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ESTIMATION OF DEMAND FUNCTION FOR MAIZE IN NIGERIA (1981 – 2018)

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Abstract

The study estimated the demand function for maize in Nigeria from 1981 to 2018. The objective was to estimate the short run and long run demand function (including price elasticities) of maize in Nigeria from 1981 to 2018. Secondary time series data were used for the study. The data were analyzed using inferential statistics of which the Johansen Maximum likelihood method of cointegration was used. The results revealed that price of substitute (0.2198) and Policy (-0.321) significantly affected maize demand in the short run with an ECM (-1) of 0.546 while for the long run, price of substitute (0.293), population (2.002) and policy (-0.408) significantly affected maize demand, while the producer price of maize (-0.043) was not significant. It was recommended that development and application of an appropriate maize price support policy to encourage farmers and to promote local production of maize in Nigeria if the country is to reduce the import bill for maize given the growing demand as a result of population growth.

Keywords: Demand function, Maize, Short-run, Long-run

1. Introduction

The position of Africa in the global community has been defined by the fact that the continent is an indispensable resource base that has served all humanity for so many centuries. (Amalu and Amalu,2019) Africa remains the centre of origin and production of several cereal crops like Sorghum, Millet, Maize, Rice and Wheat, with about 3 billion hectares of land of which only 874 million hectares is arable (Food and Agricultural Organization (FAO), 2018). In sub-Saharan Africa (SSA), maize is the most important and extensively-grown cereal staple with a total cultivated area of more than 40million hectares as at 2017 (FAOSTAT, 2018). It is estimated that more than 300 million people in SSA depend on maize as a source of food and livelihood (Macauley and Ramadjita, 2015). According to FAO (2019), maize makes up a fundamental and indispensable part of Nigerian diet and also significantly contributes to ensuring food security among rural and urban households.

Nigeria is basically an agrarian nation and the country's socio-economic history and development has been very closely tied to its agricultural sector. (Agbachom and Amalu, 2016). It is the largest single sector of the economy, providing employment for a significant segment of the work force and constituting the main stay of Nigeria's large rural community which accounts for nearly two-third of the population. The percentage of the GDP attributed to agriculture hovers between 30-40% (CBN, 2018). Nigeria is distinguished by the diversity of its ecosystems, an advantage for growing a broad range of crops. The main staple food crops produced are yam, cassava, rice, maize and beans.

In Nigeria, consumption growth rate of maize in recent years has been on the increase due primarily to population growth, urbanization, competition with animals as feed source and changing dietary habits of consumers. With further increase in population, continual urbanization and industrialization, there will likely be an increase in the consumption of maize in the future. To confront this challenge, agricultural production of maize needs to increase by almost 100% in order to meet the growing demand. (Amalu and Agbachom, 2016). Hence, the estimation of maize demand function in Nigeria is important in the context of short term and long-term policy formulation. The present study was aimed at estimating the short-run and long-run demand function (including price elasticities) of maize in Nigeria from 1981 to 2018.

2. Methodology

Study Area

Nigeria, a country with a total land area of 923,768 square kilometers and a population estimated at about 198 million (NPC, 2018). Nigeria is located between latitudes $4^0$16'and 13^0 53'North and longitudes $2^0$40'and $14^0$41' (NBS, 2018). It is located within the tropics and therefore experiences high temperatures throughout the year. The mean temperature for the country is 27°C and average maximum temperatures vary from 32°C along the coast to 41°C in the far north. (NBS, 2018) The climate of the country varies from a very wet coastal area with annual rainfall greater than 3,500 mm to the dry land savannah and Sahel region in the north, with annual rain fall less than 600mm.

Data collection and Analysis

Secondary time series data were used for the study. Data on consumption of maize were obtained from United States Department of Agriculture (USDA) Database. Data on population, Agricultural Gross Domestic Product (AGDP) were obtained from Central Bank of Nigeria (CBN) Statistical Bulletins for the years 2015 and 2017 while prices of maize and cassava were obtained from FAOSTAT database. This dataset covered the period of 1981-2018.The data were analyzed using inferential statistics (co-integration.)

Model specification

Modelling long-run and short-run relationship

Given that the study used time series data, a preliminary analysis of the unit root test of each variable under investigation using Augmented Dickey Fuller (ADF) test was carried out to avoid a spurious regression. Subsequently, the Johansen's Maximum likelihood (1991, 1995) co integration technique was employed to examine the relationship amongst the variables. Finally, the short run relationship was estimated through Vector Error Correction Model (VECM). Each estimation techniques are discussed hereafter.

Unit root test

A unit roots test analysis of each of the time series of the chosen variables was undertaken to ascertain the order of integration. Here, the order of integration for all the variables must be known prior to co-integration analysis, at least to ensure that variable is not integrated to the order greater than one (Abbott, Darnell and Evans, 2000). Unit root test was conducted using the Augmented Dickey-Fuller (ADF) (Dickey and Fuller, 1979). This was used to test if the selected variables are stationary or not. A stationary series is one with a mean value which will not vary within the sampling period. A non-stationary series will exhibit a time varying mean (Juselius, 2006). The test formula for the ADF is shown in equations 1

$$\Delta Y_t = \alpha + \partial Y_{t-1} + \Sigma\gamma\Delta Y_{t-j} + e_t \text{ ....(1)}$$

Where;

Y = series to be tested

ΔY_t = first difference of Y_t, ∂ = test difference coefficient, j = lag length chosen for ADF, e_t = white noise and t = time or trend variable

Here, the significance of ∂ was tested against the null that $\partial = 0$. Thus, if the hypothesis of non-stationarity cannot be rejected, the variables were differenced until they become stationary, that is until the existence of a unit root is rejected. We then proceed to test for co-integration.

Test for Co-integration

There are several techniques in the literature for testing for co-integrating relationships including Engle-Granger two step test (Engle and Granger, 1987), Autoregressive Distributed Lag Bound approach (Pesaran, Shin & Smith, 2001) and the Johansen Maximum Likelihood procedure (Johansen & Juselius, 1990). Of these techniques, the Johansen & Juselius (1990) Maximum Likelihood test procedure is the most efficient because it identifies the number of co-integrating vectors between the non-stationary level variables in the context of a vector autoregressive term (VAR). The study employed the maximum-likelihood test procedure established by Johansen and Juselius (1990). The starting point for Johansen co-integration test is the Vector Auto Regression (VAR) of order *p* given by:

$$Z_t + \phi + A_1 Z_{t-1} + ... + A_p Z_{t-p} + \varepsilon_t \quad \ldots\ldots\ldots\ldots.. (2)$$

This VAR can be re-written as:

$$\Delta Z_t + \phi + \sum_{i=1}^{n} \Gamma_i \Delta Z_{t-1} + \Pi Z_{t-1} + \varepsilon_t \quad \ldots\ldots\ldots\ldots (3)$$

Where;

$$\Pi = \sum_{i=1}^{p} A_i - I, \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

$$\Gamma_i = -\sum_{j=i+1}^{p} A_j \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$$

Z_t (LnDm) is a (n x 1) vector of all the non-stationary l(1) variables in the study, ϕ is a (n x 1) vector of parameters (intercepts), ε_t is an kx1 vector of innovations or random shocks. Γ and Π are (n x n) matrices of parameters, where Γ_i is a (n x 1) vector of coefficients of lagged Z_t variables. Π is a *(n x 1)* is a long-run impact matrix which is product of two *(n x 1)* matrices. If the coefficient matrix Π has reduced rank *r<n*, subsequently there exist (*n x r)* matrices *α* and *β* each one with rank *r* such that $\Pi = \alpha\beta'$ and $\beta' Z_{t}$is stationary. The *r* is the number of co integrating relationships, the elements of *α* is known as the adjustment parameters in the vector error correction model and each column of *β* is a co-integrating vector.

It is revealed that for a known *r*, the maximum likelihood estimator of *β* defines the combination of Z_{t-1} that yields the *r* largest canonical correlations of ΔZ_t with Z_{t-1} after correcting for lagged differences and deterministic variables once present. Johansen (1995) suggested two different likelihood ratio tests, the trace test which tests the null hypothesis of *r* co-integrating vectors against the alternative hypothesis of *k* co-integrating vectors and maximum eigenvalue test, which tests the null hypothesis of *r* co-integrating vectors against the alternative hypothesis of *r + 1* co-integrating vectors.

Vector Error Correction model (VECM)

If the Johansen co-integration test shows that co-integration exists among the variables, the VECM is used for the evaluation of a short term adjustment which adjusts towards the long run equilibrium in each time period. Based on this, the vector error correction mechanism (VECM) is specified as follows:

$$\begin{aligned}\Delta LnDm_t &= \delta_0 + \sum_{i=1}^{q1} \delta_1 \Delta\, LnDm_{t-1} \\ &+ \sum_{i=2}^{q2} \delta_2 \Delta\, Ln\, Pm_{t-1} + \sum_{i=3}^{q3} \delta_3 \Delta\, LnPs_{t-1} \\ &+ \sum_{i=4}^{q4} \delta_4 \Delta\, LnAGDP_{t-1} \\ &+ \sum_{i=5}^{q5} \delta_5 \Delta\, LnPOP_{t-1} + \\ &\sum_{i=6}^{q6} \delta_6 Policy + \rho ECM_{t-1} + \mu_t \ldots\ldots\ldots\ldots\ldots\ldots (6)\end{aligned}$$

Where;

LnDm = Natural logarithm of quantity of maize demanded (metric tons)

LnAGDP = Natural logarithm of Agricultural Gross Domestic Product proxy for consumer income (in millions of naira)
LnPm = Natural logarithm of own producer price of maize (naira/tons)
LnPs = Natural logarithm of price of substitute (cassava) (naira/tons)
LnPOP = Natural logarithm of Population (in millions)
Policy = (0 = Pre-SAP (1981-1985) 1= SAP (1986-1994), 3= Post-SAP (1995-2018)
Ut = Stochastic residual term
From equation (6), δ_0 is the drift; $\delta_1 - \delta_7$ represent the short-run dynamics coefficients of the model's convergence to equilibrium. ECM_{t-1} is the Error Correction Model. ρ is the coefficient of the Error Correction Model which measures the speed of adjustment to obtain equilibrium in the event of shocks to the system.
U_t = error term

***A priori* expectations**

The *a priori* expectation of the signs of coefficients (equation 6) is that $\beta_1 < 0$, $\beta_2 > 0$, $\beta_3 > 0$, $\beta_4 > 0$, β_5 >/<0, $\beta_6 > 0$, $\beta_7 > 0$, $\beta_8 > 0$, $\beta_9 > 0$

3. Results and Discussion

Short-run and long-run estimates of maize demand in Nigeria

Stationarity test

The result of the Augmented Dickey-Fuller (ADF) test of unit root is presented in Table 1. The test was applied to each variable over the period of 1981 -2018 without a time trend at the variables level and at their first difference. Most of the variables became stationary after first differencing. The findings of the study provide the justification for the Johansen co-integration Approach.

Table 1: Results of ADF Test

Variable (at levels)	ADF(stat)	Variable (1^{st} diff)	ADF(stat)	Order of integration
LnDm	-1.221	DLnDm	-7.146***	I(1)
LnAGDP	-0.129	DLnAGDP	-5.881***	I(1)
LnGNP	-0.393	DLnGNP	-5.619***	I(1)
LnPs	-1.694	DLnPs	-7.282***	I(1)
LnPOP	-0.400	DLnPOP	-7.789***	I(1)

Source: Output from Eviews 10.

NOTE: ***s significant level at 1%. LnDm = Natural logarithm of quantity of maize consumed(metric tonnes). LnAGDP = Natural logarithm of Agricultural Gross Domestic Product (millions) LnGNP= Natural logarithm of Gross National Product (millions), LnPs= Natural logarithm of price of substitutes(cassava)(naira/tons), LnPOP = Natural logarithm of Population(millions)

Co integration test result

Johansen co-integration test was utilized to address the existence of long run relationship among variables in this study. The Johansen co-integration rank test results are presented in Table 2. Both the trace statistics and eigen value statistics in the Table 2 show that there is a unique long run relationship among the variables because in both cases the test shows at most one co-integrating equation at 5 percent level of significance. Thus, the Johansen co-integration test confirms the existence of a unique long run relationship among the variables. Consequently, co-integration test results as shown in Table 2 indicates that the dependent variable is co-integrated, as such the test statistics strongly reject the null hypothesis of zero co-integrating vectors in favor of the alternative hypothesis that there are at least one co-integrating vectors. This is in line with the findings of Hallam & Zanoli (1993) in their exploration of the relevance of the error correction specification to agricultural supply modelling. They reported that, where only one co-integrating equation exist, its parameters can be interpreted as estimate of long run co-integrating relationship between variables concerned. Kargbo (2005) also stated that, the higher the number of co-integrating vectors, the stronger the relationship between the variables in the system.

Table 2: Results of Multivariate co-integration tests for maize demand

Trace					Maximum Eigenvalue				
				Maize Demand					
Null hypothesis	Eigenvalue	Trace statistic	Critical value	Prob**	Hypothesized No. of CE(s)	EigenValue	Max-Eigen Statistic	Critical Value	Prob**
None *	0.718	75.953	69.819	0.015	None *	0.718	44.347	33.877	0.002
At most 1	0.343	31.606	47.856	0.634	At most 1	0.343	14.717	27.584	0.770
At most 2	0.312	16.889	29.797	0.648	At most 2	0.312	13.092	21.132	0.444
At most 3	0.091	3.796	15.494	0.919	At most 3	0.091	3.320	14.265	0.923
At most 4	0.013	0.475	3.841	0.491	At most 4	0.013	0.475	3.841	0.491
At most 7	0.004	0.133	3.841	0.715	At most 7	0.004	0.133	3.841	0.715

* denotes rejection of the hypothesis at the 5% level.

Long- run and short-run VECM estimates for maize demand

Table 3 shows the results of the VECM estimates for maize demand in Nigeria. The underlying model passed diagnostic tests of no heteroscedasticity, and no serial correlation. The result indicates that the own price of maize carried the expected sign but was not significant both in the short-run and long-run. However, the price of cassava (other product) positively and significantly affects maize demand both in the long-run (0.293) and short-run (0.219) at 5 percent and 10 percent significance level, respectively. This implies that an increase in the price of cassava will lead to a significant increase in the maize demand for both periods. The positive sign of the cross-price elasticity of cassava reveals that cassava is a substitute for maize, but was inelastic. This finding agrees with Mushingwani (2009) who found that price elasticity between maize meal price and cassava meal demand was 0.04 suggesting that cassava is a substitute to maize, but inelastic.

The result also showed that maize demand is negatively affected by policy in the long-run (-0.408) at 1 percent level of significance while its short-run effect equally negative (-0.321) and significant at 10 percent probability level. This implies that maize has an inelastic demand and that demand for maize will be less affected by policies such as price increases, import tax reforms, trade restrictions and other government regulations that may cause increases in the price of maize.

The long-run elasticity of population is positive (2.002) and significant at 5 percent level, while the short-run elasticity is negative (-0.076) and not significant.

The error correction coefficient of (-0.546), which measures the speed of adjustment towards long-run equilibrium carries the expected negative sign and it is very significant at the 1% level. The coefficient indicates feedback of about 54.6 percent of the previous year's disequilibrium from the long-run values of the independent variables. The ECM (-1) coefficient indicates that more than 54 percent of the adjustment towards long-run equilibrium for rice demand is completed in one period.

Table 3: Long run and Short-run VECM estimates for maize demand in Nigeria

Variables	Coefficient	Standard Error	t-statistics
Long-run			
C	-24.262	12.34	-1.97*
LNPs	0.293	0.105	2.789**
LNPm	-0.043	0.111	-0.391
LNAGDP	-0.384	0.349	-1.101
LNPOP	2.003	0.963	2.079**
POLICY	-0.408	0.132	-3.081***
Short-run			
C	0.220	0.139	1.592
D(LNPs)	0.219	0.113	1.947*
D(LNPm)	-0.080	0.093	-0.865
D(LNDM(-1))	-0.075	0.082	-0.913
D(LNAGDP(-2))	0.393	0.416	0.945
D(LNPOP)	-0.0761	2.706	-0.028
POLICY	-0.321	0.162	-1.976*
POLICY(-1)	0.209	0.148	1.413
ECM(-1)	-0.546	0.171	-3.183***
Diagnostics		Decision	
R^2	0.383		
Jarque-Bera(normality)	75.107 (0.000)	Evidence of normality	
Bruesch-Godfrey	0.402 (0.673)	No higher-order autocorrelation	
Bruesch-Pagan	2.17(0.064)	No heteroscedasticity	
Durbin –Watson	1.87	No autocorrelation	

Source: Results are based on calculations from Eviews 10

Note: *, ** and *** is significant level at 10%, 5% and 1%, LnDm = Natural logarithm of quantity of maize consumed (metric tonnes), LnPm =Natural logarithm of own price of maize, LnPs = Natural Logarithm of price of substitute (cassava)(naira/tons), LnPOP = Natural logarithm of population(millions), LnAGDP = Natural logarithm of Agricultural Gross Domestic Product, ECM= Error Correction Mechanism $R^{2} =$ coefficient of determination

Conclusion and Recommendation

This paper employed the Johansen maximum likelihood test to cointegration to estimate the short-run and long run demand functions for maize in Nigeria from 1981 to 2018. The results reveal that price of substitute (0.2198) and policy (-0.321) significantly affected maize demand in the short run with an ECM (-1) of -0.546 while for the long run, price of substitute (0.293), population (2.002) and policy (-0.408) significantly affected maize demand, while the producer price of maize (-0.043) was not significant. Thus, the results obtained in this study could be essential in examining the impact of government policy measures on the maize industry. The study recommends development and application of an appropriate maize price support policy to encourage farmers and to promote local production of maize in Nigeria if the country is to reduce the import bill for maize given the growing demand as a result of population growth.

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