Vol.34, No.2, pp.118-133, 2022

Journal of Agricultural, Life and Environmental Sciences

RESEARCH ARTICLE

pISSN 2233-8322, eISSN 2508-870X
https://doi.org/10.22698/jales.20220013

Analysis of the Technical Efficiency of Potato Farmers in Mezam Division of the Northwest Region of Cameroon

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Received: 20 January 2022
Revised: 26 April 2022
Accepted: 28 April 2022

ABSTRACT

Potato is among the main cash and staple foods in Cameroon that has witnessed significant increase over the last decade. However, potato production in Cameroon lags behind that of other African countries such as Nigeria, Ethiopia, and Egypt. Therefore, this study aimed to examine the technical efficiency of potato farmers in Santa and Kumbo sub division in the North-West Region of Cameroon. Data for this study were collected from potato farmers using multistage sampling technique and subjected to a stochastic frontier production function. The result showed that potato farmers have a mean technical efficiency of 0.62. This suggests that potato production can be significantly increased through improved and efficient use of resources. Credit access and farmers' age were found to significantly influence the technical efficiency of potato farmers. As credit access improves the technical efficiency of potato farmers, it is important for the government to subsidize microfinance institutions to provide credit to farmers.

Keywords: Mezam division, Potato production, Stochastic frontier analysis (SFA), Technical efficiency, Translog production function

Introduction

Agriculture contributes to development as an economic activity, as a livelihood, and as a provider of environmental services, making the sector a unique instrument for sustainable development. Therefore, agriculture-based countries, such as sub−Saharan Africa requires productivity in smallholder farming (WDR, 2008). According to rural development report (WDR, 2008), around one billion people in the world rely on agriculture to eradicate poverty and undernourishment especially in rural areas. Owing to this, the Millennium development goals (MDGs) of eradicating poverty will not be achieved without improvement in the growth and productivity of agriculture (IEG, 2011). The agenda of improving agriculture productivity is in line with the 2th UN Sustainable Development Goal which conceptualizes the end of hunger, achievement of food security and improved nutrition, and promotion of sustainable agriculture by 2030 (Sustainable Development Goals, 2022). According to rural development report

(WDR, 2008), improving productivity and sustainability of small farmers' entails, improve access to assets (fertilizer, pesticides, water, land and human capital) and access to finance. Moreover, the environmental impact of agricultural production can be minimized through efficient use of production resources (Alem, 2021).

Agriculture is the mainstay of Cameroon's economy, engaging approximately 70 percent of the economically active population. This sector also contributes approximately 80 percent of the country's gross domestic product (WWF, 2005). By its mere size, the agricultural sector is critical for development, at least in the medium term (IEG, 2011). However, agricultural output is increasing at a decreasing rate when compared to population growth (FAO, 2020). As such, increasing smallholder farmers' productivity and technical efficiency may facilitate agricultural development and provide environmental services (sequestering carbon, managing water sheds, and preserving biodiversity) in countries like Cameroon where small-scale production predominates. Therefore, improving the productivity and efficiency of agricultural input is the first step towards sustainable agriculture.

Potato production in Cameroon

Potato is considered an important crop in Cameroon. It is ranked fifth behind major staple crops (cassava, plantain, cocoyam/taro, and maize). A country where 60 percent of its population are farmers, potato has fast become a cash crop in Cameroon. Maturing within three to four months, it has offered a quick return on investment in land and labor. Approximately 200,000 farmers are involved in the cultivation of potato in Cameroon (Harahagazwe, 2018). The cultivation of potato is mostly carried out by smallholders who are predominately women. It is cultivated on an intensive small-scale within the six regions of Cameroon. Among these six regions, north west and west region are the most predominate which accounts for approximately 80 percent of the production (Investir au Cameroon, 2021). Both regions are located on the western highlands of Cameroon, which is characterized by cool temperature and high rainfall making it suitable for potato farming. Most of the potato produced in Cameroon is either consumed locally (that is, in the form of boiled, pounded, chips or porridge) or exported to neighboring countries (Tchio et al., 2020). Over the last decade, national potato production has increased from approximately 200,000 tons in 2011 to approximately 400,000 tons in 2020 (Knoema Statistics, 2020). This increase has been attributed to the availability of domestic and international markets and technical efficiency of smallholder potatoes farmers in Cameroon (Mengui et al., 2019). Cameroon export approximately 17% of potato to sub regional countries like Congo, Equatorial Guinea, Central African Republic, and Gabon (Mengui et al., 2019). The export of potatoes also serves as an important source of foreign exchange earnings.

Although Cameroon has a suitable climate (cool temperature and high rainfall) and an available market for potatoes production, the importation of potato has double from 4 percent in 2009 to 8 percent in 2019 (FAO, 2020). In addition, despite increase in potato productivity, the annual production of approximately (400,000) is quite low when compared to a million metric tons in other African countries like Nigeria, Egypt and Ethiopia (FAO, 2020). The low potato productivity could be associated with; the production technique, efficiency of the farming method, available institutions and markets, and other management and environment-related factors.

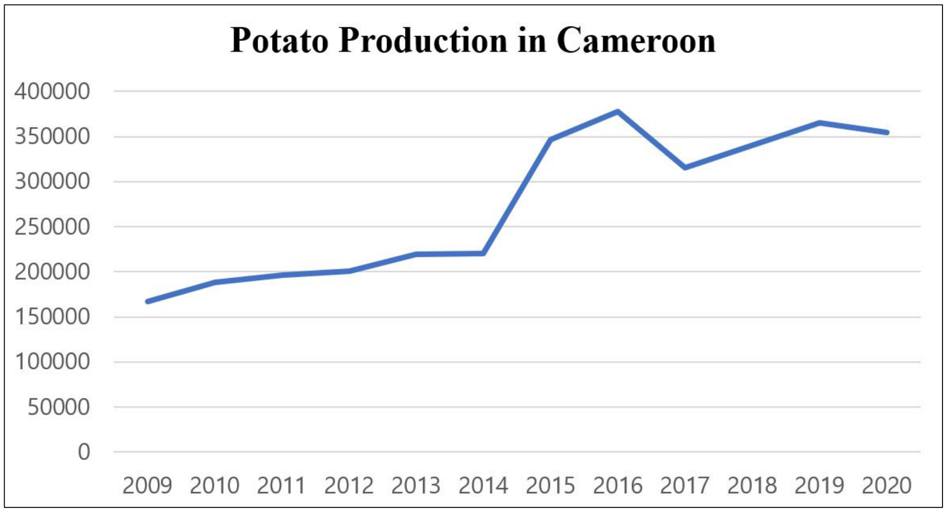

Fig. 1. Trend of Potatoes yield in Cameroon.

Fig. 1, portrays a trajectory increase in potato production in Cameroon from 2009 to 2019. This trend confirms that total production yield has increased tremendously over the past years, indicating a substantial increase in production.

Literature Review

Based on Fig. 1, there has been significant increase in the production of potato in Cameroon which is attributed to farmers' technical efficiency and improved varieties (Bihnchang et al., 2017; Mengui et al., 2019). According to Karimov (2014) efficient use of input resources is fundamental in optimizing farm productivity. Therefore, efficient agricultural production is usually determined by rational use of input resource (Karimov and NiÇo-Zarazffla, 2015). Adhering to this view, most studies relating to potato production in Cameroon have focused more on the agronomic aspect (Fontem et al., 1999; Deffo and Demo, 2003; Mbouobda et al., 2014; Anoumaa et al., 2016; Desiré et al., 2018). Notwithstanding, there are few studies that have shed light on the efficient use of resources in potato production in Cameroon (Harahagazwe, 2018; Mengui et al., 2019; FiBL, 2019). According to Mengui et al. (2019), in order to improve potato output, farmers should acquire appropriate training, extension services and have access to credit. A similar study that was carried out in Santa sub-division of Cameroon, (Akamin et al., 2017) showed that educated vegetable farmers were significantly efficient in potato production than their counterparts. The author further explained that farm inputs such as land, manure, labor, and physical capital are responsible for the increase in vegetable productivity. Likewise, Harahagazwe (2018) and FiBL (2019) emphasize that the application of inputs such as fertilizer, manures coupled with training approach will enhance the production of potato.

Different researchers have deputized how the above factors influence technical efficiency and productivity of different agricultural product. These studies attribute demographic, socio-economic, institution and environment as key factors that influence technical efficiency and productivity among different farmers (Nchare, 2007; Kane et al., 2012; Mukete et al., 2018; Mbarga et al., 2018). Relatedly, Djomo and Sikod (2012) evaluates how human capital affects agricultural productivity in Cameroon. Using SFA, they found out that farmer's educational qualification and experience significantly influence agricultural productivity. Similarly, Mukete et al. (2018), analyzed the technical efficiency of small cocoa farmers in South West region of Cameroon using a stochastic frontier model. From their analysis, they observed that access to credit and extension services significantly influenced technical efficiency of cocoa farmers. In the same way, Tabe-Ojong and Molua (2017) analyze the factors that affects technical efficiency of smallholder tomato production in semi-urban farms in Cameroon, and found that educational level and age have a positive impact on technical efficiency.

Technical efficiency studies have stood tall amongst efficiency and productivity analysis, possibly because it is important for policy making and development. The literature on agricultural productivity is both thick and mixed with different methodologies. The two main methods used in measuring and evaluating the performance of an agricultural system are: the parametric approach (stochastic frontier analysis) and the non-parametric approach, such as data envelopment analysis (DEA) (Lien et al., 2018). In both methods, the basis for performance measurement is the radial contraction or expansion connecting inefficient observed points with the reference points on the production frontier. The choice of estimation method has been an issue of debate and each approach has its advantages and disadvantages (Battese and Coelli, 1995; Kumbhakar et al., 2015)

In the case of Cameroon, there are few studies that have analyze crop production using technical efficiency (Binam et al., 2004; Djomo and Sikod, 2012; Akamin et al., 2017; Mukete et al., 2018; Mbarga et al., 2018; Mengui et al., 2019; Orelien, 2021). Predominant among the limitations of the existing studies is the difference in econometric model, food crop and study area which account for differences in research findings. For example, (Akamin et al., 2017; Mbarga et al., 2018; FiBL, 2019) focus on analyzing the technical efficiency of vegetable, maize and cocoa production respectively. To analyze technical efficiency of potato farmers and other farm crops, (Kane et al., 2012; Mbarga et al., 2018; Mengui et al., 2019) used the DEA model. The DEA model has the power to accommodate multiple outputs and inputs in technical efficiency analysis but fails to take into consideration the possible impact of random shocks like measurement error and other types of noise in the data since the measurement error is ignored (Djomo and Sikod, 2012; Tabe-Ojong and Molua, 2017). In addition, many studies (Djomo and Sikod, 2012; Akamin et al., 2017; Mengui et al., 2019) have used a Cobb Douglas production function to analyze technical efficiency. However, the Cobb Douglas production function assumes constant returns to scale which is not an actuality (Murthy, 2002). Also, Cobb Douglas production assumes a perfect competition in the factor and product market which is unrealistic (Umar et al., 2017). The Cobb Douglas production is criticized for its inflexibility (Murthy, 2002). Flexibility of functional form allows data the opportunity to provide information about critical parameter (Lau, 1986).

For example, in the previous research (Mengui et al., 2019), focused their research on one sub division which is Santa sub division. The fact that, the authors of this previous study considered only one sub-division within the Mezam division reduces the relevance of their findings for policy purpose. To fill this gap, this current research is geared at using a SFA and a translog functional form to analyze technical efficiency of potato farmers in Santa and Kumbo sub division in Mezam division of the North-West region of Cameroon. Santa and Kumbo sub division are the two main sub divisions of the Mezam division in North-West region of Cameroon that are renown for producing potato in huge quantities (Fontem et al., 2004; Strateges, 2021). The use of SFA takes into consideration random disturbance which represent favorable and unfavorable shocks such as luck, climate, topography, and machine performance (Aigner et al., 1977; Meeusen and Broeck, 1977).

Materials and Methods

Analytical Framework

There are two methods that are widely used in the literature to estimate technical efficiency. The first method is the DEA which uses a nonparametric approach that is useful for multiple inputs and multiple output production technologies. The second method is an econometric approach which aims to develop SFA based on the deterministic parameter frontier of (Aigner and Chu, 1968). The SFA has the ability to separate the effects of noise from the effects of inefficiency and confound the effects of misspecification of functional form with inefficiency, but generates good results only for single output and multiple inputs. On the contrary, the DEA approach is not stochastic and not parametric, as such it cannot separate the effects of noise and inefficiency during the calculation of technical efficiency (Kebede, 2001). However, the DEA is useful when applied to farms with multiple-inputs and multiple-output production.

Since potato production is an example of a single output and multiple input production, this study focuses on the stochastic frontier production function to estimate the technical efficiency of potato farmers. Efficiency of a production system means a comparison between observed and optimal values of its output and inputs. The comparison can take the form of the ratio of observed to maximum potential output obtainable from the given inputs. In this regard, optimum is defined in terms of production possibilities, and technical efficiency. A farmer is said to be technically inefficient if very little output is produced from a given level of inputs (Battese and Coelli, 1995)

The theoretical definition of a production function has been based on expressing the maximum amount of output obtainable from given input bundles with fixed technology (Battese and Corra, 1977). Following the work of Farrell (1957), serious consideration has been given to the possibility of estimating the frontier production functions. The idea of a frontier function can be illustrated with a farm using n inputs (X_1, X_2, X_3, $\cdots$, X_n) to produce output Y. efficient transformation of inputs into output is characterized by the production function f(X_i) which shows the maximum output obtainable from a various input vector. The stochastic frontier production function assumes the presence of technical inefficiency of production. Hence the function is defined by

$$Y_i = f(X_i, \beta) + \varepsilon_i \; i = 1, 2, \; \dots, n$$

Where Y_i is output of the ith farm, X represent the inputs use on the farm. β are the production coefficients, ε is the composite error term ($v_i - u_i$). The term v_i is a two-sided random error which represents the stochastic effects outside the farmer's control (e.g., weather, natural disasters, and luck), while u_i is a one-sided efficiency component that represents the technical inefficiency of the farm. This model is such that the possible production Y_i is bounded above by the stochastic quantity, $f(X_i, \beta) + v_i$, hence the term stochastic frontier. The random error v_i is assumed to be independently and identically distributed as $N(0, \sigma_v^2)$ random variables independent of the u_i which are assumed to be non-negative truncations of the $N(0, \sigma^2)$ distribution. The components of the error terms are guided by different assumptions about their distribution. The assumption of u_i can be half-normal, exponential (Binam et al., 2004; Kumbhakar et al., 2015). The distribution assumption used in this study is that of (Kumbhakar et al., 1991; Reifschneider and Stevenson, 1991; Huang and Liu, 1994; Battese and Coelli, 1995).

Materials

Study area and Data

This study was carried out in Santa sub division and Kumbo Sub-division of the Mezam division in North-West Region of Cameroon. Located in the western highlands of Cameroon, Santa sub division is bordered to the North by Bamenda I sub-division, to the West by Bali and Batibo Sub-Divisions, to the South by Wabane, Babadjou and Mbouda and to the East by Galim. It lies some 20 kilometers from Bamenda and 40 kilometers from Bafoussam which are the headquarters of the respective North-West and West regions of Cameroon. The close proximity of these headquarters (Bamenda and Bafoussam) to Santa sub-division offers a rich opportunity in terms of an available market for the farmers. While Kumbo Sub-division is regarded as the leading producer of potatoes in Central Africa sub-region (Strateges, 2021). These Sub-divisions were chosen because they are major agricultural production basin, which specializes in market gardening and potato production (Fontem et al., 2004; Strateges, 2021). In this study area, the researchers observed that some of the farmers cultivate for home consumption, while majority (80 percent) of the farmers cultivate for commercial purpose (Piabuo et al., 2020)

A structural questionnaire was used to carry out a survey at the rural household level. The rural households of Santa and Kumbo sub division was selected as target group for this study. A multistage sampling technique was used to select representative rural farmers for the study. The first step involved selecting Santa and Kumbo sub division from the seven divisions within northwest region of Cameroon. The second stage involved a simple random selection of two villages within Santa and Kumbo sub-division (Santa and Nzeen village). Finally, from these villages, 120 simple random selections were carried out, making a total of 120 respondents.

The households of these selected sub divisions are known for practicing agricultural (potato, cocoyam, plantain) and non-agricultural activities (trade, transport services, vocational trade). The market days of these sub division are mostly Saturdays and Sundays of each week. The authors of this papers interviewed farmers at their market sheds, farms and in their houses. The collection of the data took a period of 5 weeks, and a total of 120 households were interviewed.

Before the survey, the questionnaire was designed and pre-tested on 10 non-sampled households. After the pretest, the questionnaires were modified to fit the scope of the study. The research surveyed targeted mainly household farmers who specialized in potato farming.

Model Specification

The stochastic frontier production function methodology is used to describe potato production by rural farmers, using the yield translog frontier model. The yield translog frontier model is appropriate in farm level analysis because of its flexible functional form (Ajibefun et al., 2006). The yield translog frontier describes the production of potatoes farmer as such:

$$In\,Y_i = \beta_0 + \sum_{j=1}^{5}\beta_1 X_{ji} + \sum_{j\leq}^{5}\sum_{k=1}^{5}\beta_{jk}X_{jk}X_{ki} + V_i - U_i \tag{1}$$

Where the subscript i represents the ith sample farm; Y denotes the logarithm of the production output of the farm; X_1 represents the logarithm of the quantity of manure applied in (kilograms); X_2 represents the logarithm of potato seeds used in kilograms; X_3 represents the logarithm of farm size measured in hectare; X_4 represents the logarithm of the quantity of fertilizer used in kilogram; X_5 represents the logarithm of labor in man-days.

V_i are random variables that capture the effects on the unspecified explanatory variables, namely, measurement error, random shocks and other statistical “noise”, and are assumed to be independent and identically distributed as $N(0, \sigma_v^2)$; U_i is the inefficiency measurement, assumed to be non-negative truncation (at zero) of the normal distribution with mean, μ_i and variance, σ^2, where μ_i is defined by

$$\mu_i = \delta_0 + \delta_1 Z_1 + \delta_2 Z_2 + \delta_3 Z_3 + \delta_4 Z_4 \tag{2}$$

Where Z_1, Z_2, Z_3, and Z_4 represent the farmer’s age, credit access, education of farmers and sub division respectively. The variables, farmer’s age, credit access, education of farmers and sub division are included in the model for technical inefficiency to indicate possible effects of farmer’s characteristics on the efficiency of production.

Using STATA 13.0, the parameters of the stochastic frontier model in equation (1) and (2) are estimated using a one-step approach proposed by (Karimov, 2014).

The hypothesis tests, involving parameters of the stochastic production frontier are conducted using the generalized likelihood-ratio test. Therefore, the following hypothesis were tested in this study using a likelihood ratio test.

Hypothesis 1.	$H_0 : \beta_{jk} = 0,\ j \le k = 1,\ 2,\ \ldots,\ 5$. specifies that the Cobb-Douglas frontier model is an adequate representation of the model. The Cobb-Douglas functional form is a restricted form of the translog model in which the second-order terms in the model are restricted to be zero.
Hypothesis 2.	$H_0 : \delta_1 = \delta_2 = \delta_3 = \delta_4 = 0$. The null hypothesis specifies that farmers' specific characteristics in the inefficient model are zero. This means that the explanatory variables in the inefficient model have no influence on the level of technical efficiency of the farmers.
Hypothesis 3	$H_0 : \gamma = 0$. This hypothesis specifies that inefficiency effects in the production function are absent, as such, the data is better analyzed using the traditional average production function.

Results

Summary Statistics

Table 1 contains descriptive statistics of the variables used in this study. This includes the mean, standard deviation, minimum and maximum values of each of the variables. Land size ranges between 0.1 to 3.0 for Santa sub-division and 0.1 to 6.0 for Kumbo sub-division. This implies that most farmers grew potatoes on small-scale locally. The output of potato ranged from 2 bags (100kg per bag) to 115 bags in Santa sub-division and from 8 bags to 86 bags in kumbo sub-division. The average quantity of seed used in Santa sub-division and Kumbo subdivision is 293 kg and 432 kg respectively. The mean labor used by farmers in Santa sub-division is approximately twice the amount use in Kumbo sub-division.

Regarding the socio-economic aspect of the farmers, the average age of the farmers in Kumbo sub-division is higher than those in Santa sub-division. The mean school year attained by the farmers in both sub-divisions are approximately the same. Meaning averagely, farmers from both sub-divisions achieved secondary education.

Table 1. Summary of statistics of variables of respondent farmers

Variables	Unit of measurement	Farmers in Santa sub-division				Farmers in Kumbo sub-division			
		Mean	Std. Dev	Min	Max	Mean	Std. Dev	Min	Max
Production inputs and output									
Yield of Potatoes	Bags (1 bag = 100kilograms) (kg)	28.41	24.41	2	115	34.71	20.51	8	86
Potatoes seed	Kilograms (kg)	293.24	253.85	60	1200	432.73	408.24	25	1500
Fertilizer	Kilograms (kg)	316.08	431.31	13	2100	236.42	194.74	25	900
Labor	Man days	8.64	4.79	2	23	10.68	4.22	4.38	23
Farm Size	Hectares	0.31	0.35	.1	3.00	0.169	0.130	.1	.6
Manure	Kilograms (kg)	537.44	552.71	50	2400	791.43	668.24	120	300
Socio economic variables									
Farmer's age	Years	31.5	7.79	20	53	37.38	9.86	24	68
Credit access	Dummy	0.44	0.50	0	1	.67	.48	0	1
Farmer's education	Years in school	10.96	4.35	0	17	10.07	4.05	0	17

Hypothesis Tests, Model Selection, and Maximum Likelihood Estimates

The null hypothesis and the corresponding value are presented in Table 2. The first null hypothesis, $H_0 : \beta_{jk} = 0$, $j \leq k = 1, 2, \cdots, 5$, which identifies the Cobb-Douglas frontier model as the correct model of the data is strongly rejected. This implies that the data are better analyze using a translog frontier model. The second hypothesis $H_0 : \delta_1 = \delta_2 = \delta_3 = \delta_4 = 0$ which states that the chosen explanatory variables in the inefficiency model have no effect on technical efficiency is also rejected. Hence, the four explanatory variables in the inefficiency model significantly contribute in explaining the inefficiency effects associated with the output. Lastly, the null hypothesis, $H_0 : \gamma = 0$ which states that inefficiency effects in the production function are absent, is rejected. This implies that technical inefficiency exists in potatoes production.

Table 3 presents the maximum likelihood estimates of the parameters in the translog stochastic function. The individual coefficients of the explanatory variables are not directly interpretable. The coefficient of the gamma ratio γ in the stochastic frontier production function is 71% and is significant at 5% level. This indicates that, technical inefficiency effects are highly significant in the analysis of the data.

Elasticities and Return to Scale

The production elasticities indicate the percentage change in output relative to the percentage change in the ith level of inputs, assuming all inputs are held constant. The elasticity of the mean output with respect to inputs are derived from the parameters of the maximum likelihood estimates of the stochastic production function. Mathematical calculation of the mean elasticity output of the translog stochastic production frontier model is provided by (Ajibefun et al., 2002). The computation of the elasticity result is presented in Table 4. While fertilizer has the highest elasticity, (.57), Farm size has the least elasticity ($-$.202). Given the constant return to scale specification of the estimate function, the elasticity of fertilizer is .576, meaning that the output of potato will increase by 57 percent for every percentage increase in fertilizer. This implies that potatoes farmers could increase their output if they increase the application of fertilizer on their farms. On the other hand, the elasticity of farm size is $-$.202. This implies that the output of potato farmers will decrease by 20 percent for every percentage increase in farm size. Omotilewa et al. (2021), explained the negative relationship between farm size and productivity by pointing out that family labor is used on small farms and hired labor is used on large farms. This might be clarified by means of incentive economics: the motivation for more productive work is higher for family members than for

Table 2. Likelihood ratio tests of hypotheses for parameters of the stochastic frontier production function

Null hypothesis	Statistic test λ	Critical Value	Decision
$H_0 : \beta_{jk} = 0,\ j \leq k = 1, 2, \ \ldots, 5$	54.80	24.38**	Reject
$H_0 : \delta_1 = \delta_2 = \delta_3 = \delta_4 = 0$	81.23	13.40**	Reject
$H_0 : \gamma = 0$	171.78	5.18**	Reject

Note: The values are obtained from Table 1 of Kodde and Palm (1986) which gives critical values for tests of null hypotheses.
**statistically significant at 5% level.

Table 3. Maximum likelihood estimates of parameters of Translog form of Stochastic production function

Variables	Parameters	Translog frontier production model
	Frontier Function	
Constant	β_0	2.680(1.268)*
Manure	β_1	.325(.388)
Seed	β_2	.392(.459)
Farm size	β_3	−.884(.303)**
Fertilizer	β_4	.685(309)*
Labor	β_5	−1.016(.604)
Manure × Manure	β_{11}	.009(.047)
Seed × Seed	β_{22}	−.012(.094)
Farm size × Farm size	β_{33}	−.019(.047)
Fertilizer × Fertilizer	β_{44}	−.077(.060)
Labor × Labor	β_{55}	.027(.120)
Manure × Seed	β_{12}	−.217(.137)
Manure × Farm size	β_{13}	.014(.070)
Manure × Fertilizer	β_{14}	.027(.073)
Manure × Labor	β_{15}	.358(.146)*
Seed × Farm size	β_{23}	.141(.076)*
Seed × Fertilizer	β_{24}	.309(.109)**
Seed × Labor	β_{25}	−.130(.161)
Farm size × Fertilizer	β_{34}	−.006(.055)
Farm size × Labor	β_{35}	−.082(.104)
Fertilizer × Labor	β_{45}	−.105(.100)
	Inefficiency effects	
Constant	δ_0	2.037(.252)***
Farmer's age	δ_1	−.040(.006)***
Credit access	δ_2	−.309(.072)***
Farmer's education	δ_3	.003(.009)
District	δ_4	.075(.070)
	Variance parameters	
Sigma square	σ_μ^2	.051(.022)**
Gamma ratio	γ	.719(.251)**
Log-likelihood	ll	−2.32

Note: ***significant at 1%, **significant at 5%, *significant at 10%

Table 4. Elasticities of mean output of Translog stochastic production function

Variables	Elasticity of mean output
Manure	.052(.284)
Seed	.082(.507)
Farm size	−.202(.064)**
Fertilizer	.576(.310)*
Labor	.079(.244)

Note: **significant at 5%, *significant at 10%

hired workers. This explanation is also supported in works of (Griffin et al., 2002; Benjamin and Brandt, 2002). In another study, the negative relation between agricultural output and farm size was attributed to diseconomies of scale (Cornia, 1985).

The Inefficiency Model

The inefficiency results of this study are presented in Table 3. The coefficients show the direction of the effect by the variables in the model. From the results, farmers age and credit access have a negative effect on technical inefficiency, indicating that these variables are important in improving farmers' technical efficiency. The coefficient of farmer's age is significantly negative, implying that the older farmers are less inefficient than the younger farmers. In other word, this result implies that older farmers are more technical efficient than younger farmers. This result can be explained base on the experience of older farmers, and their ability to adapt to novel techniques and technologies than younger farmers. This finding is in line with previous study conducted by (Orelien, 2021). The coefficient of credit access is negative and statistically significant. This implies that access to credit allows farmers to acquire quality inputs (seeds, fertilizer, machinery) to increase potato productivity. This finding is in compliance with (Nchare, 2007; Mengui et al., 2019; Morais et al., 2021) where credit access was found to improve farmers' technical efficiency in Cameroon. The marginal coefficient of farmer's age and credit access have a negative effect on farmers' technical inefficiency (see Table 5)

Table 6 shows frequency distribution of technical efficiency of potato farmers. The result indicates that technical

Table 5. Marginal effect of the socio-economic variables of farmers

Variables	Marginal effects
Farmer's age	−.034
Credit access	−.261
Farmer's education	.002
District	.064

Table 6. Frequency distribution of technical efficiency of potatoes farmers

% Efficiency interval	Frequency	Percentage	Mean efficiency
30.00 − 40.00	3	2.50	2.50
40.00 − 50.00	26	21.67	24.17
50.00 − 60.00	36	30.00	54.17
60.00 − 70.00	25	20.83	75.00
70.00 − 80.00	15	12.50	87.50
80.00 − 90.00	6	5.00	92.50
90.00 − 100.00	9	7.50	100.00
Minimum		40.06	
Maximum		98.65	
Mean efficiency		61.25	

efficiency indices range from 40 percent to 98 percent, with an average of 61 percent. The wide efficiency differentials among these farmers is an indication of substantial potential for efficiency improvement in potato production. The mean efficiency of 61.25, implies that, on average, the potatoes farmers produce 61 percent of the maximum output, or about 39 percent of the potential output is lost due to technical inefficiency. Approximately 75 percent of the farmers have technical efficiency of 60 and above.

Discussion and Conclusion

The objective of this study is to estimate and analyze the technical efficiency of potato farmers in Santa and Kumbo sub division using the stochastic frontier production function. The hypothesis that Cobb-Douglas production frontier model is an adequate representation of the data is strongly rejected. In addition, the hypothesis that farmers' specific characteristics in the inefficient model have no effect on technical efficiency is rejected. Finally, the hypothesis that inefficiency effects are absent from the frontier model is rejected. The result from the analysis indicates that the mean technical efficiency of farmers is 61.25. This shows clearly an inefficient use of production factors. As such, the technical efficiency of 61 percent could be increased by 39 percent through efficient use of available resources.

The results indicate that farmer's age and credit access have negative effects on technical inefficiency of potato farmers. This implies that farmer's level of technical efficiency is significantly influenced by age and credit. The marginal effect is highest for credit access, while farmer's age has the least marginal effect on technical efficiency.

In Cameroon, potato is viewed as a useful cash crop, but its productivity when compared to other African countries (Nigeria, Egypt and Ethiopia) is quite low. Therefore, improving potato productivity in Cameroon is of prime importance. Using Battese-Coelli approach to estimate the efficiency effects of farmer's socio-economic characteristics, we found out that age and credit access has significant effect on potato production in Santa and Kumbo sub division of the North-West region of Cameroon. While our results cannot be considered as a proper representative of Cameroon, it at least provides an inside into how farmers in the study area can improve their technical efficiency in potato production. Therefore, in terms of strategies and policies, policies should be developed and implemented that facilitate the participation of older farmers. Based on our findings, in other to improve potato production in the respective sub divisions (Santa and Kumbo), farmers should apply fertilizer on their potato farms. As such, the government can step in to subsidies the price of fertilizers. This will help farmers have easy access to fertilizers and as such improve their potato yield. Also, farmers should cultivate potato on small farm size. This is because small farm size can easily be managed by rural farmers than large farm size. Regarding farmers socio economic characteristics, results from our findings showed that older farmers are more experience and as such technically efficient than younger farmers. Furthermore, the government should subsidize microfinance institutions to provide credit to farmers. Also, government and private financial institutions should relax their policies of obtaining loans towards farmers. From the results, 61% of potato farmers were efficient, while 39% were inefficient. This wide variation suggests existing opportunities to increase productivity through improved efficiency use of resources.

The study has a couple of limitation. The study used age, education, credit access and sub-division as the socio-economic variable in the inefficiency model, future studies can consider other variables such as; gender, extension service and farmer's experience. The sample size used in this study is small, future studies should consider using a larger sample size. This study uses a cross sectional data to analyze technical efficiency of potato farmers. Future studies should consider using a Panel data or a time series data.

Author Contributions: L.A Contributed to the research design, data analysis and formal analysis. S.Y supervised the research.

Funding: This research received no external funding.

Informed Consent Statement: Informed consent was obtained from all subject involved in the study.

Data: Data are available on request.

Conflict of Interest: The authors declare no conflict of interest.

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