DE GRUYTER OPEN
DOI: 10.2478/ats-2018-0019 AGRICULTURA TROPICA ET SUBTROPICA, 51/4, 165–174, 2018

Original Research Article

Determinants of food price volatility in Nigeria

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Abstract

In this paper we examined the determinants of food price volatility in Nigeria using monthly data from January, 1997 to April, 2017. We employed the multivariate GARCH approach to evaluate the level of interdependence and the dynamics of volatility across these markets. In particular, the Baba-Engle-Kraft-Kroner (BEKK) model and the Dynamic Conditional Correlation (DCC) model were used for estimation. The findings showed that information shocks originating in Consumer Price Indices (CPI), lending rate, exchange rate and oil market have a direct effect on the current conditional volatility in food market while the information shocks originating in food have a direct effect on the current conditional volatility in all the markets considered except for oil. These results were insensitive to changes in data frequency and different oil price specification. Hence, the government should encourage the use of alternative sources of energy to reduce the effect of high oil prices on food prices and provide soft agricultural credit scheme to farmers with a low lending rate through specialized banks.

Keywords: price volatility; inflation rate; exchange rate; oil prices; interest rate; multivariate GARCH models.

INTRODUCTION

The incessant increase in food price over the recent years has increasingly been gaining importance as a result of the negative outcomes, especially on the poor who spend a large share of their income on food. This volatility in food prices has led to more malnutrition and food insecurity among the poor, negative impact on trade balance, low investment and possible social unrest among most developing countries of the world (Banerjee and Duflo, 2007). Also, the policy response to changes in food prices has become more challenging due to increasing price volatility and has complicated the investment and consumption decisions of many businesses and consumers (Roache, 2010). Nevertheless, the effect of food price volatility on economic activities has led governmental and nongovernmental organizations to begin to respond with a new sense of urgency.

The sudden and large increases in food prices have been attributed to a number of individual factors such as exchange rate, lending rate, money supply, real GDP per capita, stocks, and oil price among others. Over the past few years, studies have observed the relationship existing between these individual factors and food price changes (Irz et al., 2013; Nazlioglu et al., 2013; Ahmadi et al., 2016).

The problem of food insecurity is a major challenge confronting the nation. Many households are net buyers or consumers of food in Nigeria. Therefore, food price variability distorts the consumption pattern of most households and this leads to serious implications of food insecurity in the country (Akanni, 2002). The increase in international food prices has affected the macroeconomic policy actions leading to inflationary pressures, high lending rates, and volatile exchange rate. The high interest charges on loans for agricultural production have resulted in increase of production costs. The importation of agrochemicals has made procurement difficult and again results in cost escalation arising from the depreciation of naira exchange rate. This has resulted in the low level of investment in agriculture by private sectors due to the increasing cost of farm input and a low profitability in farm enterprises in Nigeria (Olukunle, 2013).

However, in Nigeria, some studies have shown that high commodity prices were not associated with food crises since in most situations, prices of locally produced commodity reflect poor infrastructure state of the economy which creates surplus close to the farm gate and scarcity elsewhere (Azih, 2008). The high

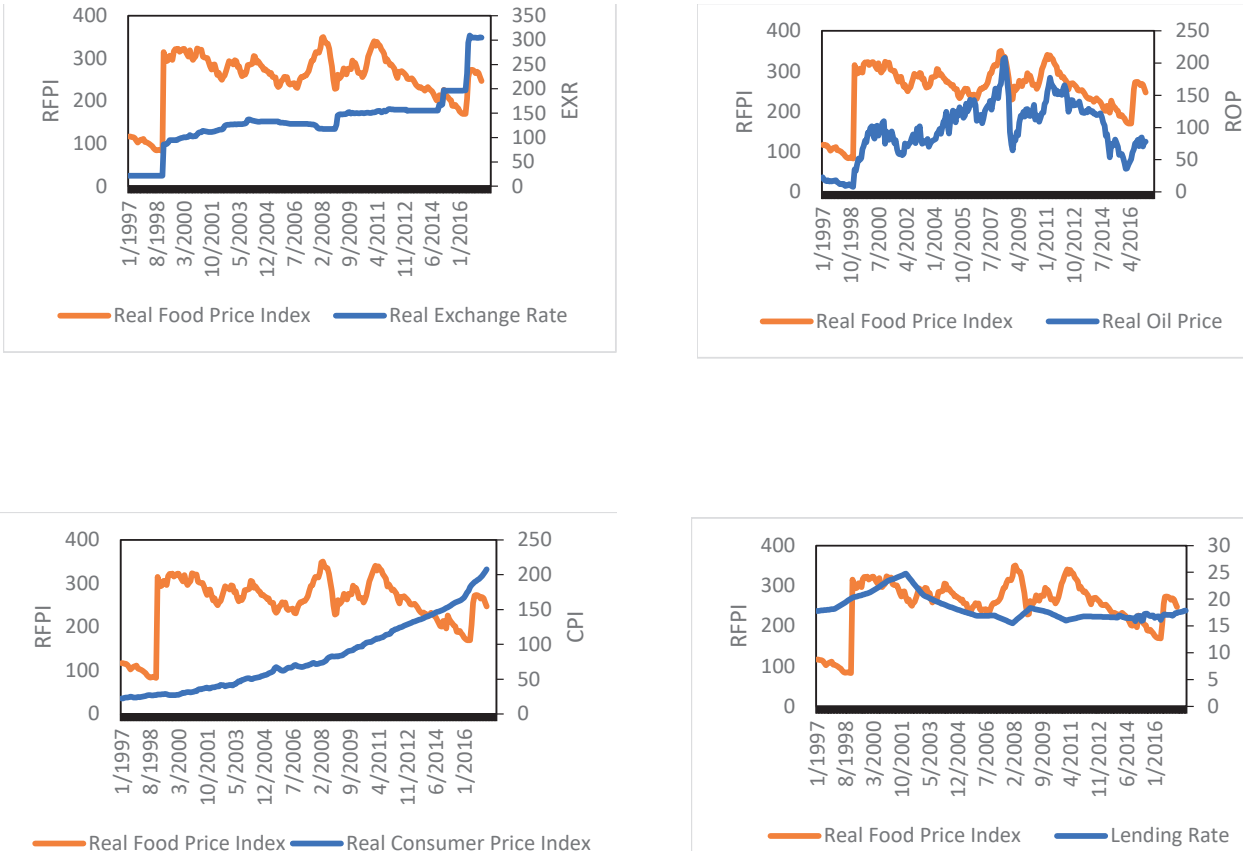

Figure 1. Monthly returns series plot of food price index (RRFPI), oil price (RROP), exchange rate (REXR), lending rate (RLR), consumer price index (RCPI).

food prices unveiled mostly in 1999 and in 2007 which continued to worsen in April 2008 as shown in Figure 1, affecting prices of food such as rice, sorghum, cassava, soybean, maize, millet, and wheat the most. The food price continued to rise even after 2008 due to the demand pressures from neighbouring countries on Nigeria as a result of its important role in ensuring food security by exporting dry grains such as millet, maize, and sorghum.

Also, food production increases have not kept pace with population growth, resulting in rising food imports and declining levels of national food self-sufficiency. Due to the high importation of food, the international market prices of food could be held responsible for the increasing prices of food experienced over the years. In 2010 and 2011, there was another high increase in the price of food due to the increase in the price of petrol which transmit to the domestic economy leading to a rise in transportation cost and food price after which the price reduces from 340 to 169 in June 2016. The depreciation of Nigerian naira to dollar led to a large increase in food price in August 2016 due to the fact that Nigeria is a net food importer.

A considerable body of studies exists on the relationships between crude oil and food prices. For example, Nwoko et al. (2016) examined the effect of oil price on Nigeria's food price volatility and found out that there exists a short-run relationship between oil price and food price volatility and in the long-run, no relationship exists between oil price and food price volatility using a yearly data. However, the use of yearly data does not provide a deeper picture of the potential relationships between markets.

Therefore, the motivation of this paper lies on the macroeconomic and financial factors influencing factors of food prices volatility in Nigeria using a higher frequency data to provide a broader picture of the potential relationships between markets using the BEKK (Baba-Engle-Kraft-Kroner model) and the DCC (Dynamic Conditional Correlation) model. Our null hypothesis (H_0) is that macroeconomic and financial factors are not drivers of food price volatility in Nigeria while the alternative hypothesis (H_1) is that macroeconomic and financial factors are drivers of food price volatility in Nigeria. Against this background, the study seeks to examine the determinants of food price volatility in Nigeria.

MATERIALS AND METHODS

Data description and sources

This study uses a monthly data from January, 1997 to April, 2017 for the Real Food Price Index

(RFPI), the Real oil price (ROP)- Bonny Light, Nigeria Exchange Rate (EXR), Lending Rate (LR), Consumer Price Indices (CPI). The data were sourced from Food and Agriculture Organization (FAO), International Financial Statistics (IFS) and Central Bank of Nigeria (CBN). Specifically, Real Food Price Index (RFPI) was sourced from the Food and Agriculture Organization (FAO), Nigeria Exchange Rate (EXR), Lending Rate (LR) and Consumer Price indices (CPI) were obtained from Central Bank of Nigeria (CBN) Statistical Bulletin whereas Real oil price (ROP) came from the International Financial Statistics (IFS) database.

The returns on the series was computed due to its attractive statistical properties such as stationarity and the fact that returns across markets can be more easily compared as well as being unit/scale free (see Belasri and Ellaia, 2017). The monthly percentage returns were calculated as $r_t = 100 * (\ln P_t / \ln P_{t-1})$ where r_t is index return, P_t is the price of food, oil, exchange rate, consumer price index and lending rate at month t and P_{t-1} is the price of food, oil, exchange rate, consumer price index and lending rate at month t-1. Each market return was calculated in the local currency. The sample period corresponds with major economic and financial events of 2008/09 crisis and 2010/11 crisis.

Methods

The model centers on a MGARCH approach to examine the level of inter-dependence and the dynamics of volatility between oil price, stocks, exchange rate, inflation, interest rate and agricultural commodities (palm oil, rice, wheat, corn, soybean) markets in Nigeria. This paper considers both BEKK (Baba-Engle-Kraft-Kroner model) and DCC (Dynamic Conditional Correlation) model. The BEKK model is suitable to characterize volatility transmission across markets and persistence between markets. The DCC model approaches a dynamic conditional correlation matrix, which permits to evaluate whether the level of interdependence between markets changes across time.

The model proposed in this study assumes that the yields (r_t) of all the used variables follow a conditionally multivariate student t distribution with zero mean and time-dependent variance-covariance matrix which the representation of the system (r_t) is:

$$r_t = y_0 + \sum_{j=1}^{p} y_j r_{t-j} + \varepsilon_t, \quad (1)$$

$$\frac{\varepsilon_t}{I_{t-1}} \sim (0, N_t),$$

where r_t is a 5 × 1 vector of price returns for food price index, oil, exchange rate, lending rate and consumer price index, y_0 is a 5 × 1 vector of long-term drifts, y_j, with j = 1..., p, are 5 × 5 matrices of parameters, and ε_t is a 5 × 1 vector of forecast errors for the best linear predictor of r_t, conditional on past information denoted by I_{t-1}, and with corresponding variance-covariance matrix N_t.

In the BEKK model having a one-time lag, the conditional variance-covariance matrix N_t is given by

$$N_t = CC' + B'\varepsilon_{t-1}\varepsilon_{t-1}^{'}B + F'N_{t-1}F \quad (2)$$

where C is a 5 × 5 upper triangular matrix of constants C_{ij}, B is a 5 × 5 matrix containing elements B_{ij} that measure the degree of origination from market i to market j, and the persistence in conditional volatility between markets i and j is shown by the elements F_{ij} of the 5 × 5 matrix F. This specification guarantees, by construction, that the covariance matrices are positive definite. The conditional variance–covariance matrix defined in Eq. (2) allows us to analyse the direction, magnitude and persistence of volatility transmission across markets.

In the DCC model, the conditional variance covariance matrix N_t is defined as:

$$N_t = D_t R_t D_t \quad (3)$$

where D_t is a diagonal matrix of time-varying standard deviations from the univariate generalised extreme value distribution for each EGARCH models.

$$D_t = diag\left(n_{11,t}^{1/2} \ldots . n_{55,t}^{1/2}\right) \quad , (4)$$

$n_{11,t}$ is defined as $n_{ii,t} = \delta_i + \alpha_i \varepsilon_{i,t-1}^2 + \beta_i n_{ii,t-1}, i = 1,\ldots,5,$ and

$$R_t = diag\left(q_{ii,t}^{-1/2}\right) Q_t diag\left(q_{ii,t}^{-1/2}\right) \quad (5)$$

with the 5 × 5 symmetric positive-definite matrix $Q_t = \left(q_{ij,t}\right) i, j = 1,\ldots,5$ given by

$$Q_t = (1 - \alpha - \beta)\bar{Q} + \alpha\left(u_{t-1}u_{t-1}^{'}\right) + \beta Q_{t-1}, \quad (6)$$

and $u_{i,t} = r_{i,t} / \sqrt{n_{ii,t}}.\bar{Q}$ is the 5 × 5 unconditional variance matrix of u_t, α and β are non-negative adjustment parameters satisfying $\alpha + \beta < 1$. Q_t basically resembles an autoregressive moving average (ARMA) type process which captures short-term deviations in the correlation around its long-run level. The variance-covariance matrix defined in Equation (3) allows us to model the degree of volatility interdependence between markets across time.

RESULTS AND DISCUSSION

Preliminary analysis of food price drivers

This section presents the descriptive statistics of the return series, the correlations of monthly price returns and the estimation results of the BEKK and DCC models used to examine the level of interdependence and volatility transmission between

Table 1. Descriptive Statistics of Return series

	RRFPI	RROP	REXR	RLR	RCPI
Mean	0.3082	0.5033	1.0848	–0.0084	0.9157
Maximum	133.3184	149.5590	136.8496	6.9656	7.1846
Minimum	–12.2792	–46.6327	–3.4008	–5.7854	–3.5729
Std. Dev.	9.3710	14.6514	9.1151	1.1138	1.4788
Skewness	11.9197	4.1222	13.8003	0.9614	0.2766
Kurtosis	168.6687	45.9546	204.4619	15.3020	5.5818
Jarque–Bera	283646.1	19369.91	418655.5	1569.764	70.5897
Observations	243	243	243	243	243

agricultural market and other markets considered which establish the base results.

Table 1 presents the descriptive statistics for the price returns in each market, revealing that price returns are higher in exchange rate market than other markets. The average monthly return in this market is 1.08% against 0.30% in food, 0.50% in oil and 0.91% in consumer price while only the lending rates have a negative average monthly returns and small standard deviations compared to the others. The returns in the five markets appear to follow a non-normal distribution using the Jarque-Bera statistic which rejects the null hypothesis that the returns are normally distributed.

The return distributions are positively skewed for all markets and the skewness are different from zero meaning that they are asymmetric distributions. The kurtosis in all markets exceeds three, pointing to a leptokurtic distribution. The oil price experienced larger fluctuations compared to other markets with difference between maximum and minimum returns (149.55 to -46.63) being the highest. Figure 2 plots the monthly returns series of Food Price Index (RRFPI), Oil Price (RROP), Exchange Rate (REXR), Lending Rate (RLR), Consumer Price Index (RCPI). It can be seen from Figure 2 that our series returns are not constant over time. Also, food price index, oil price and exchange rate exhibit a high return in January 1999 as a result of transit from military era to democratic/civilian era of governance and the introduction of Interbank Foreign Exchange (IFEM) in the economy while consumer price index show more high returns over time compared to others.

Therefore, establishing sources of interdependence on price volatility transmission requires further analysis. Table 2 reports Pearson correlations of monthly price returns providing additional perception about the potential interdependencies between the five markets. A comparison throughout the periods shows that oil, exchange rate and food markets have become more interrelated over the years. There is a statistically significant positive correlation in food price index returns, oil price returns and exchange rate return while only consumer price index returns exhibit a statistically significant negative correlation. The correlation between food and exchange rate returns is the strongest followed by the correlation between food and oil compared to the other price returns.

Finally, for a proper specification of the mean equation in a MGARCH model requires examining whether the returns series are non-stationary in order to justify for potential long-run relationships between them. Therefore, the augmented Dickey–Fuller tests with non-stationarity as null hypothesis is applied which shows that the five returns series are stationary.

Baba-Engle-Kraft-Kroner (BEKK) results

The BEKK model which allows for own- and cross volatility spillovers and persistence between markets is presented in Table 3. The y_{1ii} co-efficient denotes the dependence of the return in market *i* on its lagged value and the dependence of the return in market *i* on the lagged return in market *j* is captured by y_{1ii}. The results reveal that mean return in a market is influenced by the lagged return in the same market and also showing a positive own-mean spillover expect for oil exhibiting a negative own-mean spillover.

While most of the markets unveil a cross-market mean spillovers except for the mean return in consumer price index which is not influenced by the lagged return in food price, and lastly the mean return in food price by the lagged return in lending rate (and *vice-versa*).

Furthermore, the conditional variance–covariance equation shows the own-volatility spillovers i.e. the influence of lagged innovations on the current conditional return volatility in market *i* which is depicted by b_{ii} and the b_{ij} coefficients capture the direct effects of lagged innovations originating in market *i* on the current conditional volatility in market *j*. The results reveal significantly large positive own-volatility spillovers in two markets (lending rate and exchange rate) and a negative own-volatility spillover in consumer price index, oil and food price index. Considering the cross-dynamics, the result discloses that the lagged innovations (information

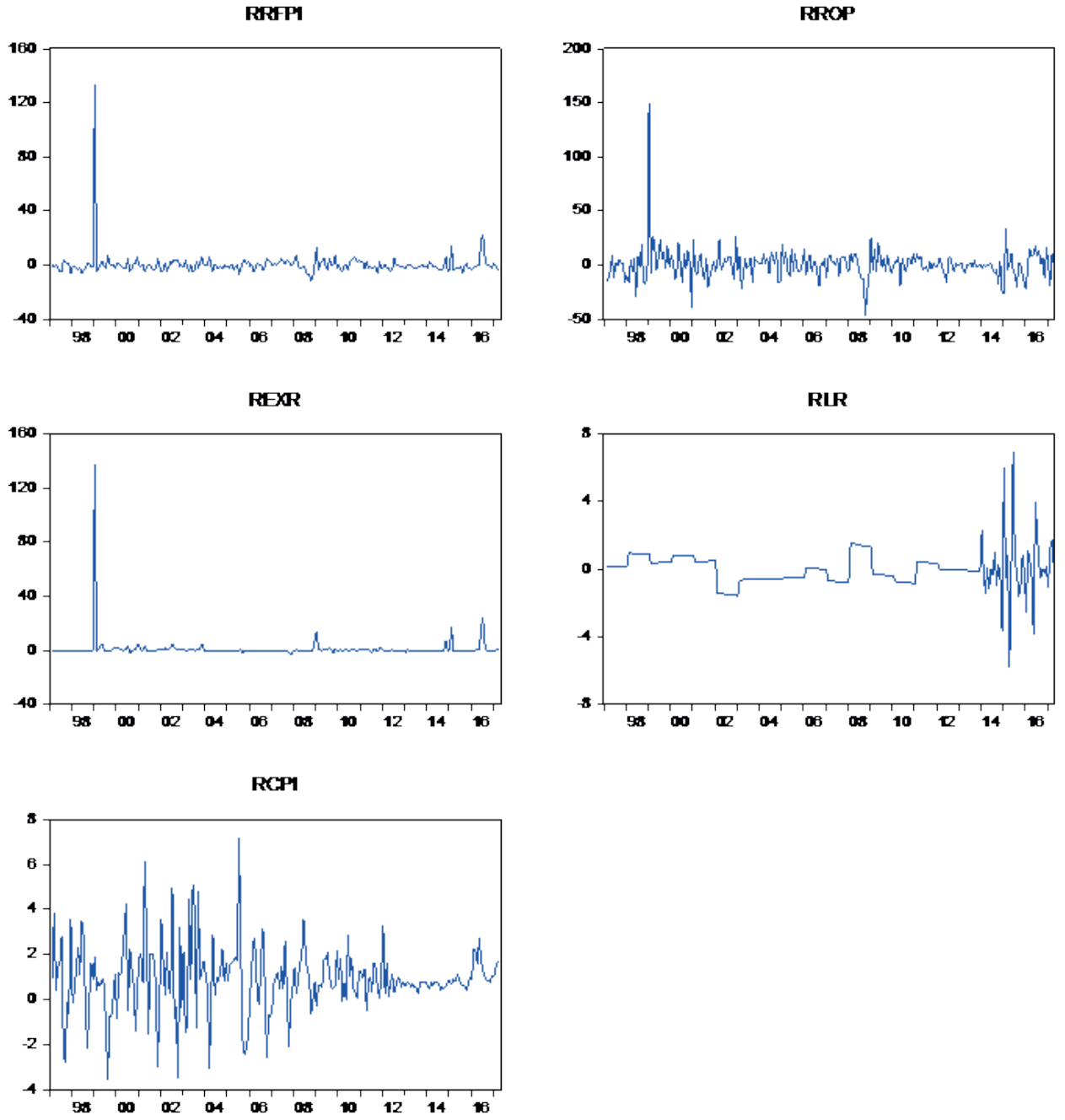

Figure 2. Monthly returns series plot of food price index (RRFPI), oil price (RROP), exchange rate (REXR), lending rate (RLR), consumer price index (RCPI).

Table 2. Correlation Matrix between monthly return series

VARIABLES	RCPI	RLR	REXR	RROP	RRFPI
RCPI	1.0000	0.0175	0.0532	–0.0214	–0.1122*
RLR		1.0000	0.1112*	–0.0364	0.0458
REXR			1.0000	0.6760***	0.9495***
RROP				1.0000	0.7138***
RRFPI					1.0000

* ** *** indicate significance at 10%, 5% and 1% critical level, respectively

Table 3. Baba-Engle-Kraft-Kroner model (1,1) - Estimation by BFGS

Coefficient	RCPI	RLR	REXR	RROP	RRFPI
	(i = 1)	(i = 2)	(i = 3)	(i = 4)	(i = 5)
Conditional mean equation					
y_0	0.4645 (0.0154)***	0.0314 (0.0009)***	–1.0574 (0.0353)***	0.5995 (0.1810)***	–1.7376 (0.0606)***
y_{12i}	0.3657 (0.0111)***	–0.0673 (0.0142)***	0.0009 (0.0041)	0.0028 (0.0010)***	–0.0050 (0.0037)
y_{13i}	–0.0003 (0.0002)	0.9451 (0.0017)***	–0.0005 (0.0003)	–0.0001 (0.0000)***	0.0000 (0.0002)
y_{14i}	0.4882 (0.0193)***	0.7409 (0.0387)***	0.1705 (0.0105)***	–0.0171 (0.0014)***	–0.0779 (0.0092)***
y_{11i}	–0.0885 (0.1769)	2.2163 (0.2105)***	–0.1184 (0.0887)	–0.3574 (0.0154)***	0.5568 (0.0763)***
y_{15i}	0.6431 (0.0404)***	0.0734 (0.0572)	–0.2477 (0.0148)***	–0.0067 (0.0040)*	0.3070 (0.0151)***
Conditional variance-covariance equation					
c_{i1}	–0.0316 (0.0328)	–0.0005 (0.0005)	–0.4301 (0.1310)***	1.1629 (0.7562)	–0.3732 (0.1423)***
c_{i2}		0.0000 (0.0004)	–0.1380 (0.0463)***	–0.1268 (0.4414)	0.5646 (0.0517)***
c_{i3}			0.1580 (0.1112)	–0.2281 (0.8450)	–0.3331 (0.1218)***
c_{i4}				7.0842 (0.3472)***	–0.2687 (0.0757)***
c_{i5}					–0.0177 (0.2585)
b_{i1}	–0.2035 (0.0093)***	0.0475 (0.0115)***	0.0424 (0.0062)***	–0.0189 (0.0013)***	–0.0125 (0.0039)***
b_{i2}	–0.2396 (0.0040)***	3.9441 (0.0794)***	–0.0938 (0.0026)***	0.0090 (0.0002)***	–0.0582 (0.0013)***
b_{i3}	–0.4309 (0.0851)***	2.6762 (0.1309)***	0.1355 (0.0258)***	–0.4851 (0.0042)***	0.1543 (0.0281)***
b_{i4}	0.4691 (0.4732)	4.0525 (0.8617)***	–0.2998 (0.1305)**	–0.2929 (0.0556)***	–0.2015 (0.1342)
b_{i5}	–0.6839 (0.1056)***	0.9263 (0.1495)***	0.4993 (0.0210)***	–0.4788 (0.0080)***	–0.1633 (0.0235)***
f_{i1}	0.9701 (0.0015)***	–0.0070 (0.0031)**	–0.0120 (0.0009)***	–0.0019 (0.0009)**	–0.0044 (0.0007)***
f_{i2}	0.0114 (0.0005)***	–0.0009 (0.0009)	–0.0002 (0.0002)	–0.0000 (0.0000)	0.0000 (0.0003)
f_{i3}	–0.0105 (0.0287)	–0.3434 (0.0236)***	0.6982 (0.0047)***	–0.0333 (0.0037)***	–0.0243 (0.0047)***
f_{i4}	0.5597 (0.1772)***	–0.5196 (0.1588)***	–0.2595 (0.0520)***	0.6578 (0.0285)***	0.5503 (0.0531)***
f_{i5}	–0.1852 (0.0332)***	–0.0550 (0.0331)*	–0.1093 (0.0076)***	–0.0270 (0.0045)***	0.8129 (0.0061)***

* ** *** indicate significance at 10%, 5% and 1% critical level, respectively.
Note: Standard errors reported in parentheses.

shocks) originating in food and oil market have a direct negative effect on the current conditional volatility in Consumer Price market while lending rate and exchange rate market have a direct positive effect on the current conditional volatility in Consumer Price market.

The lagged innovations (information shocks) originating in CPI, food and exchange rate market have a direct negative effect on the current conditional volatility in lending rate market while oil market has a direct positive effect on the current conditional volatility in lending rate market. Furthermore, the lagged innovations (information shocks) originating in CPI and oil market have a direct negative effect on the current conditional volatility in exchange rate market while lending rate and food market have

Table 4. Dynamic Conditional Correlation model (1,1) - Estimation by BFGS

Coefficient	RCPI	RLR	REXR	RROP	RRFPI
	(i = 1)	(i = 2)	(i = 3)	(i = 4)	(i = 5)
Conditional mean equation					
y_0	0.6316 (0.0638)***	0.0320 (0.0246)	0.6033 (0.1931)***	–0.7262 (0.6383)	0.4650 (0.2778)*
y_{11i}	0.2974 (0.0501)***	–0.0352 (0.0305)	–0.0138 (0.0166)	–0.0009 (0.0046)	0.0270 (0.0163)*
y_{12i}	0.0094 (0.0145)	0.8791 (0.0232)***	–0.0219 (0.0075)***	–0.0008 (0.0018)	0.0189 (0.0074)**
y_{13i}	0.0222 (0.0740)	1.2618 (0.1012)***	0.1667 (0.0439)***	–0.1349 (0.0146)***	0.0413 (0.0448)
y_{14i}	1.6994 (0.5117)***	1.6566 (0.7065)**	–0.4276 (0.3215)	–0.2914 (0.0643)***	0.7657 (0.2729)***
y_{15i}	0.1427 (0.1267)	1.5853 (0.1451)***	–0.3218 (0.0892)***	–0.1772 (0.0202)***	0.3208 (0.0934)***
Conditional variance–covariance equation					
δ_i	0.0085 (0.0033)**	0.0718 (0.0081)***	12.7891 (1.8163)***	15.5964 (15.0411)	41.1018 (3.1907)***
α_i	0.0641 (0.0100)***	1.0698 (0.2791)***	6.4871 (1.4477)***	0.2269 (0.1290)*	2.4011 (0.3797)***
β_i	0.9211 (0.0082)***	0.2865 (0.0621)***	0.0222 (0.0095)**	0.7730 (0.1443)***	–0.0222 (0.0145)
α					0.0551 (0.0194)***
β					0.8365 (0.0489)***
Log Likelihood					–2782.849
ARCH test					22.8568 (0.0000)***

Note: * ** *** indicate significance at 10%, 5% and 1% critical level, respectively. Standard errors reported in parentheses.

a direct positive effect on the current conditional volatility in exchange rate market.

However, the lagged innovations (information shocks) originating in exchange rate and lending rate have a direct effect on the current conditional volatility in oil market while food and CPI market have no direct effect on the current conditional volatility in oil market. Also, the lagged innovations (information shocks) originating in CPI and oil market have a direct negative effect on the current conditional volatility in food market while lending rate and exchange rate market have a direct positive effect on the current conditional volatility in food market.

Lastly, the lagged innovations originating in food market have a direct effect on the current conditional volatility in CPI, lending rate which is negative and exchange rate which is positive while there is no direct effect on the current conditional volatility in oil. The f_{ii} coefficients denote own-volatility persistence, i.e. the dependence of volatility in market i on its own past volatility and f_{ij} coefficients capture the direct dependence of volatility in market j on that of market i. The result shows that oil market exhibits the lowest own-volatility persistence and consumer price index exhibit the highest own-volatility persistence.

This implies that own volatility shocks in oil market derive less of their volatility persistence from their own market, as compared to lending rate, consumer price index, exchange rate and food returns where own volatility shocks have a more persistent effect over time. However, there is the direct dependence of volatility in food on that of all other markets with CPI showing the highest cross volatility persistence and there is a direct dependence of volatility in other markets on that of food except for lending rate. Also, there is direct dependence of volatility in CPI and oil price on that of all other markets while there is dependence of volatility in exchange rate on lending rate and oil price. Lastly, there is dependence of volatility in lending rate only on CPI.

Dynamic Conditional Correlation (DCC) model results

Table 4 reports the full estimation results of the DCC model. This model allows us to examine whether the level of volatility interdependence between markets has changed across time. The y_{1ii} co-efficient denote the dependence of the return in market i on its lagged value and the dependence of the return in market i on the lagged return in market j is captured by y_{1ij}.

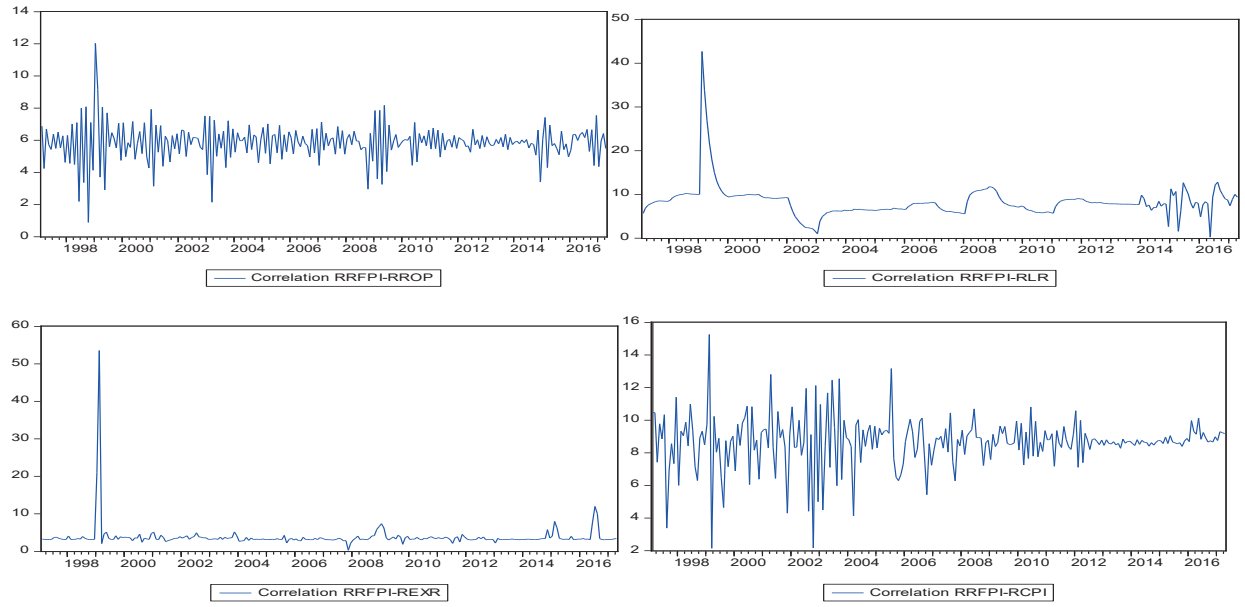

Figure 3. Conditional standard deviation Correlation

The results reveal that mean return in a market is influenced by the lagged return in the same market and also showing a positive own-mean spillover except for oil exhibiting a negative own-mean spillovers as revealed by the BEKK model estimation.

However, the result unveils a cross-market mean spillovers existing between markets except for the mean return in consumer price index which is not influenced by the lagged return in lending rate, exchange rate, and oil. Also, the mean return in lending rate is not influenced by the lagged return in consumer price and oil price. The mean return in exchange rate is not influenced by consumer price and food price while only lagged return in exchange rate is not influencing mean return in oil price. Lastly, the mean return in food price is not influenced by the lagged return in consumer price.

Considering the conditional variance–covariance equation, the adjustment parameters α and β satisfies the $\alpha + \beta < 1$ and the non-negative conditions. This implies that the time-variant conditional correlations between markets are acceptable assumption in the DCC model. The ARCH result whose probability value is less than 1% indicates that there is presence of heteroscedasticity. Thus, the hypothesis of constant variance should be rejected (see Engle, 2002).

Figure 3 presents the conditional standard deviation correlation for each market pair, which results from the GARCH model estimates. The graphs show an important increase in the level of volatility interdependence between markets in recent years. The correlation between oil and food market has basically fluctuated across time without a particular trend, but with important peaks both during the change in the governance system from military era to civilian era in the beginning of the 1999 and during the post food crisis of 2007/2008. Also, food and CPI show fluctuation across time with a peak in 1999 and 2005.

The interdependence between food and exchange rate markets also appears to have increased over the years along with the correlation between food and lending rate. These correlations considered also show peaks during the change in the governance system from military era to civilian era in the beginning of the 1999, suggesting an overall higher interrelation between food and exchange rate, food and lending markets during that specific period.

Robustness Analysis

This study further checks for robustness in order to determine the validity of the previous estimated model. Hence, different frequency data was used which is quarterly data.

The robustness table shows the same own-mean spillovers in all the market as the previous result while the cross-market mean spillovers reveals that the mean returns in CPI is influenced by the lagged returns in food and exchange rate. Also, the mean returns in oil are influenced by the lagged returns in CPI, the mean returns in food is influenced by the lagged returns in lending rate and lastly, the mean returns in lending rate are influenced by the lagged returns in CPI, exchange rate and food. This result contradicts the previous result in Table 3 while the rest of the results under the conditional mean equation in Table 5 are significant as the one in Table 3.

Furthermore, the conditional variance-covariance shows that there are own-volatility spillovers in all the markets as revealed by previous estimation result

Table 5. Baba-Engle-Kraft-Kroner model (1,1) - Estimation by BFGS

Coefficient	RCPI	RLR	REXR	RROP	RRFPI
	(i = 1)	(i = 2)	(i = 3)	(i = 4)	(i = 5)
Conditional mean equation					
y_0	2.0797 (0.0592)***	–0.0045 (0.0078)	–0.1834 (0.0039)***	–0.7530 (0.0294)***	–2.6104 (0.0391)***
y_{11i}	0.3112 (0.0089)***	0.2292 (0.0113)***	–0.0400 (0.0061)***	0.0103 (0.0014)***	–0.0151 (0.0030)***
y_{12i}	–0.0332 (0.0027)***	0.8219 (0.0100)***	0.0157 (0.0002)***	0.0107 (0.0003)***	–0.0300 (0.0005)***
y_{13i}	0.2234 (0.0019)***	–1.0118 (0.0130)***	0.6155 (0.0050)***	–0.0882 (0.0009)***	–0.3275 (0.0025)***
y_{14i}	0.1198 (0.0085)***	–4.0640 (0.0625)***	0.4475 (0.0042)***	–0.0595 (0.0016)***	0.1880 (0.0038)***
y_{15i}	0.4963 (0.0062)***	–1.9431 (0.0232)***	0.2023 (0.0073)***	–0.0239 (0.0004)***	0.0560 (0.0012)***
Conditional variance–covariance equation					
c_{i1}	0.0274 (0.0984)	0.0216 (0.0447)	0.4478 (0.3968)	0.8538 (0.6853)	0.4799 (0.5271)
c_{i2}		0.2057 (0.0409)***	–2.1148 (0.3471)***	–1.3347 (0.6190)*	–3.4463 (0.4361)***
c_{i3}			1.8640 (0.3061)***	2.5558 (0.4780)***	2.0058 (0.3724)***
c_{i4}				–0.0265 (0.0397)	–0.0448 (0.0929)
c_{i5}					0.0011 (0.0336)
b_{i1}	0.0025 (0.0242)	0.0615 (0.0424)	0.0034 (0.0102)	–0.0002 (0.0067)	–0.0465 (0.0090)***
b_{i2}	–0.0416 (0.0077)***	1.6203 (0.0463)***	0.4111 (0.0025)***	–0.1828 (0.0016)***	–0.2175 (0.0025)***
b_{i3}	1.8544 (0.0839)***	–3.2474 (0.1191)***	1.6170 (0.0249)***	–0.0981 (0.0037)***	–1.3582 (0.0248)***
b_{i4}	4.6861 (0.1136)***	–8.3492 (0.2785)***	–2.0201 (0.0159)***	1.0219 (0.0127)***	1.1611 (0.0125)***
b_{i5}	3.2596 (0.1167)***	–5.3800 (0.1454)***	0.5076 (0.0268)***	–0.0402 (0.0135)***	–0.2187 (0.0178)***
f_{i1}	0.9972 (0.0062)***	–0.1621 (0.0248)***	0.0065 (0.0062)	–0.0211 (0.0028)***	0.0372 (0.0045)***
f_{i2}	0.0636 (0.0137)***	–0.0372 (0.0154)**	0.0079 (0.0045)*	–0.0021 (0.0023)	0.0426 (0.0039)***
f_{i3}	0.0929 (0.0466)*	–0.1907 (0.0834)**	0.4944 (0.0137)***	–0.1145 (0.0089)***	0.0901 (0.0127)***
f_{i4}	0.8847 (0.1342)***	–0.3104 (0.2186)	0.3343 (0.0429)***	–0.2016 (0.0275)***	0.9631 (0.0436)***
f_{i5}	–0.1119 (0.0596)***	0.4531 (0.1053)***	–0.2382 (0.0169)***	–0.1537 (0.0116)***	0.7653 (0.0177)***

Note: * ** *** indicate significance at 10%, 5% and 1% critical level, respectively. Standard errors reported in parentheses.

except for CPI. The cross-market volatility spillovers show that the information shocks originating in food have an effect on the current conditional volatility in oil and the information shocks originating in lending rate, exchange rate and oil have no effect on the current conditional volatility in CPI which is not the same as the previous result. However, the rest of the results under conditional variance-covariance are all significant as the previous result in Table 3. Therefore, this study's analysis and conclusion is robust and it is not bias to frequency data.

CONCLUSION AND POLICY IMPLICATIONS

This study examined the determinants of food price volatility in Nigeria. The paper used BEKK and DCC models to estimate the level of interdependence and the dynamics of volatility across these markets.

The BEKK result does not provide evidence of mean spillovers in price returns between food and lending rate and from food to consumer price index. Moreover, these results showed that there are volatility spillovers from lending rate, exchange rate and CPI to food and similarly in the other direction. Except for oil where there are no volatility spillovers from food to oil but there is volatility spillover from oil to food. Obviously, costs of oil do affect production input costs of food which is reflected in this volatility spillover from oil to food. However, there is existence of own-volatility spillovers in all the market with oil exhibiting the lowest own-volatility persistence and CPI with the highest own-volatility persistence. The DCC model showed that shock in the lending rate has the highest volatility transmission effect on agriculture prices followed by consumer price index, exchange rate and oil, respectively. Intuitively, the accessibility to fund by the framers is determined by the lending rate and exchange rate has more effect on food prices compared to oil, due to the high importation of agricultural raw material and agricultural product (net importer of food).

Due to the unpredictable movement in food prices, the government should ensure that crude oil products are being organized and encourage the use of alternative source of energy to reduce the effect of high oil prices on food prices. More so, the government should provide a soft agricultural credit scheme to farmers with a low lending rate through Cooperative and Rural Development Banks so as to encourage small holder farmers to increase agricultural production and to overcome the threat of food insecurity in the country.

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Received: May 27, 2018
Accepted after revisions: January 24, 2019