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The Technical Efficiency of Smallholder Irish Potato Producers in Santa Subdivision, Cameroon

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Abstract: Irish potato is one of the major staple food and cash crops in Cameroon. Several studies have been conducted on the agronomic aspect of the crop, but very little is known on the technical efficiency of potato producers in the country. This study examines the technical efficiency of smallholder Irish potato producers in the Santa subdivision and the determinants of technical efficiency. Data were collected through surveys of Irish potato producers, and analyses were conducted using Data Envelopment Analysis (DEA) and the Tobit model. The research findings imply that, in order to reduce the level of technical inefficiencies among smallholder Irish potato producers, appropriate training should be provided to farmers in order to improve their agronomic knowledge with respect to potato production. In addition, emphasis should be placed on policies and programs that promote extension services in order to improve the performance of Irish potato producers in the Santa subdivision. Again, more credit institutions, such as microfinance institutions, should be established by the government in order to help farmers access enough credit for potato production.

Keywords: efficiency; productivity; potato; smallholder; data envelopment analysis; two limit tobit model

1. Introduction

Generally, the only region of the world where per capita food production has declined steadily in recent decades is Sub-Saharan Africa (SSA), where Cameroon is located. Here, agricultural output has grown by an average of less than 1.5% annually, with a slower increase in food production than the population growth [1]. Thus, promoting productivity and output growth in the agricultural sector, particularly in the smallholder subsector, is the main strategy for achieving effective economic development [2]. Continuously increasing agricultural productivity is often expected to be accompanied by increases in agricultural demand associated with rising per capita income and population growth [3]. However, agriculture still remains the backbone of Cameroon's economy, employing about 70% of its workforce, and providing 42% of its Gross Domestic Product (GDP) and 30% of its export value revenue [4].

Potato is the world's fourth-largest food crop, following maize, wheat and rice. Its production (225 to 285 million tons) occurs in 10% of cultivated area [5]. It is a significant food crop in developing countries, and is often grown at a significant scale in more than 130 countries around the world, including Tanzania, Nepal, Egypt, South Africa, Algeria, Morocco, Pakistan and North and South America, Europe, Cameroon, Rwanda, Nigeria, Ghana, Kenya, to name a few. It covers about 18 million hectares of land [6]. According to the International Potato Center (CIP) and the Food and

Agricultural Organization (FAO), the average annual quantity of Irish potato production exceeds 300 million metric tons and more than a billion people worldwide consume it [7].

In Cameroon, potatoes were introduced during the German colonial period (1884–1914), but widespread cultivation began later on in the 1940s, following the introduction of new varieties by the British and Dutch governments [8,9]. This crop was well received by farmers in the highlands of Western Cameroon, where it proved to be well adapted to the high plateaus. In the later 1940s, degeneration of the potato seed (probably due to viral infections) and a late blight infestation reversed the crop's initially strong inroads, especially in the extreme southern regions [10]. Irish potato production is an important agricultural activity, and it is estimated that about 50,000 to 65,000 hectares of land are used for its production in Cameroon [11]. In Cameroon, planting generally takes place at the beginning of the rainy season, usually in March, followed by a harvest in June, presumably before the occurrence of flooding. A second planting season generally takes place in November, depending on the water stored in the soil [12]. Over 200,000 farmers grow potatoes in Cameroon, mostly smallholders and predominately women [12]. Its cultivation is usually confined to one crop in areas with shorter and/or less total precipitation. However, during the drier periods, such as November and January, few farmers plant potato along the riverbanks and valleys [12]. It is cultivated on intensive, small-scale localities in six of the 10 regions of the country. The West and the North West Regions are the predominating areas, with 80% (435,354 tons) of national production. 17% is exported to sub-regional countries like Gabon, Central African Republic, Congo, and Equatorial Guinea. These two regions are located on the western highlands of the country, which are characterized by cool temperatures, and high rainfall of at least 800 mm per annum at altitudes ranging between 900 to 3000 meters above sea level [13]. Potato production is therefore still constrained by poor farming practices, pests, inefficient use of available technologies, poor soil fertility, high cost of inputs like fertilizers, seed and fungicides, lack of access to credit, and a lot more despite government subsidization. This is because not all potato farmers receive these subsidies, thereby causing a deficit in potato production [13].

Expansion in the area of Irish potato cultivation is due to the tremendous growth in the Irish potato production [14]. Cameroon accounts for 0.1% of the world's total production of potato and 0.8% of Africa's total production (220,000 tons of 29 million tons) [15]. Figure 1, below, shows trends in production and area planted to potato in Cameroon. Expansion in the area of Irish potato cultivation is due to the tremendous growth in its production. From the figure it can be seen that total production and yields have been increasing tremendously over the period from 1995 to 2016, indicating a substantial increase in production over the past three decades. From Figure 1, we can see that there has been a fourfold increase in production from 1980 to 1988, and very erratic fluctuations over the following year.

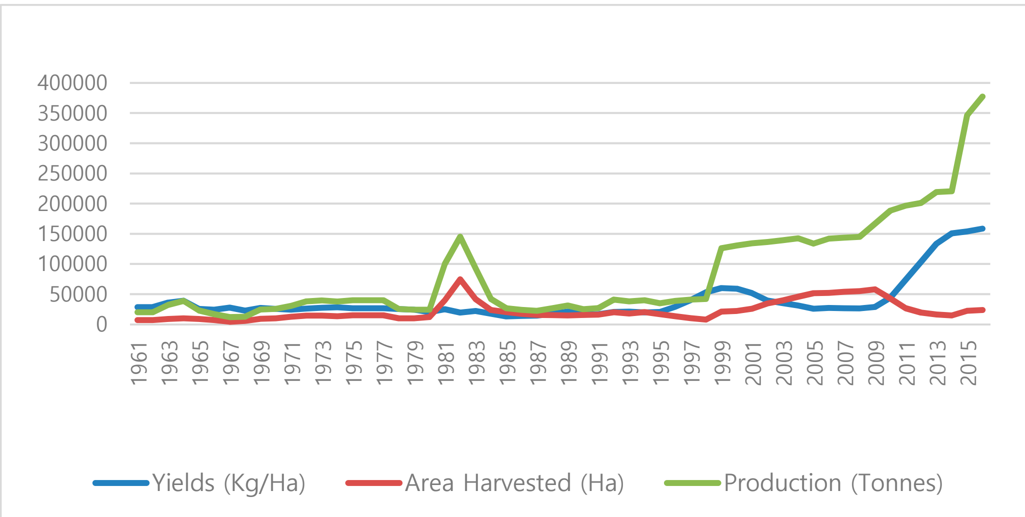

Figure 1. Trend in Irish Potato Production in Cameroon (1961–2016). Source: [15].

Generally speaking, there are two major types of efficiency measure, which are distinguished at the farm level of production economics [16]. These include: technical or productive efficiency and allocative or price efficiency. The suggested attention to gains in productivity arising from the efficient use of existing technologies is justified by the fact that in the last decade, the reduction in major technological gains across the world and specifically in Africa is largely a result of a lack of complementary inputs such as fertilizers, pesticides and irrigation [17]. According to Battese [18], technical efficiency is the maximum attainable level of output for a given level of production inputs. Allocative efficiency, on the other hand, refers to the ability of the farmer to use inputs in optimal proportions given their respective prices. Based on the fact that there has been a significant improvement in the total production of Irish potato in Cameroon over the years, we have not yet seen contributions related to efficiency strategy or the technical efficiency associated with achieving this level. Several studies have been carried out on the efficiency of smallholder Irish potato farmers, and specifically with regard to their technical efficiency, in other countries, but less has been done on the efficiency of smallholder Irish potato farmers in Cameroon.

Most works that have been carried out on potato production in Cameroon have focused more on the agronomic aspect of the crop. Anoumaa et al. [19] conducted research into the characterization of potato genotypes from the Western highlands of Cameroon. It is usually said that before determining the efficiency, the ratio of useful output to total input and the minimization of waste of resources such as physical materials, energy and time must be determined before successfully achieving a desired output. Charnes et al. [20] also confirmed this by defining efficiency as the degree to which the observed use of resources to produce output of a given quantity matches the optimal use of resources to produce output of a given quantity. An efficient use of input resources plays a fundamental role in maximizing grain productivity [21]. Thus, efficient agricultural production is usually determined by quality and the rational use of input resources and their level of provision [22]. The main challenge facing potato farmers in Cameroon is the adoption of new technologies, and this has been the main focus of recent studies aimed towards improving productivity [22].

Several studies have been conducted to date on the efficient use of resources in crop production in the country. Binam et al. [23] used a stochastic efficiency decomposition technique for a sample of 450 farmers in Cameroon to derive the technical, allocative and economic efficiency of farmers. It was revealed that the levels of technical, allocative and economic efficiency were equal to 77%, 58% and 44%, respectively. Technical, allocative, and economic efficiency indices on several farm specific socio-economic variables were regressed using the two-limit Tobit regression model, and it was found that distance from the main access road to the farm, years of schooling, credit and social capital, and access to extension services significantly affected the efficiency of farmers. Binam et al. [23] and Nchare [24] estimated factors affecting technical efficiency of Arabica coffee producers in Cameroon using a trans log production frontier and the maximum likelihood method to identify and analyze variables affecting efficiency. Their results revealed that technical efficiency varied from 0.24 to 0.98, with an average of 0.90. 10% of the output was lost due to inefficiencies pertaining to farms. Education and access to credit were discovered to have been the main socio-economic factors affecting efficiency. The government was therefore recommended to increase farmers' education capacity and access to credit in order to increase technical efficiency.

Other studies, such as Chavas et al. [25], Chepng'etich [26], and Nyagaka [27], examined the efficient use of resources in other countries using either Data Envelopment Analysis (DEA) or Stochastic Frontier Analysis (SFA). Chavas et al. [25] estimated the efficiency of farm households in Gambia using non-parametric measurements, and the results suggested that off-farm earnings were an important factor in technical and allocative efficiency. Also, the results found that gender of household, food insecurity, and poverty status had significant impacts on efficiency. Chepng'etich [26] analyzed the technical efficiency of 143 smallholder sorghum producers in Kenya (Machakos and Makindu Districts) and its determinants. The results revealed that the efficiency in sorghum production in the surveyed districts was low, and that improving the farmers agronomic knowledge could contribute to reducing inefficiency. Nyagaka [27] carried out a study on Irish potato production efficiency in Kenya using a stochastic parametric decomposition technique and showed that Irish potato producers were inefficient. Also, this study employed the two-limit Tobit model to figure out the determinants of efficiency, and the results indicated that education level, contact with extension, and membership in a farmer's association had a significant impact on economic efficiency. Other studies conducted include those of Bozoğlu and Ceyhan [28], Chimai [29], Chirwa [30], and Javed et al. [31].

Since Irish potato is one of the major staple foods/cash crops in Cameroon, and very little is known about the technical efficiency of this crop, this study is a contribution in this direction. Furthermore, increasing potato productivity will profoundly effect, either directly or indirectly, not just the income levels of the majority of the population growing potatos, but also those who live around them, while also serving as food security for the households. Based on this, this study aimed to determine the level of technical efficiency of smallholder Irish potato producers and to identify the challenges faced by smallholder Irish potato producers in the Santa subdivision, Cameroon.

2. Materials and Methods

2.1. Materials

This study was limited to Santa subdivision, which is located in the north west region of Cameroon, in the Western Highlands of the country. Generally, if Cameroon maintains its position as the breadbasket of the central African sub-region, one of the areas to be credited is the Santa subdivision, which is a major agricultural production basin, involved particularly in market gardening and potato production [12]. The population carries out organic farming, since agriculture in the region is mostly carried out by families on small parcels of farmland and the use of harmful products is very limited [12]. Most farmers use organic and inorganic fertilizers that enhance soil fertility. Thus, because of this method of cultivation, an opportunity is presented for investing in inorganic and organic farming. There are six major Irish potato producing zones in the country; the north west region and the west region are the two major producing areas, producing about 80% of the country's national output [14].

The data used in this study were obtained from both primary and secondary sources through a cross-sectional survey of Irish potatoes farmers in the Santa subdivision using a multi-stage sampling technique to select a sample of farmers for the study. Primary data were collected through survey questionnaires from randomly sampled potato farms during the 2016/2017 growing season in the area. Before the survey, the questionnaire was designed and pre-tested on 10 non-sampled households. After the pre-test, the questionnaire was modified and used for face-to-face interviews of 126 households in three villages in Santa subdivision (Santa, Pinyin and Awing). The survey targeted mainly households who had been into potato farming for at least five years. Based on this research design, the household survey method was used in collecting the data. The sample size of Irish potato producers was computed using Formula (1), developed by Kothari [32]:

$$N = \frac{Z^2 PQ}{E^2} \tag{1}$$

where N is the sample size, Z is the confidence interval (Z-value), P is the expected population proportion, Q is $1-P$, and E is the acceptable margin of error. A 95% confidence interval was assumed for this study, with an expected population proportion of 0.5 and an expected margin of error of 10%. Thus, the sample size was calculated as follows.

$$N = \frac{1.96^2(0.5)(0.5)}{0.10^2} = 96.04 \tag{2}$$

Thus giving a minimum sample size of 96, which was then adjusted to 126 households.

After collecting the data, it was discovered that out of the 126 questionnaires sent out, six of them did not have enough or accurate information to meet the requirements of the analysis. So these six questionnaires were rejected; thus, only 120 questionnaires were used for the analysis. Additionally, secondary data was also collected with regard to the description of the study site, including the location of the area, population, the type of agricultural activity in the area, its topography, data on trends in Irish potato production, and literature from previous articles of other scholars. Each of the 126 sampled households was surveyed with respect to output, which was the total potato output cultivated, measured in bags of 100 kg (dependent variable) and six inputs used in Irish potato production, including plot size, seed, fertilizer, pesticide, labor, and capital (independent variables). Output, quantity of seed and fertilizers were all measured in kilograms, pesticides in grams, capital in France CFA (the currency of Cameroon), and the data for labor was collected for both family and hired labor based on the number of hours spent on each activity during the production process. The unit of labor is man-days, which were introduced as a common means of expressing labor time. A man-day is calculated by dividing the actual working hours by the man-day equivalent; according to the International Livestock Centre for Africa (ILCA) [33], a man-day equivalent is eight hours.

The above variables were used in Data Envelopment Analysis (DEA) during the first step of the analysis for technical efficiency scores. In the second step of the analysis, the Tobit regression model was used to regress the efficiency score, which is the DEA result on socio-economic and institutional characteristics. This study used STATA version 13 (StataCorp, College Station, TX, USA) to carry out the analysis.

2.2. Methods

As mentioned above, a two-step analysis was implemented in which in the first step, Data Envelopment Analysis (DEA) was used in order to measure the technical efficiencies of smallholder potato farmer as an explicit function of discretionary variables. In the second stage, we aimed to explore the relationship between technical efficiency and other relevant environmental variables, such as farmer's age, background of farmers in agriculture, soil fertility, water availability and seed quality by using the Tobit model.

The DEA approach allows variations in the production function across decision-making units and also avoids problems associated with functional form misspecification; thus, it is a very flexible model. In contrast to Stochastic Frontier Analysis (SFA), which is another popular nonparametric method, DEA allows the analysis of the introduction of multiple inputs and outputs. Furthermore, if a two-stage DEA is used, it is able to identify the levels of inefficiency for each farm unit. It does not also enable the assumption of the distribution of the inefficiency term, which the SFA does.

The DEA model is focused on minimizing the amount of resources and increasing production. Under CRS (Constant Return to Scale) conditions, analyses always give the same results, while under VRS (Variable Return to Scale) conditions, they are always different, because under VRS, farmers' inputs vary. Therefore, the efficiency scores of the potato farms were calculated under assumptions of CRS and VRS, as well as calculation of Scale efficiency (SE) in this study. When efficiency scores are calculated based on CRS and VRS, their results will always be different. If we assume that a Decision Making Unit (DMU) can produce Y output with X inputs, other similar DMUs should also produce that same output (Y) with the same inputs (X), otherwise they are set to be inefficient. In Cameroon, farmers aimed at maximizing output in production using variable inputs. Thus, using the Tobit model, socio-economic and institutional factors affecting the efficiency of potato farmers were regressed based on an output-oriented DEA VRS assumption in the final stage of the analysis, as specified below [34].

$$\begin{gathered} min_{\theta,\lambda}\ \theta \\ \text{Subject to} \\ -y_i + Y\lambda \geq 0 \\ \theta x_i - X\lambda \geq 0 \\ N1'\lambda = 1 \\ \lambda \geq 0 \end{gathered} \tag{3}$$

where θ is a scalar representing efficiency score of i-th decision-making unit and λ refers here to an $N \times 1$ vector of a constant. It will satisfy the condition $\theta \leq 1$, with the value of 1 indicating a point on the frontier and hence a technically efficient farm, according to Farrell [35]. As stated above, the technical efficiency of the potato-producing farmers is obtained in the first step, and the DEA scores fall between the interval 0 and 1.

This study employed the Cobb-Douglas functional form of the production frontier in order to understand the contribution of one production input to the potato output. The Cobb-Douglas (CD) and the Transcendental logarithmic (Translog) function are the most commonly used functional forms when measuring the physical relationship between input and output. The Cobb-Douglas production function can handle multiple outputs in its generalized form, and again, it does not introduce any distortion, even though there are imperfections in the market. It is a simple form, very parsimonious with respect to degrees of freedom [36], and also meets the requirement of being self-dual, thus allowing the examination of Technical Efficiency (TE) and Economic Efficiency (EE). Meanwhile, the translog production function is more flexible than the CD, and takes account of interactions between variables and allows for non-linearity in the parameters. Based on this, the linear estimation (logarithmic) form of the production function is specified as follows:

$$\begin{gathered} lnYi = \beta_{0i} + \beta_1 lnPsize_{1i} + \beta_2 lnSeed_{2i} + \beta_3 lnFert_{3i} + \beta_4\ lnPest_{4i} + \beta_5 \\ lnLab_{5i} + \beta_6\ lnKtal_{6i} + \beta_{7i} lnMan_{6i} + v_i \end{gathered} \quad (4)$$

where: Yi is the total output of potato farmers, the subscript i indicates ith household in the sample (i = 1,2 . . . .,120). *Psize, Seed, Fert, Pest, Lab, Ktal, Man.* All variables appear in logarithmic form. v represents the error term, and the other variables are as defined above.

It is also of great importance to explain the efficiency scores obtained from the DEA model by analyzing the determinants of technical efficiency. In the second step of the analysis, after measuring the technical efficiency scores in the DEA model, the two-limit Tobit model was used in order to determine the causes of inefficiency. This is a censored normal regression model where the dependent variable is continuous, but its range is constrained both from below and above the cut-off point, requiring that the dependent variable be observed only if it falls above or below those same cut-off levels. Since the technical efficiency scores were known to be continuous, the Tobit regression model presented the preferable option for this study.

Several farm and farmer characteristics were hypothesized to explain variations in the levels of technical efficiency based on CRS, VRS and Scale efficiency across the sampled farms. Some socio-economic characteristics which were postulated to have either a positive or a negative influence on efficiency levels in this study included: age, gender, experience, education, and household size; while institutional characteristics included: extension services, agricultural credit, and membership in a farmers' association, as well as the use of manure. Several factors were regressed upon the DEA VRS scores in this model. The equation for the Tobit model regression is specified as follows:

$$\begin{gathered} Yi = \beta_0 + \beta_1 ln\ X_{1i} + \beta_2\ ln\ X_{2i} + \beta_3 ln\ X_{3i} + \beta_4\ ln\ X_{4i} + \beta_5\ ln\ X_{5i} \\ + \beta_6\ lnX_{6i} + \beta_7\ ln\ X_{7i} + \beta_8\ ln\ X8i + \beta_9\ ln\ X_{9i} + v_i \end{gathered} \quad (5)$$

where Yi is the natural logarithm of technical efficiency indices. The i subscript indicate the ith household in the sample (i = 1 . . . . . . 120). X_1 represent the age of the household (in years), X_2 represent gender (a dummy variable) with value 1 for male and 0 otherwise, X_3 represents experience of the household measured by the number of years the farmer has grown Irish potatoes, X_4 refers to the number of years of former schooling of the household, X_5 represents the household size of the farmers, X_6 represents the quantity of manure applied to the Irish potatoes plot (in kg), X_7 represents access to extension services measured in total number of visits by extension agents, X_8 represents access to agricultural credit (the dummy variable) with value 1 if the household had received credit and 0 otherwise, X_9 represents membership association (a dummy variable) with value 1 if the household is a member of the farmers' association and 0 otherwise. *vi* is an independent and normally distributed error term

3. Results

3.1. Descriptive Statistics and Frequency Distribution of Farmers' Characteristics

The majority of the households surveyed in the region were male headed, with less than half of the sampled households surveyed being female headed; 62.5% and 37.5% were male and female headed, respectively. This is a reflection of the situation in the study area, where most households are headed by males, and fewer are headed by females. There were various constraints faced by households in the area. According to the survey, most farmers indicated that the most important challenge they faced was the lack of good farm-to-market roads (98.3%). This was then followed by a lack of improved seed varieties (95.8%). This is possibly due to their susceptibility to plant disease and various weather conditions. The high cost of input was also one of the major challenges faced by most potato farmers during production. This is due to the fact that most of them had little or no capital investments. This has been a major problem for farmers since the 1960s. Most of the households (95%) were not able to sell their products at the expected market price due to the low market prices, which is beyond their control unless the government intervenes. Lack of agricultural chemicals was also cited as one constraint that they faced in potato production (88.3%).

Table 1, below, shows a summary of the statistics of variables used in the Data Envelopment Analysis (DEA) model for technical efficiency analysis before the generation of technical efficiency scores. The analysis included one output (total output of potato farmers) and six inputs. The inputs included land area measured in hectares planted with potato, quantity of potato seed planted, potato labor employed in potato farming, quantity of fertilizer applied to potato farm in kg, quantity of pesticides applied to potato farm, and finally the amount of total capital invested in potato farming. According to the table, the output of potato farmers ranged from 4 bags (100 kg) to 113 bags (100 kg), with a mean of approximately 31 bags (100) among the sampled farmers in the region. It was noticed that the size of the land used was as small as 0.1 ha and as large as 2.52 ha, implying that most households grew Irish potatoes on small-scale localities.

Table 1. Summarized statistics of variables used in the DEA model for technical efficiency analysis.

Inputs/Output Variables	Minimum	Maximum	Mean	Standard Deviation
Output				
Potato quantity (Bags of 100 kg)	4	113	30.62	23.24
Inputs				
Land size (ha)	0.1	2.52	0.26	0.29
Seed Quantity (kg)	25	1500	342.06	321.33
Potato Labor used (Man-days)	1.875	23	9.36	4.68
Capital (Frs CFA)	35,000	2,047,000	412,448.7	393,278.6
Fertilizer (kg)	12.5	2100	288.17	367.29
Pesticides (Kg)	0	650	114.18	122.02

Table 2 presents the socio-economic characteristics of the farmers. The results show that most of the farmers were relatively younger farmers in their 30s, as indicated by the mean age in the area (34 years). The youngest households were 20 years of age, while the oldest households were 68 years old, with an average level of education of 11 years, indicating that the average household has achieved a secondary school level of education. This implies that most of the farmers were able to read and write.

Table 2. Summarized descriptive statistics of selected farmer characteristics.

Characteristics	Units	N	Mean	Standard Deviation	Minimum	Maximum
Gender	Dummy variable (1 = Male, 0 = Female)	120	0.65	0.48	0	1
Age of household	Year	120	33.63	9.02	20	68
Education	Year	120	10.63	4.29	0	17
Size of household	Person	120	4.61	2.58	1	12
Farming experience	Year	120	12.44	8.27	1	45
Potato experience	Year	120	8.40	6.35	1	43
Extension services	Number of visits	120	1.26	0.86	0	5
Membership association	Dummy variable (1 = Member, 0 = Non)	120	0.23	0.42	0	1
Access to credit	Dummy variable (1 = Credit, 0 = Non)	120	0.52	0.50	0	1

3.2. Cobb-Douglas Production Function

The DEA model was used to incorporate some functional form analysis in order to understand the relationship that exists between inputs and output. In this regard, the Cobb-Douglas production function was the best fitted to the data in this case. This is because the coefficient of the Cobb-Douglas production function signifies elasticities of production, showing the direction of influence of one production input to output. The estimation results of the econometric function are given in Table 3. Two inputs employed in production had a positive influence on total output, and it was noticed that labor had the greatest elasticity (0.569). This implies a 0.569% increase in output due to a 1% increase in the use of labor for Irish potato cultivation. A larger coefficient means that labor had a greater impact on the output. This means that output would be increased if farmers increase the number of workers in Irish potato production, and that farmers have good access to inputs in the region. The results of the econometric estimation/Ordinary Least Square (OLS) show that the value of the adjusted R was equal to 0.69. The Breusch-Pagan LM test and White's test showed that the output variable does not have heteroscedasticity. Also, the Hausman test could not find any evidence of endogeneity, thus explaining the good relationship present between output and input variables.

Table 3. Result of the coefficients of the Cobb-Douglas production function.

Variables	Coef	Standard Error	*t*-Statistics	*p*-Value
Intercept	−4.667 ***	1.175	−3.97	0.000
ln(land)	−0.119 **	0.549	−2.17	0.032
ln(seed)	−0.023	0.118	−0.2	0.844
ln(chemical fertilizer)	0.111	0.773	1.43	0.155
ln(organic fertilizer)	0.021	0.901	0.24	0.814
ln(pest)	−0.080 *	0.454	−1.76	0.081
ln(capital)	0.187 **	0.096	1.96	0.052
Ln(labor)	0.569 ***	0.162	3.51	0.001
R-Adjusted	0.69			
Total No of Observations	120			

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

3.3. Technical Efficiency Indices

An output-oriented DEA VRS was used to estimate the overall technical efficiency scores under CRS, VRS, and SE. Table 4 shows the frequency distribution of technical efficiency (TE) scores. Of the 120 sampled households, 27 (22.5%) households were technically efficient under VRS, while only 5 (4.2%) were technically efficient under both CRS and scale efficiency. The overall mean technical efficiency was 0.663 under VRS, while under CRS it was 0.289, and it was 0.443 under scale efficiency. This means that the efficient households under VRS, CRS and SE have the possibility to reduce their production costs by 33.7%, 71.1%, and 55.7%, respectively, while still maintaining the same level of output.

Table 4. Frequency distributions of technical efficiency scores obtained from the DEA model.

Efficiency Scores	VRS	CRS	SE
1	27	5	5
0.90–1.00	3	1	1
0.80–0.90	9	2	3
0.70–0.80	15	2	6
0.60–0.70	10	0	5
0.50–0.60	18	4	17
0.40–0.50	21	8	19
0.30–0.40	10	16	30
0.20–0.30	7	22	18
0.10–0.20	0	56	16
0.00–0.10	0	4	0
Total DMUs	120	120	120
Minimum	0.246	0.088	0.107
Maximum	1	1	1
Mean	0.663	0.289	0.443

Note: VRS = technical efficiency from variable return to scale DEA, CRS = technical efficiency from constant return to scale DEA, SE = scale efficiency = CRS/VRS.

3.4. Factors Influencing Technical Efficiency

To make appropriate recommendations for relevant policy review and implementations, it is necessary to identify the sources of variation in technical efficiency among various DMUs. Thus, several environmental factors were regressed upon the efficiency scores in order to identify the determinants of efficiencies. The results of Tobit regression are presented in Table 5.

Table 5. Results of the two-limit Tobit model showing factors that influence technical efficiency.

Variables	VRS	
	Coefficient	*p*-Value
Constant	0.6450 ***	0.000
Gender (1 = male, 0 = otherwise)	−0.0950 **	0.028
Age (Years)	0.0120 ***	0.000
Size (No of persons)	−0.0240 *	0.067
Education (Years)	−81.0000	0.280
Farming Experience (Years)	0.0200 ***	0.000
Manure (Kg)	0.0002 ***	0.000
Extension Servicess (No of visits)	0.0920 ***	0.000
Receive credit (1 = Yes, 0 = otherwise)	0.1500 ***	0.009
Farmer association (1 = Yes)	−0.0754	0.323
Log likelihood	−22.8550	

Note: *, **, and *** represent levels of significance of 10%, 5% and 1% respectively. *p*-values were computed from *t*-ratios. VRS = technical efficiency from variable return to scale DEA

The results of Table 5 show that 7 out of the 9 variables regressed using the Tobit model were statistically significant. Despite this, other variables such as gender of households and household size were all negative, although statistically significant, on technical efficiency. Meanwhile, others, such as membership association and level of education, were all insignificant [37].

The farmer's age coefficient had a positive effect on efficiency and was found to be statistically significant. Nevertheless, the contribution of the age variable is somewhat controversial, as the age of farmers may have either a positive or negative impact on technical efficiency, where older farmers may be both/either more experienced or slower to accept new technologies than younger farmers. Thus, the positive and significant coefficient of the variable indicate that older farmers are more ready to adopt new practices, better technologies and inputs. Potato farming experience has a positive and statistically significant relationship with technical efficiency. This indicates that households with more years of experience in producing Irish potatoes are more technically efficient than their counterparts. The coefficient for access to extension services has a statistically significant and positive relationship with technical efficiency. This positively estimated coefficient for contact with extension workers implies that farm households with increased frequency of contact with extension workers tend to be more efficient. This result also indicates that agricultural credit has a positive and statistically significant effect on technical efficiency. The negative but significant gender coefficient shows that female-headed households are more likely to have better opportunities to carry out frequent follow-up and supervision of the farmers' activities on their farms.

4. Discussion

This study aimed to analyze the technical efficiency of potato farmers, as well as the challenges faced by smallholder potato farmers, and to identify factors that influence the efficiencies of potato farmers (households). Since potato is considered to be a staple/cash crop, acting as a tool for food security in Cameroon, it is therefore necessary to examine the performance of farmers involved in potato production in the country.

Few farmers were found to be technically efficient in their production. Most of the farmers operated at below 50% technical efficiency, while 33% of the sampled households operated at above 80% technical efficiency, and were thus termed relatively efficient. Therefore, there is considerable scope for inefficient DMUs to either increase their efficiency or reduce their input costs by maintaining the same production level. Therefore, in the short run, policy strategies aimed at improving technical efficiency should emphasize an effective and efficient use of existing technologies, and transfer instruments that enhance the capacity of the farmers to use inputs efficiently.

According to the results, there are several factors affecting technical efficiency. Our findings indicate that age of household head, farmer's experience in potato farming, soil fertility (use of manure), and access to credit were the main determinants. This study found that aged and experienced farmers tended to be more efficient. This implies that older farmers might have more experience with farming, and higher accumulated capital, thus making them more preferred by credit institutions, and therefore could be expected to be more efficient. Also, farming experience may lead to the acquisition of better managerial skills over time. The negative but significant influence of gender on efficiency means that female-headed households had greater opportunities to increase efficiency. Farmers who receive credit tend to exhibit higher levels of efficiency. Farmers' liquidity constraints can be overcome by credit in order to enhance efficiency, which may affect their ability to acquire and apply inputs and implement farm management decisions on time. The use of credit therefore reduces financial constraints and ensures timely acquisition of and use of inputs, leading to an increase in efficiency.

Since the purchase of most agricultural inputs usually takes place during the planting season, while returns are received only after the Irish potatoes have been harvested several months later, most Irish potato farmers face negative cash flow during the planting and growing period. Additionally, potato production is labor intensive; farmers who have little or no access to either formal or informal credit at the start of the season or during the growing period may have difficulties in acquiring and applying inputs on time. The liquidity constraint that farmers face can be reduced by alleviating credit constraints and thus enhancing the acquisition of inputs, especially during the planting period, leading to timely operations. Hence, the government should link farmers directly to financial institutions such as banks and microfinance institutions. Additionally, farmers can use informal channels as a source of credit. It was also noticed that access to extension serccvices had a positive and statistically significant impact on efficiency. This implies that farm households with increased frequency of contact with extension workers tended to be more efficient. Thus, production efficiency of smallholder Irish potato producers can be obtained by making improvements in substantial productivity gains. Therefore, in the near future, agricultural policies should include measures for training farmers to apply the available technology more efficiently by improving access to extension services.

5. Conclusions

This study aimed to examine the technical efficiency of smallholder Irish potato farmers in the Santa subdivision, and to identify the challenges faced by farmers. The results of this study suggest that gains from improving technical efficiency exist in all farm-specific variables, as well as environmental and institutional variables. Production efficiency of smallholder Irish potato producers can therefore be achieved by making improvements with respect to substantial productivity gains. Our findings highlighted that more than half of the sampled households were technically inefficient. The majority of the households faced a lot of challenges, including high cost of inputs, lack of good farm-to-market roads, and lack of credit to finance potato production investment. Meanwhile, this study also found that the age of farmers, experience, use of manure, and extension services were seen to be the most important determinants of technical efficiency among Irish potato producers.

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