Dynamic Linkages Between Exchange Rate Uncertainty and Food Price Volatility in Lagos State, Nigeria

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This study employed the SDLOG and EGARCH model to examine Exchange Rate Uncertainty and Variations in Prices for a range of food commodities in Lagos State, Nigeria, from 2001 – 2016. The results showed evidences of persistent food price volatility and exchange rate volatility. Asymmetric effects of shocks in favour of price increase were detected. In addition, Exchange rate variations had significant effect on the price volatility of some food commodities. We suggest that greater attention should be given to the (high) level of food prices, which could mar decisions of farmers and marketers, and reduce demand for affected food commodities.

Keywords: food price variations, livelihood, exchange rate uncertainty, Lagos, EGARCH

INTRODUCTION

Volatility is the rate of price variation over a successive period of time; It represents the directionless variability of an economic variable, that is, the dispersion of that variable within a given time horizon (Hutchet – Bourden 2011; Pierre, *et al.* 2014). Volatility in agricultural market and economic variables is not new. Food prices have been fluctuating wildly over the years, hurting both consumers and producers; undermining nutritional status and food security, and has also made ravaging impact on the poor as greater percentage of their family budget is spent on food. Extreme and persistent food price fluctuations come at a cost, since governments, policy makers and market actors will have difficulty planning ahead and adjusting to the fluctuating market signals. Exchange rate is the value of a country's currency expressed in comparison to some other country's currency and has much impact on the economic development and standard of living of any country, such that how strong or weak its value is in comparison to other currency especially the dollar has an implication on the strength or weakness of the domestic currency and country's economy (Clark *et al* 2004; Akwasi – Kanyam 2014; Ncube *et al.* 2014; Boobra *et al.* 2015). Boobra *et al.* (2015) investigated the trends in exchange rate in Nigeria from 2009-2014 and found that exchange rate in Nigeria has not been stable over time due to changes in policy and market response.

Akwasi - Kanyam, (2014) opined that food price and exchange rate instability pose significant threat to consumption and marketing, macroeconomic stability, food security and overall development achievements. Boobra *et al.* (2015) further explored the effect of exchange rate on agricultural commodity pricing and discovered that food prices and exchange rate in Nigeria have shown a steady long-term trend,

characterised by short-term variability with pronounced peaks and troughs. Data from CBN portal and LSADA, 2017 showed that in 2006, the exchange rate experienced as many as eight sudden swings, a trend which was witnessed in rice, yam and fresh tomatoes prices in Lagos state. During the 2007-2008 global food crisis, exchange rate had 10 swings, imported rice, local rice, yam, fresh tomatoes, titus and local mud fishes prices had swings of 13, 18, 16, 09, 09 and 14 respectively. Many factors could have been responsible for the disparities noticed in the swings of the variables – imported and local food commodities, forces of demand and supply, change of consumption from local to imported and vice versa, etc. (Kalu 2016).

The focus of this study is on the analysis of the extent of volatility exhibited by agricultural commodity prices, and exchange rate; the effect of the uncertainty in bureau de change exchange rate on the uncertainty in the prices of the selected food commodities and the examination of asymmetry in the variables' price volatility. This is because, FAO (2011) explained that the share of the population that depends on agriculture for its livelihood is generally larger in Africa than in other regions, and Minot (2014) confirmed that the variation in staple food prices tends to be high in Africa. Hence, to sustain means of livelihood (farmers and marketers), and also to be healthy to make a livelihood (consumers), an in depth analysis of food price volatility in the area becomes necessary because volatility in the prices of agricultural products places farmers, consumers and the economy at risk. Numerous works have been done on food price volatility in Nigeria but there are still gaps in the choice of commodities, frequency of data, years covered, area and methodology. This paper, in a bid to fill the gaps and contribute to the existing field of work on Agricultural commodity price volatility, focuses on the volatility of exchange rate and the volatility of the prices of a wide range of food commodities covering roots, cereals, vegetables, and animal products in Lagos State, Nigeria, from 2001 - 2016, using monthly data; and the effect of exchange rate variation on the variations of the food prices. It also examines the asymmetry on the variables' price volatility using the EGARCH model. The remainder of the paper is organized as follows: section 2 presents the theoretical framework and empirical review. Section 3 describes the data and methodology. The results are discussed in section 4, while section 5 provides the summary.

THEORETICAL FRAMEWORK AND EMPIRICAL REVIEW

Theoretical Framework

This study was carried out based on the theories below:

The Storage Theory

The storage theory shows how speculators will engage in commodity transactions based on their expectations of future price changes (Williams and Wright 1991). When the actual price is below the level speculators expect to prevail in the next period, speculators will store the commodity in order to sell it at a higher price during the next period, but, when there are no incentives to store, price dynamics simply follow the path of the underlying supply shocks.

The Cobweb Theory

This model, was introduced by Ezekiel (1938) and it considers price fluctuations as endogenous (volatility is generated by market functioning), rather than exogenous (as in the storage theory). The agents will base their production decision on the prevailing price, even if they know that the next period's price will likely diverge. By doing so, agents' expectations can create variations in price: when prices are low (high), they will reduce (increase) their production, so that the next period will see opposite high (low) prices (Williams and Wright, 1991).

Empirical Framework

Zheng, et al. (2008) investigated US food markets for asymmetric news effect. They analysed 25 years monthly data for 45 retail food items. Their finding showed presence of asymmetric effects in about a third of the markets with unexpected price increases being more destabilizing. The trends in exchange rate and agricultural commodity price in Nigeria from 2009-2014 was investigated by Boobra *et al.* (2015). They

explored the effect of exchange rate on agricultural commodity pricing and the consequences of agricultural commodity price fluctuations on the living standard of Nigerians using descriptive statistics. They concluded that though exchange rate fluctuation have some effect on agricultural commodity price, the trend of both variables shows that there could be some other factors responsible for the fluctuations in agricultural commodity prices, and that changes in agricultural commodities have numerous effects on the living standard of Nigerians.

DESCRIPTION OF DATA AND METHODOLOGY

Data Source

This study was carried out in Lagos State, Nigeria. Lagos State is a known commercial city, endowed with an International airport, Railway Terminus and Seaport. It is also a home for almost all tribes of the nation. Ten food commodities: Fresh Tomatoes, Garri (yellow and white), Rice (local and imported), Maize (yellow and white), Iced/frozen Titus fish (imported), fresh mud fish (local), and yam were investigated. Past studies made references to cereals and grains as mostly affected by food price crises, and this informed the choice of Rice and Maize; Importation was also said to play a role in food price volatility (this informed the choice of imported rice and titus fish (Conforti 2004). Garri, being a commodity that even the less privileged lays hold on was included in the analysis for that purpose. The bureau de change (BDC) exchange rate was preferred because it affects the common man directly, and it is more volatile than the other exchange rates in Nigeria. This was confirmed by Kalu (2016).

Monthly price data on food commodities from 2001 – 2006 were collected from the National Bureau of Statistics (NBS), while those of 2007 – 2016 were collected from the Lagos State Agricultural Development Authority (LSADA). Monthly price data from 2001 - 2016 on the Bureau de change exchange rate were collected from Central Bank of Nigeria (CBN) portal. The study period was from January 2001 to December 2016 except for the frozen and fresh fishes which had a period of 2007 – 2016 due to unavailability of complete data.

Analytical Method

The analytical techniques employed include:

Standard Deviation of Logarithm of Price in Differences/ Returns (SDLOG)

Adapting Huchet-Bourdon (2011), and Minot (2014), the model was specified thus:

$$\textbf{SDLOG} = \sqrt{\boldsymbol{var}}\ (\ln \frac{p_t}{p_{t-1}}) \quad (1)$$

where: Var = variance $\sqrt{\boldsymbol{var}}$ = standard deviation Ln = logarithm
p_t = price of the commodity i p_{t-1} = past price of commodity i

ii. Exponential Generalised Auto-Regressive Conditional Heteroskedasticity (EGARCH) MODEL

The basic ARCH models consist of two equations –mean and variance equations. In this study, the mean function contains a constant and the exchange rate price returns as explanatory variable for all food prices. Inclusion of the exchange rate price return enables a test of the effect of Exchange rate return on food price return (Narayan *et al. 2008*). The EGARCH consists of the mean and variance equations.

Mean Equation

$$\boldsymbol{rp_i = \mu + \phi rexchr + e_t} \quad (2)$$

where: rp_i = log of price return for variable i; μ = mean; e_t = error term;
$rexchr = \log of$ return on exchange rate.

Variance Equation

$$ln(\sigma_{it}^2) = \omega + \alpha \left| \frac{\varepsilon_{t-1}}{\sqrt{\sigma_{t-1}^2}} \right| + \gamma \frac{\varepsilon_{t-1}}{\sqrt{\sigma_{t-1}^2}} + \beta ln(\sigma_{t-1}^2) \quad (3)$$

where: σ_{it}^2 = measure of conditional volatility for variable i. σ_{t-1}^2 is lagged squared variance, ε_{t-1} = lagged residual, ω = the constant variance that corresponds to the long run average, α = the ARCH term which measures short run persistence to shocks, β = GARCH term, which gives information on last period's forecast variance and also measures the persistence of shocks to the variance. γ measures the asymmetry effect. If $\gamma < 0$, (leverage effect); negative shocks generate higher volatility than positive shocks. If $\gamma = 0$ the model is symmetric. If $\gamma > 0$; positive shocks (good news) generate higher volatility than negative shocks (bad news), (Narayan *et al.* 2008*;* David *et al*. 2016).

EMPIRICAL RESULTS

Descriptive Statistics of the Variables' Log Returns Series

The descriptive statistics of the log return series displayed on table 1 show that all variables recorded positive mean returns, meaning that, on the average, the price changes were more on price rises than price falls. The values of skewness indicate that none of the series is symmetric. All variables' returns have leptokurtic distribution (excess kurtosis). The Shapiro - Francia (Shapiro-F W') and Jarque-Bera (JB) normality tests results confirm that the series are not normally distributed.

TABLE 1
DESCRIPTIVE STATISTICS OF THE VARIABLES' LOG RETURNS SERIES

VARIABLE	Mean	Std. dev	Skew.	Kurt.	Shapiro-F W'	Jarque-Bera
EXCH RATE	0.0068	0.0323	1.093	7.76	0.8093*** (0.000)	218.22*** (0.000)
IMP RICE	0.0092	0.0932	0.9080	12.12	0.7729*** (0.000)	687.70*** (0.000)
LOC RICE	0.0133	0.1447	-0.7016	13.66	0.6887*** (0.000)	920.69***(0.000)
YEL. GARRI	0.0071	0.1034	-0.6265	9.50	0.8537*** (0.000)	348.60***(0.000)
WH. GARRI	0.0082	0.1217	-0.5081	8.81	0.8535*** (0.000)	276.69***(0.000)
YEL. MAIZE	0.0071	0.1332	-0.7309	11.08	0.8456*** (0.000)	536.97***(0.000)
WH. MAIZE	0.0078	0.1368	0.1435	10.23	0.8639*** (0.000)	416.44***(0.000)
YAM	0.0088	0.1771	0.1654	7.34	0.8877*** (0.000)	150.49***(0.000)
FRESH TOM.	0.0103	0.1622	0.0543	9.30	0.8041*** (0.000)	315.69***(0.000)
IMP. TITUS	0.0078	0.0703	0.4362	14.13	0.6756*** (0.000)	617.88***(0.000)
LOC. FISH	0.0028	0.0435	-1.6020	9.46	0.8140*** (0.000)	257.90***(0.000)

NOTE: ***=significant at1%; p- values in bracket;
Source: Author's calculation using data from CBN &NBS portals, and LASDA, 2017

Unconditional Volatility of the Price Series- SDLOG

Table 2 gives a yearly view of the volatility of the prices under review. A visual inspection of the food commodities columns show that, in 2005, yam had the highest price volatility of 1.14 while fresh tomatoes had the least of 0. All food commodities, except fresh tomatoes, had a reduction in price volatility in 2007. The price volatility of all food commodities also rose again in 2008, with an exception of yellow garri. Interestingly, after 2008, no price of variable attained up to a 100% volatility again. Generally, the volatilities of all variables had varying swings.

TABLE 2
YEARLY VOLATILITY (SDLOG) OF THE PRICE SERIES UNDER REVIEW

	EXCH RATE	IMP RICE	LOC RICE	YELL GARRI	WHITE GARRI	YELL MAIZE	WHITE MAIZE	YAM	FRESH TOM	IMP TITUS	LOC MUD
2001	0.071	0.116	0.005	0.392	0.488	0.414	0.495	1.000	0.957		
2002	0.037	0.418	0.260	0.095	0.644	0.378	0.461	0.249	0.631		
2003	0.051	0.292	0.053	0.402	0.645	0.528	0.550	1.050	0.804		
2004	0.043	0.163	0.204	0.474	0.549	0.449	0.692	0.845	0.64		
2005	0.033	0.552	0.313	0.436	0.455	0.543	0.410	1.141	0		
2006	0.078	0.605	0.700	0.454	0.342	0.951	0.666	0.829	0.135		
2007	0.027	0.374	0.589	0.292	0.287	0.148	0.062	0.689	0.344	0.447	0.154
2008	0.153	0.413	1.110	0.289	0.277	0.897	0.876	0.499	0.355	0.450	0.248
2009	0.182	0.080	0.443	0.495	0.444	0.473	0.440	0.310	0.593	0.099	0.184
2010	0.024	0.050	0.052	0.084	0.140	0.082	0.114	0.107	0.245	0.079	0.133
2011	0.058	0.096	0.694	0.144	0.257	0.195	0.250	0.188	0.158	0.123	0.101
2012	0.040	0.115	0.060	0.090	0.063	0.123	0.216	0.190	0.201	0.045	0.104
2013	0.028	0.050	0.090	0.117	0.122	0.225	0.060	0.257	0.048	0.069	0.073
2014	0.089	0.049	0.101	0.079	0.164	0.265	0.223	0.196	0.083	0.084	0.092
2015	0.020	0.017	0.058	0.155	0.122	0.073	0.073	0.269	0.732	0.052	0.028
2016	0.228	0.202	0.034	0.204	0.274	0.157	0.152	0.123	0.686	0.146	0.023

Source: Author's calculation using data from CBN and NBS portals, and LSADA, 2017

Conditional Variance (Volatility) Analysis

ARCH-LM Tests

The ARCH-LM test result shows that all variables' price returns rejected the null of no ARCH effects at 10% significant level, in favour of the presence of ARCH effect. The confirmation of the presence of ARCH effect in these cases indicates that the volatility in the prices of these variables are time varying. The Akaike information criterion (AIC) and the Schwarz criterion (SC) were used to select the best model with the least information criterion and highest log likelihood for each variable. This led to the choice of EGARCH 1,1 for all variables.

TABLE 3
ARCH-LM TEST RESULTS

TEST	EXCH RATE	IMPO RICE	LOC RICE	YELL GAR	WHIT GARR	YELL. MAIZ	WHITE MAIZE	YAM	FRES TOM	IMPO TITUS	MUD FISH
ARCH-LM (1)	0.46*** (0.00)	0.34*** (0.00)	0.28*** (0.00)	-0.01 (0.90)	0.05 (0.53)	0.40*** (0.00)	0.39*** (0.00)	0.06 (0.37)	0.04 (0.51)	0.38*** (0.00)	0.14 (0.13)
ARCH-LM(5)	0.14** (0.03)	0.31*** (0.00)	0.21*** (0.00)	-0.15 (0.82)	0.001 (0.44)	0.17* (0.09)	0.44*** (0.00)	0.33*** (0.00)	0.13** (0.05)	0.22** (0.02)	0.01 (0.92)
ARCH-LM(10)	0.15** (0.05)	0.42* (0.07)	0.16** (0.03)	0.23*** (0.00)	0.23*** (0.002)	0.19** (0.03)	0.32** (0.02)	0.14** (0.03)	0.15** (0.04)	0.42*** (0.00)	0.32*** (0.00)

Source: Author's calculation using data from CBN portal, NBS and LSADA, 2017;
(p values in brackets. ***, **, indicate significance at 1%, and 5% levels respectively)

EGARCH (1,1) Analysis Results

The mean equation result on Table 4 shows that a 10% increase in the bureau d'change exchange rate (ExchR) caused a 0.9% increase in the imported rice price return (ImprR), a 1.0% fall in local rice price return (LocrR), a 5% fall in white garri price return (WhgR), and a 0.4% fall in the volatility of fresh tomatoes prices (FrtoR). The mean equation result on table 4 further reveals that changes in exchange rate have no significant effect on the variations in the prices of the rest commodities.

The variance panel in table 4 shows that the ARCH effect (α) is significant for all variables. This suggests that there is the tendency of the prices of the variables to react to market shocks, with the ARCH effect on fresh tomatoes and imported Titus price returns higher than 0.90. Also, shocks on the previous period volatility have significant effect on the current period volatility of all variables except Imported Titus. The variance panel also reveals that the persistence of these shocks (β) is as high as 0.90 for six variables, indicating that the shocks do not die off on time.

The Asymmetric coefficient (**γ**) is positive and significant (0.36) for exchange rate, indicating that increase in the Naira/US$ exchange rate (naira depreciation) tends to produce higher volatility in the immediate future than negative shock of the same magnitude. The impact of negative and positive shocks on the White garri, yellow maize (YelmR), yam (YamR) and mud fish (MudR) volatility is asymmetric in favour of price increases (0.24, 0.19, 0.42, and 0.51 respectively). This means that unanticipated price increases make the prices of these commodities more volatile than unanticipated price decreases of equal magnitude. Zheng, *et al.* (2008) and Cermak, (2017) obtained similar asymmetric results in food commodity prices. The reaction of positive and negative shocks of same magnitude on the volatility of Local rice, and Imported Titus prices (TituR) is asymmetric with a leverage effect (-0.31 and -0.34 respectively). This implies that negative news from the past period (unanticipated price decreases) are more destabilizing than unanticipated price increases of equal magnitude. For Imported rice, yellow garri (YegR), white maize (WhmR), and fresh tomatoes the impact of negative and positive shocks on their volatility is symmetric, and, this shows that positive and negative shocks of the same magnitude make same impact on their variance.

TABLE 4
EGARCH ESTIMATES

PARAMETER	ExchR	ImprR	LocrR	YegR	WhgR	YelmR	WhmR	YamR	FrtoR	TituR	MudR
MEAN											
μ	0.004	0.022**	.006***	.007**	0.002	0.01	0.012	0.015	0.001	0.009	0.004*
(std. error)	(0.002)	0.004	(0.000)	(.003)	(0.008)	(0.009)	(0.010)	(0.010)	(0.003)	(0.006)	(0.00)
ϕ		0.09*	-0.10***	0.04	-0.495**	-0.06	-0.311	0.244	-0.04*	0.008	0.001
(std. error)		(0.097)	(0.005)	(0.12)	(0.200)	(0.268)	(0.402)	(0.258)	(0.13)	(0.11)	(0.03)
VARIANCE											
Ω	-1.87***	-0.75***	-0.45***	-.18**	-0.79***	-0.15***	-3.41***	-0.79***	-0.41***	-7.74***	-0.35***
(std. error)	(0.52)	(0.19)	(0.10)	(0.09)	(0.22)	(0.04)	(0.68)	(0.18)	(0.12)	(0.86)	(0.15)
α	0.15*	0.46***	0.54**	.33*	0.35***	0.10***	0.41***	0.21***	0.92*	1.08***	0.02*
(std. error)	(0.10)	(0.09)	(0.08)	(0.19)	(0.08)	(0.02)	(0.13)	(0.08)	(0.19)	(0.18)	(0.06)
β	0.76***	0.91***	0.93***	.98***	0.87***	0.98***	0.23*	0.83***	0.93***	-0.25	0.96***
(std. error)	(0.06)	(0.02)	(0.03)	(0.02)	(0.04)	(0.01)	(0.16)	(0.04)	(0.02)	(0.18)	(0.03)
γ	0.36***	-0.07	-0.31**	-0.01	0.24***	0.19***	0.03	0.42***	-0.09	-0.34**	0.51***
(std. error)	(0.08)	(0.06)	(0.13)	(0.85)	(0.07)	(0.03)	(0.12)	(0.10)	(0.02)	(0.15)	(0.07)
pers. B	0.76	0.91	0.93	0.98	0.87	0.98	0.23	0.83	0.93		0.96
Loglik	439	239.07	297.90	223	140.80	143.5	120.83	97.62	177	173.16	247.04
AIC	-4.56	-2.45	-3.04	-2.26	-1.42	-1.44	-1.20	-0.964	-1.79	-2.81	-4.08
SC	-4.45	-2.35	-2.92	-2.15	-1.32	-1.34	-1.10	-0.861	-1.67	-2.67	-3.94
Diagnostics											
Q Stat. (10)(p-val)	0.76 (1.00)	3.20 (0.98)	6.41 (0.59)	9.03 (0.53)	7.10 (0.72)	16.85 (0.78)	1.7 (1.00)	5.16 (0.88)	8.94 (0.54)	5.34 (0.87)	10.6 (0.38)
ARCH-LM (1)(p-val)	0.03 (.96)	0.04 (0.61)	-0.03 (0.85)	-0.02 (0.75)	-0.01 (0.91)	0.25 (0.10)	0.02 (0.74)	-0.06 (0.40)	-0.03 (0.65)	-0.005 (0.95)	0.11 (0.22)
ARCHLM (5)(p-val)	-0.01 (0.85)	0.002 (0.97)	0.002 (0.64)	-0.02 (0.94)	-0.06 (0.45)	0.03 (0.67)	0.05 (0.48)	0.08 (0.29)	0.06 (0.37)	-0.09 (0.12)	0.07 (0.45)
ARCHLM (10) (p-val)	0.01 (0.84)	-0.03 (0.65)	-0.03 (0.75)	-0.03 (0.57)	-0.07 (0.39)	-0.02 (0.77)	-0.02 (0.81)	-0.05 (0.46)	-0.04 (0.56)	-0.04 (0.45)	-0.04 (0.12)

Source: Author's calculation using data from CBN and NBS portals and LSADA, 2017
(*, **, *** indicate significant level at 10%, 5% and 1% levels respectively).

POST ESTIMATION TESTS

The Ljung–Box Q-statistic test for autocorrelation and the Engle ARCH test were used to examine the residuals after the analysis. These are reported in the final panels of table 4. The Q- statistics reveal no autocorrelation in the residuals while the ARCH-LM test reveals no ARCH effects in the residuals.

SUMMARY AND CONCLUSION

This study examined food price volatility and exchange rate volatility in Lagos State, Nigeria, with an aim of asserting what the volatility of food commodities is in the state, the trend, the effect of exchange rate volatility on them, and a test of asymmetry on the volatility of the variables. The result of SDLOG shows that rising and falling Volatility levels exist in the variables' prices tested and vary from commodity to commodity, and from year to year. The EGARCH 1,1 model affirmed presence of persistent volatility in the prices of the variables, with only Imported Titus price being insignificant to volatility persistence. The effect of exchange rate volatility on the food commodities is commodity specific. Negative (bad) and Positive (good) price returns (news) have equal impact on the volatilities of imported rice, Yellow garri, white maize and fresh tomatoes prices, hence, they had symmetric effect on volatility. However, Bureau d'change exchange rate, white garri, yellow maize, yam and fresh mud fish volatilities had positive asymmetry which means that good news on them (their price increase) produces higher volatility in the immediate future than bad news (price fall). This can be linked to the problem of panic buying when there is sudden rise in price and people anticipate further rise, moreso, in agricultural markets, unexpected price increases tend to increase the variance (Stigler 2011); On the other hand, Imported Titus fish and Local rice prices have the leverage effect (negative asymmetry) which implies that unanticipated price decreases of these commodities (bad news) are more destabilizing in the immediate future than unanticipated price increase (good news).

High and persistent volatility of food prices and the associated uncertainty in Lagos state is a challenge to sustainable livelihood, because, it will: - have a negative effect in agricultural and economic planning by making proper planning difficult, impede sustainable and long-term consumption decisions of households, reduce demand for affected food commodities, and increase the risk of chronic low food-intake because the bulk of volatility is caused by price increase which favoured marketers/producers at the detriment of the consumers. At the State and national levels, the results imply that greater attention should be given to the level of food prices (particularly high food prices) rather than price volatility per se, because the asymmetry effect showed that increase in prices impacted more on the price volatility than a fall in price in most commodities studied. The period, size and consequences of food price instability vary substantially across and within commodities, hence, the appropriate policy response to food price instability and risk will also vary across and within commodities.

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