Econometric Analysis of Determinants of Rice Price Volatility in Nigeria (1970-2017)

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Abstract: An attempt has been made in this study to show that price of rice is significantly volatile and to also determine the causes of this volatility for the period of 1970 to 2017. The result of Arch test confirmed that price of rice is significantly volatile. The result of Garch (1,1) model revealed that coefficients of internal factors (arch and garch term) was significant at 5%, coefficients of external shocks or factors (domestic rice production and naira/dollar exchange rate) were significant at 5% and 10% respectively. This implies that both internal and external factors were major determinants of rice price volatility and by implication; speculation (using previous flunctuations to predict current flunctuations) is one of the determinants of rice price volatility while domestic rice production, total domestic rice consumption and naira/dollar exchange rate were the external factors. Based on the result obtained from this study, the country's policymakers have to provide the enabling policies that will enhance local production and consumption of rice.

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1. Introduction

Rice has become the main diet of typical Nigerians as well as the main livelihood of majority of local farmers in the country. It is also an important agricultural commodity that draws the attention of government and policy makers as regard the wellbeing of the citizens and overall development of the nation.

Domestic rice production in Nigeria in spite of its improvement over time is nothing to write home about in meeting the domestic needs, not to talk of export. In fact, the country's policy on rice over the years had been inconsistent and has oscillated between import tariff and imports restrictions. Emodi and Madukwe (2008) capture this scenario when they affirmed that during the structural adjustment program (SAP) of 1986, ban on rice imports were put in place and this made it illegal to import rice into the country but the porous nature of Nigerian borders made policy ineffective.

Also, between 1995 and 2013, the restrictions on rice importation were lifted, before it was reintroduced again in the year 2019. Whatever the policy decision government may come out with, it is imperative to note that, rice remains an important inevitable diet for domestic consumption in Nigeria and more importantly, one of the food commodities consumed globally. Therefore, rice may affect the political and economic development of Nigeria in a number of ways:

Firstly on food security, if the country produces significantly to cater for its domestic consumption and perhaps even exports, the food crisis particularly bedevilling the Nigerian state would be solved.

Secondly on employment generation, mass rice production cannot only provide food security of the nation but will equally bring about employment generation. The high level of importation of milled rice products into Nigeria gets many farmers out of work and creates significant number of jobs to the exporting countries like; USA, Thailand and India at the expense of Nigerian farmers.

Foreign exchange earnings; if Nigeria harnesses fully its agricultural potentials and produce rice significantly, not only for domestic consumption but for exports as well, the country will earn a lot from the exports of such commodity and develop its economy. This will also complement other earnings accrued from the country's petroleum products; that remains the government's major income source.

Mass rice production will not only serve as food security to Nigeria, create employment or add to its foreign earnings, but it will as well bring about the general development of the nation. This is in the sense that, the monies realized will be injected into the economy for desired transformations and development touching other important sectors of the economy. The variation in prices of agricultural commodities in Nigeria has been attributed to a number of factors including variances in the bargaining power among consumers, cyclical income fluctuations among sellers and consumers, natural shocks such as flood, pests,

diseases, and inappropriate response by farmers to price signals among other factors.

Time series data on prices are usually observed to have seasonality or cyclical fluctuations which may be attributed to fluctuations in supply that may be caused by economic trends, weather, planting and harvesting seasons. Because of supply fluctuations, traders practice speculative storage, which has impact on price levels especially during the lean period of supply (Eleanore, 2013). The price difference across time will depend only on storage costs and the opportunity cost of capital, in which case prices may stabilize over seasons. However, speculative storage may also result in soaring prices in the long run. In the latter case, storage would not adequately stabilize price volatility (Rahji and Adewumi 2011).

For instance, Kargbo (2006) found that prices, real exchange rates, domestic production capacity, and real incomes have significant impacts on the agricultural export. Studies by DeGrauwe (1988) showed that exchange rate variability causes fluctuations in export revenue. While there is a certain consensus regarding the effects of weather, biofuel production and export restrictions on food prices, the problem is far from settled. In spite of the government effort to improve export, the agricultural sector is yet to respond to such policy signals. Instead, the performance of the agricultural exports remains dismal and discouraging. Of the massive documents on the effects of exchange rate volatility on macroeconomic variables, only very few have attempted to identify the role of third world countries' exchange rate volatility on domestic macroeconomic variables (Clark, 2004).

Most empirical studies focus primarily on granger causality tests to explain the role of speculation in price volatility (Irwin et al., 2009; Gilbert, 2010). Some researchers identified an explosive increase in prices during the 2007–2008 spikes (Gilbert, 2009; Philips et al., 2011). Pindyck and Rotemberg (1990) analyzed the co-movement of seven unrelated commodities. They used various macro-economic variables such as interest, inflation, and exchange rates but also supply and demand conditions to explain the co-movement. However, they found that after controlling for these factors, the prices still moved together, a phenomenon Pindyck and Rotemberg dubbed as *excess co-movement* and which they attributed to herd behaviour on commodity (futures) markets.

From the above, it could be inferred that disagreement still exists on the findings of many researchers on the pattern and causes of food price variability in Nigeria, this research is therefore unique in that its findings will further shed light on the trend in price change over the years to the recent time and also identify factors that are responsible for the variability in rice price from 1980 to 2017.

In the past few years, many studies had examined the causes of and solutions to soaring food prices in Nigeria (Abbot et al., 2009; Gilbert, 2010). Their findings had revealed that biofuel demand, speculation in commodity future markets, countries' aggressive stockpiling policies, trade restrictions, flunctuations in exchange rate were among the factor that causes food price variability. In view of the above stated problem, this study was conducted in order to be able to provide answers to the following fundamental research questions:

1. What is the trend of rice consumption in Nigeria 1980 to 2017?
2. What is the trend of domestic production of rice in Nigeria?
3. What is the pattern of variability in rice price in Nigeria from 1980 to 2017?
4. What are the determinants of rice price variation in Nigeria?

The general objective of the study is to analyze the determinants of rice price variation in Nigeria from 1980 to 2017 while the specific objectives are to:

1. Describe the trend of rice consumption in Nigeria.
2. Describe the trend of domestic production of rice in Nigeria.
3. Describe the pattern of rice price variation in Nigeria.
4. Estimate the factors responsible for rice price variation in Nigeria.

The null hypotheses that were tested include:

H_0: price of rice does not exhibit significant volatility

H_0: Internal and External factors do not significantly responsible for rice price volatility.

2. Materials and Methods

The study was carried out in Nigeria, located in West Africa between latitudes 4^0 to 14^0 North and between longitude 2^02^1 and $14\ ^030^1$. It is bounded to the north by the Niger Republic and Chad in the west by Benin republic, in the east by Cameroon Republic and the south by the Atlantic Ocean. Nigeria has a land area of about 923,769km2 with a North-south length of about 1450km and west–east breadth of about 800km. Its total land boundary is 4047km while the coastline is 853km.

Secondary data from 1970 to 2017 on rice price, exchange rate, crude oil price, e.t.c that was sourced from National Bureau of Statistics (NBS), Central Bank of Nigeria's economic and financial review and an online database maintained by Food and Agricultural Organization (FAO) was used for the study.

The following methods were used to analyze the data that was sourced from the sources mentioned above:

The Stationary Test or Unit Root Test

Time series data is said to be stationary if its mean value and its variance do not vary systematically overtime. For a time series data that is not stationary, such data could be said to be non-stationary or has unit root problem. To avoid the problem of spurious regression (meaningless regression result) that may resulted from the usage of non-stationary time series data that was used for this study, stationarity test (unit root test) was performed on each of the time series data.

Augmented Dickey-Fuller (ADF) test was used instead of DF test because the ADF took care of possible serial correlation in the error terms by including the lagged difference of the dependent variable.

Capturing Determinants of Volatility/Variability in Rice Price with GARCH (1,1) Model

Following the seminal contributions of Engle (1982) and Bollerslev (1986), modelling of financial asset returns has been cast in the generalized autoregressive conditional heteroskedasticity (GARCH) framework. These models allow the conditional variance to change over time as a function of past errors and volatility, leaving the unconditional (or long-run) variance constant.

The key insight of GARCH lies in the distinction between conditional and unconditional variances of the innovations process (ε_t). The term conditional implies explicit dependence on a past sequence of observations. Whereas unconditional is more concerned with long-term behaviour of a time series and assumes no explicit knowledge of the past.

Model Specification

In general, Garch model is given as:

$\sigma^2_t = w + \sum \alpha_1 \varepsilon^2_{t-1} + \sum \beta_j \sigma^2_{t-j} + V_t$; where: w = the mean or constant term

ε^2_{t-1} = Volatility measured as the lag of the squared residual form the mean equation (ARCH term)

σ^2_{t-1} = last period's forecast variance (GARCH term) or past observed volatility which is identical to h_{t-1}.

Thus, Mean Equation for the study was developed from the general Garch-Arch model as follows:

$RPV = C_1 + C_2 TDRP + C_3 TDRC + C_4 EXCHRT + e$

RPV= Rice price volatility

TDRP = Domestic Rice production (Supply)

TDRC= Domestic rice consumption

EXCHRT= Naira/dollar exchange rate

C_1 = Constant or Intercept,

C_2, C_3, C_4 = Parameters to be estimated

e = Residual or error term

Garch term (H_{t-i}) and Arch term (e^2_{t-i}) are own shock or internal/family shocks that can affect volatility of rice price such as effect of previous year's volatility on current volatility.

EXCHGRT = Exchange rate (Naira/Dollar), TWRP = Total World Rice production (Supply), TDRC= Total D Rice consumption (Demand), EXCHGRT, TDRP and TDRC are the external shocks that can affect crude oil price volatility while, C_4, C_5, C_6, C_7 and C_8 are the parameters to be estimated.

The equation tells us that tomorrow's variance is a function of today's squared residual, today's variance and the weighted average long-term variance.

Within this backdrop, Garch (11) model was used to test for volatility of Rice price by first plotting the mean equation of Rice Price as dependent variable as a function of constant C and Exchange Rate, Domestic Rice production e.t.c as the exogenous variables.

From the result of this regression model, we then plotted the residual of the model, in other to check for uniformity or variance of the residual. If the magnitude of the residuals are uniform, then we cannot represent the model by Arch-Garch model, but if the magnitude of residuals are not uniform such that we have clustering volatility in that; low volatility follows low volatility and high volatility follows high volatility for a very long term, then we can represent the model by Arch-Garch model, and we will then plot variance equation from the mean equation in order to determine the causes of this variability.

3. Results and Discussion

This section explains the result obtained from the analysis of the data and the conclusion reached about the behaviour of the variables in the short term and in the long term.

The analysis begins by checking for the stationarity attributes of the series (Rice price, domestic rice production, domestic rice consumption and naira/ exchange rate), significant volatility in rice price, Lag length used and the determinants of the volatility.

Unit Root Test

Since, it is required that series should be stationary in other to avoid meaningless or spurious regression result. The result of Augmented Dickey Fuller unit root test that was run for each of the series is as shown in the Table 4.1 below.

Table 1: Result of Augmented Dickey Fuller Unit Root Test

Series	ADF Test Statistic	1%critical Values	5% critical Values	10% critical Values	Probability	Order	Remarks
Rice Price (RP)	-1.5994	-3.58115	-2.9266	-2.60142	0.4748	I (0)	Non-Stationary
Domestic Rice Consumption (DRC)	-0.93386	-3.584743	-2.92814	-2.60222	0.7682	I (0)	Non-Stationary
Rice Price (RP)	-6.24131	-3.584743	-2.92814	-2.60222	0.0000	I (1)	Stationary
Domestic Rice Consumption (DRC)	-2.98605	-3.584743	-2.92814	-2.60222	0.0439	I (1)	Stationary

Source: Author's computation, 2019.

The result in the table 1 above indicated that rice price and Domestic rice consumption were not stationary at level. Their stationarity were obtained at first difference. That is, each of them was integrated of order one I (1).

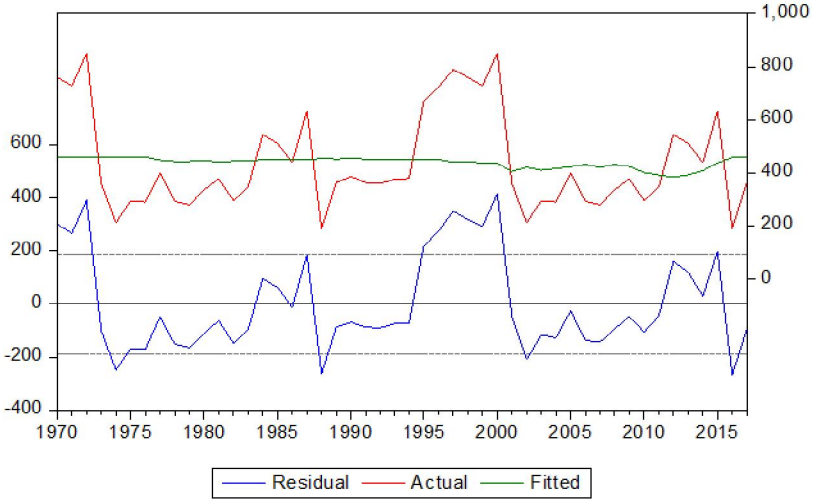
Rice Price Volatility Test

Table 2: The Result of Mean Equation

Dependent Variable: RP				
Included observations: 48				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
C	**461.1696**	**39.98424**	**11.53379**	**0.0000**
RDC	**-3.16E-05**	**4.21E-05**	**-0.750505**	**0.4568**
R-squared	**0.012097**	**Mean dependent var**		**438.9958**
Adjusted R-squared	**-0.009380**	**S.D. dependent var**		**185.7846**
S.E. of regression	**186.6538**	**Akaike info criterion**		**13.33716**
Sum squared resid	**1602624.**	**Schwarz criterion**		**13.41513**
Log likelihood	**-318.0919**	**Hannan-Quinn criter.**		**13.36663**
F-statistic	**0.563258**	**Durbin-Watson stat**		**0.848643**
Prob (F-statistic)	**0.456773**			

Source: Author's computation, 2019.

Given that rice price volatility (standard deviations from the mean of rice price) is one of the variables of concern in this study and following its high degree of fluctuation, the Generalized Autoregressive Conditional Heteroscedacity (GARCH) was introduced in the study with the view to determine whether the variable (rice price) is significantly volatile or not. The result of the mean equation in the table 4.3 above revealed that the rice price is volatile and to determine whether this volatility is significant or not, the residual of the above mean equation was plotted to obtain figure 1 below:



Source: Author's computation, 2019.

Figure 1 above revealed that the rice price was exhibiting clustering volatility because prolonged period of low volatility followed prolonged period of low volatility from 1970 to 1980 and from 1985 to

2005, while from 1980 to 1985 and from 2005 to 2017 there was a prolonged period of high volatility which was followed by prolonged period of high volatility.

This implies that there is clustering volatility and the null hypothesis (H_{01}) that says that rice price does not exhibit significant volatility should be rejected and the alternative accepted.

Arch Test for Clustering Volatility

The hypothesis that the there is no arch effect in the table 4.4 below should be rejected and the alternative accepted because the probability of 00.1% is less than 5%. So, the result of arch test showed that there is arch effect, and this confirmed the fact that crude oil price is significantly volatile and that error term is conditionally heteroscedastic and can be represented by arch and garch term. This also implies that there is clustering volatility and the null hypothesis (H_{01}) that says that crude oil price does not exhibit significant volatility should be rejected and the alternative accepted.

Table 3: The Result of Arch Test for Clustering Volatility

Heteroskedasticity Test: ARCH				
F-statistic	10.81316	Prob. F (2,42)		0.0002
Obs*R-squared	15.29531	Prob. Chi-Square (2)		0.0005
Test Equation:				
Dependent Variable: RESID^2				
Method: Least Squares				
Sample (adjusted): 1972 2015				
Included observations: 48 after adjustments				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	154.7862	74.41404	2.080067	0.0437
RESID^2(-1)	0.590476	0.159838	3.694222	0.0006
RESID^2(-2)	0.031060	0.161042	0.192868	0.8480
R-squared	0.339896	Mean dependent var		365.8356
Adjusted R-squared	0.308462	S.D. dependent var		449.2082
S.E. of regression	373.5559	Akaike info criterion		14.74835
Sum squared resid	5860850.	Schwarz criterion		14.86880
Log likelihood	-328.8379	Hannan-Quinn criter.		14.79325
F-statistic	10.81316	Durbin-Watson stat		1.953300
Prob (F-statistic)	0.000163			

Source: Author's computation, 2019

Table 4: The Result of Variance Equation

Dependent Variable: COP				
Method: ML ARCH - Normal distribution (BFGS / Marquardt steps)				
Sample: 1970 2019				
Included observations: 48				
GARCH = C (3) + C (4)*RESID (-1)^2 + C (5)*GARCH (-1) + C (6)*DRC + C (7) + EXCHGRT				
Variable	**Coefficient**	**Std. Error**	**z-Statistic**	**Prob.**
C	**-135.2661**	**19.55660**	**-6.916647**	**0.0000**
TWOP	**0.002566**	**0.000320**	**8.029810**	**0.0000**
	Variance Equation			
C	**208.3287**	**125.7611**	**1.656543**	**0.0976**
RESID (-1)^2	**0.756594**	**0.299100**	**2.529568**	**0.0114**
GARCH (-1)	**0.353183**	**0.175077**	**2.017302**	**0.0437**
DRC	**-0.003314**	**0.001882**	**-1.761424**	**0.0782**
EXCHGRT	**0.801608**	**0.005744**	**139.5616**	**0.0000**
R-squared	**0.546878**	**Mean dependent var**		**34.21277**
Adjusted R-squared	**0.536809**	**S.D. dependent var**		**29.24407**
S.E. of regression	**19.90297**	**Akaike info criterion**		**8.292403**
Sum squared resid	**17825.77**	**Schwarz criterion**		**8.567957**
Log likelihood	**-187.8715**	**Hannan-Quinn criter.**		**8.396096**
Durbin-Watson stat	**0.392737**			

Source: Author's computation, 2019.

Determinants of Rice Price Volatility

The result in the table 4 below indicated that internal factors (Arch and Garch terms) Coefficient of Rice Domestic Production (RDP) and Coefficient of Naira/Dollar exchange rate (EXCHGRT) were significant at 5% while Coefficient of total world crude oil Consumption (DRC) was significant at 10%.

This implies that the null hypothesis ($\mathbf{H_{02}}$) that says that internal and external factors do not significantly determine rice price volatility should be rejected and the alternative accepted because at 5% level of significance previous year price of rice can determine the current price of rice. That is, previous year volatility has influence on the current period volatility. It means that own shocks or internal factors (arch and garch term) can influence rice price volatility which implies that price speculation (using previous flunctuations to predict current flunctuations) is one of the major determinants of rice price volatility.

Also, external shocks or factors (EXCHGRT, DRP and DRC) are major determinants of Rice price volatility. This implies that the null hypothesis ($\mathbf{H_{02}}$) that says internal and external factors do not significantly determine rice price volatility should be rejected and the alternative accepted.

4. Conclusion

The results of this study revealed that price of rice is significantly volatile and this volatility is being determined by both internal and external factors. Based on the result obtained from this study, the country's policymakers have to provide the enabling policies that will promote local production and consumption of rice.

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