Direct Research Journal of Agriculture and Food Science

Vol. 12(3), Pp. 1-6, September 2024,

https://journals.directresearchpublisher.org/index.php/drjafs

Research Article
ISSN: 2354-4147

Stochastic Production Frontier Analysis and Technical Efficiency of Yellow Yam (*Dioscorea cayenensis*) Farmers in Orhiowmon Local Government Area of Edo State, Nigeria

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ABSTRACT

Yellow yam has both socio-cultural and traditional values in the life of the people in Orhionmwon local government area. This study applied the stochastic production frontier analysis to measure the technical efficiency of yellow yam producers, the Cobb Douglas functional form was used to estimate the technical efficiency. Two-stage sampling technique was used in selecting (100) yellow yam farmers for the study. Primary data was collected directly from the field using structured questionnaire with open and close ended questions. Descriptive and inferential statistics was used for data analysis. The study showed majority of respondents constituting 69% of the population, were males. The SPF estimates reveals that yam setts and staking materials positively and significantly influenced the output of yellow yam production at (P<0.05) and (P<0.1) respectively. The mean technical efficiency of 55% showed that the farmers were operating below the frontier. Since the yield of yellow yam is increased by farm size, farmers in the study area should acquire more land for production and younger farmers should be encouraged to go into the production of yellow yam as the present producers are relatively too old for the labour intensive practices.

Keywords: Yellow yam, stochastic production frontier, Technical efficiency

Article information
Received 2 July 2024;
Accepted 17 September 2024;
Published 20 September 2024
DOI:
https://doi.org/10.26765/DRJAFS94605641

Citation: Eweka, K. I., Egbodion, J., and Osaruwense, S. (2S024). Stochastic Production Frontier Analysis and Technical Efficiency of Yellow Yam (Dioscorea cayenensis) Farmers in Orhiowmon Local Government Area of Edo State, Nigeria. Direct Res. J. Agric. Food Sci. Vol. 12(3), Pp. 1-6. https://doi.org/10.26765/DRJAFS94605641.

INTRODUCTION

Yellow yam (*Dioscorea cayenensis*) commands a special status among the people of Benin origin, it is locally called (*Ikpen*) and highly used for cultural celebrations such as burials, marriages, and other traditional rites, among the main Benin tribe of south-south and south-west Nigeria. The tuber, which is the major component of the yellow yam plant has high carbohydrates content but low in fat and protein and is a rich source of energy. Yellow yam can be eaten either fried in oil, or boiled. After boiling, it's frequently pounded into a thick paste and eaten with soup. It can also be sun dried and transformed into flour. Because of its chemical makeup, it is used medicinally as a cardiac stimulant (Pius and Oduvwuederhie 2006). In Orhionmwon local government

area of Edo state, where majority of the yam farmers cultivate yellow yam.it plays a significant role in the social and economic life of the people. Its cultivation creates employment as a means of livelihood and income opportunities for a sizable population of the rural residents. The yellow yam is so important and command so much respect among the locals to the extent it regarded as the "king of yams." However, despite the great potentials of this crop, it appears the production has nosedived in recent times. Most of the local yellow yam farmers in the Orhionmwon local government area of Edo State appear to be primarily resource-constrained farmers that rely solely on traditional agricultural methods for their production thereby making them to be inefficient. Although several studies have been conducted on yam, these include studies on its cost and returns; Zaknayiba and Tanko (2013); Socio economic determinants and profitability; Ugwumba and Omojola (2012). However, there exists a gap on the study of the technical production efficiency of especially the yellow yam species. It is in this view that this study was carried out applying the stochastic production frontier analysis to measure the technical efficiency of yellow yam farmers in the study area. The specific objectives of the study were to; describe the socioeconomic characteristics of the farmers; determine the technical and resource use efficiencies of the farmers in the study area.

METHODOLGY

Study area

This study was conducted in Orhionmwon local government area of Edo state. Edo state is an inland state in South of Nigeria. Its capital is Benin City. It's bounded in the North by Kogi state in the South by Delta state and in the west by Ondo state. It has an estimated population of 4,542,879 using the projected annual growth rate of 2.7% (NPC, 2006). Its coordination is latitude $5^0$44'N and longitude $6^0$04'E and $6^0$43'E of the Greenwich meridian and $7^0$34'N of the equator. The major occupation of the people is Agriculture while a few others are artisans. The total land area is 17,802km^2. Edo State has 18 Local Government Areas, of which Orhionmwon is one and this is where the Study was out. Orhionmwon local government area of Edo state is considered one of the biggest local government areas in Edo South Agro Ecological Zone of the state. It comprises towns and communities. Its administrative headquarters is Abudu. Most of the habitants are farmers whose main produce are Yellow yams, cassava, rubber, coffee and cocoa. There are also traders who trade on food items, clothes and petty retail shop. It lies on latitude 6°15'13"N and longitude 5°59'3E. It is 44m above sea level (144.36ft); it has an area of 2,382km^2 and a population of 206,717 at the Census 2006. It has 66 communities.

Sampling procedure and size

A two-stage sampling technique was used, in the first stage, five communities were purposively selected on the basis of yellow yam producing farmers, the second stage involved the selection (20) yellow yam farmers using the snowball method, making a total (100) yellow yam farmers that were used for the Study.

Data collection

The data for this study were collected from primary and secondary sources. Primary data was collected directly from the field using structured questionnaire with open and close ended questions. Data was collected on the socio-economic characteristics of the respondents and their level of production. In addition, data on yellow yam output, farm size, family and hired labour input uses, quantity of fertilizers, seeds of yellow yam, and the prices of various inputs were collected. Secondary data was gotten from relevant journals, publications, libraries and internet.

Analytical techniques

Descriptive and inferential statistics were used for data analysis. The descriptive statistics include means, percentages, and frequencies. While inferential statistics are budgetary analysis (gross margin analysis and return on investment) and multiple regressions model.

Model specification

The Stochastic Frontier Production function (SFPF) using the Cobb-Douglas functional form was used to determine the technical efficiency and cost efficiency of the farmers in this study. The production function model was explicitly specified in its linear form as:

$$\ln Y_i = \beta_0 + \beta_1 \ln X_{1i} + \beta_2 \ln X_{2i} + \beta_3 \ln X_{3i} + \beta_4 \ln X_{4i} + \beta_5 \ln X_{5i} + \varepsilon_i \quad \ldots\ldots\ldots (1)$$

Where, ln = Natural logarithm
Y = Quantity of yam produced (kg)
X_1 = Farm size (ha)
X_2 = Planting material (Yam sett) (kg)
X_3 = Labour (Man days)
X_4 = Quantity of fertilizer used (kg)
X_5 = Staking materials
β_1- β_5 = Parameters to be estimated (Regression coefficients)
εi= Error term
β_0 = Intercept.
TE= Technical efficiency (range between (0 and 1)

Allocative efficiency model

To estimate the allocative efficiency, the corresponding cost frontier of the Cobb-Douglas function as follows.

Yi* = the frontiers output
TE= Technical efficiency (range between (0 and 1)
The corresponding cost frontier of Cobb-Douglas functional form which is the basis of estimating the allocative efficiencies of the farmers', is specified as follows:

Ci = g (Pi, α) exp (Vi + Ui) (Aboki, Jongur, Onuand and Umaru, 2013) 2

AE = Ci*/Ci = g (Pi, α) exp Vi/g (Pi, α) exp (Vi + Ui) = exp (Ui).....3

The explicit form of the cost frontier production form is specified as follows;

$\ln C = \alpha_0 + \alpha \ln P_1 + \alpha \ln P_2 + \alpha \ln P_3 + \alpha \ln P_4 + \alpha \ln P_5 + Vi + Ui$.....4

Where;
C = Total cost of production (₦)
Pi = Cost of fertilizer (₦)
P_2 = Cost of labour (₦)
P_3 = Cost of yam setts (₦)
P_4 = Cost of staking materials (₦)
P_5 = Cost of transportation (₦)
α_0 = Depreciation
Ci* = Predicted minimum cost (₦)
AE = Allocative Efficiency

The economic efficiency was obtained using the following relationship:

EE = 1/CE (Coelli, Rao and O'Donnell, 2005) 5

Where EE = Economic Efficiency
CE = Cost Efficiency

The technical and allocative inefficiencies model μij is defined as:

$\mu ij = \delta o + \delta i Zi + \delta_2 Z_2 + \delta_3 Z_3 + \delta_4 Z_4 + \delta_5 Z_5 + \delta_6 Z_6 + \delta_7 Z_7$.....6

Where; μij = Denotes the technical and allocative inefficiencies of the i^{th} farmer
Z_1= Age of respondent (years)
Z_2= Education (years of formal schooling)
Z_3= Household size (number of household members)
Z_4= Years of experience (years)
Z_5= Gender (1 = Male and 0 = Female)
Z_6= Member of association (1 - denotes a member of the association and 0 - otherwise)
Z_7- Extension visit (Number of visits/month)
$\delta_0^=$ Constant term
δ_1- δ_7 = Unknown parameters to be estimated

RESULTS AND DISCUSSION

Socio-economic characteristics of the respondents

Table 1 shows that majority of the respondents are males with 69% and only 31% are female. This could be because yellow yam production being labour intensive and requiring substantial energy, strength and time. This finding is in line with (Izekor and Olumese, 2010) that had a similar report; that female would prefer to grow other crops that require less labour. The age distribution of the respondents shows a mean of 61 years; however the majority of the respondents were between 40-49 years, which amounted to 75%, while 18% were from 50 years and above. These have two implications; first, this implies that the more elderly population engaged more in yellow yam production because of the socio cultural value attached to crop and secondly the future of yellow yam production in the area is threatened as older farmers might not have enough strength to carry out the tedious tasks that are associated with yellow yam farming. This could the reason for declining production in the study area.

Marital status as depicted by the (Table 1) shows that 64% are married, 18% of the respondents are single, 16% are divorced, 2% are widower and 1% is widowed. This showed that majority of the respondents are married. The implication of this is that, there is likely to be more female labour available for yellow yam production. Also, farming is a necessary condition for families to lift their households out of poverty and ensure hunger free situation in homes. This agrees with the findings of Augustine *et al*. (2008), who found that over 70% of the married couples were involved in yam production in South Eastern Nigeria. The distribution of respondents according to their household size showed that household size of 5-9 was dominant representing 48% of the entire households. The mean household size recorded in this study was 9.55. Traditionally, yam production is a labour intensive enterprise. Family size is a necessity for the size of the farm and increase in production of yam (Nahanga and Vera 2014).

Farming experience of the respondents shows that the respondents with ≤10 years farming experience accounted for 18% of the respondents, farmers with 11-20 years' experience accounted for 21%, result also showed that 24% of the farmers had 21-30 years'

Table1: Socioeconomic characteristics of yellow yam farmers.

Socioeconomic of respondents	Freq.	%	Mean	Std. Dev
Sex of respondents				
Male	69	69		
Female	31	31		
Age of respondents in years				
<30 years				
30-39 years	7	7		
40 - 49	75	75	61.65	9.39
50.	18	18		
Marital status				
Single	17	18		
Married	64	64		
Divorced	16	16		
Widow	1	1		
Widower	2	2		
Separated				
Family size				
≤5	20	20		
5 - 9	48	48		
10 - 14	30	30	9.55	5.40
15+	2	2		
Level of education				
No formal education	30	30		
Primary education	19	19		
Secondary education	46	46		
Tertiary education	5	5		
Farming experience in years				
≤ 10	18	18		
11 - 20	21	21		
21 - 30	24	24	28.72	16.41
31+	37	37		
Farm size (hectares)				
≤.50	16	16		
0.51 - 1.50	39	39		
1.51 - 2.50	44	44	1.34	0.67
2.51+	1	1		
Mode of land acquired				
Purchase	30	30		
Rented	37	37		
Inherited	2	2		
Community	31	31		

Source: Field survey, 2023

experience and 37% of the respondents had 31 years and above farming experience. Since the average farming experience was 28.72 years. This suggests that the study area is predominantly known for yellow yam production. Farm size of the respondents shows that 16% of the respondents operate on ≤ 0.50ha lands, 39% operates on 0.51 – 1.50ha lands, 44% operates on 1.51 – 2.50ha land, and only few, 1% operates on land between 2.51ha and above. The average farm size was 1.34ha, this small scale of operation probably accounts for the use of family labour.

The result of the maximum likelihood estimation on the Stochastic Frontier production from (Table 2) revealed that variables such as farm size, planting materials (yam setts) and staking materials showed positive coefficient and were significant at ($p < 0.05$) and ($p < 0.1$) respectively, which is a direct relationship with yellow yam output, an increase in these variables will result to increase in output, while labour, fertilizer also had positive coefficient but were not significant. They do not increase yellow yam output in the study area. A look at the sources of in-efficiency effects showed that, gender, house hold size, years of experience were all directly related to inefficiencies, they increased in-efficiency of yellow yam farmers, while on the other hand, age of farmer, level of education and extension visit all had inverse relationship with farmer inefficiencies,. They reduce farmers' inefficiencies and increase output of yellow yam in the study area., In contrast, Rahman and Uma (2010) had earlier reported positive coefficients for labour, while Fatuase *et al.* (2015),and Sani *et al.* (2010) agreed that fertilizer and agro-chemicals were not major factors, hence it could be easily overcome. The level of education, extension visit and member of association all had positive values and has direct relationship with yellow yam farmer inefficiencies, meaning that the older

Table 2: Stochastic Frontier Production function, and determinants of inefficiency in yam production.

Stochastic Frontier parameters	Coeff.	Std. Err.	t-ratio
Dependent Variable			
Pi = fertilizer	0.371	0.516	0.719
P_2 = labour	0.415	0.413	1.005
P_3 = yam setts	0.619	0.105	5.895**
P_4 = staking materials	0.431	0.139	3.101*
P_5 = FARM SIZE	0.316	0.283	1.117
Constant	1.519	0.081	18.753**
Inefficiency effects			
Z_1= Age of respondent (years)	0.559	0.091	-6.143**
Z_2= Education (years of formal schooling)	0.812	0.173	-4.694**
Z_3= Household size (number of household members)	0.418	0.139	-3.007*
Z_4= Years of experience (years)	0.891	0.132	-6.750**
Z_5= Gender (0 = Male and 1 = Female)	-2.592	1.327	-1.953
Z_6= Member of association (1 - denotes a member of the association and 0 - otherwise)	2.771	0.731	3.791*
Z_7- Extension visit (Number of visits/month)	3.172	1.796	1.766
Constant	26.161	10.451	2.503*
Diagnostic Statistics			
Sigma Square (σ2)	0.3036		
Gamma (γ)	0.6899***		
Log-Likelihood Function	-266.2		

Source: Field Survey, 2023
*Sign. at 10%; **Sign, at 5%; ***Sign. at 1%

Table 3: Efficiency distributions in yellow yam production.

Efficiency distribution level	Freq.	%
0 – 10	57	29.69
10 – 20	32	16.67
20 – 30	27	14.06
30 – 40	14	7.29
40 – 50	18	9.38
50 – 60	13	6.77
60 -70	12	6.25
70 – 80	10	5.21
80 – 90	9	4.69
90 – 100	0	0
Min.	0.02	
Max.	91.05	
Mean	55.85	

Source: Field Survey, 2023

the farmer gets, the more children or house hold size, the more inefficient in use of resources. But this is contrary to the opinion of Okoye *and* Okezie. (2010), and Ugwumba and Omojola (2012), who reported that age, family size and access to finance increase farmer's efficiency. The efficiency distributions in yellow yam production, as presented in (Table 3), reveals significant insights about the production. Nearly 30% of producers operate at an efficiency level ranging from 0 to 10%, indicating a substantial portion of the production faces significant challenges or inefficiencies. Additionally, around 17% of producers fall within the 10 to 20% efficiency bracket, further highlighting the prevalent suboptimal practices or resource utilization among a considerable portion of yellow yam producers. Notably, the absence of any producers in the highest efficiency range of 90 to 100% suggests a critical gap in achieving near-perfect productivity. On average, the farmers operate at an efficiency level of 55.85%, signifying that there is ample room for improvement across the board. The wide variability, evident from the range between the minimum (0.02%) and maximum (91.05%) efficiency levels, underscores the diverse practices and capabilities among farmers. This disparity in performance signals potential disparities in resources, skills, or technological adoption among producers.

Conclusion

The research revealed valuable insights into the production dynamics and input utilization efficiency. Essential inputs such as land, planting materials, labour, and chemicals were found to be underutilized, suggesting potential areas for improvement in resource allocation and farming efficiency. Addressing these inefficiencies could enhance overall productivity and contribute to the community's economic well-being.

Recommendations

Based on the findings from the study, the efficiency gaps could be reduced if following recommendations are adhered to:

1. Younger farmers should be encouraged to go into the production of yellow yam as the present producers are too old because of the labour intensive practices.
2. Since the yield of yellow yam is increased by farm size, farmers in the study area should acquire more land for production.

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