Technical Efficiency of Small-Holder Cocoyam Farmers in Anambra State, Nigeria: Implications for Agricultural Extension Policy

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TECHNICAL EFFICIENCY OF SMALL-HOLDER COCOYAM FARMERS IN ANAMBRA STATE, NIGERIA: IMPLICATIONS FOR AGRICULTURAL EXTENSION POLICY

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ABSTRACT

This study employed the Cobb-Douglas stochastic frontier production function to measure the level of technical efficiency 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 and from them 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 result of the analysis shows that individual farm level technical efficiency was about 95%. The study found education and farming experience to be positively and significantly related to technical efficiency at 1% while practice index, fertilizer use and membership of cooperative societies also had a direct relationship with technical efficiency and were significant at 5% level. Age and farm size had an indirect relationship with technical efficiency and was significant at 1% and 5% level respectively. There were no significant relationship between technical efficiency and knowledge index, credit access and family size. Expected increases in agriculture require increase in agricultural productivity. In other words, agricultural productivity very much depends on the efficiency of the production process. Hence, policies designed to educate people through proper agricultural extension services will have a great impact in increasing the level of efficiency and hence agricultural productivity of these farmers.

Key words: Technical Efficiency, Stochastic Frontier Production Function and Extension Service.

Introduction

Root and tuber crops which are among the most important groups of staple foods in many tropical African countries (Osagie, 1998) consistute the largest source of calories for the Nigeria population (Olaniyan *et. al,*. 2001). Cassava (*Manihot esculenta*) is the most important of these crops in terms of total production, followed by yam (*Dioscorea spp*), cocoyam (*Colocasia spp* and *Xanthosoma spp*) and sweet potato (*Ipomoea batatas*) (Olaniyan *et. al.*, 2001). Cocoyam which ranks third in importance and extent of production after yam and cassava is of major economic value in Nigeria (Udealor, *et al*., 1996). Edible cocoyam cultivated in the country is essentially species of *Colocasia* (taro) (Howeler *et. al*., 1993) and *Xanthosoma* (tannia). Currently Nigeria is the world's largest producer of cocoyam; however, most of the production comes from the southeastern part of the country. The average production figure for Nigeria is 5, 068,000mt which accounts for about 37% of total world output of cocoyam (FAO, 2006).

Small scale farmers, especially women who operate within the subsistence economy grow most of the cocoyam in Nigeria. Nutritionally, cocoyam is superior to cassava and yam in the possession of higher protein, mineral and vitamin contents in addition to having a more digestible starch (Parkinson, 1984, Splitstoesser *et al.,* 1973).It is highly recommended for diabetic patients, the aged, children with allergy and for other persons with intestinal disorders (Plucknet, 1970). According to Ene (1992) boiled cocoyam corms and cormels are peeled, cut up, dried and stored or milled into flour. The flour can be used for soups, biscuits, bread and puddings for bevearages. The peels can also be utilized as feed for ruminants.

Despite the importance of cocoyam, more research attention has been given to cassava and yam (IITA, 1992; Tambe, 1995). Skott *et. al.* (2000) observed that research on cocoyam has trailed behind that of other staples in Nigeria and other countries. Ezedinma (1987) had eariler noted that the totality of published scientific work on cocoyam is insignificant when compared with those of rice, maize, yam and cassava. However, Skott *et. al.* (2000) asserted that it was only in the last decade that policy makers and national agricultural research systems began to show systematic interest in the crop because of concern over biodiversity. There is a declining trend in cocoyam production as well as a shortage of its supply in domestic markets as a result of a number of technical, socio-economic and institutional constraints, which need to be addressed.

According to Ayichi and Madukwe (1996) the effort of the Federal Government of Nigeria to address these problems was articulated and instiutionalized through the formation of the public extension system (Agricultural Development Programme) in every state. The role of agricultural extension in identifying, adapting and sharing technologies that are appropriate to the needs of individual farmers within diverse agro-ecological and socioeconomic contexts can not be overemphasized. Government uses extension as a support service as well as a policy instrument for influencing farmers' behaviour to achieve its policy goals. The central objective of the public extension system is to raise the incomes of the small holder farmers through increased productivity. However, one of the major problems of the agricultural system is the inadequate knowledge of farmers' production situations and technical efficiency levels. Hence, technical efficiency measurement of the activities of farmers engaged in agriculture has been a major challenge to extension workers and researchers in Nigeria. Empirical studies in developing countries suggest that farmers are unable to utilize maximum potentiality of technology due to their management capacity. Technical efficiency here refers to the ability to produce the highest level of output with a given bundle of resources.

This study therefore, sought to to assess the technical efficiency of cocoyam farmers and to identify the underlying factors influencing the technical efficiency of farmers, using the stochastic frontier Cobb-Douglas production function.

Methodology

The Theoretical Model

A stochastic frontier production function is defined by:

$$Yi = f(Xi;\beta) \exp (Vi-Ui), \quad i = 1,2 \ldots.n \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots.. (1)$$

Where Yi is output of the i-th farm, Xi is the vector of input quantities used by the i-th farm, β is a vector of unknown parameters to be estimated, f( ) represents an appropriate function (e.g Cobb Douglas, translog, etc). The term Vi is a symmetric error, which accounts for random variations in output due to factors beyond the control of the farmer e.g. weather, disease outbreaks, measurements errors, etc. The term Ui is a non negative random variable representing inefficiency in production relative to the stochastic frontier. The random error Vi is assumed to be independently and identically distributed as $N(o, \sigma_v^2)$ random variables independent of the Uis which are assumed to be non negative truncation of the $N(o,\sigma_u^2)$ distribution (i.e. half-normal distribution) or have exponential distribution.

This stochastic frontier model was independently proposed by Aigner, *et al.*, (1977) and Meeusen and van den Broeck (1977). The major advantage of this method is that it provides numerical measures of technical efficiency. 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.

Technical efficiency (TE) = Yi/Yi*

$= f(Xi;\beta) \exp(Vi-Ui) / f(Xi,\beta) \exp(Vi) = \exp(-Ui)$ …………………………………….. (2)

Where Yi is the observed output and Yi* is the frontier output. The parameters of the stochastic frontier production function are estimated using the maximum likelihood method.

Analytical Framework

For this study, the production technology of cocoyam farmers in Anambra State, Nigeria is assumed to be specified by the Cobb-Douglas frontier production function defined as follows:

$\ln Y_i = \beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta_5 \ln X_5 + \beta_6 \ln X_6 + e$ …....…… (3)

Where Q is output of cocoyam in kg.; X_1 is farm size in hectares; X_2 is labour input in mandays; X_3 is fertilizer input in kg; X_4 is cocoyam setts planted in kg; X_5 is capital input in naira made up of depreciation charges on farm tools and equipment, interest on borrowed capital and rent on land; X_6 is other inputs in Naira, $b_0, b_1, .. b_6$ are regression parameters to be estimated while Vi and Ui are as defined earlier. In addition, Ui is assumed in this study to follow a half normal distribution as is done in most frontier production literature.

Determinants of Technical Efficiency

Identifying the determinants of efficiency is a major task in efficiency analysis. 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).

$TEi := ao+a_1Z_1+a_2Z_2+a_3Z_3+a_4Z_4+a_5Z_5+a_6Z_6+a_7Z_7+a_8Z_8+a_9Z_9$ …… ……………………...(4)

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 knowledge index (about extension services); Z_4 is the practice index (technologies adopted); 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; Z_{10} is family size; while $a_0,a_1,a_2….a_{10}$ are regression parameters to be estimated. We expect a_2, a_3, a_4, a_5, a_6, a_7, a_8, a_9 and to be positive and a_1 and a_{10} negative.

Study Site and Sampling Procedure

Anambra State in one of the 36 states of Nigeria and is located in the South Eastern zone of the country. It was created in 1991 with a population figure of 4.182 million people (NPC, 2006) and a land mass of 4415.54 square kilometers, (Nkematu, 2000). The state is divided into four agricultural zones of Aguata, Anambra, Awka and Onitsha and is further delineated into 24 extension blocks. Farming is the predominant occupation of the people, majority of who are small holders. The major available crops are yam, cassava, rice, maize, cocoyam, cowpea, tomatoes and vegetables, while the livestock produced in the state include poultry, sheep, goats and to some extent pig.

Both purposive and multi-stage random sampling techniques were employed in selecting the sample for this study. In the first stage, three out of the four agricultural zones were purposively selected on the basis of the intensity of cocoyam production. The selected zones were Aguata, Awka and Onitsha. In the second stage, two extension blocks were randomly selected from each agricultural zone (Aguata and Nnewi North from Aguata zone, Awka North and Anaocha from Awka zone as well as Idemili North and Ihiala from Onitsha zone), giving a total of six blocks. In the third stage, 2 circles were randomly selected from each block, giving a total of 12 extension circles. Finally, 10 farmers were randomly selected from each circle for detailed study, giving a total sample size of 120 farmers for the study. Data were collected by means of structured questionnaire on the socio-economic characteristics of the farmers, and their production activities in terms of input, output, and their prices for the year 2005 using the cost-route approach.

Results and Discussion

Average Statistics of Cocoyam Farmers

The average statistics of the sampled cocoyam farmers are presented in Table 1. On the average, a typical cocoyam farmer in the state was 50 years old, with 4 years of education, 13 years of farming experience and an average household size of 12 persons. The average cocoyam farmer cultivated 0.27 ha, used about 21.74kg of fertilizer and 250kg of cocoyam setts and spent about ₦2405 on capital inputs. The table further shows that an average cocoyam farmer in the state employed 41.8 mandays of labour and produced an output of 1691kg of cocoyam per annum. Cocoyam production in the state is a female dominated occupation as about 74% of the farmers were females. Skott *et. al.*, (2000) also reported that cocoyam is a woman's crop.

Table 1: Average Statistics of Cocoyam Farmers in Anambra State, Nigeria.

S/No	Variables	Mean Value	Maximum Value	Minimum Value
1	Farm size (ha)	0.27	1.50	0.01
2	Labour (mandays)	41.80	141.3	5.76
3	Fertilizer input (kg)	21.74	96.4	0.00
4	Cocoyam setts (kg)	250.25	250.25	50.00
5	Capital input (₦)	2405.10	11300.00	176.00
6	Age (yrs)	50.00	75.00	24.00
7	Education (yrs)	4.00	10.00	0.00
8	Farming Experience (yrs)	13.00	50.00	3.00
9	Household size (No)	12.00	18.00	4.00
10	Output (kg)	1691.00	10907.00	68.00
11	Other inputs (₦)	111.86	750.00	0.00
12	Female farmers (%)		74.00	

Source: Survey data, 2005

Estimated Production Function

The Maximum Likelihood (ML) estimates of the Cobb-Douglas stochastic frontier production parameters for cocoyam are presented in Table 2. The coefficients of farm size, labour, fertilizer and cocoyam setts have the desired positive signs and are statistically significant at 1% showing direct relationship with output. This implies that a 1% increase in any of these variables would increase farm size, labour, fertilizer and cocoyam setts by 0.3106%, 0.3312%, 0.0905% and 0.2114% respectively, the coefficients for capital and manure were positive but not statistically significant even at 10% level.

The estimated variance (σ^2) is statistically significant at 90% 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 cocoyam output. Gamma (γ) is estimated at 0.4264 and is statistically significant at 1% indicating that only 42.64% of the total variation in cocoyam output is due to technical inefficiency.

Table 2: Estimated Cobb-Douglas Stochastic Frontier Production Function for Cocoyam in Anambra State, Nigeria

Variables	Parameters	Coefficients	Standard Error	t-value
Production factors				
Constant term	β_o	10.4652	0.1113	94.0270***
Farm size	β_1	0.3106	0.0488	6.3647***
Labour	β_2	0.3312	0.1016	3.2598***
Fertilizer	β_3	0.0905	0.0339	2.6670***
Cocoyam Setts	β_4	0.2114	0.0733	2.8840***
Depreciation	β_5	0.0358	0.0231	1.5498
Manure	β_6	0.1635	0.1156	1.4144
Efficiency factors				
Constant term	α_0	3.8472	0.5821	6.6092***
Age		-0.8974	0.1709	-5.2510***
Levels of Education	α_2	2.7804	0.7697	3.6123***
Knowledge index	α_3	0.0292	0.4583	0.0637
Practice index	α_4	0.0175	0.0084	2.0833**
Farm size	α_5	-0.0037	0.0016	-2.3125**
Farm Experiences	α_6	0.7009	0.2317	3.0250***
Fertilizer use	α_7	0.6011	0.2355	2.5524**
Credit Access	α_8	0.0271	0.0614	0.4215
Membership of coop. societies	α_9	0.0728	0.0343	2.1224**
Family size	α_{10}	0.8523	0.6058	1.4068
Diagnostic statistics				
Total Variance (Sigma squared)	σ^2	0.9092	0.2537	3.5837***
Variance Ratio (Gamma))	γ	0.4264	0.1169	3.6475***
LR Test		27.1344		
Log-Likelihood Function		-8.4718		

Source: Computed from frontier 4.1 MLE results/Surveys data, 2005, * and ** are significant levels at 1.0% and 5.0%.**

The frequency distribution of technical efficiency in cocoyam production is presented in Table 3. Individual technical efficiency indices range between 65.04% and 97.31% with a mean of 95.15%. About 93.3% of the cocoyam farmers had technical efficiency indices of above 80%. The high levels of technical efficiency obtained in this study are consistent with the low variance of the farm effects.

Table 3: Frequency Distribution of Technical Efficiency in Cocoyam Production in Anambra State Nigeria 2005

Technical Efficiency Range(%)	**Frequency**	**Relative Frequency**
≤60	0	0
61-70	4	33.3
71-80	6	5.00
81-90	17	14.17
91-100	93	77.50
Total	**120**	**1000**

Mean technical efficiency	95.15
Minimum technical efficiency	57.23%
Maximum technical efficiency	97.31%

Source: Field Survey, 2005

Sources of Technical Efficiency

The estimated determinants of technical efficiency in cocoyam production as presented in Table 2 shows that age had a negative and significant effect on efficiency, which agrees with a priori expectation at 1.0% level of probability. This implies that increasing age would lead to increased technical inefficiency. 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). The results show that educational level of a farmer, and practices of cocoyam technologies (practical index) have positive and significant impact on technical efficiency at 1% and 5% level respectively. This indicates that farm level technical efficiency can be increased by additional investment in education including schooling and training/orientation. Farmer's knowledge index about the available crop technologies as well as access to credit had a positive relationship with technical efficiency but was not significant. The coefficient for level of experience was positive and significant at 1% level. In other words, more experienced farmers are expected to have higher levels of technical efficiency than farmers with lower farming experience.

The coefficient of farm size is negative and statistically significant at 5% indicating an indirect relationship between farm size and technical efficiency. Lau and Yotopoulos (1971) found out that smaller farms were economically more efficient than larger farms within the range of output studied. If farm size is small, farmers are able to combine their resources better (Hazarika and Subramanian, 1999). The coefficient of fertilizer use is also positive and statistically significant at 5% showing a direct relationship between fertilizer use and technical efficiency. Fertilizer, an improved technology, shifts the production frontier upwards leading to higher technical efficiency. This result is consistent with the findings of Hussain (1989). The coefficient of membership of farmers' associations / cooperative societies is positive and statistically significant at 5% showing a direct relationship between membership of farmers' associations/cooperative societies and technical efficiency. Members of farmers' associations or cooperative societies have more access to agricultural information, credit and other production inputs as well as more enhanced ability to adopt innovations than non-members. However, family size has a direct relationship with technical efficiency but was not significant.

CONCLUSION

The results of this study indicate that technical efficiency in cocoyam production in Anambra State, Nigeria is relatively high. Individual levels of technical efficiency range between 57.23% and 97.31% with a mean of 95.15%, suggesting that opportunities still exist for increasing productivity and income of cocoyam farmers in the state by increasing the efficiency with which resources are used at the farm level. Important factors directly related to technical efficiency are age, education, practical index, farm size, years of experience, fertilizer use and membership of farmers' associations/cooperative societies. These results call for policies aimed at encouraging the youths who are agile and stronger to grow cocoyam. There is need to improve farmers' access to fertilizer, extension contact and membership of farmers' associations/cooperative societies as measures for increasing technical efficiency in the study area. Technical efficiency can be further improved through provision of training/orientation to the farmers, especially toward farming practices. Women play a significant role in cocoyam production in the study area. Therefore agricultural extension policies designed to improve women access to land, fertilizer, credit, agricultural extension services, new technologies, more education especially to the girl child, will be crucial in increasing technical efficiency. The need to involve farmers more in the extension process itself should be encouraged.

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