Technical efficiency in Ghana's cocoa production: evidence from Twifo Hemang Lower Denkyira Area

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TECHNICAL EFFICIENCY IN GHANA'S COCOA PRODUCTION: EVIDENCE FROM TWIFO HEMANG LOWER DENKYIRA AREA

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Abstract

This study examined the production efficiency of cocoa farmers in Twifo Hemang Lower Denkyira area composed of two districts namely Twifo Ati Mokwa district and Hemang Lower Denkyira districts in the central region of Ghana using farm level data. Results presented were based on data collected from multi-stage sampling of 326 cocoa farmers in twenty (20) communities using standardized structured questionnaires. The productivity and technical efficiency in cocoa production were estimated through stochastic frontier production function analysis using the Frontier 4.1 software. Empirical results showed that cocoa farms in the study area exhibited increasing returns-to-scale (RTS=1.2109), indicating reducing average costs (AC) of production. This implies that cocoa farmers were operating in the irrational zone of production (stage I), an indication of inefficiency in production. The technical efficiency indexes of farmers varied from 0.116 (11.6%) to 0.9998 (99.98%), with mean of 0.54 (54%). The main factors that significantly affected technical efficiency in cocoa production were found to be estimated number of hybrid plant, level of education and age of tree. Among others, the study recommended that the Cocoa Rehabilitation Unit of the Cocobod should help farmers to rejuvenate and or re-plant the aged cocoa farms with hybrid varieties improve resource use efficiency in cocoa production in cocoa production.

Keywords: cocoa, technical efficiency, production functions, stochastic frontier analysis

Introduction

Cocoa production has been a chief support to Ghana's economy through mainly its foreign exchange earnings, employment to thousands of rural dwellers and its contribution to Gross Domestic Product (GDP). Ghana cannot be mentioned without talking about its cocoa. Likewise, one cannot think of cocoa without thinking about Ghana. Efforts to improve cocoa productivity in Ghana will not only enhance the livelihood of the actors in the cocoa sub-sector but will have a colossal impact on the macro economy because of the myriads of the benefit the economy accrues from cocoa production. However, from the findings of Gockowski (2007) and Vigneri (2005) serious concerns arise over the future sustainability of the sector, as recent research findings clearly indicated that past and present cocoa output growth have been driven mainly by land expansion and by the intensive use of labour, rather than by rise in land productivity.

The production efficiency of small holder farms has been reported to have an important implication for the development strategies in most developing countries (Ogundari *et al*., 2006). However, very little study has been conducted so far to assess the efficiency of inputs use among cocoa farmers in Ghana. In Ghana, studies had concentrated on determining productivity with little attention given to efficiency levels; however it is possible to increase agricultural production significantly, simply by improving the level of producer technical efficiency without additional investments (Dzene, 2010). The findings of this research was intended to provide a sound understanding of current inherent efficiency and its related factors to serve as a base for productivity and efficiency enhancing policies.

Nkamleu *et al*. (2010) studied the "Technology Gap and Efficiency in Cocoa Production in West and Central Africa: Implications for Cocoa Sector Development". There have been a few studies on efficiency in the Ghanaian cocoa industry. Aneani, Anchirinah, Owusu-Ansah and Asamoah, 2011; Binam *et al.*, 2008; Dzene, 2010; Kyei *et al.,* 2011 are among the few researchers who have researched into the technical efficiency of cocoa production. However, findings from these studies are quite limited in terms of applicability in specific farmer locations due to their broad geographic scope. Farmers in different agro-ecological zones have different socio-economic backgrounds and resource endowments which might impact their resource use efficiency. Therefore, an empirical study to investigate technical efficiency in different cocoa agro-ecologies is a necessary first step in our national effort to improve resource use efficiency in specific production areas/zones, boost production, and improve the overall contribution of the cocoa sector to local economic development and overall national development.

Objectives

The main objective of the study is to analyse the efficiency of inputs use in cocoa production. The specific objectives of the study include the following:

1. To determine the effect of inputs use on output in cocoa production.
2. To estimate the levels of efficiency of inputs use in cocoa production.
3. To identify the determinants of efficiency of inputs use in cocoa production.

RESEARCH METHODOLOGY

Sampling and data collection:

The population includes all cocoa farmers within the Twifo Hemang Lower Denkyira area of Central Region of Ghana. Twifo Hemang Lower Denkyira area is currently made up of two districts namely Twifo Ati Mokwa district and Hemang Lower Denkyira districts in the central region of Ghana is the geographical area for the study.

A sample of 400 cocoa farmers was randomly selected using the multi-stage sampling approach for individual personal interview. A list of names of farmers of the Licensed Buying Companies (LBC) served as the sampling frame from which the sample of farmers was selected. A three-stage sampling technique was used for the selection of sample of 400 farmers. With multistage sampling technique, the researcher combines two or more sampling techniques to address sampling needs in the most effective way possible. This involved using a mixture of probability and non probability sampling procedures at different stages in order to select the final sample.

First of all, stratified sampling technique was used to divide the study area into two strata based on the demarcations of the two newly created districts, the Twifo Atti Mokwaa district and Hemang Lower Denkyira district from the study area. The two (2) districts were considered in the first stage sampling in the study to ensure generalization of the conclusions over inputs use in cocoa production in the study area.

In the second stage, simple random sampling was employed to obtain ten (10) cocoa communities from each district and finally twenty (20) farmers were identified randomly using, again, simple random sampling technique in each of the communities. The sample size per stratum was the same because the two zones had similar population strengths in terms of cocoa farmers. However, due to some irregularities in the data, 326 respondents were used for the efficiency analysis in the study.

Method of data analysis

Battese and Coelli (1992) proposed a stochastic frontier production for (unbalanced) panel data that has firm effects, which are assumed to be distributed as truncated normal random variables, and are also permitted to vary systematically with time. However, estimation of the stochastic production frontier requires a particular functional form of the production function to be imposed. A range of functional forms for the production frontier are available. The model may be expressed as:

$$Y_{it} = X_{it}\beta + (V_{it} - U_{it}),\ i=1,\dots, N;\ t=1,\dots, T \qquad (1)$$

Where Y_{it} is (the logarithm of) the production of the i-th firm in the t-th time period; X_{it} is a k×1 vector of (transformation of the) input quantities of the i-th firm in the t-th time period; β is a vector of unknown parameters; μ is a parameter to be estimated (determining whether the inefficiencies are time varying or time invariant. A value that is significantly different from zero indicates time varying inefficiencies). The error term has a double component typical of stochastic frontiers. The noise component V_{it} is a classical disturbance term, i.e. identically and independently normally distributed Vit~i.i.dN $(0, \sigma^2_v)$. The inefficiency component U_i is, in this particular model, independently (but not identically) distributed according to a truncated normal distribution with truncation at 0, whereby assuring non-negativity $U_{it} \sim (U_{it}, \sigma^2_u)$. A higher value for U implies an increase in technical inefficiency. If U is zero, the farm is perfectly technically efficient, Battese and Coelli (1995).

$$U_{it}=\delta_0+z_{it}\delta \qquad \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots \quad (2)$$

Equation (2) defines an inefficiency distribution parameter for z_{it} a vector of firm-specific effects that determine technical inefficiency, and δ is a vector of parameters to be estimated.

The technical efficiency (TE) of the i-th firm in the period can be defined as:

$$TE_{it} = \frac{E(Y_{it} / U_{it},\ X_{it})}{E(Y_{it} / U_{it}=0, X_{it})} = \exp(-U_{it}) \dots\dots\dots\dots\dots\dots\dots\dots\dots \ (3)$$

where E is the usual expectation operator. The measure of technical efficiency is thus based on the conditional expectation of Equation 3, given the values of $(V_{it}-U_{it},)$ evaluated at the maximum likelihood estimates of the parameters in the model, where the expected maximum value of Y_{it} is conditional on $U_{it} = 0$ (Battese & Coelli, 1988). All estimates are obtained through maximum likelihood procedures, where the maximum likelihood function is based on a joint density function for the composite error term (V_{it} -U_{it}). In this case, efficiency shall be calculated for each farm per year as;

$$E= [\exp (U_i)| (V_i + U_i) (\frac{1-\emptyset(\sigma_a+\gamma(V_i+U_i)/\sigma_a}{1-\emptyset(\gamma(V_i+U_i)/\sigma_a}) \exp [\gamma+ (V_i + U_i) + \sigma_a^2/2] \text{................}(4)$$

Where $\sigma_a = \gamma (1-\gamma) \sigma^2$, $\sigma^2 \equiv \sigma^2_u + \sigma^2_v$, $\gamma \equiv \sigma^2_u/\sigma^2$, $\varepsilon_j \equiv (V_i+U_i)$, and φ and φ represent the density and the distribution function of a standard normal random variable (Battese & Coelli, 1988). A value of gamma closer to zero implies that much of the variation is due to random stochastic effects, whereas a value of gamma closer to one implies mainly cross-farm differences in technical efficiency. The output elasticity with respect to this inputs variable is a function of the value of the input in both the frontier and the inefficiency models. Assuming a transcendental logarithm function (translog), the stochastic frontier model is specified as:

$$y_i = \exp (\chi_i\beta) + \mathcal{E}_i \text{...............equation (5)}$$

where $\mathcal{E}_i$ is the composite error defined as

$$\mathcal{E}_i = \exp (\nu_i - u_i) \text{..............equation (6)}$$

For the purposes of this study the stochastic frontier (linearized) model is specified as equation 7.

$$LnY_{it} = \beta_0 + \Sigma_{j=1}^{4} \beta_j LnX_{itj} + \Sigma_{j=1}^{4}\Sigma_{i=1}^{4} \beta_j LnX_{ijt} LnX_{it} + V_{it} - U_{it} \text{ ...... (7)}$$

$$\text{Ln}Y_{it} = \beta_0 + \beta_1 LnX_{1i} + \beta_2 LnX_{2i} + \beta_3 LnX_{3i} + \beta_4 LnX_{4i} + 0.5\beta_5 LnX_{1i} LnX_{1i} + 0.5\beta_6 LnX_{2i} LnX_{2i} + 0.5\beta_7 LnX_{3i} LnX_{3i} + 0.5\beta_8 LnX_{4i} LnX_{4i} + \beta_9 LnX_{1i} LnX_{2i} + \beta_{10} LnX_{1i} LnX_{3i} + \beta_{11} LnX_{1i} LnX_{4i} + \beta_{12} LnX_{2i} LnX_{3i} + \beta_{13} LnX_{2i} LnX_{4i} + \beta_{14} LnX_{3i} LnX_{4i} + V_{it} - U_{it} \text{.. (8)}$$

where j represents the j-th input (j = 1, 2 …4) of the i-th farm (1, 2…326) in the t-th time period (t = 1); β_0 is the unknown parameter or constant and is equal to output when the explanatory variable(s) is zero, Yi represents the physical output of cocoa beans in kilogram and it excludes the portion used for planting or given out to other farmers for planting; X_{1i} is the quantity of pesticide (herbicide, insecticide and fungicide) used in litres by i-th farmer; X_{2i} represents the total area of land of matured cocoa of *i*-th farmer; X_{3i} is the estimated number of hybrid variety per farm; X_{4i} represent the quantity of fertilizer used in Kilogram; $Y_{it}(k)$ and all $X_{it}(k)$s are mean-corrected to zero in the translog functional form, which implies that the first-order coefficient estimates of the model represent the corresponding elasticities. $U_{it} = \Sigma (\exp [-\eta (t - T)]) U_i$ and U_i is defined by the non-negative truncation of the N (μ, σ2)-distribution and U_i represents the technical inefficiency in production of *i-th* farm. It is assumed to be independently and identically distributed between observations, and is obtained by truncation at point zero of the normal distribution with mean u_i, and variance $\acute{o}^2_u$, where the mean is defined by the multiple regression equation:

$$U_{it} = \delta_0 + \delta_1 \text{Gen}_i + \delta_2 \text{Exp}_i + \delta_3 \text{Hyb}_i + \delta_4 \text{Hyb-loc}_i + \delta_5 \text{Pri}_i + \delta_6 \text{M/JS}_i + \delta_7 \text{Sec/Voc}_i + \delta_8 \text{Ter}_i + \delta_9 \text{Ext}_i + \delta_{10} \text{Age}_i + \delta_{11} \text{FBO}_i + \delta_{12} \text{Cred}_i \ldots\ldots\ldots\ldots\ldots \quad (9)$$

where U_{it} = 1 - TE, $\delta_i s$ are the unknown parameters to be estimated, and gender (Gen), experience (Exp), use of hybrid plant (Hyb), use of combinations of local-hybrid (Hyb-loc), educational level; Primary (Pri), Middle School or Junior Secondary (M/JS), Senior Secondary/Technical/Vocational School (Sec/Voc) and Tertiary (Ter), Number of Extension contact per the cocoa season (Ext), Age of cocoa trees (Age), Farmer being a member of farmer-based organisation/association (FBO) and whether the farmer accessed credit for the 2012/2013 cocoa season (Cre) were the socio-economic variables expected to explain the technical inefficiency levels of inputs use in cocoa production in the study area and were fitted into a multiple regression equation. The farm level cross sectional data used for the study were obtained for the 2012/2013 cocoa season.

RESULTS AND DISCUSSION

In choosing a model that adequately represents the data for estimation of technical efficiency, we estimated two functional forms (Cobb–Douglas and translog), and then tested the assumption according to which the Cobb–Douglas functional form is an adequate representation of data, given the specifications of the translog model. This boils down to testing the null hypothesis according to which the second order coefficients of the translog functional form are simultaneously null.

It emerges that the value of the generalized likelihood-ratio statistic for testing the null hypothesis that the second-order parameters in the translog production frontier function have zero values ($H_0 : \beta_{jk} = 0$, j<k=1, 2, 3, 4, 5), was 117.14. This value exceeds the critical Chi-square value of 39.97 at 1% level of significance, with 15 degrees of freedom. Consequently, the null hypothesis that the coefficients of the second-order variables in the translog model are zero, meaning null hypothesis that the Cobb-Douglas frontier was an adequate representation for the data was strongly rejected. Thus, the Cobb–Douglas functional form was not an adequate representation of the data. Translog production function was statistically more favourable and that the specification for the translog stochastic frontier production function was more suitable to derive conclusions in the data.

Table 1: Hypothesis test that second order coefficients of the translog functional form are simultaneously null

Null Hypothesis	**Loglikelihood Value**	**Test statistic (λ)**	**Critical Value**	**Decision**
1. $H_0 : \beta_{jk} = 0$	143.69	117.14***	39.97	Reject H_0

Source: Field data, 2014.

Effect of inputs on cocoa output.

The maximum likelihood estimates of the stochastic frontier production function given in Table 1 reveals that all the inputs considered in the study were statistical significant and that they had positive effects on output of cocoa production in this study area. The output elasticity was highest for quantity of fertilizer use (0.4606), followed by estimated quantity of hybrid variety (0.3388), quantity of pesticide usage (0.2403) and farm size (0.1712). The partial elasticity values obtained indicate the relative importance of every factor used in cocoa production. The maximum likelihood estimates of the translog stochastic frontier production function are presented in Table 2.

Table 2: Estimated parameters (MLE) of the translogarithmic stochastic frontier production function

Variables	Parameters	Coefficient	Standard-error	t-ratio
Constant	B_0	0.7338***	0.0359	20.4250
Lnpesticide	B_1	0.2403***	0.0623	3.8580
Lnfarmsize	B_2	0.1712***	0.0420	4.0787
Lnhybrid	B_3	0.3388***	0.0724	4.6814
Lnfertilizer	B_4	0.4606***	0.1260	3.6558
$0.5[Ln(pesticide)]^2$	B_7	0.1004***	0.0320	3.1423
$0.5[Ln(farmsize)]^2$	B_8	0.0879	0.0892	0.9855
$0.5[Ln(hybrid)]^2$	B_9	-0.0040	0.2451	-0.0165
$0.5[Ln(fertilizer)]^2$	B_{10}	-0.4717	0.3849	-1.2257
Ln pest. x Ln fsize	B_{15}	0.0625**	0.0302	2.0682
Ln pest. x Ln hybrid	B_{16}	0.0082	0.0373	0.2202

Ln pest x Ln fert	B_{17}	0.2035***	0.0557	3.6537
Ln fsize x Ln hybrid	B_{18}	0.2401***	0.0802	2.9919
Ln fsize x Ln fert	B_{19}	0.0017	0.1352	0.0124
Ln hybrid x Ln fert	B_{20}	-0.0198	0.1330	-0.1486
Sigma-squared	Σ^2	0.2072	0.0277	7.4846
Gamma	γ	0.9999	0.278E-06	0.358E+07
Log-likelihood		-85.1155		

Note: *, **, *** indicate significance at 10 per cent, 5 per cent and 1 per cent levels, respectively
Source: Field data, 2014.

The return to scale was revealed to be 1.2109. The return to scale, defined as the percentage change in output from 1 percent change of all input factors is equal to 1.2109, implying that cocoa farming in study area were characterised by inputs with increasing return to scale. This means that a percentage increase in all the inputs of production considered in the study will elicit more than a proportionate increase in cocoa output under the current technology. To be more specific, a percentage increase in all the inputs will results in 1.2109 percentage increases in yield under the existing technology.

The implication is that cocoa farmers in the study area are operating in the irrational zone of production (stage I) where decreasing average costs (AC) of production is being experienced and this stage represents an underutilization of production. This shows that there is more room for improvement in terms of cost reduction and efficiency improvement in cocoa production. From table 2 and 3, one percent (1%) increase in any one of the variables (which are fertilizer usage, pesticide usage, farm size and number of hybrid plants) holding constant the other variables, elicited 0.4606 percent, 0.2403 percent, 0.1712 percent and 0.3388 percent increase in output respectively. Output of cocoa in the study area can be further improved by increasing the quantities of these inputs. Partial elasticities and the return-to-scale for the production model are presented in table 3

Table 3: Partial elasticity and returns to scale of production (production model)

Variables	Partial elasticities
Pesticide	0.2403
Farm size	0.1712
number of hybrid plants	0.3388
Fertilizer	0.4606
Returns to scale	1.2109

Source: Field data, 2014

Kyei *et al.* (2011) also found that greater yield can be obtained from intensification of fertilizer and this conforms to the finding of the study. Aneani *et al*. (2011) further buttresses the point on the effect of quantity of fertilizer usage on cocoa output. The researchers established that the quantity of fertilizer applied to the cocoa farm "had the highest marginal physical product (133.11 kg/ bag)" and that "a 10 percent increase in quantity of fertilizer applied elicited 3.25 percent increases in cocoa output". Omotoso (1975) showed that a crop of 1000kg dry cocoa beans removes about 20KgN, 4kgP and 10kgK. As a perennial crop and heavy feeder, cocoa productivity is surely affected by fertilizer nourishment to replenish lost nutrients. This explains the relatively large effect of fertilizer on cocoa output.

In addition, the significantly positive effect of farm size (land) on cocoa output obtained in the study is collaborated by findings of other researchers. Nkamleu and Ndoye (2003) reported that in Africa, cocoa output has been achieved by increasing the area cultivated rather than by improving yield. Aneani *et al* (2011) again pointed out that a 10 percent increase in farm size resulted in 5.14 percent increase in output. The result obtained from the study is however contrary to the study by Berry and Cline (1979) and Lau and Yotopoulos (1971). Berry and Cline and Lau and Yotopoulos however showed that there is a negative relationship between output and farm size in developing economies.

As expected, an increase in the number of hybrid variety plants on the farm increased output. The result is in line with other research finding by Kolavalli and Vigneri (2010) and Edwin and Masters (2003). For instance, Edwin and Masters (2003) report that new tree varieties yield approximately twice as much cocoa per hectare as similar-aged fields.

From tables 2 and 3, increasing the quantity of pesticide usage by one percent (1%) resulted in 0.2403 percent (0.2403%) increase in output. Kyei *et al* (2011) found a similar result. According to FAO report (1971), the control of diseases and pests of cocoa in the cocoa belt of Western Nigeria, is said to have increased cocoa output by about 40 to 50 percent in recent years. CRIG (2010) expressed the need for employing these pesticides. It reveals that mirids alone may cause about 25 percent yield loss if their numbers on the crops are not effectively managed in Ghana.

Level of technical efficiency. The technical efficiency indexes of farmers varied from 0.116 (11.6%) to 0.9998 (99.98%), with mean of 0.54 (54%) and this suggest the prevalence of technical (managerial) inefficiency and little random shocks (climatic changes, production risks etc) since the estimated gamma was 0.999. The coefficient of gamma of 0.999 implies that, about 99 per cent of the difference between the observed and the frontier value productivity was mainly due to inefficient use of resources, which was under the control of sampled farmers. From the result, 46 percent of cocoa output on the average is lost due to inefficiencies or managerial ineptitude and there was a scope to increase the value productivity of cocoa production under the existing condition and technology. Thus, in the short run, there is a scope for increasing cocoa production by about 46% by adopting new technologies, practices and efficient combination/allocation of production factors.

Sekhon *et al.* (2010) also had a similar high value of gamma (0.9999) which indicated the presence of significant inefficiency in the production of crop from a research in south-western region of Punjab state in India. Dzene (2010) used a balanced panel data for three years to show that mean technical efficiencies for cocoa farmers in the Western region of Ghana were 48.6 percent, 48.3 percent and 47.2 percent in 2002, 2004 and 2006 respectively. Binam *et al.* (2008) estimated the mean efficiency of cocoa farmers in Ghana to be 44 percent. Binam *et al*. and Dzene results are not too different from the result obtained in this study considering the time variance and as such slight improvement in the technical efficiency estimate is expected.

However, all the empirical estimates of technical efficiency for Ghanaian cocoa farmers are lower than those estimated for cocoa farmers in other West African countries. For instance, Amos (2007) showed that cocoa farmers in Nigeria were 72 percent technically efficient whiles Binam *et al.* (2008) estimated 74 percent and 65 percent as technical efficiency figures for cocoa farmers in Nigeria and Cameroun respectively.

From Table 3, 92.3 percent of the sampled farmers at most 90 percent technically efficient and about half of the respondents had technical efficiency level less than the mean value. Only 7.7 percent of respondents achieved 91 percent to 100 percent of the frontier output however about 12 percent of farmers were operating near the potential output, i.e. 91-100 percent of technical efficiency in Sekhon *et al.* 2010 study. This suggest that technical efficiency level of the respondent were generally low and therefore with the application of the appropriate agronomic and management practices, output of farmers in the study area can be substantially improved by 46 percent on the average. The distribution of level of technical efficiency estimate of inputs use obtained from the study is presented in Table 4.

Table 4: Frequency distribution of levels of technical efficiency estimates

Efficiencies level (%)	Frequency	Percent	Cumulative percent
11 - 20	8	2.4	2.4
21 – 30	49	15.0	17.5
31 – 40	53	16.3	33.7
41 – 50	42	13.0	46.7
51 – 60	56	17.1	63.8
61 – 70	40	12.2	76.0
71 – 80	16	4.9	80.9
81 – 90	37	11.4	92.3
91 – 100	25	7.7	100.0
Total	**326**	**100.0**	

Source: Field data, 2014

The result is reinforced by research work by Nkamleu (2004). The researcher stated that “technical efficiency score is globally quite low" and technology gap plays an important part in explaining the ability of the cocoa sector in one country to compete with cocoa sectors in other regions in West and Central Africa (Nkamleu 2004b). However, Nkamleu, again stated that the current gap between observed and achievable yields in cocoa production lies in Ghana somewhere between 50 to 80 percent depending on different practices adopted by farmers”.

Determinants of technical efficiency. Table 5 shows that the tertiary educational level, use of hybrid seedlings and age of tree were the main variables that significantly affected the technical inefficiency of farmers and were the important determinants of technical efficiency of inputs use in cocoa production in the study area. The coefficients of gender, years of cocoa farming, use of hybrid-local seedlings, levels of educational attainment below tertiary (primary, MLS/JSS and Secondary/Vocational), extension contacts per year, farmer based organisation/association and access to credit were not statistically significantly different from zero at the various statistical levels (1%, 5% and 10%) as indicated in Table 4. It is worth noting however that the signs of coefficients of variables such as years of cocoa farming, use of hybrid varieties, use of hybrid and local varieties, levels of educational attainment below tertiary (primary, MLS/JSS and Secondary/Vocational), Farmer based organisation/association and access to credit were in accordance with the a priori expectation.

Firstly, the coefficients of the variables of levels of formal education below tertiary had a negative and insignificant effect on technical inefficiency except primary education which was positive. From Table 5 the coefficient estimates gradually increases through the various levels. It shows that technical efficiency is enhanced with increasing formal education. The result is similar to the conclusion reached by Ajibefun and Daramola (2003) that education is an important policy variable and could be used by policy makers to improve both technical and allocative efficiency.

This is because farmers with formal education can read labels on agro-chemical, read or understand advertisement and best agricultural practices from newspapers, bulletins, literature, mass media etc, and may have also acquired relevant knowledge that can aid in production in school. Farmers can learn faster and have access to other sources of income which the farmer can acquire to buy other inputs. Pudasaini (1983) documented that education contributed to agricultural production in Nepal through both worker and allocative effects. Pudasaini reasons that even though education enhances agricultural production mainly by improving farmers' decision making ability, the way in which it is done differs from environment to environment. Kumbhakar *et al.'s* (1991) research also agrees with the research findings. Kumbhakar reveals that the levels of education of the farmer are important factors determining technical inefficiency.

The research finding conforms to the findings of Battese and Coelli (1995). Battese and Coelli reported a positive relationship between maximum years of formal schooling for a member of household and technical efficiency. Battese and Coelli reasoned that educated farmers usually have better access to information about prices, and the state of technology and its use. Better-educated people also have higher tendency to adopt and use modern inputs more optimally and efficiently, (Ghura & Just, 1992).

Age of tree has a positive significant influence on technical inefficiencies and hence an important determinant of technical efficiency of inputs use in cocoa production. This means that as the cocoa trees gets older beyond certain years, it output decreases and this increases inefficiency. In a study on technical efficiency in cocoa production, Kyei *et al.* (2011) found -0.249 as coefficient for age of cocoa trees to output and this corroborate with the finding in this study. The researchers added that the years of cocoa trees affect general output and should be given prior attention.

Again, the coefficient estimated for the variable indicating use of hybrid varieties has a significant negative sign on technical inefficiency implying that the technical inefficiency diminishes with the use of hybrid variety. The use of both hybrid and local varieties in farm also enhanced the efficiency level of cocoa production as it has a negative correlation but insignificant correlation with technical inefficiencies. The finding is in line with Chirwa (2007) who suggested that efficiency rises with hybrid seed. Contrary to the finding of this study, Dzene

(2010) found evidence that there is no significant difference in technical efficiency across seed type. Table 5 highlights the estimated determinants of the technical inefficiency of inputs use in cocoa production.

Table 5: Estimated parameters of the technical inefficiency effects model

Variables	Parameter	Coefficient	Standard-error	t-ratio
Constant	δ_0	0.3487*	0.1975	1.7658
Gender	δ_1	-0.0249	0.1089	-0.2285
Years of farming	δ_2	-0.0082	0.0052	-1.5912
Hybrid-local	δ_3	-0.1372	0.1076	-1.2750
Hybrid	δ_4	-0.2814**	0.1237	-2.2741
Primary	δ_5	-0.1654	0.1467	-1.1279
MSL/JSS	δ_6	-0.1680	0.1148	-1.4630
Sec/Voc	δ_7	-0.2858	0.2302	-1.2413
Tertiary	δ_8	-0.1135**	0.5798	-1.9576
Extension cont. per yr.	δ_9	0.0481	0.0320	1.5028
Age of tree	δ_{10}	0.0372***	0.0083	4.4773
Farmer based org.	δ_{11}	-0.1914	0.1646	-1.1631
Credit access	δ_{12}	-0.0028	0.1575	-0.0178

Note:*, **, *** indicate significance at 10 per cent, 5 per cent and 1per cent levels, respectively
Source: Field data, 2014

CONCLUSION AND RECOMMENDATION

The study showed that quantities of fertilizer application, pesticide usage, hybrid varieties and farm size significantly affected the output of cocoa production in the study area. Cocoa output in the study area can be enhanced by increasing the quantities of fertilizer application, pesticide usage, hybrid varieties and farm size. The estimated technical efficiency levels ranged between 11 percent to 99 percent with mean of 54 percent. Furthermore, 99.9 percent of the variation between the observed output and the frontier output were as results of inefficiency.

The study further showed that cocoa farmers in Twifo Hemang Lower Denkyira exhibited increasing returns to scale, indicating that cocoa production was in the irrational zone (i.e. stage I of the production function). Technical efficiency of inputs use in cocoa production was low. Hybrid varieties, tertiary level of education and age of tree were found to be the main determinants of technical efficiency of inputs use in cocoa production in the study area.

Some farmers prefer the local cocoa varieties, that is the Amazonia cocoa variety for its hardiness, thus farmers should be given education on the desireble traits of the hybrid variety and should be encouraged by the Extension division of the COCOBOD to grow them. The study recommended further that the Cocoa Rehabilitation Unit and the Seed Production Unit of the COCOBOD should help farmers to rejuvenate and or re-plant the aged cocoa farms with hybrid varieties to improve resource use efficiency in cocoa production in cocoa production in the study area.

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