Analysis of the Technical Efficiency of Small-holder Cocoyam Farms in Ondo State, Nigeria

O.I. Baruwa[1]* & J.T.O. Oke[1]

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Summary

This study carried out an analysis of the technical efficiency of cocoyam production among small scale farmers in Ondo State, Nigeria, and identified some socio-economic factors, which influence productive efficiency. The data used were generated from a farm survey involving fifty cocoyam farmers using combinations of purposive and random sampling techniques. Descriptive statistics, stochastic production frontier model as well as inefficiency model were applied to primary data. A Cobb Douglas production function was used to represent the production frontier of the cocoyam farms. The results indicate that the technical efficiencies of the farmers was found to be fairly high with a mean of 84.3% which suggests that average cocoyam output falls 15.7% short of the maximum possible level. The study further observed that only education was positively correlated and significantly influenced the level of technical efficiency of the farmers while increase in the other socio-economic variables, household size, off-farm income, access to credit and farming experience led to decrease in technical efficiency.

Résumé

Analyse de l'efficacité technique des fermes du taro à l'échelle faible dans l'état d'Ondo, Nigeria

Cette étude a effectué une analyse de l'efficacité technique de production du taro chez les agriculteurs familiaux dans l'état d'Ondo, Nigeria, et identifié certains facteurs socio-économiques, qui influencent l'efficacité productive. Les données utilisées ont été générées d'une enquête sur les exploitations impliquant une cinquante d'agriculteurs de taro utilisant des combinaisons de techniques d'échantillonnage téléologique et aléatoire. Les statistiques descriptives, le modèle de production stochastique frontière ainsi qu'inefficacité modèle ont été appliquées à des données primaires. Une fonction de production de Cobb Douglas a été utilisée pour représenter la frontière de la production des fermes taros. Les résultats indiquent que les gains en efficience technique des agriculteurs s'est avéré pour être assez élevée avec une moyenne de 84,3%; ce qui suggère que la production moyenne des taros tombe 15,7% de la teneur maximale possible. L'étude a également noté que seul l'éducation était positivement corrélée et influençait de façon significative le niveau d'efficacité technique des agriculteurs. Pour les autres variables socio-économiques, ménage, hors ferme revenu, accès au crédit et expérience d'agriculture conduisent à diminuer l'efficacité technique.

Introduction

Cocoyam ranks third in importance after cassava and yam among the root and tuber crops cultivated and consumed in Nigeria (15). Currently, Nigeria is the world's leading produces of cocoyam, accounting for up to 3.7 million metric tonnes annually (10). This accounted for about 40 percent of total world output of cocoyam (4). Nutritionally cocoyam is superior to cassava and yam in the possession of higher protein, mineral and vitamin contents, the starch is also more readily digested (14, 12). The food energy yield of cocoyam per unit land area is high (12). It could therefore be a potential source of staple food for rural poor households if resources are properly harnessed in its production. In spite of the advantages of cocoyam production, the cultivation is not encouraging as the yield/hectare is low (16). Onwueme (11) noted that the global average yield is only about 6,000 kg/ha. The ignorance of the nutritive value and diversities of the food form from cocoyam by a large percentage of the populace is a major limiting factor to general acceptability and extensive production of the crop (10).

Research and development in cocoyam production have been meagre compared with other tropical root crops. Clearly if cocoyam is to play a role as a potential source of staple food for rural poor households, new ways of expanding the output in an economically sustainable manner need to be defined. In this context, increasing productivity at the farm level stands as an option because it has potential to generate output growth without increasing quantities of inputs generating negative environmental externalities (13). Productivity growth can be achieved

[1]Department of Agricultural Economics, Obafemi Awolowo University, Ile-Ife, Nigeria.
*Correspondence: E-mail: aragbon2005@yahoo.co.uk
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Table 1
Summary statistics of variables

S/N	Variable	Minimum value	Maximum value	Mean value
1	Farm size (Ha)	0.5	6.0	2.01
2	Age (Yrs)	23.0	56.0	37.98
3	Education (Yrs)	12.0	18.0	15.43
4	Farming experience (Yrs)	2.0	19.0	5.79
5	Household size	5.0	18.0	11.0

Source: Data analysis, 2010.

Farmers' ages varied between 23 and 56 years. The mean age was 38 years. At this age, farmers had not acquired experience but were energetic to meet the rigours of farming. Level of education is believed to affect the acquisition of technical and managerial skill, which can enhance efficient use of farm resources. The mean years of education was 15 years suggesting that many cocoyam farmers in the study area had tertiary education. The implication of this is that the costs of obtaining new technical and related information by the farmers will be reduced substantially when they can read and understand published materials and simplified farm journals which are increasingly becoming the modern vehicle of disseminating information. Farmers in the study area who had stayed longest in the business started 19 years ago while the youngest entrant into the enterprise entered only 2 years ago. The mean year of experience in cocoyam farming was 6 years. This shows that most of the respondents were new in the business.

Majority of cocoyam farmers were married as expected given that majority of them were older than 36 years. This may have positive effect on the availability of family labour. However the family composition has a bearing on total family capacity measured in man-equivalents (ME). The family labour capacity to some extent determines the availability of family labour for farm work, with larger family size more labour will be readily available at the critical periods of planting and harvesting. The data revealed that the household size of the respondents ranged between family size of five and eighteen persons with an overall average household size of 11, hence more labour will be readily available. The size of household is a good indicator of labour available for farm work in subsistence farming. In many parts of the Sub Sahara Africa the area of land cultivated is decided by the amount of labour family available. If the farmers could get more labour, he could cultivate more land.

The maximum-likelihood (ML) estimates of the stochastic frontier production parameters for cocoyam production are presented in table 2. The estimate of the variance parameter, γ, is significantly different from zero at 5 percent level of significance, which implies that the inefficiency effects are significant in determining the level and variability of output of cocoyam cultivated. The presence of one-sided error component in the specified model is thus confirmed, implying that the ordinary least square estimation would not be an adequate representation of the data. The variance ratio, defined by $\gamma = \sigma_\mu^2 / (\sigma_v^2 + \sigma_\mu^2)$ is estimated to be 0.77, meaning that 77 percent of the discrepancies between observed output from the frontier output is primarily due to factors, which are within the control of the cocoyam growers in the sample under study.

The relative importance of resource inputs is revealed in the production function estimates. Only the coefficient of farm size has the desired positive signs and statistically significant at 0.01 level showing direct relationship with output. This indicates that increase in farm size will increase the output of cocoyam by about 0.9 percent. However, the coefficient of labour (X_1), cocoyam sett (X_2), and other inputs (X_4) are negative. This implies that an increase in labour input, cocoyam sett and other farm inputs will reduce cocoyam output by 0.6, 0.3, and 0.2, respectively and only labour input is statistically significant at 0.05 levels. This may due to small farm size holding per individual which led to under utilization of labour. The statistical non-significance of cocoyam sett and other inputs is probably because majority of the respondents used warehouse inputs not mindful of the quantity used. Using the significant coefficients only, the returns-to-scale (RTS) parameter which is a measure of total resource productivity is estimated to be 0.273, which

Table 2
ML estimates of the stochastic production frontier function in cocoyam production

Variable	Parameter	Coefficient	t-ratio
Constant	β_o	1.853	1.203
Labour input ($\ln X_1$)	β_1	-0.582	-2.272**
Cocoyam sett ($\ln X_2$)	β_2	-0.261	-1.060
Farm size ($\ln X_3$)	β_3	0.855	6.977*
Other inputs ($\ln X_4$)	β_4	-0.220	-1.585
Sum of elasticities		-0.208	
Inefficiency function			
Intercept	δ_0	0.197	0.230
Age	δ_1	-0.009	-0.847
Education	δ_2	-0.099	-2.291**
Household size	δ_3	0.197	0.321
Off-farm income	δ_4	0.0002	0.0003
Access to credit	δ_5	0.752	3.629*
Experience	δ_6	0.0009	0.053
Diagnosis statistics			
Sigma-square ($\sigma^2 = \sigma_v^2 + \sigma_\mu^2$)		0.52	2.54**
Gamma ($\gamma = \sigma_\mu^2 / \sigma^2$)		0.77	2.14**
ln (Likelihood)		-22.78	
LR Test		15.62	
Average Technical efficiency		0.843	

Source: Data analysis, 2010 * Significant at 1%, ** Significant at 5%.

either through technological change (development and adoption of new technologies) or improvement in technical efficiency (ability to obtain maximum output from a given input mix and the existing technology) but the most cost-effective strategy depends on the magnitudes of the inefficiencies (3). When producers are highly efficient, the former is applicable, however if inefficiencies are large the latter is likely the most cost-effective means of raising productivity. This study is therefore designed to provide empirical information on farm level technical efficiency and its determinants among small-scale cocoyam farmers in Ondo State of Nigeria with a view in making recommendations that are feasible in raising the current level of efficiency as technical efficiency is directly related to productivity of the sector.

Efficiency is one of the main factors determining competitiveness. The higher the degree of efficiency the lower will be the unit cost of production and as a result, cocoyam farmers would be able to produce at lower prices. Consequently, more efficient cocoyam farmers would have better chances of surviving and prospering in the future than less efficient ones. Along these lines, analysis of efficiency would provide information about the potential sources of inefficiency. In addition, measures of potential cost savings that can be achieved from improvements in technical and allocative efficiencies could be derived and used by cocoyam farmers as a bench mark to improved competitiveness.

Methodology

The survey was conducted in Ondo West Local Government Area of Ondo State, Nigeria. This Local Government Area (LGA) comprises important cocoyam growing towns namely Ondo township, Bagbe, Oka and Ajue. Combinations of purposive and random sampling techniques were used in selecting cocoyam farmers. The choice of the study area was based on the fact that it has higher number of farmers cultivating cocoyam in the area, while the selection of fifty cocoyam farmers was random. The study is based on cross sectional data collected during the 2009/2010 agricultural production year in the area. Data were collected using a pre-tested, well-structured questionnaire on socio-economic characteristics of the farmers (farm size, age, level of education, and farming experience), quantities and prices of production inputs (wage rate, area under cocoyam cultivation, value of fertilizer used, cocoyam sett) and output (revenue from cocoyam harvested).

Empirical model

In this study, we used a variant of the stochastic frontier production function proposed by Battesse and Coelli (1) which builds hypothesized efficiency determinants into the inefficiency error component so that one can identify focal points for action to bring efficiency to higher levels. A Cobb-Douglas functional form is employed to model the frontier functional form specified for this study. In the explicit form, the frontier production function utilized for this study is as follows:

$$\ln Y= \beta_o + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + V_i - U_i \ldots (1)$$

Where:

ln= Logarithm to base e; Y= Output of cocoyam (kg);
X_1= Farm size (ha);
X_2= Cocoyam sett planted; X_3= Labour input (man-day);
X_4= Fertilizer (kg)
$\beta_1, \beta_2, \beta_3, \beta_4$= Vectors of unknown parameters.
V_i= random error assumed to be independent of U, identical and normally distributed with zero mean and constant variance N (0, σv^2).
U_i= random variable that accounts for technical inefficiency effects which are assumed to be independent of V_i and non-negative truncation at zero or half normal distribution with N (0, σu^2).

$$|U_i|= \delta_0 + \delta_1 Z_1 + \delta_2 Z_2 + \delta_3 Z_3 + \delta 4 Z_4 + \delta_5 Z_5 + \delta_6 Z_6 + \delta_7 Z_7 \ldots (2)$$

Where:

Z_1= Age of farmers (years); Z_2= Formal education (1= formal education; 0= otherwise); Z_3= Farmers' status (1= full time, 0= part time); Z_4 = Household size; Z_5= Off farm income (1= off farm income; 0= otherwise); Z_6= Credit acquisition (Yes= 1; No= 2); Z_7= Experience in cocoyam production (years)

The maximum likelihood estimates for all the parameters of the stochastic frontier and inefficiency model, defined by equations (1) and (2), are simultaneously obtained by using the program, FRONTIER Version 4.1(2), which estimates the variance parameters in terms of the parameterisation:

$$\sigma^2= \sigma_v^2 + \sigma_\mu^2 \ldots\ldots (3)$$

and

$$\gamma= \sigma_\mu^2 / \sigma^2 \ldots\ldots (4)$$

where the γ-parameter has a value between zero and one.

Results and discussion

A summary statistics of the quantitative variables is given in table 1.
Data in table 1 show that the farm size of the respondents ranged between 0.5 and 6.0 hectares of land. The mean farm size was 2.0 hectares of land. From the above observation the majority of the farmers in the study areas were small-scale farmers. Although land was a constraint in some communities, inadequate finance for the acquisition of farm resources inputs and payment for hired labour has been identified as a major constraint to increased agricultural production in most communities where land was not a limiting factor.

indicates that cocoyam production in the study area was in stage three of production curve. Stage three is a region of decreasing returns to scale in the enterprise. This is an inefficient stage because additional inputs add less to total product than the preceding unit of input. As such a 10 percent increase in all specified inputs will lead to less than 10 percent increase in output. This means that cocoyam producers are inefficient at their level of production and their income and output can be improved if less input is utilized. As it is manifestly irrational for anybody to utilize more resources and produce less output, this is an irrational area of production.

A very important characteristic of the stochastic production frontier model is its ability to estimate individual, farm specific technical efficiencies. Table 3 shows the deciles range of the frequency distribution of estimated technical efficiencies in cocoyam production. There is a variation in the levels of efficiency. Predicted technical efficiencies ranged between 43.4 percent and 93.2 percent with the mean technical efficiency of 84.3 percent. The mean level of technical efficiency indicates that on the average, cocoyam output falls 15.7 percent short of the maximum possible level. This means that if the average farmer in the sample was to achieve the technical efficiency level of his most efficient counterpart, then the average farmer could realize a 9.5 percent cost saving [i.e.1-(84.3/93.2)x100]. A similar calculation for the most technically inefficient farmer reveals cost saving of 53.4 percent [i.e., 1-(43.4/93.2) x100].

Table 3
Frequency distribution of technical efficiencies

Efficiency	Frequency	Percentage
< 50	5	10
50< 60	2	4
60< 70	1	2
70< 80	1	2
80< 90	1	2
90< 100	40	80
Total	50	100
Mean technical efficiency	84.3	-
Minimum technical efficiency	43.4	-
Maximum technical efficiency	93.2	-

Source: Data analysis, 2010.

The majority (80%) of the respondents belonged to the most efficient category (90-100) while 10% belonged to the least efficient category (< 50%). This is suggesting that most of the cocoyam farmers were technically efficient given the existing technology.

The explanatory variables included in these models have been commonly used in estimating agricultural production frontiers for developing countries (7, 8, 9). Efficiency difference between farmers could be explained by farm-specific and farmer-specific variables. Such variables include age, household size, level of education, farming experience, access to credit, and off farm income. Empirical results concerning the potential sources of efficiency differentials among sample farms in the estimated model of equation (2) is summarised and presented in table 2. While some of the coefficients of the variables of determinants of efficiency have negative signs, some other variables carry positive signs. Those variables with positive signs implied that they have the effect of increasing the level of technical inefficiency, while variables with negative coefficients have the effect of reducing the level of technical inefficiency. The results show that while age and education have negative influence on technical inefficiency (i.e. they reduce technical inefficiency), household size, off-farm income, access to credit and farming experience have positive effect on technical inefficiency. The sign of the coefficients of the variables in the inefficiency model has important policy implications. For instance, age has negative influence on technical inefficiency, this implied that age reduces technical inefficiency; its insignificance status implies that age is not a critically determinant of technical efficiency. The negative effect of level of education of farmers on technical inefficiency and the significance follows *a priori* expectation, given that education is an important factor in technology adoption. Educated farmers are expected to be more receptive to improved farming techniques and hence make more profitable use of improved agricultural innovations than uneducated farmers. As such, they are expected to have higher level of technical efficiency than farmers with less education or no education.

The sign of the household size, off farm income, access to credit and farming experience have positive signs, thus they have the effect of increasing the level of technical inefficiency. The implication of this result is that large household size would have negative impact on profitability of cocoyam production. This finding agrees with Effiong (5), and Idiong (6) who reported that a relatively large household size enhances the availability of labour though large household sizes may not guarantee increased efficiency since family labour, which comprises mostly children of school age, are always in school and are not available for farming activities in most cases. Where such large family members are available for farming activities, farm size is small for all members to work effectively and hence there is under utilization of labour, which makes the law of diminishing marginal returns to set in. A positive and statistically significance is found between access to credit and technical inefficiency. This indicates that farmers who have access to credit tend to exhibit higher levels of inefficiency. This is contrary to *a priori* expectations that the more credit the farmers use, the more efficient they become. It might be as a result of credit received being misused (or diverted to other uses).

Conclusion

The objective of the study was to analyse the technical efficiency of cocoyam production among small scale farmers in Ondo State, Nigeria. Primary data were collected from fifty cocoyam farmers in Ondo West Local Government Area of the State. The data were analysed using stochastic frontier production function approach. Results of the analysis indicated that the level of technical efficiency varies across farms ranges from 43.4% - 93.2% with a mean of 84.3% suggesting that on the average cocoyam output falls 15.7% short of the maximum possible level. The efficiency level is positively and significantly correlated with the level of education, but unexpectedly negatively and significantly correlated with access to credit. The policy implication of these findings is that inefficiency in cocoyam cultivation can be reduced significantly by improving the level of education among the farmers.

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O.I. Baruwa, Nigeria, PhD, Agricultural Economist, Lecturer in the Department of Agricultural Economics, Obafemi Awolowo University, Ile-Ife, Nigeria.
J.T.O. Oke, Nigeria, PhD. Agricultural Economist, Lecturer in the Department of Agricultural Economics, Obafemi Awolowo University, Ile-Ife, Nigeria.