

Technical Efficiency of Maize Production in the Centre Region of Cameroon: A Data Envelopment Analysis (DEA)

Joseph Serge Evouna Mbarga[1] Joël Sotamenou[2] Martin Paul Jr.Tabe-Ojong[1,3*] Ernest L. Molua[4]
1. Centre for Independent Development Research, Buea, Cameroon
2. Faculty of Social and Management Sciences, University of Yaoundé II, Cameroon
3.Institute for Food and Resource Economics, University of Bonn, 53119 Bonn, Germany
4.Faculty of Agriculture and Veterinary Medicine, University of Buea, Cameroon, P.O. Box 63 Buea, Cameroon

Abstract
Increasing agricultural productivity and efficiency in production continues to be the cornerstone of most farming systems. Most policy makers rely on such studies as it offers the pathway to agricultural growth and economic development. This research is aimed to evaluate the technical efficiency of maize farmers in the Lekie division of the Centre region of Cameroon. We employ the two staged DEA technique where we computed the technical efficiency (TE) of the various farms in the first stage based on both the constant returns to scale and the variable returns to scale. In the second stage, we used the censored dependent Tobit model to capture the determinants of technical efficiency. Mean TE indices of 0.67 and 0.95 are gotten for farmers at the constant returns to scale and variable returns to scale respectively. This indicates that there still exist potentials to increase the TE of farms in the research area. The study also recorded a scale efficiency of 0.70. Regressing the various efficiency indices on household and farm characteristics, we found educational level, counselling services, participation in a peasant organization, acreage cultivated and age of household head to significantly increase TE. Marital status and credits rather had an inverse effect on TE. From the findings, policy implication should inclusively rest on building the educational capacity of the farmers be it through on-farm demonstrations, seminars, trainings or grouping of the farmers into clubs and associations.
Keywords: Efficiency, Productivity, data envelopment analysis, maize, Cameroon.

1. Introduction

The cultivation of crops and rearing of livestock continues to be a driving sector for most developing nations because of its provision of food, livelihood and employment (Tabe-Ojong & Molua, 2017). Faced with a steady population growth, the agricultural sector is expected to double its efforts so as to meet the food demands of this rising population. However, food production is rather decreasing in most developing nations especially in Sub-Saharan Africa. Estimates from the Global Agricultural productivity report indicates that at current rates of total factor productivity (TFP) growth, sub-Saharan Africa (SSA) will meet only 8 percent of its food demands through productivity. This is almost 50 percent lower than the 2014 projection of 15 percent, a troublesome trend (GHI, 2017). This gap between food production and population increase, if not addressed, will lead to a plethora of issues like high food prices, starvation and increased environmental burdens through deforestation. It will also lead to economic and social standstill as opined by Nkamleu *et al*. (2003).

Recently, there have been numerous policy debates on the various measures necessary to turn around tables and obtain increased productivity in agriculture as well as food production. As purported by GHI (2017), improving productivity and the level of efficiency in farm production are the necessary pathways to increased food production. Improving productivity and promoting yield growth in the agricultural sector, especially amongst smallholder farmers continues to be a necessary step in achieving economic development (Poudel *et al*., 2015). Productivity growth is achieved either from the efficient use of existing resources or the adoption of novel technologies/techniques in agriculture.

In Cameroon, agriculture has over the years been a major employment sector employing about 70 percent of its available working population, contributing 42 percent to its Gross domestic Product (GDP) and serving the purposes of food as well as feed to livestock (World Bank report, 2014). The country produces several agricultural products for local and international markets and remains one of the world's major producers of certain foodstuffs, including cocoa, coffee, banana and palm oil products.

However, agriculture is still very labour intensive and still operates at the ‘second generation level’ unlike in developed nations like Germany which are capital intensive and operate on the ‘fourth generational level’. The farming systems are also very heterogeneous with the majority of farmers still operating at the subsistence level. Classified 13th producer in Africa, Cameroon is also witnessing an uncertain level of progress in maize production, despite the shortage registered in 2011(MINADER, 2012). Maize is a major staple crop in Cameroon and grown by most farm families. It also a traditional delicacy for most ethnic groups as they either consumes it in the form of food or drink. As a form of food, it can be eaten as porridge with beans, roasted, boiled and even transformed to maize powder to obtain a corn-paste locally referred as ‘fufu’. It is also traditionally fermented and used for drinking purposes especially in rural areas. Brewery companies also make use of it in the manufacture of beers. Livestock owners also use it as feed for their animals. Because of these numerous uses, attention is gradually shifting from cultivation for food purposes to cultivation for cash.

Maize has experienced significant growth in the last five decades. As shown in figure 1, for the period 1961-2016, there was an annual average of 743,579 tons of maize produced in the country. The highest value of production of 2,164,003 tons was recorded in 2016, and the lowest 309,752 tons was obtained in 1985. Maize production and supply from 1976 to 1994 shows a “sawtooth” evolution. Before 2000, the national production was on average 460,133 tons of maize per year. From 2001 to 2008, it was 1,061,918tons per year. Since 2008, there has been a strong annual increase in maize production. This performance may be explained by the Government's national policy initiated since 2008 with emphasis on input subsidies for fertilizers, improved seeds, equipment and regular counselling and advisory support to farmers.

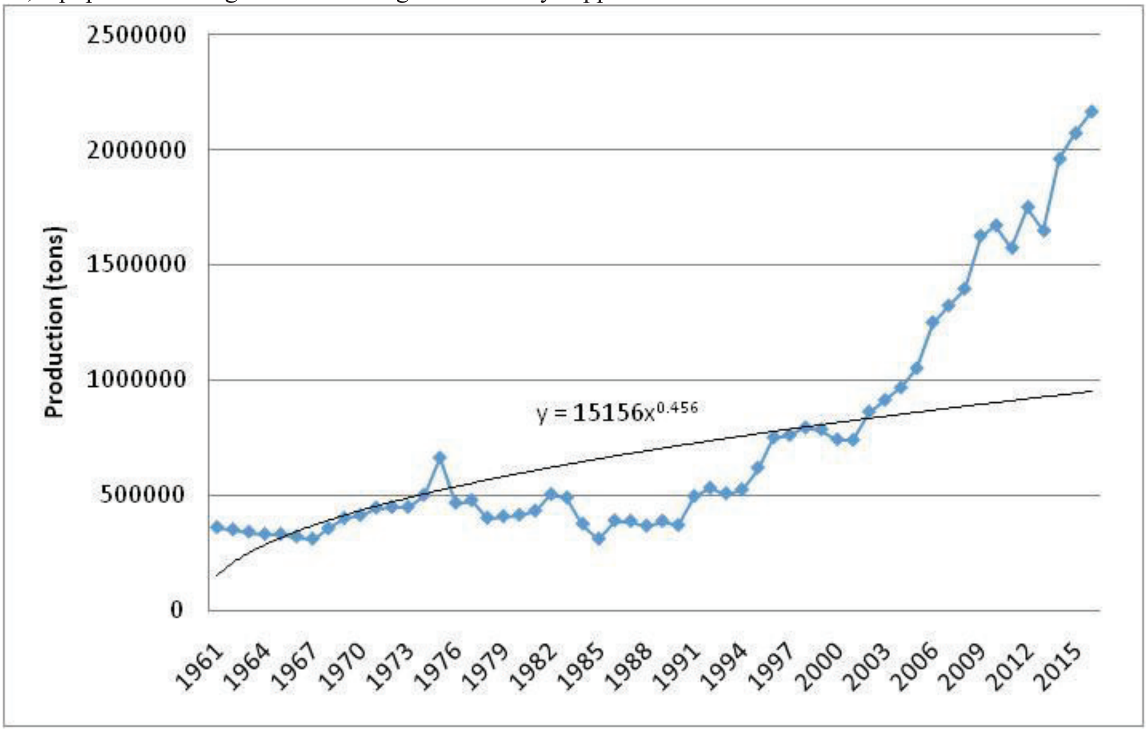

Figure 1: Maize production in Cameroon, 1961 - 2016 (Computed from FAOSTAT)

The government of Cameroon in a bid to increase production and commercialize agriculture has partnered with both national and international organizations like the German International Corporation (GIZ) and organized farm demonstrations, extension visits, seminar and trainings like the ‘farmer field school’ and the ‘farmer business schools’. They have also set up policies meant to encourage and expand the export level and adding value to farm products through processing (Achancho 2013).

Since subsistence farmers are often plagued with imperfect and asymmetric information, they usually incur high efficiency costs resulting from their high inefficiency level (Sadoulet & de Janvry, 1995). The performance of farms have always been evaluated through the use of the concept of economic efficiency (Poudel *et al*., 2015). Economic efficiency refers to the ability of a firm or producing unit to produce a maximum set of outputs with the lowest cost combinations. It encompasses both technical and allocative efficiencies, though it is more fundamental to use technical efficiency as it stresses the efficient use of scarce resources. Technical efficiency is defined as the ability of a firm or producing unit to produce more with the same set of inputs and an available technology or producing the same output with lesser combination of inputs.

Technical efficiency studies have stood tall amongst productivity and efficiency analysis, possibly because it is more relevant for policy development and policy making. The literature on technical efficiency is both thick and mixed with studies using different methodologies. For Cameroon, the literature is still emerging with studies profiling the technical efficiency of both food crop and staple crop farms. Most of these studies made use of the parametric stochastic frontier approach (Akamin et al., 2017; Binam et al., 2005; Neba et al., 2010; Tabe-Ojong & Molua, 2017). Very few studies have used the non-parametric, Data Envelopment Analysis (Kane et al., 2012; Nkamleu et al. 2003) despite its known benefits.

This study therefore adds to empirical literature by specifically contributing to the modelling of technical efficiency using the DEA and implicitly controlling for institution variables like education and membership in clubs and associations. Furthermore, unlike most previous studies which only employed a one stage efficiency measurement (Mango et al., 2015; Okoye et al., 2016; Shiferaw & Gebremedhin, 2015), this study used the two staged DEA method where a censored dependent model like the Tobit model is used to regress the efficiency indices obtained in the first stage on some specific household and farm characteristics.

The goal of the current study is to evaluate the technical efficiency of maize farmers in the Centre region of Cameroon. To achieve this, the article is structured as follows: A brief literature review on technical efficiency of smallholder farms is presented in section 2 and directly followed with an overview of the approaches used in evaluating technical efficiency with much analysis being placed on the DEA method. The results are then presented in section 4 with some discussions and section 5 provides the conclusion. The findings are relevant to a broad audience ranging from the government, policy makers, farmers and to researchers.

2. Materials and Methods

2.1 Theoretical Conceptualisation

The performance of farms in the world and in Cameroon has also been the subject of numerous studies. These studies mostly focused on analysing the technical efficiency of smallholder farmers to aid policy development. In the context of Cameroon, the literature on this is thin, though it is presently emerging. Based on different research objectives and data sources, authors have conveniently used both the Stochastic Frontier Approach (SFA) as well as the Data Envelopment Approach (DEA).

Nkamleu et al (2003) employed the DEA method on a 28 year period panel data of ten sub-Saharan African countries, including Cameroon. They also analysed the Malmquist indexes of total factor productivity (TFP) and observed a steady decline in the TFP. Their analyses point to the fact that productivity is more dependent on technological change than on technical efficiency (TE). Additionally, they found french colonized countries like Cameroon, Mali, Burkina Faso, Ivory coast and Senegal to experience higher productivity growth than English colonized countries like Zimbabwe, Ghana, Nigeria, Zambia and Uganda. Based on the agglomerated and intuitive results, many authors have set out to identify the driving factors of productivity and efficiency on a more specific country basis. Taking the lead, Binam et al.(2005) analysed the technical efficiency of peanut and maize farmers in Cameroon employing the two staged stochastic frontier analysis method. Using a modest sample of 450 farmers, the authors divided the farmers into three groups of farmers who cultivated only groundnuts, maize and farmers who intercropped groundnuts with maize. They then reported technical efficiency levels of78%, 80% and 77%, respectively for the three different systems. The authors point out that output growth can be obtained by improving the agricultural practices of the farmers. For their analysis, education and participation in farmer clubs or associations stood very tall. They therefore urged policymakers to concentrate on building the capacity of farmers by developing and implementing formal farmer clubs and groups.

Evaluating the technical efficiency of cotton farms in the semi-arid zones of Cameroon, and motivated by the intensity of cotton production in the area, Neba et al.(2010) employed parametric efficiency calculation and obtained an efficiency index of 60%. The input output relationship depicted the basic farm inputs of land, labour and capital to positively drive the production of cotton. Unlike in other empirical studies which found age to positively influence technical efficiency, these authors found the opposite, though farmer experience positively impacted efficiency.

In a bid to improve the literature on the use of the non-parametric DEA, Kane et al.(2012) evaluated the production efficiency of groundnut and maize farms in the South region of Cameroon. Applying a two staged DEA method with the use of both the variable and constant returns to scale, mean technical efficiency percentages of 44.6 and 67.8 were obtained under constant returns to scale and variable returns to scale respectively. For the Tobit model, advancement in age and membership in rural organizations were observed to improve the efficiency of farmers. From this they propose policy creates an enabling environment for farmers to effectively group themselves and enjoy the benefits of cooperating.

More recently, Akamin et al.(2017), evaluated the efficiency of vegetable farms in the humid tropics of Cameroon. With data from selected parts of the North West region of the country, the authors applied the statistical stochastic frontier approach and observed farmers to have an average efficiency level of 67%. In terms of inputs, farmyard manure was observed to be very productive as well as farm equipments. Also, female farmers depicted better TE attributes than their male counterparts. The availability of labour also showed the expected positive influence on TE. The authors concluded that access to the above mentioned farm inputs will drive vegetation production and productivity in Cameroon. In the same vein, but paying specific attention to tomatoes, Tabe-Ojong and Molua (2017) modelled the efficiency of smallholder tomato farms in the Buea area of the South west region of Cameroon. Inspired by the intensity of tomato production in the area but with limited productivity and efficiency analysis, these authors went ahead and found that farms in the area have a mean technical efficiency of 68%. Production function analysis showed the relevance of area of cultivation and adoption of improved seeds on the output level. The educational level as well as the age of the household head had a positive impact on technical efficiency while distance to an extension agent decreased the level of technical efficiency, most probably because farmers avoid walking long distances just to see extension agents. The authors concluded by stressing that policy should press on extension agents as they can significantly drive productivity and efficiency.

2.2 Study Area and Data Sources

Data for this study is obtained from maize farmers in the Lekie division of the Centre region of Cameroon. This division lies roughly between Latitude: 4º 12′N and Longitude: 11º 24′E. Lekie is an agricultural divisionin the Centre region, with an area of 2,989 km^2 and producing a lot of cocoa (*Theobroma cacao*). It accounts for 60 to 70% of the food sold in the market of the capital, Yaoundé. Three production zones are identified according to the importance of the agricultural practice: the subdivision of Evoudoula, Obala and Batchenga. Each production area was identified based on their representativeness in partnership with the producer organizations and services of the Ministry of Agriculture, in particular the Program for the Improvement of Agro pastoral Family Farms Competitiveness (IAPFFC). The criteria used to select these areas are the agro-climatic conditions (soil type, precipitation level and natural vegetation) and socio-demographic conditions. In the absence of a recent agricultural census, sampling of the farms surveyed is carried out randomly from the lists of farmers available from producer organizations and IAPFFC. Sampling allows us to randomly select one hundred and five (105) producers in three (3) areas in the Lekie division. This sampling took place in two stages: the choice of area and the choice of producers to investigate in the area.

2.3 Analytical Framework and Empirical Modelling

Since the pioneering work of Farrell (1957) on TE, two approaches have been used in estimating TE, the Stochastic Frontier Approach (SFA) and the Data Envelopment Analysis (DEA). Because of the pros and cons of the different approaches, different authors have applied them differently based on their perceived ability in handling their research objectives. The SFA is a parametric approach that offers econometric approaches in the measurement of efficiency (Aigner et al., 1977; Meeusen and Van Broeck, 1977 while the DEA is a non-parametric technique which uses mathematical programming methods to derive efficiency (Charnes et al., 1978).

The SFA offers a good hypothesis tests for the structure of production and the extent of inefficiency, thereby tackling stochastic disturbances. To do this, it specifies a particular functional form and explicitly assumes a distribution for the inefficiency component. Its main limitation stems from the fact that the functional form must be correctly specified for valid inferences (Iliyasu et al., 2014).DEA on the other hand requires no determination of a production function and measures efficiency with respect to the highest observed performance as opposed to an average (Odeck, 2007). More so, it does not require an assumption for the efficiency component. For this study, we employ the DEA because of its deterministic nature and its assumption that all deviations from the frontier is as a result of inefficiencies.

This is a non-parametric estimation method for measuring efficiency. It makes use of mathematical programming techniques to estimate efficiency and inefficiency from an observed data. The DEA has been successfully used in the fields of operation research and production economics in assessing efficiency (Odeck, 2007). We use an input oriented data envelopment analysis in a model which assumes constant return to scale (CRS). As opined by Coelli et al. (1998), the CRS assumption holds only for farms which operate on an optimal scale. However, very few farms operate under this assumption. This is the motivation for the variable returns to scale (VRS) brought forth by Banker et al. (1984). We therefore follow Boubacar et al (2016) in using the DEA employing the CRS and VRS. We seek to attain an optimal production level by minimizing the use of inputs. The mathematical problem can thus be represented as:

$Max\ u, v(\frac{u'y_i}{v'x_i})$, $u\ and\ v$ are vectors of the weights of output and input respectively (1)

Subject to $u'y_j \ / \ v'x_j \ \leq 1$, where $j = 1,2,3 \ldots . I$ (2)

$u\ and\ v \geq 0$ (3)

The above specification implies a ratio formulation which results to many infinite solutions. To address this issue, we assume that $v'x_i = 1$, thus we now have

$Max\ u, v(u'y_i)$ (4)

Subject to $v'x_i = 1$ (5)

$u'y_j - v'x_j \ \leq 1$, where $j = 1,2,3 \ldots . I$ (6)

$u\ and\ v \geq 0$ (7)

If we introduce the linear programming duality, we obtain an equivalent class represented by

$Min_{\theta,}\lambda^{\theta}$ (8)

Subject to

$-y_i + Y\lambda \geq 0,$ (9)

$\theta X_i - X_i \geq 0,$ (10)

$Y\lambda \geq 0$ (11)

Where λ is the multiplier (vector of I*1), θ is the TEcrs of i^{th} farms. When $\theta = 1,$ the farm is operating on the production curve and thus described as technically efficient. On the other hand, if $\theta < 1$, the firm is described as technically inefficient.

The methodology follows a two stage wherein the DEA is employed to profile the TE of maize producers in the use of inputs and a Tobit model used to verify the impacts of farm specific and other variables like education, household size, age and gender on technical efficiency. The Tobit model is used since our efficiency scores are censored dependent and have values between 0 and 1. The major advantage of using the two stage DEA methods stems from the premise that environmental factors and other shocks which are uncounted for in the standard DEA will be captured in the residual variance obtained from the Tobit model.

The Tobit model was developed by Tobin(1958), and it is a corner solution model. Most other corner solution models are extensions of it. Tobit type models or better still censored regression models are used when the outcome variable is censored, that is observations are accumulated at the limits of the range of the variable. Usually, these observations are accumulated at the minimum with the lower limit being zero, making the censoring at zero. It is represented as

$$y_{it}^* = x_{it} + \varepsilon_{it} \quad (12)$$

$\varepsilon_{it} \sim N(0, \sigma^2)$ where y_{it}^* is the latent variable representing the TE level of the household at a time, t. TE assumes a linear function of various covariates in the vector x_{it}, and a normally distributed error term (Engel and Moffatt, 2014).

The application of Tobit regression in this study is specified as:

$$Y_i = \beta_0 + \beta_1 Age + \beta_2 Edu + \beta_3 Marital + \beta_4 Counselling + \beta_5 Area + \beta_6 Po + \beta_7 Cred + \varepsilon_i \quad (13)$$

Where Y_i is the efficiency index, β are the parameter estimates with the rest of the variables described in table 1 below.

Table 1: Definition of variables

SN	Variables	Definition	Measure
1	Efficiency	Technical Efficiency	Continuous
2	Age	Age of the household head	Continuous
3	Level of Education	Level of education	Continuous
4	Marital status	Marital status of the farmer	Binary
5	Counselling support	Counselling Support in agriculture	Binary (1=Yes ; 0=No)
6	Area	Area cultivated by farmer	Continuous
7	Po	Adherence to a peasant organization	Binary (1=Yes ; 0=No)
8	Credit	Access to credit	Binary (1=Yes ; 0=No)

Source: Author's computation based on survey data, 2016

3. Result and Discussion

3.1. Production profile of maize farmers

On average, a sampled family farm produced 225.458 kg of maize (Table 2). However, there is a great disparity between the households, which is justified by the minimum and maximum values of production, which are 200 kg and 300 kg respectively. This may be related to the variability in the allocation of household resources. For the cropping system studied, the average cultivated area is 2 hectares, and half of the sampled households produced only for self-consumption. There is also a great disparity in the usage of seeds with minimum and maximum values of 2 kg and 5 kg respectively.

Labour inputs have an average of 2.74 man-days per household. This indicates that on average, households spend almost three working days in the cultivation of maize and other crops. Furthermore, very few households make use of agricultural machinery. This is clearly indicated in the amount spent on purchasing these equipments. This is in line with results obtained by Tabe-Ojong & Molua (2017) who reported that farming in Cameroon is still very primitive with the use of rudimentary tools and techniques of production.

Table 2: Descriptive Statistics of some covariates

SN	Description	N	Mean	SD	Minimum	Maximum
1	Maize production (kg) per ha	105	225,458	139,7738	200	300
2	Area under maize (ha)	105	2,30	1,082	1	4
3	Seed (kg)	105	816,4122	241,9435	2	5
4	Labour (man-day)	105	2,74	1,177	1	4
5	Equipments: agricultural machinery (FCFA)	105	3,35	0,554	2	4

Source: Author based on survey data, 2016

3.2. DEA model results

The mean technical efficiency for the 105 maize farms in the sample is 0.677. This clearly indicates that farmers in Lekie division only utilize up to 68% of their potential, indicating a moderate level of technical efficiency of maize farms in the Lekie division. Considering the variable returns to scale, the average level of pure technical efficiency of the maize farmers in the sample is 0.951; implying farmers can decrease their utilization of factors of production by 4.9%, while maintaining the same level of production. Further analysis also shows that 90.2% of the operators in our sample are 100% efficient. Without taking into account the full efficiency scale, this can be explained by the fact that these farmers are members of farmers' organizations. Farmer organizations like cooperatives and other informal groups have been proven to play a vital role in providing knowledge and informal education to its members. This knowledge and skills is what is required in transforming the agricultural sector and increasing productivity. The average technical efficiency of scale for the total sample is 0.707. In other words, the level of efficiency of scale on average is relatively high (70.7%). This suggests that, from the point of view of the technical efficiency of scale, maize farmers in the Lekie division of the Centre region of Cameroon do not suffer from a sub-optimal size.

3.3. Determinants of technical efficiency

The determinants of TE are presented in table 3 below. All the variables are significant and affect TE in one way or the other, either positively or negatively. To begin with, older farmers are observed to have a higher technical efficiency than their younger counterparts. This is due not only to the fact that maize cultivation in the Centre region is mainly reserved for parents. Being in the 41-60 age group increases the probability of being 5.6% effective. This is reasonable as advancement in age implies more social networks. As a result, they get information on novel techniques and technologies in production faster than young farmers. Perhaps experience which also comes as a result of age plays positively in their favour. Odeck (2007) earlier on had a similar result in his analysis on technical efficiency.

Education has a positive influence on the technical efficiency of the farmer. The high significance at 1% indicates that the farmers with at least secondary education are more efficient than the ones having just primary education. Switching to a level of education at least equivalent to the secondary level increases the operator's probability of being 17.57% efficient and 18.15% higher. This result is in line with earlier analysis performed by Haji and Andersson (2006) and Asefa (2011). Education improves the access and processing of information which are very relevant to increase technical efficiency. Unexpectedly, marital status has a negative impact on the likelihood of a farmer being technically efficient. This implies that single farmers have a greater probability of being technically efficient. This can be explained from the time dimension as single families have more time to concentrate on their farming activities.

The coefficient of counselling services has a positive influence on the probability of the household being technically efficient. Counselling is usually offered by extension agents in the form of farm visits, trainings and demonstrations. Counselling could also take place in cooperatives as well as in various farmer clubs and associations. All these services provide information to farmers on novel production techniques and skills necessary to take their production to the next level. Therefore in the face of all these services, farmers are expected to be technically efficient. As in many other efficiency studies, area of cultivation depict a positive relationship with the likelihood of the farmer being efficient. Land being a key input for agricultural production especially for maize cultivation has a role to play in improving farmer's efficiency. The greater the area of cultivation, the more likely is the farmer to be efficient. However, farmland is reducing in the centre region as a result of urbanization. This calls for agricultural intensification so as to enable food production meet the growing population. Michler and Shively(2015) obtained similar results on their analysis on land tenure, land security and efficiency in the Philippines.

Member of a peasant organization has a positive impact on the technical efficiency of a farmer (β = 0.126459) and significant (p = 0.001) at the significance level of 5%. Peasant organizations serve as a medium for exchanges and acts somewhat as a cooperative to prevent the exploitation of farmers by middlemen who usually take advantage of the poor state of farmers. These organizations also offer improved farming inputs like seeds, fertilizers and pesticides to farmers. All these inputs tend to drive the efficiency of farmers upon their usage.

Finally, against theory and *a priori* expectations, credit reduced the probability of a farmer being technically efficient. However, this is in conformity with an earlier analysis on the impacts of improved yam technology on technical efficiency in Ghana by Asante et al.(2014). This can be explained from the fact that farmers who have access to and get more credits usually invest these credits in other off-farm activities other than the farming business. From the theory of specialization, they will invest all their efforts in that off- farm activity especially if it is more profitable. This will definitely reduce the time spent in the farm, hence reducing their technical efficiency.

Table 3: Drivers of Technical Efficiency

Variables	Coefficients	p value	dY/dX
Age	0.002***	0.001	0.009
Education	0.005*	0.056	0.093
Marital status	-0.023**	0.070	-0.335
Counselling Support	0.018**	0.033	0.538
Area of cultivation	0.049**	0.023	0.033
Peasant organization	0.001**	0.016	0.957
Credit	-0.031**	0.016	0.055
Constant	0.265**	0.070	0.000
Sigma	0.115***	0.005	
Prob>chi2	0.003		
LR chi2 (7)	26.51		

Source: Author's computation based on survey data, 2016
Notes: ***,**,* represent significance at the 1%, 5% and 10% respectively

4. Conclusion

This study investigates the TE of maize farmers in the Lekie division of the Centre region of Cameroon. Previous efficiency studies only made use of the parametric and statistical stochastic frontier production approach which makes two assumptions on the functional form as well as the error terms. We therefore bridged this gap and went a step further in the use of the non-parametric technical efficiency approach, Data envelopment analysis (DEA) which allows for numerous inputs and outputs and imposes no assumptions on the functional form. We used a sample of 105 farmers collected through a multistage sampling technique in the Centre region of Cameroon.

We employed a two staged DEA technique where we computed the technical efficiency of the various farms in the first stage based on both the constant returns to scale and the variable returns to scale. In the second stage, we used the censored dependent Tobit model to capture the impacts of various household and farm characteristics on technical efficiency. Mean technical efficiency indices of0.67 and 0.95 were gotten for farmers at the constant returns to scale and variable returns to scale respectively. This indicates that there still exist potentials to increase the technical efficiency of farmers in the study area. The study also recorded a scale efficiency of 0.70. Regressing the various efficiency indices on household and farm characteristics, we obtained very significant and intuitive results.

To this end, we conclude that the level of education, membership in a peasant organization, area of cultivation, age and counselling support in agriculture significantly contribute to explaining the growth in technical efficiency. On the other hand, access to credit and marital status contribute rather in lowering technical efficiency. We therefore recommend policy to develop and build the capacity of farmers. To begin with, more emphasis should be put on specialized trainings and on-farm demonstrations. There should also be regular evaluation to be certain it is meeting its goals of building the capacity of farmers. Secondly, a lot of attention should be given and placed on extension workers as they have the potentials to drive smallholder productivity and efficiency in production. These agents should also be regularly trained so that they can intend hand it out to the farmers.

Furthermore, there should be increased access to land by the farmers. This is very relevant as arable land is rapidly being converted for other livelihood purposes other than agriculture. The Government should set in place laws which enable farmers maintain their existing areas of cultivation if there is no possibility of increasing. Lastly, the government should provide an enabling environment for farmers so that they can group themselves into cooperatives and clubs and enjoy the benefits of networking and sharing ideas. More so, these clubs and associations should be regularly monitored and provided with improved agricultural inputs like seeds and fertilizers.

References

Aigner, D. J., Lovell, C. K., & Schmidt, P. (1977)'Formulation and Estimation of Stochastic Frontier Production Function Models', *Journal of Econometrics*, 6(1), 21-37. https://doi.org/10.1016/0304-4076(77)90052-5

Achancho, V. (2013) 'Review and analysis of national investment strategies and agricultural policies in central Africa: the case of Cameroon', In: *Rebuilding West Africa's Food Potential*, ed. A. Elbehri, 117- 149. Rome: FAO/IFAD.

Akamin, A., Bidogeza, J.-C., Minkoua N, J. R. & Afari-Sefa, V. (2017) 'Efficiency and productivity analysis of vegetable farming within root and tuber-based systems in the humid tropics of Cameroon', *Journal of Integrative Agriculture*, vol. 16, no. 8, pp. 1865–1873.

Asante, B. O., Villano, R. A. and Battese, George, E. (2014) 'The effect of the adoption of yam minisett technology on the technical efficiency of yam farmers in the forest-savanna transition zone of Ghana', *African Journal of Agricultural and Resource Economics*, vol. 9, no. 2, pp. 75–90.

Asefa, S. (2011) *Analysis of technical efficiency of crop producing smallholder farmers in Tigray,Ethiopia.,* Mekelle University.

Binam, J. N., Tonye, J. and Wandji, N. (2005) 'Source of Technical Efficiency among Smallholder Maize and Peanut farmers in the Slash and Burn Agriculture Zone of Cameroon', *Journal of Economic Cooperation*, vol. 26, no. 1, pp. 193–210.

Boubacar, O., Hui-qiu, Z., Rana, M. A. and Ghazanfar, S. (2016) 'Analysis on Technical Efficiency of Rice Farms and Its Influencing Factors in South-western of Niger', *Journal of Northeast Agricultural University (English Edition)*, vol. 23, no. 4, pp. 67–77.

Charnes, A., W. W. Cooper, and E. Rhodes. (1978)'Measuring the efficiency of decision making units', *European Journal of Operational Research* 2:429–444.

Engel, C. and Moffatt, P. G. (2014) 'dhreg, xtdhreg, and bootdhreg: Commands to implement double-hurdle regression', *The Stata Journal*, vol. 14, no. 4, spp. 778–797.

Farrell, M. J. 1957. The measurement of productivity efficiency. Journal of Royal Statistical Society Series A (General) Part 3, 120:253–281

GHI (2017) 'Global Agricultural Productivity Report: A World of Productive Sustainable Agriculture'.

Haji, J. and Andersson, H. (2006) 'Determinants of efficiency of vegetable production in smallholder farms: The case of Ethiopia', *Food Economics - Acta Agriculturae Scandinavica, Section C*, vol. 3, 3-4, pp. 125–137.

Iliyasu, A., Mohamed, Z. A., Ismail, M. M. and Abdullah, A. M. (2014) 'A Meta-Analysis of Technical Efficiency in Aquaculture', *Journal of Applied Aquaculture*, vol. 26, no. 4, pp. 329–339.

Kane, G. Q., Fondo, S. and Oyekale, S. A. (2012) *Efficiency of Groundnuts/ Maize Intercropped Farms in Zoetele, South Cameroon: A Data Envelopement Approach,* Munich Personal RePEc Archive [Online]. Available at https://mpra.ub.uni-muenchen.de/62757/ (Accessed 11 March 2015).

Mango, N., Makate, C., Hanyani-Mlambo, B., Siziba, S., Lundy, M. and Elliott, C. (2015) 'A stochastic frontier analysis of technical efficiency in smallholder maize production in Zimbabwe: The post-fast-track land reform outlook', *Cogent Economics & Finance*, vol. 3, no. 1, p. 21.

Meeusen, W., & van den Broeck, J. (1977)'Efficiency estimation from Cobb-Douglas production functions with composed errors', International Economic Review, 18, 435-444. https://doi.org/10.2307/2525757

Michler, J. D. and Shively, G. E. (2015) 'Land Tenure, Tenure Security and Farm Efficiency: Panel Evidence from the Philippines', *Journal of Agricultural Economics*, vol. 66, no. 1, pp. 155–169.

MINADER, (2012).Directory of projects and programmes of MINADER.von Grebmer K., Saltzman A., Birol E., Wiesmann D., Prasai N., Yohannes Y., Menon P., Thompson J.and Sonntag A. 2014. 2014 Global Hunger Index: The Challenge of Hidden Hunger. Bonn/WashingtonD.C./Dublin: Welthungerhilfe, International Food Policy Research Institute (IFPRI), Concern Worldwide.

Neba, C., Ngassam, S. and Nzomo, J. (2010) *The Determinants of the Technical Efficiency of Cotton Farmers in Northern Cameroon,* Munich Personal RePEc Archive 24814 [Online]. Available at https://mpra.ub.uni-muenchen.de/24814/ (Accessed 7 September 2010).

Nkamleu, G. B., Gokowski, J. and Kazianga, H. 'Explaining the Failure of Agricultural Production in Sub-Saharan Africa', in *25th International Conference of Agricultural Economists, August 16-22, 2003, Durban, South Africa*.

Odeck, J. (2007) 'Measuring technical efficiency and productivity growth: A comparison of SFA and DEA on Norwegian grain production data', *Applied Economics*, vol. 39, no. 20, pp. 2617–2630.

Okoye, B. C., Abass, A., Bachwenkizi, B., Asumugha, G., Alenkhe, B., Ranaivoson, R., Randrianarivelo, R., Rabemanantsoa, N., Ralimanana, I. and Elliott, C. (2016) 'Differentials in technical efficiency among smallholder cassava farmers in Central Madagascar: A Cobb Douglas stochastic frontier production approach', *Cogent Economics & Finance*, vol. 4, no. 1, p. 1143345.

Poudel, K. L., Johnson, T. G., Yamamoto, N., Gautam, S. and Mishra, B. (2015) 'Comparing technical efficiency of organic and conventional coffee farms in rural hill region of Nepal using data envelopment analysis (DEA) approach', *Organic Agriculture*, vol. 5, no. 4, pp. 263–275.

Sadoulet, E. and Janvry, A. de (1995) '*Quantitative Development Policy Analysis*, Baltimore and London', The John Hopkins University Press.

Shiferaw, K. and Gebremedhin, B. B. (2015) *Technical efficiency of small-scale honey producer in Ethiopia: A Stochastic Frontier Analysis,* Internatinal Livestock Research Institute.

Tabe-Ojong, M. P. JR. and Molua, E. L. (2017) 'Technical Efficiency of Smallholder Tomato Production in Semi-Urban Farms in Cameroon: A Stochastic Frontier Production Approach', *Journal of Management and Sustainability*, vol. 7, no. 4, p. 27.

Tobin, J. (1958) 'Estimation of Relationships for Limited Dependent Variables', *Econometrica*, vol. 26, no. 1, pp. 24–36 [Online]. Available at http://links.jstor.org/

World Bank report (2014) 'Cameroon Agriculture Sheet ZDI', Nov. 2014; ADI 2013