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Determinants of Technical Cassava Producers Efficiency: The Case of Madimba, in Democratic Republic of Congo

Raymond Kalala Banze Kabange[1*], Moise Lufuluabo Mwabila[2], Henry Muayila Kabibu[3], Jean-Pierre Nganda Afumba[3] and Augustin Isangu Mwana Mfum[4]

[1]Doctoral Candidate, Agricultural Economics Program National Pedagogical University, Democratic Republic of Congo, E-mail: banzeraymond@gmail.com

[2]Researcher at the National Institute of Agronomic Research, and Professor of Agricultural Economics, National Pedagogical, University, Democratic Republic of Congo, E-mail: t.moisemwabila@gmail.com

[3]Rural Economics Program, Protestant University of Congo, Democratic Republic of Congo, E-mail: henrikabibu@yahoo.fr; jpafumba@yahoo.fr

4Agricultural Economics Program, University of Kwango, Democratic Republic of Congo, E-mail: isangu@wanadoo.fr

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Abstract

This article aims, firstly, to measure the technical efficiency of cassava producers in the Madimba territory of Kongo province in the Democratic Republic of Congo, and secondly, to identify the main variables on which this efficiency depends. The data used comes from a household survey administered to 775 producers. The data envelopment method was used to generate the technical efficiency scores. Furthermore, a truncated regression model was used to explain the variance of these scores. The results reveal an average efficiency of 0.89 under Crs, 0.97 under Vrs, and 0.91 under Scale. Additionally, 85.5% of producers work in the zone of increasing returns to scale, 13.5% operate in the zone of constant returns to scale, and 1% in the zone of decreasing returns to scale. This highlights that further improvement in efficiency is still possible. This study shows that the technical efficiency of cassava production among producers in the study region is significantly and positively associated with education level, agricultural experience, household income, and yield. Conversely, technical efficiency is significantly and negatively associated with marital status, production constraints, land tenure, and the lack of suitable varieties.

***Corresponding author:** Raymond Kalala Banze Kabange, Doctoral Candidate, Agricultural Economics Program National Pedagogical University, Democratic Republic of Congo.

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Introduction

Agriculture is the main economic sector on which the survival of the majority of the African population depends. This sector alone employs more than 60% of the workforce and contributes more than 35% of the GDP of the majority of African countries and more than 40% in the least developed countries of Africa. The agricultural sector continues to be the key engine of economic and social development for most poor countries. This sector most often employs the majority of the workforce and agricultural products represent a significant share of exports [1].

Efficient production of the agricultural sector can contribute positively to economic growth and the stability of the national economy. Agriculture is the most popular economic activity for people in the least developed countries. In Benin, for example, more than two-thirds of the country's working population is employed in the agricultural sector, mainlyfamily production units [2]. Also, in Africa, several countries are confronted in a general way with the problem of development. These are situations of poverty, famine, malnutrition and food insecurity [3]. The population finds agriculture the preferred way to obtain food and cover their food needs [4].

In the heart of Africa, the Democratic Republic of Congo (DRC) is a large country with immense agricultural potential. The availability of land, freshwater resources supported by the Congo River watershed, climatic diversity and the availability of labour, with a population mainly made up of young people, make it a strength in this sector [5,6]. In its 2023 report, reports that the DRC is one of the poorest nations in the world [7]. The UNDP had relegated it to last place in its ranking in terms of human development [8]. In 2022, 74.6% of Congolese lived on less than $2.15 a day. Also, a large part of the population, nearly 27 million, suffers from high levels of food insecurity, usually food poverty [9,10]. The DRC has about 70% of the active population that actively practices peasant agriculture. In 2010, the share of women in the working population in the DRC was estimated at 38.5%, of which 72.6% were active in agriculture [11]. And arable land is estimated at nearly 80 million hectares [12]. However, in order to feed its population, domestic supplies come up against the problem of inefficient agriculture.

On the other hand, cassava cultivation is spread throughout the national territory, from East to West and from North to South through the Centre. Cassava remains the product that the DRC has not imported so far. In Central Congo, and in Madimba territory in particular, cassava is grown by the entire population engaged in agriculture. This demonstrates the special place that this speculation occupies in the daily life of agricultural households. However, the fact that the producers unanimously engage in this speculation does not justify that they are all effective. In this paper we will analyze the efficiency levels of this crop in order to determine the factors associated with it.

Literature Review

Several studies have addressed the concept of effectiveness. In econometric analysis, efficiency andproductivity are two complementary terms, both of which are used to assess the efficiency of agricultural production [13]. The notion of efficiency, first used by Koopmans in 1957, reported, has since been an increasingly privileged reference in the analysis of the performance of production units [14].

The physical relationship between the quantities of input and output will define the technical efficiency of production. Technical efficiency measures how well the entrepreneur combines the factors of production when their proportions of use are given [14]. Technical efficiency results from the possibility of avoiding waste in production by obtaining the maximum output allowed by a given quantity of inputs or by employing a minimum quantity of inputs to achieve a desired level of outputs [15]. It therefore expresses the ability or capacity of a firm to obtain the maximum possible output from a given level of productive resources.

A study on the overall technical and water efficiency of some cereal farms in central Tunisia shows that the average overall technical efficiency level is around 70.72% while that of water is 64.86%. The main variables positively and significantly affecting water use efficiency are the choice of variety, the number of irrigation sources per farm, membership of an

Agricultural Development Group, supplementary irrigation and the size of the farm [16].

In his study on the technical efficiency of smallholder maize farmers in Benin, Fawaz and Adechinan found that, on average, smallholder maize producers can save nearly 19% of their current variable costs (inputs) to be allocatively efficient. This reduction in inefficiency would improve their performance [17].

Find that in Benin, the total technical efficiency of rice farms during 2001 and 2010 varies between 45.71% and 100%, with an estimated average technical efficiency of 69.10% and the average margin for improvement of 30.90%. For its part, [18] found that in Benin, only 15.89% of maize producers are allocatively efficient, indicating that most of them do not use inputs in optimal proportions given their respective prices [18].

Also in Benin, studied the technical efficiency of pineapple producers. The results obtained showed that on the whole, pineapple producers are not technically efficient [19]. But that there are possibilities for improving production using the same quantities of available resources given that the average level of efficiency is 67%. It should therefore be pointed out that the most efficient producers are to be found among those who respect the recommended technical itinerary.

By analyzing the technical efficiency and sources of inefficiency of smallholder vegetable farmers in forest areas in the South-West region of Cameroon concludes that the levels of technical efficiency in the study area are between 12 and 100% with an average value of 66% [20]. Household size, level of education and access to credit are characteristics of the producer significantly associated with this technical efficiency, and only the extension service is significantly associated with the technical efficiency of farmers. Working on urban horticulturists in Abidjan found that the technical efficiency of urban farmers ranges from 21% to 97% with an average of 76% [21]. He also finds that pesticide application is significantly positive for effectiveness. However, the total area has a negative and significant effect on productive efficiency due to the lack of labour. This is how he found that labor has a significant and positive effect on production efficiency. Because it is not only qualified, but also specialised and has a long period of experience. This significant effect is also significant for the use of fertilizer (NPK, Urea) and good seed. It concludes that 20.95% of the production units surveyed are at a technical efficiency threshold of more than 60%.

In the DRC, find that the producer's level of education positively affects the distribution of technical efficiency scores [22]. Also in the DRC, have analysed the technical efficiency of tomato producers in Kongo Central [6]. The results revealed that tomato growers are technically 99% efficient. And the seed positively determines this efficiency at 92%. Working on the determinants of technical efficiency of family poultry farms in Kinshasa, DRC, found that the average level of technical efficiency is 0.455 in the case of constant returns to scale; 0.498 when yields of scale are assumed to be variable; in addition, a scale efficiency of 0.652 [23]. This implies the existence of levers for possible improvement of production while keeping resourcesunchanged by reducing input use by 0.455; 0.502 and 0.348. Most farmers, 59.09%, operate in the zone of diminishing returns to scale, 27.27% below increasing returns to scale and 13.64% below constant returns to scale.

They also indicated that the determinants of technical effectiveness of the two CRS and VRS models are age; the level of education; proximity between farms; frequent risk exposure; The average weight at the entry of laying a clutch explains the technical efficiency negatively. While the ownership of a motorcycle, a contract between the input supplier and the farmer; saving at a financial institution; access to credit; the housing structure; the frequency of daily consumption; The breed of the hens to be raised and the access to the extension service explain the technical efficiency positively. In his thesis on the adoption of improved varieties and the performance of family farms in the territory of Kasongo-Maniema Province in the DRC, found that for under the overall technical efficiency in the adoption of improved rice varieties is between 6 and 100%, with an average of 51%±17%. And, 1.75% of farmers are on the frontier of overall technical efficiency [24]. The minimum level of overall technical efficiency is 6%, while its maximum level of 100% is achieved by only 16 farmers out of the 908 in the sample.

This author also found that pure technical efficiency varies between 30 and 100%, with an average of 62%±16%. Also, 5.86% use their inputs efficiently and 75.77% of farmers have a pure technical efficiency of more than 50%. He then found that the efficiency of scale was on average around 83%. While 3.74% are on the scale efficiency frontier and 91.29% of farmers have scale efficiency above 75%. The minimum level of scale efficiency in the sample is 10% while its maximum level is 100%.

Regarding the adoption of improved maize varieties, finds that the overall technical efficiency is between 3 and 100%, with an average of 30%±13%. Nearly 2% of farmers are on the frontier of overall technical efficiency [24]. Thus, the minimum level of overall technical efficiency overall is 3% while its maximum level of 100% is achieved by only 1.87% of producers. As for pure technical efficiency, it varies between 11 and 100%, with an average of 40%. And,2.17% use their inputs efficiently, 83.03% of farmers have a pure technical efficiency of more than 50%. Scale efficiency averages around 76%, with 4.12% of producers on the efficiency frontier and 84.47% of farmers showing scale efficiency above 75%. The minimum level of scale efficiency in the sample is 8% while its maximum level is 100.

Materials and Methods

Setting, Population, Study Period and Sampling

Madimba is a territory located at 4°9'S, 15°2'E and 210 m above sea level in the province of Kongo Central, in the Democratic Republic of Congo; 100 km from Kinshasa. It covers an area of 8,260 km² and has a humid subtropical climate with distinct seasons, rainfall and dry seasons. The average annual temperature is about 25°C and the average rainfall is 1273.9 mm and has a population of about 465,000 [25,26].

At the end of a pre-survey conducted in June 2025, a survey was conducted from July 13 to September 10. This study required a data collection tool to collect information from farm households. For example, we used the paper questionnaire, the answers to which were recorded on printed questionnaires. In view of the logistical constraints, we opted for the non-probability sampling method with proportional quotas. In passing, 755 cassava producers were questioned on the basis of 49 variables. The dependent variable (output) or y represents the total production of cassava produced by the producers surveyed during the year 2024, estimated in terms of 100kg bags. Inputs are factors of production from which production is produced. In the following lines, we present the variables of the study according to their grouping.

Data Processing

After entering and checking the data on Excel 16, the mathematical and descriptive analyses were carried out. The relationship test is based on the following assumptions: H0: the null hypothesis, if P-value<0.005 and H1: there is an effect, if P-value>0.005. For this purpose, the Spearman correlation test and the association test of Manwithny and Wilcoxon as well as Kruskal Wallis were used. The analyses were made possible by the Stata version 15 software, except for the technical efficiency scores which were generated by the DEAP4 software.

Estimating Procedure

Two methods were the subject of this study, namely: the DEA (Data Envelopent Analysis) method, used to generate the efficiency scores, and the double-censored Tobit model, used to explain the variance of the technical efficiency scores. The choice of the Tobit model is justified by the fact that the dependent variables are percentages of technical efficiency below the constant yield and variables (CRS and VRS) and that they are continuous and truncated, and taking values within the range [0, 100].

The advantage of this model is that it estimates total technical efficiency broken down into pure technical efficiency at the given scale of operations and identifying whether opportunities for increasing, decreasing, or constant returns to scale are present. Thus, the DEA method makes it possible to analyze scale inefficiencies by estimating a model with constant returns to scale and a model with variable returns to scale [27].

Table 1: Summary of the Different Studies

Case	Number of products tested	Number of farms	Country	Methods
Our study	(1) Cassava	755	Ground floor	DEA
Nkusu (2024)	(1) hen	44	Ground floor	DEA
Ndakaishe (2022)	(2) Rice and maize	908	Ground floor	DEA
Mujinga et al (2022)	(1) Tomato	120	Ground floor	FSA
Bessan et al (2018	(1) Rice	-	Benin	DEA
Fawaz and Adéchinan (2018)	(1) Maize	-	Benin	FSA
Muayila et Mujinga 2018	(1) Cassava	202	Ground floor	GODDESS
Adeguelou et al (2016)	(1) Maize	150	Benin	DEA
Gnonna (2008)	(1) Cotton	184	Benin	FSA
Kpenavoun et al., (2017)	(1) Pineapple	135	Benin	FSA
Fosso (2015)	(1) Vegetables	100	Cameroon	DEA
(Chebil, 2018)	(1) Water	170	Tunisia	DEA
Kouakou (2017)	(1) Horticulture	-	Cote d'Ivoire	-

Two countries are more interested in the issue of the technical efficiency of producers. These are the DRC and Benin. Also, the DEA model was the most used. This is how this study rallies to this logic, approaching the analysis of the technical efficiency of cassava producers using the DEA method.

Introducing the DEA Model

The DEA makes it possible to study and evaluate the effectiveness of the DMU decision-making units or to analyze the performance of the different sectors (Agriculture, Forestry, Education, etc.). In addition, compared to a reference set, the DEA differentiates and identifies units of the same units and others that are ineffective [28].

By calculating an efficiency score, it indicates whether an organization has room for improvement. By setting target values, it indicates how much inputs must be reduced and outputs increased for an organization to become efficient. By identifying the type of returns to scale, it indicates whether an organization should increase or reduce its size to minimize its average cost of production. By identifying the reference peers, it designates which organisations have the best practices to be analysed [29].

Emphasize that the DEA method is based on mathematical programming and aims to identify the functions of empirical productions [2]. This method compares all similar decision-making units (DMUs) in a given population, taking into account several dimensions simultaneously. Each DUM transforms inputs into outputs and thus consumes an amount m of different inputs in order to produce different outputs. The decision-making unit (DMU) (j) (j=I, ... m) consumes X {ij} of inputs (i=I, ...) and produces Y {rj} of outputs (r = I, ... s). The production boundary is defined from the coordinates of each DMU [30]. This study chooses the CCR radio whose mathematical program is as follows:

Or φ (1)= $\frac{\sum_{i=1}^{n} 1\mu nyn.i}{\sum_{i=1}^{p} 1vnxp.i}$

GOOD (ha, yi) = minφ (φj, han, yi) (2)

Under duress

$\sum_{j=1}^{j} \beta iyi.n \geq yj.0$ (3)

$\sum_{j=1}^{j} \beta ixp \geq \phi.xp.0$ (4)

$\sum_{j=1}^{j} \beta j = 1$ (5)

$\sum_{j=1}^{j} \beta j \geq 1$ (6) [31]

φ being the estimator of the technical efficiency to be calculated for each family holding; x the inputs or inputs used; µ the quantity of inputs; y the outputs obtained and the quantity of outputs. is the intensity vector determining the technical efficiency for each farm; n is the number of outputs (n = 1, 2,..., N); p represents the number of inputs (p= 1, 2, ..., P); j is the jvβth decision-making unit (DUM), i.e., a farm. A family farm will be qualified as efficient if its score j = 1, it will be technically inefficient when ≤ 1. []31; [32].ϕϕ

Orientation, Choice of Inputs and Output

In terms of guidance, there is evidence that farm households have more control over inputs than outputs. This is how the input orientation was chosen. The analysis of the technical efficiency of family farms, producing cassava, retained 3 inputs (the labour force of all cultivation operations, estimated in terms of man/day; the cost of land, estimated in Congolese francs, which contains in itself the area and ultimately the number of 100 m bales) and an output that is production (the number of 100 kg bags of cassava). These are the variables that generated the technical effectiveness scores.

Estimating Procedure

The operationalization of the Tobit model leads to the mathematical equation which is written as follows: Effici* = a + βiXi + εi

With Effici, the value that the latent variable can take continues for the observation of individual i; a: is the value of the y-intercept; βi: is the estimate of the parameters made by the maximum likelihood criterion; Xi: is the set of independent variables as measured for individual i; εi: constitutes the error term of the model, which differs for each observation.

A dependent variable will be said to be significant if the probability calculated on the basis of the "Z" statistic is less than α (0.05 or 0.1). Here is how the Tobit model looks under study:

(Efficiency*) = a +(β1 Gender + β2 Age + β3 Marital status + β4 Educational attainment + β5 Experience + β6 Household size + β7 Non-agricultural activity + β8 Main activity + β9 Peasant dynamics Non-agricultural activity + β10 Exposure to floods + β11 Exposure to drought + β12 Exposure to erosion + β13 Exposure to animal attacks + β14 Exposure to insect attacks + β15 Exposure to disease attacks + β16 Exposure to theft of crops + β17 Extension + β18 Subsidy + β19 Farm-house distance + β20 Land conflicts with other farmers + β21 Land conflicts with the customary chief + β22 Means of access to information + β23 Existence of a market close to the village + β24 Constraints with a negative effect + β25 Traditional practice + β26) Savings +... β49 Production + εi.

Results

Table 2: Distribution of the Dependent Variable (Technical Efficiency Scores)

Level of efficiency	Technical efficiency under CRS or overall efficiency		Technical efficiency under RSV or pure efficiency		Efficiency of scale	
	Staff	Percentage	Staff	Percentage	Staff	Percentage
0,26-0,50	50	6,61	0	0	1	0,13
0,51-0,75	82	10,85	1	0,02	131	17,33
0,76-0.99	570	75,46	633	83,8	521	69
1	53	7.02	121	16	102	12,54
Total	755	100	755	100	755	100
Average	0,89		0,97		0,91	
Maximum	1		1		1	
Minimum	0,35		0,73		0,35	
Standard deviation	0,17		0,04		0,16	

The results in Table 2 show that the overall technical efficiency of cassava production is between 0.35 and 1, with an average of 0.89±0.17. In addition, 7% of producers, or 53 farms, are on the frontier of overall technical efficiency. The majority of producers have a technical efficiency of between 0.76 and 0.99; i.e. 75% of the sample, and 11% of households have a technical efficiency under Crs between 0.51 and 0.75 and for the remaining 7%, this efficiency is between 0.26 and 0.50.

Pure technical efficiency varies between 0.73 and 1, with an average of 0.97±0.04. On the other hand, 16%, or 121 producers in the sample, use the factors of production efficiently, because they are on the production frontier. Also, 83.8% of them have a pure technical efficiency of less than 1 and between 0.76 and 0.99 and 0.02% has between 0.51-0.75.

As for the scale efficiency, it varies from 0.35 to 1, with an average of 0.91±0.16. However, nearly 13%, or 102 farms in the sample, are on the scale efficiency frontier while 69% of producers achieve scale efficiency ranging from 0.76 to 0.99; For 17% of households, their efficiency of scale is between 0.51 and 0.75, while 0.13%, i.e. 1 farm, the efficiency of scale is between 0.26-0.50. This shows that there is room for improvement.

Table 3: Returns to scale

Return to scale	Staff	Percentage
Crescent (Irs)	647	85,5
Constant (-)	102	13,5
Descending (drs)	6	1
Total	755	100

The results in Table 3 shows that 85.5% of cassava producers in Madimba territory work in the zone of increasing returns to scale, 13.5% operate in the zone of constant returns of scale and 1% in the zone of diminishing returns to scale.
The results in the table above have been corrected for heterooscedasticity and incorporate marginal effects.

Table 4: Description of Sociodemographic Variables Conditional on Technical Effectiveness

Variables	Terms	Percentage	p-value Crs	p-value Vrs
Gender	Man Women	44 56	0.0002***	0.0026***
Marital Status	Single Married Divorced Widowed	8 76 6 10	0.0022***	0.1105
Education Level	Uneducated Vocational Training Primary Secondary Higher/University	8 7 34 47 4	0.0212**	0.0154**
	Average	**Standard deviation**	**p-value Crs**	**p-value Vrs**
Age (years)	43	13,6	0.0337**	0.0277
Household members	5	2,3	0.0062***	0.1162
Agricultural experience (years)	10	7,6	0.0081***	0.0056***

Note: *** (significant at 1%), ** (significant at 5%) and *(significant at 10%)

The results in Table 4 shows that all socio-demographic variables are statistically significant of overall technical efficiency, as the p-value< 0.005. However, under pure technical efficiency, those of gender, level of education and experience show a statistically significant difference, with regard to the value of P-value.

Table 5: Description of Environmental, Institutional and Economic Variables Conditional on Technical Efficiency

Variables	Terms	Percentage	p-value Crs	p-value Vrs
Flooding	Never Rarely Regularly	80 16 4	0.1146	0.0467**
Erosions	Never Rarely Regularly	91 7 2	0.0576*	0.0303**
Subsidy	Yes Not	15 85	0.0431**	0.0588*
Constraints	Seeds/Equipment Performance and market Theft of crops Lack of land	38 26 21 14	0.0965*	0.1558
Income in thousands of CF	Less than 1000 100 to 200 201 to 300 More than 300	3 31 35 31	0.0045***	0.0232**

Note: *** (significant at 1%), ** (significant at 5%) and *(significant at 10%)

The results in Table 5 shows that there is a significant difference between overall technical efficiency and the variables of erosion, subsidy, constraint and income. This significant difference is also significant between pure technical efficiency and the variables flooding, erosion, subsidy and income.

Table 6: Description of Technical Variables Conditional on Technical Effectiveness

Variables	**Terms**	**Percentage**	**p-value Crs**	**p-value Vrs**
Land status	Owners Tenants Usufructuaries and free use	45 41 14	0.0004***	0.0022***
Varieties	Billy, Kimpebi and Sumbakani Kizelare, Kitombi et Kolo Kinshasa and others	70 28	0.3729	0.0118***
Charcoal	Yes Not	68 32	0.0003***	0.0013***
	Average	**Standard deviation**	**p-value Crs**	**p-value Vrs**
Surface area (ha)	1.4	**0,9**	0.0000***	0.0000***
Labor (man/day)	96	61	0.0000***	0.0000***
Cost of land	879268.2	**637996.3**	0.0000***	0.0000***
Cuttings (100m boot)	36	**23**	0.0000***	0.0000***
Cost of Cuttings (FC)	179774.8	116733.9	0.0000***	0.0000***
Material Cost (FC)	82999.34	35288.85	0.0000***	0.0000***
Production (100 kg bag)	67	43	0.0000***	0.0000***

Note: *** (significant at 1%), ** (significant at 5%) and *(significant at 10%)

The results reported in Table 6 reveal that there is a highly significant difference between all quantitative technical variables of technical efficiency. This is also the case for qualitative technical variables, which are all significant, except for the variety variable under Crs.

Table 7: Determinants of the Technical Efficiency of Cassava Cultivation

Variables	Crs			Vrs		
	dy/dx	T	P>|t|	dy/dx	T	P>|t|
1. Socio-demographic						
Sex	-.0023231	-0.16	0.870	-.0069032	-2.18	0.029**
Age	.0006721	0.87	0.383	.0001403	0.87	0.382
Marital Status (Single = Reference)						
Married	.0149644	0.54	0.587	.0023417	0.43	0.669
Divorced	-.0369616	-0.87	0.387	-.0007231	-0.08	0.935
Widow	-.096059	-2.54	0.011**	-.0112534	-1.52	0.129
Household size	.002535	0.96	0.339	.0002263	0.39	0.697
Educational Level (Uneducated = Reference)						
Formation. Professional.	.027812	0.76	0.445	.0001122	0.02	0.986
Primary	.0404634	1.52	0.130	.0015477	0.34	0.737
Secondary	.0473974	1.81	0.070*	.0045076	1.02	0.306
Higher and University	.0276741	0.67	0.505	-.0110162	-0.97	0.333
Experiment	.00138	1.84	0.066*	-.0110162	-0.97	0.333
2. Environmental variables						
Floods (never = Reference)						
Rarely	-.0091393	-0.55	0.584	-.004011	-0.95	0.341
Regularly	-.0116477	-0.29	0.772	-.0070278	-0.62	0.533
Erosions (never = Reference)						
Rarely	-.0219371	-0.90	0.366	-.0013906	-0.23	0.818
Regularly	-.0729529	-1.08	0.281	-.004938	-0.33	0.745
3. Institutional and Economic Variables						
Subsidy	.0189521	1.20	0.232	.0043215	1.21	0.226
Constraints (Seeds and Equipment = Reference)						
Falling yields and lack of market	.0560401	2.57	0.010**	.0051095	1.22	0.221
Theft of crops and destruction of fields by animals	.0621056	2.65	0.008***	.0020938	0.43	0.671
Lack of land	.0618674	2.66	0.008***	.0061304	1.37	0.170
Income in CF Thousands (Less than 100 = Baseline)						
100 to 200	.0696515	1.58	0.114	.0124764	1.40	0.162
201 to 300	.0552488	1.26	0.208	.0087669	0.99	0.322
More than 300	.0771479	1.76	0.079*	.0147394	1.65	0.099*

Variables	Crs			Vrs		
	dy/dx	T	P>|t|	dy/dx	T	P>|t|
4. Variables techniques						
Land Status (Owner = Reference)						
Tenant	-.0426407	-2.91	0.004***	-.0014674	-0.49	0.626
Usufructuary and free use	-.024008	-1.34	0.182	-.0031099	-0.81	0.420
Cassava Varieties (Billy, Kimpebi and Sumbakani: Reference)						
Household size	.002535	0.96	0.339	.0002263	0.39	0.697
Educational Level (Uneducated = Reference)						
Kizelare, Kitombi et Kolo	-.0450606	-2.39	0.017**	-.0226637	-6.08	0.000***
Kinshasa and others	.0037661	0.08	0.936	-.0236418	-2.18	0.029 **
Coal Process-ing	.0217997	1.65	0.099*	.003757	1.33	0.183
Production	-.0008835	-0.05	0.958	3.22E-06	9.78	0.000***
Observation = 755 Prob > chi2 = 0.0000 Pseudo R2 = -0.3599 LR chi2(27) = 96.59				Observation = 755 Prob > chi2 = 0.0000 Pseudo R2 = -0.1630 LR chi2(28) = 307.60		

Note: *** (significant at 1%), ** (significant at 5%) and *(significant at 10%)

It emerges from the analysis of these results that the Tobit model used to estimate the determinants of the overall and pure technical efficiency is globally significant at only 1%, because the probability Prob >chi2 = 0.0000. This indicates that at least one variable introduced in each model explains the overall and pure technical efficiency of cassava producers. The results show that under CRS, 8 variables that are associated with the overall technical efficiency of farming households that produce cassava. These variables are primarily socio-demographic: marital status of the head of household (1%), level of education (10%) and experience in agriculture (10%). Then come the institutional and economic variables: constraints and income (1% and 10%) and technical: land status (1%), varieties used (5%) and charcoal processing 10%.

Under Vrs, 4 variables are significantly associated with pure technical efficiency. These are varieties and production (1%), sex (5%) and income (10)%.

Under CRS, with regard to socio-demographic variables, marital status has a negative influence on overall technical efficiency in that when being widowed increases by one, overall technical efficiency decreases by 10% compared to being single. This means that when the head of the household is a widower, the probability that the effectiveness under Crs decreases is high. On the other hand, when the level of education (secondary education) increases by one, the efficiency under Crs improves by 5% compared to the uneducated producer. It goes without saying that education plays a significant role, as it brings new knowledge to producers. Also, experience in agriculture has a statistically significant and positive effect on overall technical efficiency. When this increases by one unit, the probability of the technical efficiency under Crs increasing is 0.002%.

Regarding institutional and economic variables, there is a significant influence between technical efficiency under Crs and the constraints felt by producers. This is because the fact that the yield is stable and that the market is also available influences the overall technical efficiency. The same is true of the theft of crops and the destruction of plantations by animals. When these parameters are controlled, the efficiency increases by 5% compared to the lack of seeds and equipment. It goes without saying that the fields should be protected against thieves and animals. One of the solutions to fight against destruction by animals is to always leave the plantations clean. This is also the case of a lack of soil, which has a significant impact on overall efficiency.

As for household income, it has a significant and positive statistical influence on overall technical efficiency. When the income increases by more than 300 thousand Congolese francs, compared to the income which is lower than it. Indeed, when the income increases by one unit for producers who have more than 300 thousand CF francs, the overall technical efficiency increases by 8% compared to households that do not exceed 100 thousand CF per month.

On the technical variables, the results show that technical efficiency is significantly and negatively impacted by the fact that the producer is a tenant of land. When the fact that the household is a tenant of land increases by one unit, the overall technical efficiency decreases by 4% compared to the one that owns the land. Also, the fact that producers use all-purpose varieties (Kizelare, Kitombi and Kolo) increases by one, the technical efficiency drops by 5% compared to households that use varieties (Billy, Kimpebi and Sumbakani) as well as under Vrs. However, when the intensity of turning the wood into embers increases by one, the technical efficiency increases by 2%.

Under Vrs, if the household is run by a woman increases by one unit, the pure technical efficiency decreases by 0.002% compared to the household where the man is the head of the household. When the income of more than 300,000 FC increases by one, the pure technical efficiency increases by 8% compared to the income of less than 100,000 FC. Also, low production reduces pure technical efficiency. However, environmental variables did not show their influence on overall technical efficiency, so flooding and erosion showed a statistically significant relationship in two-dimensional analysis.

Discussion

After analyzing the data, our results confirm that the producers were technically efficient, with averages ranging from 0.89 to 0.97. These results converge with those of [6] who found that tomato producers were up to 99% efficient. They are also in the same situation with the results of which found an average efficiency level of 76% as well as; 70,72 for cereals in Tunisia [16,21]. Of the technical efficiency frontier, 7% of producers were under Crs, 16% under Vrs and 12.5% under Scale. These figures are higher than those found by that nearly 3% of poultry producers had reached the efficiency frontier under Crs, 14% under Vrs, and 11% under Scale [23]. They are also far superior to those shown by saying that rice farmers who had reached the technical efficiency frontier were in the range of 1.75% under Crs; 5.86% under Vrs and 3.74% under Scale [24]. Regarding maize, 1.82% of maize farmers had crossed the efficiency frontier under CRS; 2.17% under Vrs and 4.12% under Scale.

With regard to the determinants of cassava's technical efficiency, this study found that educational attainment, income, charcoal processing and low constraints had a significant and positive effect on technical efficiency and are therefore its determinants. These results confirm those of [24], according to which the level of education significantly and positively affected the distribution of cassava efficiency scores [24]. They also agree with those of [23] on the significant and positive impact that the level of education has on the technical efficiency of laying hens in Kinshasa [23]. These results further confirm those of that the level of education had a significant and positive effect on the technical efficiency levels of smallholder vegetable farmers in South-West Cameroon [20].

Our results also show the case of owned land ownership, which has a significant and positive effect on technical efficiency. Because being a land tenant significantly and negatively affects the distribution of technical efficiency scores. This is in line with those of stating that the possession of owned arable land had a significant and positive effect on the technical efficiency of cassava producers [22]. Household size was not significant of the model in this study, although it is for [20]. This is also the case for extension services, which were not significant in the model, contrary to the results according to which the extension service significantly and positively explained the technical efficiency of poultry production [23].

In contrast to our results, found that the average technical efficiency of rice producers is 51% and it is 30% for producers who have adopted improved varieties in Maniema in the DRC [24]. This is also the case for pineapple producers who are not technically efficient with regard to the average level which is 0.67 [19]. Also the average level of water use efficiency in Tunisia equal to 64.86% [16]. Our results still differ from those found by who detected the inefficiency of cassava farmers with the mean efficiency score of 0.318 and 0.272 respectively under REV and REC, not to mention that our results are contrary to those of who estimated an average maize producer efficiency score in Benin of 0.6540 [17,22]. This shows that these authors have found that the respective producers are not efficient, and that there is room for improvement.

Conclusion and Implications

The objective of this paper was to estimate the level of technical efficiency of cassava producers. The study used data collected between July and September 2025 from cassava farmers in Madimba territory in Kongo Central in DR. Congo. The non-probability proportional quota sampling method was used and 755 households were surveyed using a paper-based survey questionnaire. The statistical software stata version 15 and DEAP4 were used respectively for the estimation of parameters and the generation of technical efficiency scores, after the data had been entered on Excelle 16.

Among the sampled producers, the results revealed that overall cassava farmers in the study area are effective. The average level of overall technical efficiency is 0.89; it is 0.97 for pure technical efficiency and 0.91 for scale efficiency. It appears from this analysis that 82.5% of producers operate in the efficiency zone. But only 7% have crossed the frontier of overall technical efficiency and 16% have crossed the pure technical efficiency. These producers operate respectively on returns to scale due to 85.5%n increasing; 13.5% constant and 1% decreasing.

The analysis also showed that factors such as the marital status of the head of household, level of education, experience in farming, constraints faced by producers, household income, land status, cassava varieties used, charcoal processing and good harvest play a major role in the completion of the production frontier under CRS. The same is true of the sex of the head of household, income, variety used and production under Vrs.

In terms of implications, the results show that land policy needed to be revisited in order to facilitate access to arable land for households. A policy for the distribution of improved seeds is necessary, as it will aim to boost the production of these poor households who are unable to obtain them at the current price. Also, it will be necessary to put in place a policy towards seed producers so that they are able to put a sufficient quantity of seeds on the market.

The implications also go in the direction of strengthening the capacity of producers through the retraining of producers, and or investment in education; I know that educational attainment is an important factor in this area. It goes without saying that the purchasing power of households should also be supported, so that they can enter the market for factors of production with ease.

Finally, producers will not have to do without the combination of organic and mineral fertilization. For producers, cassava cultivation does not require a mineral amendment, while the poverty of the soil can also be one of the important parameters.

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