.2. Sampling procedure

A multistage sampling technique was employed in selecting 180 respondents used for the study. Firstly, the study area was stratified based on the Edo State Agricultural Development Programme delineation that is Edo South, Edo Central and Edo North agro - ecological zones, so as to get a State wide coverage.

The second stage involved the random selection of two (2) local government areas (LGAs) from each of the agro ecological zones. The selected LGAs were Orhiomwon and Uhunmwonde for Edo South, Esan West and Esan South East for Edo Central, Owan East and Estako West for Edo North. The third stage involved the random selection of three villages from each LGA while the last stage involved the selection of ten (10) yam farmers from each village using simple random sampling technique.

2.3. Analytical technique

Simple descriptive statistics such as percentage and frequency distribution were used to describe the socio economic characteristics of the respondents.

The Stochastic Frontier Production function using the Cobb –Douglas functional form was used to analyze the technical efficiency of yam farmers in the study area. This function have been employed in other studies to determine technical efficiency of agricultural production (Bakhsh et al., 2006; Erhabor and Emokaro, 2007; Binuomota et al., 2008).

The production function model is explicitly specified as:

$$\ln Yi = b_0 + b_1 \ln X_{1i} + b_2 \ln X_{2i} + b_3 \ln X_{3i} + b_4 \ln X_{4i} + b_5 \ln X_{5i} + \varepsilon_i \qquad (1)$$

where,

ln = Natural logarithm

Y = Quantity of yam produced (Kg)

X_1 = Farm Size (Ha)

X_2 = Yam Sett/Seed (Kg)

X_3 = Labour (Man days)

X_4 = Quantity of Fertilizer used (Kg)

X_5 = Quantity of Agro Chemicals used (Litres)

b_0 - b_5 = Parameters to be estimated (Regression coefficients)

ε_i = Composite error term defined as $V_i - U_i$

V_i = Random variables which are assumed to be independent of U_i, identical and normally distributed with zero mean and constant variance N $(0, S_v^2)$.

U_i = Non – negative random variables which are assumed to account for the technical inefficiency in production and are often assumed to be independent of V_i such that U_i is the non negative truncated normal distribution.

The inefficiency of production, U_i is modeled in terms of the factors that are assumed to affect the efficiency of production of the farmers. Some of the factors related to the socio-economic characteristics of the farmers. The determinant of technical inefficiency is defined by:

$$U_i = \delta_0 + \delta_1 Z_1 + \delta_2 Z_2 + \delta_3 Z_3 + \delta_4 Z_4 + \varepsilon_i \quad (2)$$

where:

U_i = technical inefficiency

Z_1 = Age (Years)

Z_2 = Educational Level (Years)

Z_3 = Farming experience (Years)

Z_4 = Household size (number)

ε_i = Error term

δ_0 - δ_4 = parameters to be estimated

The sigma square (σ_s^2) which indicates the goodness of fit of the model used and the correctness of the distributional assumption and the gamma (γ) which gives the proportion of the deviation of the output from the frontier due to technical inefficiency were also determined. The parameters of the Stochastic Frontier Production Function (SFPF) were obtained using the computer programme Frontier 4.1 by Coelli (1994).

3. Result and discusssion

3.1. Socio economic characteristics of respondents

The socio economic characteristics of the yam farmers in the study area are presented in table 1. The result revealed that yam production in the study area was dominated by males (83.33%) as against females with 16.67%. This result compares favourably with the findings of Ekunwe and Orewa (2007) who noted that 98.6% of yam farmers in Kogi State were males. Majority (55.0%) of the respondents were within the age group of 50 – 59 years old. The ages of farmers sampled ranged from 35 – 65 years with average age of 51 years. This implies that farmers in the study area were ageing. This finding corroborates that of Ajibefun and Abdulkadiri (1999) stating that small scale farmers in Nigeria are old and ageing. It further corroborates the findings of Ekunwe et al. (2008) that yam farmers in Delta and Kogi State are ageing with mean ages of 52years and 53 years respectively. The result also showed that most of the farmers (87.22%) were married while the others were single, separated or divorced. As regard household size, 45.56% of the respondents had five persons or below and 36.11% of respondents had between 6 – 8 persons per household. The household size ranged from 3 – 15 persons with an average of 6 persons per household indicating that yam

farmers in the study area had relatively low household size. This finding is closely supported by those of Ojo (2007) and Oluwatusin (2011) that reported a mean household size of 8 persons and 7 persons per household for yam farmers in Ondo State and Osun States respectively.

On educational level of respondents, 45.56% of the respondents had secondary school education and 35.56% had primary education. This showed that the farmers were fairly educated people. The number of years of the respondents in farming ranged from 3years for the least experienced to 28years for the most experienced, with an average of 15years. About 31% of the respondents had farming experience of 5 – 10 years and 28.89% had 11 – 15 years of experience. This shows that yam farmers in the study area were relatively experienced implying a significant level of specialization and expertise in yam production. This compares favourably with the findings of Oluwatusin (2011) that indicated a farming experience of 14 years for yam farmers in Osun State.

3.2. Estimated OLS and MLE

The estimated result of the ordinary least square (OLS) and the maximum likelihood estimate (MLE) of the production function parameter for yam production in Edo State is presented in table 2. The sigma square (σ_s^2) value of 2.910 which was positive and significantly different from zero indicated a good fit and the correctness of the distributional assumption specified. The variance ratio (γ) which measures the effect of technical inefficiency on the observed output gave a value of 0.990. This implies that 99% of the variation in the output of yam was attributed to technical inefficiency. The ratio of the log likelihood test was also significant, implying the major presence of technical inefficiency among the farmers.

The maximum likelihood coefficient for farm size (0.495), yam sett (0.540), fertilizer (0.040) and labour (0.367) were also positive and statistically significant. This suggests that more output of yam would be obtained from the use of additional quantities of these variables, *ceteris paribus.* The significance of these variables could be attributed to their importance in crop production in the sense that a shortage would have direct negative effect on production. This is in line with the findings of Shehu et al. (2010) who reported that the coefficients of land resource, seed yam, labour and fertilizer were positive and significantly influenced changes in yam output in Benue State.

However for the OLS function, only the coefficients for yam sett and farm size were positive and statistically significant at 1% and 5% level respectively.

3.3. Determinants of technical inefficiency

The inefficiency variables were specified as those relating to farmers' socio-economic characteristics. The results of the analysis of the determinants of technical inefficiency are presented in table 3. The estimated coefficient of the inefficient function provides some explanation for the relative efficiency levels among individual farmers. Since the dependent variable of the function represents inefficiency, a positive sign of an estimated parameter implies that the associated variable has a negative effect on efficiency and a negative sign indicates the reverse.

The coefficient for educational level of respondents (-0.284) was negative and significantly related to technical inefficiency at 1% level of significance. This implies that farmers with more years of education tend to be more technically efficient in yam production. The reason may be that educated farmers are more receptive to improved farming techniques. This result agreed with the findings of Pius and Odjuvwuederhie (2006), Ekunwe et al. (2008), Ojo et al. (2009), Shehu et al. (2010) and Oluwatusin (2011). The result asserted that more years of formal education is imperative to better understanding and adoption of new technology. Furthermore, educated farmers are expected to be more receptive to improved farming techniques and therefore should have higher level of technical efficiency than farmers with less education (Ajibefun and Aderinola, 2003).

Household size coefficient was negative and statistically significant implying that it has the effect of reducing the farmers' technical inefficiency. This result corroborates the finding of Shehu et al. (2010) that observed a negative relationship between household size and yam farmers' technical inefficiency in Benue State and Oluwatusin (2011) for yam farmers in Osun State explaining that more adult persons in the household meant more quality labour would be available for carrying out farm activities.

Farming experience (0.294) was found to be statistically significant and also contributed negatively to farmers' inefficiency. This implies that as the yam farmers' years of experience increases their efficiency also increases. This result is in line with the conclusion of Oluwatusin (2011) for yam farmers in Osun State, that with increased years of experience, farmers become more specialised.

3.4. Yam farmers technical efficiency indices

The estimated technical efficiency (TE) indices of the yam farmers in the study area are presented in table 4. It showed that the technical efficiency levels of the sampled farmers were less than one (100%) implying that all the yam farmers in the study area were producing below the maximum efficiency level. The distribution showed a high technical efficiency variation among the respondents. The technical efficiency indices of the respondents ranged from 0.001 to 0.9570 with a mean of 0.6932.

The average technical efficiency index of 0.6932 suggest that an average yam farmer in the area still has the capacity to increase technical efficiency in yam production by additional 31% to achieve the maximum possible level and by 27% from the 'best' practice farmer in the study area. It therefore shows that there is efficiency gap but with scope for improvement in yam production among yam farmers in the study area. These results compare favourably with the findings of Ekunwe and Orewa (2007), Ekunwe et al. (2008), Ojo et al. (2009) and Shehu et al. (2010) that observed efficiency gap from the optimum efficiency level among yam farmers in Nigeria and with scope for increased efficiency.

Table 1. Socio-economic characteristics of respondents

Characteristics		Frequency	Percentage
I.	**Sex**		
	Male	150	83.33
	Female	30	16.67
II.	**Age**		
	30 – 39	13	7.22
	40 – 49	59	32.78
	50 – 59	99	55.00
	≥ 60	9	5.00
III.	**Marital Status**		
	Single	1	0.56
	Married	157	87.22
	Seperated	16	8.89
	Divorced	6	3.33
IV.	**Household Size**		
	≤ 5	82	45.56
	6 – 8	65	36.11
	9 – 12	27	15.00
	>12	6	13.00
V.	**Educational Level**		
	No Formal Education	28	15.56
	Primary	64	35.56
	Secondary	82	45.56
	Tertiary	6	3.33
VI.	**Farming Experience**		
	< 5	6	3.33
	5– 10	55	30.56
	11 – 15	52	28.89
	16 – 20	30	16.67
	21 – 25	10	5.56
	>25	27	15.00

4. Conclusion

The study estimated the technical efficiency of yam farmers in Edo State. Result from the study indicated that the production input which could lead to increased production of yam are farmland expansion, increased use of yam sett, fertilizer and labour. Educational level of respondents, household size and farming experience were the socio economic characteristics that had significant and negative effect on the farmers' technical

inefficiency. None of the sampled respondents operated at the maximum efficiency level indicating that there was efficiency gap hence there is still scope for improvement in yam production in Edo State.

Increase productivity and improvement in their technical efficiency can be achieved by addressing the factors responsible for the inefficiency. These include a more intensive use of land, increased use of yam sett and fertilizer input given the prevailing state of technology. The farmers should be encouraged to increase their yam production by making available improved and disease free varieties of yam sett at affordable price. Education was found to have a significant effect on the efficiency of the farmers; therefore government should also assist by improving the educational status of the farmers through adult education and literacy campaigns. Farmers should also be encouraged to register with adult/continuing education centres to improve on their education.

Table 2. The Ordinary Least Square (OLS) and Maximum Likelihood Estimate (MLE) For Yam Production in Edo State

Variable	Parameter	OLS	MLE
Constant	b_o	4.564 [2.451]	1.363 [1.754]
Farm Size (Ha)	b_1	0.783 [2.306]**	0.495 [3.599]*
Yam sett (Kg)	b_2	0.478 [3.528]*	0.540 [8.254]*
Labour (Man day)	b_3	0.061 [0.390]	0.367 [6.698]*
Fertilizer (Kg)	b_4	0.056 [1.141]	0.04 [2.221]**
Agro chemical (Litres)	b_5	0.057 [0.492]	0.008 [0.193]
Sigma Square	σ_s^2		2.910 [8.517]*
Gamma	γ		0.990 [120.175]*
Log likelihood ratio			31.614

Figures in parentheses are t-ratios

** Estimate is significant at 1% level of significance*

*** Estimates is significant at 5% level of significance*

Table 3. Inefficiency parameters of yam farmers in Edo State

Variable	Parameter	Coefficient	t-value
Constant	z_0	-2.291	-1.93
Age	z_1	0.009	0.293
Educational Level	z_2	-0.284	-3.555*
Farming Experience	z_3	-0.294	-5.917*
Household Size	z_4	-0.33	-2.876*

** Estimate is signifcant at 1% level of significance*

Table 4. Distribution of technical efficiency indices among yam farmers in study area

Technical Efficiency Range	No.	%
0.00 – 0.10	2	1.11
0.11 - 0.20	2	1.11
0.21 - 0.30	3	1.67
0.31- 0.40	7	3.89
0.41 - 0.50	10	5.56
0.51 - 0.60	30	16.67
0.61 - 0.70	32	17.78
0.71 - 0.80	30	16.67
0.81 - 0.90	55	30.56
0.91 - 1.00	9	5.00
Total	**60**	**100**
Mean Efficiency	**0.6932**	
Maximum	**0.965**	
Minimum	**0.001**	

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