

# The Economic Analysis of Resource Used Efficiency for Cocoa Production in Cameroon: The Case Study of Lekie Division

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**Abstract** The general objective of this study is to present an economic analysis of the resources efficiently used for cocoa production in the Lekie division of Cameroon. Data were collected in around forty cocoa farms which were selected randomly across five towns (Obala, Monatele, Evodoula, Ebebda and Okola) of the division “Lekie”, Center Region of Cameroon. The data were analyzed using descriptive and regression techniques through stochastic production functions. The average cocoa production recorded in this study area was 643.275kg/ha. Our results showed the technical efficiency ranges from 10% to 100%, with an average efficiency of 43.7%. This implies that on average 56.3% more output would have been produced with the same level of inputs, if farmers were following best practices. The results observed that the size of the farmers’ household, marital status, access to bank credit, area of arable land and farmer’s membership in a cooperative are the main socioeconomic determinants of efficiency across farms in the division of Lekie. Technical training of farmers, extension service and rotation of cultivated land are the important measures that can be taken for increasing cocoa production in this part of Cameroon.

**Keywords:** *technical efficiency, cocoa production, resource, return to scale*

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## 1. Introduction

On 25 September 2015 in New York, the UN General Assembly adopted the reduction of hunger and the promotion of sustainable agriculture as second objective for a sustainable development. This objective is a major challenge, as we now need to feed 7 billion people around the world. According to FAO projections, the population will increase from 7 billion people today to 9.1 billion in 2050. To meet these needs, the increase of ~ 70% in world food production and especially 100% in developing countries will be necessary (FAO, 2017). There is a general agreement that poverty and food insecurity in Africa are phenomena that affect primarily the rural population. Hunger and malnutrition have reached crisis proportions in much of Africa. About 200 million people are undernourished in Sub-Saharan Africa (FAO, 2012). According to Sanfo [1], rural poverty will continue to surpass urban poverty in all developing countries. In this context, the agricultural sector should therefore play a very important role in any attempt to reduce poverty.

Agriculture is the economic engine of most economies in Sub-Saharan Africa (SSA), contributing at least to 70% of employment, 40 % of export earnings, and 30% of Gross Domestic Product (GDP) and up to 30% of foreign exchange earnings (IFAD, 2002) [2]. In Cameroon, 90%

of the rural population is estimated to be engaged in small-scale agriculture including cocoa production [3]. Also, according to Sanfo [1], agriculture remains the most logical source of significant economic growth. Agricultural growth is shown to contribute indirectly to the reduction of poverty through labor markets, by providing employment (agricultural workers) to the poorest farmers. For instance, many cocoa farmers and workers are among the 2.1 billion people living on two dollars a day [3].

The key role of agriculture in reducing poverty is linked to the high weight of agriculture in terms of consumption, production and income [4]. As Eicher [5] pointed out, it is mainly because of its low productivity that the agricultural sector cannot fulfill its essential role in stimulating economic growth, thus providing foreign exchange (currency) and generating jobs. This explains why the main challenge for the next twenty-five years will be mainly to increase agricultural productivity in Africa. In order to increase the income of the poor people, the productivity of their labor must be increased. Productivity enhancement would therefore be a determining factor in raising individual incomes and development dynamics . Improving the productivity of rural and agriculture-based enterprises will have a major impact on the economic growth of the majority of African countries over the next ten to fifteen years. Fei and Ranis [6] and Jorgenson [7] consider agriculture as a reservoir of abundant labor and argue that its economic surplus must be transferred to

industry. Agriculture plays a catalytic role in the development process [8].

In Cameroon, agriculture still remains the main economic activity for the majority of the population, and particularly for poor people. Agriculture provides food for the teeming population, contributes about 23% of the Gross Domestic Product (GDP) of the Nation and employs 70% of the working population and generates more than one third of total export earnings (insert a reference). This sector contributes about a quarter of economic-added value. Going by the tenets of Vision 2035 which has as objective the need to transform Cameroon into “an emerging economy by 2035” and since agriculture is the backbone of the Cameroonian economy, it is necessary to design ways of sustainable agriculture. This is achieved by taking into consideration its role as the major source of raw materials for industrial development, sustainable lives and markets for industrial outputs.

The agricultural sector and indeed cocoa production has always been an important component of Cameroonian economy. This reason led the government to adopt a plan to revive the cocoa sectors (reference). By 2020, the government aims to achieve a production of 600,000 tons of cocoa. To reach this level of production, it will be necessary to develop new cocoa plantations.

Cocoa (*Theobroma cacao*) is a major cash crop in Cameroon in particular and many countries of the tropical world in general, where its production and export contributes significantly to the national economy and in poverty alleviation. According to the United Nations Conference on Trade and Development, UNCTAD, (2004), cocoa is a highly competitive and lucrative economic cash crop ranked highest in terms of income generation among other agricultural activities in the global markets. Africa supplies nearly three quarters (73%) of the world's cocoa [3]. Globally, an estimated average of 3 million metric tons of cocoa are produced every year (UNCTAD, 2004). Of these 3 million metric tons, 90% of the world's production comes from eight countries which are partitioned as follows: Ivory Coast (38%), Ghana (21%), Indonesia (13%) Nigeria and Cameroon (5%), Brazil (4%) Ecuador (3%), Dominican Republic (1.4%) and Malaysia (0.9%) (UNCTAD, 2004).

The cocoa tree known as *Theobroma Cacao*. In Latin, the word *Theobroma* means, "Food of the gods". Cocoa has its gene center in the upper Amazon region of the South America from where it spread to different parts of the world [9]. The two major climatic variables which are important in determining cocoa growth are temperature and rainfall (ICCO, 2011). Cocoa generally requires high temperatures with a maximum annual average of 30-32°C and a minimum average of 18-21°C. An annual rainfall level of between 1500mm and 2000mm which is well distributed is good for cocoa production. The cocoa plant grows best on high nutrient content coarse soil with a depth of 1.5m, allowing for good root development, water retention and drainage. A pH of 5.0 – 7.5 with 3.5% of organic matter in the top 15 centimeters and nitrogen/total phosphorus ratio of 1.5 are necessary for optimal growth (Coulibaly, 2012 quoted by [3]). Apart from these natural factors, other factors such as capital, labor, cocoa prices and the number of years of farming (experience) are very essential in defining a cocoa production.

There are three broad types of cocoa namely Forastero, Crillo and Trinitario. Trinitario plants are not found in the wilderness as they are cultivated hybrids of the other two types. The Trinitario is the one cultivated in Lekie Division. Trinitario cocoa trees are grown mainly in the Caribbean, Cameroon and Papua New Guinea. The pods are hard and melon shaped, between 15-20cm long and each weighing about 450g each. When the pods are ripe they change from green to yellow, red or orange. Also, the pods contain about 30 or more beans.

Cocoa production was introduced in the coastal zone of Cameroon between 1886/1887 during the era of German governor Julius Von Soden (NCCB, 2017). Cocoa has long played a vital role in Cameroon's economic development [10], and remains an important source of income for approximately 1.4 million people (KIT Royal Institute, AgroEco/Louis Bolk Institute, & Trading, 2010). The cocoa production in Cameroon results from a cultivated surface area estimated at 450,000 hectares, yielding 200,000 tons in 2012 and representing 2.1% of GNP. This productivity remains low compared to that of other African countries such as Ivory Coast, Ghana and Nigeria (Amougou, Tchindjang et al., 2013). About 50% of Cameroon's cocoa beans come from the South West, 35% from the Center and 15% from the South East Regions (CAMACO, 2010). Cameroonian cocoa belt represents about 37% of total cultivated soil of the country.

Between 2003 and 2007, the cocoa sector contributed about 0.89% to 1.45% of Cameroon's gross domestic product and accounted for between 5 to 9.6% of annual total export revenues (reference).

At the national level, cocoa represents an important source of national income, accounting for 6% of the country's exports in 2006, a contribution of 115 billion CFA francs to the national economy (INS, 2006) and about 260,000 planters for an area covering 400,000 ha (MINADER, 2006).

Annual production in Cameroon grew from 120,619 tons in 2000 to 225,000 tons in 2013 (NCCB, 2014), making Cameroon the fourth largest producer of cocoa in the world after Ivory coast, Ghana, and Indonesia (ICCO, 2014). Cocoa farming is thus a major source of foreign currency, accounting for approximately 15% of total annual exports revenue in 2009 (KIT Royal Institute, AgroEco/Louis Bolk Institute, & Trading, 2010), and 2.1% of Cameroon's Gross National Product [10]. In the 2014/2015 fiscal year, Cameroon exported 188,129 tons (with 100,000 tons of certified cocoa) to eleven (11) countries with the Netherlands welcoming over 73 percent of Cameroon's beans, followed by Belgium and Germany. The official balance sheet showed that 85 percent of Cameroon's cocoa was shipped to Europe.

The production was projected to rise by 6 per cent between 2009 and 2013 to 3.98 million tons. It is estimate that the industry sector will need an annual production of at least 4.5 million tons of cocoa by 2020 to satisfy the growing demand [3]. With about 180,000 tons, Cameroon is among the leading cocoa producers in Africa (NCCB, 2015). Figure 1 depicts the annual growth in cocoa production in Cameroon. As we can see, the cocoa production in Cameroon has been steadily increased since 2004. The production of cocoa rose from 158,000 tons in 2004 to approximately 232,000 tons in 2014. This clearly

shows the efforts endeavored by the Cameroonian government to pace up with the world global production.

Given the many impediments cocoa farmers face, they rarely get to exploit their potential to improve profit from the sales of their products. The bottlenecks in cocoa production in Cameroon include:

- Crop age: Most of the cocoa trees are more than half a century old with extremely low production potential;
- Age group of farmers
- Gender disparity for which female farmers are greatly discriminated in the cocoa production system with regards to land tenure, marketing and extension benefits;
- Technical know-how; Due to the low level of education of most farmers that prevent them from easily adopting new technologies or investing appropriately in the cocoa business;
- Poverty which limits the ability of the farmers to obtain inputs such as fertilizers, pesticides and hired labor; poor infrastructure especially roads which inhibit farmers from transporting the produce from farm to market;
- Non-availability of high quality planting materials due to the limited potentials of the research institutions assigned to the production of planting materials;
- less added value due to the limited knowledge possessed by the farmers to transform the cocoa beans (raw materials) to more profitable products (finite product);
- Poor soil fertility due to the fact that farmers fail to replenish the soils after extracting nutrients through harvests;
- Climate change which has resulted to unforeseen dry spells and floods that negatively affect the yield of the crop [3].

The main objective of this study is to analyze the resource use efficiency for cocoa production in Lekie Division of Cameroon.

The specific objectives are :

1. To evaluate and Analyze the socioeconomic determinants of the cocoa production in the study area;
2. To determine the output of cocoa production in the study area.

The following hypotheses will be tested and they are stated as follows:

1. The socioeconomic characteristics of the cocoa farmers do not have any significant effect on output;
2. The farm resources used by the cocoa farmers do not significantly influence their level of output;
3. The cocoa farmers do not allocate their farm resources efficiently.

The motivation of this study emanates from the fact that cocoa is important in the economy of Cameroon in general and Lekie Division in particular. The market value for one kg of cocoa is about 1.5-3.5 dollars depending on the environment of cocoa market internationally. Cocoa production provides revenue (115.5 billion FCFA) for the government of Cameroon through export duties on exported cocoa from the country. It also contributes to aggregate export earnings. At the level of the small-scale producer, the sale of cocoa is the main source of income which enables it to increase farm investment and provide for family needs (health, education of children, etc.).

This study will add to existing literature on technical and allocative efficiency as they relate to Cameroon. Farm and farmer characteristics observed among efficient farmers will be used to formulate policy recommendations that will help policymakers to develop strategies that will help inefficient farmers. NGO, private and public agencies will be able to focus their investments towards the promotion of those farms and farmer characteristics positively influencing productivity. Considering that farming household grows cocoa, increased productivity from efficient use of available technologies is expected to contribute towards poverty alleviation in the rural areas. Farming household will have better access to food through increased production and incomes. Improving the conditions of the small-scale cocoa farmers will go a long way to assure high and sustainable yields.

Every procedures that perform in this study including human participants is approved by the Ethics Committee of the School of Economics and Management, Nanjing Agricultural University, China and which bases its foundations on the 1964 Helsinki declaration.

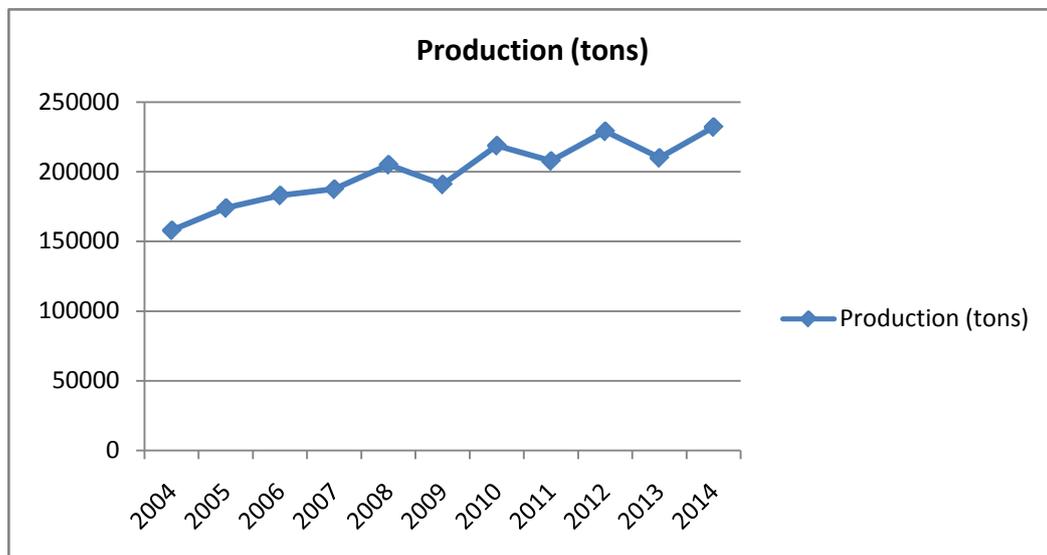


Figure 1. Annual production of cocoa in Cameroon, source: NCCB

## 2. Methodology

### 2.1. Presentation of the Studied Area

With an area of 2989 km<sup>2</sup>, the department of Lekie is located in Cameroon more precisely in the central region. The department includes the cities of Monatele, Evoudoula, obala, Okola, Sa'a, Ebebda and Elig-Mfomo. The department is populated by the Etons and the Manguissas ethnicities. These two ethnicities are mainly agriculture-driven and produce 60 to 70% of the food sold in market of the capital city Yaounde. The dwelling population is about 500,000 inhabitants with a density of 100 to 500 people / km<sup>2</sup>. This population constituting the fifth of the overall population of the Centre province and spread in more than 700 distinct villages.

The department of Lekie is located in the heart of the central region, just north of the 4th parallel of the equator. The Lekie enjoys an equatorial climate composed of two rainy seasons and two dry seasons. The temperature (23°C to 26°C) registered in this department is favorable to the cultivation of cocoa. Bordering the department of Mbam, the Lekie is the second biggest producer of the cocoa of Cameroon. The department is a forest area. We chose this study area because it contains a large number of farmers' organizations that cultivate cocoa.

To the north is the river Sanaga, serving as a border between the Lekie and the department of Mbam. Other rivers flow in the department such as the Afamba, the Ngobo.

### 2.2. Nature and Source of Data

The primary data used in this study come from a field survey carried out from 30 June 2017 to 8 July 2017 in the towns of Monatele, Ebebda, Evoudoula, Oballa and Okola located in the department of Lekie. Data collection was conducted using a questionnaire. Our sample is made up of 40 agricultural households whose main activity is the cultivation of cocoa. The sample representative has been selected by a random sampling. These agricultural households were categorized according to the size of their cocoa fields, their income, household size, age of head of household, level of education, type of cocoa material and sex of the head of the household.

Data processing was first done manually to strip and classify the information collected from the questionnaire. Subsequently, processing using Excel and Stata 11 software was necessary to generate the results of the study in graphical, statistical and econometric form. The DEAP (Data Envelopment Analysis Program) program developed by Battese and Coelli enabled us to calculate the efficiency indices (reference)

### 2.3. Data Analysis Method

The methods of analysis of the data used in our study are descriptive statistics and econometric.

### 2.4. Descriptive Statistics

Descriptive statistics enabled us to identify the social-economic characteristics of the studied farm

households. For this, we calculated the mean, standard deviation, frequencies, coefficient of variation, variance, mode and median to better describe our studied sample. The development of the circular diagram, the histogram and the curves was necessary to synthesize the information to be collected on our study population.

### 2.5. The Econometric Method

At this level, the analysis process was carried out in two stages. The first stage consisted of the construction of a stochastic production boundary and the calculation of the efficiency index. In the second step, we use the efficiency index as dependent variables in a social-economic model. It identifies factors of inefficiency of agricultural households.

#### a) Presentation of the Stochastic Production Frontier (SPF) Model and Efficiency Measurement Method

- **Stochastic frontier (SPF) analysis and measurement of efficiency**

The frontier approach is a method to measure productive inefficiency of individual producers. Inefficiency measured by deviation from the frontier, which represent a best – practiced technology amount all observed firms. Coelli [11] presents two reasons to estimate frontier functions rather than cost functions, which are conventionally estimated by Ordinary Least Square (OLS) method. First, the frontier function is consistent with theoretical representation of production activities, which is derived from an optimization process. For example, the production function consist of a series of outputs attainable, given different combinations of inputs, while cost and profits function are represented by frontiers derived from optimization. Second, the estimated of frontier function provides a tool for measuring the efficiency level of each firm within a given sample. The stochastic production frontier (SPF) method is chosen for this study.

The stochastic production frontier is expressed as (reference):

$$Y_i = f(X_{i,\beta}) e^{v_i - u_i} \quad (1)$$

In logarithm terms the SPF is expressed as:

$$\ln Y_i = \ln f(X_{i,\beta}) + V_i - \mu_i \quad (2)$$

Where  $Y_i$  is the output vector,  $X_i$  is the input vector  $\beta$  is an unknown parameter vector,  $V_i$  is the random error term assumed to follow the normal law  $N(0, \sigma^2)$ ,  $\mu_i$  is the inefficiency term independently distributed from  $V_i$ .

For the technical efficiency of firm  $i$  at time  $t$ ,  $\mu_{it}$  is transformed as  $TE_{it} = \exp(-\mu_{it})$ , which now represents the technical efficiency index.

The technical efficiency of the firm  $i$  defined by  $TE_i = \exp(-\mu_i)$ , has a technical inefficiency effect,  $\mu_i$  is unobserved.

The technical efficiency of an individual firm is defined in terms of observed output to the corresponding frontier output, conditional on the levels of input used by the firm. Hence, the technical efficiency of the firm  $i$  is expressed as:

$$TE_i = \frac{\ln Y_i}{\ln Y^*} = \frac{f(X_i, \beta) \exp(v_i - \mu_i)}{f(X_i, \beta) \exp(v_i)} = \exp(-\mu_i) = e^{-\mu_i} \quad (3)$$

Such that,  $0 \leq TE \leq 1$ .

As a result of the above expression, a firm specific technical inefficiency index is given by  $1 - e^{-\mu}$ .

If  $U=0$ , it means that cocoa production lies on the stochastic frontier and production is technically efficient.

If  $U>0$ , it implies cocoa production lies below the frontier and is inefficient. Inefficiency in production could result from the quality and availability of labor and land, the use of capital and materials, and unhealthy interactions between these factors.

• **Empirical estimation of allocative efficiency of cocoa production**

Allocative efficiency reflects the ability of a firm to use inputs in optimal proportions, given their respective prices. A production process is said to be allocatively efficient if it equates the marginal rate of substitution between each pair of inputs with the input price ratio. The requirement for the fulfillment of allocative efficiency is that the marginal physical product (MPP) of all productive resources to be known [12].

In many studies, the allocative efficiency of labor and capital are most often calculated because these factors are substitutable in the production process.

The estimated process is based on the allocative efficiency rule which states that the slope of the production function (MPP) should equal the inverse ratio of input price to output price at the point of profit maximization [12]

$$MPP_i = \frac{W}{P_y} \tag{4}$$

where  $W$  is the wage rate,  $P_y$  is the price of output (cocoa) cross multiplying yields

$$MPP_L \cdot P_y = MVP_L = W$$

$$\frac{MVP_L}{W} = \frac{W}{W} = 1.$$

That is, the marginal value product of the variable input (MVPL) divided by the input price should equal one.

The elasticity of labor factors (EL) and capital (Ek) are directly obtained from a Cobb-Douglas production function.

The marginal physical products will be calculated as follows:

$$MPP_L = \frac{\mu Y_i}{\mu X_i} * E_L \text{ (Marginal physical product of labor) } \tag{5}$$

$$MPP_K = \frac{\mu Y_i}{\mu X_i} * E_K \text{ (Marginal physical product of Capital). } \tag{6}$$

The allocative efficiency ratios are then expressed as:

$$Z = \frac{MVP_L}{W} = \frac{MPP_L * P_y}{W} = \frac{MPPL * P_y}{MFC} \tag{7}$$

$$= \frac{MVP_L}{MFC} \text{ (allocation efficiency ratio for labour input);}$$

where  $w$  is the unit price of labour input or marginal factor cost (MFC).

$$Z = \frac{MVP_K}{P_K} = \frac{MPP_K * P_y}{P_K} = \frac{MPP_K * P_y}{MFC} \tag{8}$$

$$= \frac{MVP_K}{MFC} \text{ (allocation efficiency ratio for capital input);}$$

$P_K$  is the unit price of capital or marginal factor cost (MFC).

Where  $MPP_L, MPP_K$  are the marginal physical products of labor and capital respectively,  $\mu Y_i$  and  $\mu X_i$  are the arithmetic means (logs) of the output and inputs respectively of the production process,  $MVP_L$  is Marginal value product of Labour and  $MVP_K$  is Marginal value product of capital.

The allocative efficiency index for a single input is given by  $Z = \frac{MVP_X}{P_X}$  for any variable  $X$

If  $Z= 1$ , it implies that the input is utilized efficiently and there is optimum utilization of resource  $X$ ;

If  $Z > 1$  it implies an under utilization of factor input and there is under utilization of resource  $X$ ;

If  $Z < 1$ , it implies an over utilization of the factor input in other hand it suppose that there is over utilization of resource  $X$ .

• **Empirical estimation of technical efficiency**

For our empirical analysis, the Cobb-Douglas frontier production specifies the technology of the production process. The model is defined as:  $Y = f(\text{land, lab, pest})$

**Definition of variables**

• **The endogenous variable or output**

The endogenous variable ( $Y$ ) refers to the production of cocoa in kilograms obtained in a cocoa field.

• **Exogenous variables or inputs**

Land (land): Refers to the area of cocoa field in hectare per season;

Labor (lab): Refers to the number of hours of both family and hired labor required to harvest cocoa within one day working hours . In this study, we chose 8 working hours per day.

Pesticide (pest): Expresses the quantities in liters of fungicides and insecticides used in cocoa fields.

The operational Cobb-Douglas stochastic frontier function for cocoa production will be expressed:

$$\ln Y_i = \beta_0 + \beta_1 \ln \text{land}_i + \beta_2 \ln \text{lab}_i + \beta_3 \ln \text{pest}_i + \varepsilon_i \tag{9}$$

Where  $\ln$  = natural logarithm

$$\ln Y_i = \beta_0 \beta_1 \ln \text{land}_i + \beta_2 \ln \text{lab}_i + \beta_3 \ln \text{pest}_i + v_i - u_i \tag{10}$$

where  $\varepsilon_i$  is the composed error term given as,  $\varepsilon_i = V_i - U_i$ , where  $V_i$  is the statistical and random shocks such as bad weather, errors in measurement,  $U_i$  is the error term measuring the level of efficiency in production. The  $\beta_k$  represents parameters of linear terms.  $\beta_0 = Y - \text{intercept}$ ,  $\beta_0$  to  $\beta_3$  are coefficients to be estimated. It is expected that  $\beta_1, \beta_2$  and  $\beta_3$  will have positive signs.

Farm output is expected to be influenced positively by farm size (land), labor and pesticide quantity.

• **Hypothesis testing**

For the frontier model, the null hypothesis that there are no technical inefficiency effects in the model can

be conducted by testing the null and the alternative hypothesis

$H_0: \gamma = 0$  against  $H_1: \gamma > 0$ .

Coelli [11] recommended the one-sided generalized likelihood ratio test of size  $\alpha$  which says:

Reject  $H_0: \gamma = 0$  in favor of  $H_1: \gamma > 0$  if  $\lambda$  exceeds  $\chi^2_{2(\alpha)}$  the value for a test of size  $\alpha = 0.05$ , is 2.706.

The first hypothesis which specifies that the sample enterprises are technically efficient will be tested using the generalized likelihood ratio test statistic, which is defined by:

$$\lambda = -2\ln[L(H_0)/L(H_1)] \quad (11)$$

where  $L(H_0)$  is the value of the likelihood function for the frontier model, in which the parameter restrictions specified by the null hypothesis,  $H_0$ , are imposed, and  $H_1$  is the value of likelihood function for the general frontier model.

If the new hypothesis is true, the  $\lambda$  has approximately a chi-square (or mixed square) distribution with degrees of freedom equal to the difference between the parameters estimated under  $H_1$  and  $H_0$ , respectively.

The second hypothesis will be tested using the ratio of the estimated coefficient of the policy variable to the standard error.  $\gamma$  is limited between zero and one and defined as:

$$\gamma = \frac{\sigma_u^2}{\sigma^2} \quad (12)$$

The regression is estimated using the values selected in the grid search as starting values in an iterative procedure to obtain the final Maximum Likelihood (ML) estimates of the coefficients  $\beta$  and  $\gamma$ , together with the variance parameters that are expressed as:

$$\sigma^2 = \sigma_v^2 + \sigma_u^2 \quad (13)$$

The maximum likelihood (ML) estimated for the parameters of the stochastic frontier model and the predicted technical and allocative efficiency estimates were obtained by using the computer program DEAP frontier (Coelli, year).

#### b) Social-economic model and determinants of efficiency

The influence of some socioeconomic factors on the computed technical efficiency was determined by incorporating the socioeconomic factors directly in the frontier model, because there have influence on efficiency [13]. The socioeconomic model was specified as:

$$\begin{aligned} U_i = & \alpha_0 + \alpha_1 age_i + \alpha_2 educa_i + \alpha_3 exp_i + \alpha_4 credi_i \\ & + \alpha_5 family_i + \alpha_6 marital_i + \alpha_7 agenvulga_i \\ & + \alpha_8 farmsize_i + \alpha_9 farmage_i + \alpha_{10} cooperativ_i + \varepsilon_i \end{aligned} \quad (14)$$

$\alpha_0 = Y - intercept$ ;  $\alpha_0$  to  $\alpha_{10}$  are parameters that will be estimated.

#### Definition of variables

##### • Dependent variable

The dependent variable ( $U_i$ ) represents the average technical efficiency of firms. We refer to the work of Dawson, Lingard and Wood Ford [14], as well as those of Yao and Liu [15].

##### • Independents variables

age: age for farmer (years);  
 education (educa): years spent in school;  
 experience (exp): farming experience in years (cocoa only);  
 credit (credi): access to credit during the cropping season (dummy);  
 Family: household size (numbers);  
 marital status (marital): marital status of farmer (dummy);  
 Agent vulgarization (agenvulga): Visit of extension agents to farmers (dummy);  
 Farm size: Cultivated area of cocoa in hectare;  
 Farm age (agefarm): Age of the cocoa field in the year;  
 Cooperative (cooperativ): Membership of a cooperative (dummy).

These variables are assumed to influence technical efficiency of the farmers. In this study, we assume that the coefficients  $\alpha_2, \alpha_3, \alpha_4, \alpha_5, \alpha_7$  and  $\alpha_{10}$  will be of positive sign. On the other hand,  $\alpha_1, \alpha_6, \alpha_8$  and  $\alpha_9$  are to be preceded by a negative sign.

Age of farmers is expected to have a negative effect on technical efficiency. This is because old people are less energetic and less receptive to agricultural innovations and hence develop inefficient production routines and practices.

Education level of farmers is expected to have positive effect on technical efficiency. This is consistent with the findings of Bravo-Ureta and Pinheiro (1997) that formal education is likely to increase farm level efficiency. Thus education improves understanding and receptiveness to agricultural innovations. The result of this would be effective utilization of inputs, which in turn, increase the technical efficiency of the farming operation.

Farming experience of farmers is expected to have positive effect on technical efficiency. This would lead to effective utilization of inputs, which in turn increases the technical efficiency of the farming operation.

Access to credit during the cropping season is expected to have a positive effect on technical efficiency. This is because credit increases the ability of farmers to acquire agricultural inputs and to easily manage their farms.

Household size is expected to have positive effect on technical efficiency. This is mainly through availability of labor and its productivity. The larger the households size the more the family labor and the more the labor the more the utilization of inputs. Effiong [16] reported that a relatively large household size enhances the availability of family labor which reduces constraints on labor cost in agricultural production.

Marital status has a negative influence on the technical efficiency of farmers. This is because the head of family sometimes has to arbitrate between allocating his income to the purchase of farm inputs or ensuring family responsibilities.

Access to extension service is expected to have a positive effect on the technical efficiency because it provides the incentive and means for farmers to access improved crop technology. Tchale [17] had noted that availability of extension services and information about technical aspects of crop technologies plays an important role in increasing farm level efficiency.

Farm size is expected to have a negative effect on technical efficiency. This implies that technical efficiency decreases with the size farm.

Farm age is expected to have a negative effect on technical efficiency. This is because the efficiency decreases as the farms get older.

Household head membership of farmer cooperative is expected to have a positive effect on technical efficiency. This is an indication of the impact of added advantage derivable from such organization in farm resources acquisition and utilization.

### 3. Results

#### 3.1. Statistical Results on the Socioeconomic Characteristics of the Lekie Cocoa Farmer

The population that has caught our attention in this study is composed of 40 cocoa farmers from the division

of Lekie. Among these farmers, we found that 72.5% of these farmers are married while 27.5% are unmarried. The size of agricultural households varies between 3 to 20 people. Agricultural households in this study area are composed of 8 people on average. The similar result was found by T. Amos [18] in Nigeria. About 67.5% of the farmers manage a household of 5 to 10 people (as can be seen in Figure 2). In these households, a high number of people holds a great meaning for conservative African tradition; Great number of family members is considered as a wealth making since these members are a source of labor for agricultural activities.

The age of the Lekie cocoa farmers varies between 23 and 69 years. As a result, these farmers have an average age of 44 years. The age group most represented in the sample is 48 years. However, 65% of the surveyed farmers have an age ranging between 23 and 48 years. In addition, 45% of these farmers have reached the productive age between 23 and 39 years (as depicted in Figure 3).

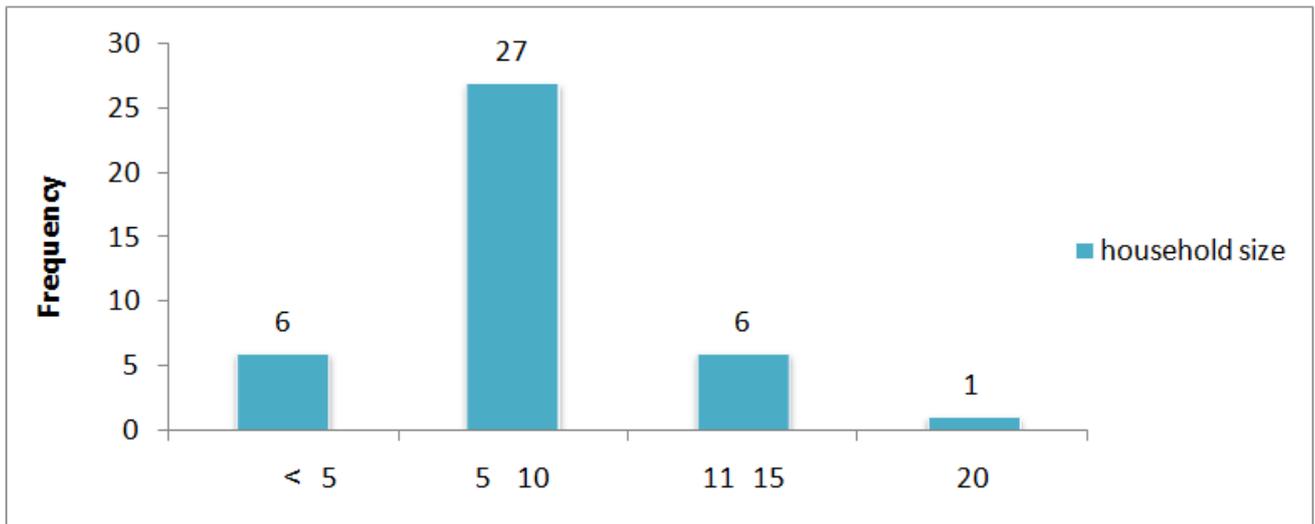


Figure 2. Size of agricultural households in Lekie division Source: The author, based on the survey data for 2017

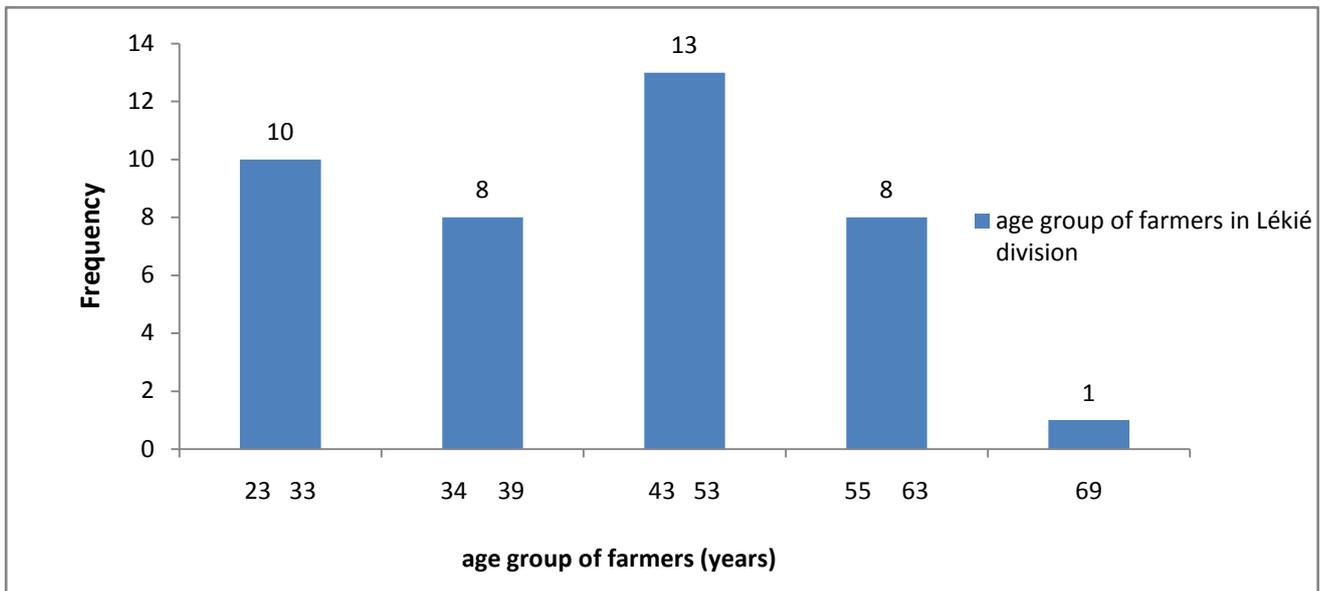


Figure 3. Age of the cocoa farmers of Lekie Source: The author, based on the survey data for 2017

The results of this study shows that farmers in the age group of 43 to 53 have an average production of 1209.23 kg while those of age group 34 to 39 years are an average production of 983.75 kg. This suggests that the age group 34-39 years are less productive than the 43 to 53 year age group. To summarize, cocoa production therefore increases with the farmer's age (see Table 1). In Lekie, older farmers are more productive than young farmers.

Table 1. Age group of farmers and mean output

age group of farmers (years)	frequency	percentage	Mean output (kg)
23 ~ 33	10	25	1114.2
34 ~ 39	8	20	983.75
43 ~ 53	13	32	1209.23
55 ~ 69	9	23	1864.44
Total	40	100	

Source: The author, based on the survey data for 2017.

As far as the level of education of farmers is concerned, 5% have not carried out any school studies, 32% have completed primary school, 13% have completed higher

education and 50% have secondary education (as can be see in Figure 4). Nevertheless, most of the Lekie cocoa farmers have completed 13 years of schooling. To summarize, the average level of education is 10 years for all farmers in the studied area.

In addition, 57.5% of farmers say they have already received training in cocoa farming compared to 40% who have not yet received such training. This low level of training in cocoa cultivation has implications for farmers' ability to adopt new agricultural technologies that can increase their technical or allocative efficiency in the resources used to produce cocoa. On the other hand, 62.5% of cocoa farmers reported that they received agricultural extension agents last year. This shows that the large dispersion of cocoa production observed among the farmers of the Lekie is due to the poor application of the agricultural techniques granted by extension agents. Yet, 52.5% of the farmers surveyed have less than eleven years of experience in cocoa farming. 10% of farmers have already spent 3 years in cocoa farming. The average experience of farmers is 16 years, while the modal experiment is 8 years in the cocoa cultivation. The majority of farmers have 5 to 10 years of experience in cocoa cultivation (according to Figure 5).

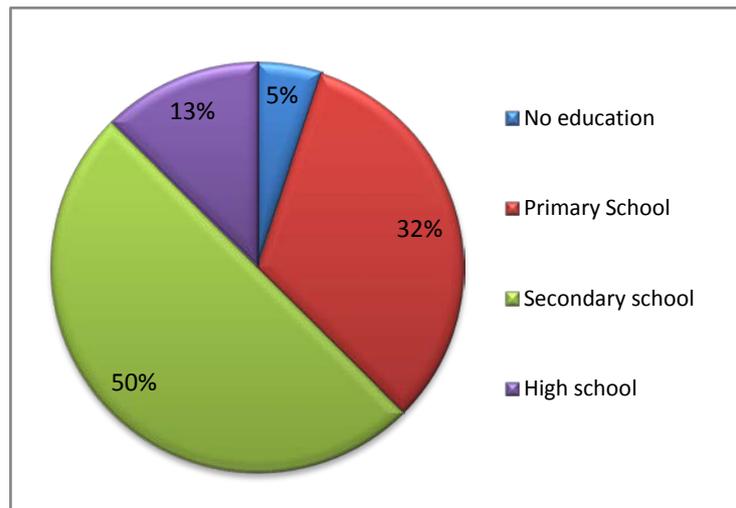


Figure 4. Distribution of farmers according by level of education Source: The author, based on the survey data for 2017

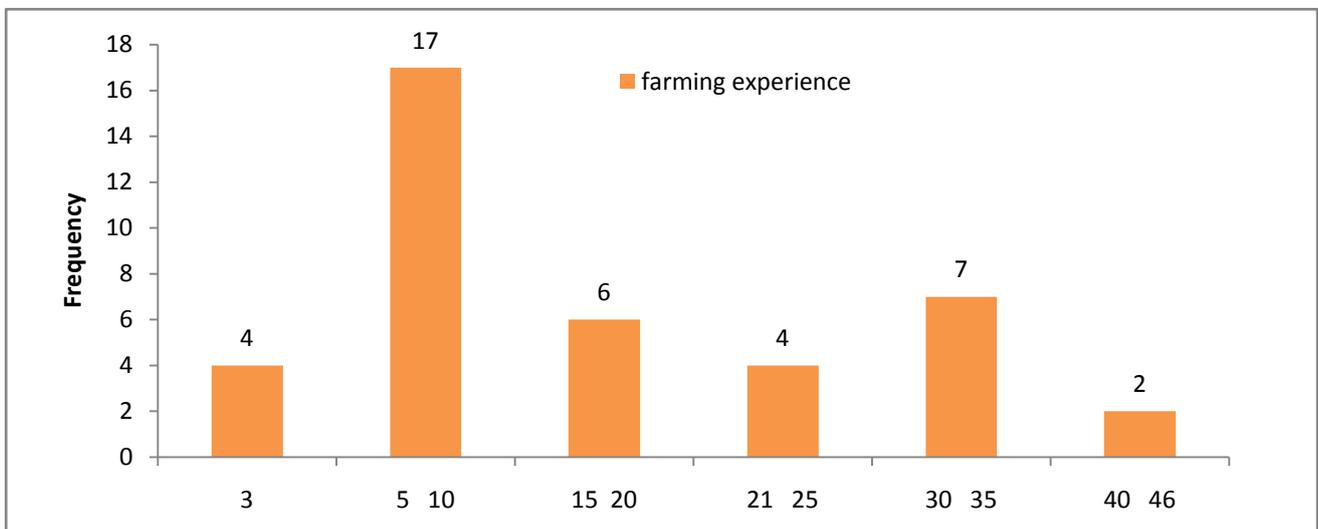


Figure 5. Histogram of farming experience (years) Source: The author, based on the survey data for 2017

In this area of study, half of the farmers produce 850 kg of cocoa, while 25% of the farmers harvest 350 kg of cocoa. The most observed cocoa production was 735 kg (see Table 2). The average cocoa production recorded in the study area was 1286.55 kg, that is 1.268 tons. However, this average cocoa production remains constantly lower compared to the production (1489.20 kg) obtained in the division of Meme in the South West of the country. This result agrees with Balogun and Obi-Egbedi [19], that the falling cocoa production output in Africa can be explained by some constraints such as diseases and pest, low adoption of the cocoa production technologies, inefficiency in the use and allocation of resources. As a result, the replacement of old cocoa plantations with new ones would considerably increase cocoa production in the Lekie division.

Table 2. Cocoa production of Lekie farmers

Cocoa production (kg)	frequency	percentage
≤ 42	1	2
200~500	10	25
510~960	12	30
1000~1400	4	10
1500~1870	4	10
2000~2400	7	18
5620~8000	2	5
<b>Total</b>	<b>40</b>	<b>100</b>

Source: The author, based on the survey data for 2017.

Figure 6 portrays the distribution of cocoa production by town in the Lekie department. Observing the average cocoa production recorded in the various towns of the Lekie division, the town of Oballa is the leader with an average production of 2002.14 kg of cocoa, followed by Monatele (1505 kg), Evodoula (743.33 kg), Ebebda (735 kg) and Okola (702.66 kg).

The high value of the coefficient of variation (113.9%) highlights this dispersion of the quantities of cocoa produced between the farmers of different towns of Lekie. This heterogeneity of cocoa production volume also illustrates a variety of production techniques and a differentiated allocation of factors of production by farmers.

In Lekie, cocoa farmers receive on average an income of 910,180 FCFA per year per farm. 50% of the farmers in the studied area earn an income of 569,800 FCFA per crop

and 25% receive 356,250 FCFA. The most observed income from these farmers is 500,000 FCFA per year. Farmers plant an average of 1111 cacao stems on an area of one hectare of land. The Lekie cocoa farms have an average age of 20 years. However, the cocoa fields dominant in the studied localities are over 30 years old (as can see in Table 3). Therefore, these cocoa fields are getting old. The majority of cocoa farms (85%) were acquired by inheritance and the remainder (12.5%) per purchase.

Table 3. Age of cocoa farm (years)

age of cocoa farm (years)	frequency	percentage
3~6	7	17
10~15	9	22
20~25	5	13
30	19	30
<b>Total</b>	<b>40</b>	<b>100</b>

Source: The author, based on the survey data for 2017.

It should be noted that 26 out of 40 farmers belong to a cooperative. The cooperative allows farmers to store cocoa and sell locally at an approved price.

This study reveals that 87.50% of farmers have not received bank credit, while 12.5% say they received a bank loan last year. The low quantity of credit granted to farmers is a factor hindering cocoa production in the study area. In particular, access to credit is likely to increase the ability of poor households to acquire agricultural inputs such as fertilizers, fungicides and insecticides.

Concerning the use of fertilizer, 11 out of 40 farmers claim to have used fertilizer, while 29 farmers have never used it. 50% of cocoa farms require 4.5 kg of fertilizer per year to guarantee their production. In fact, the price of one liter of fertilizer is 12000 FCFA. In order to maintain their cocoa farms, all farmers in the studied area use fungicides and insecticides (pesticides). Averagely, Lekie farmers use 3 kg of fungicide and 3.15 liters of insecticides every year per farm. These amounts of fungicide and insecticide represent an average of 6.15 liters of pesticide used in a year per farm. Therefore, the price of one sachet of fungicide (50 g) is 700 FCFA. On the other hand a liter of insecticide costs 7500 FCFA. Nevertheless, most cocoa farmers spray their fields at least once a month. So, 82.50% of cocoa farms are located near a water stream, which facilitates the spraying of cocoa fields.

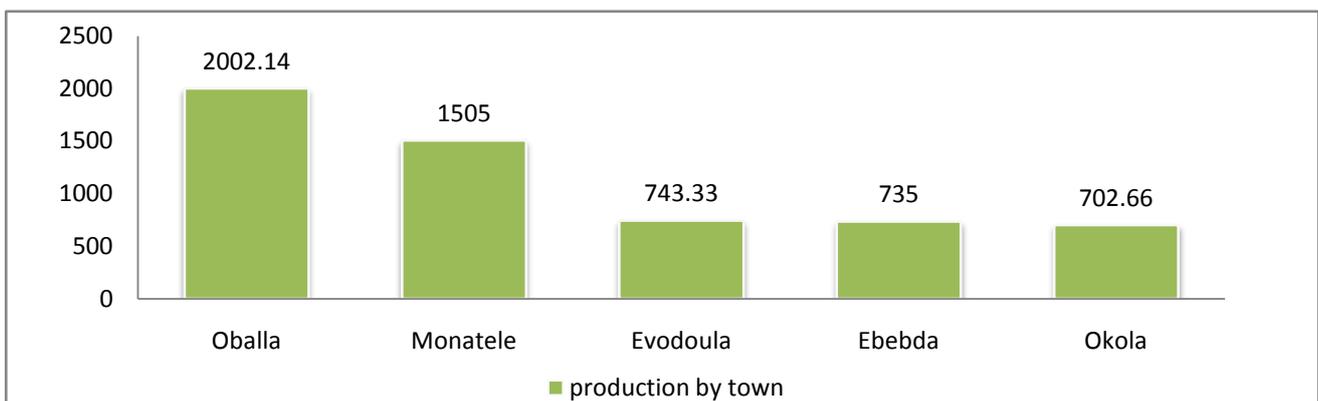


Figure 6. The average production of cocoa in the towns of Lekie Source: The author, based on the survey data for 2017

**Table 4. Descriptive Statistics of socioeconomic variables of farmers in the Lekie division**

Variables	Mean	Standard deviation	Minimum	Maximum
Marital (dummy)	0.725	0.452	0	1
Household size (number of persons)	8	3.37	3	20
Age of farmer (years)	44	12.7	23	69
Education (years)	10	4.41	0	16
Training (dummy)	0.575	0.50	0	1
Access to extension services (dummy)	0.625	0.49	0	1
Framer's cooperative society (dummy)	0.65	0.48	0	1
Farming experience (years)	16	11.48	3	46
Output (kg)	1286.55	1465.77	42	8000
Farm size (hectares)	2.5	2.35	0.5	15
Age of cocoa farm (years)	20	10,66	3	30
Labour (man days)	92.2	60.33	16	240
Credit (dummy)	0.125	0.33	0	1
Cocoa price (FCFA)	1060	230.62	700	2100
Fertilizer (dummy)	0.275	0.45	0	1
Pesticides (liters)	6.15	4.39	0.75	22.5

Source: The author, based on the survey data for 2017.

## 3.2. Econometric Results

### 3.2.1. Result of the Production Boundary

The use of Cobb-Douglas model of frontier production allows us to analyze the the technology of the production process. The model analysis already defined in Eqs. (9) and (10) and the variables defined therein gives the following results which are summarized in ( Table 5).

The total elasticity of production is 0.9733, i.e. if all factors of production increase by 100%, cocoa production would increase by 97.33%. The returns to scale are thus decreasing. The area of land used by farmers to grow cocoa has a positive and not significant (10%) influence on cocoa production. When the cultivated land area increases by 1%, cocoa production increases by 0.181% .

The workforce used in cocoa farms acts positively but not significantly (at 10%) on the cocoa production. An increase in working hours of 1%, increases cocoa production by 0.194%. Nevertheless, the average productivity of the land factor is higher than that of the

labor factor. The average productivity of land in this study area is 450324 FCFA / ha, while the average productivity of labor per head is 12061 FCFA per man-days.

On the other hand, the quantities of pesticides (liters) influence positively and very significantly (1%) the cocoa production of the Lekie. While the amount of pesticide (fungicide and insecticide) used in cocoa fields increases by 1%, cocoa production increases by 0.597%.

The study shows that the marginal productivity of the pesticide production factor is higher than that of land and labor (as can be seen in Table 6). The allocative efficiency of land (0.383) and labor (0.147) are less than 1.

From Table 7 below, both land, labor are over exercised in the production process. This implies an inefficient utilization of the two factors of production. This is because the allocative efficiency ratios (Z) for both factors are less than unity. This may be due to the fact that almost all the operations on the farm are carried out manually on a fixed piece of land, usually smaller in size.

**Table 5. Maximum likelihood estimates of the stochastic production function for cocoa production**

Variables	Parameters	Coefficients	Standard error	t-statistics
Constant	$\beta_0$	4.837068***	1.31592	3.68
Ln(land)	$\beta_1$	0.1812115	0.248712	0.73
Ln(lab)	$\beta_2$	0.1942437	0.220959	0.88
Ln(pest)	$\beta_3$	0.5978933***	0.2201739	2.72
<b>Variance parameters</b>				
Sigma U		0.0211279	1.278372	0.0165
Sigma V		0.7634287***	0.0863293	8.843
Sigma square		0.5832698***	0.1348497	4.325
Log likelihood function		-45.96		

Notes: \*\*\*, \*\* and \* represents 1%; 5% and 10% significance levels respectively.

**Table 6. Marginal productivity of all the resources used by cocoa farmers**

Marginal productivity of Land	Marginal productivity of Labor	Marginal productivity of pesticides
1.809	0.303	2.53

Table 7. Allocative efficiency estimates

Variables	MVP	MFC	Z = MVP /MFC
Land	1917,54	5000	0.383
Labour	321.18	2175	0.147

Table 8. Distribution of technical efficiency of cocoa farmers across study area

Efficiency level	Frequency	Percentage
0.1 – 0.287	20	50
0.313 – 0.505	9	22
0.596 – 0.916	4	10
0.974 - 1	7	18
Total	40	100
Mean	0.437	
Standard deviation	0.308	
Minimum	0.1	
Maximum	1	

### 3.2.2. Result of the Determinants of Technical Efficiency

#### 3.2.2.1. Presentation of technical efficiency of agricultural holdings

The stochastic production function was used to evaluate the level of farmer technical efficiency. The technical efficiency of cocoa farms in the Lekie division varies between 10% and 100%, with an average efficiency of 43.7%. This mean efficiency is low compared to that one obtained in the Meme division which is 86.6%. This low level of average technical efficiency recorded in the cocoa farms of the division of Lekie shows that the production resources are not allocated optimally. Apart from inefficiency in the use and allocation of resources, this low score can also be explained by brown rot that attacks cocoa plantation viability, old age farms and low adoption of cocoa production technologies in the studied area. It is noted that 20 out of 40 cocoa fields have a technical efficiency of 20%. On the other hand, 23% of these cocoa farms have a technical efficiency of more than 41%. In addition, 4 out of 40 cocoa farms have a technical efficiency of between 59.6% and 91.6%. Then, the study revealed that 6 out of 40 cocoa fields have reached the production boundary, i.e. they achieve a technical

efficiency of 100% ( as presented in Table 8). Moreover, the 43.7% mean technical efficiency implies that on average, 56.3% more output would have been produced with the same level of inputs if producers were to produce on the most efficiency frontier following best practices.

#### 3.2.2.2. Socioeconomic Model and Determinants of Efficiency

In order to determine the influence of socioeconomic factors on technical efficiency, we introduced socioeconomic variables into a frontier model as suggested by Kalirajan in his study in 1981 [13]. The socioeconomic model was specified as:

$$U_i = \alpha_0 + \alpha_1age_i + \alpha_2educa_i + \alpha_3exp_i + \alpha_4credi_i + \alpha_5family_i + \alpha_6marital_i + \alpha_7agenvulga_i + \alpha_8farmsize_i + \alpha_9farmage_i + \alpha_{10}cooperativ_i + \varepsilon_i$$

$\alpha_0 = Y - intercept$ ;  $\alpha_0$  to  $\alpha_{10}$  are parameters which will be estimates.

#### Definition of variables

- **Dependent variable**

The dependent variable ( $U_i$ ) represents the average technical efficiency of firms.

- **Independents variables**

- age: age for farmer (years);
- education (educa): years spend in school;
- experience (exp): farming experience in years (cocoa only);
- credit (credi): access to credit during the cropping season (dummy);
- Family: household size (numbers);
- marital status (marital): marital status of farmer (dummy);
- Agent vulgarization (agenvulga): Visit of extension agents to farmers (dummy);
- Farm size: Cultivated area of cocoa in hectare;
- Farm age (agefarm): Age of the cocoa field in the year;
- Cooperative (cooperativ): Membership of a cooperative (dummy).

These variables are assumed to influence technical efficiency of the farmers. In this study, we assume that the coefficients  $\alpha_2, \alpha_3, \alpha_4, \alpha_7$  et  $\alpha_{10}$  will be of positive sign. On the other hand,  $\alpha_1, \alpha_5, \alpha_6, \alpha_8$  et  $\alpha_9$  are to be preceded by a negative sign.

Table 9. Determinants of technical efficiency as derived from the socioeconomic model

Variables	Parameters	Coefficients	Standard error	t-statistics
Constant	$\alpha_0$	0.6172494	0.5100499	1.21
age	$\alpha_1$	0.0036287	0.0043244	0.84
educa	$\alpha_2$	-0.0116438	0.0091728	-1.27
exp	$\alpha_3$	0.00033	0.0042475	0.08
credi	$\alpha_4$	0.4793564***	0.1088865	4.40
family	$\alpha_5$	-0.0314127**	0.0133786	-2.35
marital	$\alpha_6$	-0.2193822*	0.119955	-1.83
agenvulga	$\alpha_7$	0.0887243	0.0818696	1.08
farmsize	$\alpha_8$	-0.0412027**	0.0192961	-2.14
agefarm	$\alpha_9$	0.0007575	0.0036209	0.21
cooperativ	$\alpha_{10}$	0.2451429***	0.0932439	2.63

Notes: \*\*\*, \*\* and \* represents 1%; 5% and 10% significance levels respectively.

The farmer's age has a positive but not significant influence (10%) on the technical efficiency of the cocoa farm. When the farmer's age increases by 10%, the technical efficiency of cocoa farms increases by 0.036% (Table 9). The level of education influences the technical efficiency of the Lekie cocoa fields negatively and in a non-significant way (at 10%). When the farmer's number of years of study increases by 10%, the efficiency of cocoa farmers decreases by 0.116% (see Table 9). Professional experience has a positive but weak effect on the technical efficiency of farmers. A 10% increase in the number of years of experience in cocoa growing, increases technical efficiency only by 0.0033%. In the socioeconomic model, this coefficient is insignificant at the risk of 10%. On the other hand, access to bank credit participates positively and very significantly (at 1%) in the technical efficiency of cocoa farms. When farmers access bank credit, they increase their technical efficiency. Thus, a 1% increase in access to bank credit increases the technical efficiency of farmers by 0.48%.

The size of the household negatively affects the technical efficiency of farmers. Indeed, an increase in the size of the household of 10%, decreases by 0.314% the technical efficiency of the farmers. However, this variable remains significant at 5% risk.

Marital status has a negative influence on the technical efficiency of farmers. It can be seen that when the number of married farmers increases by 1% their technical efficiency decreases by 0.219%. However, this coefficient is significant at the risk of 10%. Visits of extension agents to farmers increase the technical efficiency of cocoa farmers positively but not significantly (at 10%). An increase in visits by agricultural extension agents of 10% increases the technical efficiency of the cocoa fields by 0.887%. The increase in land area used to grow cocoa has a significant (5%) negative impact on the technical efficiency of cocoa farms. A 10% decrease in the cultivated area of cocoa increases the technical efficiency of the cocoa fields by 0.412%. The age of the cocoa field contributes positively but weakly to the technical efficiency of cocoa farming. When the field age increases by 10%, the technical efficiency of cocoa farms increases by only 0.0075%. This coefficient is not significant at 10%. Lastly, belonging to a cooperative participates positively in the technical efficiency of the Lekie cocoa farmers. When the number of members of agricultural cooperatives increases by 1%, technical efficiency increases by 0.245%. This coefficient is significant at the 1% level.

#### 4. Discussion

The results of the stochastic production boundary show that there is a positive relationship between cocoa production and the area of cultivated land. However, the land production factor is not significant at the 10% threshold. The low elasticity of the land factor (0.181) is due to the old age of the cocoa farms in the studied area. Indeed, most cocoa fields are more than 30 years old, which requires a renewal of these farms or the use of fertilizers to fertilize the soil. In the department of Lekie a large number of cocoa farmers (72.50%) do not use fertilizers to fertilize the soil of their farms. Olufemi (1980)

suggests that rotation of the soil should be considered to increase soil fertility. Moreover, the non-significance of the land-use factor can also be explained by the bad weather conditions that prevailed last year in the studied area.

Similarly, the labor factor influences positively and not significantly the cocoa production in the Lekie. The low elasticity of the labor factor (0.194) is justified by the small number of farmers trained in cocoa cultivation. This study shows that only 23 out of 40 farmers have received practical training in cocoa cultivation. This shows that 40% of farmers do not yet master the new agricultural techniques in cocoa cultivation. Despite the large number of workers (12 people) required to harvest cocoa, the labor factor remains unproductive. A similar result was found in Nigeria by Ogunfowora et al., [20]. The latter asserted in their study that traditional farming requires excessive labor but is often inefficient.

The study shows that the increase in the use of fungicide and insecticide (pesticides) in the Lekie cocoa fields leads to an increase in cocoa production. The high elasticity of the pesticide factor (0.597) shows that the use of this agricultural input is very important in improving the cocoa production of the Lekie. In particular, the increased use of pesticides makes it possible to control insects and brown rot which generally attack cocoa. This result is similar to that found in Ghana by Kyei, Gordon and Ankoh [21]. These researchers had shown that the increase in pesticide quantities in cocoa fields in the Offinso district of Ghana had a positive effect on cocoa production. In addition, a study conducted in Ghana by Aneani and al., [22] revealed similar results that cocoa farm size, quantity of insecticides and quantity of fungicides were 0.514, 0.273 and 0.090 respectively.

The study shows that there is a positive but not significant relationship between the age of the farmer and the efficiency of cocoa farms. The fact that this variable is not significant is justified by the low rate of farmers who have reached the productive age. Indeed, our study shows that only 45% of farmers have reached the productive age (23 years-39 years). However other studies [23,24] revealed that this rate must be 76%. Moreover, in some countries (Nigeria and Ghana), young people start agriculture at the age of 18. While, our study shows that the young people of Lekie start the cultivation of cocoa at the age of 23 years.

The coefficient of education is negative and insignificant on the technical efficiency of the Lekie cocoa farms. This is explained by the fact that most of the surveyed farmers received formal general education and very little specific training in cocoa cultivation. It can also be assumed that the educational structures and systems are of poor quality, which makes it impossible to have a skilled workforce. A similar result was found by Avom, Amadou and Mignamissi [25]. These authors showed that in the case of the CEMAC economies, a percent increase in the gross secondary school enrollment rate decreases the rate of economic growth by 0.36%.

Similarly, work by Ngoe Mukete, Jing Zhu et al. [26] also showed that education has a negative effect on the technical efficiency of cocoa farms in southwestern Cameroon. The low quality of human capital does not allow Lekie farmers to properly allocate inputs, which in turn undermines the technical efficiency of their cocoa farms.

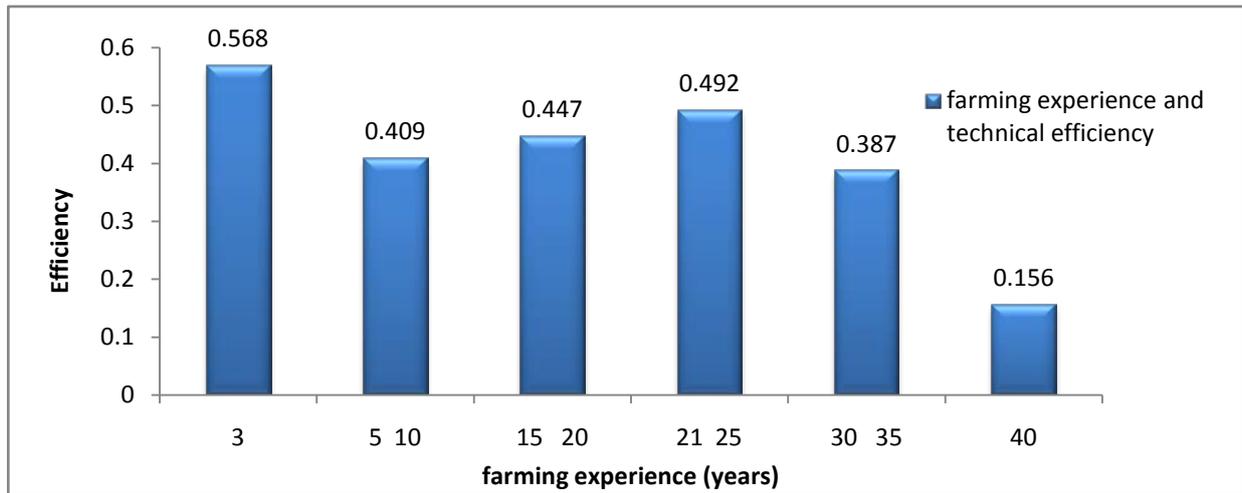


Figure 7. Farming experience and mean technical efficiency (Source: The author, based on the survey data for 2017)

The coefficient of professional experience is positive and not significant on the technical efficiency of cocoa fields. Figure 7 displays the technical efficiency versus years of experience in cocoa farming. This study reveals that experience increases the technical efficiency of the Lekie cocoa farms. Despite an average experience of 16 years spent in cocoa cultivation, farmers in Lekie have a low average efficiency (0.437) in their cocoa farms. We also find that farmers who have spent only three years in cocoa growing have a high average technical efficiency of 0.568, while farmers with 35 years of experience are less successful with an average efficiency of 0.387 (Figure 7). The average technical efficiency of the Lekie cocoa farms thus decreases when the farmer reaches more than thirty years of experience.

Experience therefore has a positive influence, but it has little effect on the technical efficiency of farms. The positive coefficient indicates that farming experience leads to an increase in technical efficiency. But the low value of this coefficient assumes that many farmers do not have complete control of new cocoa growing techniques or are faced with random phenomena beyond their control. As a result, farmers in the study area still need capacity building on the routine tasks needed to grow cocoa.

Our study shows that the credit coefficient is positive and significant. This means that farmers who access credit are more efficient than those who do not. Access to credit is therefore important to increase the performance of the Lekie cocoa producers. Indeed, access to credit allows the farmer to easily purchase agricultural inputs and to assume the managerial function of his cocoa farm.

On the other hand, the size of the household deteriorates the technical efficiency of the Lekie cocoa farms. Indeed, an increase in the number of dependents of the farmer results in a decrease in the technical efficiency of the farms in the study area. However, the size of the household has a negative effect on the technical efficiency of cocoa farms because the farmer employ not only family labor force but also hired labor during the cocoa harvest. This surplus of labor increases the cost of labor, which in turn reduces technical efficiency. However, the size of the household is significant because the number of persons belonging to the household constitutes an abundant and free family labor for the cultivation of cocoa. In particular,

this family labor is important in the production process, especially for the operations of removing the dents, clearing the field, drying and spraying cocoa farms.

Similarly, marital status significantly and negatively influences the performance of the Lekie cocoa farms. This is due to the fact that the head of the household sometimes has to arbitrate between allocating his income to the purchase of farm inputs or ensuring family responsibilities such as nutrition, education and the health of household members. The technical efficiency of the Lekie cocoa farms increases when agricultural extension workers visit farmers regularly. Indeed, the action of these extension agents is necessary because it makes it possible to disseminate information on the market, the management of agricultural fields and agricultural techniques to the farmers. However, the extension coefficient is not significant.

The coefficient of land used to grow cocoa is negative but significant (5%), indicating that farmers with small cocoa farms are more efficient than those with large cocoa farms. This is also justified by the high price of land in the study area. The use of large areas of agricultural land requires additional quantities of inputs and management efforts that increase operating costs and reduce the technical efficiency of cocoa fields. For this reason, the majority of farmers in the Lekie division prefer to grow cocoa on small areas of land.

The age of the cocoa field contributes positively and not significantly to the technical efficiency of cocoa farms. In this study, cocoa farms with 10 to 15 years of age have a high average efficiency of 0.545, while cocoa fields that have reached the age of 30 have rather a low mean efficiency of 0.42 (see Table 10). This suggests that the former cocoa farms are technically less efficient than the new cocoa farms.

Table 10. Age group of cocoa farms and mean efficiency

age group of cocoa farms (years)	frequency	percentage	Mean efficiency
3 - 6	7	17	0.375
10 - 15	9	22	0.545
20 - 25	5	13	0.379
30	19	48	0.423
Total	40	100	0.43

Source: The author, based on the survey data for 2017.

## 5. Conclusion

At the end of this study it is important to recall that our general aim was to conduct an economic analysis in order to assess whether resources are efficiently used for the production of cocoa in the division of Lekie in Cameroon.

More specifically, the objective was to analyze the socioeconomic determinants (variables) of cocoa production in the Lekie division and to assess the volume of cocoa production in the studied area. This led us to state three hypotheses of research namely:

-The socioeconomic characteristics of the cocoa farmers do not have any significant effect on output;

-The farm resources used by the cocoa farmers do not significantly influence their level of output;

-The cocoa farmers do not allocate their farm resources efficiently.

To achieve our objective, we have indicated in the first articulation that the cultivation of cocoa in Cameroon plays an important role in the creation of jobs, the fight against hunger and the reduction of poverty in rural areas. Furthermore, the second articulation made it possible to make a theoretical and empirical review of the literature in connection with our topic of study. It is clear from this presentation that the production is simply the output made from specific inputs, while technical efficiency is the maximum possible level of output attainable from a given set of inputs.

In order to test the hypotheses of our study, it seemed appropriate to retain a methodological framework. Using the statistical method, we identified the socioeconomic characteristics of 40 cocoa farmers selected in this study.

In a complementary way, we chose the econometric method based on the stochastic production boundary approach to analyze the factors of cocoa production in this study area. After calculating the technical efficiency index of the cocoa farms by the frontier program [27], we introduced and formulated the socioeconomic variables in a border model to determine the influence of socioeconomic factors on the farm technical efficiency.

The average production of cocoa in the study area was 1286.55 kg, that is 1.286 tons. The total elasticity of production is 0.9733, i.e. if all factors of production increase by 100%, cocoa production would increase by 97.33%. The returns to scale are thus decreasing.

## 6. Recommendations

In all, five main economic policy recommendations emerge:

Firstly, in order to significantly increase the average cocoa production in the Lekie division, initiatives must be taken to replace the old cocoa plantations with new ones. In addition, farmers may advocate the use of fertilizers to fertilize cocoa fields or use a rotation of cultivated land.

Secondly, given the scarcity of bank credit in the studied area, the economic policy authorities must not only create an agricultural bank, but also ensure that the interest rate charged by the structure to Farmers is low in order for them to benefit from a large amount of money to buy fertilizers, fungicides and insecticides.

Thirdly, in order to allow education to have a positive impact on the technical efficiency of farmers in the Lekie division, emphasis should be placed on technical training of farmers to provide them with specific and practical know-how in agriculture. Similarly, the quality of educational structures needs to be improved.

Finally, in view of the fact that professional experience has a weak and insignificant effect on the technical efficiency of farmers in the Lekie division, farmers in the study area still have to benefit from capacity building on Routine tasks necessary for the cultivation of cocoa. One solution to this problem of lack of mastery of agricultural techniques is to ensure a good diffusion of technical information through an agricultural extension system.

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