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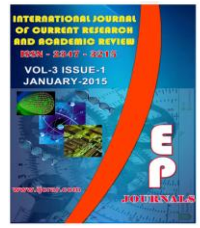

Profitability and Technical Efficiency of Sweet Potato Production in Osun State, Nigeria

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KEYWORDS

Profitability, Technical efficiency, Sweet potato, Stochastic frontier, Osun State

A B S T R A C T

This study estimates the profitability and technical efficiency of sweet potato production in Odo-Otin LGA of Osun State, Nigeria. A simple random sampling technique was used to select 120 sweet potato farmers in the study area. Data were collected and subjected to net farm income analysis. Maximum likelihood estimation technique was used to estimate Cobb-Douglas stochastic frontier production function. The empirical results revealed that sweet potato production was profitable in the study area with the Average Rate of Return (ARR) per naira invested of 0.48, implying that for every one naira invested in sweet potato production there is a profit of 48 kobo. Total cost of production per hectare was ₦129,345:00. Average yield/hectare was 4246 kg, selling price per unit kg was ₦45:00 and total revenue per hectare was estimated to be ₦191,070:00. The estimated Net Farm Income per hectare was ₦61,725.00. The estimated gamma parameter (γ) of 0.7881 in the study area indicates that 78.8% of the total variation in sweet potato output was due to difference in technical efficiency. The estimated mean technical efficiency was 76 percent, indicating that total output can be further increased with efficient use of resources and technology. The analysis further revealed that farm size, hired labour, fertilizer and herbicides were positive and statistically significant production factors. The results also show that Age of farmer, Years of schooling, Farming Experience, Household size, Access to agric credit, Membership of Association, Amount incurred on treatment / prevention of diseases, and Work days lost due to illness/disease were statistically significant inefficiency factors. The study suggested that sweet potato production should be increased in order to meet the objective of boosting food production so as to reduce the level of food insecurity in Nigeria.

Introduction

Sweet potato (*Ipomoea batatas* (L.) Lam.) is a root crop in tropical Africa belonging to the family convolvulaceae. It originated from Central Africa (Nwauzor and Afuape 2005) and is the only member of the genus *Ipomoea* whose roots are edible, and is one of the world's most important food crops due to its high yield and nutritive value (Data and Eronico, 1987).

Sweet potato is an important crop in many countries and has been cultivated for food, animal feed and industrial raw material. The cultivation and production of sweet potato is on the increase in Nigeria (Afuape, 2006). The crop has moved up from the minor crop status it used to occupy (Agboola, 1979) to an enviable position of being the fourth most important root and tuber crop in Nigeria after cassava, yam and cocoyam. Its production has increased from 149,000 metric tons in 1961 to 106,197 million metric tons (FAO, 2007). Despite this increase, yield on farmers' fields have remained low at 6.8t/ha (Tewe *et al.,* 2003). Sweet potato is a highly recommended food security crop that can help low-income countries ride out turmoil created by food price increases (IYP, 2008).

Contrary to the myth that eating sweet foods, including sweet potato, causes diabetes (type 2 diabetes), sweet potato is often a recommended food for diabetics since it has a lower glycemic index (GI) than many other starch foods. This is due in part to its high soluble fiber content. Low GI foods release glucose slowly into the blood stream which helps to control blood sugar (glucose) level. Many diets promote sweet potato as a fat-burning food and it is at the top of many Best foods to eat lists (Sweet potato Knowledge, 2012).

According to Tewe *et al*. (2003), mostly local and a few improved sweet potato varieties are grown in all the states in Nigeria. The major production areas are however the Oyan division in the present Osun State, Oyun division (Offa and its environs) of Kwara State in the north central part of Nigeria (Adekanye, 1998), as well as the areas around the NRCRI at Umudike, Abia State.

Research conducted in Oyan showed that nearly every household cultivated sweet potato and the average farm size was 0.4 ha per farmer. About 90% of the farmers were men while the remaining 10% consists of women and children (Adekanye, 1998; Tewe *et al.*, 2003).

Adekanye (1998) examines the economics of sweet potato production by peasant farmers in Odo-Otin Local Government Area of Osun State. The study found that the average size of sweet potato farm per farmer was 0.78 hectare, while an average of 50 man-days of family labour was employed. On average, ₦5,292 was been spent on hired labour, 50Kg of fertilizer were been used and ₦2,077 spent on miscellaneous. Average Output per this farm size was 3,015kg, which in turn fetched the farmer a gross income of about ₦27,000.

Despite the importance of sweet potato to the rural farm households not much has been done in terms of research with a view to suggesting measures of achieving increased production of the crop (Ewell, 1991). The rationale of this paper is therefore to empirically examine the profitability and technical efficiency of Sweet potato production in Odo-Otin local government area of Osun state, Nigeria

Materials and Methods

The study was carried out in Odo-Otin local government area of Osun state in the south western part of Nigeria. Odo-Otin Local Government Area of Osun State was purposively chosen for this study because of the prime importance of the local government area in terms of sweet potato production in the state. Oyan, one of the major towns in the local government area is popularly known for sweet potato production and it also host the National Headquarter of Potato growers, processors and marketers Association of Nigeria (POGPMAN).

Simple random sampling procedure was employed to get representative farmers. The study used a cross-sectional primary data collected from 120 farmers randomly selected from the list of potato farmers obtained from ADP Record and that of Potato growers, processors and marketers Association of Nigeria (POGPMAN). The tool for collecting the data was a well structured questionnaire. Data for the 2013 cropping season were collected for this study. The information collected in the survey included data on farm size cultivated, inputs utilized, yield obtained, selling price per unit quantity of inputs and output, days of incapacitation due to illness/diseases, as well as socio-demographic characteristics of the respondent farmers.

Data obtained were subjected to Net farm income analysis, and stochastic frontier production function.

Net farm income analysis: Net farm income analysis was used to estimate the levels of costs, returns and net profit that accrue to sweet potato farmers. This tool was used to determine the profitability of the farms. The model used for estimating the net farm income is represented by:

$$NFI = \sum_{i=1}^{n} PiYi - \sum_{j=1}^{m} Pxj \sum_{xj-k=1}^{k} Fk \dots\dots\dots\dots\dots\dots\dots 1$$

Where: NFI = Net Farm Income. (₦/ha); Y_i = Output (kg/ha); P_i = Unit price of product (₦/kg).

X_j = Quantity of variable input (where j = 1, 2, 3… m variable input); P_iX_j = Price per unit of variable input (₦); F_k = Cost of fixed input (₦) where k = 1, 2, 3 … k fixed inputs).

Σ= summation (addition) sign.

The Model Specification

The study made use of the Cobb-Douglas stochastic frontier production function to estimate the coefficients of the parameters of the production function and also to predict technical efficiencies of the farmers. The choice of this model is premised on the fact that the model allows for the presence of technical inefficiency while accepting that random shocks (weather or disease) beyond the control of the farmer can affect output. The model specifies output (Y) as a function of a set of inputs (Xs) and a disturbance term (e_i). That is

$$Yi = f(xi,\beta) + e_i \dots\dots\dots\dots\dots\dots (2)$$

Where:

Y_i = Output of the ith farm in kg; X_i = Vector of actual input quantities used by the ith farm

β = Vector of parameters to be estimated; e_i = composite error term

Following Coelli and Batesse (1996)

$$e_i = v_i - u_i \dots\dots\dots\dots\dots\dots (3)$$

V_i = Decomposed error term measuring technical efficiency of the ith farm.,

u_i = The inefficiency component of the error term.

The symmetric component (v_i) represents the variation in output due to factors (weather or disease attack) beyond the farmer's control. This symmetric component of the error term is independently and normally distributed as $N(0, \delta^2 v)$. A one sided component ($U_i > 0$) shows technical inefficiency relative to the stochastic frontier. Hence, if $U_i = 0$, production lies below the frontier and U_i is assumed to be independently and identically distributed and truncated at zero with the variance δ^2_V ($N0, \delta^2 V$). The parameter estimators (β) and the variance parameters were obtained by the maximum likelihood estimation method.

$$\delta^2 = \delta^2 u + \delta^2 v \quad \text{.........(4)}$$

$$\gamma = \frac{\delta^2 u}{\delta^2} \quad \text{...........(5)}$$

$$\lambda = \frac{\delta u}{\delta v} \quad \text{...............(6)}$$

Where:

$1 - \gamma$ = inefficiency

γ = The variance ratio parameter (Gamma), and by Battese and Corra (1977), $0 \leq \gamma \leq 1$.

The variance ratio parameter (γ) has two important characteristics. First, when $\delta^2 v$ tends to zero, u_i is the predominant error term in equation (2), implying that the output of the sample farmers differs from the maximum output mainly because of the difference in technical efficiency. Second, when $\delta^2 u$ tends to zero, v_i is the predominant error term in equation (2) and so γ tends to zero, thus differences between farmers output and the efficient output can be determined based on the value of γ (Kalirajan, 1981).

The empirical model of the stochastic production frontier function is specified as follows:

$$\ln Y = \beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta_5 \ln X_5 + \beta_6 \ln X_6 + V_i - U_i \quad \text{............(7)}$$

Where,

ln = the natural logarithm; Y =Output of i-th farmer measured in Kilogramme;

X_1 = the farm size cultivated in hectares; X_2 = family labour in mandays

X_3 = hired labour in Naira; X_4 =the quantity of fertilizer used (in kilograms)

X_5 =the herbicides used in litres; X_6 = value of vines (planting material) in Naira. βs are the coefficients to be estimated.

Based on a number of socio-economic factors identified to be influencing the technical efficiency of the farms, the Coelli and Battese (1996) inefficiency model was employed to estimate the parameters of the variables. The model assumes that the inefficiency effect U_i is independently distributed with mean u_i and variance δ^2. The model is specified as:

$$U_i = ɗ_0 + ɗ_1 Z_1 + ɗ_2 Z_2 + ɗ_3 Z_3 + ɗ_4 Z_4 + ɗ_5 Z_5 + ɗ_6 Z_6 + ɗ_7 Z_7 + ɗ_8 Z_8 + ɗ_9 Z_9 \quad \text{..........(8)}$$

where:

z_1= age of farmer; z_2 = years of schooling of farmer; z_3 = farming experience (in years);

z_4 = household size (in number); z_5= access to credit, dummy (if access 1, 0 otherwise);

z_6= number of extension contact during planting season;

z_7 = membership of association, measured as dummy (yes =1, 0 otherwise)

z_8 =amount incurred (in Naira) by the farmer on prevention and treatment of major/common diseases such as fever, malaria, coughs, etc on his household members.

z_9 = work days lost to illness / diseases during cropping season (measure as number of days of incapacitation due to illness or diseases).

These variables are assumed to influence technical efficiency of the farmers, and d_S are unknown scalar parameters to be estimated.

β_S , d_S, δ^2 (Sigma squared) and γ (gamma) are unknown parameters to be estimated. δ^2 and γ coefficients are diagnostic statistics that indicates the relevance of use of the stochastic production frontier function and the correctness of the assumptions of the disturbance of the error term. The gamma (γ) indicates that the symmetric influence that are not explained by the production function are the dominant sources of random errors. The statistical significance of gamma (γ) shows that in the specified model, there is the presence of a one-sided error component (v_i). This implies that the traditional OLS regression model cannot adequately represent the data and hence the use of stochastic production frontier function estimated by the maximum likelihood estimation method is appropriate. The computer programme frontier version 4.1 (Coelli, 1994) was used to run the maximum likelihood analysis.

Results and Discussion

A. Net Farm Income

The result of the Net Farm Income Analysis of sweet potato production shown in table 1 below indicated that the Gross Return from sweet potato production was ₦191,070.00. The Total Variable Cost (TVC) on land preparation, vines, agrochemicals, fertilizer, labour, harvesting, and transportation amounted to ₦127,345.00 while the Total fixed cost (TFC) for depreciation of fixed items such as sprayers, hoes and cutlass amounted to ₦1,815.00. The Net Farm Income per hectare was ₦61,725.00. The Average Rate of Return per naira invested was 0.48, implying that for every one naira invested in sweet potato production there is a profit of 48 kobo. This indicates that sweet potato production is profitable in the study area.

B. Maximum likelihood estimate and inefficiency estimates:

The MLE estimation results for sweet potato Production is presented in Table 2 below.
The presence or absence of technical inefficiency was tested in the study using the important parameter of Log Likelihood in the half-normal model $\lambda=\delta u / \delta v$. If $\lambda=0$, there was no effect of technical inefficiency, and all deviations from the frontier were due to noise (Aigner *et al.* 1977). The estimated value of $\lambda=1.929$ significantly different from zero at 1% ($p<.01$), suggest the existence of inefficiency effects for sweet potato farmers in the study area. The estimated variance, sigma square (δ^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 sweet potato output. Gamma (γ) is estimated at 0.7881 and is statistically significant at 1%.This suggests that, 78.8% of the variability of sweet potato output for the farmers was due to difference in technical efficiency.

The elasticity of farm size, hired labour, fertilizer and herbicides were positive while family labour and planting materials (vines) were negative. This implies that increasing any of those inputs with positive coefficient would increase output while increasing family labour and vine quantity used would decrease output. The magnitude of the coefficient of farm size is 0.7655 and was significant at 1% ($P < 0.1$) which implies that a unit increase in farm size would lead to 0.765 percent increase in output. The elasticities of hired labour, fertilizer and herbicides used were 0.479, 0.738 and 0.4837 and were significant at 1%, 5% and 5% respectively. This implies that a unit increase in the quantity of each of these inputs will result to a 0.479%, 0.738% and 0.483% increase in sweet potato output respectively in the study area.

The estimated coefficient of family labour was -0.078 and statistically significant at 5%, implies that a unit increase in the family labour has the potential to reduce the output by 0.078%. This may be due to the fact that some sources of this family labour may be inexperienced and also not available at the required time as timeliness is important in some critical farm operations such as planting, weeding and harvesting.

Similarly the estimated coefficient of planting materials (vines) used was -0.053 and statistically significant at 5%, implies that a unit increase in the quantity of the vines used will reduce the yield by 0.05%. The negative coefficient of the planting material (vines) may not be unconnected with the over-reliance on old stocks of local varieties for planting and incorrect spacing which tends to lowers the expected yields.

Sources of Technical Inefficiency:

The sources of technical inefficiency were examined by using the estimated ɗ-coefficients associated with the inefficiency effects in Table 2. Age had a positive coefficient and statistically significant at 10% level of probability. This implies that increasing age would lead to increase in technical inefficiency. Ageing farmers would be less energetic to work, leading to low productivity as well as low technical efficiency.

The years of schooling has a negative coefficient and statistically significant at 10% ($p<0.10$) level of probability. The coefficient for farming experience was negative and significant at 5% level. The estimated coefficient of Household size was negative (-0.612) and statistically significant at 5%. The coefficient of access to credit was negative and significant at 5% level of probability. Membership of farmers' associations/cooperative societies was negative and statistically significant at 5%. This is an indication that all these variables have direct relationship with efficiency but inversely related with inefficiency as the increase in any of them will results in a significant decreases in technical inefficiency and significant increase in technical efficiency and vice-versa.

Extension contact has a negative coefficient but not significant, indicating that the extension services was not a significant inefficiency factor in the study area.

The amount incurred by the households on prevention/treatment of common diseases was negative and statistically significant at 1%, indication that, as farm household invest on the health of family members, it tends to reduce technical inefficiency of the farm households. Therefore investment in health of household members increases technical efficiency.

The days lost to incapacitation due to illness and farm injuries have positive sign and were significant at 5%. This follows a priori expectation that ill health has a direct relationship with technical inefficiency of the farmers. That is, increase in the days lost to illness/diseases reduce technical efficiency.

Frequency Distribution of Technical Efficiency of Sweet Potato farmers

Table 3 shows the estimated technical efficiency's frequency distribution for the sweet potato farmers. The minimum and maximum values for estimated technical efficiencies are 14.22 and 92.36 percent with a mean technical efficiency 92.36 percent respectively. This result indicates that by using the available inputs the yield of sweet potato can be improved, suggesting that, on average, the interviewed farmers can potentially increase their production by as much as 24 percent through more efficient use of production inputs.

Table 1: Net farm income per hectare for Sweet potato production

Variables	**Average quantity per hectare**	**Unit price (₦)**	**Value (₦)**
1. **Gross farm income**:			
Average yield (kg)	4246	45	191,070
2. **Variable inputs**			
a. Land preparation			
i. clearing, packing & burning		4500/ acre	11250
ii. ploughing	1	3500/acre	8750
iii. ridging	1	3500/acre	8750
b. Vines	20000	1	20,000
c. Weeding			
i. Chemicals (herbicides & Labour for application)			11,200
ii.Supplementary hand weeding		6000/acre	15,000
d. Fertilizer (kg)	125	3000/50kg bag	7,500
Labour (fertilizer application)		500/bag applied	1,250
e. pesticide & labour for application			4130
f. Harvesting	15 Mandays	1500/ Manday	22,500
Bags for packaging	120	60	7200
g.Transportation			10,000
3. **Total variable cost**			**127,530**
4.Total fixed cost/ Depreciation on fixed items: i.e hoes, cutlasses and sprayer			**1815**
6. **Total cost** (TVC + TFC)			**129,345**
7. **Net farm income** (GI-TC)			**61,725**
8. **Average rate of return** (NFI/TVC)			**48.4**

Source: Computed from survey data, 2014.

Table.2 Determinants of technical efficiency in sweet potato production

Variables	Parameter	Coefficients	Standard Error	T-Statistics
Stochastic Frontier				
Constant	β_0	0.9998	0.2578	3.878
Farm size(X_1)	β_1	0.7655	0.3091***	2.476
Family Labour (X_2)	β_2	-0.0784	0.0300**	-2.613
Hired Labour (X_3)	β_3	0.479	0.184***	2.608
Fertilizer used (X_4)	β_4	0.738	0.177**	4.169
Herbicide used (x_5)	β_5	0.4837	0.569**	0.850
Planting materials (X_6)	β_6	-0.053	0.096**	-0.550
Inefficiency Model				
Constant	d_0	0.985	0.015	65.667
Age of farmer	d_1	0.057	0.313*	-0.182
Years of schooling	d_2	-0.302	0.050**	-6.040
Farming Experience	d_3	-0.461	0.003*	-153.667
Household size	d_4	-0.612	0.071**	-8.620
Access to agric credit	d_5	-0.224	0.004**	-56.000
Extension Contact	d_6	-0.376	0.008	-47.000
Membership of Association	d_7	-0.676	0.359**	-1.883
Amount incurred on treatment / prevention of diseases.	d_8	-0.360	0.183***	-1.967
Work days lost to illness	d_9	0.342	0.048**	7.125
Diagnostic Statistics				
Log Likelihood ratio		-41.666		
Sigma-Squared	δ^2	0.2437	0.674***	0.362
Gamma	γ	0.7881	0.646***	1.210
Lambda	λ	1.929	0.937***	2.059
Number of Observation 120				

Source: Computed from survey data, 2014. *significant at 10 %; ** significant at 5%; *** significant at 1% level of probabilities.

Table 3. Frequency distribution of efficiency indices

Technical Efficiency Level (%)	Number of Respondents	Percentage of Total
>90 ≤ 100	05	4.17
>80 ≤ 90	41	34.17
>70 ≤ 80	58	48.33
>60 ≤ 70	06	5.00
>50 ≤ 60	05	4.17
>40 ≤ 50	03	2.50
>30 ≤ 40	02	1.66
Mean TE: 76.20		
Minimum TE: 14.22		
Maximum TE: 92.36		

Source: Computed from survey data, 2014

Conclusion and recommendation

The study has been able to evaluate the profitability, and identify the major determinants of technical efficiency of sweet potato production in Odo-Otin local government area of Osun State, Nigeria. This study found out that sweet potato is a profitable enterprise in the study area. Results show that except family labour and planting material, all input variables have significant effect on sweet potato production in the study area.

The estimated Stochastic Production Frontier model together with the inefficiency parameters shows that all determinants except extension contact have significant effect on efficiency. The sign of coefficients of determinants followed a priori expectation. This study also contributed to the importance of health capital as one of the major production input (variable).

Sweet potato production should be increased in order to meet the objective of boosting food production so as to reduce the level of food insecurity in Nigeria. Introduction of mechanized farming which allows efficient use of land and other agro-inputs for the cultivation of sweet potato can do this. Farmers in the study area should be encouraged to adopt the cultivation of Orange Fleshed Sweet Potato (OFSP) because of its nutritional and health importance.

It is therefore, recommended that extension workers should work hand in hand with community health workers to improve general health conditions of the farmers by educating them on health tips through health talks and seminars.

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