TECHNICAL EFFICIENCY OF COCOA FARMERS IN GHANA

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Keywords

technical efficiency, stochastic production frontier, cocoa households, Ghana

Abstract

The commitment of the government in promoting and encouraging the welfare of cocoa farmers makes cocoa policies critical in Ghana. Having dropped below global production levels, however, technical efficiency in Ghana has continued to decline over the years. This study aims to analyse the extent of productivity and find the sources of technical efficiency in cocoa-producing households by applying the stochastic frontier approach to the Ghana-Living Standards Survey Round Five of 2005/06. The estimated technical efficiency has a mean of 47.82%. Crop diversification, mechanised farming and hired labour enhance technical efficiency, while emigration results in its deterioration. Other critical factors that influence efficiency are also identified.

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1. Introduction

Since the 1940s, cocoa has been the most directly beneficial cash crop and productive capital good affecting Ghana's economic growth, as it is directly inclined toward the balance of payments and improvements in the gross domestic product. For Ghana, the cash crop is a source of livelihood for most families and households by creating many types of employment along its value chain.

Ghana's cocoa production has fed on natural agricultural resources, relying on natural land productivity and farmland size expansion. However, decline in both cocoa farmland size and quality has had negative effects on outputs. The accessibility of resource-rich land for cocoa production has remained one of the major challenges to farmers, while existing cocoa land has eventually lost its fertility. Thus, farmers' dependence on natural land and climatic conditions for the production of cocoa is unsustainable. In addition, cocoa production has declined over the years as prices of farm inputs like agrochemicals are increasing relative to farmers' real income. Under such circumstances, Ghana must identify and estimate sources of productivity of the cocoa sector to boost its growth.

The World Bank (2008) confirms that the growth performance of developing countries is highly dependent on agricultural performance and that their per capita growth and economic welfare are also dependent on total factor productivity. Hence, estimating sources of total factor productivity becomes imperative to find out new technologies and practices that could enhance the output and incomes of farmers, which will also provide valuable information about the optimal mix of existing resource endowments.

Just as the International Cocoa Organisation (ICCO) recognises cocoa farmers as key components, the Ghanaian government developed the Food and Agricultural Sector Development Policy (FASDEP II) in 2002 and revised it in 2008 as an effort to modernise the agricultural sector of Ghana and encourage sustainable resource use. Despite the fact that worldwide cocoa consumption primarily in the form of chocolate products has increased in recent years, Ghana's average productivity level is below that of its subregional competitors. With declining cocoa production and productivity, an urgent need exists to reverse the trend in a sustainable manner that conforms to government development strategies. Consequently, many studies have attempted to estimate pro-

ductivity in cocoa production (Amos, 2007; Binam et al., 2008; Danso-Abbeam et al., 2012; Dzene, 2010; Kyei et al., 2011; Ogunniyi et al., 2012; Teal & Vigneri, 2004). Building on the previous studies, this study aims to investigate sources of productivity for Ghanaian cocoa farmers to support the government agenda.

For the specification and identification of inefficiency factors among cocoa farmers, most studies have centred on farmer-specific effects rather than institutional/farm-specific effects (Hill, 1963). Also, none of the existing cocoa productivity and technical efficiency studies has considered all six cocoa pro-ducing regions in Ghana. In addition, the only study that tried to use the Ghana Living Standards Survey (GLSS) has used the normal supply response function (Teal & Vigneri, 2004). In this study, however, we consider household in-efficiency effects for all six cocoa-producing regions in Ghana by applying the stochastic frontier approach to a data set compiled from the GLSS. In this re-gard, the study might complement the existing literature in understanding the productivity structure of cocoa producing households in Ghana.

The main objective of this study is to estimate the productivity of Ghanaian cocoa farming households and find sources of technical efficiency. For this purpose, we employ the two stage stochastic frontier analysis procedure. In the first stage, we apply the stochastic frontier approach to esti-mate a Cobb‐Douglas production function for Ghanaian cocoa households in a four factor input model of capital, labour, material and land. Then, we utilise the Tobit estimator in the second stage to investigate determinant factors of technical efficiency.

Based on the cross-sectional survey data compiled from the Ghana Statistical Service, our estimation shows that the estimated technical efficiency has a mean of 47.82%. We find that crop diversification, mechanised farming and hired labour enhance technical efficiency significantly while emigration re-sults in its deterioration. We also identify other critical factors that influence efficiency.

The rest of the study is organised as follows. Section 2 surveys the Ghanaian cocoa industry and reviews the existing literature on cocoa productivity. Section 3 presents the empirical model and data. Section 4 pro-vides and discusses the empirical results, and section 5 presents policy implications.

2. The Cocoa Industry in Ghana and Its Productivity

As the Ghanaian economy has relied greatly on agricultural contribution to the GDP over the years, Ghana derives a great deal of macroeconomic benefits from cocoa. Cocoa is directly inclined toward the balance of payments and GDP improvements.[1] The 2012 national budget accredited the high growth performance of the crops subsector to the growth performance of the cocoa subsector (MOFEP, 2011). Furthermore, cocoa's significant contribution to agricultural and export earnings, at 44% and 20%, respectively, will continue to be fundamental in Ghana's middle income pursuit by 2015 (Breisinger et al., 2008). After all, growth targets in Ghana's 2010‐2013 medium-term development framework is based on the assumption that cocoa will continue to supply export earnings and incomes (NDPC, 2010).[2]

　　World production of cocoa beans has mostly come from Africa. For the years from 2004/05 to 2008/09, Cote d'Ivoire was the world's largest producer of the bean, accounting for 39% of the world total supply, while Ghana trailed behind at 20.4% as the world's second largest producer (ICCO, 2010). Africa supplied 68.4%, 74.9% and 70.8% of the total world output respectively in 2009/10, 2010/11 and 2011/12, and Ghana supplied nearly 24% of it in 20011/12 (USDA, 2012).

　　Globally, cocoa provides employment for about 14 million people, out of which Africa counts closely 10 million (Kaplinsky, 2004). About 95% of world cocoa production depends on small-scale land use of approximately 3 ha. As rural community agriculture, most producing countries have per capita incomes below the United Nations recommended US$2 mark, isolating them within the poor income group. This is a result of low productivity and market inefficiency. Average productivity in most producing nations is low with about 500 kg/ha cocoa yields (Nkamleu et al., 2010; Wahyudi & Misnawi, 2008).

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[1] The sector contributes, on average, over 37.8% of the annual foreign exchange earnings.

[2] In 2010, the 5.4% growth performance of the crop subsector outpaced growth in the agricultural sector, which levelled at 2.8%. Of this 5.4% crop sector growth, the cocoa sector accounted for a significant 14%, a sharp increase over the 4.5% targeted performance.

The average yields of cocoa vary widely according to producing nations. In Nigeria and Cote d'Ivoire, cocoa average yields are 1082－1680 kg/ha and 600－700 kg/ha, respectively. In Colombia, the average yields are around 450 kg/ha. In Latin American countries, the yields are 700－2400 kg/ha (Mejia, 2011). However, the yields are much lower in Ghana. In 2005, Zeitlin (2005) measured the performance of land at 256 kg/ha for the Ashanti region of Ghana. Anon (1999) also reported a national average cocoa yield of 360 kg/ha for Ghana in comparison with a respective 800 kg/ha and 1800 kg/ha for Cote d'Ivoire and Malaysia.

Previous studies have also modelled productivity and technical efficiency sources in the cocoa industry to enhance its productivity. Amos (2007) used a sample of 250 cocoa farmers in Nigeria to espouse technical efficiency sources among smallholders. He found that cocoa production experienced increasing returns to scale at 1.26 with an average technical efficiency of 72%. Binam et al. (2008) used the meta-frontier stochastic production approach to estimate and find sources of technical efficiency in cocoa production for West African countries. They reported that Cameroon, Ghana, Nigeria and Cote d'Ivoire have technical efficiency of 65%, 44%, 74% and 58%, respectively.

Danso-Abbeam et al. (2012) found that Ghanaian cocoa farmers are 49% technically efficient with returns to scale at 1.26 in the Bibiani-Anhwiaso-Bekwai District of the Western Region of Ghana. By applying a stochastic production approach to data from three rounds of the Ghana Cocoa Farmers Survey in 2002, 2004 and 2006, Dzene (2010) reported mean technical efficiency of 48.6%, 48.3% and 47.2% in 2002, 2004 and 2006, respectively. Kyei et al. (2011) suggested that the size of farmland, and quantity of fertiliser and pesticide influence farm production and output in the Offinson District of the Ashanti Region of Ghana. Ogunniyi et al. (2012) suggested that technical efficiency is positively influenced by the experience of the farmer and the age of cocoa plants among female cohorts, whereas the efficiency among male farmers is influenced negatively by the age of the farmer, educational level, and experience in cocoa farming. Teal and Vigneri (2004) used two cross sections of the Ghana Living Standards Survey of 1991 and 1998 and showed 6% output growth rate and 39% labour productivity increases, while land productivity remained unchanged over the period.

Table 1 summarises previous studies that estimated productivity and its determinants of the cocoa industry in Ghana and West Africa.

TABLE 1. Summary of Previous Studies on Cocoa Productivity

Author(s)	Data	Methods	Country of Study
Amos (2007)	2003/04 Survey	Stochastic Frontier Production Function	Nigeria
Binam et al. (2008)	2002 survey	Stochastic Frontier Metaproduction	Cameroon, Cote d'Ivoire, Ghana, Nigeria
Danso-Abbeam et al. (2012)	2010 Survey	Stochastic Production Function	Ghana
Dzene (2010)	2002, 2004, 2006 survey	Stochastic Frontier Production, Tobit	Three Regions in Ghana
Kyei et al. (2011)	2009/10 Survey	Stochastic Production Frontier	Ghana
Nkamleu et al. (2010)	2002 Survey	Stochastic Frontier Metaproduction	Côte d'Ivoire, Ghana, Nigeria, and Cameroon
Ogunniyi et al. (2012)	2005 Survey	Stochastic Frontier Production	Nigeria
Teal & Vigneri (2004)	1990/1 – 1997/8 Survey	Supply response production function/OLS/2SLS	Ghana
Zeitlin (2005)	2001/2 – 2003/4 Survey	Total factor productivity function/OLS/2SLS	Ghana

Notably, the specification and identification of inefficiency factors among cocoa farmers is a source of worry. Most studies have centred on farmer-specific effects rather than institutional/farm-specific effects, and none of the existing cocoa productivity and technical efficiency studies considers all six cocoa producing regions. Also, the only study that tried to use the GLSS did not use the stochastic frontier approach but instead used the normal supply response function (Teal & Vigneri, 2004). With reference to these, we try to consider household inefficiency effects of all six cocoa-producing regions in Ghana by applying the stochastic frontier approach to a data set constructed from GLSS to further the existing literature.

3. Empirical Model, Data and Cocoa Farm Characteristics

3.1. Empirical Model

Frontier models acknowledge that firms do not fully utilise the existing technology because of various non-price and organizational factors. As a consequence, changes in overall productivity are affected not only by technical progress, but also by changes in technical efficiency.

As a frontier technique, the stochastic frontier approach includes two measures of error in estimating the production frontier: an inefficiency error term, which represents loss due to technical inefficiencies, and a statistical noise error term. Thus, this method utilises statistical tests to investigate the validity of the functional specification and estimated coefficients. In the approach, technical efficiency is estimated by subtracting statistical noise from calculations of the total deviation of actual production from the production frontier. However, this method is vulnerable to specification error because it requires parametric specification.

In contrast, data envelop analysis (DEA) is very versatile and can accommodate multiple inputs and multiple outputs. DEA also does not require any parametric specification and thus is not susceptible to specification error. For this reason, this method has been widely used in studies investigating the production efficiency of activities involving complex or unknown relationships among multiple inputs and multiple outputs. However, DEA assumes the absence of random fluctuation in the production frontier, thus deterring statistical inference and possibly overestimating technical inefficiency because all deviations from the frontier are considered inefficiencies. As a result, DEA is sensitive to outliers that might exaggerate the actual frontier.[3]

Between these two approaches, this study utilises the stochastic frontier approach because a large number of sample farmers are likely to involve many outliers that could produce estimation bias when DEA is used.

A stochastic production function for the cocoa-farming household is specified by

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[3] This discussion about frontier models draws on Kim (2011).

$$ln\,Y_i = \beta_0 + \beta_K lnK_i + \beta_L lnL_i + \beta_M lnM_i + \beta_N\,lnN_i + v_i - u_i, \tag{1}$$

where Y_i is the output of the ith cocoa farm (i = 1, .., n), and K, L, M, N are capital, labour, material and land inputs, respectively. Additionally, $u \geq 0$ is the output-oriented technical inefficiency, which is assumed to be independent of the statistical error v, which is assumed to be independently and identically distributed as $N(0, \sigma_v^2)$. The statistical error (v_i) will capture random statistical noise such as measurement errors that are not under the influence or control of cocoa producers, along with omitted explanatory variables. On the other hand, frontier error (u_i) will estimate the random, non-negative technical inefficiency resulting from unobserved household-specific effects that prevent households from reaching their maximum potential production frontier.

In estimation, composite error is estimated simultaneously with parameters, and then the composite error is divided into the statistical error and the frontier error based on distributional assumptions on the frontier error. Also, statistics of $\lambda = \sigma_u/\sigma_v$ and $\gamma = \sigma_u^2/\sigma^2$, where $\sigma = \sqrt{\sigma_v^2 + \sigma_u^2}$ are reported for model diagnostics. Lambda (λ) represented the ratio between inefficiency and noise effects, whereas gamma (γ) measures the ratio of frontier error variation in the composite error variation and lies in (0, 1).

From equation (1), the returns to scale (RTS) of cocoa production can be estimated as the sum of output elasticities with respect to each production factor input β_i:

$$RTS = \Sigma_i \beta_i, \quad i = K, L, M, N. \tag{2}$$

The technical efficiency level of farm i (TE_i) is defined as the ratio between the actual output and the potential output:

$$TE_i = \exp(-u_i). \tag{3}$$

The efficiency estimates enter the second stage analysis to determine sources of technical efficiency among cocoa-producing households. The maximum likelihood Tobit regression is specified for Ghanaian cocoa households as follows:

$$TE_i = \alpha_0 + \alpha_1 D_i + \sum_{j=2}^{l} \alpha_j D_i Z_i^* + \sum_{j=l+1}^{k} \alpha_j Z_i + e_i, \tag{4}$$

where D_i is crop diversification (a key policy variable) and Z_i is a (k – 1) explanatory variables that influence the ith cocoa household production efficiency, among which Z_i^* also affects the efficiency interactively with diversification, α_js are (k + 1) unknown parameters to be estimated and e_i is white noise.

3.2. Data and Variables

The data used in this study are drawn from the Ghana Living Standards Survey Round Five (GLSS5), collected by the Ghana Statistical Service (GSS) in collaboration with the World Bank during the 2005/06 cocoa season. The GLSS is part of the Living Standards Measurement Study (LSMS) introduced in the 1980s by the Policy Research Division of the World Bank, and had been conducted in five rounds respectively for 1987, 1988, 1991/92, 1998/99 and 2005/06. Among these surveys, this study is focused on the latest one (GLSS5), which includes comprehensive questions on household-related variables.[4]

The GLSS survey covers all six cocoa producing regions in Ghana; it therefore has the widest coverage of cocoa household surveys in Ghana and allows for the participation of a greater number of cocoa-farming households than any other national survey conducted in Ghana. In GLSS5, a cocoa-farming household is classified as one in which any member produced or harvested cocoa during the last 12 months, so most variables in the survey are household-related. Therefore, individual observations are integrated into household units using the household identifier. That is, the average level of cocoa production, the household output, production activities and resource endowments are categorised into their household total, even though household-head figures

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[4] These surveys cannot be integrated to constitute a panel due to lacking identifications across surveys. We have also tried to pool the most recent three surveys, but we do not have enough observations to carry out second-stage analysis of product determination, as earlier surveys do not have the relevant variables to warrant any meaningful analysis.

are used as being representative of the household for some instances. All monetary values are converted into Ghana cedis (GH₵).

For output (Y), the value of output (income) from cocoa households is composed of total household incomes from the production of cocoa, maize, plantain and cassava.[5] Outputs collected in different units are converted into kilogramme quantities, which are valued at their current prices using 2005/06 market price indices obtained from the Ghana Cocoa Board and the Ghana Statistical Service.

Four production factor inputs representing Capital (K), Labour (L), Material (M) and Land (N) are used to estimate the cocoa production function. Capital is the real value of machinery and equipment owned by the household plus aggregate expenditure on renting equipment for farm production. This definition enables us to allow for not only all the farming machinery and equipment cocoa farm households possess, but also other capital they rent for farming. To combine stock and flow components of capital, we use their current money equivalent.[6] Labour input is represented by the number of workers engaged on the farm. Material input is measured by the current value of the costs of fertiliser (organic and inorganic), insecticides, herbicides and seeds and seedlings input into production. Finally, land is represented by the total size of farmland (hectares) used by the household.

The variables used in the determination of sources of technical efficiency are grouped broadly under farm household's characteristics, human capital, technology, diversification and regional dummies.

Under the farm characteristics, demographic, farm and managerial quality variables and land ownership indicator are included. For these farm charac-

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[5] According to Teal and Vigneri (2004), this study defines cocoa households as those who deem cocoa to be of primal or secondary essential income source, so the value of output includes incomes earned from crops other than cocoa. However, cocoa constituted nearly 95% of the total harvest in the forest zone of Ghana in GLSS5 survey. Furthermore, the definition of output enables us to investigate impacts of diversification on productivity.

[6] This definition of capital is applied to include all the capital farm households utilise for farming, and thus capital stock owned by farmers is likely to be overrepresented than rented capital services in estimation. After carefully inspecting the dataset, however, we find the owned capital stock is very small and ignorable for most of sample farm households, thus making this bias minimum at largest.

teristics, household demographics, migration indicator, farm ownership and labour quality variables have been included. The age of the household head is taken as a representation of household age. Households with male heads are assigned 1 and those with female heads are assigned 0. The size of the household is the total number of individuals within each cocoa household. Migration represents a dummy created for households in which any member has ever moved out of the town or village; households are assigned to 1 if any member ever moved out. The quality of labour is represented by the total value of household-hired farm labour to allow for hired labour that might bring different skills or expertise from household labour. Male-labour composition ratio has been used to represent the composition of farm labour among households. Farm ownership, proxied by the sharecropping indicator variable, is also included to seek the impact of farm ownership on technical efficiency (sharecropping = 1).[7]

For human capital, two variables are included to allow for the effect of educational qualification and household medical expenditure on technical efficiency. A dummy relating to household education is generated for all households that have members who have attended school (schooled households = 1). Again, the highest educational attainment level has been included to realise the effect of educational qualifications on household production efficiency. For the health situation of households, the total household medical expense has been included.

Household farm technology and its quality are identified by the total amount of loans acquired by the household and an indicator of equipment ownership, respectively. The level of household farm technology is included to verify the effect of farm technology on their productivity. The quality of household equipment, a dummy variable, has been generated to represent households that own farm equipment (tractor, plough, trailer and sprayer). For households that own any of this equipment, an indicator of 1 is assigned.

Crop diversification is a policy variable that represents households that produce other crops such as maize, plantain and cassava in addition to cocoa. A dummy is created to denote diversified cocoa farmers (diversification = 1). We include three interaction terms among diversification and land, labour and

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7 Sharecropping is a system of farm ownership in which the landlords relinquish authority of their land to caretaker-farmers for a period of time agreed upon by both parties, and the seasonal outputs are divided after the harvest.

total household loans to estimate the interactive impact of diversification on productivity.

Five regional dummies are observed to allow for the differences among the six cocoa-producing regions in Ghana. These are the Ashanti, Central, Eastern, Volta and Western Regions of Ghana.

Table 2 presents summary statistics of the variables used to estimate productivity and its determinants of the cocoa industry in Ghana.

TABLE 2. Measurement of Cocoa Household Variables in Productivity Estimation

Variable		Definition	Construction	Mean (SD)/ Count
Production Function Variables	Farm Income (Y)	Total value of farm output	Cocoa, maize, cassava and plantain	1466.35 (6572.89)
	Capital (K)	Total value of equipment and machinery	Value of equipment, expenditure on hiring equipment and hand tools	33.85 (92.63)
	Labour (L)	Total number of individuals engaged on farm	Number of males and females	3 (3)
	Material (M)	Total expenditure on farm materials	Expenditure on fertilisers, insecticides, herbicides, seeds and seedlings	99.13 (548.71)
	Land (N)	Size of land owned by household	Acreage of farmlands in hectares	5.23 (40.42)
Farm Characteristics	Gender	Sex of the head of household	Male = 1	769
	Age	Age of household head	Age in years	50.58 (15.13)
	Migration	Indicator of migratory activities of household members	Migration = 1	243
	Household size	Total number of individuals within households	Count of household membership	5 (3)
	Male-Labour Composition	Composition of male labour in total household labour	Ratio of male labour to total household labour	0.6089 (0.2825)
	Labour quality	Total value of hired labour in cocoa	Expenditure on hired labour	54.45 (219.13)

Variable		Definition	Construction	Mean (SD)/ Count
		households		
	Sharecropping	Indicator of farmland ownership	Sharecropping = 1	62
Human Capital	Educational qualification	Indication of educational attainment level of head	Ordinal indication of qualification	2 (2)
	Medical expenses	Total medical expenses incurred by entire household	Summation of household medical expenditure	.30 (3.16)
Technology	Loan	Total amount of loans acquired by household	Summation household loans amount in GH₵	69.95 (382.29)
	Equipment	Indicator for households owning farm equipment	Equipment = 1	333
Diversification	Crop diversification	Indicator of multiple cropping system	Diversification = 1	901
Regional dummies	Regional dummies	Indicator of farm regional location	Dummies for each of the 6 regions, (Region = 1, 0 otherwise)	AR = 230 BA = 123 CR = 171 ER = 162 VR = 31 WR = 255

Note: AR, BA, CR, ER, WR and VR represent the Ashanti, Brong-Ahafo, Central, Eastern, Volta and Western Regions respectively.

4. Empirical Results

4.1. Analysis of Cocoa Household Production Function

Table 3 shows the maximum likelihood estimation (MLE) of the stochastic frontier models. All of the estimated coefficients are statistically significant at the 1% level of significance. The Wald chi-square value of 251.14 also shows the overall significance of the estimated model in the Cobb‑Douglas function.[8]
　　　　Several tests are utilised to find the relevance of the stochastic model

and its functional form. First, the likelihood ratio (LR) test is conducted to ex-amine whether the Cobb‒Douglas or the translog production function better represents the data of Ghanaian cocoa household production. For this, the trans-log production function is estimated and tested to find out whether its square and interactive terms of four factors are jointly significant. The estimated LR test statistic of 19.95 is lower than the critical chi-square statistic value of 25.19 with 10 degrees of freedom at the 99% confidence interval.

Second, estimated gamma (γ) is significant with 0.6006, a figure that is closer to 1 than 0. Thus, the deviation in household farm income from the frontier is attributable to 60.06% of technical inefficiency. Additionally, the ra-tio between inefficiency and noise effects, represented by lambda (λ), is also significant at 1.2263. This brings out the fact that inefficiency effects within the model are much higher than the corresponding idiosyncratic noise effects. The null hypothesis that the variance of the inefficiency error term is zero is also rejected at the 1% significance level, implying a high variation in inefficiency error.

TABLE 3. Coefficient estimates of Cobb‒Douglas stochastic production function

Variables	Coefficient	Std. Error
Ln(Capital)	0.2146***	.0449
Ln(Labour)	0.4419***	.0813
Ln(Material)	0.2825***	.0388
Ln(Land)	0.0978***	.0276
Constant	5.1954***	.2118
Parameterisation		
σ_v	0.9707	.0673
σ_u	1.1903	.1537
σ^2	2.3591	.2803
λ	1.2263	.2092

[8] The number of sample used in estimating production function decreases to 525 from 972, which is the number of total sample as reported in Table 1, because many sam-pled farm households lack the relevant variables required to estimate the function.

Variables	Coefficient	Std. Error
γ	0.6006	
Log likelihood	– 842.18	
Likelihood-ratio test: $\sigma_u = 0$	7.66***	
Wald-χ^2	251.14***	
N	525	

Notes: ** and *** represent coefficients significant at the 5% and 10% levels respectively.

Coefficient estimates of all four factor inputs of capital, labour, material (mostly agrochemicals) and land are significantly different from zero at the 1% significance level. The return to scale is estimated at 1.037. The Wald test for the null hypothesis that technology is a constant returns to scale cannot be rejected with p-value of 0.656, implying constant returns to scale technology for the Ghanaian cocoa industry.[9]

The estimated mean technical efficiency of cocoa households ranges between 0.0285 and 0.8556, with a mean technical efficiency of 0.4782. A considerable level of variation exists in technical efficiency among Ghanaian cocoa households with a standard deviation of 0.1396. The mean technical efficiency of 0.4782 indicates that on average, farmers produce 47.82% of potential output given the level of farm production technology available. Conversely, most Ghanaian cocoa households produce 52.18% below their production frontier. Thus, an opportunity of increasing production by 52.18% in the Ghanaian cocoa sector exists, which is possible just by applying best practices to farming without increasing any inputs.

This study finds interesting outcomes when examined alongside existing studies. For example, Danso-Abbeam et al. (2012) concluded that cocoa is produced at a 49% efficiency level in the Bibiani-Anwiaso-Bekwai District. Binam et al. (2008) had reported an estimate of 44% for Ghanaian cocoa production efficiency. Dzene (2010) estimated average efficiency at 48.6%, 48.3% and 47.2% for the three leading producing regions of cocoa as a representation

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[9] This suggests that most of cocoa households produce their crops based on manual labours without realising scale economies.

for Ghana in 2002, 2004 and 2006, respectively. His estimate of 47.2% concurs with our 47.8% for the same 2006 period.

Quite unsurprisingly, however, all these reported estimates are below global and subregional efficiency levels. Binam et al. (2008) reported that Nigeria, Cameroon and Cote d'Ivoire produce at respective efficiencies of 74%, 65% and 58%. Amos (2007) estimated a 72% technical efficiency for Nigerian cocoa producers. The Western Region, the leading cocoa-producing region in Ghana, produces at the highest efficiency level of 53.76%, whereas the Volta Region produces at the lowest efficiency of 41.66%.

4.2. Determinants of Technical Efficiency

Table 4 shows the analysis of factor determinants of cocoa household technical efficiency. The likelihood ratio chi-square statistics is significant at the 1% level of significance in all four models, implying that all the variables in each of the four models jointly explain technical efficiency among cocoa households in Ghana.

Four models have been estimated because these models could not be estimated together as a single model because of correlation among the inter-active terms. Therefore, four different models are estimated. Model 1 includes all variables with the exception of interactions between diversification and other variables. Model 2 adds an interaction between diversification and land to Model 1. Instead, Model 3 and Model 4 add an interactive variable between diversification and labour, and that between diversification and loans, respectively. Model 4, however, includes all variables except loans, the inter-active terms of diversification with both land and labour. In this model, loan was omitted because it is nonsignificant in all of the previous models. The effects of these diversified farming practices could be traced more accurately by including the interaction terms.

All variables in the estimated models are classified into farm character-istics, human capital, technology, diversification and regional dummies. For farm and household characteristics, Model 1 indicates that gender and age of household head, migration, household size and quality of labour significantly influence technical efficiency. These data suggest that the male-labour ratio and

farm ownership have no significant effects on technical efficiency. Factors such as age, gender, labour composition and quality of labour have a positive influence on farm productivity, whereas factors such as size of household and indicators of household migratory activities and farm ownership (sharecropping) have a negative influence. Male-headed households are more efficient than female-headed ones by 0.0326% (Model 1).

TABLE 4. Tobit Estimation of Determinants of Efficiency in Cocoa Households

Variable		Model			
		1	2	3	4
Farm characteristics	Gender	.0326 (.0168)**	.0321 (.0168)**	.0310 (.0169)*	.0325 (.0169)**
	Age	.0012 (.0004)***	.0011 (.0004)***	.0012 (.0004)***	.0011 (.0004)***
	Migration	– .0398 (.0134)***	– .0393 (.0133)***	– .0416 (.0134)***	– .0398 (.0134)***
	Household size	– .0039 (.002)*	– .0042 (.0021)*	– .0033 (.0022)	– .0038 (.0021)**
	Male-labour	.0311 (.0227)	.0293 (.0221)	.0335 (.0228)	.0312 (.0227)
	Sharecropping	– .0184 (.0222)	– .0189 (.0221)	– .0171 (.0222)	– .0184 (.0222)
	Labour Quality	.00003 (.00002)*	.00001 (.00003)	.00004 (.00002)**	.00003 (.00002)
Human capital	Education qualification	.0022 (.0031)	.0025 (.0031)	.0023 (.0031)	.0022 (.0031)
	Medical expense	.00003 (.0024)	– .00006 (.0022)	.0003 (.0022)	.00003 (.0022)
Technology	Loan	– 7.21e – 6 (.00001)	– .7.21e – 7 (.00001)	– .4.43e – 7 (.00001)	
	Equipment	– .0294 (.0121)**	– .0301 (.0121)**	– .0279 (.0121)**	– .0292 (.0121)**
Diversification	Diversification	.0609 (.0249)**	.0583 (.0247)**	.0682 (.0255)***	.0641 (.0247)**
	Diversity*Land		.0007 (.0006)		
	Diversity*Labour			– .0023 (.0019)	

Variable		Model			
		1	2	3	4
	Diversity*Loan				−2.62e−06 (.00001)
Regional dummy	AR	.0318 (.0192)*	.0322 (.0191)*	.0310 (.0191)	.0319 (.0192)*
	CR	.0653 (.0213)***	.0675 (.0213)***	.0636 (.0213)***	.0653 (.0213)***
	ER	.0255 (.0229)	.0260 (.0229)	.0246 (.0229)	.0255 (.0229)
	WR	.1278 (.0184)***	.1282 (.0184)***	.1259 (.0185)***	.1278 (.0184)***
	VR	.0030 (9.037)	.0029 (.0376)	−.0014 (.0378)	.0027 (.0377)
Constant		.2907 (.0406)***	.2950 (.0407)***	.2840 (.0409)***	.2901 (.0407)***
LR-χ^2		99.29***	100.73***	100.62***	99.33***
Log likelihood		335.70	336.42	336.37	335.72
Observation		525	525	525	525

Notes: Asymptotic standard errors are in parenthesis. *, ** and *** represent coefficients significant at the 10%, 5% and 1% levels, respectively.

Hill (1963) also noted that male labour is much more productive than female labour in Ghana. However, Ogunniyi et al. (2012) found no significant difference in efficiency among male and female cohorts in the Nigerian cocoa industry. Note that household land sizes for males are much higher than households headed by females. Relating land and farms as collateral for households, especially in cocoa communities, we agree with MASDAR (1998), which noted that those who have less access to collateral in the form of farmland have less access to credit. Thus, our results suggest that male-headed households have access to more productive resources in cocoa farm production than their female counterparts.

Significant at the 1% level in all four models, technical efficiency increases by 0.0012% as the age of the farm head increases by 1 year, suggesting the positive impact of experience in cocoa production. In the case of the Bibiani-Anhwiaso-Bekwai District, Danso-Abbeam et al. (2012) found that experience has a positive influence on the technical efficiency of cocoa farmers.

Dzene (2010) also identified that age is positively related to technical efficiency among cocoa households in Ghana. However, Ogunniyi et al. (2012) found age to negatively influence technical efficiency in male-headed households in Nigeria. Amos (2007) also found age to reduce technical efficiency in a similar study in the Nigerian cocoa industry.

Migration, a measure of movements from households, is related significantly negatively with household technical efficiency at the 1% significance level in all four models. Households without emigrated members have higher incomes than those with emigrated ones, and households lose technical efficiency by 0.0398% when a family member leaves the household. This implies that emigrants from cocoa households leave with some productive resources.

Household size has a significantly negative impact on technical efficiency in Models 1, 2 and 4. The technical efficiency of households declines with an increase in household size. Model 1 indicates that the addition of a single individual to cocoa-fproducing households reduces technical efficiency by 0.0039%. Our results are consistent with previous studies on Ghanaian cocoa farms. For example, Danso-Abeam et al. (2012) and Dzene (2010) found a similar negative relationship between household size and technical efficiency for Ghana. These results suggest that households experience diminishing marginal returns of labour as farm size increases, and that large households claim additional costs for feeding and providing other utilities that could be otherwise used to boost efficiency.

Composition of labour as measured by the ratio of male-to-labour does not have a significant influence on productivity, while the quality of household labour as measured by the expenditure on hired labour is significant at the 10% and 5% levels in Models 1 and 3, respectively. Similarly, Teal and Vigneri (2004) concluded that output increase among cocoa households in Ghana was primarily due to labour productivity. Even though their finding is consistent with our results, they did not differentiate household labour from hired labour. Our results suggest that technical efficiency increases with hired labour but might decrease with household labour that adds unpaid or cheap labour to farm production.

Ownership of land as proxied by the sharecropping indicator is negatively related to technical efficiency in all four models but is nonsignificant. Thus we can say that either households that do not own land but sharecrop are less technically efficient or that owner-households may be more productive due

to their positive effect on technical efficiency.

Human capital-related variables, highest educational qualification and total medical expenses of household do not show significance, even though both educational qualifications and medical expenditures relate positively with technical efficiency. In this regard, Amos (2007) found education to have an impact on Nigerian cocoa output.

Even though both household farm technology and its quality as respectively measured by total loans acquired and equipment ownership indicator are negatively associated with technical efficiency, only the equipment ownership indicator is significant at the 5% significance level in all four models. Households that own farm equipment lose technical efficiency by 0.0294% compared to their non-owning counterparts. As cocoa farming is non-mechanised, households that own equipment do not concentrate much on cocoa production. Tractors, trailers, ploughs, and sprayers generate other forms of income to households owning them. Moreover, against a priori expectations, total loans as a measure of household access to finance and credit is negatively related to technical efficiency but is nonsignificant. Thus, no evidence from the data exists to conclude that household access to finance influences technical efficiency among cocoa households in Ghana. Unlike this case, Binam et al. (2008) found that credit availability has a positive influence on cocoa production in Ghana.

Crop diversification has a positive influence on technical efficiency at least at the 5% significance level in every model, implying that technical efficiency critically depends on multi-cropping. Households that diversify their crop base gain technical efficiency by 0.0609% relative to their counterparts that grow only cocoa. However, none of the interactive terms between diversification and other farm characteristic factors show any statistical significance.

The positive association between multi-cropping and productivity suggests that there might exist a lot of disguised employees in cocoa farming households who are engaged with subsistence farming without significantly contributing to productivity owing to limited land during the working seasons and lack of works during the off seasons. Under the circumstances, crop diversification could provide an opportunity for the farmers to devote their labours to make profits, thus enhancing the overall farm productivity.[10]

Coefficient estimates of three of the regional dummies are significant, implying a significant difference in technical efficiency among cocoa-producing

regions in Ghana. Farm households in the Ashanti Region are more efficient than those in the Brong-Ahafo Region by 0.0318%, while those in the Central Region are more efficient by 0.0653%. Farms in the Western Region, which is Ghana's most productive region, are more efficient than those in the Brong-Ahafo Region by 0.1278%. Declining land quality across Ghana has shifted cocoa production to the south-western corridors of the nation. The forest lands of this zone, the Western and part of Central Regions, have superior land quality to support the efficiency gains in cocoa household farm production. Due to the quality of land in these areas, other productive resources like labour have moved to these areas. Asuming-Brempong et al. (2007) also confirm the migration of labour from the north to the south of Ghana, where cocoa is produced most efficiently.

5. Conclusions

The empirical results of this paper show that the average technical efficiency of farm households is 47.82%, and that diversified households produce more efficiently than their nondiversified counterparts. The age and gender of the household head, hired labour, crop diversification and production that occur in the Ashanti, Central and Western Regions of Ghana significantly increase the technical efficiency of households. The migratory activities, equipment ownership indicator and size of household cause declines in technical efficiency.

As a fast developing economy, expectations in the cocoa sector of Ghana are that more people will move out of farming households and more farmland will be transferred to support economic activities other than cocoa production. Thus, the cost of hired labour will increase and more input will be needed to complement land and labour shares. Eventually, the cost of labour and prices of farm inputs will increase, creating a negative effect on cocoa production. To meet these socio-economic changes, the government should critically consider the rising costs of hired labour, fertiliser, insecticide and herbi-

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10 For the concepts of subsistence farming and disguised employees in the agricultural sector in Africa, see Lewis (1954).

cides on cocoa production. In this regard, the government introduced the cocoa mass spraying exercise in 2001 to maintain and increase productivity in cocoa production. Thus, the spray programme is proactive and should continue.

Encouraging hired labour among the households is welfare-enhancing. Household labour is in excess, causing diminishing returns on cocoa production. Redirecting this excess labour into some other productive investment is worthwhile. Moreover, age or experience is seen to have a positive effect on technical efficiency. As these youths seem to have less efficiency in farm production, redirecting their energies to education seems positive.

Low productivity of Ghanaian cocoa farmers is likely to be related with low quality of their cocoa crops, as farmers' outputs are measured in value terms. Considering ever shrinking farm land with rapid urbanisation of the country, boosting the quality could make a logical strategy to enhance the productivity of cocoa households. For this reason, current practice of price-setting and buying-out of all the crops by the government should be carefully evaluated to see if the policy discourages farmers to make less effort in improving the quality. If it does, deregulation in the market should be implemented to enhance the productivity.

Finally, a need exists to develop a holistic alternative support programme that encompasses not only cocoa as a stand-alone policy but the inclusion of other food crops. This comprehensive scheme should be built on strategies that support household food consumption needs. It is self-sustainability that enables cocoa production in these households. Cocoa farmers need a source of sustenance to keep them as they wait for their seasonal cocoa incomes. Thus, the existing COCOBOD programme should be made to include the sustainability of the entire agricultural farming practices in cocoa-producing regions to optimise cocoa production.

The data used in this study are drawn from the Ghana Living Standards Survey Round Five (GLSS5) collected during the 2005/06 cocoa season. Thus, some of our empirical results might not reflect current environments of Ghanaian cocoa farmers. To complement these shortcomings, we wish new studies using latest dataset should be continued in the future.

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