

Analysis of the Technical Efficiency of Smallholder Cocoa Farmers in South West Cameroon

Ngoe Mukete^{1*}, Jing Zhu¹, Mukete Beckline², Tabi Gilbert¹, Kimengsi Jude³, Aniah Dominic⁴

¹College of Economics and Management, Nanjing Agricultural University, 1 Weigang, Nanjing 210095, Jiangsu Province, China

²School of Forestry, Beijing Forestry University, 35 Qinghua Dong Lu, Haidian District Beijing, 100083 China

³Department of Economics and Management, University of Buea, Box 63 Buea, South West Region, Cameroon

⁴Farmer Training Centre, Box 763, Bolgatanga 038 20, Ghana

*Corresponding author: ngoer@yahoo.com

Abstract In this study, we assess the technical efficiency of smallholder cocoa farmers in the Meme division of South West Region, Cameroon. Through stochastic production functions and field surveys, the study further examines how the cocoa sector socioeconomically impacts the Cameroonian economy. Using a participatory research approach, data were collected from 515 household heads across four villages on the quantity of cocoa produced, number of cocoa trees per hectare, quantity of fertilizer, and labour availability and socio-economic characteristics. Our results showed the technical efficiency to range between 0.11 and 0.99, with a mean technical efficiency of 0.86. We also observed access to credit and extension services to significantly influence technical efficiency. Therefore, innovative institutional arrangements that enhance extension and farmer training, accompanied by improved access to credit are likely to efficiently boost cocoa production in this part of Cameroon and elsewhere.

Keywords: *technical efficiency, smallholder farmers, cocoa sector, cameroon, stochastic functions*

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1. Introduction

Cocoa (*Theobroma cacao*) plays a vital role in Cameroon's economic development and remains an important source of income [1,2,3]. Cocoa belts occupy about 37% of total area under cultivation and annual production has grown from 120619 tons in 2000 to 232530 tons in 2014 [4]. At this production level, Cameroon is the world's fourth largest cocoa producer after Côte d'Ivoire, Ghana and Indonesia [4].

Cocoa is Cameroon's major agricultural export crop and guarantees employment for about four million individuals especially the rural population. Annual exports accounted for about 14% of non-oil exports in 2012, average revenue of 1215622 FCFA (2055USD) and annual average revenue of 145933 FCFA (247USD) per person [2,5].

The sector is dominated by smallholdings or peasant farmers who have limited resource endowment compared to other farmers in the agricultural sector [3,6,7]. These limitations are often related to differences in agroecological zones, land, capital, and skill. More so, these could be linked to associated differences like farmer age, educational level, access to extension and credit, family size, gender, and market access [8]. In addition access to improved technologies which include fertilizer, agro-chemicals, tractor and improved seeds may impact on technical efficiency [9,10].

Thus sustaining and increasing productivity among smallholdings requires a good knowledge of the current resource endowment which translates into efficiency and inefficiency inherent in the sector and its associated drivers [11,12]. This production efficiency comprises technical and allocative efficiencies where, technical efficiency is the ability of maximizing output for a given set of resource inputs while allocative or factor price efficiency, involves the ability to use the inputs in optimal proportions given their respective prices and production technology [13,14].

In Cameroon, several studies have examined cocoa production in relation to technical efficiency such as [15]. Their study attributes gender disparity with regards to land occupation as one of the problems affecting the multiplicity and increasing harvest in the cocoa growing communities of Southern Cameroon. Relatedly, [16] examined the degree to which socioeconomic determinants influence the performance of cocoa production in Meme Division, South West Cameroon. Using the Generalized Method of Moments (GMM) and Trend analyses for cocoa output, they found socioeconomic variables such as labour, capital, price, political influence and gender to affect cocoa production. They affirmed that the degree and direction to which each variable affects output varied. Similarly, [17] examined the effect of climate variability on cocoa production using the four point likert scale survey. Here, the coefficient of variation (CV) revealed that the CV for rainfall (15.1%) and temperature (11.0%)

all exceeded the variability threshold of 10% indicating that they exhibited significant variability.

Our study seeks to add to the existing knowledge on the technical efficiency levels of cocoa farmers in Cameroon with particular emphasis on Meme Division. To do so, we use a combination of stochastic production functions and field surveys to assess the relationship between technical efficiency and cocoa production activities. These will create the possibility of building a broad knowledge on the technical efficiency levels of the smallholder cocoa farmers and socioeconomic aspects of the study area. It could further provide a basis for the sustainable production of cocoa elsewhere in Cameroon.

2. Methodology

2.1. Study Area

This study was carried out in Mbonge Municipality (4° 32' 11" N; 9° 6' 40" E) located in the Meme Division of South West Cameroon. The Mbonge Rural Council was carved out of the former Bile Council Area in the old Kumba Division by Presidential decree No. 77/203 of 29th June 1977. The council changed its appellation to Mbonge Council following Presidential decree No. 2004/018 of 22nd July 2004 which transformed Rural and Urban councils throughout Cameroon to mere councils [18].

The council is made up of 86 villages covering a total surface area of about 3000km² with an estimated population of over 230000 inhabitants. It is bounded to the North by Kumba 1 council, to the South by Bamusso council, to the West by Ekondo Titi council, and to the East by Muyuka and Idenau councils. The main indigenous and migrant ethnic groups include Mbonge, Bakundu, Balue, Ngolo, Bamilike, Batibo, Kom and the Efiks and Ibos from neighbouring Nigeria [18].

Agriculture is the main economic activity where farmers are engaged in food crops (cassava, yams, plantains, and vegetables) and cash crop (cocoa, oil palm, coconut and rubber) cultivation. The climate is hot and humid with two distinct seasons, the dry and wet season. The dry season runs from November to April while the wet season runs from May to October. The soils are lateritic, sandy, clayey and volcanic which are very rich in humus thus favourable for plant growth.

2.2. Socioeconomic Data Collection

Using a participatory research approach, data were collected from 515 household heads across four villages located within the Mbonge Council area (Big Nganjo, Mabonji, Metoko Bekondo and Nganjo Titi). These data were based on the quantity of cocoa produced, number of cocoa trees per hectare, quantity of agrochemical application, quantity of fertilizer, and labour availability and some important socioeconomic variables about the household heads. The villages have distinct areas with abundant land resources and where, inhabitants are mostly involved in agricultural activities and also to minimize fieldwork travel time.

Therefore, the selected villages are typical of other villages within the same council area. In addition, the

household was the basic unit for research within each of the villages with no predefined sampling units. This was a door to door survey as such; no criteria were set for selection of households to be assessed in each village.

All procedures performed in this study involving human participants were approved by the Ethics Committee of the School of Economics and Management Forestry, Nanjing Agricultural University, China and which bases its foundations on the 1964 Helsinki declaration.

2.3. Data Analysis

We used descriptive statistics to estimate the mean, standard deviation and variances of the socioeconomic and production characteristics of respondents. In addition, the stochastic production function was used to evaluate the level of farmer technical efficiency. Here, we assumed the production technology of the cocoa farmers to be specified by the Cobb-Douglas frontier production function according to [9,19]. The specified cocoa production function is written in the form;

$$\ln Y_i = \beta_0 + \beta_1 \ln X_{1i} + \beta_2 \ln X_{2i} + \beta_3 \ln X_{3i} + \beta_4 \ln X_{4i} + V_i - U_i \quad (1)$$

Where;

ln=natural logarithm

Y_i = output of farmer in kilograms per hectare

X₁ = seeds (number of cocoa trees per hectare)

X₂ = quantity of fertilizer (kg)

X₃ = quantity of agro-chemical (kg)

X₄ = labour (man days)

Bo = Y – intercept

B1 to β4 are parameters to be estimated.

V_i and U_i are composite error terms

The production frontier can be specified as according to (9)

$$Y_i = f(x_i, \beta) \exp(v_i) \exp(-u) \quad (2)$$

Where y_i is the output of the i-th farm, x_i is vector of inputs, β is vector of parameters to be estimated, v_i is assumed to account for random effects on production that is not within the control of the producer and u_i is a non-negative error term measuring the technical inefficiency effects that fall within the control of the decision unit.

$V_i \sim N(0, \sigma_v^2)$ and $U_i \sim N^+(0, \sigma_u^2)$ are the random error and the inefficiency term.

The technical efficiency of the i-th farm (TE_i) is given by according to (9).

$$TE_i = \frac{y_i / y_i^* = E(y_i / x_i, u_i)}{E(y_i) / x_i, u_i = 0} = \frac{f(x_i, \beta) \exp(v - u)}{f(x_i, \beta) \exp(v)} = \exp(-u_i). \quad (3)$$

In further analysis, influence of some socioeconomic factors on technical efficiency was obtained by introducing socioeconomic variables into the frontier model according to [20]. The technical efficiency model is written as;

$$U_i = q_0 + q_1 Z_{1i} + q_2 Z_{2i} + q_3 Z_{3i} + q_4 Z_{4i} + q_5 Z_{5i} + q_6 Z_{6i} + q_7 Z_{7i} + q_8 Z_8 + q_9 Z_{9i} + 10q_{10} Z_{10i} + q_{11} Z_{11i} \quad (4)$$

Where;

U_i = Technical efficiency; Z₁ = Gender (sex); Z₂ = Household size (numbers), Z₃ = Age of farmer (in years); Z₄ = Education (years of schooling); Z₅=Farm size, Z₆ = Access to credit; Z₇ =Farming experience (years); Z₈ = Age of cocoa farmland (in years), Z₉=Farmer’s cooperative society (groups, associations); Z₁₀ =Access to extension services, Z₁₁ =Number of extension visits (extension services contacts), Z₁₂ =Production contracts
 $q_0 = y - \text{intercept}$ and q_1 to q_{12} are coefficients that were estimated.

3. Results

3.1. Descriptive Statistics of Variables

Table 1 illustrates descriptive statistics of socioeconomic variables and where average age of farmers was 40.26 years for an average household size of 6.15 members. Meanwhile farmers had on average 7.56years of formal education and 13.45 years’ experience in cocoa farming.

Also over 4% belonged to farmer’s cooperative societies (associations/groups) and 34% had access to micro credit schemes for production. Further analysis found 48% of the farmers to have signed production contracts while only 10% had access to extension services (see Table 1).

The mean farm size was 3.66 hectares and where each farm contained about 1055.96 cocoa trees per hectare on average. Similar results were obtained by [21,22] for the savannah and southern regions of Cameroon respectively.

3.2. Estimating Maximum Likelihood Using Stochastic Production Frontier Function

Table 2 depicts the Maximum Likelihood values as obtained from stochastic frontier production functions. Our results show cocoa production to be determined by agro-chemical quantities and labour and which are both statistically significant at the level of significance of 10%. Additional analysis showed that though fertilizer use is statistically significant, it had a positive influence on cocoa output. This study also found a negative relationship between the level of output and the seeds (number of cocoa trees per hectare).

Table 1. Descriptive statistics of socioeconomic and efficiency variables

Variables	Mean	Standard deviation	Minimum	Maximum
Output (kg)	1489.20	1654.36	45	10000
Fertilizer (kg)	4.33	16.58	0.25	200
Agro-chemicals (litres)	3.75	3.67	0.86	42.24
Labour (man days)	4.94	4.54	0.20	35
Cocoa trees (number of trees)	1055.96	36.13	938	1113
Farm size (hectares)	3.66	2.51	1	16
Gender (dummy)	0.90	0.30	0	1
Household size (dummy)	6.15	3.77	2	19
Age of farmer (years)	40.26	10.90	20	68
Education (dummy)	7.56	3.86	0	14
Credit (dummy)	0.34	0.47	0	1
Years of farming (units)	13.45	8.67	1	48
Age of cocoa trees (years)	22.96	9.96	6	53
Farmer’s cooperative society (dummy)	0.04	0.20	0	1
Access to extension services (dummy)	0.10	0.31	0	1
Number of extension visits (units)	0.22	0.75	0	5
Production contracts (dummy)	0.48	0.50	0	1

Table 2. Maximum likelihood estimates of the stochastic production function for cocoa production

Variable	Parameters	Coefficients	t-statistics
Constant	β_0	10.560*	1.870
Ln (Fertilizer)	β_1	0.008	0.253
Ln (Agro-chemical)	β_2	0.321***	10.756
Ln (Labour)	β_3	0.120***	3.187
Ln (Seed)	β_4	-0.719	0.888
Variance parameters			
Sigma U		-2.172***	-5.462
Sigma V		-1.402***	-21.111
Log likelihood function		-404.72	

Notes: * p < 0.1; ** p < 0.05; *** p < 0.01.

Table 3. Values of technical efficiency as derived from the inefficiency model.

Variable	Coefficient	t-statistics
Gender	0.168	0.373
Household size	-0.000	-0.010
Age of farmer	0.013	1.174
Education	-0.002	-0.089
Farm size	0.578***	-3.933
Access to credit	0.452***	2.608
Years of farming	0.035	-1.149
Age of cocoa farms	0.016	-0.994
Farmer’s cooperative society	-0.849	-1.378
Access to extension services	3.917***	8.520
Number of extension service visits	-3.183	0.000
Production contracts	-0.499**	-2.370
Constant	-21.549	-0.891

***, ** and * represents 1%, 5% and 10% significance levels respectively.

Table 4. Distribution of technical efficiency of cocoa farmers across the study area

Efficiency class	No. of farmers	Percentage
≤0.20	2	0.39
0.21-0.40	10	1.94
0.41-0.60	22	4.27
0.61-0.80	76	14.76
0.81-1.00	405	78.64
Total	515	100.00
Mean	0.86	
Standard deviation	0.15	
Minimum	0.11	
Maximum	0.99	

3.3. Estimating the Determinants of Technical Efficiency

Table 3 illustrates values of technical efficiency as derived from the inefficiency model. Our results show the coefficient of gender to have a positive sign. Meanwhile, household size coefficient is negative and not significant whereas the age of farmer coefficient is positive. Our results also show the education coefficient (years of school) to be negative whereas access to credit coefficient is positive and 10% significant. Similarly, years of farming (farmer's experience) and age of cocoa trees have negative coefficients. Studying smallholder farmers in the slash and burn agriculture zone of Cameroon [23] obtained similar results. Farmer's cooperative society (association, groups) and extension service visits (contacts) have negative influences on technical inefficiency.

3.4. Estimating Technical Efficiency Distribution

Table 4 shows the efficiency levels of the sampled farmers and which indicates a technical efficiency range from 0.11 to 0.99. Additional analysis illustrates that the mean technical efficiency of the cocoa farmers in the study area is 86%. Therefore, on the average, cocoa farmers in the study area are 14% below the best practice frontier output given the existing technology and available input in the locality. The efficiency distribution also shows 93.4% of farmers to have efficiency scores between 0.61 and 1.00 while 6.6%, were less than 60% efficient in their production process.

4. Discussion

This study observed a positive relationship between the level of cocoa output, quantities of agro-chemical and labour used. This may be related to the fact that production levels largely depend on the quantities of these various farm inputs. However, this can only be up to a level that is considered optimal after which farmers will be operating at sub optimal levels. Additionally, there was a positive relationship between output and fertilizer application because increase in fertilizer application, is known to increase cocoa output. Relatedly, the negative relationship between the level of output and seeds (number of cocoa trees) may be as a result of delays in weeding, pruning, and lack of adequate shade control. It is

also often likened to poor cocoa breeds as well as lack of regular and systematic suppression of side shoots.

Gender had a positive coefficient indicating that male farmers obtained higher levels of technical efficiency than their female counterparts in the area. Similar results were obtained by [24] showed that cocoa farming is quite dominated by males in the study area. This is due to cocoa farming being a tedious job that requires more physical strength which females are often not able to provide. The positive coefficient of age of farmers proved that old farmers are technically more inefficient than younger ones. According to [9,25], older farmers are less likely to have contact with extension workers and are equally less inclined to adopt new techniques and modern inputs. Here, younger farmers have greater opportunities for formal education and may be more skillful in the search for information and the application of new techniques.

Farm size was negative but significant illustrating that farmers with larger farms were more technically efficient than farmers with smaller farms [26,27]. In addition, credit value was positive and significant which means that credit accessibility is vital in improving the performance of cocoa producers. This is because credit is thought to assist farmers in enhancing efficiency by overcoming financial constraints. These constraints often influence farmer ability to purchase and apply inputs as well as timely implement farm management decisions thus increasing efficiency. Therefore, farmers who have access to credit are technically more efficient than those with little or no access to credit [28]. Still from a financial perspective, farmers belonging to farmer associations were more technically efficient than farmers who were not. This can be attributed to the fact that farmers who were members of an association had access to relevant information on farm management and introduction of new technologies which could boost productivity [25].

Access to information as a factor which increases technical efficiency is portrayed in extension service visits or contacts. Here increasing number of contacts with extension officer's increases technical efficiency due to availability of market, technical and farm management information [25,28]. Similarly, cocoa farmers who sign production contracts are more technically inefficient than those without contracts. In the study area, Cocoa farmers often sign input (provisions), (output) produce, supply, and credit contracts with individual output buyers. The contract terms are always not mutually beneficial, and where agrochemicals are supplied to the cocoa farmer at higher prices which often doubles local market prices. These farmer also bound by these contracts to sell their output only to these individual buyers, thus affecting the farmers' credit availability. This credit provisions contracts between the farmers and the individual output buyers always have high interest rates. Most often, the farmers receive these inputs and credit too late which affects their farming calendar and hence productivity and efficiency.

5. Conclusion

Low production and poor quality of cocoa in Meme Division are continuous processes requiring constant

monitoring and evaluation. The role of socioeconomic causes such as lack of access to credit, extension services, and gender within the study area necessitates more attention. This is because, these factors enhance farmer technical efficiency, improves quality and harvest of cocoa which is a source of livelihood for local populations. Thus understanding their functioning and state will help define, develop and implement adequate and major farm management policies. Areas for further scientific investigation in the study area would include how national cocoa governance and institutional weakness as well as the economic crisis have individually affected technical efficiency hence production. In addition, further research could examine the oil palm plantation boom, and field surveys used to document underlying causes and how these have affected cocoa production and farmer efficiency. Similarly, field work could be used to evaluate local cocoa farming household adaptations to climate variability and how this affects technical efficiency.

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