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Analysis of Technical Efficiency of Smallholder Cocoa Farmers in Cross River State, Nigeria

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Abstract

The technical efficiency involved in cocoa production in Cross River State was estimated using the stochastic frontier production function analysis. The effects of some selected socio-economic characteristics of the farmers on the efficiency indices were also estimated. The study relied upon primary data generated from interviewing cocoa farmers using a set of structured questionnaire. A multi-staged random sampling technique was adopted in selecting two hundred (200) cocoa farmers from Ikom Agricultural Zone in the state. The data on the socio-economic characteristics of the farmers were analyzed using descriptive statistics, while the stochastic production function, using the Maximum Likelihood Estimating (MLE) techniques was used in estimating the farmer's technical efficiency and their determinants. Result of the analysis showed that farmers were experiencing decreasing but positive returns to scale in the use of the farm resources. The efficiency level ranged between 0.20 and 0.93 with a mean of 0.69. The result of the generalized Likelihood Ratio (LR) tests confirmed that the cocoa farmers in the area were technically inefficient. The major contributing factors to efficiency were age of farmers, farm size, level of education, sex of farmer and age of the farms. The study observed that there is enough room to improve efficiency with the farmers' current resource base and available technology and concluded that policies that would directly affect these identified variables should be pursued.

Keywords:
Cocoa production, Technical efficiency, Stochastic frontier, Likelihood ratio, Maximum likelihood ratio

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INTRODUCTION

Agriculture in developing countries is characterized by low productivity leading to low farm incomes. In Nigeria, cocoa production is characterized by several problems that lead to low productivity. This has resulted to a fall in percentage share of cocoa output. As Amos (2007) notes, two reasons are said to be responsible for the fall in percentage share of cocoa output. First is the negligence of the agricultural sector by the past administration due to the discovery of the petroleum resources that now accounts for the bulk of foreign exchange earnings. Second is the endemic problem in the cocoa industry. Therefore, increasing productivity will increase the percentage share of cocoa production. Analysis reveals that increasing agricultural production has probably been the simple most important factor in determining the speed and extent of poverty reduction. Most of these evidences are derivable from the Green Revolution in Asia (Adeniran, 2007). In China rapid productivity gains achieved largely through technological advances of the Green Revolution directly increased producers income and labourers' wages by lowering the price of food and by generating new livelihood opportunities as success in agriculture provides the basis for economic diversification. The importance of productivity is that it gives a measure for efficiency.

In Nigeria, there have been studies on farm level efficiency in tree crop production and very few have focused on cocoa production. Among these are studies by Giroh *et al.,* (2008) who carried out analysis of the technical inefficiency of gum Arabic based cropping patterns among farmers in the gum Arabic belt of Nigeria and that of Amos (2007) whose study is analysis of productivity and technical efficiency of small holder cocoa farmers in Nigeria. The authors employed the stochastic frontier production function analysis in their studies. However we do not have such studies in Cross River State which is a major cocoa producing area in Nigeria. Recent studies carried out on cocoa production in Cross River State examined the Socio-economic variables and cocoa production (Oluyole and Sanusi, 2009). Fertilizer use and cocoa production and Investment in cocoa production in Nigeria: .A Cost and Return analysis of three cocoa production management system in Cross River State cocoa belt by Nkang *et al.,* (2009). None of these studies examined the technical efficiency of the cocoa farmers.

Objectives:

This study was carried out to provide estimates of levels of technical efficiency of cocoa farmers in Cross River State using farmers in Ikom Agricultural zone, where there is a high concentration of cocoa farmers in the state. The study was interested in whether the cocoa farmers were fully technically efficient, the current level of efficiency and factors that influenced efficiency. The study therefore was to estimate the level of and determinants of technical efficiency among cocoa farmers in Cross River State.

MATERIALS AND METHODES

Study area

This study was conducted in the two major Cocoa Producing Local Government Areas in Cross River State; Etung and Ikom. Cross River State is located in the Niger Delta region of Nigeria. It is bounded in the North by Benue State, in the South by Atlantic Ocean, in the East by Cameroon Republic and on the West by Akwa Ibom State, Abia and Ebonyi States. The state lies within latitude 40° 4, South and 60°30, North and between longitude 8° and 9° 00" East of the equator. It has three distinct ecological zones, the mangrove forest to the south, the tropical rainforest in the middle and the guinea savanna to the north. The annual mean rainfall ranges between 1500mm and 2000 mm.

Sampling procedure and sample size

The multistage random sampling technique was adopted for this study. The first stage involved a purposive selection of two (2) Local Government Areas in the Ikom Agricultural Zone- Ikom and Etung. This is because Ikom and Etung are the major cocoa producing areas in Cross River State. The second stage involved the random selection of Five (5) villages from each of the selected Local Government Areas,

giving a total of Ten (10) villages. The villages selected in Ikom were Akparabong, Ayukasa, Okondi, Alok and Ajassor, while those selected in Etung were Effraya, Agbokim, Bendeghe Ekim, Abijang and Abia. A simple random selection of twenty (20) farmers from each of the selected villages was carried out making up a total of one hundred (100) farmers from each of the two Local Government Areas which gave us 200 cocoa farmers for the study. Information was obtained on socio-economic characteristics of the farmers, output, labour, farm size and prices of variables using a set of structured questionnaire.

Model specification

Descriptive statistics including mean, standard deviation and variances were used to analyse the socio-economic characteristics of farmers while the stochastic production function was used to analyze the level of technical efficiency. The production technology of the cocoa farmers was assumed to be specified by the Cobb-Douglas frontier production function (Tadesse, and Krishnamorthy, 1997; Amos, 2007).

The specified cocoa production function was given as follows;

$$\text{In } Y = \text{In } \beta_o + \beta_1 \text{In} X_{1i} + \beta_2 \text{In} X_{2i} + \beta_3 \text{In} X_{3i} \beta_4 \text{In} X_{4i} + V_i - U_i \quad (1)$$

Where;

Y = Quantity of cocoa produced (kg)
X_1 = Farm size (hectares)
X_2 = Quantity of fertilizer (kg)
X_3 = Quantity of fungicide (litres)
X_4 = Labour (man days)
B_o = Y - intercept

B_1 to β_4 are coefficients to be estimated and V_i and U_i are error terms. It is expected that β_1, β_2, β_3, and β_4 will have positive signs.

Determinants of technical efficiency

The influence of some socio-economic factors on the computed technical efficiency was determined by incorporating the socio-economic factors directly in the frontier model, because they have influence on efficiency (Kalirajan, 1981). The technical efficiency model was specified as:

$$Ui = ąo + ą1Z1í + ą2Z2í + ą3Z3í + ą4Z4í + ą5Z5í + ą6Z6í + ą7Z7í \quad (2)$$

Where

U_i = Technical efficiency
Z_1 = Sex of farmer (dummy)
Z_2 = Marital status (dummy)
Z_3 = Age of farmer (years)
Z_4 = Education (years spent in school)
Z_5 = Family size
Z_6 = Age of farm (years)
Z_7 = Farm size (ha)
$ą_o$ = y - intercept

$ą_1$ to $ą_7$ are coefficients that were estimated. It was expected that $ą_3$ would have a negative sign, while $ą_2$, $ą_4$, $ą_5$, $ą_6$ and $ą_7$ would have positive signs. The sign of ą1 was indeterminate.

In determining the level of technical efficiency of the cocoa farmers and analyzing the determinants of technical efficiency among the cocoa farmers, a generalized likelihood ratio (LR) test was used to test the hypothesis of full technical efficiency effects defined as

$$LR = -2 \text{ In } (\log H_1 - \log H_2) \quad (3)$$

Where, H1 is the log – likelihood function of the average function. H_2 is the log- likelihood function of the frontier function. The value has a mixed chi-square distribution with degrees of freedom equal to the number of parameters plus one. A computer programme frontier version 4.1 by Coelli (1994) was used in the computation, while the testing of the parameters was done at 1 and 5 percent levels of significance.

RESULTS AND DISCUSSION

Socio-economic characteristics of the sampled cocoa farmers

The distribution of sampled cocoa farmers according to their sex, age, marital status, educational level, family size and farming experience is presented in Table 1. The results indicates that majority (88.5%) of the farmers were males while few (11.5%) were females. The cultural setting of the area allows the males to have easy access to land especially, where majority of them are the heads of their respective households.

The table also indicates that majority of the farmers (44.5%) were within the 47 to 57 years age bracket. This was closely followed by the farmers with age 36-46 years (32%). Farmers

that were in the minority constituted 1.5% and these farmers were above the 68 years age bracket. This shows that about 86% of the farmers were in their most economically active age bracket (25-57) years. However, there was a widespread of farmers among all the age groups, implying that cocoa farming was embraced by all the age groups. The results also showed that most of the farmers (68.5%) were married while 31.5% were single (Table 1).

Furthermore, the distribution of the cocoa framers according to their educational level (number of years spent in school), shows that majority (76.5%) of the farmers had attained one level of formal education or the other. The mean level of educational attainment (years spent in school) of the farmers in the area was about 6 years, with 11% of the farmers having tertiary education. This is an indication that some graduates were involved in cocoa farming in the study area. This is a good pointer to improved productivity as the level of education is a tool with which an individual could be efficient at whatever endeavour being undertaken by the individual (Oluyole and Usman, 2006). As regards family size, a high proportion (86.5%) of the farmers had family sizes of 5 persons and above, while 13.5% had less than 5 persons in their household. The mean family size of the cocoa farmers was 7 persons. Effiong (2005) reported that a relatively large household size enhances the availability of family labour which reduces constraints on labour cost in agricultural production.

The table also shows that a very high proportion (99%) of the farmers had between 5 and above thirty (30) years of experience in cocoa farming. The mean farming experience was about 15 years. Farmers sometimes count more on their experience than educational attainment in order to increase their productivity (Nwaru, 2004). The result implies that a good number of the farmers are experienced farmers and therefore are expected to have higher technical efficiencies.

Table 1: Distribution of socio-economic characteristics of sampled cocoa farmers

Variables	Frequency	Percentage
Sex:		
Male	177	88.5
Female	23	11.5
Total	200	100
Age of farmer (years):		
25 – 35	19	9.5
36 – 46	64	32.0
47 – 57	89	44.5
58 – 68	25	12.5
>68	3	1.5
Total	200	100
Means	47.70 (8.91)	
Marital status:		
Single	63	31.5
Married	137	68.5
Total	200	100
Mean	2.02(1.61)	
Educational level (school years):		
0	47	23.5
6	81	40.5
8	14	7.0
12	36	18.0
14	14	7.0
16	8	40
Total	200	100
Mean	6.45 (4.49)	
Family size:		
<5	27	13.5
5 – 7	76	38
8 – 10	54	27
11 – 13	24	12
14 – 16	9	4.5
17 – 19	7	3.5
>19	3	1.5
Total	200	100
Mean	7. 11 (4.66)	
Farming experience (years)		
<5	2	1.0
5 – 10	74	3.7
11 – 15	54	2.7
16 – 20	33	16.5
21 – 25	19	9.5
26 - 30	6	3.0
>30	12	6.0
Total	200	100
Mean	15.22 (7.70)	

Source: Field Survey 2010
Note: Values in parentheses are standard deviations.

Mean output and other production variables in cocoa production in Cross River State

The statistics of the production variables obtained from cocoa farmers in the study area are summarized in table 2. The mean output of cocoa farmers in the area was 2428.10kg/annum/farmer. This is relatively high compared to figures of less than two tonnes recorded elsewhere. This may be related to the age of the farms as most farms in Cross River State are within the productive age of 11 to 40 years (Table 3) compared to farms in other parts of Nigeria. For labour, the

Table 2: Summary statistics of output and other variables for sampled Cocoa farmers

Variables	Minimum	Maximum	Mean	Standard Deviation
Output (kg)	760.00	76200.00	2428.10	2343.53
Farm size (ha)	1.00	40.00	6.90	6.35
Fertilizer (kg)	0.00	200.00	18.50	37.09
Fungicide (litres)	0.00	2500.00	1142.80	644.37
Labour (man days)	18.00	93.00	51.49	14.65
Age of farmer (years)	25.00	71.00	47.70	8.91
Family size	1.00	26.00	7.00	4.66
Farming experience (years)	4.00	50.00	15.22	7.70

Source: Derived from Field Survey Data 2010

mean man- days used by the farmer during the production season were 51.50 man days. Farm sizes in Nigeria have been described as small, medium or large scale, if they fall into categories of less than 5ha, between 5ha and 10ha, or more than 10ha, respectively (Upton,1972). Most of the farms in Nigeria are of small to medium scale categories. The average farm size among the cocoa farmers in the study area is 6.90 hectares scattered in different locations in the locality, hence the small holdings. It was observed that majority of the cocoa farmers in Cross River State did not use fertilizer in cocoa production. The mean fertilizer used by the farmers was 18.50, which is very low. The result is in line with Oluyole and Sanusi, (2009) which reported that 98.13% of cocoa farmers in Cross River State did not use fertilizer in cocoa production.

An average of 1142.80 litres of fungicide was applied by the cocoa farmers (Table 2). The high rate of application may be due to the less resistance of the cocoa variety to infection.

Classification of cocoa farmers according to age groups and their mean output in the study area

The sampled farms were grouped according to their age groups and mean output and majority (92%) of the farms are within the productive age of 11 to 40years age group (Table 3). The mean output initially increased within this age as the cocoa trees get fully established, and thereafter output declines as shown in the table.

Maximum likelihood estimates of stochastic production frontier function for cocoa farmers in Cross River State

The coefficient of the Maximum Likelihood Estimates (MLE) of the parameters of the stochastic frontier models of cocoa farmers is shown in Table 4. The variance parameters of the stochastic frontier production function are represented by sigma squared (δ^2) and gamma (y). From the table, the sigma squared is 0.171 and significantly different from zero at one percent level. This indicated a good fit and correctness of the distributional form assumed for the composite error term. Gamma (y) indicates that the systematic influences that are unexplained by the production function are the dominant sources of random error. The gamma estimate which is 0.327 and significant at five percent level shows the amount of variation resulting from the technical efficiencies of cocoa farmers

Table 3: Age group of farmers and mean output

Age group	Frequency	Percentage	Mean output	Standard deviation
5 - 10	5	2.5	6305.2	6305.2
11- 20	81	40.5	8064.1	8064.1
21-30	81	40.5	8797.0	8797.0
31- 40	22	11.0	10448.0	10448.0
41- 50	8	4.0	7465.1	7465.1
>50	3	1.5	6573.0	6573.0
	200	**100**	**(2428.1)**	**(2428.1)**

Source: Field Survey Data 2010

Note: The values in parenthesis are the mean output and standard deviation of the farms respectively and do not represent the total mean output and standard deviation of the groups.

Table 4: Maximum likelihood estimates of the stochastic production function for cocoa production

Variable	Parameters	Coefficients	Standard errors	Standard errors
Constant	β_o	7.450	0.141	52.837***
Farm size	β_1	0.155	0.016	9.688***
Quantity of fertilizer	β_2	0.013	0.001	1.30
Quantity of fungicide	β_3	0.002	0.004	0.50
Labour	β_4	0.009	0.003	3.00***
Diagnostic statistics				
Gmma (Y)	Y	0.327	0.144	2.71**
Sigma square	δ_2	0.171	0.037	4.622***
Log likelihood function		-88.08		
Likelihood ratio (LR)	λ	71.42		

Source: Computed from Field Survey Data 2010 using Frontier 4.1
Note: *** P < 0/01, ** P < 0/05

in the study area. This means that more than 32% of the variation in farmer's output is due to difference in technical efficiency.

The result further shows that the signs of all the estimated coefficients of the stochastic production frontier are positive which is consistent with a priori expectation. This implies that there is a positive relationship between the level of output of cocoa and farm size, the quantity of fertilizer, fungicide and labour used. This is expected as the level of production depends largely on the quantities of these inputs used on the farm. This can only be up to a level that is considered optimal after which farmers will be operating at sub optimal level. However, the coefficients of the slope, farm size and labour were significant at one percent indicating that farm size and labour are important determinants of cocoa output.

Determinants of technical efficiency in cocoa production

The analysis of the efficiency model shows that the signs of the estimated coefficients in the efficiency model have important implications on the technical efficiency of cocoa farmers in the study area. The coefficient of sex ($z \leftarrow\leftarrow 1$) had a positive sign indicating that the male farmers obtain higher levels of technical efficiency than their female counterparts in the area. Cocoa farming is dominated by males in the area. This is so because cocoa farming is a tedious job and requires more strength which females may not be able to provide (Oluyole and Sanusi, 2009).

The coefficient of marital status (Z_2) is indeterminate. However, it is negative as shown in Table 5.

The coefficient of age (z_3) is also positive. This does not agree with a prior expectation. As farmers age, there is a tendency that productivity will continue to fall owing to their declining strength. However, this result could be attributed to the fact that most of the farmers in the study area started farming at early age. Hence, the older they are the more experienced and efficient they would be, since farmers' experience increases with the number of years spent in farming, it implies that the longer the time spent in

Table 5: Determinants of Technical Efficiency

Variable	Parameter	Coefficient	Standard error	t-ratios
Constant	a_o	-1.278	0.699	-1.828
Sex of farmer	a_1	0.009	0.415	0.022
Marital status	a_2	-0.209	0.135	-1.548
Age of farmer	a_3	0.011	0.136	0.801
Educational level (sch yrs)	a_4	0.054	0.204	0.265
Family size	a_5	-0476	0.236	-2.016**
Age of farm	a_6	-0.012	0.723	-0.017
Farm size	a_7	0.081	0.010	8.10***

Source: Computed from Field Survey Data 2010 using Frontier 4.1
Note: *** P < 0/01, ** P < 0/05

Table 6: Elasticity of production and returns to scale

Variables	Elasticity
Farm size	0.155
Quantity of fertilizer	0.086
Quantity of fungicide	0.420
Labour	0.094
RTS	0.179

Source: Field Survey, 2010

farming the more experience they are.

Furthermore, the coefficient of educational level (z_4) was positive but not significant. This implies that the level of technical efficiency of the farmer increases with the level of education but not significantly. However, the result agrees with a prior that technical efficiency should increase with increases in years of schooling of the farmers since education and adoption of innovation were expected to be positively correlated.

The coefficient of family size (z_5) has a negative sign and is significant at the five percent level. This implies that increase in family size will lead to decrease in technical efficiency. This result does not agree with a prior expectation. However, given that the cocoa farmers utilized more of hired labour than family labour and less labour (weeding and pruning) is required once the cocoa has been established, it could be acceptable. The farmers pay wages that are more than the value of their marginal production and hence would be inefficient as a result of allocative inefficiency (Idiong, 2006).

The negative coefficient of age of farm (Z_6) implies that efficiency decreases as the farms get older. Amos, (2007) had a similar result. Lastly the coefficient of farm size (Z_7) was positive and significant at the one percent level. This implies that technical efficiency increases with the size of farm. This result agrees with those of Giroh *et al.,* (2008) and Amos (2007). Large farm sizes if properly managed should have higher efficiency. However, there is a threshold where returns to scale decreases with increase in farm size.

Elasticity of production and returns to scale

Typical of the power function (Cobb-Douglas), the estimated coefficients for the specified function can be explained as the elasticities of the explanatory variables.

The values of the variables indicates that a 10 percent increase in the size of farm, fertilizer, fungicide and labour will lead to a 1.5, 0.9, 4.2 and 0.9 percent increase respectively in

Table 7: Test of hypotheses that cocoa farmers in Cross River State are fully technically efficient (Y= 0)

Efficiency	Likelihood function (λ)	Log likelihood ratio (LR)	Critical X^2 0.05	Conclusion
Technical	-88.08	10.712	10.371	Reject

Source: Derived from Table 4. Critical X^2 was obtained from Kodde and Palm (1986).

Table 8: Frequency distribution of technical efficiency estimates

Efficiency level	Frequency	Percentage
0.20 – 0.30	2	1
0.31 – 0.40	3	1.5
0.41 – 0.50	20	10
0.51 – 0.60	17	8.5
0.61 – 0.70	38	19
0.71 - 0.80	91	45.5
0.81 – 0.90	26	13
>90	3	1.5
Total	200	100
Mean	0.69	
Minimum	0.20	
Maximum	0.93	

Source: Derived from output of the computer programme, Frontier 4.1 by Coelli (1994)

output of cocoa (Table 6). The value of the returns to scale (RTS) was 1.79 indicating that the farmers were operating in the region of decreasing but positive returns to scale (stage II of the production function). Therefore, increasing the units of inputs will not be the best option to the farmers as it will add less to total cocoa output (Table 7).

Technical efficiency estimates of the sampled cocoa farmers in Cross River Sate

The predicted farm specific technical efficiencies (TE) ranged between 0.20 and 0.93 (Table 8). The mean efficiency of the cocoa farmers was 0.69. The 69% mean efficiency indicates that in the short run, there is a scope of increasing cocoa production by about 31% by adopting the technologies and techniques practiced by the best cocoa farmers in the study area (Table 8).

The efficiency distribution also indicates that majority of the cocoa farmers (79%) were having efficiency of between 61% and 90% while a few of them (21%) were less than 60% efficient in their production process. The high levels of efficiency may be due to the long years of farming experience of the farmers.

CONCLUSION

This study reveals that, cocoa farmers in Cross River State are not fully technically efficient in their resource use. The policy variables that were identified as having significant effects (positive and negative) on the efficiency levels of the cocoa farmers are farmers age, family size, farm sizes, educational level, and age of the farm. It is believed that farmers' technical efficiency in resource use could increase since cocoa farmers in the area were not fully technically efficient; hence, there is room for improvement in the level of this efficiency if the important policy variables are addressed. Majority of farmers were in the productive age bracket and this was directly related to technical efficiency of cocoa farmers in the area. It is therefore important that a policy that would make cocoa farming attractive to persons within this age bracket. The 69% mean efficiency indicates that in the short run, there is a possibility of increasing cocoa production by about 31% by adopting the technologies and techniques practiced by the best cocoa farmers in the study area.

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