Technical Efficiency of Small Holder Cocoyam Production in Anambra State,Nigeria: A Cobb-Douglas Stochastic Frontier Production Approach

B.C Okoye and C.E Onyenweaku and G.N Asumugha

Micheal Okpara University of Agriculture, Umudike, Abia State, National Root Crops Research Institute, Umudike, Abia State

2007

Technical Efficiency of Small Holder Cocoyam Production in Anambra State,Nigeria: A Cobb-Douglas Stochastic Frontier Production Approach.

Okoye, B. C[1] and Onyenweaku, C. E[2] and Asumugha, G. N[1]
[1]National Root Crops Research Institute, Umudike, Abia State. *okoyebenjamen@yahoo*
[2] Dept. of Agricultural Economics, Micheal Okpara University of Agriculture, Umudike.
chrisonyenweaku@yahoo.com

ABSTRACT

This study employed a Cobb-Douglas stochastic frontier production function to measure the level of technical efficiency and its determinants in small-holder cocoyam production in Anambra state, Nigeria. A Multi-stage random sampling technique was used to select 120 cocoyam farmers in the state in 2005 from whom input-output data were obtained using the cost-route approach. The parameters of the stochastic frontier production function were estimated using the maximum likelihood method. The study found farm size, labour and fertilizer to be positively and significantly related to output at 5% level of significance. Socio economic determinants influencing technical efficiency directly were farming experiences and credit access at 5% level of significance. Age and farm size were negatively and significantly related to technical efficiency at 5% level of significance. The test of significance using ANOVA showed that there were significant differences in the technical efficiencies among zones.

Key words: Cobb-Douglas Stochastic Frontier Production Function and Technical Efficiency.

Introduction

Cocoyams (*Colocasia* and *Xanthosoma* spp.) are stem tubers that are widely cultivated in both the tropical and sub-tropical regions of the world (Purseglove, 1972). Cocoyams are an important carbohydrate staple food particularly in the Southern and Middle belt areas of the country (Asumugha and Mbanaso, 2002). Nigeria is the highest producer of cocoyam in the world, accounting for about 37% of total world output of cocoyam (FAO, 2006). Most of the crop is grown in southern Nigeria including Anambra State. Cocoyam ranks third in importance after yam and cassava in extent of production among the root and tuber crops of economic value in Nigeria (FAO, 2006) and is in direct competition with cassava and yam as food (Nwagbo *et al*., 1987). The cultivation of cocoyam is declining (Onyenweku and Eze, 1987; Zuhair and Hunter, 2000), while most of what is produced is consumed locally (Mbanaso and Enyinnaya, 1989)

Production of cocoyam has not been given priority attention in many countries probably because of its inability to earn foreign exchange and its unacceptability by the high income countries for both consumption and other purposes (Onyenweaku and Ezeh, 1987). Cocoyam research and development has been meagre compared to other tropical root crops and mainly grown by resource poor farmers largely women (Okorji, 1988). The process of resource utilization for food and fibre production, under conditions of rapid economic development, rural communities are faced with decisions of what, how and when to produce and utilize scarce resources (Awoke and Okorji, 2003). Specifically there is the problem of deciding on how much of the available factor productivity or resurces to be devoted for future growth as well as how much to satisfy current consumption needs (Johnson, 1982)

Efficiency is an important factor of productivity growth as well as stability of production especially in developing agricultural economy (Hazarika and Subramanian, 1999). In view of the slow growth and increasing instability in production (Bhuyan and Hazarika, 1997). The study determined the technical efficiency of resource use among the small holder cocoyam farmers in Anambra State.

Methodology

The study area: The study was carried out in Anambra State of Nigeria. Anambra State is located in the South Eastern region of Nigeria between longitude 6^0 36`E and $7^0$ 21`E and latitude $5^0$38`N and $6^0$ 47`N. It has a land area of about 4,415.54 square kilometers, 70% of which is rich for agricultural production. (Nkematu, 2000). The State for administrative convenience is divided into four agricultural zones viz Aguata, Anambra, Awka and Onitsha zones. The zones are further delineated into 24 extension blocks and 120 circles. The climate can generally be described as tropical with two clear identifiable seasons, the wet and dry seasons. Farming is the predominant occupation of the people, majority of who are small-holder farmers.

Sampling procedure: Three out of the four agricultural zones were purposively selected for the study using the multi-stage sampling technique. They are Aguata, Awka and Onitsha zones based on intensity of cropping. Two blocks were randomly selected from each zone and two circles from each block; finally 10 farmers were randomly sampled from each of the circles. Thus a total of 120 cocoyam farm families were involved in the study.

Data collection procedure: Data was collected using the cost-route approach with the aid of well structured questionnaires between the months of March 2005 and February 2006. The primary data covered the main agronomic practices from land clearing to harvesting. The data collected included such variables as output, inputs such as land, capital, labour, fertilizer etc and socio-economic characteristics of respondents.

Analytical procedures: Descriptive statistics like percentages, frequencies and tables were used to discuss the socio-economic and production data of the farmers.

(a) The Cobb-Douglas functional form using the stochastic frontier production function was used to estimate the technical efficiency of the farmers. The stochastic frontier production model is specified as follows.

$Y_i = F(X_i;\beta) \exp(V_i - U_i)$; : =1,2,- -n ---------------------- (1)

Where,

Y_i = denotes output of the ith farm

X_i = is a vector of functions of actual input quantities used by the ith farm

β = is a vector of parameters to be estimated

$V_i - U_i$ = is the composite error term (Aigner *et al.*, 1977, Meeusen and van den Broeck, 1977)

Where,

Vi and Ui = are assumed to be independently and identically distributed

U_i = is a non-negative random variable, associated with technical inefficiency in production.

V_i = is a random error, which is associated with random factors not under the control of farmers.

The functional form of this model used in estimating the level of technical efficiency is the Cobb-Douglas type (Bravo-Ureta and Evenson, 1994) is

$\text{Ln } Y_i = \beta_0 + \beta_1 \text{Ln } X_1 + \beta_2 \text{Ln } X_2 + \beta_3 \text{Ln } X_3 + \beta_4 \text{Ln } X_4 + \beta_5 \text{Ln } X_5 + V_i - U_i$ ………(2)

Where,

Ln = represents the natural logarithm

The subscript i represents i-th sample farmer

Yi = Cocoyam output in kg of the i-th farm

X_1 = Farm size measured as total land area in hectares

X_2 =Labour, in mandays used in production

X_3 =Quantity of fertilizer used in kg

X_4 = Quantity of cocoyam setts planted in kg

X_5 = Depreciation on capital inputs (in naira)

β_0 = intercept.

β_1 -β_5 = coefficients estimated

(b) Determinants of Technical Efficiency: In order to determine factors contributing to the observed technical efficiency in cocoyam production, 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 (Coelli, 1996).

$$TEi := ao + a_1Z_1 + a_2Z_2 + a_3Z_3 + a_4Z_4 + a_5Z_5 + a_6Z_6 + a_7Z_7 + a_8Z_8 + a_9Z_9 \ \ldots\ldots \qquad (3)$$

Where TEi, is the technical efficiency of the i-th farmer, Z_1 is farmers age in years, Z_2 is farmers level of education in years, Z_3 is the number of extension contacts made by the farmer in the year, Z_4 is household size, Z_5 is farm size in hectares , Z_6 is farmer's farming experience in years, Z_7 is fertilizer use, a dummy variable which takes the value of unity for fertilizer use and zero otherwise, Z_8 is credit access, a dummy variable which takes the value of unity if the farmer has access to credit and zero otherwise, Z_9 is membership of farmers associations/cooperative societies, a dummy variable which takes the value of unity for members and zero otherwise while $a_0, a_1, a_2 \ldots . a_9$ are regression parameters to be estimated. We expect a_2, a_3, a_5, a_6, a_7, a_8 and a_9 to be positive and a_1 and a_4 negative.

(c) Analysis of variance (ANOVA) was carried out to test for significant differences among zones.

Results and Discussion

Socio-Economic Characteristics

Table 1 shows the frequency distribution of respondents according to sex, age, education, farming experience, farm size and house hold size. Seventy four percent of the respondents were females while 31% consist of males. This implies that women constitute a greater percentage of those involved in cocoyam production in Anambra State. More than 50 percent of the farmers constitute of those that have attained the age of fifty years and above. Cocoyam production is less laborious than other root and tuber crops and does not require a lot of physical strength. A total of 62.5 percent therefore had very low level of formal training. This implies that the study area is largely dominated by illiterate farmers. Educated farmers are expected to be more receptive to improved farming techniques (Okoye *et al*, 2004).

About 12.5% of the respondents had less than 5 years of farming experience while 87.5% had more than 5 years of farming experience. The mean farming experience was 13 years, with an average of 13 years faming experience farmers are therefore described as experienced and are expected to have higher efficiency. Nwaru (1993) reported that farmers count more on their experience than educational attainment in order to increase on their productivity. Forty eight of the respondents have cocoyam holdings of less than 0.1ha. This implies that cocoyam production in the study area is dominated by small-scale producers given the average farm size of 0.27ha for the area. The data on Table 1 also depicts that a large percentage (98%) of the respondents have household sizes of 5 persons and above while less than 2% have household size of less than 5 persons. Effiong (2005) and Idiong (2005) reported that a relatively large household size enhances the availability of labour though large household sizes may not guarantee for increased efficiency since family labour which comprises mostly children of school age are always in school.

Estimation of Technical Efficiency

Table 2 shows that the estimate of the variance parameter (σ^2) was significantly different from zero indicating a good fit and the correctness of the distributional assumption specified. The variance ratio (γ) which was significantly different from zero showed that the farm specific variability contributed about 25% variation in yield among the respondents, which implies that about 25% of the differences between the observed and maximum production frontier outputs were due to differences in farmer's levels of technical inefficiency and not related to random variability. These factors are under the control of the farm and the influence of which can be reduced to enhance technical efficiency of the cocoyam producers. The coefficients of the variables are important in the analysis of data.

As expected, the signs of the slope coefficients of the stochastic frontier were all positive. This implies that any increase in the variables whose coefficient was positive would lead to increase in output which agrees with a priori expectations. Labour has the highest coefficient of 0.56 followed by farm size at 0.16 and fertilizer at 0.045, being significant at 5%.

Determinants of Technical Efficiency

In the analysis of the determinants of technical efficiency as presented in table 2, coefficient for age was negative and significantly related to technical efficiency, which agrees with a priori expectation at 5.0% level of probability. This implies that increasing age would lead to decreased technical efficiency. Ageing farmers would be less energetic to work, leading to low productivity as well as low technical efficiency, this is in line with the findings of Ajibefun and Daramola (2003) and Ajibefun and Aderionla (2004).

Farm size had a negative coefficient and highly significant at 5% level of probability. This result contrasts from those of Onyenweaku and Effiong, (2005), Onyenweaku and Nwaru (2005), and Onyenweaku, Igwe and Mbanasor (2004). This may be attributed to the ageing number of people who are involved in the production of cocoyam because cocoyam productivity declined with age. If the farm size is small, they are able to combine their resources better. Following Hazarika and Subramanian (1999) in their study on tea.

The coefficient for level of experience was positive and significant at 5% level of probability. This also confirms a priori expectations, more experienced farmers are expected to have higher level of technical efficiency than farmers with lower farming experience This result agrees with the findings of Onyenweaku and Effiong, (2005), Onyenweaku and Nwaru (2005), Onyenweaku, Igwe and Mbanasor (2004) and Kalirajan (1981) in India.

Access to credit also had a positive coefficient at 5.0% level of significance which confirms a priori expectation.

Estimation and Analysis of Efficiency differences among Zones:

Table 3 presents the technical efficiency values and their means for Onitsha, Aguata and Awka Agricultural Zones for cocoyam production. In the Onitsha zone, the computed technical efficiency varies between 0.81 and 0.98, with a mean value of 0.91. In Aguata zone, the computed technical efficiency varies between 0.47 and 0.98, with a mean value of 0.76. In Awka zone, the computed technical efficiency varies between 0.77 and 0.98, with a mean value of 0.91. The result shows that the highest mean technical efficiency comes from Onitsha and Awka zones. The test of significance using ANOVA is shown in Table 4. The F-statistic was computed in order to indicate if there are significant differences between the technical efficiency estimates across zones. The result shows that there were significant differences between the three agricultural zones studied in the State.

Conclusion

The study revealed that cocoyam farmers in Anambra State are predominantly women majority of who are aged with little or no basic education. All factors directly related to technical efficiency call for policies aimed at incorporation of all the significant variables especially policies that would encourage farmers to allocate the bulk of their landholdings to cocoyam production as well as women’s access to production inputs.

Table 1: Distribution of Cocoyam Farmers According to their Sex, Age, Education, Farming experience, Farm size and Household size

Variable	Frequency	Percentage (%)
Sex		
Male	31	25.83
Female	89	74.20
Total	120	100
Age (in years)		
24-29	5	4.16
30-35	6	5.00
36-40	11	9.17
41-45	14	11.17
46-50	17	14.17
>50	67	55.83
Total	120	100
Mean	50(yrs)	
Educational level		
No Schooling	54	45.00
Primary	21	17.50
Secondary	31	25.83
Tertiary	14	11.70
Total	120	100
Mean	6.3(yrs)	
Farming Experience (yrs)		
< 5	15	12.5
5-10	48	40
11-16	17	14.17
17-22	20	16.6
>22	20	16.6
Total	120	100
Mean	13.35 (yrs)	
Farm size(ha)		
0.01 – 0.05	54	45.00
S0.06-0.10	3	2.50
0.20-0.60	52	43.20
0.70-1.00	9	7.50
1ha and above	2	1.70
Total	120	100
Mean	0.27(ha)	
Household Size		
2-4	2	1.67
5-7	23	19.17
8-10	7	5.83
11-13	16	13.33
>13	72	60.00
Total	120	100
Mean	12(persons)	

Source: Field Survey, 2005

Table 2: Maximum likelihood Estimation of the Cobb-Douglas Stochastic Production Function

Production factors	Parameter	Coefficient	Standard Error	t-value
Constant term	β_o	4.8534	0.4421	10.9767**
Farm size	β_1	0.1626	0.0608	2.6747**
Labour	β_2	0.5630	0.0863	6.5256**
Fertilizer	β_3	0.0452	0.0204	2.2134**
Setts	β_4	0.0872	0.0510	1.7100
Depreciation	β_5	0.0448	0.0468	0.9609
Efficiency factors				
Constant term	α_0	0.4527	0.2512	1.8019
Age	α_1	-0.0148	0.0061	-2.4376**
Levels of Education	α_2	-0.0133	0.0130	-1.0276
Extension visit	α_3	-0.0092	0.0300	-0.3065
Family size	α_4	0.0086	0.0153	0.5621
Farm size	α_5	-0.9595	0.3653	-2.6267**
Farm Experiences	α_6	0.0174	0.0067	2.5902**
Fertilizer use	α_7	0.02343	0.1354	1.7296
Credit Access	α_8	0.2730	0.1258	2.1769**
Membership of coop. societies	α_9	-0.0653	0.9753	-0.6693
Diagnostic statistics				
Total Variance	σ^2	0.0835	0.0094	8.9140**
Variance Ratio	γ	0.2511	0.1502	1.6718
LR Test		16.6180		
Log-Likelihood Function		-5.7863		

Source: Computed from frontier 4.1 MLE/Survey data, 2005

Table 3: Estimates of technical efficiency values among zones.

Technical Efficiency values among zones			
	ONITSHA	**AGUATA**	**AWKA**
Mean	0.91	0.76	0.91
Minimum	0.98	0.47	0.77
Maximum	0.81	0.98	0.98

Source: Computed from output of computer programme frontier 4.1 by (Coelli, 1996)

Table 4: Test of significant differences in technical efficiencies among zones.

Source of Variation(Technical)	Sum of Squares	Degrees of Freedom	Mean Square	F-stat
Between groups				
	10,770	(3-1)=2	5,385	
Within groups				
	1,889	(120-3)=117	16.14	333.6
Total	12,656	(120-1)=119		

REFERENCES

Asumugha, G. N and Mbanaso, E. N. A. (2002). An assessment of the Cost Effectiveness of Farm Gate Cocoyam processing into Frizzles. In Agriculture, a basis for poverty eradication and conflict resolution. Proc. of the 36th Annual Conference of Agric. Soc. Of Nig. FUTO, Owerri, Imo State, Nigeria: 94-97

Awoke, M.U. and Okorji, E.C (2003) Analysis of constraints in Resource use efficiency in multiple cropping system by small-holder farmers in Ebonyi State of Nigeria. Global Journal of Agric Science 2(2): 132-136.

Bhuyan, R. P and Hazarika, C. (1997) An Analysis of Growth and Instability in Tea Production in Assam. Journal of Interacademicia, Vol. 1. No. 3 pp 248-254.

Effiong, E.O. (2005) Efficiency of Production in Selected Livestock Enterprises in Akwa-Ibom State, Nigeria. Unpublished Ph.D Dissertation. Department of Agricultural Economics, Michael Okpara University of Agriculture, Umudike.

FAO Statistics (2006) Data base Results (Website)

Hazarika, C and Subramanian, S.R. (1999) Estimation of Technical Efficiency in the Stochastic Frontier Production Function Model – An Application to the Tea Industry in Assam.

Idiong, I.C. (2005) Evaluation of Technical, Allocative and Economic Efficiencies in Rice Production Systems in Cross River State, Nigeria. An unpublished Ph.D Thesis, Univ. of Ibadan, Nigeria.

in Nigeria, Production, Processing and Utilization, NRCRI Umudike.

Johnson, D.T. (1982). The Business of Farming. A guide to farm Business Management in the Tropics. Macmillan: 200-204.

Mbanaso, E.N.A and Enyinnaya, A.M. (1989) Cocoyam germplasm conservation. NRCRI Annual Report:60.

Nkematu, J.A., (2000) Anambra State ADP Extension Service Report for 1999. In: Proc. Of the 14th Annual Farming Systems Research and Extension Workshop in SE Nigeria, 9-12 Nov. 1999: 100-105.

Nwagbo, E.C., Okorji, E.C and Ugwu, D. (1987) Cocoyam and the food crop economy of Anambra State: A case study of two major producing areas of Anambra State In: Arene, O.B., Ene, L.S.O., Odurukwe, S.O. and Ezeh, N.O.A (eds) Cocoyam in Nigeria. Proceedings of the 1st Nat. Workshop in Cocoyam, NRCRI Umudike: 101-112.

Nwaru, J. C. (1993) A comparison of the Allocative Efficiency of Co-operative and non Co-operative Farms in Food Crop Production in Imo State Nigeria. An Unpublished M.Sc Thesis, Federal Univ. of Tech. Owerri, Nig.

Okorji, E. C. (1988) Strategies for Effective Credit Administration: A case Study of Arable Crop Production in The Abakaliki Agricultural Zone of Anambra State, Nigeria. Journal of Rural Development and Cooperatives, Vol. 1, No. 4

Okoye, B. C., Okorji, E. C and Asumugha, G. N (2004) Outlook on Production Economics of Paddy Rice under Resource constraints in Ebonyi State. Proc. of the 38th Annual conference of the Agricultural Society of Nigeria. (ASN), 17- 21 Oct. 2004, Lafia Nasarawa State. Pp 337-342.

Onyenweaku, C. E. and Ezeh, N. O. A (1987) Trends in Production, Area and
Pp 94 - 100
Productivity of Cocoyams in Nigeria 1960/61 – 1981/84: In Cocoyams

Purseglove, J.W. (1972) Araceas – In Tropical Crops: Monocotyledons. Longman, Essex, UK 58-74.

Zuhair, M and Hunter, D.G. (2000) Taro cultivation and use in the Maldives. 1PGRI session. 12th symp of ISTRC; Tsukuba Japan: 97.