The Determinants Of the Technical Efficiency of Cotton Farmers in Northern Cameroon

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THE DETERMINANTS OF THE TECHNICAL EFFICIENCY OF COTTON FARMERS IN NORTHERN CAMEROON

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Abstract

This paper, seeks to evaluate the technical efficiency of cotton farms in the northern part of Cameroon through the use of a parametric production frontier. The evaluation approach used is a stochastic type which shows that in spite of the fact that cotton yields in Cameroon are amongst the highest in sub-Saharan Africa, efficiency indexes are still as low as 60% in average. Having had a diagnosis overview aimed at identifying the determinant of technical efficiency with the use of a regression function, the main findings show that the characteristics of the producer as well as environmental factors all influence technical efficiency.

Key Words: technical efficiency, cotton farms, northern Cameroon.

Résumé

Dans ce travail, on évalue l'efficacité technique des exploitations cotonnières du Nord Cameroun en se servant d'une frontière paramétrique de production. La méthode d'évaluation utilisée est de type stochastique et permet de constater que malgré que les rendements du coton au Cameroun sont un des plus élevés en Afrique subsaharienne, les indices d'efficacité techniques restent très faibles, 60% en moyenne. Après avoir mené un diagnostic cherchant à identifier les déterminants de l'efficience technique à l'aide d'une fonction de régression, les principaux résultats auxquels on aboutit sont que, les attributs liés au chef de l'unité de production et les facteurs environnementaux influencent l'efficacité technique des producteurs.

Mots clés : efficience technique, exploitations cotonnières, nord Cameroun.

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1. INTRODUCTION

The production of cotton is carried out in the three northern provinces of Cameroon. It is the main activity and source of income for more than 356 thousand producers corresponding to one third of the population of the region. It is also the means of subsistence of more than a million people. These producers face strong competition from European and American producers. For most observers, this competition is made tough by the different protectionisms implemented in these Countries. Considering the importance of the cotton sector and the fierce competition facing them, African producers in general and Cameroonian ones in particular embarked on a protest movement against the protectionism of American and European markets. In return, there is nothing that guarantees that the lifting of the trade barriers would reinforce sustainably the competitiveness of this sector which depends on many factors. To ensure the sustainability of the cotton sector in Africa, it is also important to analyze under which conditions this sector can withstand foreign competition if trade barriers were lifted in these foreign markets.

In the assessment of the competitiveness of the cotton sub-sector in Cameroon, one of the approaches frequently used is based on the Cost of Internal Resources (CIR) coefficient that depends on the market prices of inputs and outputs which are exogenous to the producers. Economic growth performance is not reducible to the markets (Lesueur and Plane, 1997), it also depends on organizational efficiency, the capacity to innovate and especially on the capacity of the production units to mobilize minimal quantities of factors for the realization of a given quantity of production.

Moreover, production in general and more precisely the output per hectare is the most used performance indicator in agricultural production units. In the agricultural sector it is a very important ratio but for the fact it is a partial indicator of productivity, linking output to a single factor, Levêque et al. (2004). Agricultural production and more precisely that of cotton makes use of a set of factors used simultaneously in the production process in such a way that the productivity of a given factor can be improved by one or more other factors. In the production of cotton for example, the output per hectare or the productivity of the factor land can be improved by an increased used of fertilizers, pesticides, and/or labor. Also, the proportion of factors used for the production of cotton varies from one producer to another, as well as the socioeconomic and ecological environment in which the producers operate. As such, cotton production units are not a priori comparable if we take into consideration the diverse conditions under which they operate and the constraints that they face. All these environmental factors interact on the total productivity of factors. If the partial productivity ratio has the advantage of being easy to calculate and interpret, its weakness lies in its fragile and disaggregate nature which does not take into consideration control variables, this usually lead decision makers into approximations. In any case therefore, partial ratios of productivity remain insufficient to appreciate the degree of rationality of a farmer. However, in microeconomic theory a technically rational agent is expected to produce the maximum possible output with a given level of technology and inputs.

The global productivity index in order to palliate the weaknesses of partial indicators is based on a system of weighting either using prices or the share of factors in total cost. Though these indexes provide a global measure of the production process, they are however very sensitive to the weighting coefficients used. At times, certain factors due to their nature can contribute to the production of a good without being exchangeable in a market and therefore not having a price. The international comparison of the performances of production units using global productivity indexes computed using prices as weights is another limitation even if these prices are estimated in purchasing power parity.

One of the ways to know to which extend a cotton farmer is capable of producing the maximum level of output with a given level of technology and inputs available to him is to consider his technical efficiency and its determinants using the frontier technique. This is what is what we propose to do focusing particularly on the role of agro ecological factors and socioeconomic characteristics (family attributes) on technical efficiency. The choice of technical efficiency indexes does not in any way marginalize partial ratio analysis. To achieve our aim, this paper is organized as follows: the first section presented the introduction, the second deals with the methodology of the study, results and discussions are presented in the third section and the fourth section concludes and gives some recommendations.

2. METHODOLOGY OF THE STUDY

2.1. Presentation of the study area

One cannot pretend to carry out a study on agricultural problems in their production aspects without having knowledge of the environment in which the peasants operate and its probable effects on production. Also, one can measure the pertinence of actions to undertake only in a well determined environment (Madi, 1994).

This being, cotton in Cameroon is cultivated in its three Northern provinces; Extreme North, North and Adamawa. The production of cotton is carried out under the supervision of the Société de Développement du Coton (SODECOTON) created in 1974 by the Cameroon government. More than 60% of cotton is produced in the North province where climatic conditions and soil characteristics are more favorable for its cultivation, as such one registers outputs ranging from 1400 to 1500 kg per ha in the North and Adamawa against only 1200kg per ha in the Extreme North.

SODECOTON has been highly involved in many development projects since its creation, notably the North-East Bénoué development project which included among others the construction of roads, schools, hospitals, industrialization, commercialization, follow up of farmers, just to name this few. Besides, SODECOTON contributed to the displacement of 120 thousand people by spontaneous migration from the overpopulated Extreme North to the relatively less populated North with land more appropriate for cotton cultivation. This increased the demographic pressure in the North-East part of the North province brought along a beginning of land scarcity problems

The North and Extreme North provinces are zones of extensive and intensive agriculture, producing food crops (cereals, vegetables, etc) and cash crops for exportation, notably cotton. The rate of soil occupation by cotton is higher in the North meanwhile the cereal –cotton conflict is more noticed in the Extreme North. The agricultural cycle begins with the first rains (March-June) and last three and six months in the Extreme North and North provinces respectively and ends in December-January.

The impact of the SODECOTON project is not negligible as only the spreading of harnessed cultivation and/or ameliorated seeds or the use of chemical treatment products and fertilizers are generalized in the production of cotton, even though they remains weak. Production units are essentially family owned and the organization of production remains traditional.

Plowing is done by animal traction for those who have and also manually. Weeding is reserved for women and children and occasionally hired labor.

2.2. Sampling, Data and construction of the frontier.

2.2.1. Sampling and Data

The study uses mainly primary data that was collected with the help of a questionnaire that was administered for a four month period during the 2004 season. This data was collected in the northern provinces of Cameroon which is the only zone of cotton production of the country. Considering previous studies that have been carried out in this zone and information collected from SODECOTON field agents, investigations were carried out in one stage after a one month period of impregnation. The choice of production units to be studied was done by stratification.

The first strata consisted in the choice of provinces. This led to the choice of two provinces: the North and Extreme North, main producers of cotton. The choice of provinces done, five production zones were retained in the two provinces. These zones were selected based on their shares in the total production of cotton. These zones were: South-East Benoue Zone, Garoua Zone, Dakoula Zone in the North province; the KOZA zone and Zamay zone in the Extreme North. After choosing the zones, it was the turn of villages in each zone. Zones with a large number of producers would therefore provide the highest number of villages. Once the choice of villages was done, production units were then selected randomly on the basis of the list of producers that was provided by SODECOTON.

At the end of the survey, 202 units of production were questioned in 20 villages. Information was on production, surface area of fields, quantity of inputs used, capital endowments, socioeconomic characteristics of the production units, etc.

2.2.2. Construction of the frontier

There are many methods for constructing the frontier. Berger and Humphrey survey principally five different techniques: 2 non parametric approaches; the Data Envelopment Approach (DEA) and the Free Disposal Hull (FDH) and 3 parametric approaches; the Stochastic Frontier Approach (SFA), the Distribution Free Approach (DFA) and the Thick Frontier Approach (TFA). We opted for the parametric approach and precisely the SFA because it is based on a conventional economic theory of production (Dudu, 2006) considering a pre-established functional relation (Murillo-Zamorano, 2004) between a product and a set of production factors. Besides, our preoccupation is at the level of productive performance of a good, in contrast with the non parametric method (notably the DEA method) that does not take into consideration the possible measurement errors found in the data and seems appropriate for situations of technological complexities(multi products/multi factors).

Finally, we justify the choice by considering that there exist on the one hand factors that are out of the control of enterprises which affect their productive performance, and on the other hand omitted explanatory variables grouped under usual symmetrical hazards.

The production frontier stochastic model whose variables are presented in Table 1 permits the construction of the frontier and to determine the elasticities of production in the program Frontier 4.1. (Coelli, 1994) from the following equation (see detailed presentation in the box in appendix)

$$\text{Log}Y_i = \beta_0 + \beta_1 \log(\text{land}) + \beta_2 \log(\text{labor}) + \beta_3 \log(\text{capital}) + \beta_4 (\text{soil}) + V_i - U_i.$$

The procedure of estimation is the following: the β parameters are first estimated using the maximum likelihood method. These estimators allow the determination of γ by sweeping process. Next, the scores of technical efficiency estimated by the relation:

TEi = exp (-Ui) = exp ($-Z_i$ δ- W_i) and gotten from the estimation of the previous frontier are used as a vector of dependent variable in the relation

$\mathbf{U_i} = \delta 0 + \delta_1$ (experience) + δ_2 (age) + δ_3 (animal traction) + δ_4 (population density) + δ_5 (project).

This relationship is used to estimate the parameters δ_i by the Tobit method in order to take care of the truncated nature of the endogenous variable between 0 and 1.

Table 1: Variables of the model and specifications

Variables	Specifications	Units of measure
Production	Quantity of cotton produced per farmer	Kg
surface area	Land area used for cotton	Ha
Labor	Amount of labor used	Daily manpower
Capital	Amount of capital used in the farm being inputs (fertilizers, pesticides, seeds, fungicides) and the value of depreciation of all materials used (plower, tracting animal, truck, etc.)	in CFA francs estimated using deflated price
Soils	Type de soils, that is, easy root penetration and water retention, binary variable	1= deep soil 0= shallow soil
Experience	Experience of the producer	year
Age	Age of producer	year
Animal traction		1= practices animal traction 0= does not practice animal traction
Population density	Population density, binary variable	1 = high population density ($\geq$ 100 hbts/km2) 0 = low population density (<100 hbts/km2)
Project	Farm land situated in an extension zone of development projects, binary variable	1 = if land is in a project zone 0 = if far mis not in project zone.

Source: Aothors

3. RESULTS AND DISCUSSIONS

3.1. Some socioeconomic characteristics of cotton production units.

Table 2 shows that average output is estimated at 826.56 kg for an average cotton farmland surface of 0.625 ha. This corresponds to an output of about 1320 kg per ha. This output is close to that obtained from SODECOTON statistics. Cotton production units use on the average 2,361 daily manpower and an average capital evaluated at 95207.85 constant CFA francs.

The average age of the farmers is 40 years 4 months for an average years of experience estimated at 17 years 18 days.

65% of production units work on deep clay soil while only 60 % use animal traction. A non negligible fraction of production units, about 60% produce cotton and one other good with or without practicing fallowing.

Table 2: Description of variables

variables	nomber	Mean	Standard deviation	minimum	maximum
Production	202	0.826	2.516	0.100	10.500
land	202	0.626	1.413	0.25	7.000
labor	202	2.361	1.751	1	11
Capital	202	95207.85	141574.01	3300	1747004
Experience	202	17.05	10.73	0	22
Age	202	40.12	12.37	23	76
Soils	202	64.35	Na	0	1
Animal traction	202	60.40	Na	0	1
Population density	202	58.91	Na	0	1
Project	202	50,13	Na	0	1

Na= not applicable
Source: Authors from 2004 survey data.

3.2. Elasticities of cotton production

Elasticities of production define in what proportion production would change if the quantity of a factor on which it depend changes by 1%. This being Table 3 presents the different coefficients obtained using a production function of the Cobb-Douglas type.

The mobilization of the survey results reveals the stochastic nature of the production frontiers if we trust the likelihood test ratio which is significant at a level of 1%. Also, the parameter γ of value 0.902 shows that the contribution of technical efficiency in observed total variation between frontier production and the actual production of the producers are very high.

Table 3: Determinants of the production of cotton

Variables	Coefficients	t values
Constance	3,41000	16,300***
land	0,00082	7,310***
Labor	0,9260	26,001***
Capital	0,00078	6,101***
Soils	0,07120	1,040
LR	- 147,0	23,8***
δ^2	0,645	7.223***
Υ	0,902	23.862***

***, **, * = significant at 1 %, 5%, 10 % levels respectively

Source: *Authors from 2004 survey data.*

The estimation of the parameters also show that all factors of production (land, labor, capital, soils) significantly and positively contribute to the growth of production as shown in table 3. A comparative analysis of the elasticities of production reveals that the coefficients of land and capital factors are the least. This can be explained by the fact that land pressure and the situation of competition between cotton, maize, sorghum, reduce the amount of land (on average 0.626 ha) available for cotton production and this implies the intensification of the cultivation system only through labor.

Capital intensity remains weak or limited because the inputs provided by SODECOTON are limited and proportional to surface area of the cotton farm without taking into consideration the adverse effects of fertilizers and pesticides and diversion of these inputs to other uses. Moreover, producers due to their low revenues and savings are unable to buy modern inputs from the market and so are dependent on input credits granted by SODECOTON. This vulnerability of the production of cotton has been shown by Madi (1994).

The variable type of soil though having a positive coefficient higher than those of the variables land and capital is less significant and as such put to doubt the effect of this factor on production. This result is pertinent as it has been obtained in an area where soil characteristics are no supposed to favor the production of cotton.

The results obtained from the frontier analysis made it possible to estimate technical efficiency indexes which vary from 11% to 91%. On average, cotton producers only produce 60.203% of what they could produce with their factor endowments.

Table 4: Distribution of technical efficiency indexes

Efficience indexes (in %)	Nomber	Percentage	Cumul
≤ 25	10	4,95%	4,95
25 < efficacité ≤ 50	50	24,75%	29,70
50 < efficacité ≤ 75	88	43,60%	73,30
Efficacité > 75	54	26,70	100
Total	**202**	**100**	**60,203**

Source: Authors from 2004 survey data.

Table 4 shows that about 30% of cotton producers have technical efficiency indexes less than or equal to 50%, meanwhile less than 74% have efficiency indexes less than 75%. Also, a large number of producers (88) have technical efficiency indexes between 50 and 75%.

The calculated low technical efficiency entails a loss of 40% of production. It is therefore important to identify the causes and to propose corrective measures.

3.3. Factors liable to influence technical efficiency.

The results obtained so far calls only for reflection and do not guide on corrective measures than can be taken. To be able to do this, the identification of some explanatory factors was undertaken using a Tobit statistical adjustment.

The main objective of running a regression based on efficiency indexes is to identify and appreciate the contribution of each of the indentified factors to the level of efficiency attained.

The analysis shows that, family attributes (experience of the farmer, his age and the practice of animal traction) and environmental factors (population density and the effect of development projects) play a non negligible role on the technical efficiency of cotton producers.

As concerns family attributes, the sign and coefficients are both in conformity with expectations. Nevertheless, the impact of the practice of animal traction on technical efficiency of production units is questionable as its coefficient is statistically not significant.

Table 5: Factors explaining technical efficiency

Variables	**Coefficients**	**t- values**
Constance	27,06	1,36*
Experience	1,05	1,65**
Age	- 0,84	-1,43*
Animal traction	2,81	0,27
Population Density	27,30	2,44***
Project	20,20	1,98**
Technical follow-up	-0,10	-0,11
Sigma	65,54 (19,90)***	
Log de vraisemblance	-1109,12	
N	198	

*****, **, * = significant at 1 %, 5%, 10 % levels respectively**

Source: *Authors from 2004 survey data.*

The results in Table 5 indicate that the more the producer gains age, the less technically efficient he becomes. This is in line with the results obtained by Audibert (1997) in Mali. Know-how obtained through experience increases technical efficiency. However, the coefficient of age is less statistically significant. The absence of a correlation between age and experience was established contrary to the results obtained by Audibert (1997), this justifies why this variable was jointly used with the variable age.

For environmental factors, the results were positive and significant as concerns population density. This confirms the results obtained by Nkendah et al (2001) on plantain cultivation in West Cameroon and is in line with the Hypothesis of Boserup (1970). It should however be noted that the intensification of production due to demographic pressures which lead to high population density can be done only through labor. But the demographic pressure which leads to technological development (Boserup, 1970) should have been obtained more through capital intensification (use of fertilizers and improved species, etc.) than with labor such that the reduction of available farmland should be compensated by an increase in the quantity of inputs used in order to stabilize or increase production.

The fact that a cotton farm is situated in an area covered by a development project influences technical efficiency since its coefficient is positive and significant. The development projects initiated in the 1950s in the framework of the five years development plans consisted among others of: the modernization of production through the introduction of new species of cotton, displace and resettle cotton producers on lands suitable for cotton production, construction of social infrastructures (schools, health centers), construction and maintenance of rural roads, creation and irrigation of production farms so as to fight against food insecurity, fight against illiteracy, etc. Even though these projects have positive effects, it is worth noting that the technical assistance offered farmers (proxied by number of visits of SODECOTON field workers to producers) seems not to affect the level of technical efficiency of the producers since its coefficient is not statistically significant.

4. CONCLUSION AND RECCOMENDATIONS

The production technical frontiers have revealed that the returns of factors of production remain relatively very weak. Again, cotton is constantly competing with other products such as sorghum, millet, and maize particularly in the Extreme North province where added to the land pressure which is highest there, makes that intensification is done using less capital (notably inputs) for cotton which makes the other crops to benefit from inputs and after effects. The same remark had already been made by Nkendah and al. (2001) on plantain production in West Cameroon. From this result we notice that the false increase in cotton output witnessed for some years now is insufficient with respect to potentials. The average technical efficiency of 60.23% is weak on our opinion and this brings out the weaknesses of performance evaluation based on partial productivity ratios.

We were able to note that the determinants of the technical efficiency of cotton producers are of two types: environmental factors and attributes of the farm head. Environmental factors are related to the localization of the farm, notably in areas covered by development projects and population density. As such, cotton producers would have been more technically efficient if there was a continuation of agricultural land development policies in the framework of integrated development projects.

This study also revealed that technical efficiency increases with population density and mostly through intensification in labor rather than capital.
Concerning the attributes of the farm head, his age has been confirmed to reduce the technical efficiency of the farm. Meanwhile, know –how acquired through experience increases technical efficiency.

Other than factors linked to the characteristics of the farm head, we notice that the practice of animal traction has a doubtful effect on technical efficiency. Policies aimed at the vulgarization of the practice of animal traction seem not to be yet beneficial to the producer. SODECOTON has been following this path for more than two decades now, but efforts seem to be insufficient as we noticed that only 60% of the farmers owned at least a plow.

At the end of this study, some few areas of future research emerge:
First, variables considered as determinants of technical efficiency are insufficient and make us believe that other factors affect this efficiency. The data mobilized in this study did not allow us to consider them. We think among others of the effect of formal and informal education, credit, social and family cohesion, policy changes, etc.

Secondly, the study uses cross sectional data. This did not permit us to appreciation the evolution of technical efficiency in time and as such the probable effects of technological change. A study based on panel data will reveal more on the effects of a change in technical and political changes (structural adjustment, devaluation, etc.) on technical efficiency. Studies of this type have already been carried out in Mali by Audibert (1994) on subsistence cultivation, by DUDU (2005) on agricultural households in Turkey. Recently, Agbodji (2006) analyzed the productive performance of the manufacturing sector in Togo using the non cylindered panel data method of estimating a stochastic production frontier, just to name a few.

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APPENDIX : Estimation procedure of model parameters

Log Yi = $\beta_0 + \sum_{n=1}^{N} \beta_n$ Log $Xit + Vi - Ui$, **(1)** is a log linearised Cobb Douglas production function, in this function,

- Y_{it} Cotton production of the i[th] farmer expressed in Kg per ha.

- X_{it} is the vector of $(n = 1,2,3)$ inputs used by the farmer and made up of: farm surface area in ha, labor, capital and soil type.

- β_n is the vector of unknown parameters associated with factor Xn to be estimated.

- the V_{it} are random errors of distribution $N\left(0, \delta^2 \sqrt{x}\right)$ also known as white noise (iid)

- U_t, independent of random errors are the parameters of technical efficiency.

By hypothesis, the follow a non negative distribution, truncated at 0, and mean $M_i = Z_i . \delta_n$.

No theoretical model permits till now to select a priori any variance distribution δ^{2_u} specified by the function:

$$U_i = Z_{it}\ \delta + W_{it} \qquad \textbf{(2)}$$

In equation (2),

- Z_{it} is a (1x m) vector of explanatory variables associated to the technical efficiency of farms made up of: the use of a plow, age of farmer, experience of farmer, multi activity rate, démographic pressure and level of rainfall.

- δ is a (Mx1) vector of unknown parameters

- W_i is the residual.

This being, the model to be estimated is the following:

$\mathrm{Log}Y_i = \beta_0 + \beta_1 \log(\mathrm{land}) + \beta_2 \log(\mathrm{labor}) + \beta_3 \log(\mathrm{capital}) + \beta_4 (\mathrm{soil}) + V_i - U_i$ **(3),** for the production frontier.

The technical efficiency index of the farmer is determined by the following relation **(4)**

TEi = exp (-Ui) = exp $(-Z_i\ \delta - W_i)$, error terms are supposed independent from each other and the inputs, it is possible to estimate the equation by the maximum likelihood method ? the parameters associated with Ui and Vi being $\delta^2 = \delta_u^{2} + \delta_v^2$ and $\gamma = \delta_u / \delta_u^{2} + \delta_v^2$

The effects of technical efficiency are determined by the following relation:

U_i = $\delta_0 + \delta_1$ (experience) + δ_2 (age) + δ_3 (animal traction) + δ_4 (population density) + δ_5 (project) (5)