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AFRICAN DEVELOPMENT BANK GROUP

***Technology Gap and Efficiency in Cocoa
Production in West and Central Africa:
Implications for Cocoa Sector Development*** ⁽¹⁾

Guy Blaise Nkamleu, Joachim Nyemeck and Jim Gockowski

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Abstract

Guy Blaise Nkamleu, Joachim Nyemeck and Jim Gockowski

This paper applies the recently developed metafrontier function technique to investigate productivity potentials and efficiencies in cocoa production in West and Central Africa. The methodology enables the estimation of national technology gap ratios (TGRs) by using a decomposition result involving both the national production frontiers and the (regional) metaproduction frontier. Empirical results are derived using a comprehensive dataset collected during one of the larger surveys of cocoa

farmers in four West and Central Africa countries, namely Cameroon, Ghana, Nigeria and Cote d'Ivoire. The data and analysis support the view that technical efficiency in cocoa production is globally low, and technology gap plays an important part in explaining the ability of cocoa sector in one country to compete with cocoa sectors in other countries in the West and Central Africa region. The paper ends by highlighting relevant strategies for sustainable cocoa development in Africa.

Key words: Productivity potential, efficiency, cocoa farmers, metaproduction function, Africa
JEL classification: O47 ; Q18 ; C51

Introduction

The centrality of agriculture to the development of least developed countries or developing economies is now beyond dispute. A vast body of knowledge has assigned a phenomenal role to agriculture in the early stages of industrialisation. In West and Central Africa, agriculture has continued to play a dominant role in the provision of food, raw material for industries, employment for the majority, and foreign earnings, which are used in financing development activities. In the course of the last 40 years, industrial tree crops, notably cocoa, coffee, oil palm, and rubber, have dominated the export agriculture.

Perennial tree crop systems in Africa are important for national macroeconomic balances and rural livelihoods. In a period of rapid globalisation and food crisis, countries in Africa are pursuing their comparative productive advantage to foster growth under a new liberal economic context. The pursuing of comparative advantage implies a continued (if not larger) role for tropical commodity exports in order to generate foreign exchange and to promote economic growth.

Among the perennial tree crops, cocoa sector is of particular interest for West and Central Africa, and for the global chocolate industry. Approximately 70 percent of the world supply of cocoa originates from there. Producing countries derive a large proportion of their foreign income from cocoa. For example, in 2001, Côte d'Ivoire exported more than 1.4 million tons of cocoa. This contributed about 40 percent of exports, 14 percent of GDP, and more than 20 percent of government income (Nkamleu and Kielland 2006).

Recent global and African production trends are shown in Table 1. In Africa, cocoa production is dominated by four countries. Côte d'Ivoire and Ghana produce approximately 41 percent and 17 percent of the world output respectively. The other two important producers are Cameroon and Nigeria, each contributing approximately five percent of the world cocoa production.

In the 1980s, the cocoa sector experienced an economic recession as the world cocoa market went through a period of extremely low prices. The stagnation and decline in this sector during the period paralleled the overall collapse in economic growth in sub-Saharan Africa. The price received by farmers has hardly risen above \$0.50 USD per kg. With the new liberal economic environment and within the world globalisation context, new strategies and policies need to be established to take up the fresh challenges that have arisen. The main one is how to increase cocoa production to meet up with income and development needs. Attaining these goals require a drastic increase in cocoa productivity.

In Africa, growth in the cocoa sector has been achieved by increasing the area cultivated rather than by improving yield. Indeed, cocoa cultivation is among the most significant causes of the near disappearance of the West African rainforest (Gockowski *et al.* 2000; Nkamleu and Ndoye 2003). The conflict between the poverty alleviation opportunity cocoa presents and the environmental challenge associated with the expansion of its production underscores the need to revitalise its productivity in the region (Nkamleu and Coulibally 2000).

Cocoa productivity levels can be enhanced either by improving technical efficiency and/or by improving technological application. A relevant question for agricultural policymakers is whether to pursue a strategy directed towards technological change (bringing new technologies) or a strategy towards efficiency (improving the use of existing technologies) (Nkamleu 2004; Nkamleu 2004b). The presence of shortfalls in production efficiency means that output can be increased without requiring additional conventional inputs and without the need for new

technology. If this is the case, then empirical measures of efficiency are necessary in order to determine the magnitude of the gain that could be obtained by improving performance with a given technology. In the presence of technological gap, technical progress is the rational strategy to adopt to significantly increase agricultural production.

In this paper, we apply recently developed techniques – a metafrontier production function – to investigate productivity potentials (technological gap) and efficiency differences of cocoa sectors in different countries in West and Central Africa. This methodology has the advantage of making it possible to compare technical efficiency of agriculture in different countries that may not share the same technology. The study used data from one of the larger surveys of cocoa farmers carried out in Africa. The paper is divided into five sections. Section 2 presents the theoretical framework and econometric model used in this article. Section 3 describes data and presents the empirical model. Section 4 discusses the results, while section 5 ends the discussions with conclusions and some policy lessons.

2. Theoretical framework and econometric model

The metaproduction function concept used in this paper was first introduced by Hayami (1969) and Hayami and Ruttan (1970, 1971). As stated by Hayami and Ruttan (1971, p. 82), “The metaproduction function can be regarded as the envelopment of commonly conceived neoclassical production functions.”

In the analysis, we employed a *stochastic frontier* metaproduction, which is characterised by the fact that the error term comprises a symmetric random error and a non-negative technical inefficiency term as in the stochastic frontier production function model originally proposed by Aigner, Lovell and Schmidt (1977) and Meeusen and van den Broeck (1977).

This concept of stochastic frontier metaproduction function is extensively discussed by Battese and Rao (2002) and Battese *et al.* (2004), and is adapted here to serve our purpose. Let us consider that the whole sample of producers is composed of K subsets ($K > 1$) representing K countries, and farmers in each country operate under a country specific technology, T^k ($k=1, 2, \dots, K$).

Since all the K 's technology can be considered as a subset of an “over-arching technology” referred to as the meta-technology, which is represented by T^* , the meta-technology can be stated as the “absolute best” technology produced by the state of knowledge, and is accessible if neither endowment nor policy constraints are facing producers. Battese *et al.* (2004) showed how technical efficiency scores for farms across countries can be estimated using a stochastic frontier metaproduction function model, and used a decomposition result to present an analysis of regional productivity potential and efficiency levels. The same type of analysis is performed here.

Suppose that the inputs and outputs for farms in a given cocoa sector are such that stochastic frontier production function models are defined for different countries within the cocoa sector. Suppose also that for the j -th country, there are sample data on N_j farms that produce cocoa from the various inputs. The stochastic frontier model for this country is defined by:

$$Y_{ij} = f(x_{ij}, \beta_j) e^{V_{ij} - U_{ij}}, \quad i = 1, 2, \dots, N_j, \quad (1)$$

The V_{ij} s in the equation are assumed to be identically and independently distributed as $N(0, \sigma_v^2)$ -random variables, independent of the U_{ij} s, which are defined by the truncation (at zero) of the $N(\mu_{ij}, \sigma^2)$ -distributions. For simplicity, the subscript, j , is omitted and following Battese and Coelli (1992, 1995), the model for the j -th country can be written as:

$$Y_i = f(x_i, \beta) e^{V_i - U_i} \equiv e^{x_i \beta + V_i - U_i} \quad (2)$$

This expression assumes that the exponent of the frontier production function is linear in the parameter vector, β , so that x_i is a vector of functions (e.g., logarithms) of the outputs for the i -th farm. The metafrontier production function model for farms in all countries of the cocoa sector is expressed by:

$$Y_i = f(x_i, \beta^*) e^{V_i^* - U_i^*} \equiv e^{x_i \beta^* + V_i^* - U_i^*}, \quad i = 1, 2, \dots, N, \quad (3)$$

β^* denotes the vector of parameters for the metafrontier function such that

$$x_i \beta^* \geq x_i \beta. \quad (4)$$

Equation (4) states that the metafrontier dominates all the country's frontiers. That is the meta-technology that describes the unconstrained best practice according to the state of knowledge. The metafrontier production function is thus defined as a deterministic parametric function (of specified functional form), such that its values are no smaller than the deterministic components of the stochastic frontier production functions of all the different groups involved.

The observed output for any unit can be consequently defined by the stochastic frontier for the j -th group (equation 2) using the metafrontier function (3), such that:

$$Y_i = e^{-U_i} \times \frac{e^{x_i \beta}}{e^{x_i \beta^*}} \times e^{x_i \beta^* + V_i} \quad (5)$$

The first term of the right-hand side of equation (5) is the technical efficiency relative to the stochastic frontier for the j -th group,

$$TE_i = \frac{Y_i}{e^{x_i \beta + V_i}} = e^{-U_i} \quad (6)$$

The second term on the right-hand side of equation (5) is the technology gap (TGR) for the sample farm involved,

$$TGR_i = \frac{e^{x_i \beta}}{e^{x_i \beta^*}} \quad (7)$$

This measures the ratio of the output for the frontier production function for the j -th group, relative to the potential output that is defined by the metafrontier function, given the observed inputs. The technology gap ratio ranges from zero to one because of equation (4). The technical efficiency of the i -th farm, relative to the metafrontier, denoted by TE_i^* , is defined in an analogous way to equation (6). It is the ratio of the observed output relative to the last term on the right-hand side of equation (5), which is the metafrontier output adjusted for the corresponding random error, i.e.,

$$TE_i^* = \frac{Y_i}{e^{x_i \beta^* + V_i}} \quad (8)$$

Equations (5)-(8) imply that an alternative expression for technical efficiency relative to the metafrontier is given by:

$$TE_i^* = TE_i \times TGR_i \quad (9)$$

Equation (9) implies that the technical efficiency ratio of the *ith* producer relative to the metafrontier is the product of the technical efficiency relative to the stochastic frontier for the given group and the TGR. In other words, the technical efficiency scores for producers that don't use the same technology can be corrected (to make them comparable) using the distance between the regional frontier and the leading metafrontier. Note that this precludes the technical efficiency with respect to the meta-technology from being greater than the technical efficiency measure relative to the regional frontier.

The $\hat{\beta}^*$ – parameters can be estimated by solving the optimisation problem (Battese *et al.* 2004):

$$\min L \equiv \sum_{i=1}^N (x_i \beta^* - x_i \hat{\beta}_{(j)}) \quad (10)$$

$$s.t. \quad x_i \beta^* \geq x_i \hat{\beta}_{(j)}.$$

Some econometric advantages of applying the metaproduction function are discussed by Lau and Yotopoulos (1989). However, the lack of comparable data and the presence of inherent differences across regions are the major limitations of the approach. More generally, the major weakness of the stochastic frontier model is its failure to provide an explicit distribution assumption for the inefficiency term. Different assumption about the distribution of the disturbance can sometimes produce widely different results.

3. Data and empirical model

The present study is based on data collected by the International Institute of Tropical Agriculture in 2002 in Côte d'Ivoire, Ghana, Nigeria, and Cameroon. A baseline survey of major cocoa-growing regions of West and Central Africa was conducted to provide baseline parameter estimates of production systems in the sub-region. In all of the countries indicated, villages and clusters of households were randomly selected and household heads interviewed using structured questionnaires (Table 1).

In Nigeria, 1,083 households were visited in 35 villages and towns of Ondo State, which accounts for more than 40 percent of annual cocoa production in Nigeria. In Cameroon, 1,003 households in 83 villages in the Southwest, Center, and South Provinces were visited. Cocoa output from these sites accounts for over 80 percent of national production. In Ghana, the surveys were conducted with 1,000 households from 85 villages in the Brong Ahafo, Ashanti, Eastern, and Western regions, which together account for approximately 90 percent of national cocoa production. In Côte d'Ivoire, a list of farmers obtained from a national census of cocoa and coffee producers conducted in 1998 presented the opportunity to select households using a random number procedure. A total of 1,372 households from 20 subdivisions and 134 villages, hamlets, and cocoa "camps" across the cocoa belt of Côte d'Ivoire were interviewed.

Table 1: Number of villages and farmers surveyed.

	Villages	Farmers
Côte d'Ivoire	134	1372
Ghana	85	1000
Nigeria	35	1083
Cameroon	83	1003
Total	337	4458

The functional form chosen for the stochastic frontier function for all the countries is the translog form. The translog functional form for the i th farmer in a particular country is defined by:

$$\ln Y_i = \beta_0 + \sum_{m=1}^4 \beta_m x_{m_i} + \sum_{m=1}^4 \sum_{k \geq m}^4 \beta_{mk} x_{m_i} x_{k_i} + v_i - u_i \quad (11)$$

Indices i and m respectively represent the input m used by farmer i . $\ln Y_i$ denotes the natural logarithm of the total quantity of cocoa produced, measured in kilograms.

Four inputs were included in the model. Most of these variables have been commonly used in estimating agricultural production frontiers for developing countries (Bravo-Ureta and Pinheiro 1997; Nyemeck *et al.* 2008). ' x_1 ' denotes the total productive cocoa area in hectares. Generally, a cocoa tree becomes productive after around six years. ' x_2 ' represents the cost of pesticide (fungicides and insecticides) used in cocoa production. It is measured in USD. ' x_3 ' stands for the amount of labour, which includes both family, exchange, and hired labour in man-days. ' x_4 ' refers to the average age of cocoa farms measured in years. v_i, s are assumed to be independently and identically distributed $N(0, \sigma_v^2)$ two-sided random errors, independently of the u_i, s .

4. Results

The single-stage maximum likelihood procedure of the FRONTIER 4.1 program (Coelli 1996) was used to estimate the parameters of the stochastic frontiers (maximum attainable output) for each country and for pooled data. Results are presented in Table 2.

Two sets of specification tests were performed. First, the null hypothesis that there are no technical efficiency effects in the models is tested using a likelihood ratio (LR) test of the one-sided error. The null hypothesis is strongly rejected as the LR test statistics 55.82, 42.80, 52.68, 51.98, and 135.99 for Cameroon, Ghana, Nigeria, Côte d'Ivoire, and pooled stochastic frontier, respectively, are all greater than the tabular Ki-square value (3.84). Second, if the stochastic frontiers across nations do not differ, then it is possible to just use the pooled stochastic frontier. Therefore, an LR test was performed to see if all the national stochastic frontiers shared the same technology. A generalised LR test statistic for the null hypothesis that the national frontiers were identical for all cocoa sectors in West and Central Africa was calculated. The LR Statistic is defined by $\lambda = -2[\ln(L(H_0))/\ln(L(H_1))] = -2[\ln(L(H_0)) - \ln(L(H_1))]$, where $\ln(L(H_0))$ is the value of the loglikelihood function for the stochastic frontier estimated by

pooling the data for all countries, and $\ln(L(H_1)) = \sum_{i=1}^4 LLF_i$ is the sum of the values of the loglikelihood functions for the four national production frontiers.

The degrees of freedom for the Chi-square distribution involved are 78, the difference between the number of parameters estimated under H_1 and H_0 . The value of the LR statistic was found to be 668.940, which is highly significant. This result strongly suggests that the four national stochastic frontiers for cocoa farmers in West and Central Africa are not the same, implying that production structure and technology are different among the four countries.

The parameters of the metafrontier are estimated by solving the LP problem. The LP problem in equation (10) was solved using Lingo software. The LP was preferred in the present paper after Battese, Rao, and O'Donnell (2004) found an insignificant difference between the LP and the QP estimates for the parameters of the metafrontier function. However, as expected, there are significant differences between the metafrontier coefficients and the corresponding coefficients of the stochastic frontier for the pooled data.

The values of the *TGR*, together with the technical efficiencies obtained from the national stochastic frontiers (*TE*) and the metafrontier (*TE**) were computed for all farmers in the different countries. Summary statistics for these measures are presented in Table 3.

The *TGR* values represent the distance between the metafrontier and the national efficiency frontier for a given vector of inputs. For the studied countries, the technical efficiency scores ranged from 0.44 to 0.74, with a weighted average of about 0.61, indicating that the cocoa sector in West and Central Africa produces on average, only 61 percent of the potential output given the technology available in each country. This result evidences that technical efficiency is quite low. It also demonstrates that improving the managerial skills and technical capacity of farmers without adding any input can help increase agricultural output by up to 39 percent.

Nigeria is the relatively most efficient country while Ghana is the least efficient. Imperfect competition, financial constraints etc., may cause a farmer not to be operating at optimal level. The low efficiency score is a significant finding. It suggests that in the achievement of high levels of performance in cocoa production in West and Central Africa, technical efficiency is an important constraint.

The more interesting feature is the difference between the average technical efficiency scores from the national and the metafrontier models. For example, the average technical efficiency for Cameroon relative to the metatechnology is only 45 percent, while its mean efficiency is quite large with respect to its own national frontier (65 percent). The differences between the two efficiency scores indicate the order of bias of the technical efficiencies obtained by using the national frontier, relative to the technology available for the cocoa sector in West and Central Africa. Generally, the technical efficiencies from the national frontiers should be greater than those obtained from the metaproduction frontier because of the constraint in the linear programming problem (equation 10).

Estimates for the technology gap ratios (*TGR*) reveal that the four countries have productivity potential ratio ranging between 0.70 and 0.96. These values can be interpreted as the technological gap faced by the cocoa sector in those countries when their performances are compared with the regional level. Cameroon has the lowest productivity potential ratio. This suggests that even if all cocoa farmers from Cameroon achieved best practice with respect to the technology observed in their country, they will still be lagging behind because the technology in Cameroon lags behind regional technology with a *TGR* of 0.70. This implies that even if the mean cocoa producer in Cameroon were fully technically efficient (i.e., producing on

the national efficiency frontier), he/she could still increase output by 30 percent if he/she adopted the most efficient meta-technology in the region. The technology gap ratios were much greater in Nigeria and Côte d'Ivoire (0.96 and 0.92 respectively), indicating that the technologies in these countries are near the possibilities' frontier of the meta-technology.

Figure 1 illustrates the results presented above. In the same graphic are frontier curves of the four countries, and the metafrontier curve. The inefficiency levels are indicated by the distance between the production point and the frontier curve, while the technology gap ratios are represented by the distance between the country-frontier and the metafrontier curves.

From a policy point of view, these regional differences show the type of interventions necessary to enhance productivity of the cocoa sector in each region. In Cameroon, priority should be on reducing the technology gaps by investing in new technological innovations already existing within the region. A country-to-country technology transfer arrangement should be encouraged. In Nigeria and Cote d'Ivoire, the findings suggest that to achieve significant growth in the cocoa sector, priorities should be on improving the know-how of cocoa farmers. This could be achieved by putting in place sound government extension programmes and the development of rural credit institutions to help cocoa farmers acquire technologies already available in the country. In Ghana, both types of strategies should be pursued to tackle the observed very low efficiency level and the technology gap.

Table 2: The maximum-likelihood estimates of the translog stochastic frontiers for cocoa farmers in different countries in West and Central Africa, together with estimates of parameters of the metafrontier production function.

Variable	Coefficient	Cameroon	Ghana	Nigeria	Côte d'Ivoire	Pooled	Meta (LP)
Constant	β_0	6.715 (11.321) ^b	4.941 (-10.822)	5.96 (7.406)	5.293 (13.718)	4.951 (25.482)	5.727
Area	β_1	0.645 (3.692)	0.728 (5.053)	0.652 (3.135)	0.767 (4.406)	0.931 (12.020)	0.689
Labour	β_2	0.310 (4.12)	-0.025 (-0.142)	0.026 (0.115)	0.509 (2.662)	0.181 (2.113)	0.252
Pesticides	β_3	-0.366 (-5.842)	-0.075 (-1.846)	-0.585 (-6.112)	-0.235 (-5.464)	-0.062 (-1.760)	0.0001
Trage	β_4	-0.277 (-1.223)	0.955 (3.577)	0.254 (0.685)	0.759 (3.021)	0.91 (7.763)	0.387
Area ²	β_{11}	0.002 (0.072)	0.055 (1.957)	-0.007 (-0.268)	-0.092 (-3.036)	0.009 (0.604)	0.0017
Labour ²	β_{22}	0.046 (1.644)	-0.001 (-0.030)	-0.017 (-0.612)	-0.003 (-0.094)	0.036 (2.717)	0.0109
Pesticide ²	β_{33}	0.031 -12.258	0.013 (4.529)	0.066 (17.065)	0.023 (6.301)	0.046 (13.307)	0.0424
Trage ²	β_{44}	-0.003 (-0.097)	-0.11 (-2.281)	-0.02 (-0.347)	-0.155 (-3.345)	-0.156 (-7.807)	-0.04
Area*Labour	β_{12}	-0.111 (-2.157)	0.026 (0.619)	0.008 (0.175)	0.086 (1.552)	0.031 (1.238)	0.009
Area*Pesticide	β_{13}	0.002 (0.234)	-0.006 (-1.014)	-0.03 (-1.641)	-0.014 (-1.891)	-0.061 (-6.843)	-0.0018
Area*Trage	β_{14}	-0.085 (-2.014)	-0.028 (-0.534)	-0.059 (-1.196)	0.019 (0.302)	-0.115 (-4.354)	-0.0012
Labour*Pesticide	β_{23}	-0.013 (-1.140)	-0.002 (-0.364)	0.018 (0.955)	-0.009 (-1.260)	-0.007 (-0.756)	-0.0003
Labour*Trage	β_{24}	0.025 (0.47)	0.018 (0.292)	0.01 (0.161)	-0.094 (-1.518)	-0.018 (-0.607)	0.0163
Pesticide*Trage	β_{34}	0.03 (2.228)	-0.017 (-2.049)	0.003 (0.105)	0.022 (2.617)	0.015 (1.408)	0.0131
<i>Variance parameters</i>							
	$\sigma^2 = (\sigma_u^2 + \sigma_v^2)$	1.054 (3.122)	0.703 (6.169)	1.631 (3.20)	1.277 (3.134)	0.937 (9.437)	
	$\gamma = \sigma_u^2 / (\sigma_u^2 + \sigma_v^2)$	0.712 (7.209)	0.753 (7.758)	0.802 (12.673)	0.785 (13.3)	0.624 (13.967)	
	Log Likelihood	-866.31	-930.66	-1042.41	-1138.48	-4312.33	

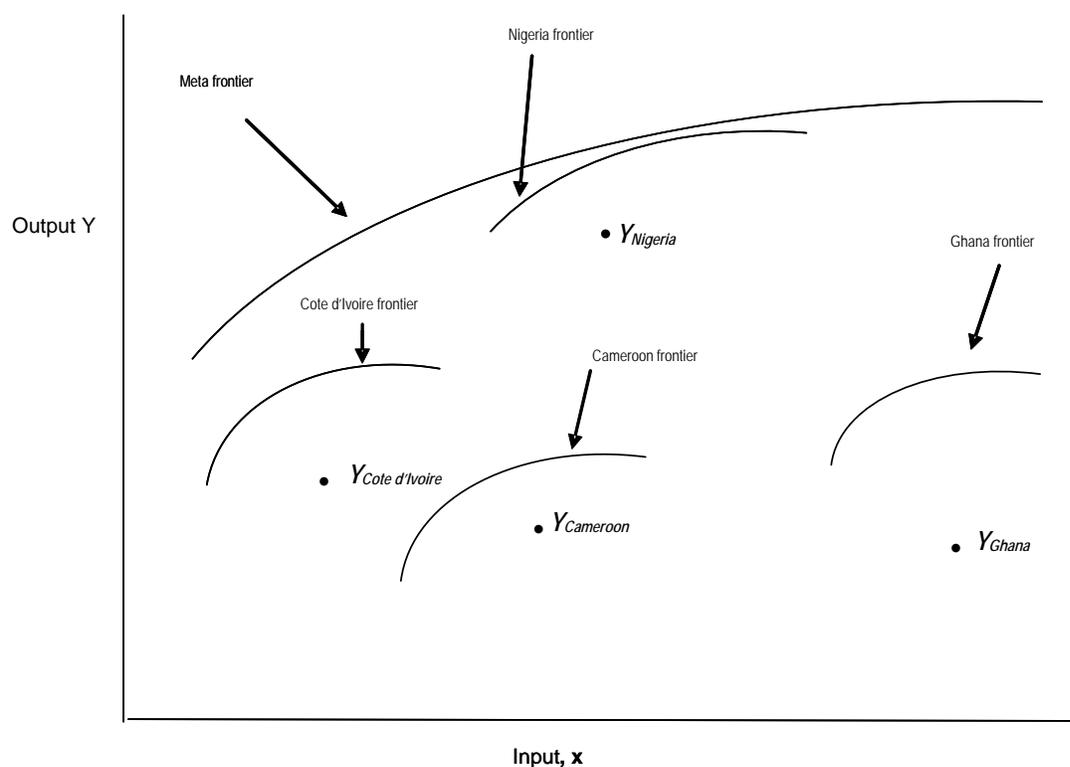
^bVariables in parenthesis are asymptotic t-ratios

Table 3: Summary statistics for the TGRs and the technical efficiencies obtained from the national stochastic frontiers and the metafrontier production function for West and Central Africa cocoa farmers^(**)

	Cameroon	Ghana	Nigeria	Côte d'Ivoire	Prob.
Technical Gap Ratio (TGR)	0.70 (0.08)	0.88 (0.014)	0.96 (0.015)	0.92 (0.16)	< 0.001
National Technical Efficiency (TE)	0.65 (0.16)	0.44 (0.19)	0.74 (0.12)	0.58 (0.17)	< 0.001
Metafrontier Technical Efficiency (TE*)	0.45 (0.12)	0.39 (0.16)	0.71 (0.12)	0.53 (0.16)	< 0.001

^(**) figures in parenthesis are standard deviations

Figure 1: Graphical representation of the performance of cocoa sector in West and Central Africa.



5. Conclusion

In this paper, we apply a recently developed metafrontier function technique to investigate productivity potentials and efficiencies in cocoa production in West and Central Africa. Since technology is a representation of the state of knowledge pertaining to the transformation of agricultural inputs into output, we conceptualise the existence of an over-arching technology referred to as the metatechnology, which is represented by the metafrontier production function. The methodology enables the estimation of national technology gap ratios by using a decomposition result involving both the national production frontiers and the (regional) metaproduction frontier. Empirical results are derived using a comprehensive dataset collected during one of the larger surveys of cocoa farmers in four West and Central African countries, namely Cameroon, Ghana, Nigeria, and Cote d'Ivoire.

Separate stochastic frontier models are estimated for farmers in these countries, along with a stochastic metaproduction frontier to obtain alternative estimates for the technical efficiencies of farmers in the different states. The results of the analysis show large productivity potential gaps between countries of the region in relation to cocoa production. The gaps range between 0.70 and 0.96. These values can be interpreted as the technological gap faced by the cocoa sector in those countries when their performances are compared with the regional level. Cocoa sector in Cameroon had the lowest technology gap, while that of Nigeria had the highest. In terms of production efficiency, Nigeria's cocoa sector has the highest mean technical efficiency relative to the national frontier and also to the regional frontier. Ghana appears as the least performing region. The data used in this study support the view that technical efficiency score is globally quite low and technology gap plays an important part in explaining the ability of the cocoa sector in one country to compete with cocoa sectors in other regions in West and Central Africa (Nkamleu 2004b).

From a policy standpoint, the results of this study have important implications for policy targeting. The fact that cocoa farmers are not realising the full potential of the system indicates that there is need for sustained improvements on performance. This will require enhanced roles by the public sector and international agencies in research and extension activities to significantly raise technical efficiency. New technologies are sometimes introduced in the rural sector without ensuring that farmers are exploiting their full potential. A promising possibility may be to train farmers in production programs so that they gain knowledge in crop management and new technology.

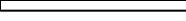
The study makes it possible to identify the type of interventions each country needs to enhance cocoa production. In some countries, such as Cameroon, the priority target should be to raise technology (to close the gap between the regional frontier curve and the global frontier curve). In Cote d'Ivoire and Nigeria, the urgency is on improving the know-how of farmers. The level of technology in those countries is quite good, but the extent of their exploitation is poor. Knowing what the right inputs are, how to combine them, and when to use them, are as important as using more inputs.

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