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Original Research Article

Volatility and Co-movement: an Analysis of Food Commodity Prices in Nigeria

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Abstract

This study explains volatility as a measure and interaction of the possible movement in a particular economic variable. Prices change rapidly in adjustment to market circumstances. Food prices hike experienced overyears has resulted in widespread menace which led to increase in food price volatility. However, volatility and co-movement had generally been lower for the past two decades than for the previous ones. Wide price movements over a short period of time connote high volatility, rendering the producers and consumers vulnerable. Excess volatility can be subjected to sector ineffectiveness and is commodity specific. Producers and processors are mostly concerned about increased price volatility, which greatly exposed them to unpredictable risks and uncertainty associated with price changes. This study examined the volatility and co-movement of food commodity prices in Nigeria using price series data on rice, maize, sorghum, cassava and yam for the period of 1966 to 2013. The data were analysed using Vector Autoregressive Model to forecast food price volatility and to examine the food commodity prices that Granger cause food price volatility in other food commodities. The GARCH regression model is used to estimate the magnitude of volatility which revealed that, food commodity prices exhibit high volatility and there is persistent increase in prices over the period of study. The Nigerian food commodity prices have experienced high fluctuations over the period; therefore, the study recommends proper storage facilities and infrastructure for the food distribution corporations in Nigeria.

Keywords: food price volatility; co-movement; Vector Autoregressive Model.

INTRODUCTION

Food matters to every living being for sustenance. Governments have an important responsibility to make sure that people have enough to eat. Therefore, food must be available on people's table; not only that, it also needs to be affordable and accessible through a resilient and reliable supply system (Defra, 2008).

Price of food commodity as stated by Goetz et al. (1986), is a key variable in an economy that is market-oriented with perfect information. For both spot markets and long-term contracts, it is necessary to forecast price to develop bidding strategies or negotiation skills so as to maximize profits. According to White and Dawson (2005), planting decisions taken majorly depend on the expected price at harvest; therefore, forecasting food price will open the farmers to better opportunities of information which will help them in taking right decisions regarding planting in the future.

In the last decade, particularly since 2007/2008, the world food prices have experienced rapid increase volatility (FAO et al., 2011). The food price volatility experienced had caused risk related agricultural policies to be debatable. According to Tangermann (2011), the rise in volatility experienced in the international markets has successfully exposed the European Union's domestic prices to international price signals. It was further explained that the high agricultural commodity prices have suppressed the market measures such as border protection, subsidies, production quotas and the likes, and failed to achieve their aims. According to Taya (2012), price volatility is characterised by unexpected price changes which involved risk to farmers that react to it by reducing their output supply and investments in productive inputs. Evidence has shown that the effect of price volatility in the global markets is not limited to farm gate, but it has extended its tentacle to the downstream sector, that is, the consumers (Assefa et al., 2013). Unstable food price co-movement that was experienced during the financial crisis of the 2000s rekindled interest in understanding the driving forces behind volatility and price co-movements across food commodities. The food price shock that is raging world market is destabilizing governments and the resultant effect really causes hunger, street riots and theft in the developing nations (Nazlioglu et al., 2013).

The impact of food price volatility is very evident on the consumers and producers to the extent of reducing their purchasing powers. It leads people to poor people by limiting their food consumption causing ill-health in the short and long run (Habyarimana et al., 2014). Also, Shively (1996) explained that the impacts of increased price instability on both consumers and producers of agricultural commodities are detrimental. He further explained that stocks characterised farm household's portfolio in developing countries, and their income being a factor in bearing risks, the sensitivity of low-income farmers to price risks is always high.

Evidence regarding the behaviour of rural households during the recent price surge is meagre. In Kenya, a critical study on households' responses suggested that approximately 38 percent experienced a food deficit and resorted to various coping strategies. These included selling livestock, seeking farm and non-farm employment, decreasing the purchase of agricultural inputs and disinvesting in human capital. These coping strategies enhance future production and income streams. Delays in the payment of school fees and sub-standard health care services were also common; these suggest that price upswings can cause irreversible impact on human capital (FAO et al., 2011).

Food commodity prices exhibit fluctuations abstractly in upward or downward swings, depending on their comparison with price fluctuation in producing or speculative markets (Lapp et al., 1970). It was further explained that food commodity prices fluctuate more recurrently and extensively. As described by Frimpong-Ansah (1996), the main outcome of these fluctuations in food commodity prices is explained by the peasant nature of agricultural industry which is characterised by poor storage, flexible market fragmentation, poor irrigation and transportation system. There have been wide ranges of price instability at international level because fluctuations in supply of commodities are on the rampage due to output variation. Kuwornu et al. (2011) revealed that, output variation can be attributed to natural occurrences, cessation in buffer stock arrangements and oscillations in demand among others. They further explained that commodity price fluctuation or instability finds it sources from some impulsive happenings such as currency devaluation, changes in government policy or change in prospects of war.

Instability and variation in food production over years contribute immensely to food insecurity as a result of high volatility and co-movement of food commodity prices. The downward trend in the supply of food commodities in Nigeria can be traced to food price inflation as revealed by Badmus and Ogundele (2008). Fluctuation in the prices of food commodities has a strong impact on food security because household incomes and purchasing power are seriously affected, as a matter of fact; it can complicate the status of vulnerable people to be poorer and even hungry people. Price volatility (that is, price instability) also interacts with price levels of commodities to affect the welfare and food security. However, HLPE (2011) explained that the higher the price of commodities, the stronger the welfare consequences of volatility for consumers and vice-versa for the producers.

The food crises that occur in the late 2007 and early 2008 explained the rapid adjustment the prices of agricultural commodities underwent. Price volatility is a normal occurrence in the markets in a situation where seasonal production cycle and discontinuity of supply appear to be greater uncertainties of a rapidly changing economic and natural environment (Meyers and Meyer, 2008).

Furthermore, up to this recent time, many researches have been conducted on volatility and co-movement of food commodity prices in the world and even in Sub-Saharan Africa. These research works have revealed diverse measurement of volatility, but little was done in Nigeria to find out the ripple effect of volatility and co-movement on the agricultural commodity prices. This work wants to bridge the gap and contribute to this area in measuring the volatility of the selected food commodity prices in Nigeria. Also, the majority of the studies reviewed focused primarily on food grains like rice, maize, sorghum, wheat and so on which are the main staple food grains in their area of research. Although they claimed that crops like yam, cassava and other root and tuber crops are also important staples, but they are of interest due to the fact that they cannot be stored long after harvest. On the contrary, this research will focus on both food grains (rice, maize and sorghum) and root and tuber crops (yam and cassava) to check if the shelve life of these food crops contribute immensely to the variation or instability in their prices.

MATERIALS AND METHODS

Data Source and Description

The data used for the study were yearly time series data for the producers' price of food commodities (rice, maize, sorghum, yam and cassava) from 1966 to 2013 which was sourced from Food and Agriculture Organisation data bank. The prices were recorded in Naira per tonne. The specific reason to choose yearly data was because of non-availability of monthly data set for yam and cassava. In order to have uniformity of data sets, yearly data set for the selected food commodity prices were used for the study.

Data Analysis Techniques

Unit Root Test

The test for non-stationary of the time series was explored using the unit root test. A time series is said to be stationary when its mean and variance are the same over time and the covariance that exists between the two variables does not depend on the observed time, but rather on their lag length of time. Out of many tests available to determine, the most common test used – the Dickey-Fuller test was employed for this study. This empirical paper makes use of log transformation of the price series before performing the unit root test. The ADF results of the logged data failed to reject unit root, the data was then treated for first difference which was used to render time series stationary. The application of the ADF was based on the lag-length that minimizes criterion information (Chris, 2008). The computed ADF, which is the ratio of the t-calculated to the standard error of the parameter was compared with critical ADF values. The hypothesis to be tested:

$H_0{:}Y_t{\sim}I(1)$ against $H_1{:}Y_t{\sim}I(0)$ was tested

Then the Dickey and Fuller (1979) critical values are used as criteria to reject or accept H_0 according to the property; if the absolute value of t-statistic is greater than the critical value, and then H_0 is rejected.

GARCH Model

The model mainly used to model and forecast volatility is Generalized Autoregressive Conditional Heteroskedasticity (GARCH). This model was introduced to lime light by Bollerslev (1986) which was the development from the limitations of Autoregressive Conditional Heteroskedasticity (ARCH) model. ARCH has some limitations in capturing the dynamic patterns in conditional volatility. ARCH has ability to capture time-varying variance but it cannot be used for high parameter because it has low precision capability. A restriction is made on the parameter to make it stationary and positive (this makes estimating the parameter difficult). As a result, a lagged conditional variance is added to ARCH model to minimize thecalculation problem. Conditional variance is a one-period future estimation for the variance which is dependent upon its previous lags. GARCH (1, 1) model is mostly used in GARCH and is stated thus:

The current fitted variance is σ_t^2, it is the function of long term average value which depend on the constant term (α_0) , the previous volatility $(\alpha_1 \cdot \varepsilon_{t-1}^2)$ (, and the first lag $(\alpha_2 \cdot \sigma_{t-1}^2)$. The conditional variance (σ_t^2) have to be ≥0, and to achieve this, the following condition must be satisfied: $\alpha_0 > 0, \alpha_0 > 1$, and $\alpha_2 \geq 0$.

Vector Autoregressive Model (VAR)

VAR is an econometrics tool or model that shows thedynamic interrelationship amongst stationary variables. VAR is consisting of endogenous variables and allows for the variables to depend not only on its own lags. For the selected agriculture commodities (Rice, Maize, Sorghum, Cassava and Yam) a VAR model was set up for these five series. To evaluate the model's forecasting accuracy, RMSE and R-Square were used.

Considering a bivariate VAR of two variables, y_{1t} and y_{2t}, the dependent variables on the combination of their lags, k, and error terms:

$$y_{1t} = \beta_{10} + \beta_{11} y_{1t-1} + \ldots + \beta_{1k} y_{1t-k} + \alpha_{11} y_{2t-1} + \ldots + \alpha_{1k} y_{2t-k} + \varepsilon_{1t}$$

$$Y_{2t} = \beta_{20} + \beta_{21} y_{2t-1} + \ldots + \beta_{2k} y_{2t-k} + \alpha_{21} y_{1t-1} + \ldots + \alpha_{2k} y_{1t-k} + \varepsilon_{2t}$$

where ϵ_{it} is a white noise disturbance with $E(\varepsilon_{it}) = 0$, $(i = 1,2)$, $E(\varepsilon_{1t}\varepsilon_{2t}) = 0$. After this follows the use of Vector Autoregressive (VAR) model to perform granger causality test, forecast food price volatility and derive Impulse Response functions. Granger causality test is considered as a useful technique for determining whether one-time series is good for forecasting the other. In carrying out Granger causality test, one wants to see how much of a current series A can be explained by the past values of B. It can also be used to know whether adding lagged values of another series B can improve the explanation of the variance of A or not.

Moreover, VAR's impulse response was employed in order to show the statistically significant impacts of each variable on the future values, take for instance, whether there is a positive or negative effect in the changes of variables on other variables in the system. Impulse responses show how the shocks to any single variable affect the dependent variable in the VAR. More specifically, impulse responses, record the size of the impact inflicted by single shocks to the errors to the VAR system. Moreover, n^2 impulse responses will be generated afterwards for the total of n variables in the system.

RESULTS AND DISCUSSION

Commodities price characteristics

The range, which is the difference between the minimum and maximum prices and the mean prices of the selected food commodities over the period of 1966 to 2013 reveals that there exists price volatility in the selected food commodities. As shown in Table 1, the mean prices of the food commodities in Nigeria give a noticeable pattern. The mean price of yam has the highest value of ₦20,032.31 per tonne among all the selected food commodities while cassava has the least with the value of ₦8010.90 per tonne. Also, it was noticed that there is no significant difference between the mean prices of the food grains (rice, maize and sorghum). The standard errors and standard deviation (mean values) show that price of rice and maize per tonne were slightly stable compared to other food commodity. However, the prices of sorghum and cassava were not stable compared to others food commodities. Table 1 data report that all series exhibit

Table 1. Descriptive Statistics of data sets

Food Comodities	Obs	Range	Min.	Max.	Mean	Mean Std. Err.	Std. Deviation	Variance	Skewness
Rice	48	75028	110	75138	19057.48	3428.331	23752.172	5.642E+08	.981
Maize	48	82406	46	82452	16899.19	3309.316	22927.610	5.257E+08	1.158
Sorghum	48	79417	35	79452	15131.83	2971.656	20588.234	4.239E+08	1.319
Cassava	48	33628	18	33646	8010.90	1438.623	9967.071	9.934E+07	.872
Yam	48	89301	40	89341	20032.31	3789.188	26252.263	6.892E+08	1.095

positive skewness, which indicates that the series have a symmetric distribution with a longer right tail.

A variable is said to be non-stationary when the ADF test-statistics is smaller in absolute terms than the critical values (Adeoye et al., 2010). The results of the Augmented Dickey Fuller test are shown in Table 2. It shows that all the series "Rice, Maize, Sorghum, Cassava and Yam" were not stationary at their level, that is, there is the existence of a unit root. This is because the values of the ADF test-statistics were smaller in absolute term than the Mackinnon critical values.

The first difference of logged data for all the series was used to rend them stationary and to test if all series satisfy astability condition. The null hypothesis were, however, rejected at first difference I(1) at 1% level of significance for all the price variables. This agrees with the findings of Kuwornu et al. (2011) and Habyarimana et al. (2014) that series (variables) are stationary at first difference. This confirmed that they were all generated by the same stochastic processes and thus, capable of exhibiting long-run spatial equilibrium.

Stability Test Condition and Optimal Lag Length in the Vector Autoregression (VAR)

According to Johansen (1992a,b), the choice of an optimal lag length is the major criteria for estimating a Vector Autoregressive (VAR) system. The Vector Autoregressive (VAR) of differenced data satisfies the stability condition so far all the eigenvalues lie inside the unit circle. In this paper, the differenced data was used to specify the optimum lag-order that was used in VAR model to get estimates and forecasts. It was found that, VAR model for all differenced data satisfy the stability condition at any lag less or equal to 7 while at any lag greater than 7, the VAR model of all differenced series does not satisfy stability condition (if at least one eigenvalue lies outside the unit circle). Thus, lag 7 was used to determine the optimum lag-order. The pre-estimation lag-order selection statistics is shown in Table 3. As shown in the table, 7 lags were used as the maximum lag order to determine the appropriate VAR lag length. At 95% level of significance, Likelihood Ratio (LR) test selected lag 7, Akaike Information Criterion selected lag 7, Hannan-Quinn Information Criterion selected lag 7 and Schwarz Bayesian Information Criterion selected lag 7 as the appropriate VAR lag length. The subsequent analyses were based on VAR with the lags 6 because VAR result with lag 7 omitted some important information necessary for explaining the model.

Vector Autoregression Results

This paper uses a sample that took yearly prices of all specified food commodities from 1966 to 2013. The number of observation is 48; this does not include the first difference and the optimum lag-order of six. Each equation was estimated with 31 parameters, the constant included. As shown in Table 4, the value of RMSE for each equation is relatively small, thus percentage changes in each independent variable should be well explained by the percentage changes in independent variables recorded in the lagged year(s) up to the 6th period before the current price. The R-squared results show that; the current price of Rice can be explained by past prices of all food commodities specified in the model and itself by 71.42%, the current price in Maize can be explained by past prices of all food commodities specified in the model and

Table 2. Test of Unit root in first differenced data

		Test Statistics	Interpolated Dickey-Fuller 1% Critical Value	5% Critical Value	10% Critical Value	MacKinnon approximate p-value for Z(t)
ln Rice (1st difference)	Z(t)	−7.884	−3.607	−2.941	−2.605	0.0000*
ln Maize (1st difference)	Z(t)	−8.739	−3.607	−2.941	−2.605	0.0000*
ln Sorghum (1st difference)	Z(t)	−9.88	−3.607	−2.941	−2.605	0.0000*
ln Cassava (1st differece)	Z(t)	−7.543	−3.607	−2.941	−2.605	0.0000*
ln Yam (1st difference)	Z(t)	−8.267	−3.607	−2.941	−2.605	0.0000*

*, significant at 5%

Table 3. Lag-order selection statistics (pre-estimation)

lag	LL	LR	Df	p	FPE	AIC	HQIC	SBIC
0	–2034.63				1.10E + 37	99.494	99.5701	99.703
1	–1922.56	224.12	25	0	1.60E + 35	95.2471	95.7036	96.5009
2	–1828.99	187.16	25	0	6.00E + 33	91.9018	92.7389	94.2005
3	–1738.42	181.13	25	0	2.90E + 32	88.7034	89.921	92.047
4	–1607.93	260.98	25	0	2.30E + 30	83.5575	85.1555	87.9459
5	–1353.85	508.16	25	0	5.90E + 25	72.3828	74.3613	77.8161
6	–1081.58	544.55	25	0	1.10E + 21	60.3207	62.6797	66.7989
7	–795.956	571.24*	25	0	4.3e + 16*	47.6076*	50.3471*	55.1306*

Selection-order criteria: (Sample: 1973–2013); Number of observations = 41

itself by 74.55%, the current price of Sorghum can be explained by past prices of all food commodities specified in the model and itself by 74.47%, the current price of Cassava should be explained by past prices of all specified food commodities in the model and itself by 84.64% and the current price of Yam should be explained by past prices of all specified food commodities and itself by 85.47%.

The VAR results revealed that the current price of Rice can significantly be explained by its own price happened at the 6th period prior to the current period, it can be explained by Maize prices happened at the 1st, 2nd, 3rd and 6th periods prior to the current period, by Sorghum prices happened at the 2nd and 3rd periods prior to the current period, by Yam prices happened at the 3rd period prior to the current period.

The current price of Maize can significantly be explained by its own price happened at the 1st, 2nd and 5th periods prior to the current period, by Rice prices happened at the 1st, 2nd, 3rd and 6th periods prior to the current period, by Sorghum prices happened at the 2nd and 5th periods prior to the current period, by Cassava prices happened at the 2nd and 5th periods prior to the current period, and by Yam prices happened at the 3rd periods prior to the current period.

The current price of Sorghum can significantly be explained by its own price happened at the 2nd and 5th periods prior to the current period, by Rice prices happened at the 3rd and 4th periods prior to the current period, by Maize prices happened at 1st, 2nd and 5th periods prior to the current period, by Cassava prices happened at the 2nd, 5th and 6th periods prior to the current period, and by Yam prices happened at the 3rd, 5th and 6th periods prior to the current period.

The current price of Cassava can significantly be explained by its own price happened at the 5th periods prior to the current period, by Rice prices happened at the 1st, 3rd and 6th periods prior to the current period, by Maize prices happened at 1st and 5th periods prior to the current period, by Sorghum prices happened at the 1st, 2nd, 3rd, 5th and 6th periods prior to the current period, and by Yam prices happened at the 3rd, 5th and 6th periods prior to the current period.

The current price of yam can significantly be explained by its own price happened at the 1st, 2nd, 3rd and 6th periods prior to the current period, by Rice prices happened at the 1st, 2nd, 3rd, 5th and 6th periods prior to the current period, by Maize prices happened at 1st, 4th, 5th and 6th periods prior to the current period, by Sorghum prices happened at the 1st, 4th and 5th periods prior to the current period, and by Cassava prices happened at the 1st, 2nd, 3rd,4th, 5th and 6th periods prior to the current period.

Granger Causality Test

Table 5 provides the results of Granger causality analyses carried out for each of the food commodity prices using an optimal lag length of six. Significant probability values denote rejection of null hypothesis. The Granger test results show that: changes in the prices

Table 4. Vector Autoregression Estimates

	dlnrice	dlnmaize	dlnsorghum	dlncassava	dlnyam
dlnrice					
L1.	0.2536 (0.93)	0.6436** (1.99)	0.5233 1.53	0.5183** 2.24	0.5789** 2.43
L2.	–0.1918 (–0.72)	0.5581* (1.75)	0.4397 1.31	–0.3114 –1.37	0.4473* 1.91
L3.	0.4464 (1.52)	0.9124*** (2.61)	0.8629** 2.34	1.2233*** 4.9	1.1374*** 4.42
L4.	0.0595 (0.22)	0.3400 (1.04)	0.6161* 1.78	–0.0495 –0.21	0.0708 0.29
L5.	0.3116 (1.13)	0.4253 (1.3)	0.4285 1.24	–0.3364 –1.44	–0.6704*** –2.78

	dlnrice	dlnmaize	dlnsorghum	dlncassava	dlnyam
L6.	0.9010*** (3.26)	0.6532** (1.99)	0.4723 1.36	0.7942*** 3.39	0.8213*** 3.4
dlnmaize					
L1.	−0.9970*** (−2.7)	−1.3430*** (−3.06)	−1.0269** −2.22	−1.7210*** −5.5	−1.6112*** −5.00
L2.	−0.8765** (−2.2)	−1.4228*** (−3.01)	−1.3243*** −2.65	−0.3242 −0.96	−0.0046 −0.01
L3.	−1.5408*** (−3.52)	−0.5385 (−1.04)	−0.3506 −0.64	−0.5253 −1.42	0.0193 0.05
L4.	−0.6437 (−1.28)	0.4136 (0.69)	0.0523 0.08	0.4526 1.06	1.0810** 2.46
L5.	0.0861 (0.15)	1.2360* (1.83)	1.5426** 2.17	1.6455*** 3.42	2.0301*** 4.09
L6.	−1.3484*** (−3.08)	−0.5293 (−1.02)	−0.8174 −1.49	0.0832 0.22	−0.7743** −2.02
dlnsorghum					
L1.	0.5930 (1.57)	0.5886 (1.31)	0.1592 0.34	1.0215*** 3.19	1.3588*** 4.12
L2.	1.1778*** (2.66)	1.2075** (2.3)	1.1412** 2.05	0.8956** 2.38	0.4200 1.09
L3.	1.8842*** (4.00)	0.5486 (0.98)	0.6260 1.06	0.7798** 1.95	−0.0438 −0.11
L4.	0.8006 (1.27)	−0.8834 (−1.18)	−0.5257 −0.66	−0.3167 −0.59	−1.9107*** −3.46
L5.	0.1839 (0.23)	−1.9236** (−2.05)	−2.3359** −2.36	−1.5364** −2.3	−2.4349*** −3.53
L6.	0.5906 (1.19)	−0.6198 (−1.05)	−0.5891 −0.94	−0.8376** −1.98	−0.0260 −0.06
dlncassava					
L1.	−0.0902 (−0.56)	0.1813 (0.96)	0.2290 1.14	−0.0063 −0.05	0.5517*** 3.95
L2.	0.0716 (0.37)	0.4997** (2.18)	0.4321* 1.79	0.1286 0.79	0.7491*** 4.45
L3.	−0.0619 (−0.3)	0.0831 (0.34)	0.1493 0.58	0.0210 0.12	0.4011** 2.23
L4.	0.0375 (0.23)	0.2821 (1.47)	0.2068 1.02	−0.1297 −0.95	0.6883*** 4.87
L5.	0.1484 (0.67)	0.5500** (2.1)	0.5676** 2.06	0.6277*** 3.36	0.7597*** 3.95
L6.	0.1630 (1.08)	0.2558 (1.42)	0.3764** 1.98	−0.0638 −0.5	0.3314** 2.5
dlnyam					
L1.	−0.0948 (−0.33)	−0.3469 (−1.01)	−0.2731 −0.75	0.0244 0.1	−0.7282*** −2.87
L2.	−0.0411 (−0.14)	−0.3698 (−1.08)	−0.2852 −0.79	−0.0388 −0.16	−0.5620** −2.23
L3.	−0.6580*** (−2.84)	−0.6412** (−2.33)	−0.8215*** −2.82	−1.0606*** −5.39	−1.0257*** −5.06
L4.	−0.1303 (−0.65)	0.1065 (0.45)	−0.0365 −0.15	0.1363 0.81	0.1271 0.73
L5.	−0.0006 (0.00)	0.3735 (1.61)	0.5616** 2.28	0.3112* 1.87	0.1405 0.82
L6.	0.1169 (0.63)	0.0369 (0.17)	0.1447 0.63	−0.6277*** −4.02	−0.5468*** −3.4
Constant	−0.0435 (−0.75)	0.0217 (0.32)	0.0403 0.55	0.0605 1.23	0.0081 0.16

	dlnrice	dlnmaize	dlnsorghum	dlncassava	dlnyam
Diagnostic Statistics					
Parms	31	31	31	31	31
RMSE	0.317125	0.376594	0.397943	0.268972	0.277146
R-sq	0.7142	0.7455	0.7447	0.8464	0.8547
chi2	102.4784	120.1217	119.6026	225.9904	241.2511
P>chi2	0.0000	0.0000	0.0000	0.0000	0.0000
Sample: 1973–2013				No. of obs	41
Log Likelihood	209.8657			AIC	–2.67637
FPE	4.77E–07			HQIC	–0.31739
Det(Sigma_ml)	2.46E–11			SBIC	3.801765

*, **and *** implies statistics is significant at 10%, 5% and 1% respectively
t-values are in parenthesis()

of Maize, Sorghum and Yam granger cause changes in the prices of Rice; changes in the prices of Rice, Sorghum and Cassava Granger cause changes in the price of Maize; changes in Rice, Maize, Cassava and Yam prices granger cause changes in the price of Sorghum; changes in the prices of Rice, maize, Sorghum and Yam Granger cause changes in the price of Cassava and changes in the prices of Rice, Maize, Sorghum and Yam Granger cause changes in the price of Yam. The result indicates that there is bidirectional causality among the selected food prices and therefore, the hypothesis that the price of one food commodity price does not Granger cause the others is rejected while the hypothesis that the price of one food commodity price Granger cause the others is accepted. The result implies that the price of one of the selected food commodity has been significant in influencing the price others over the period under study. This could be attributed to the influence of the buyers and sellers of the food commodity in the market.

Table 5. Granger Causality Test

Equation	Excluded	chi2	df	pro>chi2
Rice	Maize	45.367	6	0.000***
	Sorghum	40.806	6	0.000***
	Cassava	4.9806	6	0.546
	Yam	11.388	6	0.077*
	ALL	79.407	24	0.000***
Maize	Rice	24.594	6	0.000***
	Sorghum	23.934	6	0.001***
	Cassava	15.217	6	0.019***
	Yam	7.1094	6	0.311
	ALL	85.595	24	0.000***
Sorghum	Rice	19.108	6	0.004***
	Maize	30.796	6	0.000***
	Cassava	12.384	6	0.054**
	Yam	12.303	6	0.056**
	ALL	74.878	24	0.000***
Cassava	Rice	68.793	6	0.000***
	Maize	48.954	6	0.000***
	Sorghum	28.923	6	0.000***
	Yam	50.762	6	0.000***
	ALL	188.89	24	0.000***
Yam	Rice	60.116	6	0.000***
	Maize	72.451	6	0.000***
	Sorghum	75.862	6	0.000***
	Cassava	41.329	6	0.000***
	ALL	212.14	24	0.000***

*, **and *** implies statistics is significant at 10%, 5% and 1% respectively

Impulse Response Analysis

Impulse response analysis shows the effects of shocks on the adjustment path of the prices of food commodities (rice, maize, sorghum, cassava and yam). It is used to determine the effects of external shocks on the prices of the food commodities. Impulse Response Function (IRF) of each food commodity shows an unexpected change in one food commodity price at the beginning affects another commodity price through time. This was used to assess how shocks of the prices of the food commodities (rice, maize, sorghum, cassava and yam) reverberate through a system.

Table 6 shows the response of the prices of rice, maize, sorghum, cassava and yam to their own shocks. It revealed that the responses were contemporaneously

Table 6. Impulse ResponseFunction (R = Rice; M = Maize; S = Sorghum; C = Cassava; Y = Yam)

Step	i=R r=R	i=R r=M	i=R r=S	i=R r=C	i=R r=Y	i=M r=R	i=M r=M	i=M r=S	i=M r=C
0	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000	0.0000
1	0.2536	0.6436	0.5233	0.5183	0.5789	−0.9970	−1.3430	−1.0269	−1.7210
2	−0.5605	0.0582	−0.0446	−0.7422	0.1326	−0.0912	−0.6184	−0.5846	0.3930
3	0.2912	0.1693	0.2118	1.0204	0.5459	−1.2666	−0.3315	0.0056	−0.4305
4	−0.4138	−0.6051	−0.0973	−0.1745	−0.5883	0.2569	0.6820	0.1500	0.4443
5	0.4183	0.9564	0.6186	−0.2503	0.0173	−0.3852	−0.6954	−0.1190	0.3800
6	0.9495	0.6947	0.3961	0.9698	0.3156	−1.4966	−1.9333	−2.5353	−1.3219
7	−0.0017	−0.7334	−0.8167	−0.5748	0.7537	−0.6621	0.3936	1.0838	0.3417
8	−0.2210	0.4191	0.9054	0.8103	−0.3393	−0.0821	−1.2965	−1.7666	−0.9507
9	−0.4789	−0.7086	−0.8846	−0.8178	−0.0075	−1.1357	−0.1093	0.2844	−0.4017
10	0.5780	0.9457	0.9035	0.3419	0.4414	−0.0392	−0.6237	−0.9944	−1.0183
11	0.0988	−0.0287	−0.0870	0.6025	−0.3427	−1.0139	−0.5095	0.0487	−0.7352
12	−0.0575	0.1375	0.0393	−0.6588	0.1413	−0.2312	−0.9341	−1.0021	−0.0575

Step	i=M r=Y	i=S r=R	i=S r=M	i=S r=S	i=S r=C	i=S r=Y	i=C r=R	i=C r=M	i=C r=S
0	0.0000	0.0000	0.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1	−1.6112	0.5930	0.5886	0.1592	1.0215	1.3588	−0.0902	0.1813	0.2290
2	0.4106	0.6148	0.6063	0.7353	0.3793	−0.3947	−0.0480	0.1404	0.0831
3	−1.1684	1.4502	0.4622	0.3538	0.6400	1.1621	−0.0907	−0.4310	−0.2661
4	1.1304	−0.2900	−0.4206	−0.3315	−0.5194	−1.0464	0.0288	0.0798	−0.0271
5	−0.8262	0.8181	0.6570	0.0660	0.1020	1.2068	−0.1492	0.2372	0.1575
6	−0.1035	0.6119	1.0213	1.6952	0.5401	0.1773	0.0904	−0.2144	−0.1108
7	−1.7623	0.5344	0.2927	−0.0641	−0.0980	0.9096	−0.1633	−0.2333	−0.1673
8	0.7379	0.3631	1.1463	1.1482	0.7114	−0.1568	−0.1061	0.0591	0.0508
9	−1.4090	1.2394	0.4988	0.1474	0.1447	1.6049	0.4225	0.3349	0.3896
10	0.2038	0.1233	0.6702	1.2604	1.7928	−0.3999	0.1862	−0.1440	−0.2784
11	−0.8004	0.4365	−0.2031	−0.7483	0.0486	0.6666	−0.0657	0.0422	0.1457
12	−0.8786	0.5166	1.2163	1.1334	0.2671	0.8143	0.2808	0.0948	0.0874

Step	i=C r=C	i=C r=Y	i=Y r=R	i=Y r=M	i=Y r=S	i=Y r=C	i=Y r=Y
0	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	1.0000
1	−0.0063	0.5517	−0.0948	−0.3469	−0.2731	0.0244	−0.7282
2	0.0173	0.3108	0.1856	0.1313	0.1823	0.2121	0.1146
3	−0.0010	−0.2166	−0.6316	−0.1997	−0.4886	−1.0739	−0.5764
4	−0.2903	0.2994	0.3002	0.3058	0.3173	0.3582	0.1542
5	0.1178	−0.3460	−0.1903	−0.4898	−0.1110	−0.0110	−0.3918
6	−0.1439	0.1158	0.1076	0.2481	0.0993	−0.6844	0.0761
7	−0.4087	−0.3680	0.3892	0.5445	0.4630	0.9454	0.1059
8	−0.2646	−0.3849	0.0325	−0.6556	−0.6198	−0.3295	0.5075
9	0.1645	0.1289	−0.1558	0.2848	0.3794	1.0244	−0.3731
10	0.2728	0.0974	−0.3933	−0.5914	−0.6596	−0.8021	−0.2674
11	0.1371	−0.0634	0.4680	0.6322	0.5087	−0.1298	0.5580
12	−0.0401	0.2756	−0.1310	−0.2440	−0.1665	0.4007	−0.4393

strong and positive for the initial periods before it subsides to zero towards the end of the period.

This means that any unanticipated increase in the prices of these food commodities consistently reduces the deviation between the short term equilibrium values of their prices and the long-run equilibrium values.

Table 6 displays the response of maize, sorghum, cassava and yam prices to one standard deviation shock in the price of rice; their effects eventually die out. It was revealed that the shock to the prices of Rice, Maize and Sorghum create smaller, but a significant response and temporary oscillations in prices of Rice itself and Cassava that does not die out quickly whereas, shocks to Sorghum and Maize prices create response to Rice, Maize and Sorghum which dies out very quickly. As also shown in Table 6, the shock to the prices of Cassava and Yam create smaller but significant response and temporary oscillations in the prices of Maize, Sorghum, Yam and Cassava that do not die out quickly nonetheless, the shocks to Cassava and Yam prices create response to Rice, Cassava itself and Yam itself which dies out very quickly.

It was discovered that even though the shock of the price of one food commodity creates a smaller response, significant response and temporary oscillations in other food commodities and itself, the impact of the shock does not persist and the effect eventually dies out.

GARCH (1, 1) Estimation of Food Commodities Prices

The result of GARCH (1, 1) estimation of the food commodity prices in Nigeria is shown in Table 7. The period 1966 to 2010 was used to estimate the model, while the in-sample forecast was represented with the series from 1966 to 2013. The maximum likelihood estimation was used under the assumption of a Gaussian distribution of conditional errors.

For rice price, the constant in the mean and variance equations are significant at 1 percent and 5 percent level of significance respectively which is consistent with the work of Kuwornu et al. (2011). Similar results have been reported in studies that have focused on the increase in food prices (rice, millet and maize) and its implications on food and nutrition situation of people, Alderman (1992), and Jones and Sanyang (2008). This explained that the price of rice depends on immediate past prices and a constant term. Therefore, the behaviour of rice prices and the coefficient influences the prices of rice today and future. The sum of the ARCH and GARCH effect is 0.4372 which indicates that, rice prices are volatile and it is concluded that the long term value plays very little role in determining the rice price.

The coefficients of the conditional mean and variance equation of maize are positive and significant

Table 7. Garch (1, 1) Estimation Result

Parameter	Estimate	Std. Error	Prob.
Rice Price (Pr)			
β_0	15908	1806.789	0.0000
β_1	0.694999	0.29737	0.0194
α_0	2.89E + 08	2.96E + 08	0.3283
α_1	1.456166	1.332468	0.2745
α_2	−1.01894	0.06877	0.0000
Maize Price (Pm)			
β_0	706.4528	206.3499	0.0006
β_1	0.705128	0.215866	0.0011
α_0	2.65E + 08	1.41E + 08	0.0600
α_1	2.394506	1.845474	0.1945
α_2	−0.99997	0.000215	0.0000
Sorghum Price (Ps)			
β_0	1479.54	283.9155	0.0000
β_1	0.572629	0.026475	0.0000
α_0	2.19E + 08	1.19E + 08	0.0662
α_1	3.409715	1.756341	0.0522
α_2	−0.99971	0.001381	0.0000
Cassava Price (Pc)			
β_0	1267.882	201.4184	0.0000
β_1	0.552917	0.574884	0.3362
α_0	53341835	30115816	0.0765
α_1	2.712544	3.874546	0.4839
α_2	−0.99855	0.00456	0.0000
Yam Price (Py)			
β_0	965.7796	241.1107	0.0001
β_1	0.774148	0.214287	0.0003
α_0	4.12E + 08	2.21E + 08	0.0623
α_1	2.566489	3.598858	0.4758
α_2	−1.00001	0.00032	0.0000

at 1 percent and 10 percent level of significance respectively. This indicates the presence of ARCH and GARCH effect. The sum of the ARCH and GARCH effect is 1.3945 indicating high volatility of maize price. Considering the price of sorghum, the constant terms of the mean and variance equation are both significant at the one percent level. This gives an explanation that the price of sorghum depends on immediate past prices and a constant term. The sum of ARCH and GARCH effect of sorghum price is 2.41006 which indicates that sorghum prices are very volatile. The equation for the price of cassava revealed that the coefficient on the conditional variance is negative and individually significant at the one percent level. This indicates the presence of ARCH and GARCH effect. The coefficient of the first lagged value of cassava was not significant. Hence the price of cassava today is not determined by the immediate past cassava price. The sum of the ARCH and GARCH effect (1.7140) indicates that cassava prices are highly volatile. Yam price shows similar characteristics as for rice and maize even though they are grains. The coefficients on the conditional mean and variance equation of yam are positive and significant at one percent and 10 percent level of significance, respectively. The coefficient of the first lagged value of yam was significant at the one percent level. The sum of the ARCH and GARCH effect (1.5665) indicates that the prices of yam are highly volatile.

The sum of the ARCH and GARCH effect of all the selected food commodity prices indicate the presence of price volatility which are high in the prices of maize, sorghum, cassava and yam while it is relatively low in rice price. This agrees with the work of Hossain (2014) and Habyarimana et al. (2014). However, the static forecast was used to forecast the food commodity prices. This is due to the seasonality of the food commodities. The Theil inequality coefficients of rice, maize, sorghum, cassava and yam are 0.4716, 0.7351, 0.7178, 0.7684 and 0.7686 respectively. It indicates the good performance of the model in forecasting. The bias proportion indicates that, the mean of the forecast is 0.014, 0.342, 0.324, 0.3209 and 0.3476 from the actual value of rice, maize, sorghum, cassava and yam prices respectively. The forecast variance is 0.014, 0.3105, 0.335, 0.484 and 0.331 from the variance of the actual prices of rice, maize, sorghum, cassava and yam. For all the food commodities, the bias is concentrated covariance, therefore the forecast is good.

CONCLUSION AND POLICY IMPLICATIONS

Despite the various efforts to combat high fluctuations in prices of food commodities in the markets, it has been an economic menace limiting the ability of consumers (processors) to secure supplies and control input costs. Persistency in food price transmission results to contracting and relatively low percentage of raw commodities in the processed products (Trostle, 2008).

This paper used VAR model to test stationary in food commodity price series, to check on stability condition in thetransformed series, to test Granger causality among food price volatility, to analyse impulse response of shock in price of one food commodity to the other food commodities in the model, and to forecast food commodity price volatility in Nigeria. Also, GARCH model was used to estimate the magnitude of the food commodity price volatility. This study revealed that the logged of food commodities price series is stationary at first difference which satisfy stability condition. The Granger causality test explained that there is the presence of bidirectional causality from the price of one food price to the others over the period under study. As a result, the impulse response analysis explained that the shock to the price of one food commodity exhibit smaller, but significant response and also temporary oscillations in other food commodities and itself. Moreover, the impact of this shock on other food creates little or no persistency and that their effects eventually die out. The outcome of this study revealed that forecast of a food commodity can be relatively explained by the past price volatility of the same commodity and that of others. The magnitude of conditional volatility of the selected food commodities shows that the past behaviour of the selected food prices and a constant term influences their prices today and future. The sum of the ARCH and GARCH effects indicates that, the prices are very volatile. This could be attributed to their seasonality in production.

Owing to the pronounced fluctuations of the food commodity prices across the years in Nigeria, the study recommends that the government and private bodies should help in facilitating proper storage facilities and infrastructure for the food distribution corporations in Nigeria. Without adequate storage facilities, food prices are more volatile, causing great havoc for both producers and consumers.

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