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Technical Efficiency in Ghana's Cocoa Bean Industry: Evidence from Western Region of Ghana

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Abstract
This study analyses the determinants of output and technical efficiency of cocoa production using cross-sectional data collected from 160 cocoa farmers in the Sefwi-Wiawso Municipality, Ghana. The study employed the stochastic frontier analysis to achieve its objectives. The analysis suggests that output of cocoa respond positively to land size and fertilizer applications. However, output of cocoa responds negatively to fungicides application. Cocoa farmers in the study area were described as exhibiting increasing return to scale. The average technical efficiency of cocoa farmers in the study area was about 76% indicating that cocoa farmers on the average produce 24% less than their potential output. Exogenous factors such as age of cocoa farmers, sex, household size, educational attainment, and membership of farmer-base-organization and the mean age of cocoa trees were found to significantly affect technical efficiency of cocoa farmers. The study therefore recommends that farm level policies oriented towards improving managerial skills with respect to the use of inputs such as fertilizer, insecticides and fungicides according to Ghana COCOBOD recommendations will be very imperative. Farmers should also be encourage to join farmer-based-organizations as this will help them have access to certain support services to improve on their efficiency level.
Keywords: Stochastic frontier analysis, technical efficiency, cocoa, Sefwi-Wiawso, Ghana

1. Introduction

The centrality of cocoa to the development of the Ghanaian economy is without dispute. To the Government of Ghana, cocoa is a golden crop that generates lot of revenue for developmental projects such as construction of roads, building of schools and hospitals. To the Ghanaian farmer, cocoa is a life-line in that it provides household income for the family. Cocoa has continued to play a dominant role through its significant contributions to economic growth and development. Its sizeable foreign exchange earnings are incomparable to any single agricultural export commodity crop. It provides significant farm income to smallholder farmers especially in the Western part of Ghana, direct and indirect employment generation, tax revenue and also serves as an important source of raw materials for industrial production both locally and globally, among others. Mckay and Arytee (2005) reported that cocoa has historically been a key economic sector and a major source of export and fiscal earnings in Ghana. In 2005, cocoa beans and cocoa products (processed) accounted for about 28 percent of total exports, slightly behind gold (BoG, 2007). Moreover, there was an increase of cocoa's share in agricultural GDP from 13.7 percent in 2000-2004 to 18.9 percent in 2005/2006 (Breisinger *et al*., 2008). The Ghana COCOBOD in 2008 attributed the general growth in Agriculture to the impressive growth in the cocoa sector.

In Ghana, the growth in the cocoa sector is largely attributed to the expansion in area under cultivation rather than productivity per hectare (MOFA 2006, COCOBOD 2007). Ghana's average cocoa yields are well below that of the international averages which simply suggest that Ghana has the potential for increasing cocoa growth through productivity driven factors rather than farm expansion. Ghana is less than half-way below the achievable yields of cocoa of about 1-1.5 tons per hectare (FAO 2005, MOFA 2007). For instance, whilst the average yield of cocoa per hectare is only about 400kg, Ghana's counterparts in Malaysia and Cote'Ivoire have 1800kg per hectare and 800kg per hectare respectively (Barrietos et al 2008). Abekoe et al (2002) attributed low productivity of cocoa to poor farm maintenance which includes farmer's inability to minimize cost per production levels, high incidence of pest and diseases and high cost of labour. Binam et.al (2008) indicated that Ghanaian cocoa farmers appear to be the least efficient producers as compared to other farmers in Nigeria, Cote D'Ivoire and Cameroun.

One of the major objectives of stakeholders in the Ghanaian cocoa industry is to increase productivity on the sustainable basis at the farm level through cost minimization. This suggests that every factor of production must be efficiently and effectively utilized. Proper farm maintenance through efficient use of inputs like fertilizer, pesticides and labour could help achieve a farm frontier level. For these reasons, efficiency has remained one of the vital areas of empirical investigations particularly in the developing nations where majority of farmers are resource-poor (Amos 2007, Binam et.al 2008, Nkamleau et.al 2010 and Danso-Abbeam et.al 2012). Technical and allocative efficiency can be combined into a measure of total economic efficiency, referred to as cost efficiency. Technical and allocative inefficiency; that is, excessive inputs use and misallocation of inputs are costly, hence, it is desirable to be able to identify the sources and levels of these inefficiencies. High cocoa productivity is dependent on the abilities of farmers to effectively combine farm inputs at a minimum cost to produce a given level of output at the existing technology. For Ghana to increase its production level, producers ought to optimize input use in the industry.

Accelerated growth in cocoa sector needs to be driven by productivity effects rather than land expansion. The issue of enhancing productivity growth in African agricultural sector has posed a dizzy but relevant policy question; that is, whether to pursue a strategy that will bring new technologies (technological change) or a strategy that will improve upon the existing technology (technical efficiency) (Nkamleu, 2004). The fact that there is a significant gap between current and achievable yields of cocoa simply means that the Ghanaian cocoa industry has the potential to increase output through improvement on the existing technology. The sustainable accelerated growth in the Ghanaian cocoa industry is dependent on the ability of farmers to optimize the management of their farm resources, hence technical efficiency. This raises the following questions of the study; (1) what are the determinants of cocoa output growth in Ghana, (2) what are the levels of technical efficiency in cocoa production in Ghana and (3) what are the factors influencing such levels? Thus, the study seeks to analyze the extent to which farm inputs, socioeconomic, farm specific and institutional factors affects farmers' ability to increase cocoa yield in the Western region of Ghana. Understanding the farm level efficiencies and its relationship with factors of production can assist policy makers in creating efficiency enhancing policies at the farm level. Also, considering the vast number of Ghanaian farmers whose livelihood are dependent on cocoa coupled with fact that cocoa generates so much income for the government means that any strategy that succeeds in improving on the yields of cocoa will better the lives of majority of rural folks and the government of Ghana. Thus, increases in productivity are translated into income gains for farmers which will also be passed on to government as foreign exchange through export.

2.0 METHODOLOGY

2.1 Study Area

The underlying research was carried in Sefwi-Wiawso Municipality which is one of the 22 metropolitan, municipalities and districts in the western region of Ghana. It has Wiawso as its municipal capital and shares boundaries with Bibiani-Anhwiaso-Bekwai to the east, with Bodi district to the West, to the North with Aowin district all in the Western region and to the south with Asunafo South in the Brong-Ahafo region. It has a land area of about 2635 square kilometers and falls within the tropical rainforest climatic zone with warm temperature throughout the year and moderately to heavy rainfall. The municipal has a total estimated population of about 139,200 with agriculture and its related work as the major economic activities. The soil type is of forest and supports the cultivation of crops such as cocoa, oil palm, maize, cassava, plantain and cocoyam with cocoa been the major perennial tree crop serving as a source of income for majority of farmers in the area.

2.2 Data and Sampling Methods

The data used in this analysis is predominantly from primary sources. We randomly sampled 160 farmers engaged in cocoa production in 10 randomly sampled communities from the study area. Structured and semi-structured questionnaires were used to collect data from the selected farmers. Variables of interest that we collected information on include farmer characteristics such as age, gender, educational achievement, household composition, farmers' membership of farmer-based-organization and farm specific characteristics such as the mean age of cocoa tree. In terms of production and marketing, we recorded information on total acreage allocated to cocoa farming, cocoa output and quantities of inputs used.

2.3 The empirical Framework

The study employs the stochastic frontier analysis (SFA) to estimate and analyse the determinants of technical efficiency of cocoa farmers in the study area. The stochastic frontier production function was independently proposed by Aigner, *et al*., (1977) and Meeusen and Van den Broeck (1977). In the stochastic frontier models, it is only factors that are within the control of production units account for inefficiency but at the same time recognises the role of factors that are beyond the control of such production units. In this case, the farmer is restricted to produce at or below the deterministic production frontier. The stochastic production function is defined by;

$$Y_i = f(x_i, \beta) + \varepsilon_i \text{ where } i = 1,2,3...,n \quad [1]$$

$$\varepsilon_i = v_i - u_i$$

Where Y_i represents the output level of the *i*th sample farm; $f(x_i, \beta)$ is a suitable function such as Cobb-

Douglas or translog production functions, x_i is a vector of inputs for the i^{th} farm and β is a vector of unknown parameters. ε_i is an error term made up of two components: v_i is assumed to account for random effects on production associated with factors such as measurement errors in production and other factors which the farmer does not have control over and u_i is a non-negative error term connected to farm-specific factors, which leads to the i^{th} farm not reaching the deterministic frontier level. Thus, u_i measures the technical inefficiency effects that falls within the control of the farmer. The approach specifies technical efficiency of an individual farm as the ratio of the observed output to the corresponding frontier output, conditioned on the level of inputs used by the farm. The technical efficiency of the i^{th} farmer is defined as;

$$TE_i = e^{-U_i} \quad [2]$$

Where U_i is the inefficiency component of the model. According to Battese and Coeli (1995), the error term v_i is assumed to be identically, independently and normally distributed with zero mean and a constant variance, $N(0,\sigma_V^2)$. The error term u_i is also assumed to be distributed as truncation of the normal distribution with mean u_i and variance $N(u_i;\sigma_u^2)$ such that the inefficiency error term can be explained by exogenous variables specified as;

$$u_i = Z\delta_i \quad [3]$$

Where Z_i is vector of explanatory variables and δ_i is an vector of unknown parameters to be estimated. In this study, we estimate the technical efficiency levels of cocoa farmers and the determinants of inefficiency simultaneously by the use of the single -stage maximum likelihood approach. The simultaneous estimation approach ensures that the assumption of identical distribution of the error term u_i is not violated. The maximum likelihood estimates of the stochastic frontier model provide the estimates of β and the gamma (γ), where the gamma explains the variation of the total output from the frontier output. The gamma estimate is specified as, $\gamma = \dfrac{\sigma_u^2}{\sigma^2}$.

Where γ lies between zero and one $(0 \le \gamma \le 1)$, σ_u^2 is the variance of the error term associated with the inefficiency and σ^2 is the overall variation in the model specified as the sum of the variance associated with the inefficiency (σ_u^2) and that associated with random noise factors (σ_v^2). Thus; $\sigma^2 = \sigma_u^2 + \sigma_v^2$.

The closer the value of the gamma (γ) is to one (1), the more the deviation of the observed output to the deterministic output which is as a result of inefficiency factors. However, if the value is closer to zero, then deviations are as a result of random factors and if the value lies between one (1) and zero (0), then deviations are as a result of both inefficiency and random factors. In terms of functional form, we used a transcendental logarithmic (translog) production function developed by Christensen et al (1973) to define the relationship between the inputs included in the model and the output after a preliminary test that suggest that Cobb-Douglas was not appropriate given the data set. The translog production function has been proven to be flexible in that, it does not place any restriction on the elasticity of production unlike the Cobb-Douglas. A number of studies (see Donkoh 2013, Asante et al 2014, Onumah et al 2013) have used the translog production function in modeling technical efficiencies in the Ghanaian agricultural crop economy. However, some studies have also used the Cobb-Douglas production function (Danso-Abbeam et al 2012) due its simplicity and the fact that it is self-dual even though it has been criticized for its restrictiveness.

2.4 The Empirical Specification

Following the works of Donkoh (2013), Asante et al (2014) and Onumah et al (2013), we define the translog production function to be estimated as;

$$\ln Y = \beta_0 + \sum_{j=1}^{4} \beta_j \ln X_{ji} + \frac{1}{2}\sum_{j\ge}^{4}\sum_{k=1}^{4} \beta_{jk} \ln X_{ji} \ln X_{ki} + V_i - U_i \quad [4]$$

Where the subscript *i* denotes the i^{th} farmer in the sample (i = 1, 2, 3, 4, 5…160)*;* Y denotes the quantity of cocoa harvested (in bags) for the sampled farmer, X_1, X_2, X_3 and X_4 denotes the total land area allocated to cocoa farming in acres, quantity of insecticides applied in litres, quantity of fertilizer applied in kilograms and quantity of fungicides applied in grams. The Vis are random errors that are assumed to be independent and identically distributed as $N(0,\sigma_V{}^2)$ whilst the $U_i s$ are the non-negative technical inefficiency effects that are assumed to be independently distributed among themselves and between the $V_i s$, such that the U_i is defined by the truncation (at zero) of the $N(U_i,\sigma^2)$ distribution.

The inefficiency effects U_i to be estimated can be defined as;

$$U_i = \delta_0 + \sum_{j=1}^{10} \delta_j Z_{ji} \qquad [5]$$

Where Z_1……….Z_{10} denotes age, age squared, sex, household head, household size, number of years in formal educational, whether farmer receives extension visit or not within the last 12 months; farmer belonging to farmer base organization; mean age of cocoa tree and mean age squared of cocoa tree.

2.5 Input Elasticities and Return to Scale

To measure the partial elasticity of production with respect to individual inputs included in the transcendental logarithmic model, the inputs variables were rescaled to have unit means.

This means that the first order coefficients in model (5) below can be interpreted as direct elasticities.

$$\varepsilon_q = \frac{\partial \ln E(Y_i)}{\partial \ln(X_{ji})} = \left\{ \beta_i + \beta_{jj} \ln X_{ji} + \sum_{i=1}^{n} \beta_{jk} \ln X_{ki} \right\} = \beta_j \qquad [6]$$

Return to scale can be computed as the summation of the input elasticities, thus;

$$RTS = \sum \varepsilon_{qj} \qquad [7]$$

Where *RTS* is return-to-scale and ε_{qi} is the elasticity of the j^{th} inputs. If RTS is greater than one (RTS > 1) implies increasing return to scale, RTS equal to unity (RTS = 1) implies constant return to scale and if RTS is less than one (RTS < 1) implies decreasing return to scale.

2.6 Specification of Hypotheses

In estimating the stochastic frontier model for cocoa producers in the study area, three main null hypotheses were performed to examine the appropriateness of the specified model used, the presence of inefficiency and the significance of exogenous factors in explaining inefficiency among cocoa producers. The three hypotheses are presented as follows;

1. $H_0 : \beta_{jj} = \beta_{ji} = 0$ [8]

   The coefficients of the square values and the interaction terms in translog model sum up to zero.
2. $H_0 : \gamma = \delta_0 = \delta_1 .... \delta_8 = 0$ [9]

   There are no inefficiency effects
3. $H_0 : \delta_0 = \delta_1 = ... \delta_{10} = 0$ [10]

   Exogenous factors are not responsible for the inefficiency term μ_i

These hypotheses were tested by using the generalized likelihood-ratio test statistic specified as;

$$LR(\lambda) = -2[\{\ln L(H_0)\} - \{\ln L(H_1)\}] \qquad [11]$$

Where $L(H_0)$ and $L(H_1)$ are the likelihood functions under null and alternate hypotheses respectively. If the given null hypothesis is true, then the test statistic (λ) has a chi-square distribution of degree of freedom which is equal to the difference between the estimated parameters under (H_1) and (H_0). However, if the null hypothesis involves $\gamma = 0$, then the asymptotic distribution involves a mixed chi-square distribution (Coeli, 1995).

3.0 RESULTS AND DISCUSSIONS

3.1 Descriptive Statistics of Variables

Table 1 presents the descriptive statistics of the continuous variables used in the frontier model analysis. It can be observed that the mean age of cocoa farmers in the study area is about 46 years. This indicates a relatively active economic adult population, who when well-motivated can help to increase revenue for themselves and the government through increase in productivity. This is contrary to the assertion that farming population in Ghana is generally old, as it does not seem so lucrative to the young adult population. Also, the mean years of formal education is about 9 years indicating that on the whole most of the farmers had completed Junior High School. Household size ranges between 1 and 25 persons per household with the mean of about 5 persons per household. The study further revealed that the mean age of cocoa tree across the cocoa farming population in the study area is about 14 years with a minimum and maximum age of 6 and 50 years respectively.

Table 1 Descriptive Statistics of Variables

Variable	*Minimum*	*Maximum*	*Mean*	*Std Deviation*
Age	20	77	46.33	10.608
Education	0	15	8.913	4.498
Household size	1	25	5.12	3.946
Age of cocoa tree	6	50	14.475	8.131
Farm size	2	25	7.979	5.184
Fertilizer	0	138	15.506	16.468
Insecticides	1	132	11.666	14.661
Fungicides	1	677	43.788	100.737
Output	4	120	29.366	25.244

Source: Field Survey, 2014

It has been reported that about 92% of farm households in Ghana operate on small scale (Donkoh et al, 2013). This report is similar to the results of this study as the mean farm size is about 8 acres. Moreover, the mean quantities of fertilizer, insecticides and fungicides stand at 15.5kg, 11.67 litres and 43.79 grams respectively. As indicated earlier, land holdings for cocoa farmers are generally low and this has translated into output levels. The average output level is about 29 bags (1,812.5kg).

3.2 Tests of Hypothesis

As indicated in table 2 below, three main null hypotheses were tested in this study. Hypothesis one tested whether or not Cobb-Douglas was appropriate functional form for the data set. The Cobb-Douglas production function was rejected in favour of the transcendental Logarithmic (translog) functional form since the generalized likelihood ratio test statistic (λ) was greater than the critical value. This implies that the translog functional form was more appropriate and consistent compared with that of the Cobb-Douglas functional form. The second hypothesis was that there were no inefficiency effects in the model. That is, there is an absence of inefficiency term (μ_i) in the model and that the model can be estimated by a simple average response model with (v_i) as the only error term. Again, the results revealed that the stochastic frontier function had a better fit to the data than the average response model.

Table 2: Results of Hypothesis Tested

Tests	Test Statistic (λ)	Critical Value $(\chi^2_{0.001} / Mixed\ \chi^2_{0.001})$	Decision
1. H$_0$: $\beta_{jj} = \beta_{ji} = 0$	46.788	12.810***	Reject H$_0$
2. H$_0$: $\gamma = \gamma_0 = \ldots\gamma_{10} = \delta = 0$	51.446	50.524***	Reject H$_0$
3. H$_0$: $\delta_1 = \ldots\delta_{10} = 0$	36.606	28.856***	Reject H$_0$

Source: Field Survey, 2014

That is, inefficiency term (μ_i) is present in the model. The final hypothesis test indicated that the socio-economic variables in the inefficiency model do not explain the variation in the inefficiency term (μ_i). This was also rejected in favour of the fact that the socio-economic variables in included in the inefficiency model determine the inefficiency term (μ_i).

3.3 Determinants of Cocoa Output

Table 3 presents the maximum-likelihood estimates of the determinants of cocoa output in the study area. The gamma was estimated to be 0.8503 indicating that about 85% of the output deviation from the frontier was as a result of inefficiency in input use and other farm practices, while about 15% came from random shocks such as unfavorable weather conditions and measurement errors. The sigma squared is 0.2147, indicating 'goodness of fit' and the appropriateness of the distributional functional form assumed for the composite error term. The results indicate that, farm size, fertilizer and fungicides are important factors in explaining the variation in the output of cocoa. The quantity of insecticides applied had no influence on cocoa production in the study area. The squared variables indicate the effect of continuous usage of that variable on output. The interaction terms indicate a complementarity or substitutability of the inputs employed on the farm. A significant positive coefficient of interaction term means the two variables are complements whilst a significant negative term means the two variables are substitutes.

It can be observed from the results that, farm size had positive significant coefficient indicating that an increase in farm size will increase output while farm size squared had no significance influence on output indicating that continuous use of farm land will have no effect on output. The significant positive effect of farm size on output is similar to recent findings by Danso-Abbeam et al (2012).

Table 3 Maximum Likelihood Estimates of the Translog Cocoa Production Function

Variable	Parameter	Coefficient	Standard Error	t-ratio
constant	β_0	0.4671	0.4041	1.16
Farm size	β_1	0.9806	0.6201	1.581
fertilizer	β_2	1.4932	0.3251	4.593
fungicides	β_3	-0.9588	0.3382	-2.835
insecticides	β_4	0.4485	0.4547	0.986
(farm)(fertilizer)	β_{12}	-0.1349	0.3162	-0.427
(Farm)(fungicides)	β_{12}	-0.2805	0.149	-1.883
(Farm)(insecticides)	β_{13}	-0.3055	0.348	-0.878
(Fertilizer)(Fungicides)	β_{23}	0.1441	0.1792	0.804
(Fertilizer)(Insecticides)	β_{24}	-1.4371	0.3208	-4.48
(Fungicides)(Insecticides)	β_{34}	-0.041	0.1997	-0.2055
(Farm size)(Farm size)	β_{11}	-0.1815	0.3069	-0.591
(Fertilizer)(Fertilizer)	β_{22}	0.0974	0.1635	0.596
(Fungicides)(Fungicides)	β_{33}	0.404	0.0931	4.34
(Insecticides)(Insecticides)	β_{44}	0.8254	0.2518	3.28
Gamma	γ	0.8503	0.0686	12.4
Sigma-squared	σ_s^2	0.2147	0.0676	3.18
Log likelihood Function		-26.22		

****, **, * represents significant at 1%, 5% and 10% respectively*

Moreover, the coefficient of quantity of fungicides is negatively signed and significant at 5% level of significance implying that output falls as we increase quantity of fungicides. On the contrary, the squared of the fungicides which indicate a continuous use provide positive significant coefficient. This indicates that, at the beginning of its use, less of it should be employed if we are to increase output. However, as time goes on, more should be employed if output is to be increased. However, interaction of farm size with fungicides had significant negative coefficient indicating substitutability. That is, to increase output, cocoa farmers ought to increase fungicides while decreasing their farm size, and vice versa. A similar study conducted by Onumah et al (2013) in Ghana's cocoa bean industry reported a negative significant interaction between land size and agrochemical usage in cocoa farms.

The coefficient of quantity of fertilizer is positive and significant at 1% percent level of significance indicating that fertilizer is an increasing function of cocoa output. However, its continue use had no effect on output. Moreover, the interaction between fertilizer and insecticides produce negative significant coefficient, which suggests that while one is increasing, the other must be decreasing if cocoa farmers are to increase output.

This is half-way similar to the findings reported by Adzawa et al (2013) who studied technical efficiency among cotton farmers in the northern region of Ghana. Their analysis suggested that fertilizer usage is an increasing function of output (in agreement with this study), however, its interaction with insecticides had no effect on output (in variance with this study).

3.4 Output Elasticities and Return to Scale

The empirical results in table 4 indicates that the estimated output elasticities of cocoa with respect to farm size, fertilizer, fungicides and insecticides are 0.98, 1.49, -0.96 and 0.45 respectively at mean input values. This indicates that, if farm size, fertilizer application and insecticides applications are individually increased by 1%, then the mean output of cocoa is estimated to be increased by 0.98%, 1.49% and 0.45% respectively. On the other hand, if fungicides application is increase by 1%, mean output of cocoa is estimated to decrease by 0.96%.

Table 4 Output Elasticities and Return to Scale

Variable	**Coefficient**	**Standard Error**	**t-ratio**
Farm size	0.9806	0.6201	1.581
Fertilizer	1.4932	0.3251	4.591
Fungicides	-0.9588	0.3382	-2.835
Insecticides	0.4484	0.4547	0.986
Return to Scale	1.9635		

Source: Field Survey, 2014

Further, the estimated return to scale was revealed to be 1.96 implying that cocoa output function in the study area exhibited increasing return to scale. This means that a percentage increase in all inputs used, the mean output of cocoa is estimated to increase by 1.96% which is more than a proportionate increase in factors of production. This may be partly attributed to good agronomic practices and management of farms. Thus, farmers may be improving on their managerial skills as they as they increase the levels of inputs used in production.

3.5 Determinants of Technical Efficiency among Cocoa Farmers in the Study Area

The determinants of inefficiency among cocoa farmers in the study area are shown in table 5 below. The signs of the estimated coefficient in the model have significant implications on the technical efficiencies in the Ghanaian cocoa industry. The estimated coefficient of age and age squared of the cocoa farmer are positively and negatively signed respectively, and significant at 10% level of significance. This indicates that young farmers are technically less efficient than old farmers. This could be so because most farmers started farming in the early age of their lives. Hence, they become more experience which translates into efficiency as they grow older. Similar results were reported by Damian-IIa et al (2012) among cocoa farmers in the cross river state, Nigeria. The estimated coefficient of the variable, sex had a positive sign is significant at 10% level of significance. The positive coefficient means that male farmers in the study area were more technically inefficient than their female counterpart which is contrary to our a priori expectation.

Table 5 Sources of Technical Efficiencies among Cocoa Farmers

Variable	Parameter	Coefficient	St. error	t-value
Constant	δ_0	-3.8873	2.137	-1.82
Age	δ_1	0.2054	0.0926	2.22
Age squared	δ_2	-0.0024	0.0011	-2.22
Sex	δ_3	0.5845	0.3294	1.77
Household head	δ_4	-0.0768	0.1350	-0.57
House size	δ_5	-0.0491	0.0281	-1.75
Educational attainment	δ_6	0.0402	0.0231	1.74
Farmer Base Organization	δ_7	-0.4669	0.1789	-2.61
Extension Visit	δ_8	-0.1922	0.1371	-1.4
Mean age of cocoa tree	δ_9	-0.0841	0.0362	-2.32
Mean age of cocoa tree squared	δ_{10}	0.0017	0.0008	2.16

Source: Field Survey, 2014

In Ghana, cocoa farming is basically men bias occupation. Women normally help their husbands on the farm by involving in farm activities such as pod breaking, fermentation, transportation of the beans from the farm to the house (where drying usually take place) and drying of the cocoa beans. However, some women venture into cocoa farming as their full time business. Women being more technically efficient than male farmers could partially be attributed to the recent women empowerment programmes held on media and the fact that some NGO's are training only women cocoa farmers in the study area. Contrary results were reported by authors like Onumah et al (2013), Oguniyi et al (2012) and Onumah and Acquah (2010).

Consistent with a study by Amos (2007), the study revealed that farm households with larger family sizes are more technically efficient than those with smaller sizes. Thus, the coefficient of household size is negatively signed and significant at 10% level of significance. This could be attributed to the fact that most cocoa farm households in Ghana use family labour as their main source of labour in cocoa production. However, the result is contrary to that of Danso-Abbeam et al (2012) who reported a positive relationship between cocoa farmers' inefficiency and household size.

Educational attainment is expected to have positive effect on farmers' level of efficiency. However, the results indicate a negative effect of farmers' educational attainment on their technical efficiency level as the estimated coefficient is positively signed and significant at 10% level of significance. Thus, farmers who had spent more years in formal education tended to be less technical efficient than those with less years of formal education.

The coefficient of farmer base organization has negative significant effect on farmer's technical level. That is, members of farmer base organization are more technically efficient than non-members of farmer base organization. This could be due to the fact that farmer base organization members receive input and support services from many donors and NGO's. The results of the study oppose to the one conducted by Addai et al (2014) who documented that there is no significant difference in terms of technical efficiency between members and non-members of farmer base organization.

Productivity and efficiency of cocoa production can also be influenced by tree characteristics as such as the age of the cocoa tree. The results indicated that while the mean age of cocoa tree is negatively signed and significant, the mean age of cocoa tree squared is positively signed and significant. This implies that as cocoa tree ages, it adds to farmer's level of efficiency up to a certain age (usually after 30 years) after which inefficiency sets in due to old age of the tree. This could be attributed to the fact that yields of cocoa increases rapidly between the age of 5 -10, increases at a diminishing rate between the age of 11-30 years after which yield declines.

3.6 Frequency Distribution of Technical Efficiency Scores

Table 6 presents the frequency distribution of technical efficiency indexes among cocoa farmers in the study area. The estimated efficiency score ranges between 20% and 100% with 95%, 76% and 25% as the maximum, mean and minimum efficiency respectively. The mean technical efficiency level of 76% means that on the average, cocoa farmers in the study area produce below 24% of their potential output, given the current state of technology. This result is quite comparable to findings of other similar studies. Onumah et al (2013) estimated the mean technical efficiency of cocoa farmers in the Eastern region of Ghana to be 85% whilst Binam et al (2008) estimated 75% among Nigerian cocoa farmers. Moreover, it can be observed from the table that about 70% of cocoa farmers in the study area had about 70% level of efficiency.

Table 6 Efficiency Distribution

Efficiency Index	*Frequency*	*Percentage*
20 - 30	3	1.9
31 - 40	4	2.53
41 - 50	10	6.33
51 - 60	7	4.43
61 - 70	24	15.2
71 - 80	26	16.45
81 - 90	59	37.34
91 - 100	25	15.82
	158	100
Maximum	0.95	
Mean	0.76	
Minimum	0.25	

4.0 CONCLUSIONS AND RECOMMENDATIONS

The study examined the determinants of cocoa output growth and technical efficiency in Sefwi-Wiawso Municipality, Ghana by collecting data from 160 sampled cocoa farmers. The stochastic frontier analysis (SFA) which involves a one estimation of the stochastic frontier model was used. Cocoa output growth was significantly influenced by farm size, fertilizer and fungicides applications. The return to scale of cocoa producers in the study area was 1.96 implying an increasing return to scale and yet producing 24% below their potential output level since the mean technical efficiency was 76%. Moreover, about 70% of farmers produce at an efficiency level of about 70% and above. The study further revealed that household sizes, age squared, membership of farmer-based-organizations and mean age of cocoa tree improves the technical efficiency of cocoa production whilst age of cocoa farmer, sex, educational attainment and mean age squared of cocoa tree reduce the technical efficiency level of cocoa production in the study area. To improve upon farmers' level of efficiency, it is recommended that farm level policy oriented towards improving managerial skills with respect to the use of inputs such as fertilizer, insecticides and fungicides according to Ghana COCOBOD recommendations will be very imperative. Farmers should also be encourage to join farmer-base-organizations as this will help them have access to certain support services to improve on their efficiency level.

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