Estimating Farm Level Technical Efficiency and Elasticity of Production among Smallholder Yam Farmers in Oriire Local Government Area, Oyo State, Nigeria

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Abstract

This study broadly examined the profitability of yam production in Oriire Local Government Area of Ogbomoso Oyo state. A Multi Stage Random Sampling Technique was used to select 110 yam farmers in the Local Government Area. Out of the one hundred and ten (110) cassava-based farmers sampled using random sampling technique during 2018/2019 cropping season, only eighty (80) of them provided all the information needed for the data analysis. The study specifically described the socio-economic characteristics of the smallholder yam farmers in the study area; and analyzed the technical efficiency of the smallholder yam farmers in the study area. The study employed Descriptive Statistics (such as frequency counts and percentages) and Inferential Statistical Model (such as Stochastic Frontier Approach). In the preferred model (model 2), the significant variables include: quantity of yam sett, farm size, agrochemicals and labour quantity and were all directly related to the yam output. All the significant variables such as quantity of yam sett, farm size, agrochemicals and labour quantity have positive signs indicating that they greatly impact positively on yam output of smallholder farmer in the study area. For the estimated elasticities of the explanatory variables of the preferred model (Model 2), quantity of yam sett, farm size, agrochemicals and labour quantity were all positive (increasing) to yam output indicating that the use and allocation of these variables was profitable and as such a unit increase in these inputs will eventually result in an increase in the yam output of the smallholder farmers in the study area. For the decile range of the frequency distribution of the TE, 87.50% of the smallholder yam farmers had TE of over 70 % and 11.25% of them had TE ranging between 51 % and 70 %. The predicted yam farm specific technical efficiency (TE) for the smallholder yam farmers' indices ranged from a minimum of 45.11% to a maximum of 97.50% for the farms, with a mean of 88.43%. The estimated sigma square (σ^2) of the smallholder yam farmers is 0.1730 and highly significant at 1% level of significance. The estimated gamma (γ) parameter of the smallholder yam farmers is 0.2153 and is not significant at level of significance. The most technically inefficient smallholder yam farmer has an untapped ability to realize a cost-saving of about 53.73%. The Return to Scale shows that the RTS for the smallholder yam farmers is 1.2379 in the study area. Thus, the smallholder yam farmers in the study area are experiencing increasing returns to scale and are operating in the irrational zone of production (stage 1).

Keywords: Yams, Efficiency, Smallholder, Production

1.0 Introduction

Yams are the fifth most harvested crops in Nigeria, following after cassava, maize, guinea corn, and beans/cowpeas. Moreso, after cassava, yams are the most commonly harvested tuber crops in this country. Yams do not only serve as the main source of earnings and food consumption, but also as a major employer of labour in Nigeria. Despite the importance of yams to people, the attention to its production with regards to its profitability is still low (National Bureau of Statistics, 2012; Verter and Bečvářová, 2014).

Yams are among major cash and most consumed food crops West African countries (GTZ, 1999) like Nigeria. Its cultivation is very profitable despite high costs of production and price fluctuations in the markets. An average profit per yam seed, after harvest and storage in Nigeria, was calculated at over US$13,000 per hectare harvested (National Bureau of Statistics, 2012; IITA, 2013). Households demand for yam consumption is very high in Sub-Saharan Africa. Nutritionally, yam is major staple food consumption, providing food for millions of people in the West Africa. It is eaten in different forms such as fufu (the so-called poundo yam and amala in Nigeria), boiled, fried and roasted (IITA, 2009). The role this tuber plays in the diet of smallholder farmers cannot be overemphasized, and they had contributed over 40% to the country's annual average of real GDP. Arguably, yam is the major sources of employment generation for family members in rural areas (National Bureau of Statistics, 2012).

Yams like many other crops in Nigeria are labour intensive. The high cost of labour has been among the major constraints to yam production. It has constrained smallholder yam farmers from enhancing productivity. Pests' related issues have also been identified as major constraints to yam production. These include parasitic nematodes; insects such as leaf and tuber beetles; fungi such as leaf spot, tuber rot, and other viruses (IITA, 2009; Kleih *et al*., 2012; Migap and Audu, 2012; Zaknayiba and Tanko, 2013).

The analysis of efficiency is generally associated with the possibility of farms producing a certain optimal level of output from a given level of resources or certain level of output at least cost. Thus, examining the concept of efficiency is a very important factor for productivity growth in any economy where resources are scarce and opportunities to use new technologies are limited. It is efficiency studies that will reveal the potential possibility to raise productivity in developing agriculture where resources are meagre by improving efficiency without necessarily developing new technologies or increasing the resource base.

Measuring technical efficiency at the farm level, identifying important factors associated with the efficient production systems would serve as a panacea to assessing potential for developing sustainable aquaculture (Kareem et al., 2008; Bifarin et al., 2010); and of all the types of efficiencies identified by Battese and Coelli (1995), Yao and Liu (1998), Ohajianya et. al, (2006), and Parikh et. al.,(1995), this work is focused on the technical efficiency. Technical efficiency refers to the ability of firms to employ the "best practice" in an industry so that not more than the necessary amount of a given set of inputs is used in producing the "best" level of output (Mijindadi, 1980; Onyenweaku and Nwaru, 2005; Ohajianya, 2006). This study therefore estimated the farm level technical efficiency and elasticity of production among smallholder yam farmers in Oriire Local Government Areas of Oyo State.

2.0 Methodology

The study was conducted in Oriire Local Government Area of Oyo State. The Local Government Area has a total land area of 2,040 km^2 with population of about 42,242 people. The study used a multi-stage random sampling technique. The first stage involved purposive selection of yam farmers in Oriire Local Government Areas in Oyo State. Of the 120 smallholder yam farmers were sampled, only 80 of them has the complete information suitable for data analysis, while the rest of the sampled farmers had issues with certain information needed for data analysis. The primary data collected for this study include socio-economic characteristics of the catfish farmers (such as age, gender, years of formal education or educational level, marital status, household size, years of experience in farming, among others). Input-output data of the smallholder yam farmers as pertained to the production season were also collected. Output data included quantity and values of yam output, market prices, while input data include quantity and cost of inputs.

The analytical techniques employed in this study include: the descriptive statistics, and stochastic frontier production model. The descriptive statistics was used to discuss the socio-economic characteristics of the smallholder yam farmers in the study area; and Stochastic Frontier Production Function (Cobb Douglas functional form) was used to analyze the technical efficiency and elasticity of production of the smallholder yam farmers in the study area. For the sake of this study, the stochastic frontier production functions in which Cobb-Douglas as

proposed by Battese and Coelli (1995) represents the best functional form of the production frontier and also as confirmed by Yao and Liu (1998) was applied in the data analysis in order to better estimate the efficiency of yam farmers.

The model of the stochastic frontier production for the estimation of the TE is specified as:

$$\ln Y_i = \beta_0 + \beta_1 \ln X_{1i} + \beta_2 \ln X_{2i} + \beta_3 \ln X_{3i} + \beta_4 \ln X_{4i} + V_i - U_i \quad \text{.....(1)}$$

Where subscript i refers to the observation of the ith farmer, and

Y = Output of yam tubers (Kg)

X_1 = Quantity of Yam Sett (Kg)

X_2 = Farm Size (Hectares)

X_3 = Labour quantity (Man day)

X_4 = Agrochemicals (Litres)

β_i's = the parameters to be estimated

ln's = natural logarithms

V_i = the two-sided, normally distributed random error

U_i = the one-sided inefficiency component with a half-normal distribution.

For this study, it is assumed that the technical inefficiency measured by the mode of the truncated normal distribution (i.e. U_i) is a function of socio-economic factors (Yao and Liu, 1998). Thus, the technical efficiency was simultaneously estimated with the determinants of technical inefficiency defined by:

$$U_i = \delta_0 + \delta_1 Z_{1i} + \delta_2 Z_{2i} + \delta_3 Z_{3i} + \delta_4 Z_{4i} + \delta_5 Z_{5i} \quad \text{.....} \quad (2)$$

Where:

U_i = technical inefficiency of the ith farmer

Z_1 = Age of farmer (years)

Z_2 = Marital status

Z_3 = Educational level

Z_4 =Family size

Z_5 = Farming experience

The above equation was used to examine the influence of some of the smallholder farmers' socio-economic variables on their technical efficiency. Therefore, the socio-economic variables in equation above were included in the model to indicate their possible influence on the technical efficiencies of the smallholder yam farmers. In the presentation of estimates for the parameters of the above frontier production, two basic models were considered. Model 1 is the traditional response function in which the inefficiency effects (U_i) are not present. It is a special case of the stochastic frontier production function model in which the parameter $\gamma = 0$. Model 2 is the general frontier model where there is no restriction in which γ, $\sigma^2 s$ are present. The estimates of the stochastic frontier production function were appraised using the generalized likelihood ratio test, and the T-ratio for significant econometric relevance.

3.0 Results and Discussions

3.1 Socio-economic characteristics of respondents

Village: 22.50% of the respondents were from Tewure; 13.75% of the respondents were from Iluju; 12.50% of the respondents were from Saamo; 11.25% of the respondents were from Ladokun; 17.50% of the respondents were from Alaroponla; and 22.50% of the respondents were from Ikoyiile.

Age of respondents: 5% of the respondents were about 30years of age; 82.5% of them were between the age range of 31-60 years; and the rest 12.5% of them were more than 60years of age.

Sex of respondents: 85% of male and 15% of female, which deduced that the production and yam farming in this area are mostly practiced by men in the study area.

Marital status of respondents: 85% of them were married; 10% of them were single; 2.5% of them were widowed and divorced respectively.

Household size of the respondents: 37.5% of the respondents had a household size of about 5 members; 52.5% of them had a household size of between 6 – 10 members; and 10% of them had a household size of more than 10 members.

Educational level of the respondents: 33.75% of the respondents had no formal education; 30% of them had primary education; 20% of them had secondary education; 13.75% of them had tertiary education, while the rest just 2% has adult education.

Years of Farming Experience: 28.75% of the respondents had about of 10years of farming experience; 32.50% of them had between 11-20 years of farming experience; and the rest 38.75% of them had more than 20years of farming experience.

Farm size: 77.5% of the respondents cultivated about 5hectares of land, while the rest 22.5% of them cultivated between 6-10 hectares of land. This suggest that majority of the respondents were small scale farmers.

Mode of Land Acquisition by the respondents: 68.75% of the respondents inherited the lands used for farming; 16.25% of them rented the land used for farming; 6.25% of them were leased the land being used for farming; 5% of them were given the land being used for farming as gift; 2.50% of them purchased the land being used for farming, and the rest 1.25 % of them acquired their farmland through other means.

Challenges of yam production: 80% of the respondents are been faced with financial challenges for their production; 73.75 are faced with a problem of shortage of labour; 23.75% of them faced the problem of lack of processing equipment; 56.25% of them are affected by the fluctuating in the market price of yam produce.

Table 1: Socio-Economics Characteristics of Smallholder Yam Famers In Oriire L.G.A, Oyo State

Variables	Frequency	Percentage
Village		
Tewure	18	22.50
Iluju	11	13.75
Saamo	10	12.50
Ladokun	9	11.25
Alaroponla	14	17.50
Ikoyiile	18	22.50
Total	80	100
Age		
20-30	7	8.75
31- 40	26	32.50
41- 50	27	33.75
51- 60	16	20.00
> 60	4	5.00
Total	80	100
Sex		
Male	61	85.00
Female	19	15.00
Total	80	100
Marital Status		
Single	8	10.00
Married	68	85.00
Divorced	2	2.50
Widower	2	2.50
Total	80	100
Household Size		
≤ 5	30	37.50
6-10	42	52.50
≥11	8	10.00
Total	80	100
Educational Level		
Non-formal	27	33.75
Adult education	11	13.75
Primary	24	30.00
Secondary	16	20.00
Tertiary	2	2.50
Total	80	100

Years of Farming Experience		
≤ 10	23	28.75
11- 20	26	32.50
≥21	31	38.75
Total	80	100
Farm Size		
≤ 5	62	77.50
6 – 10	18	22.50
Total	80	100
Mode of Land Acquisition		
Purchase	2	2.50
Rent	15	16.25
Lease	5	6.25
Inheritance	55	68.75
Gift	5	6.25
Total	80	100

Constraints	**Yes**		**No**	
Financial Constraint	64	80.00	16	20.00
Shortage of labour	59	73.75	21	26.25
Lack of processing equipment	19	23.75	59	73.75
Fluctuating market price	44	56.25	35	43.75
Total	80	100		

Source field Survey, 2018

3.2 The Result of the Stochastic Frontier Production Function Analysis

The ordinary least square (OLS) (Model 1) and the maximum likelihood parameter estimates (MLE) (Model 2) of the stochastic production frontier models which were specified as Cobb-Douglas frontier production function for smallholder yam farmers are presented in Table 2. The coefficients of the variables are very important in discussing the results of the analysis of data. These coefficients represent percentage change in the dependent variables as a result of percentage change in the respective independent variables.

In model 1, the significant variable among the smallholder yam farmers in the study area include: quantity of yam sett, farm size, agrochemicals and labour quantity and were all directly related to the yam output. While labour quantity was significantly at 10%, quantity of yam sett, farm size and agrochemicals were all significant at 1%. The implication of the above findings is

that in the study area, the major limiting factors among the smallholder yam farmers in the study area are quantity of yam sett, farm size, agrochemicals and labour quantity respectively.

In the preferred model (model 2), the significant variables include: quantity of yam sett, farm size, agrochemicals and labour quantity and were all directly related to the yam output. While agrochemicals was significantly at 5%, quantity of yam sett, farm size and labour quantity were all significant at 1%. All the significant variables such as quantity of yam sett, farm size, agrochemicals and labour quantity have positive signs indicating that they greatly impact positively on yam output of smallholder farmer in the study area. Among the above three major significant inputs, labour quantity has the highest coefficient with a value of 0.3752 in the preferred models (model 2) and therefore, it exists as the most limiting factor that greatly determine what yam output would be like among the smallholder yam farmers in the study area. The variables with positive coefficient imply that any increase in such variables would lead to an increase in yam output of the smallholder farmers.

The estimated sigma square (σ^2) of the smallholder yam farmers is 0.1730 and highly significant at 1% level of significance. The estimated gamma (γ) parameter of the smallholder yam farmers is 0.2153 and is not significant at level of significance. The value is not too large, but yet significantly different from zero. This means that 21.53% of the variations in the yam output among smallholder farmers in the study area is due to the differences in their technical efficiencies. The analysis of the inefficiency model shows that the signs and significance of the estimated coefficients in the inefficiency model have important policy implications on the technical efficiency (TE) of the smallholder yam farmers. Among the smallholder yam farmers in the study area, the inefficiency variables that were significant include marital status, family size and farming experience. The coefficient of marital status were negative thereby conforming to *a priori* expectation with the implications that they are negative with inefficiency but positively influence the technical efficiency of the smallholder yam farmers in the study area. Family size and farming experience had positive relationship with the technical inefficiency of the smallholder yam farmers with the implications that they are positive with inefficiency but negatively influence the technical efficiency of the smallholder yam farmers in the study area.

The estimated productivity parameters such as elasticities of production and returns to scale are discussed in Table 3 below. Among the smallholder yam farmers, the estimated elasticities of the explanatory variables of the preferred model (Model 2) show that quantity of

yam sett, farm size, agrochemicals and labour quantity were all positive (increasing) to yam output indicating that the use and allocation of these variables was profitable and as such a unit increase in these inputs will eventually result in an increase in the yam output of the smallholder farmers in the study area. The elasticity of yam output with respect to labour quantity has the highest value among the smallholder yam farmers. These findings indicated that labour quantity has the most important variable factor of production among the smallholder yam farmers in the study area and should be readily attended to. The analysis of result of the Return To Scale shows that the RTS for the smallholder yam farmers is 1.2379 in the study area. Thus, the smallholder yam farmers in the study area are experiencing increasing returns to scale and are operating in the irrational zone of production (stage 1).

The predicted technical efficiency estimates obtained using the estimated stochastic frontier models for the individual catfish farmers in the study area presented Table 4 below. The predicted yam farm specific technical efficiency (TE) for the smallholder yam farmers' indices ranged from a minimum of 45.11% to a maximum of 97.50% for the farms, with a mean of 88.43%. Thus, in the short run, an average smallholder yam farmer has the scope of increasing his/her yam production by about 11.57% (i.e.100% – 88.43%) by adopting the technology and techniques used by the best practiced (most efficient) smallholder yam farmers in the study area. Such smallholder yam farmers could also realize 9.30% cost savings (i.e.1 – [88.43/ 97.50] in order to achieve the TE level of his/her most efficient counterpart (Bravo-Ureta and Evenson, 1994; Bravo-Ureta and Pinheiro, 1997). The above findings unfolds the capacity of an average smallholder yam farmers to increase his/her technical efficiency level to a tune of 11.57% and in turn attain a cost-saving status of about 9.30% that the most technically efficient smallholder yam farmers had enjoyed in his/her yam production enterprise using the available production techniques and technology in the study area. A similar calculation for the most technically inefficient smallholder yam farmers in the study area reveals cost saving of about 53.73% (i.e., 1 – [45.11/97.50] as shown in Table 5. The decile range of the frequency distribution of the TE as shown in Table 4 indicates that about 87.50% of the smallholder yam farmers had TE of over 70 % and 11.25% of them had TE ranging between 51 % and 70 %. The above findings from the analyses of the most technically inefficient smallholder yam farmer revealed that he/she has an untapped ability to realize a cost-saving of about 53.73%. To realize this latter cost-saving status, the smallholder yam farmer would have to employ the right amount of the various production

inputs, maximize the use of available technology as well as proper supervision of their yam farms to the activities of thieves and intruders on their farms.

Table 2: Maximum Likelihood Estimates for the Parameters of the Stochastic Frontier Production Function for Smallholder Yam Farmers in Oriire Local Government Area, Oyo State, Nigeria.

Variables	Parameters	Model 1	Model 2
General Model (Production Function)			
Constant	β_0	10.4948 (11.7940)	11.3147 (13.2233)
Quantity of Yam Sett	β_1	0.4163 (5.1079)*	0.3719 (4.8722)*
Farm Size	β_2	0.3496 (3.1028)*	0.3224 (3.0856)*
Labour Quantity	β_3	0.2304 (1.8281)***	0.3752 (3.2028)*
Agrochemicals	β_4	0.1781 (2.5466)*	0.1684 (2.0931)**
Inefficiency Model			
Constant	δ_0	-	-0.7619 (-0.7918)
Age	δ_1	-	-0.0093 (-1.1278)
Marital Status	δ_2	-	- 0.4646 (-2.4003)**
Educational Level	δ_3	-	0.0506 (1.3926)
Family size	δ_4	-	0.0241 (1.8194)***
Farming experience	δ_5	-	0.5490 (2.9800)*
Variance Parameters			
Sigma Squared	σ^2	-	0.1730 (8.2399)*
Gamma	γ	-	0.2153 (1.5168)
Log Likelihood Function		-	40.7980

Notes: * =1% level; ** = 5%; *** = 10% (Figures in parentheses are t- values).

Source: Computed from Field Survey Data, 2018.

Table 3: Elasticities (εP) and Returns-to-Scale (RTS) of Smallholder Yam Farmers in Oriire Local Government Area of Oyo State.

Variables	Elasticity Coefficient
Quantity of Yam Sett	0.3719
Farm Size	0.3224
Labour Quantity	0.3752
Agrochemicals	0.1684
RTS	1.2379

Table 4: Decile Range of Frequency Distribution of Technical Efficiencies of Smallholder Yam Farmers in Oriire Local Government Area of Oyo State.

Decile Range (%)	Technical Efficiency	
	No	%
>90	54	67.50
81-90	14	17.50
71-80	2	2.50
61-70	4	5.00
51-60	5	6.25
41-50	1	1.25
31-40	-	-
21-30	-	-
Minimum	45.11%	
Maximum	97.50%	
Mean	88.43%	

Table 5: Summary of Cost Savings According to Efficiency Indicator by Smallholder Yam Farmers in Oriire Local Government Area of Oyo State.

Efficiency Indicator			Value of Savings (%)
	Most	Technically	9.30
TE	Most	Technically	53.73

4.0 Summary, Conclusions and Recommendations

This study estimated the farm level technical efficiency and elasticity of production among smallholder yam farmers in Oriire Local Government Areas of Oyo State. A total of 80 smallholder yam farmers were sampled from various selected villages in the study area, and they include: Tewure, Iluju, Saamo, Ladokun, Alaroponla and Ikoyiile. The study specifically described the socio-economic characteristics of the smallholder yam farmers in the study area; and analyzed the technical efficiency of the smallholder yam farmers in the study area. The smallholder yam farmers were selected through a multistage sampling technique across the local government area with the use of interview schedule. The study employed the following analytical tools in order to analyze the data collected from the field: Descriptive Statistics like frequency counts and percentages as well as Inferential Statistical Model such as Stochastic Frontier Approach. The null hypotheses stated were tested by the use of tools such as generalized likelihood ratio test and t-ratio test. 85% of the respondents were males and married respectively. 87.5% are about 60years of age; 52.5% of them had a household size of between 6-10 members; 65.75% of them had one form of education or the other; 61.25% of them had about 20years of farming experience; 97.5% of them had no secondary occupation; 77.5% of the respondents cultivated about 5 hectares of land; 68.75% of the respondent got their lands by inheritance. In the preferred model (model 2), the significant variables include: quantity of yam sett, farm size, agrochemicals and labour quantity and were all directly related to the yam output. While agrochemicals was significantly at 5%, quantity of yam sett, farm size and labour quantity were all significant at 1%. All the significant variables such as quantity of yam sett, farm size, agrochemicals and labour quantity have positive signs indicating that they greatly impact positively on yam output of smallholder farmer in the study area. Among the above three major significant inputs, labour quantity has the highest coefficient with a value of 0.3752 in the preferred models (model 2) and therefore, it exists as the most limiting factor that greatly determine what yam output would be like among the smallholder yam farmers in the study area.

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