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RESOURCE PRODUCTIVITY AND DETERMINANTS OF TECHNICAL EFFICIENCY AMONG CASSAVA FARMERS' IN NORTH CENTRAL, NIGERIA

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Abstract

This research analyzed resource productivity and determinants of technical efficiency among cassava farmers in North Central, Nigeria. This research employed a multi-stage sampling technique. Primary data were used based on a well-designed questionnaire. Inferential and descriptive statistics were employed for data analysis. The results of resource productivity of inputs show that cassava cuttings and fertilizer have the highest and lowest elasticities, respectively. The mean-TE (Technical Efficiency) score of 74% (0.74) indicates that an average smallholder cassava producer in the sample needs about 26% (0.26) additional inputs to get to the frontier. In the TE components, the coefficients of labour, and fertilizers are significant different from zero at 1% probability level. The coefficients of agrochemicals, land inputs are significantly different from zero at 5% probability level, while the coefficient of cassava cuttings are significant different from zero at 10% probability level. In the TIE (technical inefficiency), component the coefficients of age, credit received, members of cooperatives are significant different from zero at 1% probability level. The policy formulations should be directed towards considering technological substitutions and mechanized agriculture. Excessive labour supply, characteristics of the developing agriculture in sub-Saharan Africa, could be pushed into the secondary sector of the Nigerian economy such as the cassava processing industry, therefore generating income, employment and maintaining Nigeria in the first (1st) position in the world ranking in term of cassava output. Also, it is recommended that improved cuttings, agrochemicals, and fertilizers should be made available to cassava farmers at appropriate time to increase productivity. Furthermore, credit should be made available to cassava farmers at a single digit interest rate, devoid of cumbersome administrative procedures.

Keywords: Resource productivity, technical efficiency, cassava farmers, stochastic frontier model, Nigeria

INTRODUCTION

Cassava (*Manihot esculenta*) has a major contribution to the agricultural sector of sub-Saharan Africa particularly in Nigeria. Cassava can be cultivated on poor soils, with low rainfall, with less inputs, and under better management practices and substantially increasing yields with more fertilizers (Gbigbi, 2021). Nigeria occupies the first position in the world ranking as the largest producer of cassava (FAO, 2024). The Democratic Republic of Congo and Thailand occupy the second and the third positions in the 2022 world ranking with approximately 48774623 tons and 34068005 tons of cassava, respectively (FAO,2024). In 2021 and 2022, Nigeria produced approximately 58237500 tons and 6083553996 tons of cassava, respectively (FAO, 2024). In Nigeria, the area cultivated for output of cassava in 2021 and 2022 was approximately 9979330 ha and 10029844 ha, respectively (FAO, 2024). The world output of cassava in 2021 and 2022 was approximately 32601571.5 tons and 330408753.77 tons, respectively (FAO, 2024). In 2021 and 2022, the area cultivated for output of cassava in the world was approximately 31461363 ha and 32043055 ha, respectively. This means that Nigeria produced approximately 17.86% and 18.41% of the world output of cassava in 2021 and 2022, respectively.

Cassava is a good source of carbohydrate and can be consumed in processed or raw form. It can be used to produce garri, fufu, starch, cassava chips, biofuel, alcohol, cassava flour, for human food or industrial purpose (Alabi & Safugha, 2022). Cassava can also be fed to livestock as a protein supplement (Itam et al., 2015). Its production a major source of employment and income for rural dwellers in Nigeria, in addition to being a major food crop for most rural and urban communities in Nigeria (Abang et al., 2001).

Cassava farms in Nigeria are characterized with low productivity. Producers can increase and sustain cassava production within existing resources and available technologies by increasing agricultural productivity and efficiency in resource use (Fan et al., 2012). Despite the position occupied by cassava in addressing the rural poverty, the smallholder farmers who produce the bulk of cassava in Nigeria continue to be inefficient in terms of available resources. The role of efficiency in increasing agricultural output has been widely recognized in both developing and developed countries of the world (Giroh & Adebayo, 2009). However, cassava production is still small-scale and this accounted for low the productivity and the poor returns to capital investment in Nigeria (Itam et al., 2015).

Objectives of the Study

The aim of the paper is to analyze the resource productivity and the determinants of technical efficiency among cassava farmers in North Central, Nigeria. Specifically, the objectives are defined as follows:

(i) to determine the summary estimates of factors on interest,

(ii) to estimate the resource productivity among cassava farmers,

(iii) to evaluate the TE of cassava production, and

(iv) to evaluate the socio-economic stimulus influencing the TIE of cassava production.

MATERIALS AND METHODS

The research employed a multi-stage sampling technique. The total sample number of cassava producers (100 respondents) consisted of 50 cassava producers each from the Federal Capital Territory and the Niger State respectively. Primary sources of data were based on a well-designed questionnaire that was subjected to validity and reliability test. This research used the formula established by Yamane (1967) in obtaining the sample number as follows:

$$n = \frac{N}{1+N(e^2)} = 100 \ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

Where,

n = The Sample Number

N = The Total Number of Cassava Farmers (Number for the 2 States)

e = 5%

The SPEFM (Stochastic Production Efficiency Frontier Model)

According to Alabi et al. (2022), the SPEFM is stated as follows:

$$Y_i = f(X_i, \beta_i)e^{v_i - u_i} \ldots\ldots\ldots\ldots\ldots\ldots(2)$$

$$Ln\,Y_i = Ln\,\beta_0 + \sum_{j=1}^{5} \beta_i\, LnX_i + (v_i - u_i) \ldots (3)$$

$$TE_i = \frac{Y_i}{Y_i^*} \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots .(4)$$

$$TE_{ij} = \frac{F(X_i, \beta)\exp(v_i - u_i)}{F(X_{i,}\beta)\exp(v_i)} \ldots \ldots \ldots \ldots ..(5)$$

$$TE_{ij} = \exp(-u_{ij}) \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots ..(6)$$

Where,
Y_i = Output of Cassava (Kg)
Y_i^* = Unobserved Frontier Output of Cassava (Kg)
X_i =Stimulus
β_i = Vectors of Evaluated Parameters
V_i = Noise Term
U_i= Noise Term due to TIE (Technical Inefficiency)
X_1 = Labour (Mandays)
X_2 = Agrochemicals (Litres)
X_3 = Cassava Cuttings (Kg)
X_4 = Fertilizer (Kg)
X_5 = Land (Ha)

$$U_i = \gamma_0 + \gamma_1 P_1 + \gamma_2 P_2 + \gamma_3 P_3 + \gamma_4 P_4 + \gamma_5 P_5 \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots .(7)$$

Where,
P_1 = Experience in Cassava Farming (Years)
P_2 = Educational Level (Years)
P_3 = Age (Years)
P_4 = Credit Received (Naira)
P_5 = Members of Cooperatives (Years)
γ_0 = Constant Term
$\gamma_1 - \gamma_5$ = Evaluated Parameters
U_i= Noise Term due to TIE

Resource Productivity of Inputs

This is given as:

$$MP_x = \frac{P_x}{P_y} \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots ..(8)$$

$$\beta_{ij}\left[\frac{Y_i}{X_{ij}}\right] = \frac{P_x}{P_y} \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots (9)$$

$$\text{RTS}= \sum \boldsymbol{\varepsilon_p} \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots .(10)$$

Where
MP_x = Marginal Product of the input
β_{ij} = Elasticities of Input ,
P_x = Price of the Stimulus Input,
P_y = Price of Output
Y_i = Output of Cassava
X_{ij} = Stimulus Inputs
RTS = Return to Scale
$\boldsymbol{\varepsilon_p}$ = Input Elasticities

RESULTS AND DISCUSSION

Summary Statistics of Factors of Interest

The summary information about the variables of interest is displayed in Table 1. They include the unit of measurement, mean value ($\overline{\boldsymbol{X}}_{\boldsymbol{i}}$) and SD (standard deviation) for each of the factors used in the evaluation. The average farm size used in cassava production is 1.7 ha. Similarly, the average fertilizer, output, price and labour utilization were approximately 87.96 kg/ha, 35 t/ha, 150000 Naira/ton, and 724.31 man-days, respectively. Also, the cassava farmers had an average of 11 years of school education. The mean age of cassava farmers was 46 years. The farmers had 12 years' experience in cassava farming. Furthermore, the respondents had 5 contacts with extension officers per month. The implication of the large average man-days evaluated signifies that an average cassava farmer depends heavily on the human labour to do most of the activities on the farm, and this is a characteristic feature of the agriculture in developing nations such as Nigeria. This is in agreement with the outcome of Ogundari (2008) who documented that most farming operations in developing nations are not mechanized. This is in agreement with the outcome of Gbigbi (2021) who obtained an average age of 40.79 years for cassava farmers in Delta state, Nigeria. An average cassava producer having the farm size of 1.7 ha is a smallholder farmer who cultivated less than 5 hectares of farmland.

Table 1. Summary Data on Variables

Variables	**Unit of Measurement**	$\bar{X}_i$	**SD**
Land	Hectare	1.7	2.34
Age	Years	46	37.63
Education	Years	11	09.71
Experience	Years	12	10.02
Fertilizer	Kilograms	87.96	47.87
Output	Tons/ha	35	12.06
Price	Naira/ton	150,000	567.04
Labour	Man-days	724.31	720.1
Contact with Extension	Number	5	3.71

Source: Field Survey (2024)

Resource Productivity of Inputs

The resource productivity of inputs and RTS is presented in Table 2. The explanation of the estimates that enter directly the production function is reported as partial elasticities of production. Additionally, this is documented as a way of examining the degree of responsiveness of a relative change in the output of cassava as a result of a relative change in stimulus, this serves as a measure of resource productivity of inputs. The estimated coefficients in the TE component fall between 0 and 1, thus all marginal products (MPs) are positive and diminishing at the mean of factors. This connotes with a preliminary expectation, in consonance with the estimates obtained by Abdulai & Abdulahi (2016) who documented the significant and positive influence of the frontier factors on the output of maize producers in Zambia. According to the model, a 1 % rise in the farm size, labour, fertilizer, agrochemicals, and cassava cuttings could lead to increase in the output of cassava by 0.17%, 0.19%,0.11%, 0.13%, and 0.21%, respectively. The addition of the first order derivatives of the output factors which is called the scale efficiency shows the decreasing return to scale in the frontier model adding up to 0.81. Increasing all factors by a certain proportion will give rise to a less than commensurate rise in the output of the smallholder cassava farmers. In other words, the summation of the partial elasticities ($\sum \boldsymbol{\varepsilon_p}$) of inputs is 0.81.This signifies than an increase in all stimuli at the sample mean by 1% will give rise to an increase in the output of cassava by 0.81 which is significantly different from zero. This outcome is in agreement with Ogunniyi et al. (2013) who obtained an estimated return to scale of 0.54 for the cassava farmers in Oyo state, Nigeria.

Table 2. Resource Productivity of Inputs and RTS

Elasticity($\boldsymbol{\varepsilon_p}$)	Land	Labour	Fertilizer	Agrochemical	Cuttings	RTS= ($\sum \boldsymbol{\varepsilon_p}$)
Estimates	0.17	0.19	0.11	0.13	0.21	0.81

Source: Field Survey (2024)

Determinants of Technical Efficiency (TE) of Cassava Production

The ML (maximum likelihood) estimates of determinants of TE of cassava production using SPEFM is presented in Table 3.

In the TE components, the coefficients of labour, and fertilizers are significantly different from zero at 1% probability level. The coefficients of agrochemicals, land inputs are significantly different from zero at 5% probability level, while the coefficient of cassava cuttings are significant different from zero at 10% probability level. All the coefficient of the factors in the TE are positive and in agreement with a priori expectations. The coefficient of labour is positive at 0.1902 this signifies that a 1% rise in labour input keeping all other factors fixed will give rise to 19.02% increase in output of cassava. In addition, the coefficient of farm size is positive at 0.1705, this means that a 1% increase in farm size keeping all other factors fixed will give rise to 17.05% increase in the output of cassava.

In the TIE (technical inefficiency), all the coefficients of socio-economic factors have negative values. All negative coefficients in the TIE components increase the TE, while the coefficients with positive values increase the TIE of cassava production. The TIE component, the coefficients of age, credit received, members of cooperatives are significant different from zero at 1% probability levels. The coefficients of experience in cassava farming, and of educational level are significant different from zero at 5% level of probability. A 1% increase in the experience in cassava farming keeping all other factors fixed will give rise to 36.07% increase in the TE of cassava production. In addition, a 1% increase of educational level keeping all other factors fixed, will give rise to 24.39% increase in the TE of cassava production.

Table 3. Maximum Likelihood (ML) estimates using SPEFM

Variables	**Coefficient**	**Std. Er.**	***P*-value**
Labour	0.1902***	0.0264	0.000
Agrochemicals	0.1304**	0.0497	0.034
Cuttings	0.2120*	0.0963	0.051
Fertilizer	0.1141***	0.0170	0.000
Land	0.1705**	0.0738	0.039
Constant	2.208***	0.3880	0.000
RTS	**0.81**		
Inefficiency Model			
Experience in Farming	-0.3607**	0.1496	0.041
Educational Level	-0.2439**	0.0956	0.034
Age	-0.2361***	0.0264	0.000
Credit Received	-0.2275***	0.0292	0.000
Members of Cooperatives	-0.2971***	0.0362	0.000
Diagnostics Information of Variance Estimates			
δ^2	4.3463***		
γ(Gamma)	0.8328		
LLF (Log-Likelihood Function)	-817.54		
Mean Efficiency Score	0.74		

Source: Field Survey (2024)

The mean-TE score of 74% (0.74) indicates that an average smallholder cassava producer in the sample needs about 26% (0.26) additional inputs to get to the frontier, in other terms, smallholder cassava producers lose on average 26% of produce due to technical inefficiency (TIE).

In the diagnostic statistics component, the coefficient of variance ratio(γ) also called gamma is 0.8328, this connotes that 83.28% of variations in the output of cassava were due to differences in the TE. Furthermore, this connotes that 83.28% of the random fluctuation in the output of the cassava farmers were due to the farmers' inefficiency. Therefore, reducing the influence of the effect of gamma or variance ratio will improve the output of cassava and greatly enhance the TE of the farmers. The coefficient of total variance (σ^2) also called sigma square is 4.3463, which is statistically significant different from zero at 1% probability level. This means that the model used and the data obtained were well fitted. The LLF (Log-Likelihood function) is -817.54. The outcome is in agreements with results of Itam et al. (2015) who reported that farm size, labour, capital, and cassava cuttings had positive coefficients and significant influence on the output of cassava farmers in Cross River State, Nigeria.

CONCLUSION

This research analyzed the resource productivity and factors influencing the technical efficiency among cassava farmers in North Central Nigeria. The primary data were used for this study based on a well-designed questionnaire administered to the cassava producers. The questionnaire employed was subjected to reliability and validity test. Inferential and descriptive statistics were used for data analysis. The average age, education, experience, labour and output of cassava farmers approximately were 46 years, 11 years, 12 years, 724.34 man-days, and 35 tons per hectare respectively. A measure of the resource productivity of inputs shows that a 1% rise in the farm size, labour, fertilizer, agrochemicals, and cassava cuttings will produce an increase in output of cassava by 0.17%, 0.19%,0.11%, 0.13%, and 0.21% respectively, with cassava cuttings and fertilizer having the highest and lowest elasticities, respectively. The addition of the first order derivatives of the output factors which is called the scale efficiency shows the decreasing return to scale in the frontier model adding up to 0.81. In the TE components, the coefficients of labour, and fertilizers are significant different from zero at 1% probability level. The coefficients of agrochemicals, land inputs are significantly different from zero at 5% probability level, while the coefficient of cassava cuttings are significant different from zero at 10% probability level. In the TIE (technical inefficiency), the component of the coefficients of age, credit received, members of cooperatives are significant different from zero at 1% probability levels. The coefficients of experience in cassava farming, educational level are significant different from zero at 5% level of probability. The mean-TE score of 74% (0.74) indicates that an average smallholder cassava producer in the sample needs about 26% (0.26) additional inputs to get to the frontier. Based on the outcome of this research the following suggestions are made:

(i) The policy formulations should be directed towards considering technological substitutions and mechanized agriculture. Excessive labour supply, a characteristics of developing agriculture in sub-Saharan Africa, could be pushed into secondary sector of the Nigerian economy such as cassava processing industry.

(ii) The ratio of the number of cassava producers to an extension contact should be increased in terms of policy implication, by employing more extension officers to increase cassava productivity and maintain the first position in the global ranking.

(iii) Credit facilities with a low interest rate should be made available to cassava producers devoid of cumbersome administrative procedures to increase productivity.

(iv) Improved cassava cuttings, agrochemicals, fertilizers should be provided for cassava producers at a subsidized rate to increase productivity.

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