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Price Competitiveness and Supply Response of Rice Producers in Nigeria: Implications for Agricultural Trade

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Authors' contributions

This work was carried out in collaboration among all authors. Author ENA carried out the statistical analysis, design the study and wrote the protocol and first draft of the manuscript. Authors COAU and UO supervised the study and literature searches. All authors read and approved the final manuscript.

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ABSTRACT

This study examined the price competitiveness and supply response of rice producers in Nigeria and its implication for agricultural trade. Specifically, it examined the trade balance for rice; examined price volatility; estimated supply response coefficients and the determinants of supply response of rice producers in Nigeria. Data were collected from secondary sources and covered the period 1972 to 2017. Data analyses were achieved using descriptive and inferential statistics. Results indicated a negative trade balance (x = - ₦20/kg) between imported rice and domestic rice. Price volatility result showed that volatility in agricultural markets was high, with that of imported rice being higher than domestic rice, then maize. Supply response coefficients for rice indicated that production output, price of maize and annual rainfall statistically and significantly influenced supply of rice while domestic price of local rice, price of imported rice and government expenditure on agriculture were not significant. All the series were stationary in the first difference and there was linear combination or long-run equilibrium relationship among the co-integrated variables. There

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were price adjustments between short-run to long-run equilibrium and the error correction coefficient was -0.209. Further results showed that the price and probably favoured quality of imported rice constrained domestic production and negatively impacted rice exports from Nigeria. This indicates a potentially significant impediment to the expansion of rice production in Nigeria. Government must put in place guaranteed minimum price for rice, and be ready to act as buyer of last resort, as incentives for the farmers, to sustainably increase production and the country to attain self-sufficiency in the short-run. Government and non-governmental institutions should provide improved production inputs and modern processing facilities to enhance the competitiveness of local rice against imported rice, both in terms of quality and price.

Keywords: Supply response; rice production; agricultural trade; error correction model; Nigeria.

1. INTRODUCTION

Agriculture is one of the oldest and most important occupation of man. Development of agriculture is important for any country because it is a primary sector of the economy which provides the basic ingredients necessary for the existence of mankind [1,2]. In Nigeria, the sector is an important contributor to the Gross Domestic Product (GDP) and economic development despite the oil boom [3]. This is because it provides employment opportunities for the teeming population, food for the citizens, and is therefore fundamental for cutting hunger and reduction in the burden of food import [4] as cited by [5].

Rice (*Oryza sativa*) is a cereal belonging to the Gramineae, a large monocotyledonous family of some 600 genera and around 10,000 species. Two species have emerged as the most cultivated rice, *Oryza sativa* and *Oryza glaberrima*; with *Oryza sativa* being the more widely produced. Rice is valued as the most important staple food for over half of the world population [6] as cited by [7] and ranks third after wheat and maize in production on world basis. A major staple crop with good prospects for improving food security in the country because of its versatility, wide acceptability and productivity [8].

Nigeria is the continent's leading consumer of rice, one of the largest producers of rice in Africa and simultaneously, one of the largest rice importers in the world [9]. Rice generates more income for Nigerian farmers than any other cash crop in the country [10]. In 2008, Nigeria produced approximately two million metric tonnes (MT) of milled rice and imported roughly three million metric tonnes, including the estimated 800,000 MT that is suspected to enter the country illegally on an annual basis [9].

There has been a dramatic increase in rice production in the country in recent years [11]. However, after a policy turn around towards promoting agriculture, Nigeria has realized an estimated ₦102.6 billion as revenue from the value of rice produced locally by farmers [12]. Local rice production saves Nigeria ₦216 billion from importation [13]. The improvement in rice production in recent years is attributed to various government policies aimed at fast tracking production, for attainment of self sufficiency, thereby conserving huge foreign exchange expended on importation [14]. According to the Agricultural Performance Survey (APS), the estimated cropped area for rice was 3.90 million hectares, which represented an increase of about 6.9 percent over the 3.17 million hectares cultivated in 2016. The survey also reported that a total output of 8.02 million mt (paddy) was produced in 2017 as against the 6.99 million mt recorded in 2016, showing a significant increase in output of about 14.7 percent [15].

The inadequate response of the agricultural sector to meet needs of the rising population and consumer demand highlights the inefficiencies across the supply chain, from production to distribution and marketing. Nigeria's agriculture is largely subsistence and entails large inefficiencies in resource allocation which is compounded in the face of competition from well – protected subsidized farmers in the developed countries, whose products are seemingly dumped into the Nigeria market [16]. Integrating traditional small holder peasants into the market economy is important for stimulating growth, economic development, food security and poverty alleviation. Yet, much remains to be learned-both conceptually and empirically about the commercialization process, the response of farmers, and determinants of supply response in the face of an increasing globalised economy.

Supply response is important in the analysis of economic issues in Nigeria. The farmer's response to price changes is useful for policy information. If farmers respond positively to prices movement, supply of rice will be affected by the increase in price. For Nigeria, this proposed research thus anticipates unraveling the need to support local rice farmers and domestic production effort through price variables. Both forward and backward linkages could be derived by supporting local farms and providing sufficient conditions for better market performance. The potential benefit of rice production and processing will affect all the key players and stakeholders with the purpose of bridging the widening demand-supply gap, improve their income and enhance food security.

There are quite a number of studies that have attempted to estimate supply response of rice farmers in many countries in Africa including Nigeria using both primary and secondary data. This includes [17,18,19,20,21]. The studies can be criticized on the basis that they gave insignificant attention to the analysis of the impact of imported rice prices on supply response in Nigeria's agriculture and also on the basis of the modeling technique adopted. This research sets out to complement the present efforts by the government, non-governmental organization, business firms and the people towards promoting the production, processing, utilization and the exportation of rice in Nigeria and also search for the knowledge that will facilitate the policy makers to put together suitable strategies to facilitate improvement of estimations of the entire proceeds from rice sud-sector of the country. This is particularly important as the dearth of production information makes investors and government agencies to intuitively take decisions that are most often not routinely based on empirical findings.

This novel study therefore aimed at providing empirical evidence of the price competitiveness and supply response of rice producers in Nigeria: implications for agricultural trade. It specifically sought to examine the trade balance for rice in Nigeria; examine the price volatility; estimate supply response coefficients for rice; and establish the determinants of supply response of rice in Nigeria.

2. MATERIALS AND METHODS

The study was carried out in Nigeria. Nigeria is a federal republic in West Africa. The federation comprises of 36 States and one federal capital territory, where the capital Abuja is located [22]. It has a total area of 923,768 sq km (356,669sq.miles) and is contained within a 4900km (3.045miles) land boundary [8] and lies between latitude 10°00' North of equator and longitude 8°00' East of Greenwich Meridian. The population of Nigeria is 195,874,683 in 2018 based on the United Nations estimates [23]. Nigeria is blessed with abundance of resources and has rich land and water resources that are ripe for agricultural expoitation.

This study collated time series data on national rice production and marketing for a period of 45 years from 1972 to 2017. Data for the different variables were obtained from the FAO online statistical database (FAOSTAT), CBN Annual Reports, International Rice Research Institute (IRRI), Annual Statistical year book from the Federal Ministry of Agriculture, National Bureau of Statistic (NBS) and Nigeria Metrological Agency (NIMET). Collected data were analyzed using descriptive and inferential statistics. Nerlovian output adjustment supply function, Unit Root Test, Co-integration analysis and Error Correction regression methods were used for the analyses.

2.1 Analytical Framework

2.1.1 Measurement of volatility

The descriptive statistics used the coefficient of variation to test for the variability that explains the price volatility in agricultural commodities. The coefficient of variation (relative standard deviation) is the ratio of the standard deviation to the mean. It is best used when comparing data sets that use the same units of measure. The higher the coefficient of variation, the greater the level of dispersion around the mean and the lower the value of the coefficient of variation, the more precise the estimate. It is generally expressed in percentage. The standard formula for the coefficient of variation is expressed as:

$$CV = \frac{\sigma}{\bar{x}} \times 100\%$$

$$\sigma = \sqrt{\frac{\sum(x - \bar{x})^2}{n - 1}}$$

where:

cv = the coefficient of variation
σ = the standard deviation
x = each value of the data set
$\bar{x}$ = the mean value of the data set
n = the number of values in the data set.

2.1.2 The supply function

Most agricultural supply response studies have been influenced by the [24] framework. In actual estimations, the original model has been modified in many diverse ways [25]; [26] and [27]. In this research, we assume Y_t to be the yield of rice and P_t indicates the price levels. An implicit supply response function is expressed as:

$$Y_t = f(P_t^d, P_t^m, P^s_t, A_t, R_{t,}, W_{t,}, G_t^x, U_t) \qquad (1)$$

Where,

P_t^d= The domestic price of local rice
P_t^m= The price of imported rice
P_t^s= The price of substitutes
A_t= The acreage
R_t = The exchange rate of Nigeria currency to foreign currency
W_t= The weather condition (e.g. rainfall)
G_t^x= Government expenditure on agriculture
U_t = The stochastic error term assumed to be independently and normally distributed with zero mean and constant variance. A prior it is expected that:

$$\partial f/\partial P_t^d>0; \quad \partial f/\partial P_t^m<0; \quad \partial f/\partial A_t>0; \partial f/\partial W_t>._<0; \partial f/\partial R_t<0; \ \partial f/\partial G_t^x>0 \qquad (2)$$

This means that output is expected to vary positively with domestic price of local rice, but it could fall with the domestic price of imported rice and strengthening of the local currency against major currencies. Output is expected to vary positively with land under cultivation but it could either rise or fall with changes in rainfall depending upon whether or not we have a normal rainfall or flood or drought. Equation (1) could be modified to account for the impact of price of substitute products. Hence we obtain:

$$Y_t= f(P_t^d, P_t^m, P_t^s, A_t, R_t, W_t, G_t^x, U_t) \qquad (3)$$

Supply response could be assumed to be equivalent to response of acreage under cultivation to changes in economic and non-economic factors [28],[29]. Acreage of rice cultivation rather than output may be employed since output could be directly influenced by other extraneous variables e.g. weather, technology, etc. Thus, we have:

$$A_t= f(P_t^d, P_t^m, P_t^s, R^t, G_t^x, W_t, U_t) \qquad (4)$$

However, since yield is fairly constant, then output (Qt) measured as product of yield and area (i.e. Y*A) may tract area better. Hence equation (4) becomes:

$$Q_t= f(P_t^d, P_t^m, P_t^s, R^t, G_t^x, W_t, U_t) \qquad (5)$$

A central problem in the estimation of supply response equation is that producers respond to expected as opposed to actual prices. In addition, observed quantities may differ from the desired ones because of adjustment lags in the reallocation of variable factors. It is imperative, in the spirit of Nerlovian models, that we explicitly specify these adjustment lags and the associated dynamic processes [24],[30]. In this light, we specify the relationship in equation (4) as:

$$q_t^d= \beta_1+\beta_2 P_t^e+\beta_3 Z_t + U_t \qquad (6)$$

where,

q_t^d = The expected output of rice in period t
P_t^e= The expected price
Z_t= The set of exogenous shifters (weather, W_t: exchange rate, R_t)
U_t= accounts for unobserved random effects affecting the output from cultivation and has an expected value of zero

β's are parameters with β_2 the long-run coefficient (elasticity) of supply response for rice.

In Nigeria's peasant agriculture, adjusting the actual acreages towards the desired yield level need not be possible in a single time-period. Response by rice farmers may be constrained by very small acreages combined with the need to diversify production to spread risks, credit constraints, lack of availability of inputs etc. To allow for this possibility, we assume, in the Nerlovian tradition that the change in acreage between periods occurs in proportion to the difference between the expected output for the current period and the actual output in the previous period. In other words, since full adjustment to the desired output level is possible only in the long-run, the actual adjustment in yield and acreage is a fraction (δ) of the expected adjustment. This translates to output changes, i.e.:

$$q_t - q_{t-1}=\delta(q_t^d - q_{t-1})+V_{t,} \qquad (7a)$$

Rearranging:

$$q_t = q_{t-1} + \delta(q_t^d - q_{t-1}) + V_t \; 0 \leq \delta \leq 1 \quad (7b)$$

Where,

q_t= The actual output of rice
q_{t-1}= The actual output in period t-1
q_t^d= The expected output in period t
δ= The partial- adjustment coefficient
V_t = Error term

The relationship is not deterministic, and is affected by random shocks as captured by the error term V_t. The adjustment parameter δ must lie between 0 and 2 for the adjustment to converge over time, but $\delta>1$ implies persistent over-adjustment and does not appear plausible in subsistence peasant agriculture. So we limit δ to lie between 0 and 1.

The price rice farmers expect to prevail at harvest time is not observed. It is thus imperative that we specify a model that accounts for how farmers form expectations based on actual and expected prices. To address this, we employ the method developed by [26]. That is:

$$P_t^e - P^e_{t-1} = \gamma(P_{t-1} - P^e_{t-1}) + \omega_t \quad (8a)$$

Rearranging:

$$P_t^e = \gamma P_{t-1} + (1-\gamma) P^e_{t-1} + \omega_t \quad (8b)$$

Where,

P_t^e = The expected price in period t
P_{t-1}= The price that prevails when decision making for rice cultivation in period t occurs
γ = The adaptive-expectation coefficient
ω_t = A random term with zero expected value.

This formulation accounts for the learning process in which farmers adjust their expectations as a fraction (γ) of the magnitude of the mistake they made in the previous period, by relying on the average price over a long-run period. Since P_t^e and q_t^d are not observable, we eliminate them from equations 6, 7a and 8b. We substitute equation (6) and equation (8b) into equation (7b), and rearrange to yield the reduced form;

$$q_t = \theta_1 + \theta_2 P_{t-1} + \theta_3 q_{t-1} + \theta_4 q_{t-1} + \theta_5 Z_t + \theta_6 Z_{t-1} + e_t \quad (9)$$

Where,

$\theta_1 = \beta_1 \delta\gamma$
$\theta_2 = \beta_2 \delta\gamma$, the short-run coefficient (elasticity) of supply response
$\theta_3 = (1-\delta) + (1-\gamma)$
$\theta_4 = -(1-\delta)(1-\gamma)$
$\theta_5 = \beta_3\delta$,
$\theta_6 = -\beta_3\delta\,(1-\gamma)$,
$e_t = v_t - (1-\gamma)v_{t-1} + \delta u_t - \delta(1-\gamma)u_{t-1} + \beta_2\delta\omega_t$

Equation (9) is the estimatable form of the rice supply response model defined by equation (6), (7b) and (8b). Estimating equation (9) and using the relationship of e_t, we derive unique estimates of β_1 and β_2, but not those of β_3 as noted in equation (6). To derive unique estimates of β_3, we require (unique) estimates of δ and therefore γ. It is possible to obtain $\gamma+\delta=2-\theta_2$ and $\gamma\delta=1+|\theta_3|-\theta_2$ which may possibly yield estimates of δ and γ. However, this does not allow for computation of unique estimates of long-run supply elasticities with respect to the ‘nonprice’ of the reduced form:

$$\theta^2_6 - \theta_4\theta^2_5 + \theta_3\theta_5\theta_6 = 0 \quad (10)$$

The model is estimated using nonlinear, maximum-likelihood techniques. The presence of the lagged dependent variable term introduces (first-order) autocorrelation in the error term and correction must be made for the serial correlation. The structural coefficients are solved with the following equations:

$$\theta^2 + (\theta_3 - 2)\delta + 1 - \theta_3 - \theta_4 = 0$$

$$\gamma = 1 + \theta_4/(1-\delta),$$

$\beta_1 = \theta_1/\delta\gamma$,
$\beta_2 = \theta_2/\delta\gamma$, the long-run coefficient (elasticity) of supply response

$\beta_5 = \theta_5/\delta\gamma$

The short-run price response is estimated by θ_2, and the long-run price response is calculated as β_2, where $\beta_2=\theta_2/\delta\gamma \geq \theta_2$ since both δ and $\gamma \leq 1$. As expected, the long-run supply response exceeds the short-run supply response.

2.1.3 Co-integration and error correction modeling: Estimation techniques

The established technical relationships from equation (1) to equation (10) and experiences from previous studies, allows for the specification of an empirical parsimonious supply function (in the double log form) as follows:

$$\ln q_1=\theta_1+\theta_2 \ln P_{t-1}^{d}+\theta_3 \ln P_{t-1}^{m}+\theta_4 \ln q_{t-1}+\theta_5 \ln P_t^{s}+\theta_6 \ln W_{t-1+}\theta_7 \ln G_{t-1}^{x}+\theta_8 d+e_t \quad (11)$$

The other variables are as previously defined, and d is related to dummy variables. Given that the research employed techniques in time-series statistical and econometric analysis to establish the validity of the model [31]; [32]. The Engle-Granger approach is employed [32], and we test for possible co-integration. We begin by testing whether the data series for each variable involved in the empirical model exhibit similar statistical properties, by testing for stationary in each of the series. The Augmented Dickey-Fuller (ADF) statistics are used to test for stationarity and the lag length chosen that ensures that the residual is empirical white-noise (to test if errors are serially correlated or otherwise).That is, for each variable, per se:

$$\Delta q_t = \psi_0 + \Omega q_{t-1} + \sum_{t=1}^{k} \omega \Delta \bar{q}_{t-1} + \varphi_t \quad (12)$$

Where the lag length K chosen for ADF ensures that φ_t is empirical white noise. Ho (null hypothesis) holds that a_t is 1(1) as against H_a being 1(0). H_o is rejected if the t-statistics on Ω is negative and statistically significant when compared to appropriate critical values established for stationary tests. If found to be non-stationary, the series a_t requires differencing to become stationary. Once stationary properties of all the individual series (q_t, P_t^d, P_t^m, q^t) are established. Linear combinations of the integrated series are tested for co-integration, for unless they co-integrate, they cannot describe equilibrium relationships. In sum, an equilibrium relationship exists when variables in the model are co-integrated [33]. The idea of co-integration suggests that if q(t) and p(t) are both integrated of order 1, i.e.1(1), without trends in means, so that their changes are both 1(0) and with zeros means, then it is possible that there exists a constant such that a linear combination of q(t) and p(t), say x(t) - kp(t) =z(t) is 1(0). The variables are also tested for casual relationship, using the Granger causality test. We then test for the nature of the equilibrium relationship that exists between variables in the model. If established that the data series have a long-run equilibrium relationship but have significant short-run divergences, the model is given an error-correction representation, theoretically defined as:

$$\Delta q_1= \pi_0+ \pi_1 \Delta q_t^{*}+\pi_2|q_{t-1}^{*} - q_{t-1}| \quad (13)$$

Where,
Δq_t^* is the change in the desired equilibrium level. The error correction mechanism captures the short-run dynamics, while making the model consistent with long-run dynamics.

3. RESULTS AND DISCUSSION

3.1 Statistics of Variables and Trade Balance for Rice

Table 1 shows descriptive statistics results of mean, minimum and maximum for rice output and its related variables for the data series. For the time period under study, rice has a minimum output of 310,000MT and a maximum output of 4,662,000 metric tonnes (MT) with a mean of 1,730,674MT. Domestic price of local rice for one kilogram on the average was ₦61.27, with a minimum of ₦0.63 and a maximum of ₦296.24. The mean, maximum and minimum prices of one kg of imported rice were ₦81.67, ₦406.30 and ₦1.89 respectively. Comparatively, the mean price of one kg of imported rice which was ₦81.67 was higher than that of domestic rice (₦61.27) by ₦20.40. The higher price of imported rice gave rise to high demand for local rice.

The average rainfall as it affected rice production took the mean value 1406.37 millimeter (mm) showing a steady supply of rainfall to the production of rice in Nigeria. Generally, the standard deviations of the variables were also very high indicating wide variations in the period under study. The trade balance for rice was -₦20.40 indicating a negative balance or trade deficit. This implied that greater percentage of the rice consumed was imported.

Trade balance = Mean price of domestic rice – Mean price of imported rice

= ₦ 61.266– ₦ 81.669

= - ₦20.40.

3.2 Price Volatility

Using price data extracted from National Bureau of Statistics and Federal Ministry of Agriculture and Rural Development for domestic rice, imported rice and its substitute (maize) and computing the coefficient of variation (cv) of changes in price from 1972-2017, Table 2 showed increasing volatility over time for the commodities. The result indicated that between 1972 to 1982 that the imported rice prices fluctuated by 23.53%, domestic rice prices fluctuated by 54.74% and for substitute (maize), the price fluctuated by 41.57%. The highest mean price for the period was ₦222.61 recorded between 2007 to 2017 for imported rice, with a median of ₦197.40 and standard deviation of 83.06. The imported rice price had the highest coefficient of variation of 70.26% reflecting highest fluctuation in price, followed by the domestic rice price (62.85%) and the price of the substitute (maize) (56.68%) during the period 1983-1994. When comparing coefficient of variation values between the sub-time period 1972-1982 and 1983-1994, the values are higher for the second (1983-1994) sub-time period for all commodities than the first (1972-1982) sub-time period. The highest increase is shown for imported rice price from 23.53% to 70.26%, followed by maize price from 41.57% to 56.68% and domestic rice price from 54.74% to 62.85%.

Using this measure of volatility, it would be natural to suggest that the Nigerian agricultural commodity prices have experienced higher variability between 1983 and 1994 over the period. This could possibly be attributed to the fact that agricultural product markets experience not only price fluctuations from year to year but also volatile prices because of the relatively unstable conditions of supply and demand and the low elasticities of demand and supply. This finding is consistent with the findings of [34] and [35] which attributed most of the volatility in commodity prices to macroeconomic and political factors.

3.3 Supply Response Coefficients for Rice

The supply response function was adopted to estimate the supply response coefficients for rice. The independent variables used were domestic price for local rice (P^d), price of imported rice (P^m), output of rice (q^t), price of substitute (maize) (P^s), weather condition (rainfall) (W), and government expenditure on agriculture (G^x). The dependent variable was the actual output of rice (q^t). The regression results of the log linear supply response function (Table 3) shows that the regression coefficients of the output of rice, price of substitute and rainfall were statistically significant and domestic price of local rice, price of imported rice and government expenditure on agriculture were not significant.

The coefficient of lagged production output of rice was positive and had statistically significant effect on supply of rice in Nigeria at 1% significant level. The inelastic response of 0.649 indicates that an increase in output of rice by 1 percent in the previous year would lead to an increase in supply of rice in Nigeria by 0.649 percent. This indicated that the supply of rice in Nigeria was responsive to the production output of rice. This result contradicts that of [36] and [37], that changes in output is responsive to changes in price and supply of rice and the response is elastic.

The coefficient of lagged price of the substitute (maize) was positive and had statistically significant effect on the supply of rice in Nigeria at 10% level, but the supply response was inelastic (0.183). This implied an increase in maize price by 1 percent would lead to a less than proportionate increase in supply of rice by 0.183 percent; an indication that maize might not be the best substitute for rice in Nigeria.

Table 1. Summary statistics of variables in Nigeria

Variables	Mean	Minimum	Maximum	Standard Deviation
Output of rice (MT)	1,730,674.00	310,000.00	46,622,000.00	11,442,927.00
Area harvested (HA)	1,620,239.00	275,000.00	3,600,000.00	971,873.10
Domestic price of local rice (₦/kg)	61.27	0.63	296.24	69.69
Price of imported rice (₦/kg)	81.67	1.89	406.30	94.21
Price of substitute (maize) (₦/kg)	36.26	0.41	140.00	40.01
Weather Condition (rainfall) (MM)	1,406.31	923.60	2,300.00	304.96
Government Expenditure (₦ Billion)	26.14	0.02	138.90	36.98
Quantity of imported rice (MT)	1,057,522.00	2,000.00	3,200,000.00	895,033.70

Source: Computed based on research data from Federal Ministry of Agriculture and Rural Development and National Bureau of Statistics, 1972-2017

It is generally asserted that in Nigeria, many of the farmers depend on rain fed as the farms rely on rainfall for the production of crops. The coefficient of lagged rainfall indicated a positive and statistically significant relationship with the supply of rice in the study area at 10% alpha level. This implied that a percentage increase in the quantum of rainfall in the area resulted to an increase in the supply of rice by 0.225 percent. It could mean that adequate and equitable distribution of rainfall or the adoption of reliable irrigation practices would more likely lead to supply of rice in Nigeria.

The coefficient of adjusted R^2 value (0.958) implied that 96% variability in rice supplied was explained by the independent variables while the rest 4% was as a result of stochastic noise. The Durbin-Watson statistic value of 2.49 signifies the absence of autocorrelation among observations of the regressors. The F-statistic value of 169.66 was statistically significant at 1% level of probability indicating that the independent variables in the model jointly influenced supply of rice in Nigeria and that the regression model was a good fit for the data.

3.4 Unit Root Tests

Based on the philosophy that test for constancy of economic series must precede their inclusion in regression model with the intention of avoiding estimating spurious regression, and to obtain reliable estimates for the parameters, it was first tested if there was an equilibrium relationship of the variables in equation [12] that is, whether there existed similar statistical properties. This study employed the [37] co-integration tests using the Augmented Dickey-Fuller (ADF) statistic. The result of the ADF test statistic for unit root of the individual series is summarized in Table 4. The variables used were domestic price for local rice (P^d), price of imported rice (P^m), output of rice (q^t), price of substitute (maize) (P^s), weather condition (rainfall) (W), and government expenditure on agriculture (G^x). Natural logarithm of the variables was taken to linearize them to the same levels.

Table 2. Estimated coefficient of variation for agricultural commodities prices

Real Price Series	Period	Mean	Median	SD	CV
Imported Rice ($P^m{}_t$)	1972-1982	2.55	2.41	0.60	23.53
	1983-1994	31.7	29.74	22.33	70.26
	1995-2006	74.90	64.01	26.89	35.90
	2007-2017	222.61	197.40	83.06	37.31
Domestic Rice ($P^d{}_t$)	1972-1982	1.37	1.55	0.75	54.74
	1983-1994	23.15	18.13	14.55	62.85
	1995-2006	60.59	49.63	17.87	29.49
	2007-2017	163.47	144.28	63.93	39.11
Maize ($P^s{}_t$)	1972-1982	0.89	0.98	0.37	41.57
	1983-1994	11.91	14.14	6.75	56.68
	1995-2006	38.59	32.13	19.34	50.12
	2007-2017	95.66	94.63	27.69	28.95

Note: Prices are in Naira/kg; SD=Standard Deviation; CV=Coefficient of Variation in %

Table 3. Estimates of the supply response of rice in Nigeria

Variable	coefficient	Std. Error	T. Statistic	Prob.
C	2.913032	1.725746	1.687984*	0.0996
$InP^d{}_t(-1)$	-0.184821	0.160533	-1.151296	0.2568
$InP^m{}_t(-1)$	0.169398	0.220291	0.768972	0.4467
$InQ_t(-1)$	0.649049	0.122323	5.306020***	0.0000
$InP^s{}_t(-1)$	0.183058	0.09795	1.868785*	0.0694
$InW_t(-1)$	0.225188	0.131345	1.714473*	0.0946
$InG^x{}_t(-1)$	-0.011527	0.024444	-0.471561	0.6399
R^2	0.964013	F-statistic	169.6563	
R^2 adjusted	0.958331	Prob (F-statistic)	0.000000	
S.E of regression	0.159237	Durbin-Watson stat	2.492091	
Log likelihood	22.63339			

****Significant at 1% level of probability; *Significant at 10% level*

Table 4. Result of augmented Dickey-Fuller unit root test of the variables

	Level				First Difference			
Variables	ADF Test Statistics	K	Prob*	Decision	ADF Test Statistics	K	Prob*	Decision
InQ_t	-0.965898	2	0.7569	Non stationary	-3.941837	1	0.0039	Stationary
InP^d_t	-0.893062	0	0.7814	Non stationary	-6.735775	0	0.0000	Stationary
InP^m_t	-0643827	0	0.8502	Non stationary	-6.753420	0	0.0000	Stationary
InP^s_t	-0703803	1	0.8352	Non stationary	-7.167944	0	0.0000	Stationary
InW_t	-5.233457	0	0.0001	Stationary	-8.901086	1	0.0000	Stationary
InG^x_t	-1.555539	0	0.4967	Non stationary	-6.539095	1	0.0000	Stationary

Critical value for the ADF statistic is -2.92 at 5%. Mackinnon (1996) one-sided p-value.
K=Lag length based on Schwartz Information Criterion

According to the results, the ADF test statistic together with the details on number of lags indicate that all the series were non-stationary at level except weather condition (rainfall) which was found stationary at the level while all the non-stationary series however became stationary at first difference. This is in agreement with [17] that ADF test shows some variables are stationary at level while virtually all are stationary at first difference. The ADF test was carried out to test the null hypothesis of non-stationarity of the variables or there is unit root against the alternative of stationarity of the variables or there is no unit root.

The null hypothesis of no unit root was strongly rejected for the series in their level form as the ADF statistic values were below the critical value of -2.92, but cannot reject the null hypothesis at the first difference of the series because the ADF statistic values were above the critical value. Therefore, the series under the study were first difference stationary, that is, they had unit root or were 1(1) and the possibility of a long-run equilibrium relationship in their difference form existed. These observations are robust as they compared favorably with the result of [38] which reported that the null hypothesis for the existence of unit root cannot be rejected for the series in their level form.

3.5 Co-Integration and Long-Run Dynamics

The unit root test showed that all the variables subjected to ADF tests were significant at first difference except weather condition which was significant at level, implying that the data used for the analysis have stable statistical properties, that is they have constant mean and variance, and thus can support further analysis, without fear of spurious or not significant results. To ascertain the effects of domestic and imported prices on rice exports, export quantities were regressed on lagged values of these important parameters on the premise that although the variables may drift apart in the short-run (as in Table 4), an equilibrium or stationary relationship is guaranteed to hold between them in the long-run.

The result in Table 5 indicated that relative domestic price and imported price of rice combine with variations in government expenditure on agriculture to significantly account for 93.4% of the variation in production as shown by the adjusted R^2. Rice production output may increase 3.70% for a ten percent increase in imported rice price. A ten percent increase in domestic rice price accounts for 2.26% decline in rice production output. Government expenditure was observed to have positive but not significant contributory effects. The result thus highlights that variations in output (export) levels are caused by random fluctuation in agricultural prices and other supply-side factor e.g. government expenditure on agriculture. This implied export supply which hinges on abundant harvest and good supply management may in the long-run depend on agricultural price inflation or deflation which significantly impact on returns to exports. This is in line with [38] who deduced that variations in output levels are caused by random fluctuations in agricultural prices and other supply-side factors. However, it contradicts [39] and [40] who reported that impediments to export supply response include the effect of real exchange rate, issues of anti-export bias, the costs and quality of infrastructure and financing costs and credit availability.

Since the variables under study are integrated of the same order, there is need to employ the Engle and Granger two step estimation procedure to test for co-integration between the independent variables in the model and the production output of rice which is the dependent variable. The ADF test statistic value was compared with the Mackinnon 1996 critical value. The result of the ADF test given in Table 6 shows that the ADF test statistic value (-4.006) is more negative than the Mackinnon (1996) critical values of -3.58 and -2.92 at 0.01 and 0.05 significance level respectively. So the null hypothesis of unit root test at level is rejected for the estimated error term from the regression. It is concluded that the linear combination of the 1(1) time series P^m_t and G^x_t is stationary at level. The stationarity of the error term at level implies that there exists a long-run or equilibrium relationship between the variables. In this case, the regression is concluded to be co-integrating regression. The co-integrating coefficients (given in Table 5) are statistically and significantly different from zero at 1% level of significance. Price of imported rice and government expenditure on agriculture as determinants of production output of rice in Nigeria are co-integrated which is, there exists a long-run equilibrium relationship between them.

3.6 Granger Causality Tests

The structures of the causal relationships between variables were analyzed through the Granger causality approach. The Granger causality test is a statistical hypothesis test for determining whether one time series is useful for forecasting another. If probability value is less than any alpha level, then the hypothesis would be rejected at that level. Table 7 presents results for the causality test. The probability values for Granger F-tests of the null hypothesis that domestic rice price do not granger cause production output of rice, imported rice price do not granger cause domestic rice price, weather condition do not granger cause imported rice price and government expenditure on agriculture do not granger cause weather condition (rainfall). Low probability values (less than 0.05) indicate rejection of the hypothesis while high values indicate no causality.

The F-statistics show that the null hypothesis of imported rice price do not granger causethe domestic rice price is rejected at 1% significant level. This implied that past values of imported rice influence the current values of domestic rice. sIt could be presented that the direction of Granger causality for the whole period varies among the different variables significantly when two lags were applied with both unidirectional as well as bidirectional relationship being present. However, the presented evidence in Table 7 provides strong support to the hypothesis that the production output of rice changes due to changes in significant variables. In one out of the five independent variables, no Granger causality was found between the government expenditure on agriculture and the price substitute (maize). Even in the four variables that a statistically significant causal relationship was found, this runs from domestic rice price to production output of rice supporting the conservation hypothesis.

Understanding agricultural commodity prices relationship are important as they help producers improve their awareness regarding production costs and ultimately aid in income determination.

ome of the data series have a long-run equilibrium relationship, hence an error correction representation (ECM) was formulated to capture the short-run dynamics. The residuals from the equilibrium co-integrating regression are used as an error-correcting regression (EC_t lagged one period). Results of the ECM and the diagnostic tests are presented in Table 8. In the short run, domestic and imported rice market prices had significant effect on changes in exports. Imported rice price was highly significant and the coefficient of 20596.3 signified that if imported rice price increased by one percent, export supply would increase by 205.9 percent in the short-run. The significant positive relationships suggest that imported rice price had complementary direct relationship with rice holdings in Nigeria. This result is in line with the study of [39] that world price for rice had significant positive effect on rice production.

3.7 Error Correction Model and Short-Run Dynamics

Domestic rice price is the next significant variable with a coefficient of –21479.0. This indicated that a percentage increase in domestic price would decrease export supply by 214.7 percent. Lagged values of maize price as substitute crop did not have significant short run dynamic effect on changes in rice exports. Change in export supply was determined by lagged values of weather in terms of rainfall which was statistically significant and positive. This is in agreement with [21] that price of domestic rice and rainfall positively enhanced the supply of rice. In addition, rice export supply response was low suggesting that imported rice constrains rice exports from Nigeria.

Table 5. Engle Granger test for co-integration

Regressors	Coefficient	Std. Error	T. Statistic	Prob
Constant	12.04467	1.160747	10.37665	0.0000
$InP^d{}_t$	-0.438498	0.193454	-2.266678	0.0289
$InP^m{}_t$	0.887944	0.239766	3.703375	0.0006
$InP^s{}_t$	-0.003756	0.124420	-0.03019	0.9761
$InG^x{}_t$	0.032402	0.03113	1.040819	0.3047
R^2	0.941376	Akaike info criterion		-0.201611
R^2 adjusted	0.934048	Schwarz Criterion		0.036907
SE. of regression	0.205914	Hannan-Quinn Criter		-0.112261
F-Statistic	128.4625	Durbin-Watson Stat		1.016581
Prob (F-statistic)	0.000000	Log likelihood		10.63706

Table 6. Unit root test of error correction model (ADF) for co-integration

		t-Statistic	Prob.
Augumented Dickey Fuller test statistics		-4.006002	0.0032
Test critical values:	1% level	-3.584743	
	5% level	-2.928142	
	10% level	-2.602225	

Mackinnon (1996) one sided p-values; Lag Length: 0 based on Schwatz information criterion

Table 7. Pairwise Granger causality tests results

Null Hypothesis	Obs	F-Statistic	Prob.
PDT does not Granger cause QT	44	3.80203**	0.0310
QT does not Granger cause PDT		2.34769	0.1090
PMT does not Granger cause QT	44	3.62793**	0.0359
QT does not Granger cause PMT		0.94419	0.3977
PST does not Granger cause QT	44	3.51594**	0.0395
QT does not Granger cause PST		3.88715**	0.0289
WT does not Granger cause QT	44	2.91051*	0.0664
QT does not Granger cause WT		0.44036	0.6470
GXT does not Granger cause QT	44	1.46199	0.2442
QT does not Granger cause GXT		2.54785*	0.0912
PMT does not Granger cause PDT	44	8.14740***	0.0011
PDT does not Granger cause PMT		6.04510***	0.0052
PST does not Granger cause PDT	44	0.40213	0.6716
PDT does not Granger cause PST		3.66869**	0.0347
WT does not Granger cause PDT	44	5.28390***	0.0093
PDT does not Granger cause WT		2.68652*	0.0807
GXT does not Granger cause PDT	44	0.02167	0.9786
PDT does not Granger cause GXT		3.57087**	0.0377
PST does not Granger cause PMT	44	1.42949	0.2517
PMT does not Granger cause PST		7.24570***	0.0021
WT does not Granger cause PMT	44	3.94386**	0.0275
PMT does not Granger cause WT		2.84713*	0.0701
GXT does not Granger cause PMT	44	0.50536	0.6072
PMT does not Granger cause GXT		6.06352***	0.0051
WT does not Granger cause PST	44	3.03065*	0.0598
PST does not Granger cause WT		3.33951**	0.0458
GXT does not Granger cause PST	44	2.37270	0.1066
PST does not Granger cause GXT		1.67169	0.2011
GXT does not Granger cause WT	44	3.33296**	0.0461
WT does not Granger cause GXT		0.32562	0.7240

*Notes: Obs.= Observations. Lags=2; *** Significant at 1% level of probability; **Significant at 5% level; *Significant at 10% level*

Table 8. Error correction model regressions for rice in Nigeria

Variable	Coefficient	Std. Error	T. Statistic	Prob
Constant	61570.64	45398.10	1.356238	0.1845
$\triangle \ln P^{d}_{t-1}$	-8237.336	8174.122	-1.007733	0.3211
$\triangle \ln P^{m}_{t-1}$	1989.6s00	4943.477	0.402470	0.6900
$\triangle \ln P^{s}_{t-1}$	5350.186	6194.935	0.863639	0.3942
$\triangle \ln W_{t-1}$	241.3866	141.9149	1.700924	0.0987
$\triangle \ln G^{x}_{t-1}$	-2308.984	2900.868	-0.795963	0.4319
$\triangle \ln P^{d}_{t}$	-21479.04	7748.324	-2.77089	0.0092
$\triangle \ln P^{m}_{t}$	20596.37	5722.904	3.598937	0.0011
$\triangle \ln P^{s}_{t}$	5138.315	6113.790	0.840447	0.4069
$\triangle \ln W_{t}$	49.88205	138.7098	0.359614	0.7215
$\triangle \ln G^{x}_{t}$	-2191.075	2681.104	-0.817229	0.4198
ECM (-1)	-0.209353	0.111507	-1.877489	0.0696
R-squared	0.494201	Mean dependent var		98181.82
Adjusted R-Squared	0.320333	S.D dependent var		302840.4
S.E of regression	249667.5	Akaike info Criterion		27.92065
Sum squared resid	1.99E+12	Schwarz Criterion		28.40725
Log likelihood	-602.2543	Hannan-Quinn Criter		208.10110
F-statistic	2.842386	Durbin-Watson Stat		2.590046
Prob (F-statistic)	0.010378			

The error correction coefficient (ECM) represents the speed of adjustment from short-run deviation to its long–run equilibrium with a negative shock and statistically significant coefficient at 10% level. It confirms the existence of stable long-run relationship. The error correction coefficient of -0.209 implied that 20.9% of disequilibrium from the previous year's shock converged back to the long-run equilibrium in the current year. This is in line with [39] that error correction term gave the expected negative sign and was statistically significant. Overall, the result suggested that the rice sub-sector was quite responsive to prices. The ECM coefficients for rice export integrated the short-run dynamics in the long-run relationship. Given that the regressants are cast in the first difference, the empirical results indicated a satisfactory statistical fit as judged by the adjusted R^2.

The F-statistic test shows that the overall regression of the variables was statistically significant. This is because observed value of the F-statistic (2.842386) was greater than its P-value. Durbin-Watson statistic for randomness of the residuals and the assumption of ordinary least square was not violated. Durbin-Watson test (2.59) shows that the model is free from Autocorrelation problem and that prediction base of the ordinary least square estimates were efficient and unbiased. These test statistics do not reject the hypothesis that the estimated equation posses a normal distribution. The relation does not fail the Akaike information Criterion test for structural stability; hence the relationship is structurally stable.

4. CONCLUSION

This research work on price competitiveness and supply response of rice producers in Nigeria derived both the short-run and the long-run elasticity parameters. Generally, the results showed relative stability and volatility of prices, low co-integration of variables and high rate of price adjustments of co-integrated pairs. The empirical result suggested that rice producers are responsive not only to prices but to non-price factors such as government expenditures on agriculture and rainfall. The study revealed that, while the rice sector has been heavily penalized by price and marketing policies as well as macroeconomic policies, rice productivity has not significantly gained from productivity-enhancing investments.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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