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Maize Supply Response To Cross Price Change In Nigeria (1990-2020)

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Abstract
The study examined maize supply response to cross price changes in Nigeria. Time series data were obtained from the Food and Agriculture Organization between 1990 and 2020. Augmented Dickey-Fuller and Phillip Peron tests were used to ascertain the stationarity status of the series. Vector Error Correction Model (VECM) was used to analyze the data. Validity of the estimates was confirmed through normality and structural stability tests. Findings showed that the normalized coefficients of sorghum and millet prices were negative and statistically significant ($p<0.05$), suggesting that these crops were competitive with maize. Conversely, the normalized coefficient of rice was statistically significant ($p<0.05$) but positively signed, indicating that rice was supplementary to maize in supply. Findings further showed that there was unidirectional causality from sorghum price to maize price and from maize price to rice price. Study concluded that as competitive crops to maize, increase in sorghum and millet prices can induce crowd-out effect on maize enterprise. It is therefore recommended that maize dealers keep a close watch and respond appropriately to price change in sorghum and millet crops in order to achieve sustainable maize production and subsequent supply.
Keywords: maize, supply, cross price change, stationarity, long-run, short-run

Introduction

After rice, maize (*Zea mays*) is the second most important cereal in sub-Saharan Africa, including Nigeria. It is extensively grown in a variety of agro-ecological zones of Nigeria (Egwuma & Oladimeji, 2016). Maize production is predominantly done in rainfed ecosystem; it is done mostly by smallholder farmers who cultivate an average of 2 hectares. Thus, it is easily accessible to consumers across the country. Maize is estimated being a source of food and livelihood for more than 300 million people in Sub-Saharan Africa (Agbugba *et al*., 2020; Maqbool *et al*., 2018; Ogunniyi *et al*., 2021). Maize is an important raw material to produce fuel, starch, and food sweeteners, in addition to providing food for humans and livestock (FAO, 2021).

Maize is used for various food commodities and processed into a number of food products. According to Kolawole *et al*. (2021), maize accounts for over 30% of the dietary energy supply. Ewool *et al*. (2016) stated that maize supplies vitamin A in breast milk. Apart from its relevance to feed formulation for livestock, maize is widely used in the industrial sector. According to Ranum *et al*. (2014), an important part of maize production is being used to generate ethanol fuel. With the growth in Nigeria's population, coupled with urbanization and industrialization, the demand for maize is likely to increase. Invariably, increase in demand for a commodity theoretically leads to increase in its own price. Unless, the increase in demand is matched by supply, maize price can, *ceteris paribus*, rise above the reach of an average Nigeria, thus, worsening the prevalent food inflation and food insecurity (Eme *et al*., 2014; Ogbanje & Oraka, 2021; Timmer, 2008; Woertz *et al*., 2014).

After South Africa, Nigeria is the second largest producer of maize in Africa (FAOSTAT, 2018). Maize exports have bright prospects because of their heavy demand. industrialized and major exporting nations. For instance, the Food and Agriculture Organization reported that, maize supply in the United States of America was tight in 2021 as a result of domestic consumption and industrial utilization. The same report held maize quotations from Brazil remained elevated in the same year. On the demand side, international maize purchases by China quadrupled, accounting for nearly all the growth in world maize trade in 2020/21 (FAO, 2021).

On the supply side, the law stated that an increase in the price of a commodity is directly proportional to its supply. This is akin to the goal of profit maximization. However, price changes in a commodity as essential as maize can exhibit asymmetric effect on other grains, which could be competitive, complementary or supplementary. From the perspective of an econometrician, the statistical significance and the sign of price changes in other commodities with respect to the supply of a response commodity will determine the nature of relationship between maize and other grains. This is the concept of cross price. Agricultural supply response represents the agricultural output response to changes in agricultural prices or, more generally, to agricultural incentives (Benton *et al*., 2021; Biswas & Saha, 2014; Olajide *et al*., 2010).

The estimation of agricultural supply response is based on two frameworks, namely, the Nerlovian expectation model and profit-maximizing approach. In the former, price expectations and/or adjustment costs are incorporated to capture agricultural dynamics, while the latter involves the joint estimation of output supply and input demand functions (Ogundari, 2018). The maize supply response in Nigeria has been limited by structural and instrumental constraints that have persisted despite market reforms. Non price factors such as infrastructural condition, marketing services, input availability, credit and government support in the form of research and extension services, weather and soil conditions all affect the supply equation of maize. It was in order to ensure an adequate supply of grains for security in the long- run, coupled with affordability, that this study was undertaken. Hence, the study examined supply response of maize to cross price changes of some selected staple crops

Methodology
Methodology

The Study Area

The study area is Nigeria, located at the extreme inner of the Gulf of Guinea on the West Coast of Africa. Nigeria occupies an area of 923,768 sq. km and it bordered by Chad on the North East, by Cameroon on the East, by the Atlantic Ocean (Gulf of Guinea) on the South, by Benin formerly Dahomey on the West, and by Niger on the North West. Major crops produced in the country includes beans, rice, sesame, cashew nuts, cassava, cocoa beans, ground nuts, and gum Arabic, kola nut, maize, melon, millet, palm kernel, palm oil, plantains, rubber, sorghum, soybean, banana, and yams. In the past, Nigeria was famous for the export of ground nut and kernel oil. The country is not left out in livestock production such as maize, goat, poultry, among others (Abah *et al*., 2021; Agbugba *et al*., 2020; Ajah & Nmadu, 2012).

Design of the Study and Data Collection

The data used were secondary data and were obtained from FAO (FAOSTAT) website. Data were collected on prices and output of maize, millet, rice and sorghum for a period of 32 years (1990–2020).

Method of Data Analysis

i) The study objective was achieved using Maize Supply Response Equation as specified below:

$$LnMOP_t = \lambda_0 + \lambda_1 LnMPt + \lambda_2 LnSPt + \lambda_3 LnMIP_t + \lambda_4 LnRPt + \mu_t ......1$$

Where;

MOP= Maize Output in tonnes

MP= Maize Price in Naira

SP = Sorghum Price in Naira

MIP = Millet Price in Naira

RP = Rice Price in Naira

T= Time series

Ln= Natural Log

λ_{0-4}= Parameter

ii) Stationarity (unit root) test:

The variables in equation 1 were subjected to unit root test so as to avoid spurious regression results. According to Mohammed *et al*. (2014) and Gujarati & Porter (2009), the popular test statistic for variable stationarity diagnosis were Augmented Dickey-Fuller (ADF) Test and Phillips and Perron (PP) test. Hence the two methods were used in testing for unit root property of the variables.

iii) Co-integration Test Using Johansen-Juselius (VECM) Approach

The Vector Error Correction Model approach is a VAR-based test. Each variable is treated as an endogenous variable. Each variable depends on its own lags, the lags of other variables and error correction term. Two test statistics: Trace and Maximal Eigenvalue were used to confirm the presence of co-integration among the variables as suggested by Adeniyi *et al*. (2012), (Osabohien *et al*., 2020) and Santangelo (2018). The test procedure is sequential. First, null of zero co-integration vector against at most one. If rejected, then the null of one against at most two and so on. The lag order of VAR needs to be set by least values of Akaike Information Criterion (AIC) and Schwarz Criterion (SC). With p variables, the maximum number of co-integrating vectors is (p – 1). If the number of co-integrating vectors is p, then ALL variables are stationary.

To avoid small sample biasness as the study' total observation was 31, both statistics – trace and maximal eigenvalue were multiplied by the correcting factor as suggested by Reinsel and Ahn (1992) in Gujarati (2003). The correction factor is specified as (T-np)/T, where T = number of effective observations, n = number of endogenous variables, and p = number of lags

iv) The VECM framework of JJ approach can be illustrated implicitly as follows:

$$\Delta Y_t = \alpha_1 + \sum_{i=1}^{k} \delta_{1i}\, \Delta Y_{t-i} + \sum_{i=1}^{k} \varphi_{1i}\, \Delta X_{t-i} + \lambda\varepsilon_{t-1} + \mu_{1t}$$

$$\Delta X_t = \alpha_2 + \sum_{i=1}^{k} \delta_{2i}\, \Delta Y_{t-i} + \sum_{i=1}^{k} \varphi_{2i}\, \Delta X_{t-1} + \lambda\varepsilon_{t-1} + \mu_{2t} \;.....2$$

Where:

Y_t= Vector for dependent variable (as defined in equation 1)

X_t= vector independent variables (as defined in equation 1)

ε_{t-1}= Error Correction Term in lag

iii) Long run Estimation Using JJ (VEC) Model

The Johansen-Juselius Vector Error Correction model approach, apart from providing information on the variables' co-integration property, also provides the estimate of the long run relation. This was done in line with such authorities as Ogbanje & Ihemezie (2021) and Mehdi *et al*. (2016).

Result and Discussion

Stationarity Status of the Variables

The summary results of unit root status of the variables is presented in Table 1. Both tests, namely, ADF and PP confirmed the existence of unit root at levels in the following variables: MOP, MP, SP, MIP and RP. The result also shows that the variables became stationary only after making the first difference. This implies that estimating the variables using OLS Estimation Method without overcoming the non-stationarity property of the variables can lead to spurious regression. Spurious regression results are meaningless and cannot be used for policymaking. (Mohammed *et al*., 2014).

Co-integration Test Using Johansen-Juselius (VECM) Approach

The test involved determining the set of variables to be tested. This is followed by estimation of a vector error model with lag 1 and check out for whether the error terms for each equation are serially correlated. If correlated, the lag is increased to 2 then 3 until the error terms are not correlated. The final lag is used for co-integration test. The Interpretation of the test is done using statistics (trace and maximal eigenvalue. Schwarz Criterion or Akaike Information Criterion can also be used.

The result of Johansen-Juselius co-integration test is presented in Table 2. To avoid small sample biasness as the study' total observation was 31, both statistics – trace and maximal eigenvalue were multiplied by the Reinsel and Ahn correcting factor. Hence, only the corrected statistics were used for decision on co-integration. The result confirmed the presence of one co-integrating equation at 5% level of significance.

Long-run Estimates

The results in Table 3 show the long-run relationship between the maize supply and the determining factors. The table shows that the normalized coefficient of maize price was statistically significant ($p<0.01$) and had a positive sign. This is in line with *apriori* expectation, as it suggests an increase in the producer price of maize can trigger an increase in the quantity of maize supply in the long run. This finding is in line with (Ogundari, 2018) that maize supply responds significantly to its own price, and it is consistent with the production theory. The normalized coefficient of sorghum price was also statistically significant ($p<0.01$), but with a negative sign. This implies that maize production and subsequent supply could be reduced by price increase in sorghum in the long run. Therefore, sorghum can be considered a competitive crop for maize production and supply. Price increase in sorghum will cause suppliers of sorghum to increase the supply of the commodity as encapsulated in the law of supply, as the goal is profit maximization. One consequence of this market behaviour is that resources that were intended for the production of maize would be diverted to the sorghum sector. Hence, the production of maize would decline. For this reason, an increase in the price of sorghum can lead to a decline in maize production and supply. The normalized coefficient of millet price was also statistically significant ($p<0.01$) and carried a negative sign. This implies an increase in the price of millet will lead to a reduction in the production and supply of maize. As the price of millet rises, for instance, millet suppliers will bring more of the commodity to the market. In like manner, producers of maize are likely to shift their productive resources to the millet sector. As a result, maize supply will decline. In line with the theory of cross-price elasticity, this result is a proof that maize and millet are competitive crops. The behavior of rice price was different, as its normalized coefficient was statistically significant ($p<0.01$) but carried a positive sign. This means that rice crop could be considered as supplementary to maize, as a rise in rice price could increase maize production and supply. The result further implies that, the production and supply of maize is inelastic to the price changes in rice.

Short- run Estimate of Granger Causality Test

The Engle Granger causality test results are presented in Table 4. The results show that Granger causality runs from sorghum price ($p<0.05$) to maize price and not vice versa ($p>0.05$). This implies a unidirectional causality. Consequently, past values of sorghum price changes can be used to predict the price of maize in the current years as well as the future. However, since sorghum enterprise is competitive to maize, the Granger causality effect of price change in sorghum on maize price could be positive on the short run. The results also show that the causality from the price of maize to the price of rice was statistically significantly ($p<0.05$) in the short-run. In other words, the past value of maize price can be used to predict the present price of rice. However, there was no feedback, implying that the causality was also unidirectional. Since, maize enterprise is supplementary to rice, the Granger causality effect of price change in maize on rice price could be neutral on the short run. Post-estimation tests were carried out to validate the results for policy formulation and review. For normality, the result shows that the Jarque-Bera statistic (1.57) was statistically insignificant ($p>0.05$) as shown in Figure 1. Hence, the null hypothesis of normal distribution of errors cannot be rejected. The implication is that the errors of the series were normality distributed. Consequently, the result of the estimation in this study can be confidently recommended for policy formulation and review.

Similarly, there was also a test of structural stability, as shown in Figure 2. Since the blue line lies perfectly between the upper and lower bounds, the model is ascertained to be structurally stable. In other words, the model can withstand any economic shock that occurs to the system. Hence, the estimation in this study can be used for policy formulation and review.

Conclusion

The study assessed the response of maize supply to its own price and the prices of competitive crops. From the findings, increase in the producer price of maize would lead to increase in maize supply in the long-run. While sorghum and millet are competitive crops to maize, rice is a supplementary crop to maize. In the short-run, the sorghum price regime could be used to predict the current and future prices of maize. Similarly, maize price regime could be used to predict price change in rice commodity. Since sorghum and millet enterprises are competitive to maize supply, maize dealers should keep close watch and respond appropriately to price change in sorghum and millet crops in order to achieve sustainable maize production and supply.

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Table 1: Unit root status of the variables

Variable	Level		First Difference	
	ADF	PP	ADF	PP
LMOP	-1.4053	-1.3222	-5.6172***	-5.6172***
LMIP	-2.5394	-2.3817	-5.5928***	-7.9981***
LMP	-2.8528	-2.7284	-8.0118***	-9.4989***
LRP	-2.7585	-2.6247	-7.0492***	-7.0492***
LSP	-3.0813	-3.0188	-5.9373***	-9.2763***

Table 2: Johansen-Juselius Co-integration Test Summary

Null Hypothesis	Test Statistics		[a]Corrected Statistics		Critical Value 5%	
	Trace	Max-Eigen	Trace	Max-Eigen	Trace	Max-Eigen
None*	87.144	44.219	73.089	37.087	69.819	33.877
At most 1	42.925	23.645	36.001	19.831	47.856	27.584
At Most 2	19.277	11.454	16.167	9.606	29.797	21.132
At Most 3	7.823	6.688	6.561	5.609	15.495	14.265
At Most 4	1.134	1.134	0.949	0.949	3.841	3.841

a: Corrected statistics to rid-off small sample biasness as suggested by Reinsel and Ahn (1992),
* Rejection of null hypothesis

Table 3: Long run Estimates using JJ VECM

Co-integrating Variables	Coefficients	Normalized Coefficients	Std. Error	t-statistics
C	-4.987033	4.987		
LMOP(-1)	1.000			
LMP(-1)	-7.772675	7.773	1.45125	5.35586***
LSP(-1)	6.531346	-6.531	0.83370	-7.83417***
LMIP(-1)	4.014970	-4.015	0.98967	-4.05688***
LRP(-1)	-3.632749	3.633	0.63823	5.69193***

*** statistical significance at 1% level

Table 3: Short Run Granger Causality Test

Dependent Variables	Independent Variables				
	X^2 – Statistics of lagged of 1st Differenced Term				
	ΔLMOP	ΔLMP	ΔLSP	ΔLMIP	ΔLRP
ΔLMOP		1.627	1.053	0.047	0.725
		(0.202)	(0.305)	(0.828)	(0.395)
ΔLMP	0.103		4.498**	0.095	0.703
	(0.748)		(0.034)	(0.758)	(0.402)
ΔLSP	0.104	0.746		0.386	2.128
	(0.748)	(0.388)		(0.534)	(0.145)
ΔLMIP	0.068	0.746*	2.097		0.351
	(0.795)	(0.052)	(0.148)		(0.554)
ΔLRP	0.004	4.520**	3.110*	3.768*	
	(0.951)	(0.034)	(0.078)	(0.052)	

*, ** significance at 10% and 5% respectively.
The figure in parenthesis represents P-value of Chi-square statistics

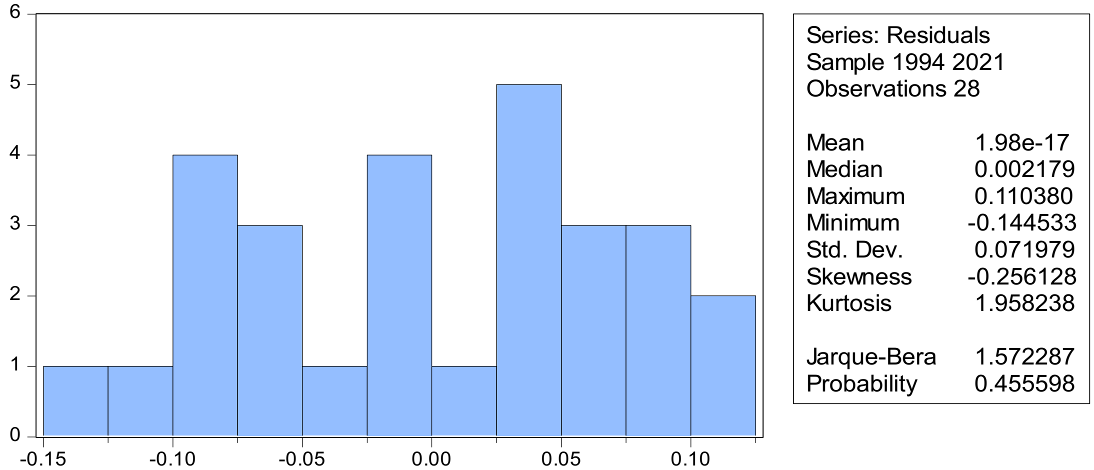

Figure 1: Normality test by Jarque-Bera statistic

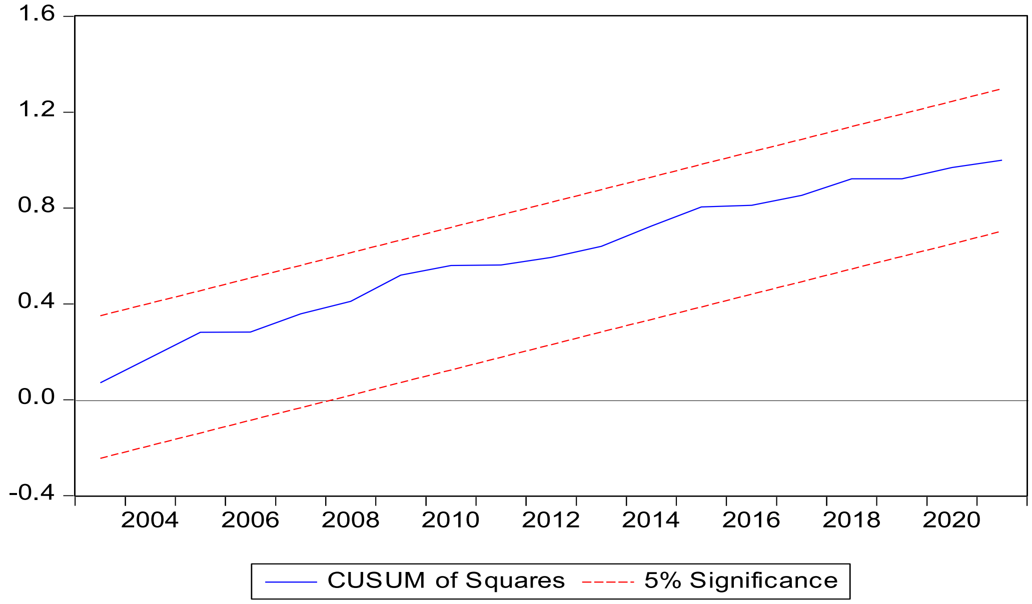

Figure 2: Structural stability test