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Dynamics and competitiveness of Nigeria's sesame production in international trade: Vector error correction method

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ABSTRACT

This research study evaluated the dynamics and competitiveness of Nigeria's sesame (*Sesamum indicum*) production in international trade. Secondary data were used, in the data period of 1982 to 2022 (41 years). The data used were sourced from NBS, CBN, FAO, World Bank publication, and General Household Survey-Panel (GHS-P) in conjunction with Federal Ministry of Agriculture and Rural Development. The econometric tools used were Augmented Dickey-Fuller (ADF) unit root test, Johansen co-integration test, Zivot – Andrews (Z-A), Lee Strazicich (LM) structural break unit root tests, and vector error correction model (VECM). The result of the ADF unit root test shows that all the test variables were stationary at first difference I (1). The results of the Johansen co-integration test for the time series data shows that the trace test statistics indicate 2 co-integrating equations, the Max-Eigen values also indicates 2 co-integrating equations. The estimated long run effect using VECM shows that area, yield, and world trade in oilseed, were positively and significantly related to the dynamics and competitiveness of Nigeria's sesame seed in international trade. The real exchange rate had a negative coefficient and was non-significantly related to the dynamics and competitiveness of Nigeria's sesame seed in international trade. The coefficient of the error correction term (ECM) is with the expected negative sign and statistically significant at 1% level of probability, this is an indication of a move back towards equilibrium with a magnitude of -0.95. Policies that would encourage exportation of sesame should be pursued and enhancing research activities on improving quality of sesame produced.

1. Introduction

Sesame (*Sesamum indicum*) is one of the world's most ancient oilseed crops cultivated in tropical and subtropical regions (Bedigian 2015). Nigeria's sesame production and export in 2022 was recorded at 450000 tonnes and 297022 tonnes respectively (FAO 2024). Nigeria's sesame area and yield in 2022 was reported at 365080 ha and 1232.9 Kg ha^{-1} respectively (FAO 2024). Nigeria's sesame export value and agricultural products export value in 2022 was recorded at 330.9 million USD and 1.561 billion USD respectively (FAO 2024). According to FAO (2019), the world production of sesame exceeded 5.5 million tonnes in 2017, out of which 57% was produced in Africa and about 40% was produced in Asia. Sesame ranks third among the oilseed crops in the world (Umar 2020). The world trade in oilseed export in 2022 was reported at 197679390 tonnes (FAO 2024). Sesame seeds are very nutritious and are used for edible oil and food (Wacal et al. 2021). Sesame is a good source of healthy fat, plant protein, and can be used as an alternative to animal fats and animal protein in human diets. Sesame is also a good source of minerals, vitamins, and fibre (Zebib et al. 2015). Sesame, in terms of health benefits, is good as an antioxidant and as an ingredient for the pharmaceutical industry. Sesame seeds bring a lot of foreign exchange when exported (FAO 2011). By 2025, it is expected that the global sesame seed international market will be valued at US $17.77 billion (Cision PR Newswire 2019).

Today, competitiveness is one of the most used terms in global trade. In the context of this study, competitiveness on a macroeconomic level is based on market shares for export (Fagerberg 1988). Competitiveness is defined as the ability to produce goods and services that meet the test of international markets and simultaneously expand and maintain real income that raises the welfare of a country's citizens (Haque 1995). According to Umar (2020), competitiveness is substantially related tothe productivity growth of the countries, both at the microeconomics and at macroeconomics level. The real exchange rate (RER) is the key determinans of agricultural export for many countries. It is expected that as domestic currencies depreciate, the agricultural export will increase and vice versa, and this is a measure of competitiveness. The yield (YED) is included in the model to measure the contribution of the agricultural production capacity and technology in use in Nigeria to sesame export earnings. The area (ARE) was used as an indirect measure to capture the effect of rainfall variation. Abbott and Bredahl (1992), reported that the progress and long term competitiveness of agriculture is not associated with short term factors such as price and input costs. For this reason, price and interest rates are not considered in this model. The research gap is that Nigeria's agricultural produce is not competitive enough in the global market. Enough documents on the competitiveness of Nigeria's sesame is needed for policy decisions makers. The specific objectives are to: examine the stationarity and co-integration involving factors of the time series data, and evaluate the factors influencing export competitiveness of sesame production in Nigeria.

2. Materials and Methods

This research study was conducted in Nigeria. Nigeria is located between longitudes 3° and 14° east and latitudes 4° and 14° north (NBS 2016). The country has a land mass of 923 768000 km^2 and is bordered by the Republics of Benin to the west, Niger to the north, Chad to the north-east, and Cameroon to the east, and the Atlantic Ocean to the south. The estimated population of Nigeria stands at 229152217 persons growing at a rate of 2.39% per annum (NPC 2024). Agriculture remains the base of the Nigerian economy, supplying food for most Nigerians and also exporting primary seeds/crops and fruits to other countries. Agriculture employs two-thirds of Nigeria's labour force, contributes over 40% to the Gross Domestic Product (GDP) and provides about 88% of non-oil earnings (NBS 2016). Secondary data were used, the data covered the period 1982 to 2022 (41 years). The data were sourced from World Bank (WB) publications, Central Bank of Nigeria (CBN), Food and Agriculture Organization (FAO), National Bureau of Statistics (NBS), and general household survey-panel (GHS-P) sourced from the National Bureau of Statistics in conjunction with the Federal Ministry of Agriculture and Rural Development. The data were analyzed using the following descriptive and econometric tools:

2.1. Augmented Dickey-Fuller (ADF) model for unit root test

The unit root test is conducted to determine primarily the level of integration among factors under consideration. The unit root test is evaluated through the application of Augmented Dickey-Fuller (ADF). The Augmented Dickey-Fuller model as developed by Dickey and Fuller (1981), Dickey and Wayne (1979) is stated thus:

$$\Delta Y_t = \pi Y_{t-1} + \sum_{j=1}^{P} \gamma_j \, \Delta Y_{t-1} + \varepsilon_t \tag{1}$$

Where, Δ = Notation for the First Difference Operator, π and γ_j = Estimated Parameters, ε_t = Disturbance Error Term, Y_t = Time Series to be Tested, P = Proxy for the Maximum Lag Length for the Variables.

2.2. Johansen co-integration test

Co-integrating is the statistical analysis of the existence of long run equilibrium relationships between the factors. The Johansen co-integrating test is a superior test that relies on asymptotic properties. The Johansen co-integrating test was applied because the factors included in the model are non-stationary at their level form but become stationary after difference. The Johansen co-integrating method gives two (2) test statistics. Firstly, the value of the Likelihood ratio (LR) test which is based on the minimum Eigen-value. Secondly, the value is based on the trace statistics of the stochastic matrix. In other words, the Johansen co-integrating test is analyzed via the Trace statistics and Maximum Eigen-value. The decision rule is that if either is greater than the 5% critical value, we reject the null hypothesis of no co-integration among the variables. If the LR is greater than the critical value, the hypothesis of co-integration is accepted.

The null hypothesis for LR test based on Eigenvalues is as follows:

$$LR_\lambda = T \sum_{i=r+l}^{n} \{(Ln(1-\lambda_i^*)) - (Ln(1-\hat{\lambda}_i))\} \tag{2}$$

Where, $\hat{\lambda}_i$ = Eigen-value of the Unrestricted Model, λ_i^*= Eigen-value of the Restricted Model

T= Total Number of Observation,n=Number of Endogenous Factors, If LR $>$ Critical Value, then the null hypothesis is rejected (the critical value is at $n-r$ degree of freedom), r= The number of co-integration relations of unrestricted model.

2.3. Vector Auto Regressive (VAR)

When the data used are stationary at the same level of differencing, and there is co-integration, then VAR can be combined with error correction and become the vector error correction model (VECM). In general, the model can be defined as:

$$y_{t,i} = c + \sum_{i=1}^{p} \emptyset_i \, y_{t-1} + \varepsilon_t \tag{3}$$

Where,

y_t = the element vector of y at time t, $\emptyset_i$= Matrix order n $\times$ n, element are the coefficient of vector y_{t-1} for i= 1, 2 ….p, p= The lag length, c= Vector intercept, ε_t= Random vector of shock

2.4. The Vector Error Correction model (VECM)

The Vector Error Correction Model (VECM) can be defined as a multiple time series model that evaluates the speed at which a dependent variable returns to equilibrium relationship after a change in an independent variable (Alabi et al. 2022). VECM is interested in both long term and short term relationships. Also, a negative error correction coefficient from VECM gives sufficient evidence of the presence of a short run equilibrium relationship. The size of the error correction coefficient gives the speed of adjustment towards equilibrium. If two (2) factors are co-integrated at the first (1st) difference order, their relationship can be expressed as Vector Error Correction Model (VECM) by taking past disequilibrium as an explanatory factor for the dynamic behavior of the current factor. The VECM corrects the equilibrium error in one period by the next period.

2.5. The Model Specification

The implicit form of the dynamics and competitiveness of Nigeria's sesame (*Sesamum indicum*) production in international trade using vector error correction model (VECM) is given as:

$$\mathrm{SES} = f(\mathrm{ARE}, \mathrm{YED}, \mathrm{WOT}, \mathrm{RER}) \quad (4)$$

Where, SES = The Share of Sesame Export Value as a Percentage of Nigeria's Agricultural Export Value (%), ARE= Area (Ha), YED= Yield (Kgha^{-1}), WOT= World Trade in Oil Seed (Metric Tonnes), RER= Real Exchange Rate (Naira per Dollar). The Vector Error Correction Model (VECM) with co-integration rank r≤ k is presented in its original form as follows:

$$\Delta y_t = c + \Pi Y_{t-1} \sum_{i=1}^{p-1} \Gamma_i \Delta Y_{t-1} + \varepsilon_t \quad (5)$$

Where, y_{t-1} = Vector variable endogenous with 1st lag, Δ= first difference operator, ε_t = noise term, c= vector intercept, Π= matrix coefficient of co-integration, $\Pi = \alpha\beta$, α = vector adjustment, with matrix order (k × r), β= vector cointegration, long term parameter matrix (k × r). Γ_i= matrix with order k × k of endogenous coefficient of the ith variable. The model specification of dynamics and competitiveness of Nigeria's sesame (*Sesamum indicum*) production in international trade is stated thus:

$$Ln\,SES = \alpha_0 + \alpha_1 LnARE_{1t} + \alpha_2 LnYED_{1t} + \alpha_3 LnWOT_{1t} + \alpha_4 LnRER_{1t} + \alpha_5 \mu_{t-1} + \varepsilon_{it} \quad (6)$$

Where,

SES = The Share of Nigeria's Sesame Export Value as a Percentage of Nigerian Agricultural Export

Value (%), ARE_{1t} = Area (Ha), YED_{1t} = Yield (KgHa^{-1}), WOT_{1t}= World Trade in Oil Seed (Metric Tonnes), RER_{1t}= Real Exchange Rate (Naira per Dollar), μ_{t-1}= Lag of the Residual Term Representing Short Run Disequilibrium Adjustment of the Estimates of the Long Run Equilibrium Error, ε_{it}= Stochastic Error Term, α_5= Coefficient of the Error Correction Term ,α_0= Constant Term, $\alpha_1 - \alpha_4$ = Estimated Parameters. The Real Exchange Rate (RER) following Kingu (2014) is calculated by using the following equation:

$$RER = \frac{CPI_{Nigeria}}{CPI_{USA}} \times NER \quad (7)$$

Where, $CPI_{Nigeria}$ = Consumer Price Index of Nigeria, CPI_{USA} = Consumer Price Index of United States of America (US), NER = The Nominal Exchange Rate in Local Currency (₦$$^{-1}$).

3. Results and Discussion

3.1. Descriptive statistics of variables in dynamics and competitiveness of Nigeria's sesame production in international trade

The data covering 41 years on dynamics and competitiveness of Nigeria's sesame production in international trade were subjected to descriptive statistics to examine their means, minimum, and maximum values over the period as well as to evaluate the skewness, kurtosis and the spread and are presented in Table 1. Also, the trends of sesame area and yields within the period of 1982 to 2022 are displayed in Figures 1 and 2. The mean values of ARE, YED and WOT were 366 873.51 ha, 230487 100g ha-^{1} and 90994416.75 tons respectively. The mean values of SEV and APEV were 201.5551 million USD and 21, 582, 877.875 thousand USD respectively. The variables ARE, YED and WOT have maximum values of 4070100 ha, 19932 100g ha^{-1} and 215460396 tons in 2015, 2012, and 2020 respectively (Table 1, Figures 1 and 2), while the maximum values of SEV and APEV were 352 million USD and 1871.2 million USD and this was recorded in the years 2019, and 2021 respectively. The minimum values of ARE, YED, WOT, were 85500 ha, 2999 100g ha^{-1}, and 31907094 tons, and this was recorded in the years 1987, 1985, and 1989 respectively (Table 1, Figures 1 and 2). The kurtosis, skewness, and Jarque - Bera statistic tests were conductedfor the normality of data, the kurtosis of 3 and skewness of 0 implies that the series are normally distributed, while the probability of the Jarque – Bera statistics of greater than 0.05 implies the acceptance of the null hypothesis that the series are normally distributed. All the factors are negatively skewed since their skewness values are less than 0. The factors have kurtosis less than 3 implying that they are not thick tailed, as kurtosis measures the symmetry of the distribution. The probability of estimates greater than the stipulated 0.05 indicate that all the factors are normally distributed. This result is in line with the findings of Umar (2020).

Table 1. Descriptive statistics of variables in dynamics and competitiveness of sesame (*Sesamum indicum*) production in ınternational trade in Nigeria

Variables	ARE (Ha)	YED(100g Ha^{-1})	WOT(tons)	SEV(1000 USD)	APEV(1000 USD)
Mean	366873.51	230487	90994416.75	201551.25	21582877.875
Maximum	4070100	19932	215460396.9	352008	1871202
Minimum	85500	2999	31907094	68000	601069
Std Deviation	634561.72	3122.03	59353571.31	101065.068	651061.7504
Skewness	-0.03571	-0.476825	-0.03224	-0.03563	-0.03748
Kurtosis	2.29824	2.385362	2.36482	2.367624	2.36521
Jarque- Bera	**0.360297**	**0.3254656**	**0.28006926**	**0.28858673**	**0.27050938**
Sum	15041814	230487	3730771087	363224820	122126046
Probability	0.0678956	0.068923	0.072466	0.081254	0.09732
Observation	41	41	41	41	41

Source: FAOSTAT (2024), SEV- Sesame Export Value, APEV-Agricultural Product Export Value, USD-United States Dollar.

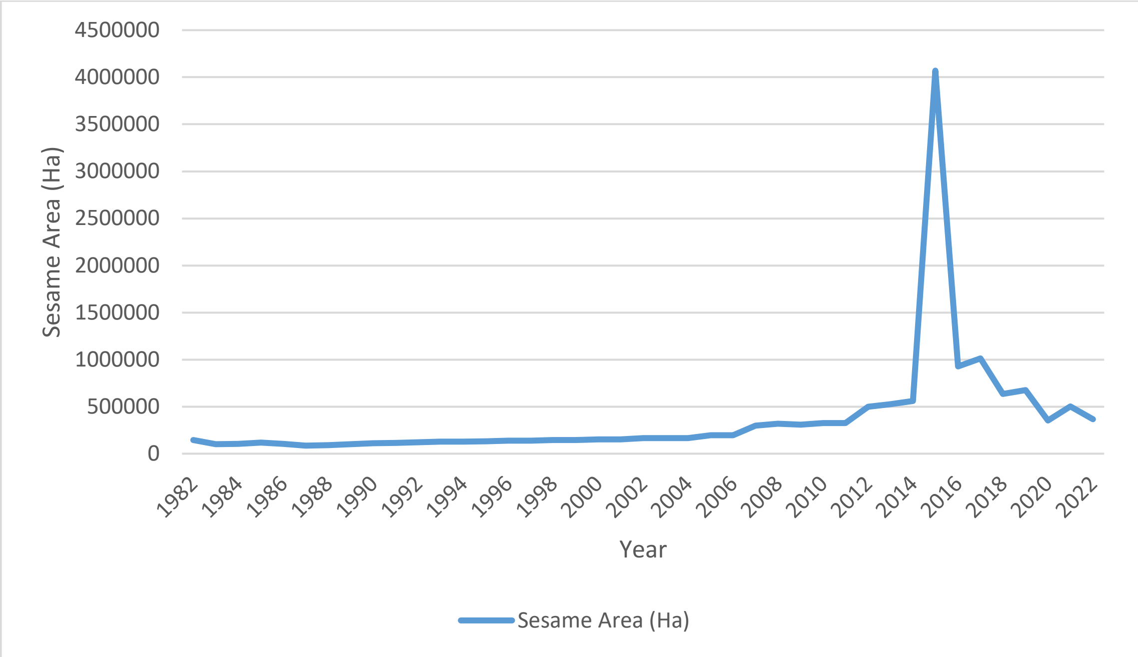

Figure 1. Trends of sesame area in hectare from 1982 to 2022.

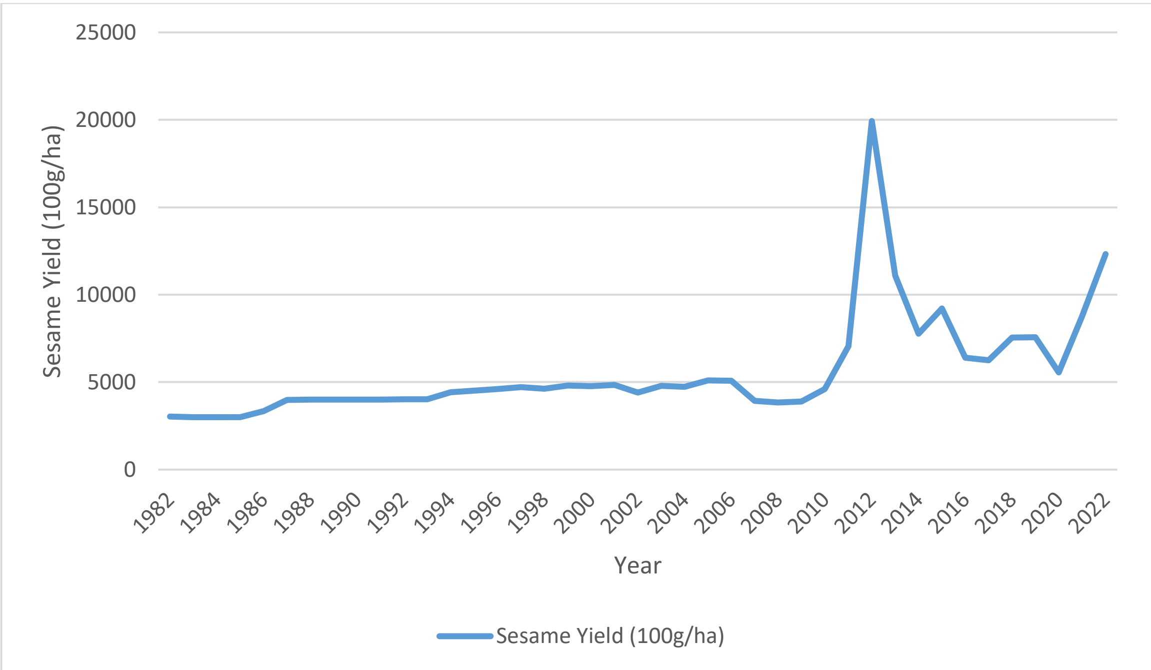

Figure 2. Trends of sesame yield (100 g ha^{-1}) from 1982 to 2022.

3.2. The Augmented Dickey-Fuller (ADF) stationarity

The unit root test is used to examine the stationarity of the time series data. The Augmented Dickey-Fuller (ADF) Statistic was used to test for the stationarity of the series, the results arepresented in Table 2. The critical value at 5% is reported in columns 3. The ADF test statistics are reported in columns 2 and 5. The unit root test was conducted to give information on the characteristics of the time series data used in explaining the dynamics and competitiveness of sesame production in Nigeria. As observed in Table 2, the variables SES, ARE, YED, WOT, and RER attained stationarity after first difference I (1). The result after the unit root tests are displayed in column 6 and the decision is that the time series data were stationary at first difference order one I (1). This gives the justification for using the vector error correction model (VECM) test to test for co-integration and examining short and long run relationships between the variables influencing the competitiveness of sesame production in international trade. This result is in conformity with the findings of Alabi et al. (2022), who obtained similar results while evaluating the export performance of ginger in Nigeria and Okuduwor et al. (2022), who obtained similar result while assessing agricultural export evidence on economic growth in Nigeria.

3.3. Johansen co-integration test

The co-integration test was carried out using the Johansen co-integration test, which is a superior test that relies on asymptotic property and it also robust. The results of the Johansen co-integration test for the time series data arepresented in Table 3. The trace test statistics indicate 2 co-integrating equations. The Max-Eigen statistics also indicates 2 co-integrating equations. The trace statistics and the Max-Eigen statistics are greater than their respective critical values for the 2 co-integrating equations at these points. Thus, the null hypothesis of no co-integrating equations among the time series data is rejected. This signifies that even though the time series of the variables are stationary at 1st difference, their linear combinations are co-integrated. This further means that there exists a long run relationship among the variables at 5% level of significance. This result supports the findings of Alabi et al. (2022) and Aro-Gordon (2017).

3.4. Unit root test with structural break using Zivot-Andrews (Z-A Tests) and Lee Strazicich (LS) Lagrange Multiplier (LM) test

Table 4 shows the Zivot- Andrews (1992) unit root test with a single structural break. From the outcome, the data are not stationary after and at first differenceTherefore, we relied on another, stronger test, the Lee and Strazicich (2004). Table 5 shows the Lee and Strazicich (2004) unit root test indicating two structural breaks. The outcome confirmed that all variables are non-stationary in the level, and are not stationarity at first difference.

3.5. The dynamics and factors ınfluencing the competitiveness of Nigeria's sesame seed in international trade

Table 6 shows the long run effect of ARE, YED, WOT and RER on the dynamics and competitiveness of Nigeria's sesame seed in international trade. The signs and the magnitude of the estimated coefficients indicate that the area of land (ARE) measured in hectares used to cultivate sesame seed has a positive and significant effect on sesame seed production and export at 1% level of significance. This is in line with both apriori expectation and also economic criteria. The result indicates that a unit increase or decrease in ARE will lead to a 0.70 increase or decrease in sesame (SES) export. This shows that the policy of promoting SES production by the government has and can significantly increase the production and export of Nigeria's sesame seed. The yield of sesame production (YED) measured in Kgha^{-1} shows a positive coefficient and significant effect on SES production and export at 1% level of significant. This is also in agreement with apriori and economic criteria. The result indicates that a unit increase in YED will lead to a 0.53 increase in Nigeria's sesame seed export. This has resulted from the

Table 2. Augmented Dickey-Fuller (ADF) stationarity test

Variables	ADF Test Statistics at Levels	5% Critical Value	Order of Integration	ADF Test Statistics at First (1st) Difference	Order of Integration
SES	- 0.39	-2.96	NS	-5.89	I (1)
ARE	- 2.06	-2.96	NS	-7.94	I (1)
YED	- 0.84	-2.96	NS	-7.58	I (1)
WOT	-0.67	-2.96	NS	-7.95	I (1)
RER	- 0.27	-2.96	NS	-5.81	I (1)

NS- Not Stationary.

Table 3. Johansen co-integration test

Null- Hypothesis	Trace Statistics	5% Critical Value	Null-Hypothesis	Max-Eigen Statistics	5% Critical Values
$r = 0^*$	149.34	68.71	$r = 0^*$	74.97	34.87
$r \leq 1^*$	69.86	46.74	$r \leq 1^*$	41.58	28.69
$r \leq 2$	27.60	28.68	$r \leq 2$	14.53	22.24
$r \leq 3$	8.48	16.38	$r \leq 3$	5.86	15.37
$r \leq 4$	2.50	3.92	$r \leq 4$	2.75	3.95

Table 4. Unit root test with structural break using Zivot-Andrews (Z-A Tests)

	Levels			First Difference		
Variables	A	B	C	A	B	C
SES_t	-3.51 (4)	-2.16 (4)	- 2.46 (4)	- 3.41 (4)	-3.76 (4)	-4.52 (4)
TB	1987	2004	1995	2016	2015	2013
$AREA_t$	0.30(4)	-1.17 (4)	- 1.39 (4)	-4.16 (3)	-4.89 (4)	- 4.92 (4)
TB	2016	2016	1994	2008	2016	2016
YED_t	-4.89 (5)	- 4.20(4)	-3.92 (4)	-4.02 (4)	-4.61 (5)	-5.56 (5)
TB	2002	2004	1992	2004	2001	2005
WOT_t	-2.74 (5)	-2.68 (4)	-3.24 (4)	-4.50 (4)	- 3.87 (4)	- 4.69 (4)
TB	2002	2003	1998	2011	2018	2011
RER_t	-4.81 (5)	- 4.39 (4)	- 3.78 (4)	- 4.36 (4)	- 4.53 (4)	- 4.63 (4)
TB	2000	2004	2011	2009	2006	2002

*-Significant at 10% Probability Level, **-Significant at 5% Probability Level, ***Significant at 1% Probability Level, TB-Time of Break, ( ) – Optima Lag Length.

Table 5. Unit root test with structural break using Lee Strazicich (LS) Lagrange Multiplier (LM) Test

Variables	Level	First Difference	I (…)
	A	A	
SES_t	-5.78 (6)	- 6.45 (7)	
TB_1	2003	1998	I (1)
TB_2	2012	2017	
$AREA_t$	- 4.37 (5)	-6.26(7)	
TB_1	2000	2001	I (1)
TB_2	2017	1987	
YED_t	- 5.45 (6)	-5.49 (7)	
TB_1	2004	2001	I (1)
TB_2	2015	1996	
WOT_t	-5.81 (7)	-6.91 (7)	
TB_1	2002	2009	I (1)
TB_2	2012	1994	
RER_t	- 5.92(7)	-6.93 (7)	
TB_1	2004	2011	I (1)
TB_2	1996	2016	

*-Significant at 10% Probability Level, **-Significant at 5% Probability Level, ***Significant at 1% Probability Level, TB-Time of Break, ( ) – Optima Lag Length.

Table 6. Estimated long run result

Variable	Coefficient	Standard Error	t- Value
ARE	0.70***	0.096	7.24
YED	0.63***	0.043	14.75
WOT	0.96**	0.102	9.45
RER	-0.05	0.034	1.48
R^2= 0.692			
DW= 1.91			
F= 69.9**			

DW-Durbin Watson Statistics, **- Significant at 5% Probability Level, ***- Significant at 1% Probability Level.

government's export promotion program, that encourages the development of Micro small and Medium enterprises and which has expanded products and markets for domestic products under various international trade agreements lsuch as the African Growth and Opportunity Act of the United States of America (AGOA), ECOWAS trade liberalization scheme, and the growth of the oil and as industry in Nigeria. This export growth is mainly of a primary nature that commands low prices in the international market due to poor quality, worse still in the environment of volatile exchange rate. The world trade in oil seed (WOT) has a positive and significant effect on Nigeria's SES export at a 5% level of significance, this is in agreement with apriori and economic criteria. The result indicates that a unit increase in WOT will lead to 0.96 increase in Nigeria's SES export, similarly, a unit decrease in WOT will lead to a 0.96 decrease in Nigeria's SES export trade in international market. The growth in Nigeria's SES when world trade in SES export increases will need investment in the production of SES to sustain it, but agricultural credit is difficult to access in Nigeria, this limits the productivity of the farmers. The farmers are resource poor farmers who may not be exposed to improved techniques. The real exchange rate (RER) indicated a negative coefficient and effect on SES export. The result shows that if Naira depreciates by a unit, SES export will increase by 0.05, if Naira appreciates by a unit, SES export will decrease by 0.05. The Nigerian Naira exchange rate has been volatile over the years, and this has implications on the export and import of goods and services including sesame. When the Naira depreciates it makes Nigeria's sesame export cheaper to others from other countries, making it the preferred product. When the Naira appreciates, Nigeria's SES export will be more expensive to the rest of the world, so it will not be preferred. The RER exhibits a negative effect on sesame seed export (SES), but the effect of this on its share of export market growth is low (0.05), this potentially large source of export trade is limited by low human and capital investment in the production of sesame seeds, this is worsened by the primary nature of the seeds, given that this commands low prices, and can be labelled low quality by the market leaders. This results agrees with Umar (2020). The summary statistics in Table 6 shows that the model's estimates are generally robust. The R^2 of 0.692 implies that about 69.2% of total variation in SES is explained by the regressors with the 30.8% accounted for by exogenous factors in the model covered by the error term. The overall model is statistically significant at 5% level of significant as shown by the F-statistics estimated at 69.9. The Durbin Watson statistics was estimated at 1.91 which is very close to 2, this depicts the presence of minimal positive serial correlation. These observations necessitate the test for long run relationships.

The Estimated Long Run Equation is stated thus:

$$\boldsymbol{SES} = 0.70ARE + 0.63YED + 0.96WOT - 0.05\,RER \quad (8)$$
$$(0.096) \quad (0.043) \quad (0.102) \quad (0.034)$$

3.6. VAR lag length selection criteria

The stationarity of the residuals is potent evidence that there is convergence to long run equilibrium among the integrated variables. To be able to ascertain whether there is co-integration among the variables of interest, it is important to first determine the optimal lag of the variables to be used (Table 7). The result shows that all the selection criteria indicate that 1 lag length is selected for application of this study.

3.7. Error correction method

The error correction model (ECM) is designed for use with non-stationary time series that are known to be co-integrated. The ECM has co-integration relations built into the specification so that it restricts the long run behavior of the endogenous variables to converge to their co-integrating relationships, while allowing for short run adjustment dynamics. The co-integration term is known as the error correction term since the deviation from long run equilibrium is corrected gradually through a series of partial short run adjustments. The summary of the error correction model is given in Table 8. The coefficients SES, ARE, YED, and WOT display signs of conformity to a priori expectation, while the coefficient RER does not. The model shows five (5) significant variables, they are SES (P<0.05), ARE (P<0.05), YED (P<0.01), ECM (P<0.01) and Intercept (P<0.05). The parameter estimates of WOT and RER are statistically not significant. The coefficient of the error correction term is with the expected negative sign and statistically significant at 1% level of probability, this is an indication of a move back towards equilibrium with a magnitude of -0.94. The magnitude shows that if there is any deviation, the long run equilibrium is adjusted speedily where about 94% of the disequilibrium may be removed in each period. The coefficient of error correction model was negative at - 0.94. This measures the speed of adjustment towards the long run equilibrium. The coefficient of multiple determinations (R^2) of 0.92 signifies that 92% of dynamics and competitiveness of Nigeria's sesame (*Sesamum indicum*) production in international trade were explained by the test variables included in the model. This signifies goodness of fit, the F-statistics of 32.97 was statistically significant at 1% probability level. This confirmed the good explanatory power of the entire model. This result is in agreementwith the findings of Alabi et al. (2022) and Umar (2020).

4. Conclusion and Recommendations

This study has established that Nigeria has exported sesame seeds in tonnes to the international market within the stipulated period of 1982 to 2022 (41 years). The test variables included in the model were area (ARE), yield (YED), world trade in oil seed (WOT), and real exchange rate (RER). All the test variables were significant and stationarity at first difference I (1) using the Augmented Dickey-Fuller unit root test. The Johansen Co-Integration test conducted shows that co-integration equation exists among the variables. The Trace statistics have 2 co-integrating equations, the Max-Eigen statistics test also indicates 2 co-integrating equations. This further means that there exists a long run relationship among the variables at a 5% level of significance. The Zivot- Andrews (1992) unit root test, with a single structural break, shows that the data are not stationary after first difference, and are not stationary at first difference. The Lee and Strazicich (2004) unit root test showing two structural breaks confirmed that all variables are non-stationary in the level, and are not stationarity at first difference. The vector error correction model was employed because of the existence of co-integration among the test variables. The estimated long run equation shows that the signs and the magnitude of area of land (ARE), cultivated for sesame seed, yield (YED), world trade in oil seeds (WOT) have positive and significant effect on the competitiveness of Nigeria's sesame seed in international trade. While, the real exchange rate (RER) has a negative effect on the competitiveness of Nigeria's sesame seed in international trade. The short run equation shows that the signs and the magnitude of area of land (ARE), cultivated for sesame seed, yield (YED), world trade in oil seeds (WOT) have positive coefficient but only area of land (ARE), cultivated for sesame seed, and yield (YED) have significant effects on the competitiveness of Nigeria's sesame seed in international trade. The coefficient of error correction model was negative at -0.95. Based on these findings the following recommendations were made:

(i) Macroeconomic policies that will stabilize the real exchange rate should be formulated and implemented, (ii) The policies that would encourage exportation of sesame should be pursued. Such policies should be directed towards the provision of storage facilities, granting of tax holidays and long term export credit at concessionary interest rates to exporters of sesame, (iii) Enhancing the productive capacities of farmers of sesame such as provision of basic farm inputs, fertilizer input, chemical input, extension services, and access to land input. Feeder roads infrastructures should be constructed for easy movement of sesame produce to nearby market centres, (iv) Research activities should be financed on improving the quality of agricultural produce devoid of contaminations, pesticides, mycotoxins, and aflatoxins, (v) Government should be consistent on favourable policies that affect international trade such as real exchange rate, and enhancing capacity buildings on proper packaging.

Table 7. VAR lag length selection criteria

Lag	LogL	LR	FPE	AIC	SIC	HQ
0	-165.0	NA	5.83	6.94	8.27	8.04
1	68.7*	379.6*	1.26*	-0.67*	1.67*	0.24*
2	109.4	48.03	2.70	-0.13	4.16	1.48

*-Indicates Lag Order Selected by the Criterion, LR-Likelihood Ratio Test, FPE-Final Prediction Error, HQ-Hannan-Quin Information Criterion, AIC-Akaike Information Criterion, SIC-Schwartz Information Criterion, Log L-Log Likelihood.

Table 8. Error correction model

Variable	Coefficient	Standard Error	t-Statistics
ECM	- 0.95***	0.2398	-3.96
$D(SES$ (-1)	0.69**	0.2685	2.57
$D(ARE$ (-1)	0.08**	0.0323	2.48
$D(YED(-1)$	0.04***	0.0107	3.74
$D(WOT$ (-1)	0.19	0.1376	1.38
$D(RER$ (-1)	0.09	0.0638	1.41
$Intercept$	10.15**	3.406	-2.98
R^2	0.92		
$Adjusted\ R^2$	0.90		
F- Statistics	32.97***		

*- Significant at 10% Probability Level, **- Significant at 5% Probability Level, ***- Significant at 1% Probability Level.

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