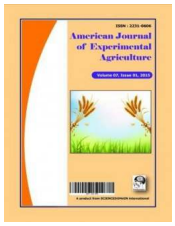

American Journal of Experimental Agriculture
12(1): 1-7, 2016, Article no.AJEA.22057
ISSN: 2231-0606

SCIENCEDOMAIN *international*
www.sciencedomain.org

Technical Efficiency of Small-holder Sweetpotato Farmers in Southeast Agro-ecological Zone of Nigeria

H. N. Anyaegbunam[1*], B. C. Okoye[2], J. O. Nwaekpe[1], M. E. Ejechi[1] and P. N. Ajuka[3]

[1]Extension Services Programme, National Root Crops Research Institute, Umudike, PMB 7006, Umuahia, Abia State, Nigeria.
[2]Cocayam Research Programme, National Root Crops Research Institute, Umudike, PMB 7006, Umuahia, Abia State, Nigeria.
[3]Department of Agricultural Economics and Extension, Abia State University, Uturu, Nigeria.

Authors' contributions

This work was carried out in collaboration between all authors. Author HNA designed the study, wrote the protocol and wrote the first draft of the manuscript. Author BCO reviewed the experimental design and all drafts of the manuscript. Authors JON and MEE managed the analyses of the study. Author PNA identified the plants. Authors HNA and BCO performed the statistical analysis. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AJEA/2016/22057
Editor(s):
(1) Peter A. Roussos, Lab. Pomology, Agricultural University of Athens, Greece.
Reviewers:
(1) Mevlut Gul, Suleyman Demirel University, Turkey.
(2) Anonymous, MingDao University, Taiwan.
(3) Alejandro Cordova Izquierdo, Universidad Autonoma Metropolitana Unidad Xochimilco, Mexico.
Complete Peer review History: http://sciencedomain.org/review-history/14022

Original Research Article

Received 15th September 2015
Accepted 22nd January 2016
Published 5th April 2016

ABSTRACT

The paper investigated the level of technical efficiency and its determinants in sweetpotato production in South-East agro-ecological zone of Nigeria. A multistage random sampling technique was used in the selection of states and respondents. Two states, Abia and Enugu were randomly selected from the five states of south-east agro-ecological zone (Abia, Anambra, Ebonyi, Enugu and Imo States). 120 respondents were randomly selected (60 respondents from each state). Data collecting instrument was a well-structured questionnaire. Stochastic frontier production function

**Corresponding author: E-mail: helenkol8@yahoo.com;*

was used to analyze the data. The result of the maximum likelihood estimate shows that labour (1 percent), fertilizer (10 percent), capital input (1%) and farm size (10%) were significant and contributing factors to the output of sweetpotato farmers. The result of the scholastic frontier estimate reveals that the value of total variance and variance ratio were significant at 1 percent with the values of 0.4040 and 0.5464 respectively. The maximum technical efficiency computed was 0.93; the minimum was 0.27 while the mean was 0.80.This implies that the farmers are technically in-efficient in resource allocation. Determinants of technical efficiency include; age, farm size, extension visit and farming experience were significant at varied risk levels. The results call for policies aimed at empowering the extension agents to enhance technology dissemination and transfer. Also, farmers, especially the younger ones are to be assisted in terms of capital input in order to boost productivity and increase efficiency.

Keywords: Technical efficiency; stochastic frontier; sweetpotato; production.

1. INTRODUCTION

Sweetpotato (*Ipomoea batatas* (L) *Lam*) is an important tropical root crop. It belongs to the morning-glory family known as *convolulaceae* and originated from Latin America [1]. It ranks second after cassava among the tropical root crops. The crop can be considered in promoting nutritional security particularly in agriculturally backward areas. Besides carbohydrates, it is a rich source of protein, lipid, calcium and carotene. It becomes an ideal crop for popularization in areas with poor soils and poor agricultural infrastructural facilities.

In annual production, sweetpotato ranks as the fifth most important food crop on a fresh-weight basis in developing countries after rice, wheat, maize, and cassava. Sweetpotato is cultivated in 114 countries and ranks among the five most important food crops in over 50 countries. Asia has the world's major production area for sweetpotato. In Asia, the greatest share of production is in China that accounts for about 85% of global production [2]. According to [3], 23 countries produce 90% of all sweetpotato in Sub-Saharan Africa. Uganda and Nigeria dominate in terms of overall sweetpotato production accounting for 33% of total production. There has been an increase in the production of sweetpotato in Nigeria. Sweetpotato production rose from 2.516 million metric tonnes in 2006 to 3.4 million metric tonnes in 2007 [4,5]. These increases were attributed to improved technological inputs, and international and national research efforts.

Optimally combining production factors to achieve the highest gains is the chief aim of sweetpotato enterprise. Applying business skill with technical knowledge is critical for managing every essential step. In dynamic sweetpotato production environments, varying input levels, price effects and continued adverse changes create challenges for sweetpotato growers, processors and marketers [4]. The process of resource utilization for food and fiber production under conditions of rapid economic development, rural communities are faced with decisions of what, how and when to produce and utilize scarce resources [6]. Specifically, there is the problem of deciding on how much available factor productivity or resources to be devoted for future growth as well as how much to satisfy current consumption needs [7].

The analysis of efficiency is generally associated with the possibility of farms producing at certain optimal level of output from a given bundle of resources at least cost. [8] as quoted by [6] made clear between three types of efficiency namely;

Technical efficiency: This is the physical ratio of output to the factor input. The greater the ratio, the greater the magnitude of technical efficiency.

Allocative or price efficiency: A farm is allocatively efficient when production occurs at a point where marginal value product is equal to marginal factor cost.

Economic efficiency: This is obtainable where both technical and allocative efficiencies have been attained.

Enhancing the unrealized potential of sweetpotato through efficient production will increase the demand and improve the income generating opportunity for farmers or producers [9]. There is insufficient information on technical efficiency of sweetpotato production in Abia and Enugu States; therefore, this paper was designed to estimate the farmers' technical efficiency and the determinants in the study areas.

2. METHODOLOGY

2.1 Sampling Procedure

Multistage random sampling technique was used in selecting states and respondents. Two states Abia and Enugu were selected out of the five states of the Southeast agro-ecological zone (Abia, Anambra, Ebonyi, Enugu and Imo.) Two agricultural zones were subsequently selected from each state and 30 farmers from each of the agricultural zones making it a total of 120 respondents or farmers (60 farmers from each. State) Data were collected through cost route approach and structured questionnaire was also used. Data collection was done between April-June, 2013. Data covered the main agronomic practices from land preparation to harvesting. The data collected included variables such as inputs –land, labour, capital, fertilizer and socio-economic characteristics of the farmers.

2.2 Analysis of Data

Descriptive statistics like percentages, frequencies and tables were used to discuss the socioeconomic characteristics and production data of the farmers while the Cobb-Douglas functional form using the scholastic frontier production function was used to estimate the technical efficiency of the farmers.

2.3 Theoretical Framework

A stochastic production function is given by:

$$Y_i = f(X_i, \beta) \exp(V_i - U_j) = 1, 2\ldots.n \quad (1)$$

Where

Y_i is output of the i^{th} farm, X_i is the vector of input quantities used by the i^{th} farm, β is vector of unknown parameters to be estimated, f (X_i, β) represents an appropriate function (e.g. Cobb Douglas, Translog, etc). The term V_i is a symmetric error, which accounts for random variation in output due to factors beyond the control f the farmer e.g. weather, disease outbreaks, measurement errors, etc, while the term U_j is a non-negative random variable representing inefficiency production relative to the stochastic frontier. The random error V_i is assumed to be independent and identically distributed as N(0, δ_u^2) random variables independent of the U_j which are assumed to be non-negative truncations of the N(0, δ_u^2) distribution (i.e. half normal distribution) or have exponential distribution [10]. The stochastic frontier was independently proposed by [10]. The technical efficiency of an individual farmer is defined in terms of the ratio of the observed output to the corresponding frontier output given the available technology [11].

$$\text{Technical efficiency (TE) } Y_i/Y_i^* = f(X_i, \beta) \exp(V_i)/ f(X_i, \beta) \exp(V_i) = \exp(-U_j) \quad (2)$$

Where

Y_i = observed output
Y_i^* = frontier output

The parameters of the stochastic frontier function are estimated using the maximum likelihood method/ratio.

The empirical model: For this study, the production technology of sweetpotato production farmers in Southeast agro ecological zone, Nigeria is assumed to be specified by the Cobb-Douglas frontier production function defined as follows:

$$\text{Ln } Q = b_0 + b_1 \ln X_1 + b_2 \ln X_2 + b_3 \ln X_3 + b_4 \ln X_4 + b_5 \ln X_5 + Vi - U_i \quad (3)$$

Where

Q = Quantity of sweetpotato produced (kg)
X_1 = labour (man days)
X_2 = planting material (cost₦ (kg)
X_3 = fertilizer (kg)
X_4 = capital input (₦)
X_5 = farm size (ha)
V_i = random error
U_i = technical inefficiency

2.4 Determinants of Technical Efficiency

In order to determine factors contributing to the observed technical efficiency, the following model was formulated and estimated jointly with the stochastic frontier model in a single stage maximum likelihood estimation procedure using the computer software frontier version 4.1 [12] as follows:

$$TE = б_0 + б_1 Z_1 + б_2 Z_2 + б_3 Z_3 + б_4 Z_4 + \ldots\ldots + б_8 Z_8 \quad (4)$$

Where

TE = technical efficiency pf the i-th farmer
Z_1 = Age (years)
Z_2 = Farming Experience (years)

Z_3 = Household size
Z_4 = membership of cooperative societies (yes = 1, 0 = No)
Z_5 = No of Extension Contacts
Z_6 = Education (Years)
Z_7 = credit access (yes = 1, 0 = No)
Z_8 = farm size (Ha)

While $б_0$, $б_1$, $б_2$…..$б_8$ are the parameters to be estimated.

3. RESULTS AND DISCUSSION

Table 1 shows the mean socioeconomic characteristics of sweetpotato farmers according to age, farming experience, membership of cooperatives, Extension Contact, education, credit access and farm size.

The table reveals that the mean age of the farmers was 44 years. This indicates that sweetpotato production in the study area is carried out by young farmers. The reason could be attributed to the profitability inherent in the activity [13] and also access to credit facility (60%). The mean farming experience was 13 years and therefore the farmers could be described as being experienced. About 64% of the farmers belong to different cooperative societies. Membership of cooperative societies creates room for exchange of ideas and information [13]. Table 1 also depicts that the farmers were visited four times within the planting season and also had a mean educational attainment of 12 years. The level of education not only increases efficiency and productivity but also enhances the ability to understand and evaluate new production technologies [14]. The mean household size was 6 persons. This has implication on the provision of labour for farming activities [15]. The results also show that the mean farm size was 1.7 ha. This implies that sweetpotato production in the study area is dominated by small scale.

3.1 Estimated Production Functions

The maximum likelihood estimates (MLE) of the stochastic frontier production parameters for sweetpotato are presented in Table 2. The table shows that the five production functions, labour, planting material, fertilizer, capital input and farm size were all significant. The coefficient of labour was negative and significant at 1 percent. This implies increase in labour will reduce sweetpotato output. This could be as a result of misallocation or over utilization of labour.

This result is at variance with earlier studies by [16,17] Coefficient of farm size was positive and significant at 1 percent. This is consistent with previous findings of [17,10,18]. The elasticity of farm size 0.3306 implies that a 1 percent increase in farm size, all things being equal would lead to an increase 0.3306 of percent in the output of sweetpotato production and vice versa. Large hectares of farm is required to expand production of crops and since land is limited in supply the shortage results in reduced crop production. The Coefficient (0.5347) of capital input was positive and significantly related to production at 1 percent. Therefore, 1 percent increase in capital input will result to 0.5347percent increase in total output of sweetpotato. The result is in consonance with [5,19,20,16]. Against an a priori expectation, the coefficient of fertilizer was negative and significant at 10 percent level. This implies that as the use of fertilizer increases, production decreases. This could be attributed to the inadequate use of fertilizer by those who even use [16]. The result is at variance with [17,11,21] and [18] who indicated that increase in the use of fertilizer resulted to increase in output.

3.2 Sources of Technical Efficiency

The determinants of technical efficiency in sweetpotato production are shown in Table 3. The result of the analysis shows that age, farm

Table 1. Mean socio-economic characteristics of sweetpotato farmers in southeastern Nigeria

Variables	Mean	Minimum	Maximum	Standard deviation
Age (years) Z_1	44	32	60	6.3980
Farming experience (years) Z_2	13	0	18	4.2747
Household size Z_3	6	2	11	1.8235
Membership of cooperative (%)Z_4	64	-	-	-
Extension contact Z_5	4	4	15	3.9319
Education (years) Z_6	12	0	18	4.7155
CreditAccess (%)Z_7	60	-	-	-
Farm size (ha) Z_8	1.7	0.2	8	1.4073

Source: Field survey, 2013

size, extension contact and farming experience were statistically significant at varied risk levels. Coefficient of age of the farmers was negative and significantly related to technical efficiency at 10 percent. This result agrees with those of [22]. [17,11,18] which implies that increase in age would lead to decrease in technical efficiency since aging farmers would be less energetic to work in the farm. But the result is at variance with that of [23] whose result showed age to be positively related to technical efficiency. Farm size had a negative coefficient and highly significant at 10 percent level of probability. This implies that as farm size increases Technical efficiency reduces. This result is consistent with [18,16] but contrasts with those of [11,24]. The result may be attributed to the ageing number of sweetpotato farmers, because sweetpotato productivity decline with age, if farm size is small, they may be able to continue their resources effectively [25]. The coefficient of extension visit was positive and significantly related to technical efficiency at 5% level of probability. This result is in consonance with [24,8,26]. The result implies that visits by the extension agents increase technical efficiency. This is based on the fact that farmers will be more encouraged to adhere to correct use of technological packages that enhance efficiency and production. The result is at variance with [18] whose study indicated that increase in extension visits reduces technical efficiency. Coefficient of farming experience was negative and significant at 5 percent. This implies an inverse relationship with technical efficiency. The reason for this could be attributed to the fact that farmers who have spent more years in farming are the aged, ones and are less energetic resulting to inefficiency. The result was at variance with [11] who reported a positive relationship between farming experience and technical efficiency but consistent with [24].

The diagnostic statistics possess coefficients which are all statistically significant at 1 percent level of probability. The coefficient of total variance (6^2) is 0.4040 while the variance ratio is 0.5464. Variance ratio is the measure of the ratio of farm specific technical efficiency to total variance; implying that 54% of the variance in output among sweetpotato farmers was due to the disparities in technical efficiency. The total variance of 0.4040 is significant and denotes a

Table 2. Estimated stochastic frontier production function for sweetpotato production in southeastern Nigeria

Variable	Parameter	Coefficient	Standard error	T-value
Constant	β_0	4.6487	0.5945	7.8194***
Labour	β_1	-0.1004	0.0211	-4.7619***
Planting material (cost)	β_2	-0.1653	0.1075	-1.5379
Fertilizer	β_3	-0.1518	0.0892	-1.7021*
Capital input	β_4	0.5347	0.0766	6.9761***
Farm size	β_5	0.3306	0.0698	4.7860***

Source: Computed from field survey data, 2013
****Significant at 1%, **Significant at 5%, *Significant at 10%*

Table 3. Estimated determinants of technical efficiency in sweetpotato production

Variance	Parameter	Coefficient	Standard error	T-value
Constant	∂_0	3.9595	1.5692	2.5233**
Education	∂_1	-0.0331	0.0244	-1.3570
Age	∂_2	-0.0906	0.0548	-1.7906*
Farm size	∂_3	-0.3310	0.1783	-1.8564*
Extension visit	∂_4	1.3219	0.5508	2.3999**
Household size	∂_5	-0.0387	0.0510	-0.7581
Credit access	∂_6	-0.0287	0.0401	0.7162
Membership of co-operative society	∂_7	-0.0953	0.1340	0.7109
Farming experience	∂_8	-0.0280	0.0131	-2.1413**
Diagnostic statistics				
Total variance	$\sum\partial^2$	0.4040	0.0961	4.2044***
Variance ratio	Γ	0.5464	0.1271	4.2997***
LR test		20.3162		
Log likelihood function		-89.2659		

Source: Computed from field survey data, 2013
****Significant at 1%, **Significant at 5%; *Significant at 10%*

Table 4. Frequency distributed of technical efficiency of sweetpotato production in southwestern Nigeria

Technical efficiency range	Frequency	Percentage
0.21-0.41	4	3.33
0.41-0.61	8	6.66
0.61-0.81	32	26.66
0.81-1.00	76	63.34
Total	**120**	**100**
Mean technical efficiency	0.80	
Maximum technical efficiency	0.93	
Minimum technical efficiency	0.27	

Source: Field survey, 2013

good fit and correctness of the specified distributional assumption of composite error term.

3.3 Distribution of Technical Efficiency

Table 4 shows the distribution of technical efficiency of sweetpotato production in the Southeast agro-ecological zone in Nigeria. The table reveals that the technical efficiencies of the farmers ranged between 0.27 and 0.93 with a mean technical efficiency of 0.80. About 27 percent of the farmers are operating below the mean technical efficiency against 93 percent who are operating above the mean. There exists a wide gap between the technical efficiencies of the best and worst (or technically inefficient) sweetpotato farmers. It will take an average sweetpotato farmer 1-0.80/0.93 that is 22 percent saving cost to become the most technical efficient sweetpotato farmer and for the most technically inefficient farmer, it will take him 1-0.27/0.93 (78 percent) cost saving to become the most technically efficient farmer.

4. CONCLUSION AND RECOMMENDATIONS

The study analyzed the technical efficiency and determinants of sweetpotato production in south east agro ecological of Nigeria. The result of the maximum likelihood estimation revealed that labour, fertilizer, capital input and farm size were significant variables influencing the output of farmers. The technical efficiency of the farmers ranged from 0.27-0.93 with a mean technical efficiency of 0.80. This implies that the farmers are technically in-efficient in resource allocation.

The results also showed that age, farm size, extension visit and farming experience were significant factors contributing to technical efficiency. The results call for policies aimed at empowering the extension agents to enhance technology dissemination and transfer. Also, farmers, especially the younger ones are to be assisted in terms of capital input in order to boost productivity and increase efficiency.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Low J, Lynam J, Lemagea B, Crissman C, Barker I, Thiele G, Namanda S, Wheatley C, Andrade M. Sweetpotato in Sub-Saharan Africa. 'In' the Sweetpotato. 2009;7-9.
2. Srinivas T. Economics of sweetpotato production and marketing. 'In' the Sweetpotato. Loebenstein G, Thottapilly G. (eds) Spring Science Business Media. B.V. 2009;436-247.
3. FAOSTAT. Food and Agricultural Organization of the United Nations. Production Statistics; 2008.
4. Akoroda M. Sweetpotato in West Africa 'In' the Sweetpotato. Loebenstein G and Thottapilly G, (eds). Spring Science Business Media B. V. 2009;456-457.
5. Onyenweaku CE, Igwe KC, Mbanasor JA. Applications of stochastic frontier production function to the measurement of technical efficiency in yam production in Nassarawa State, Nigeria. Journal of Sustainable Tropical Agricultural Research. 2004;13:20-25.
6. Awoke MU, Okorji EC. Analysis of constraints in resource use efficiency in multiple cropping systems by small-holder farmers in Ebonyi State of Nigeria. Global Journal of Agric. Science. 2003;2(2): 132-136.

7. Johnson DT. The business of farming. A guide to farm business management in the tropics. Macmillan. 1982;200-204.
8. Farrel MJ. The measurement of productive efficiency. Journal of the Royal Statistical Society, Series A. 1957;120:253-281.
9. Best R, Westby A, Ospina B. Linking small-scale cassava and Sweetpotato farmers to growth markets, experiences, lessons and challenges. Aucia Horticulture. 2006;703:39-46.
10. Battese GE, Coelli TJ. A model for technical inefficiency effects in a stochastic frontier production function for panel data, Empirical Economics. 1995;20:325–32.
11. Onyenweaku CE, Nwaru JC. Application of stochastic frontier production function to the measurement of technical efficiency in food crop production in Imo State of Nigeria. The Nigerian Agricultural Journan. 2005;36:1-11.
12. Coelli T. A guide to FRONTIER Version 4.1: A computer program for frontier production function estimation. CEPA Working Paper 96/07, Department of Econometrics, University of New England, Armidale; 1996.
13. Anyaegbunam HN, Nto P. Economic viability of sweetpotato production and marketing. Journal of Sustainable Development. 2013;10(1):15-2.
14. Obasi PC. Resource and efficiency in food crop production. A case of the Owerri Agricultural zone, Imo State. MSc Thesis University of Ibadan, Nigeria; 1991.
15. Effiong EO. Efficiency of production in selected livestock enterprise in Akwa Ibom State of Nigeria. Thesis, Dept of Agricultural Economics, Michael Okpara University of Agriculture, Umudike; 2005.
16. Adewumi MO, Adebayo FA. Profitability and technical efficiency of sweetpotato production in Nigeria. Journal of Rural Development. 2008;3(5):105-120.
17. Ohajianaya DO, Otitolaiye JO, Saliu OJ, Obitoye SJ, Ibekwe UC, Anaeto FC, Ukwuteno OS, Audu SI. Technical efficiency of sweetpotato farmers in Okene Local Government Area of Kogi State, Nigeria. Asian Journal of Agricultural Extension Economics and Sociology. 2014;3(2):108-117.
18. Okoye BC, Onyenweaku CE, Asumugha, GN. Technical efficiency of smallholder cocoyam production in Anambra State, Nigeria. A cobb-douglas stochastic frontier production approach. The Nigerian Agricultural Journal. 2007;38:70-81.
19. Iheke OR. Technical efficiency of cassava farmers in Southeastern Nigeria: Stochastic Frontier Approach. Medwell Agricultural Journal. 2008;3(2):152-156.
20. Likita T. Technical efficiency in arable crop production in Kebbi State, Nigeria. Journal of Agriculture and Food Science. 2005;3(2):165-174.
21. Ademiluyi IO, Adepoju SO, Okeke-Agulu, K. Technical efficiency of sustainable cassava farming in Kogi State, Nigeria. Journal of Sustainable Development. 2013;10(1):56-60.
22. Amanze JO, Eze CI, Chukwudi J. Technical efficiency of broiler production in Umuahia, Abia State, Nigeria. Journal of Sustainable Development. 2012;9(1):10-17.
23. Belbase K, Grabowski R. Technical efficiency in Nepalese agriculture. Journal of Development Areas. 1995;19(4):515-525.
24. Onu JK, Amaza PS, Okunmadewa FY. Determinants of cotton production and economic efficiency. African Journal of Business and Economic Research. 2000;1(2):34-40.
25. Hazarika C, Subramanian SR. Estimation of technical efficiency in the stochastic frontier production function model – An application to the tea industry in Assam; 1999.
26. Anyaegbunam HN, Ogbonna MC, Asumugha GN. Determinants of adoption of cassava technologies by small-scale farmers in Abia State, Nigeria. Paper presented at the 40th Annual conference of the Agricultural Society of Nigeria held at the NRCRI, Umudike. 2006;776-780.

Peer-review history:
The peer review history for this paper can be accessed here:
http://sciencedomain.org/review-history/14022