

RESEARCH ARTICLE

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Modelling the price of Maize and its Determinants in Nigeria: Error Correction Model Approach

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Abstract

Maize is one of the top-ranking cereals in Nigeria based on its use as staple food for the populace and also as raw material for several industries most especially in livestock feed production. Over the years, there has been volatility in maize prices evident in the fluctuation observed which is mostly of an upward trend. Rising food commodity prices, maize especially, coupled with the low income earnings of most individuals has far reaching implication on food security in Nigeria and of course welfare of many, considering maize is a major staple in the country. This study was therefore carried out to identify the determinants of maize price in Nigeria using an error correction approach. Time series data spanning 46 years (1970-2015) was used in the study. Data were secondarily sourced from FAOSTAT, CBN and NBS. Data collected were analysed using econometric tools including Unit root test, Cointegration test and Error correction mechanism. The study revealed that maize price in Nigeria responds negatively to the Gross Domestic Product and positively to Annual money supply, Official exchange rate and insurgency in the long run. Whereas in the short run, maize price is positively influenced by own export quantity, insurgency and trade liberalization while production has a negative influence on the price of maize. Some of the recommendations include the need to: take cognizance of the relevant macroeconomic variables in agricultural planning; encourage farmers to increase maize production; implement policies targeted at regulating maize export such as to ensure this is not detrimental to domestic availability; and intensify effort at tackling insurgency in order to provide producers and traders an enabling trade environment.

Keywords: Co-integration, Error Correction Model, Maize, Price determinants

1. Introduction

Maize is grown worldwide and is a major traditional food cereal in the tropics. In Nigeria, maize production is very popular owing to its increased use as food for humans and livestock. In addition, maize has a relative yield advantage over traditional crops, such as millet and sorghum. International research centers, such as IITA, in collaboration with national research institutes, are continuously developing new maize varieties [5]. Maize is an important food crop in Nigeria due to its high yield potential, storability and diversity of uses [12,4] and it is one of the most important cereal crops being a major staple consumed by households in Nigeria. Maize produced in Nigeria was 7.6 million tons in 2012/2013 of which 1.7

million tons were used for feed production [18]. Nigeria is the 10th largest producer of maize in the world and major producer in tropical Africa with an annual production in excess of 6 million metric tons [17]. There is a rising demand in prices of maize grain owing to its use as an important raw material in the animal feed, food and beverage industries [14] and also in the biogas industry for the production of ethanol. The importance of maize in Nigeria cannot be overemphasized considering the eminent role it plays as a major staple consumed all year round by numerous households. Over the years, there has been very high volatility in the price of maize compared to other cereal

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crops in the country. This may be attributable to the multiplicity of use to which the crop is put. The rising price of maize calls for urgent attention considering the crop plays very pertinent roles in food security in Nigeria and likewise in the economy given its use as raw materials in the livestock industry especially. According to Agboje *et al.* (2013) [3], One of the determining factors to how much an average poor Nigerian can consume this available energy giving food is price. The nominal price of the individual grains has continuously fluctuated over the past years. Akpan *et al.* (2015) [8] stated that agricultural commodity price is one of the major determinants of quantity of commodities supplied by farmers and demanded by consumers. Product price instability among agricultural commodities is a regular phenomenon in markets across Nigeria [7]. Instability in commodity prices among markets could be detrimental to the marketing system and the economy as a whole. It could cause inefficiency in resources allocation among sellers and consumers depending on the source of variability (that is, whether it is induced by supply or demand side or both). It could also increase poverty level among low income earners in the society [8, 16]. Several studies have been carried out to investigate the topical issue of soaring food prices in developed countries. Some of these researches [1, 13] have come up with findings that attribute soaring food prices to increasing biofuel demand, speculation in commodity future markets, countries' aggressive stockpiling policies, trade restrictions, economic growth, exchange rate among others. In Nigeria however, based on the peculiarity and characteristic low level of agricultural technology coupled with the rising population hence higher challenges of attaining self-sustainability in food production, the limelight has lingered on the aspect of improving yield and production of improved varieties of maize such as drought-tolerant, stress tolerant maize varieties to mention a few. For this reason, research has not been rigorous in the aspect of understanding the determinants of maize prices in Nigeria. It is against this background that this study was therefore designed to examine the determinants of maize price in Nigeria from an error correction model approach. This study is justified in that in most cases, despite the fact that rising prices of food commodity will enable farmers garner more incomes hence giving a positive outlook, the volatility in food prices will ultimately impact on the individuals negatively as their food security status may be placed in jeopardy. It may

therefore be substantially said that such situation will eventually affect the economy as a whole hence the need for attention.

2. Materials and Methods

The study area was Nigeria. The country is a federal constitutional republic comprising 36 states and its Federal Capital Territory, Abuja. The country is located in West Africa on the Gulf of Guinea and has a total area of 923,768 km² (356,669 sq mi). Nigeria shares land borders with the Republic of Benin in the west, Chad and Cameroon in the east, and Niger in the north. In some contexts, the states are aggregated into six geopolitical zones: North West, North East, North Central, South East, South South, and South West. Nigeria is a huge country with a diverse climate and terrain. It ranges from the equatorial climate of the southern lowlands, through the tropical central hills and plateau, to the arid northern plains which mark the southernmost extent of the Sahara desert. Nigeria is one of the most ethnically and linguistically diverse countries in the world, with three major ethnic groups (Hausa, Yoruba and Igbo) and several minor ones. It is Africa's most populous country and one of the ten most populous countries in the world. The population is growing rapidly, rising from 88.9 million people in 1991 to 140 million in 2006 and 193.4 million in 2017 [2, 15]. Nigeria is endowed with rich natural resources, of which oil and gas have been the mainstay of the economy in the last few decades, providing 20% of GDP, 95% of foreign exchange earnings, and about 65% of budgetary revenues [19]. About 70% of the population are engaged in agricultural production. However, the largely subsistence agricultural sector has failed to keep up with rapid population growth, and Nigeria, once a large net exporter of food, now must import food [20]. This study engaged time series data sourced from Food and Agricultural Organization statistical data base for United Nations, Agricultural Development Program Offices, publications of National Bureau of Statistics, Federal Ministry of Agriculture and Central Bank of Nigeria. Time series data for a 46-year period spanning 1970-2015 was used and the choice of forty-six years was premised on the need to allow examination of various periods and agricultural programmes basically falling in the pre-liberalization (before 1986) and post liberalization eras. Data collected were analysed using econometric tools including Unit root test, Cointegration test and Error correction mechanism. In order to investigate the

determinants of maize price over the study period, the time series data were first subjected to unit root test which is a basic preliminary test carried out on time series data to establish the order of integration of the variables included in the model. In this study, the augmented dickey fuller test [9] was employed in testing for unit root in the variables. The next stage in the analysis entailed the cointegration test which was to investigate whether time series of the modelled variables display a stationary process in a linear combination despite presence of non-stationarity characteristics in the different variables. This study engaged the two stage Engel-granger procedure [10]. The presence of cointegration would imply the existence of long run relationship between the dependent and independent variables indicating that at least one of the variables modelled react to deviations from the long-run relationship. Following establishing the presence of long run relationship among the variables, the error correction model was specified in order to determine the roles of the modelled independent variables in correction for disequilibrium. The Linear regression model used in order to investigate the determinants of the prices of maize in the period under investigation is considered to be of the general form specified as:

$$\ln Y_{mi} = \beta_0 + \beta_1 \ln X_{1mi} + \beta_2 \ln X_{2mi} + \dots + \beta_{11} \ln X_{11mi} + D_1 + D_2 + \varepsilon_i, \quad i = 1, 2, \dots, 46 \quad \dots (i)$$

Whereas, the short run dynamics between the exogenous variables and the price of Maize is specified as:

$$\Delta \ln Y_{mi} = \theta_0 + \theta_1 \Delta \ln X_{1mi} + \theta_2 \Delta \ln X_{2mi} + \dots + \theta_{11} \Delta \ln X_{11mi} + \theta_{12} D_{1mi} + \theta_{13} D_{2mi} + \theta_{14} ECT_{mi-1} + \tau_{mi} \quad \dots (ii)$$

Where Y_{mi} = Annual producer price of maize (₦/Tonne), X_1 = Annual Production of maize (Tonnes), X_2 = Annual harvested hectareage of maize (Ha), X_3 = Maize annual export quantity (Tonnes), X_4 = Maize annual import quantity (Tonnes), X_5 = Annual World price of maize (\$/Tonne), X_6 = Gross Domestic Product (2005 prices), X_7 = Annual Money Supply (₦), X_8 = Annual Interest rate %, X_9 = Annual USD:₦ Exchange rate, X_{10} = Crude oil Prices (\$/barrel), X_{11} = Constant Price Inflation %, D_1 = Insurgency (1 for yes; 0 otherwise), D_2 = Liberalization era (1 for Post; 0 for Pre), ε_i = Stochastic error term and $\varepsilon_i \sim iid(0, \sigma^2)$, ECT_{i-1} is the error correction term and τ_i is the error term from static regression equation (i). The significance of ECT_{i-1} , is that there exists adjustment

mechanism of maize price as the response to the changes in the exogenous variables modelled in the study.

3. Results and Discussion

Table 1 presents the result of the unit root test carried out on the modelled variables. The ADF statistics revealed that the variables were not stationary at levels but all became stationary after the first differencing. The result also revealed that the variables were integrated after the order of 1 $I(1)$ which therefore qualifies the time series for further econometric testing as previously stated.

In examining the determinant of maize price in the period under investigation, the test for co-integration regression was carried out using Engel-granger procedure which involved estimation of both short and long run models. The logarithmic values of the variables were used in this analysis and the result obtained is as depicted in Table 2.

The result in Table 2 shows the estimates of the parameters based on the Ordinary Least Square method of Regression on which various tests were carried out in order to be able to ascertain the validity of the results that was obtained. Durbin-Watson statistic of 2.188 indicates that there is no problem of autocorrelation since values closer to 2 indicates the absence of autocorrelation in the specified model. With an adjusted R squared value of 0.9818, it can be said that 98.18% of the dependent variable can be explained by the explanatory variables in the model. There was no challenge of heteroscedasticity nor multicollinearity in the specified model given the white test and variance inflation factors respectively as examined.

The result of co-integration regression shown in table 2 indicates that in the long run, gross domestic product, annual money supply, official exchange rate and insurgency were statistically significant at 5%. A unit increase in the gross domestic product can be seen to result in a 1.131 decrease in the prices of maize which implies that the GDP has negative influence on maize prices. This finding is similar to that of Faheem and Dilawar (2015) [11] which indicated that GDP is a determinant of food price inflation in Pakistan, with GDP having an inverse relationship. From the table, it is further revealed that a unit increase in the annual money supply resulted in 0.8745 unit increase in the

prices of maize while a unit increase in the official exchange rate resulted in 0.35547 unit increase in maize prices. On the aggregate, the prices of maize rose by a factor of 0.1638 in those years where there was insurgency in the Nigeria.

The results above are in tandem with expectation as increase in the GDP implies that the economy is thriving. This may be attributed to increased production across diverse sectors of the economy agriculture inclusive which may account for the observed lowered prices. Increase in maize price as annual money supply increased is consistent with apriori expectation and economic principles because the increase in money

supply may in some cases lead to inflation which will cause more money to be available and without a corresponding increase in output, may result in rise in general price level.

In the case of increasing exchange rate, prices of maize in the country may increase as the exchange rate has the chances of making exportation of maize more lucrative and attractive hence causing there to be a competition between domestic availability and maize exportation which has the tendency of increasing the prices.

Table 1: Summary of the Unit Root Stationarity Tests Using Augmented Dickey Fuller (ADF) Statistics

Variable Description	Variable	Statistics	Lag	Levels		Lag	First Differences	
				RWC	RWCT		RWC	RWCT
LnMaize Annual producer Price	Ln Y _m	t Stat	0	-0.883054	-1.505972	0	-8.615916	-8.559106
		P value		0.7846	0.8128		0.0000***	0.0000***
LnMaize Annual Production	Ln X ₁	t Stat	0	-0.64944	-2.086781	0	-6.976459	-6.901456
		P value		0.8489	0.5389		0.0000***	0.0000***
LnMaize Annual Harvested Hect.	Ln X ₂	t Stat	3	-1.534544	-2.639664	0	-6.263247	-6.192183
		P value		0.5066	0.2658		0.0000***	0.0000***
LnAnnual Maize Export Quantity	Ln X ₃	t Stat	1	-0.892023	-2.633694	0	-9.996467	-10.03793
		P value		0.7816	0.2681		0.0000***	0.0000***
LnAnnual Maize Import Quantity	Ln X ₄	t Stat	1	-2.312395	-2.321281	0	-11.38174	-11.26334
		P value		0.1727	0.4142		0.0000***	0.0000***
LnAnnual World Price of Maize	Ln X ₅	t Stat	0	-2.128911	-2.064458	0	-5.849208	-5.797408
		P value		0.2347	0.5509		0.0000***	0.0001***
LnGDP 2005 Prices	Ln X ₆	t Stat	0	1.13413	-0.411865	0	-4.680409	-4.974097
		P value		0.9972	0.9841		0.0004***	0.0011***
LnAnnual Money Supply	Ln X ₇	t Stat	1	-1.489124	-2.203053	0	-4.109184	-4.274751
		P value		0.5298	0.4762		0.0024***	0.0078***
LnAnnual Real Interest Rate	Ln X ₈	t Stat	4	-2.199734	-3.226909	1	-8.218416	-8.137539
		P value		0.2095	0.0934*		0.0000***	0.0000***
LnAnnual Official Exchange rate	Ln X ₉	t Stat	0	-0.253123	-1.611113	0	-5.48839	-5.423135
		P value		0.9236	0.7728		0.0000***	0.0003***
LnAnnual Crude Oil Prices	Ln X ₁₀	t Stat	1	-2.51396	-2.31135	0	-6.271578	-6.362337
		P value		0.1191	0.4193		0.0000***	0.0000***
LnConstant Price Inflation	Ln X ₁₁	t Stat	4	-2.412507	-2.668995	0	-6.79076	-6.7114
		P value		0.1447	0.2541		0.0000***	0.0000***
Insurgency	D ₁	t Stat	1	-1.403675	-2.866222	5	-5.35749	-5.80475
		P value		0.5720	0.1829		0.0001***	0.0001***
Trade Liberalization	D ₂	t Stat	0	-1.359194	-1.626495	0	-6.63325	-6.60803
		P value		0.5937	0.7665		0.0000***	0.0000***

Note: RWC – Random Walk model with Constant RWCT- Random Walk model with constant and Trend Significance at 1%***, 5%** and 10%*

Table 2: Results of the Co-integrating Regression of the Model showing the Determinants of Maize Prices in the Long Run Period

<i>Variable</i>	<i>Co-int Coeff. Est</i>	<i>Std. Error</i>	<i>t-ratio</i>	<i>p-value</i>
Const	4.05501	2.83399	1.431	0.1622
Ln_Maize_prod	-0.641792	0.409174	-1.569	0.1266
Ln_Harv_Hect	0.343467	0.384618	0.8930	0.3785
Ln_Mexp_Qty	0.0172256	0.0174490	0.9872	0.3309
Ln_Mimp_Qty	0.00801379	0.0115850	0.6917	0.4941
Ln_World_price_	0.345095	0.367821	0.9382	0.3552
Ln_GDP_2005	-1.31106**	0.582553	-2.251	0.0314
Ln_annual_Money	0.874492***	0.194058	4.506	8.29e-05
Ln_Real_int_rat	0.001132	0.001691	0.6694	0.5081
Ln_off_xchage_R	0.355547**	0.156519	2.272	0.0300
Ln_CrudeOil_price	-0.352847	0.272132	-1.297	0.2040
Ln_Cons_price_Inf	0.115102	0.0935364	1.231	0.2275
Insurg	0.163823**	0.087119	1.880	0.0492
Trade_liberaliz	0.270746	0.217877	1.243	0.2230
Mean dependent var	3.504002	S.D. dependent var	1.117044	
Sum squared resid	0.726093	S.E. of regression	0.150633	
R-squared	0.987069			
Log-likelihood	30.14936	Akaike criterion	32.29872	
Schwarz criterion	-6.697739	Hannan-Quinn	22.70844	
rho	-0.105523	Durbin-Watson	2.188498	

Findings from this study is in tandem with that of Ajibade *et al.* (2017) [6] where they investigated the impact of selected economic variables of sorghum prices in Nigeria and found that GDP, annual exchange rate and money supply all have influence on sorghum prices. This is an indication that food prices may be generally influenced by certain economic variables.

The Error Correction Model (ECM) was used to find out the short run dynamics of the variables that were included in the specified model. The Error Correction Model was due to the fact that at the first difference, the variables were not stationary whereas the error term was stationary. The results of the short run relationships among the residuals of the variables included in the model is as shown in Table 3. Durbin-Watson statistic of 2.4482 indicates that there is no problem of autocorrelation in the specified model. With an R squared value of 0.6382, it can be said that in the short run, about 64% of the dependent variable can be explained by the explanatory variables included in the model. Diagnostics testing indicated there were no challenges of heteroscedasticity nor multicollinearity thereby indicating the validity of the specified model. The result of co-integration regression shown in table 3 indicates that in the short run, maize production,

quantity of maize exported, insurgency, trade liberalization and error correction model of the residuals were statistically significant at 5%. The error correction coefficient for the model for maize was indicated to be -1.205. A unit increase in the quantity of maize exported may be seen to result in 0.0234 increase in the prices of maize implying that maize export has a positive influence on the price of maize. On the aggregate, price of maize increased in the years that there were insurgency by a factor of 0.1506. Trade liberalization had a negative influence on the price of maize as maize price generally reduced by a factor of 0.14908 in the post liberalization period.

Based on the results indicated in table 3, the coefficient of the error correction model (-1.205) is negative and statistically significant hence indicating there exist a quick convergence to equilibrium in each period with intermediate adjustments captured by the differenced terms. This result therefore validates the existence of a stable long run equilibrium relationship among the time series in the modelled equation. It may be said that the price of maize in the period under study is sensitive to departure from its equilibrium value in the previous period. In the absence of variations in the exogenous variables, the model's deviation from the long run

relation will tend to be corrected by a 120.5% increase in the maize price by the following year.

Table 3: Results of the Error Correction Model Showing the Determinants of Maize Prices in the Short Run Period

<i>Variable</i>	<i>OLS Resid est</i>	<i>Std. Error</i>	<i>t-ratio</i>	<i>p-value</i>
$\Delta \text{Ln Maize annual price}$	0.27061	0.19073	1.4188	0.16662
$\Delta \text{Ln Maize Production}$	-0.23032**	0.32977	0.6984	0.04904
$\Delta \text{Ln Maize Harvested Hect}$	0.06331	0.35808	0.1768	0.86089
$\Delta \text{Ln Maize Export Qty}$	0.0234**	0.01187	1.9717	0.04825
$\Delta \text{Ln Maize Import Qty}$	-0.007	0.00747	-0.931	0.35952
$\Delta \text{Ln Maize World Price}$	-0.4645	0.32918	-1.411	0.16888
$\Delta \text{Ln GDP 2005 prices}$	-0.6664	1.09738	-0.6072	0.54842
$\Delta \text{Ln annual Money Supply}$	0.03451	0.31627	0.1091	0.91387
$\Delta \text{Ln Real Int rate}$	0.00042	0.00097	0.4357	0.66628
$\Delta \text{Ln off exchange}$	-0.3159	0.19781	-1.597	0.1211
$\Delta \text{Ln Crude oil price}$	0.38154	0.23267	1.6398	0.11185
$\Delta \text{Ln Constant price Inflation}$	-0.0575	0.09071	-0.6338	0.5312
Insurg	0.1506**	0.05721	2.633	0.01343
Trade liberalization	0.14908**	0.05768	2.5847	0.01505
ECMm(-1)	-1.205***	0.25135	-4.7944	0.00004
Mean dependent var	0.0652		S.D. dependent var	0.1579
Sum squared resid	0.4517		S.E. of regression	0.1249
R-squared	0.6382			
F(15, 29)	3.4167		P-value(F)	0.0022
Log-likelihood	38.306		Akaike criterion	-46.619
Schwarz criterion	-19.856		Hannan-Quinn	-36.694
Rho	-0.2306		Durbin-Watson	2.4482

As shown in Table 3, one unit increase in the quantity of maize produced is observed to result in 0.23032 unit decrease in the price of maize. This is consistent with apriori expectation since an increase in production will result to a situation of excess supply over demand leading to a fall in prices to re-establish market equilibrium. It is also observed that a unit increase in the quantity of maize exported resulted in 0.0234 unit increase in price of maize. This is in tandem with apriori expectation since exportation of maize will lead to a decrease in the quantity of maize available for domestic consumption and other usage. The inability of supply to meet up the local demand will invariably result in a rise in maize price.

Price of maize can be seen to increase by a factor of 0.1506 during the years that insurgency was recorded in the nation. This is consistent with apriori expectation considering the fact that maize is a cereal crop which is most commonly grown in the Northern part of the Nigeria and incidentally, the Northern region is where most of the unrest and crisis have occurred in the country. The implication of insurgency therefore is far

reaching as traders are forced to buy from peaceful and safer farming communities though at higher prices which invariably affect selling prices of maize subsequently. Trade liberalization also positively influenced the price of maize in the short run. On the aggregate, the price of maize increased by a factor of 0.1491 during the post liberalization era. This implies that prices were lower before market liberalization which means that there some agricultural policies embedded in the pre-liberalization era which worked at stabilizing prices of maize in the nation. Likewise, liberalizing trade imply the removal of government imposed barriers and prices which may have in turn allowed the forces of the market to determine the price of maize rather than the price limit being set by the government. Allowing the market to determine the price may have resulted in increased price of maize in the post liberalization era.

4. Conclusions and Recommendations

Econometric analysis carried out in this study has revealed that maize price in Nigeria responds negatively to the Gross Domestic Product and positively to Annual money supply, Official exchange rate and insurgency in the long run. Whereas in the short run, maize price is positively influenced by own export quantity, insurgency and trade liberalization while production has a negative influence on the price of maize. Based on the foregoing, this study recommends that macroeconomic variables such as annual money supply, official exchange rate and the Gross domestic product must be considered as integral part of agricultural planning in Nigeria given how these have been demonstrated to affect maize price in the Nation. Since increase in maize production influences its own price negatively, it is recommended that maize production should be boosted among by the farmers considering the high impact the crop has on food security in the Nigeria being a major staple food. Exportation of maize should not be at the detriment of the local prices therefore it is recommended that there should be regulatory policies implemented to ensure there is a proper balance between export and local availability of maize in Nigeria. Even though trade liberalization has proven to be beneficial in the market place, there may still be the need for re-implementation of certain policies that existed pre-liberalization in Nigeria considering price of maize generally rose in the post liberalization era meaning that there were some policies in the pre-era which helped in promoting maize price stabilization. Insurgency in Nigeria requires utmost attention in order to maintain good relation among the maize markets in Nigeria considering that insurgency has resulted in rising maize price in Nigeria. Putting checks in place that promotes trade between the regions will definitely keep the price of maize relatively stable in the country.

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