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An Analysis of Productivity and Technical Efficiency of Smallholder Cocoa Farmers in Nigeria

T. T. Amos

Department of Agricultural Economics and Extension, Federal University of Technology, PMB 704, Akure, 340001. Nigeria
E-mail: ttamos2001@yahoo.com

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ABSTRACT The productivity and technical efficiency involved in cocoa production in Nigeria was estimated using the stochastic frontier production function analysis. The study relied upon primary data generated during the 2003/ 2004 production season. Data were collected through the use of a set of structured questionnaire administered on two hundred and fifty cocoa farmers in five Local Government Areas of Ondo State, Nigeria. Result of the analysis showed that farmers were experiencing increasing returns to scale in the use of the farm resources. The efficiency level ranged between 0.11 and 0.91 with a mean of 0.72. There existed some inefficiency among the sampled farmers. The major contributing factors to efficiency were age of farmers, level of education and family size. The study observed that there was an opportunity for increase in farmers' efficiency and concluded that policies that would directly affect these identified variables should be pursued vigorously.

INTRODUCTION

The cocoa tree known as *Theobroma Cacao* belongs to the family *stericuliniacea*. Cocoa has its gene centre in the upper Amazon region of the South America from where it spread to different parts of the world (Osun, 2001). It is generally believed that cocoa cultivation in Nigeria started about 1879 when a local chief established a plantation at Bonny in the defunct Eastern Nigeria. However, cultivation in the western Nigeria began afterwards. Production has been reducing in recent years as a result of old age of farmers and farms, inefficiency in the use of resources by farmers. The implication of this has been reduced cocoa production at a time when there are more processing industries and the increased demand for Nigerian cocoa as a result of world political instability and the growth in consumption of chocolate the world over.

Cocoa is a concentrated food with high nutritive value. It provides carbohydrate, protein, fat and minerals. Again it is usually used for making beverages, wine chocolate, cream and livestock feed. Nigeria was second largest cocoa producer in the world with about 97% of its total production from the southwestern region. Recently, the trend seems to have changed in the negative with production declining rapidly. The fall in percentage share of cocoa output may be attributable to two reasons. First is the negligence of the agricultural sector by the past administrations due to the discovery of the petroleum resources that now accounts for the enormity of foreign exchange earnings. Second is the endemic problem in the cocoa industry.

The impact of the declining production level is the fall in the income accruing to the farmers. Realization of the potentials of cocoa in the economy of the country, the government set up the defunct cocoa marketing board, which was program scraped as part of the Structural Adjustment (SAP) in 1986. The dissolution of the Commodity Board and the introduction of free market pricing system encouraged farmers who had hitherto abandoned their cocoa farms to embark on rehabilitation and establishing new holdings. Farmers enjoyed high farm-gate prices for their cocoa. Thus young men and women returned to cocoa farming again. This led to the injection of huge amount of money into the subsector. This had significant impact on the economy and socio-political stability of the producing region. The era of commodity trade liberalization has also witnessed unprecedented drawbacks. It led to complete dismantling of all the infrastructures and administrative systems, which facilitated efficient commodity trade. Although the farmers are still enjoying market-determined prices for their commodity, they have lost all the subsidies and support from government as well as stable price development. The debilitating impacts started showing that production output are on the downward trend

and government is paying lip service to ensure an upward upswing. The uncontrolled entry and exit of middlemen and exporters resulted to loss of money at the domestic market, and poor quality of produce and declining output.

The trend must be reversed if farmers' output and thus their income are to be commensurate with the efforts the farmers put into cocoa production.

Research Problem, Motivation and Hypotheses

Empirical evidences suggest that poverty, inefficiency and unemployment are of great concern to policy makers in developing countries. This is particularly relevant against the backdrop of the forecast of the World Bank Development Report (1990), that the sub Saharan African economy will hardly be able to grow faster than the population growth rate. Hunger and malnutrition have reached crisis proportions in much of Africa. About 200 million people are undernourished. Africa is said to be the only region in the world to have experienced a substantial increase in the number of undernourished in the past 30 years. With business as usual, it will be impossible to achieve the Millennium Development Goal of cutting hunger by half in 2015. The growth in the rural sector has been put at 4.0 percent as against 3.0 percent for the urban sector. It is clear that the rural sector consisting of farm families offer great potential for employment generation for the teeming population. However this potential will not be achieved if productivity and efficiency are not increasing within the rural sector. Increasing productivity and efficiency within the agricultural sector particularly among small-scale producers requires a good knowledge of the current efficiency or inefficiency inherent in the sector as well as factors responsible for this level of efficiency or inefficiency.

Nigeria has a great potential for better economic growth both in the short and long run than current experiences. The need to efficiently allocate productive resources for development purposes cannot be overemphasized. In that case, every factor of production should be efficiently and effectively mobilized to reduce the gap between actual and potential national outputs. Therefore any attempt at studying efficient allocation of resources on the farm represents a veritable source of achieving growth in the economy.

The efficient allocation of resources at the farm levels has great implication for overall national development. It will also lead to rise in Gross National Product (GNP) and per capita income will increase. The following reason could be adduced for measuring efficiency on the farm. It is firstly a success indicator, and performance measure. Secondly, it is only by measuring efficiency and separating its effects from the effects of the production environment that one can explore hypotheses concerning the sources of efficiency differentials (Ajibefun and Daramola, 2003). When the sources of inefficiency are identified, policy formulations to improve farmers' performance can be effectively done. Thirdly, the ability to quantify efficiency helps decision-makers monitor the performance of the units under study. In some cases, the use of theory will not give clear picture of the impact of some factors on the performance level. The use of empirical measurement will provide both qualitative and quantitative evidence (Coelli, 1995). Many researchers have been able to show that small farms are desirable not only because they provide a source of reducing rural unemployment, but also because they provide a more equitable distribution of income as well as an effective demand structure for other sectors of the economy (Bravo-Ureta and Evenson, 1994; Domer, 1975). This has lead many researchers to focus attention on the impact of the adoption of new technologies on farm income and productivity (Hayami and Ruttan, 1985; Kuznets, 1966). In developing countries especially Nigeria, there are few farm level studies on efficiency. Few that exist have not focused on cocoa production. Given the importance of cocoa in Nigeria economy, the formulation of policy measures have been hampered by the lack of relevant empirical studies at the farm level in cocoa production. The policy questions therefore are: what is the current farm level efficiency in cocoa production in Nigeria? What factor(s) influence this level of efficiency? The challenge of this study therefore, is to estimate the current level of technical efficiency and the factor(s) influencing this level of efficiency in Nigeria. The result of the study would be useful as a guide to policy formulation and implementation.

The objective of this study, therefore, is to empirically determine the efficiency of cocoa farmers in Nigeria. Specifically the study estimates the productivity and technical efficiency of the farmers; it also identifies and analyses the

determinants of efficiency among the sampled farmers.

The motivation for this study is that cocoa production is important in the economy of Nigeria. The agricultural sector and indeed cocoa production has always been an important component of Nigerian economy. Cocoa production provides revenue for the government of Nigeria through export duties on exported cocoa from the country. It also contributes to aggregate export earnings. Cocoa serves as income to farmers and to many other groups such as processors.

It provides market for the agro-allied industry as well as serves as major employment generation for the teeming population working on the plantations. Finally, by-products of cocoa such as the husk serve as animal feed and raw material for detergent production.

For meaningful results, the following hypotheses were tested.

i. The cocoa farmers are efficient and have no room for efficient growth
ii. No policy variable significantly influences the efficiency of the cocoa farmers in Nigeria.

Cocoa and the Nigerian Economy

To many people, Cocoa is a different thing. To the farmer, it is an important tropical tree for income earning which is used for the upkeep of his family and himself. To the government, it is a premium cash crop whose export provides much needed foreign exchange for financing capital project. It was first introduced to Nigeria in 1892. By 1962, Nigeria has become the world's leading cocoa producer with twenty percent of the world total production. The production level dropped to 16 percent before the end of the 1960s losing her prime position to Brazil and Cameroon. Within two decades, Nigeria's cocoa production capacity has reduced drastically. The major reason being the lack of attention paid to the productive capacity by cocoa farmers who are small-scale farmers. Despite this cocoa remains the leading major foreign exchange earner in the agricultural sector of Nigeria. Through cocoa production, employment opportunities are opened to Nigeria in the different aspects of cocoa production, processing and marketing.

Analytical Framework

This study employs the frontier production function analysis. The use of this tool has gained prominence in econometric and applied economic analysis in the last two decades. Early applications of this tool include those of Aigner et al., 1977. They applied the tool in the analysis of the US agricultural data. Ojo (2004) recently applied the tool in poultry production in Nigeria. Other notable studies recently include those of Battese et al.(1993) Ajibefun and Abdulkadri (1999), Ojo and Ajibefun (2000), Ajibefun and Daramola (2003).

The production frontier can be specified as:

$$Y_i = f(X_i, Á) \exp (V_i - U_i)_i = 1, 2\ldots\ldots, n$$

Where V_i is a random error, which is associated with random factors not under the control of the farmer, while U_i is the inefficiency effects. The model is such that the possible production Y_i is bounded above by stochastic quantity, $f(X_i, Á) \exp (V_i - U_i)$ hence the term stochastic frontier. There are some other assumptions of the model. This include the fact that the random error Vi is assumed to be independent and identically distributed as N $(0,ä^2_v)$ random variables independent of the U_is, which are assumed to be non-negative truncations of the N $(0,ä^2_v)$ distribution (i.e half-normal distribution) or have exponential distribution.

The technical efficiency of an individual farm from the above can be defined in terms of the ratio of the observed output to the corresponding frontier output, given the available technology. The technical efficiency is thus empirically measured by decomposing the deviation into a random component (U) (Ojo, 2004).

In that case,

Technical efficiency (TE) = Y_i/Y^*_i

$= ,f(X, Á) \exp (V_i - U_i) / f(X, Á) \exp (V_i)$

$= \exp (-U_i)$

where Y_i is the observed output and Y^*_i is the frontier output. This is such that $0 \leq TE \leq 1$. The stochastic frontier production function model is established using the maximum likelihood estimation procedure (MLE).

MATERIALS AND METHODS

Study Area: The data for this study were collected through a cross sectional survey of cocoa farmers in Ondo State, Nigeria. The State is one of the 36 States in Nigeria. It is located in the southwestern part of the country. With a population of about 2.2 million (Federal Office of

Statistics, 1996), the State is one of the densely populated States in Nigeria with a land area of 8802 square kilometres. The climate of the area is highly favourable for the agrarian activities of her teeming population who grow crops such as cocoa, kola nut, palm tree and arable crops like maize, yam and cassava. The annual rainfall is between 1000mm and 1500mm with a high daily temperature of about 30 ^{0}C. The vast majority of the population consists of peasant farmers cultivating food and cash crops at a small-scale level. Livestock keeping is a minor occupation of the population of Ondo State dealing on goats, sheep, rabbits and fish farming. Other activities include trading and civil service. The people live mostly in organised settlements, towns, villages and cities. Important towns include Akure (State capital), Ikare, Ondo, Ile Oluji, Ore, Owo and Okitipupa.

***Data Collection*:** The data for this study were primary data collected from 250 cocoa farmers selected from five Local Government Areas (Ondo East, Ondo West, Ile Oluji, Akure south and Odigbo) of Ondo State, Nigeria. The sampling method used was multistage sampling technique. The first stage involved a purposive sampling of the five Local Government Areas based on the population of cocoa farmers in the State. The second stage involved a simple random selection of 50 cocoa farmers from each Local Government Area (LGA). Data were collected with the use of a structured questionnaire designed for collecting information on output, inputs, prices of variables, and some important socio economic variables about the farmers.

Measurement of Variables

***Value of Output**:* This was obtained by adding cash receipts from the sale of cocoa produced by farmers in the 2003/2004 farming season.

Inputs: Inputs were categorized into five namely: Quantity of Fertilizer (kilogram), quantity of fungicide (kilogram), Cost of Weeding (Naira), Cost of Pruning (Naira), Cost of Processing (Naira).

***Socio Economic Characteristics**:* These variables include Age (years), Level of Education (years of formal education), Farm size (hectare), Family size (number in house of farmer), Age of Farm (years since plantation was established). The variables were considered to see their influence on the estimated technical efficiencies of the cocoa farmers.

***Method of Analysis**:* Descriptive statistics including mean, and stochastic production function were used to analyse the socio-economic data generated during the survey. In addition, productivity and Technical efficiency for further analysis of data collected. The production technology of the cocoa farmers is assumed to be specified by the Cobb – Douglas frontier production function (Tadesse and Krishnamoorthy, 1997) that is defined as follows:

$$In\text{Œ}_i = In\ ß_0 + ß_1 InX_{1i} + ß_2 InX_{2i} + ß_3 InX_{3i} + ß_4 InX_{4i} + ß_5 InX_{5i} + V_i - U_i$$

Where

Œ = Value of cocoa produced per hectare

X_1 = Quantity of Fertilizer (kilogram)

X_2 = quantity of fungicide (kilogram)

X_3 = Cost of Weeding (Naira)

X_4 = Cost of Pruning (Naira)

X_5 = Cost of Processing (Naira).

V_I = Random errors as previously defined

U_i = Technical inefficiency effects as previously defined.

The Technical inefficiency effects U_i is defined by

$$U_i = ä_o + ä_1 Z_{1i} + ä_2 Z_{2i} + ä_3 Z_{3i} + ä_4 Z_{4i} + ä_5 Z_{5i}$$

Where: Z_1 to Z_5 represent, Age of farmer, Level of Education of farmer, Farm size, Family size, Age of Farm. These were included in the model to indicate their possible contribution to and influence on technical inefficiencies of the farmers. The ßs, and äs are scalar parameters to be estimated. The variances of the random errors $ä_y^2$ and that of the technical inefficiency effects $ä^2$ are related as follows:

$ä^2 = ä^2_v + ä^2_u$ and the ratio $ã = ä^2_u / ä^2$, measures the total variation of output from the frontier which can be attributed to technical inefficiency (Battesse and Corra, 1997). The estimates for all the parameters of the stochastic frontier production function and the inefficiency model are simultaneously obtained using the program frontier version 4.1 (Coelli, 1994).

For this study, two different models were estimated. The first model is the traditional response function in which the inefficiency effects are not present. It is a special case of the stochastic frontier production function model in which the total variation of output from the frontier output due to technical inefficiency is zero, that is, $ã = 0$. The second model is the general model where there is no restriction and thus $ã \neq 0$.

The two models were compared for the

presence of technical inefficiency effects using the generalized likelihood ratio test which is defined by the test statistics, Chi-square (χ^2) $\chi^2 = -2\ In\{H_o/H_a\}$ Where χ^2 has a mixed chi-square distribution with the degree of freedom equal to the number of parameters excluded in the unrestricted model. H_o is the null hypothesis that $\tilde{a} = 0$. It is given as the value of the likelihood function for the frontier model and H_a is the alternative hypothesis that $\tilde{a} \neq 0$ for the generalized frontier model. The first model was finally excluded since the null hypothesis was rejected. Since the calculated chi-square was significant at 5% level with a value of 6.02.

RESULTS AND DISCUSSION

In this section, the results obtained from data analysis are presented and discussed as outlined below. Three sections are used in the presentation as follows: firstly, the characteristics of the respondents are presented, secondly, the maximum likelihood estimates and efficiency estimates; finally, the determinants of efficiency.

Socio-economic Characteristics of Farmers

From Table 1, the average cocoa farmer is about 56 years old. Thus the farmers are old and should be able to make rational decision about his/her farm operations in Ondo State. They keep an average family size of eight in line with the African tradition of large family size. These family members provide farm hands during peak farming activities, which incidentally coincides with the vacation period (August to September) of school children. The old age of the farmers translated to high farming experience as majority started farming at an early age. This experience is important for day-to-day running of the farming activities, as cocoa cultivation is a very tasking business. The farmers own an average farm size of six hectares. This is scattered in different locations in the locality. This farm size led to an average output of 1348.1kg. This is relatively small compared to potential figures of over two tones obtainable elsewhere. This may be related to the age of the farms as most farms in Ondo State are bedevilled by old age.

Estimates of the Stochastic Frontier Production Function Parameters

The maximum likelihood Estimates for parameters of the frontier model are presented in Table 2. This was used as it gave a high log-likelihood value when compared to the trans-log frontier model. The selection of the Cobb Douglas frontier model has also solved the problem of degrees of freedom normally encountered in the trans-log model.

Form the Table; it could be observed that there was presence of technical inefficiency effects in cocoa production in the study area as confirmed by a test of hypothesis for the presence of inefficiency effects using the generalised likelihood ratio test. The null hypothesis of no inefficiency effect in cocoa production, $g = 0$, was strongly rejected. The estimated sigma parameter (d) show that about 89% of the variation in cocoa production among the farmers was attributable to differences in the efficiencies of cocoa farmers.

Table 1: Summary statistics of respondents' characteristics

Variable	*Mean*
Age (years)	56.2
Family Size (Number)	8
Farming Experience (Years)	30.5
Farm Size (Ha.)	6.0
Quantity of Harvest (kg)	1348.1

Source: Survey data, 2004.

Table 2: Maximum likelihood estimates of the stochastic production function for cocoa production in Ondo State

Variable	*Parameter*	*Coefficient*	*Std. Error*
Constant	β_0	2.025	0.016
Quantity of Fertilizer	β_1	2.805	2.741
Cost of fungicide	β_2	0.668	0.237*
Cost of Weeding	β_3	-1.91	1.371
Cost of Pruning	β_4	-0.335	0.469
Cost of Processing	β_5	0.035	0.003*

Source: Survey data, 2004.
Log-likelihood function = 60.2 g^2 = 2.08* d = 0.89

From Table 2, there was a positive relation ship between the level of output of Cocoa and the quantity of fertilizer used, cost of herbicide, and cost of processing. This scenario is expected as the level of production depends largely on the quantities of these inputs used on the farm. However, this can only be up to a level that is considered optimal after which farmers will be operating at sub optimal level. There was a negative relation ship between the level of output and the cost of weeding and that of pruning. This is quite unexpected but given that there is little weeding and pruning done once the cocoa has been established, it could be acceptable. Cost of processing and fungicide were the major determinants of Cocoa output in the State. Thus, farmers should embark upon policies that will lower these components of cost. Fungicide cost in recent times has been on the increase. This is probably due to the declining value of the naira as the chemical is imported though there is little domestic production of the fungicide in Nigeria. The introduction of some level of subsidies would be appropriate. Also, the issue of adulteration of this chemical is a common occurrence in the state.

Determinants of Technical Efficiency in Cocoa Production

The significant value of the g^2 shows the presence of inefficiency effects in cocoa production in the area. The analysis of the inefficiency model shows that the signs of the estimated coefficients in the inefficiency model have important implications on the TE of cocoa farmers.

From Table 3, Age, Level of Education and Family size are the major determinants of efficiency of Cocoa farmers in the State. While age of farmers and age of farms reduce the efficiency level of cocoa farmers, other variables were observed to increase the efficiency of the farmers. This is plausible given that majority of the farmers are old and may not be willing to try new innovations so are less efficient in the supervision role of their farms. Again, cocoa farms in Ondo State are aging as has been noted by writers. On the other variables, the *a priori* is that TE should increase with increase in years of schooling of the farmers since education and adoption of innovation were expected to be positively correlated. Thus the result is in agreement with the expectation regarding education and output or income of farmers.

Table 3: Determinants of Technical Efficiency

Variables	*Parameter*	*Coefficient*	*Std. error*
Constant	Φ_0	0.124	0.489
Age of farmer	Φ_1	0.024	0.006*
Level of Education	Φ_2	-0.577	0.068*
Farm size	Φ_3	-0.389	0.039
Family size	Φ_4	-0.433	0.012*
Age of Farm	Φ_5	0.020	0.075

Source: Survey data, 2004.

The major reason why farmers keep large family members is for the provision of farm labour during peak production period. Thus, the larger the family member, the more labour is available for faming operations thus increasing the efficiency of farmers.

Technical Efficiency Analysis

From Table 4, the predicted farm specific technical efficiencies (TE) ranged between 0.11 and 0.91. A mean efficiency of the Cocoa farmers was 0.72. Thus, in the short run, there is a scope of increasing cocoa production by about 28% by adopting the technologies and techniques practiced by the best cocoa farmer in the area. Many of the farmers were having efficiency of between 51% and 80%. This is probably due to the long years of farming experience of the farmers. However a few (19%) of the farmers were less than 50% efficient in their production process.

Table 4: Frequency distribution of technical efficiency estimates

Efficiency level	*Frequency*
< 0.1	0
0.11 – 0.20	2
0.21 – 0.30	4
0.31 – 0.40	5
0.41 – 0.50	8
0.51 – 0.60	14
0.61 – 0.70	11
0.71 – 0.80	15
0.81 – 0.90	21
> 0.91	24
Mean	0.72

Source: Survey data, 2004.

Elasticity of Production and Returns to Scale

The elasticity of production shows that farmers were experiencing increasing returns to

scale in cocoa production in the study area with a value of 1.26. However, they can do well by increasing their level of weeding, pruning and processing to increase the production (Table 5). This is because further analysis reveals that cost of fungicide and cost of processing were positive decreasing functions to the factors. This is indicative that variable allocation and use were in the stage of economic relevance of the production function (stage II). Also, the elasticity of cost of weeding and that for pruning was negative decreasing function to the factor indicative of overuse of factors and in stage III. For the pruning, it might be due to the fact that pruning is done year round.

Table 5: Elasticity of production and returns to scale

Variable	*Elasticity*
Quantity of Fertilizer	2.805
Cost of fungicide	0.668
Cost of Weeding	-0.91
Cost of Pruning	-0.335
Cost of Processing	0.035
RTS	1.26

Source: Survey data, 2004.

CONCLUSION AND RECOMMENDATIONS

The study observed that TE of cocoa farmers varied due to the presence of technical ineffi-ciency effects in cocoa production. This shows that there is a great opportunity for farmers to increase their level of efficiency in cocoa pro-duction.

Again, Age, Level of Education and Family size were significant variables greatly influencing TE of cocoa farmers. Therefore education policy that would encourage farmers to be literate would increase the efficiency level of farmers and should be embarked upon by the government.

Finally, since an increase in age would lead to a reduction in efficiency levels in cocoa production, policies that would make the youths to return to the land and take up cocoa farming would yield positive dividends to the Ondo State economy in particular and the Nigerian economy at large.

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