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PRICE GENERATING PROCESS AND VOLATILITY IN NIGERIAN AGRICULTURAL COMMODITIES MARKET

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Abstract

The literature on agricultural commodity price volatility in Nigeria has constantly reflected that an excessive price movement is harmful for both producers and consumers, particularly for those who are not able to cope with that new source of economic uncertainty. It has also raised an extensive debate on the main determinants behind the large agricultural commodity price swings observed in the last years without recourse for the price generating process. To narrow this gap, the study examined the price generating process and volatility in the Nigerian agricultural commodities market using secondary data for price series on meat, cereals, sugar, dairy and aggregate food for the period of January 1990 to February 2014. The data were analysed using the linear Gaussian State-Space (SS) model. The results of the descriptive statistics showed that the coefficients of variation for cereals (39.88%), food (32.65%) and dairy price (43.08%) were respectively higher during the overall time period (January 1990 to February 2014) than during the first (January 1990 to January 2002) and second (February 2002 to February 2014) sub-time periods. The results of the inferential statistics showed that authoregressive moving average (ARMA) model is the most selected Nigeria agricultural commodity price generating model for the time periods, that a unit increase in the past price state of cereals, dairy, sugar, meat and aggregate food would increase the future price of sugar, meat and aggregate food by ₦0.14, ₦0.28 and ₦0.15 respectively but decrease future price of cereals and dairy by about ₦1.00 and ₦0.21 respectively, and that the one-step ahead predicted value for the first out-of-sample period for cereals, meat, dairy and sugar price were 6317.86, 10.24 and 2.06 respectively. The Nigerian agricultural commodity prices have experienced high variability over the period, and such volatility, price-generating process and the determinants of the Nigerian food commodities prices can best be described by the simple ARMA model with time-variant hyperparameters.

Keywords: *price, volatility, state-space, stationarity, ARMA.*

1. Introduction

In a market-oriented economy with perfect information, a key variable in the food system is the price of the commodities (White & Dawson, 2005; Gortz & Weber, 1986 cited in Kuwornu, Mensah-Bonsu, & Ibrahim, 2011). Prices of agricultural commodities in Nigeria have been on the increase over the years. Food price index rose by 23% in 2006 and then increased to 37% for the period between December 2006 and December 2007 while food prices rose by 55% from June 2007 to February 2008 (Food and Agriculture Organisation, FAO, 2008). These swings in agricultural commodity price cannot be attributed to international trade policies, the emergence of bio-fuels, increasing urbanization and population growth only (Abbot, Hurt, & Wallace 2008; Benson, Mugarura, & Wanda 2008; Mitchell, 2008) without recourse for the unobservable structural changes. Various studies have used different models to forecast food price and food prices volatility without concern for the time-variant parameters in such models (Kumornu *et al.*, 2011; Gilbert, 2010; Ghysels, Santa-Clara, & Valkanov, 2006). The data on agricultural commodity prices are uncertain, are aggregated estimates rather than perfect measures, and are not easily observable, necessitating the use of proxies. Even the estimates from them are not only imperfect measures, they differ substantially among themselves and from the commodities they explain with respect to some unobservable price indicators while some contain coefficients are inherently time-varying, making economic relationships potentially unstable. Rather than the descriptive models which do not estimate directly the causal relationship between price volatility and its drivers (Clapp, 2009; Gilbert & Morgan, 2010; Wright, 2011; Anderson & Nelgen, 2012; Nissanke, 2012), mathematical modelling such as partial equilibrium models (Miao, Yu, Bao, & Tang, 2011; Babcock, 2012) and empirical models which use reduced-form (Balcombe, 2009), cointegration analysis (Pietola, Liu, & Robles, 2010), and different specifications of the GARCH(1,1) model (Zheng, Kinnucan, & Thompson, 2008; Roach, 2010; Hayo, Kutan, & Neuenkirch., 2012; Karali & Power, 2013), the nature of agricultural commodity price variability, measurement of such variability of agricultural product prices, and the effect of other unobservable impacting factors within the series are important (Ghysels & Valkanov, 2006; Mittnik & Zadrozny, 2005; Ghysels *et al*, 2006; Ghysels & Wright, 2008; Clements & Galvao, 2008; Marcellino & Schumacher, 2007; Schumacher & Breitung, 2008). This is in view to capturing the time-varying coefficient and extracting the unobserved components from observed series. The study, therefore, examined the price volatility in the Nigerian agricultural commodities market using the state space approach. To achieve this, the study examined the price volatility in the Nigeria agricultural commodities market, examined the time-varying variability model that best explain the price volatility, and examined the effect of other unobservable impacting factors on the price volatility in such market. This study differs in analytical approach from existing literature on agricultural commodity price volatility in general and of such studies in Nigeria in particular. The study used the state space model to capture the time-varying coefficient and in the extraction of unobserved components from observed series (Wang, 2003; Harvey, 1984, 1989).

2. Methodology

The study used data obtained from various publications of the Central Bank of Nigeria, Nigeria Statistical Bulletin, Food and Agriculture Organisation (FAO), World Trade Organisation (WTO) and the vintages of the World Bank database for price time series on meat, cereals, sugar, dairy and aggregate food for the period of January 1990 to February 2014. The entire period was divided into two sub-periods. These are the first period (January 1990 to January 2002) and the second period (February 2002 to February 2014). The data were analysed using both descriptive and inferential statistics taking cue from Piot-Lepetit (2011). The descriptive statistics used the coefficient of variation while the inferential statistics fitted the Autoregressive Moving Average (ARMA), Autoregressive Conditional Heteroskedasticity (ARCH) model, the Generalised Autoregressive Conditional Heteroskedasticity (GARCH) model, the Exponential Generalised Autoregressive Conditional Heteroskedasticity (EGARCH) model and the Asymmetric Power

Autoregressive Conditional Heteroskedasticity (APARCH) model version to test for the best time-varying variability model that explains the price volatility in the Nigeria agricultural commodities market ranked according to three information criteria, the Schwarz Information Criterion (SIC), Akaike Information Criterion (AIC) and the Hannan–Quinn Information Criterion (HQIC). The criteria were also used to select the appropriate lag. The data were first transformed to render them stationary by taking the first difference. The ARMA, ARCH, GARCH, EGARCH and APARCH used were ARMA (!, 1), ARCH (1), GARCH (1, 1), EGARCH (1, 1) and APARCH (1, 1), and given respectively as:

$$\sigma_t^2 = \alpha_0 + \alpha_1 \epsilon_{t-1}^2 \qquad \text{ARCH (1) model} \qquad (1)$$

Where autoregression in its squared residuals has an order of 1

$$\sigma_t^2 = \alpha_0 + \alpha_1 \epsilon_{t-1}^2 + \beta \sigma_{t-1}^2 \qquad \text{GARCH (1,1) model} \qquad (2)$$

Where autoregression in its squared residuals has an order of 1, and the moving average component has an order of 1.

$$\ln(\sigma_t^2) = \alpha_0 + \beta \ln(\sigma_{t-1}^2) + \alpha_1 \left[\left| \frac{\epsilon_{t-i}}{\sigma_{t-i}} \right| - \sqrt{\frac{2}{\pi}} \right] - \gamma \frac{\epsilon_{t-1}}{\sigma_{t-1}} \qquad \text{EGARCH (1,1) model} \qquad (3)$$

$$\sigma_t^2 = \alpha_0 + \beta \sigma_{t-1}^2) + \alpha_1 (|\epsilon_{t-1}| - \gamma \epsilon_{t-1})^2 \qquad \text{PGARCH (1,1) model} \qquad (4)$$

Where ϵ_{t-1}^2 is the ARCH term providing information about the volatility from previous period, σ_{t-1}^2 is the GARCH term measuring the last forecast variance while α, β and γ are parameters to be estimated from the price series for the commodities. The model with the smallest value based on the criteria was then chosen as the best-fit model. The linear Gaussian multivariate state-space (SS) model for the discrete-time 5-variate observable stochastic process was then used on the identified generating process. The state space equations, fitted into the ARMA (1, 1) models, for the five agricultural commodities were given as:

$$C_t = \alpha_t + \beta_1 \mu_t + \varepsilon_t,\ \varepsilon_t \sim NID(0, \sigma_\varepsilon) \qquad \text{Observation Equation for price of cereals}$$
$$\alpha_t = \beta_2 \alpha_{t-1} + \exp(\beta_3) + \epsilon_t,\ \epsilon_t \sim NID(0, \sigma_\epsilon) \qquad \text{State Equation for price of cereals}$$
$$\mu_t = \alpha_{t-1}$$
$$F_t = \gamma_t + \delta_1 \tau_t + \omega_t,\ \omega_t \sim NID(0, \sigma_\omega) \qquad \text{Observation Equation for price of aggregate food}$$
$$\gamma_t = \delta_2 \gamma_{t-1} + \exp(\delta_3) + \xi_t,\ \xi_t \sim NID(0, \sigma_\xi) \qquad \text{State Equation for price of aggregate food}$$
$$\tau_t = \gamma_{t-1}$$
$$M_t = \theta_t + \vartheta_1 \pi_t + \varrho_t,\ \varrho_t \sim NID(0, \sigma_\varrho) \qquad \text{Observation Equation for price of meat}$$
$$\theta_t = \vartheta_2 \theta_{t-1} + \exp(\vartheta_3) + \nu_t,\ \nu_t \sim NID(0, \sigma_\nu) \qquad \text{State Equation for price of meat}$$
$$\pi_t = \theta_{t-1}$$
$$D_t = \lambda_t + \partial_1 \phi_t + o_t,\ o_t \sim NID(0, \sigma_o) \qquad \text{Observation Equation for price of dairy}$$
$$\lambda_t = \partial_2 \lambda_{t-1} + \exp(\partial_3) + \kappa_t,\ \kappa_t \sim NID(0, \sigma_\kappa) \qquad \text{State Equation for price of dairy}$$
$$\phi_t = \lambda_{t-1}$$
$$S_t = \eta_t + \zeta_1 \rho_t + \varsigma_t,\ \varsigma_t \sim NID(0, \sigma_\varsigma) \qquad \text{Observation Equation for price of sugar}$$
$$\eta_t = \zeta_2 \eta_{t-1} + \exp(\zeta_3) + \psi_t,\ \psi_t \sim NID(0, \sigma_\psi) \qquad \text{State Equation for price of sugar}$$
$$\rho_t = \eta_{t-1} \qquad (5)$$

Where the C_t, F_t, M_t, D_t, and S_t are the measured price variables, α_t, γ_t, θ_t, λ_t, and η_t are the level component analogous to the intercept in the classical regression model, β_1, β_2, β_3, δ_1, δ_2, δ_3, ϑ_1, ϑ_2, ϑ_3, ∂_1, ∂_2, ∂_3, ζ_1, ζ_2, and ζ_3 are parameters measuring slope as in classical regression model while σ_ε, σ_ϵ, σ_ω, σ_ξ, σ_ϱ, σ_ν, σ_o, σ_κ, σ_ς, and σ_ψ are measures of the heteroschedastic variance called hyperparameters of the model.

3. Results and Discussion

Table 1 shows the Dickey-Fuller (DF) and Augmented Dickey-Fuller (ADF) statistics for the variables. The DF and ADF statistic values for the variables in their first difference form were lower than the critical values at 1%, 5% and 10%, so that the null hypothesis that it has a unit root at first difference was rejected. However, the DF and ADF statistic values for the variables at level form were greater than the critical values at 1%, 5% and 10%, so that the null hypothesis that it has a unit root at level form was not rejected. Augmented Dickey-Fuller (ADF) test for the variables indicate that all variables are non-stationary at levels but stationary at first difference. This implies that the results of the econometric analysis at the level of the series may not be suitable for policy making.

Table 1.Dickey-Fuller and Augmented Dickey-Fuller Estimate for Stationarity

Variable	Dickey-Fuller (DF)		Augmented Dickey-Fuller (ADF)	
	Level	First Difference	Level	First Difference
Cereals Price	-2.059	-6.590***	-2.114	-6.545***
Aggregate Food Price	-0.838	-6.028***	-0.900	-6.037***
Meat Price	-1.734	-1.415***	-1.704	-7.744***
Dairy Price	2.798	-8.634***	1.978	-8.531***
Sugar Price	-1.372	-4.466***	-1.450	-6.872***

Source: Computed from 1990-2014 Food and Agriculture Organisation (FAO) (2014), World Bank Commodity Price Data (2014), and World Trade Organisation (WTO) Price Series, ***Significant at 1% level

Table 2 shows the estimated coefficient of variation for prices of food items in Nigeria. The results show that for aggregate food price, the dispersion was 32.65% for the entire period and 11.47% and 30.26% respectively during the first (January 1990 to January 2002) and second (February 2002 to February 2014) sub-time periods. In the second sub-time period (February 2002 to February 2014), sugar price was the most dispersed (45.23%), followed by the price of dairy products (34.45%) while meat price had the least (23.11%). The results also showed that the coefficients of variation for cereals price (39.88%), aggregate food price (32.65%) and dairy price (43.08%) were respectively higher during the overall time period (January 1990 to February 2014) than during the first (January 1990 to January 2002) and second (February 2002 to February 2014) sub-time periods while the coefficients of variation for meat price (21.40%) and sugar price (43.89%) were respectively higher only during the overall time period (January 1990 to February 2014) than during the first (January 1990 to January 2002) sub-time period that corresponds to the possible price process existing before the recent price increase. When comparing coefficients of variation values between the sub-time periods 1990–2002 and 2002–2014, the values are higher for the second (February 2002 to February 2014) sub-time period for all food items than the first (January 1990 to January 2002) sub-time period. The highest increase is shown for sugar price from 23.48% to 45.23%, followed by dairy price from 13.69% to 34.45%. It may suggest that the Nigerian agricultural commodity prices have experienced higher variability between 2002 and 2014 over the period. This is not unexpected as agricultural product markets experience not only price fluctuations from year to year but also volatile prices because of the relatively unstable conditions of supply and demand and the low elasticities of demand and supply (Schnepf, 2005; Meyers & Meyer, 2009; Robles, Torero, & von Braun, 2009; 2010; 2009; Christiaensen, 2009; Gilbert, 2010; FAO, 2008; Trostle, 2008). However, for an importing country like Nigeria, increasing prices would result in rising import bills and high prices with the attendant impact on the ability of poor consumers to purchase necessary food items.

Table 2. Estimated Coefficient of Variation for Agricultural Commodities Prices in Nigeria

Variable	Coefficient of Variation		
	Entire Period	**1990/01-2002/01**	**2002/02-2014/02**
CPI	39.88%	15.61%	35.55%
AFP	32.65%	11.47%	30.26%
MPI	21.40%	11.62%	23.11%
DPI	43.08%	13.69%	34.45%
SPI	43.89%	23.48%	45.23%

Source: Computed from 1990-2014 Food and Agriculture Organisation (FAO) (2014), World Bank commodity Price Data (2014), and World Trade Organisation (WTO) price series, CP is cereals price, AFP is aggregate food price, MP is meat price, DP is dairy price and SP is sugar price

Table 3 presents the model for food items prices and the selection criteria. The results show that cereals price had 6.52 AIC criterion values for the ARMA (1, 1) model as the smallest for the overall time series, and 5.32 and 7.06 respectively for the sub-time periods 1990–2002 and 2002–2014. This implies that cereals price model in Nigeria agricultural commodities market is the ARMA (1, 1) for the overall time series and the two sub-time period series, and that the future volatility of the cereals price in Nigeria is the sum of the current variance and the weighted one-period lag autoregressive moving average of the residuals.. Similarly, the model for aggregate food price is ARMA (1, 1) with the smallest AIC criteria values of 5.360 for the overall time series and 4.33 and 5.84 respectively for the sub-time periods of 1990-2002 and 2002-2014. This is also true for meat price model with the smallest AIC criterion values of 5.40 for the overall time series and 5.26 and 5.48 respectively for the sub-time periods of 1990–2002 and 2002-2014. The results are also true for dairy and sugar prices. Thus, the ARMA (1, 1) model is most selected model during the overall time periods of January 1990-February 2014. This implies that the today's time-varying agricultural commodities heteroscedastic prices variance in Nigeria is a function of the one-time lag autoregressive moving average of their residuals. This implies that, regarding the existence of a common price process in Nigeria, ARMA (1, 1) explains the price process for aggregate food in general, and the price process for cereals, dairy, sugar and meat in particular. The volatility in agricultural commodities prices in Nigeria is the result of current variability and the weighted one-period lag of their residuals.

Table 3. Model for Food Items Prices and Their Selection Criteria

Variable	Model for the Entire Period				Model for 1990/01-2002/01			Model for 2002/02-2014/02		
	Model	**AIC**	**SIC**	**HQIC**	**AIC**	**SIC**	**HQIC**	**AIC**	**SIC**	**HQIC**
Cereals Price	**ARMA**	**6.521**	6.560	6.536	**5.319**	5.380	5.345	**7.056**	7.117	7.081
	ARCH	8.539	8.577	8.554	7.194	7.256	7.219	10.430	10.491	10.455
	GARCH	8.542	8.593	8.562	7.194	7.276	7.227	10.458	10.540	10.491
	EGARCH	8.643	8.706	8.668	7.254	7.357	7.296	10.437	10.539	10.478
	PARCH	9.583	9.659	9.613	7.246	7.369	7.296	10.435	10.559	10.485
Aggregate Food Price	**ARMA**	**5.360**	5.398	5.375	**4.325**	4.387	4.350	**5.843**	5.905	5.868
	ARCH	8.436	8.474	8.451	6.876	6.938	6.901	10.143	10.205	10.168
	GARCH	9.224	9.275	9.244	6.876	6.957	6.909	10.176	10.258	10.209
	EGARCH	8.472	8.535	8.497	6.921	7.024	6.963	10.191	10.293	10.232
	PARCH	8.888	8.964	8.918	6.908	7.031	6.958	10.207	10.330	10.257
Meat Price	**ARMA**	**5.404**	5.443	5.420	**5.261**	5.323	5.287	**5.476**	5.538	5.501
	ARCH	8.197	8.235	8.212	7.507	7.569	7.532	8.963	9.025	8.988
	GARCH	8.204	8.255	8.224	7.545	7.627	7.578	9.331	9.413	9.364
	EGARCH	8.265	8.329	8.291	7.554	7.656	7.595	9.028	9.182	9.121
	PARCH	8.216	8.292	8.247	7.664	7.787	7.714	9.208	9.331	9.258
Dairy Price	**ARMA**	**6.469**	6.507	6.483	**5.395**	5.457	5.420	**6.918**	6.979	6.943
	ARCH	9.012	9.050	9.027	7.404	7.466	7.429	9.923	9.984	9.948
	GARCH	9.017	9.068	9.038	7.407	7.489	7.440	10.685	10.767	10.719
	EGARCH	8.996	9.060	9.022	7.490	7.592	7.531	10.663	10.766	10.705
	PARCH	9.029	9.106	9.060	7.426	7.550	7.476	10.671	10.794	10.721
Sugar Price	**ARMA**	**8.063**	8.101	8.078	**7.255**	7.317	7.280	**8.495**	8.556	8.520
	ARCH	10.091	10.139	10.106	9.178	9.240	9.204	11.042	11.104	11.067
	GARCH	10.083	10.134	10.103	9.180	9.262	9.213	11.137	11.220	11.171
	EGARCH	10.119	10.183	10.145	9.181	9.284	9.223	11.236	11.339	11.278
	PARCH	10.132	10.208	10.163	9.273	9.396	9.323	11.048	11.173	11.100

Source: Computed from 1990-2014 Food and Agriculture Organisation (FAO) (2014), World Bank commodity Price Data (2014), and World Trade Organisation (WTO) price series, bold figures indicate criteria for selection

Table 4. Parameter Estimates of the State Space Model and their Associated Errors.

Cereal		**Dairy**		**Sugar**		**Meat**		**Aggregate Food**	
Parameters	Coefficients	Parameters	Coefficients	Parameters	Coefficients	Parameters	Coefficients	Parameters	Coefficients
β_1	-0.9993*** (1.33E-09) (-7.50E+08)	∂_1	-0.2051*** (1.59E-05) (-12882.58)	ζ_1	0.1435*** (0.0002) (698.2179)	ϑ_1	0.2811*** (6.11E-07) (460067.8)	δ_1	0.1519*** (0.0003) (527.4885)
β_2	5.8958*** (0.0510) (115.6836)	∂_2	0.0012*** (8.37E-06) (144.4650)	ζ_2	-0.0322*** (3.59E-05) (-897.3708)	ϑ_2	1.21E-09 (0.0145) (8.32E-08)	δ_2	-0.0500*** (0.0015) (-32.4592)
β_3	-0.8924*** (8.90E-08) (-10027943)	∂_3	0.0008 (0.0002) (5.1691)	ζ_3	0.0415*** (0.0016) (26.5843)	ϑ_3	1.67E-09 (0.0042) (3.99E-07)	δ_3	0.0408*** (1.67E-06) (24367.19)
α	6317.858*** (1.020809) (6189.071)	λ	34.4462 (1.0004) (34.4322)	η	10.2409*** (0.9840) (10.4073)	θ	2.061836** (0.9025) (2.2846)	γ	8.61E-09 (1.0000) (8.61E-09)
μ	22472.48*** (0.0757) (296780.8)	ϕ	240.0462*** (0.0000) (NA)	ρ	247.0594*** (0.0000) (NA)	π	1704.978 (2.98E-08) (5.72E+10)	τ	5.1429 (0.9855) (5.2185)
Log likelihood	-8.16E+09								
Akaike info criterion	56248263								
Schwarz criterion	56248263								
Hannan-Quinn criterion	56248263								

Source: Computed from 1990-2014 Food and Agriculture Organisation (FAO) (2014), World Bank commodity Price Data (2014), and World Trade Organisation (WTO) price series, ***Significant at 1% level, **Significant at 5% level

Table 4 shows the parameter estimates of the state space model. The results show that most of the coefficients were significant at the 1% level and, at convergence, the maximum of the log likelihood was-8.16×〖10〗^9. The coefficients -0.8924, 0.0415, and 0.0408 are the log variance of the error term for state equation of the prices of cereals, sugar and aggregate food. The respective variances of the errors were 0.4097, 1.0424, and 1.0416. These imply that the volatility in price of Nigeria agricultural commodities is highest in sugar, followed by aggregate food and least in cereals. The coefficients -0.999, -0.2051, 0.1435, 0.2811 and 0.1519 are the respective marginal effects of past price state of cereals, dairy, sugar, meat and aggregate food. These imply that a unit increase in the past price state of cereals, dairy, sugar, meat and aggregate food would increase the current or future price of sugar, meat and aggregate food by N 0.14, N 0.28 and N 0.15 respectively but decrease future price of cereals and dairy by about N 1.00 and N 0.21 respectively. That the values are not zero and statistically different from zero further implies that the state variance for the slope components change with time. The maximum likelihood estimates of the level at t=1 are respectively 6317.86, 34.45, 10.24, and 2.06 for cereals, dairy, sugar and meat. The final states of seasonal and cyclical unobserved components for cereals, food aggregate, meat, dairy and sugar were respectively 22472.48, 5.14, 1704.98 240.05 and 247.06. The values 6317.86, 2.06, 34.45 and 10.24, shown in the Table are the one-step ahead predicted value for the first out-of-sample period for cereals, meat, dairy and sugar price respectively.

4. Conclusion

Agricultural commodity price volatility requires in-depth knowledge of the commodity market prices and the tools capable of facilitating their measurement. Some econometric models can be and are used for simulation or policy analysis but not without consideration to the time-variant parameters. The study fitted the Autoregressive Moving Average (ARMA), Autoregressive Conditional Heteroskedasticity (ARCH) model, the Generalised Autoregressive Conditional Heteroskedasticity (GARCH) model, the Exponential Generalised Autoregressive Conditional Heteroskedasticity (EGARCH) model and the Asymmetric Power Autoregressive Conditional Heteroskedasticity (APARCH) model version to test for the best time-varying variability model that explains the price volatility in the Nigeria agricultural commodities market ranked according to three information criteria, the Schwarz Information Criterion (SIC), Akaike Information Criterion (AIC) and the Hannan–Quinn Information Criterion (HQIC) after a first difference transformation of the price series. The criteria were also used to select the appropriate lag. The prices of cereals, meat, dairy, sugar and aggregate food show great volatility in the period 1990-2014 with a unit increase in the past price state of cereals, dairy, sugar, meat and aggregate food increasing the future price of sugar, meat and aggregate food by ₦ 0.14, ₦ 0.28 and ₦ 0.15 respectively but decreasing that of cereals and dairy by about ₦ 1.00 and ₦ 0.21 respectively. The estimates of the weights (slope) are not zero and statistically different from zero implies that the state variance for the slope components change with time. The Nigerian cereals, meat, dairy, sugar and aggregate food prices have experienced high variability over the period, and such volatility, price-generating process and the determinants of these Nigerian commodities prices can best be described by the simple ARMA model with time-variant hyperparameters. The volatility in agricultural commodities prices in Nigeria is the result of current variability and the weighted one-period lag of their respective residuals.

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