



EVALUATING MAIZE PRICE VOLATILITY AND ITS IMPLICATION FOR FOOD SECURITY IN NIGERIA

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ABSTRACT

Evaluation of food price volatility is useful as price variations can be demanding when large and sudden, thereby creating risks for consumers, producers and traders. This paper examined maize price volatility and its implication for food security in the Nigeria by using Autoregressive Conditional Heteroskedasticity (ARCH) model and its extensions (GARCH and TGARCH) based on monthly maize prices between November, 2010 and October, 2017. The results show that maize price is relatively unstable although no evidence of leverage effect was observed. The absence of leverage effect would mean that positive news such as useful policies and good weather have bigger impact on volatility than negative news at the same scale. Consequently, investments in reducing post-harvest losses and storage facilities need to increase to guarantee stable prices and food security.

Keywords: Food security, GARCH/TGARCH, Maize price, Nigeria, Price volatility.

INTRODUCTION

Maize is one of the most significant cereal crops in Nigeria where over 150 million people consume an average of 43 kilogrammes per year (Oyelade and Awanane, 2013). The author further reported that among different income groups, maize is a relatively more important source of calories for the poorer proportion of consumers. According to Cadoni and Angelucci (2013), maize consumption is prevalent across the country and amid households of different wealth. Over the years, prices of agricultural commodities in Nigeria have been on the increase (Ojogho and Egware, 2015).

The choice of maize for this study is based on the fact that it is an important staple food crop. Production of maize dominates the farming system in Nigeria and for this reason, it is of strategic importance for food security and the socio-economic stability of the country, with more than 50% of all households assigning over 50% of their cereal area to maize (Oyelade and Awanane, 2013).

The prices of globally traded commodities frequently experience unexpected and significant fluctuations as a consequence of a wide range of forces and factors (Pop, *et al.*, (2013). Commodity prices fluctuate continually throughout the year due to changes in the underlying supply and demand variables (Musunuru *at el.*, 2013). The determinants of price volatility differ from one commodity to another, but in general, sudden price movements are the consequence of low elasticities of demand and supply in the short term (UNCTAD, 2008). Moreover, price changes tend to have sources that go beyond market fundamentals, adding to supply and demand shocks. *Severe volatility in commodity prices, particularly of food commodities, affects poor agricultural labourers and labour engaged in unorganized sector adversely because their wages are not index- linked (Sekhar, 2003). Market prices of agricultural commodities typically increase before harvest and fall after harvest, thereby causing volatility (Musunuru *at el.*, 2013). According to Sukati (2013), unpredictable weather



patterns and climate change will result in volatile price movements in agricultural commodities because they will cause supply interruptions. Under the impact of climate change, world crop price level and volatility will both increase almost threefold between 2000 and 2080 (Tran *et al.*, 2012). As a consequence, unpredictable and low maize output as a result of climate change is expected to increase price volatility in the local maize market as well (Sukati, 2013).

An increase in price volatility means greater uncertainty about future prices as the range in which prices might lie in the future becomes wider. Therefore, producers and consumers can be affected adversely by increased price volatility as it expands the uncertainty and risk in the market. In particular, increased price volatility can decrease the accuracy of producers' and consumers' forecasts of future agricultural commodity prices, thus causing welfare losses to both producers and consumers of agricultural commodities (Binswanger and Rosenzweig, 1986; and Saha and Delgado, 1989). At the producer level, high price volatility creates uncertainty and limits the decision of the farmers to invest. At the consumer level, increases in price volatility translate into larger fluctuations in the purchasing power they hold. By insulating the domestic market from world prices, the government could theoretically protect its internal players from the transmission of high price volatility in the external market (Götz, *et al.*, 2013).

According to Godana *et al.* (2014), food price volatility has strong and long-lasting effects on emerging economies and low-income people. It has a harmful impact on the economy of the country through earnings instability for producers, consumers and whole sellers and also leads to a major decline in potential output. According to Apergis and Rezitis (2011), volatility refers to variations in economic variables over time. According to Kuwornu *et al.* (2011), the analysis of price volatility is necessary to develop bidding strategies or negotiation skills in order to maximize profit.

Maize is one of the staple foods produced and consumed in Nigeria. Therefore, the fact that its price fluctuates, would be of great concern to farmers as well as consumers. Over the years, prices of agricultural commodities in Nigeria have been on the increase (Ojogho and Egware, 2015). According to Food and Agriculture Organization [FAO] (2008), food price index rose by 23% in 2006 and 37% in December 2007 while food prices rose by 55% between June 2007 and February 2008. A rise in food prices causes other commodity prices to rise ultimately leading to inflation and unstable economy (Munir and Esteban, 2011). Measuring of food price volatility is important as variations in prices become challenging when they are large and cannot be anticipated. As a result, this creates a level of insecurity which tends to increase risks for producers, traders, consumers and governments and result in sub-optimal decisions (FAO, 2011). Price volatility indicates the range within which prices might vary in the future (Natcher and Weaver, 1999).

Autoregressive Conditional Heteroskedasticity (ARCH) models are specifically designed to model and forecast conditional variance of the dependent variable. The application of GARCH family models to study volatility of agricultural commodity markets was discussed by Stigler (2011). The author is of the opinion that volatility clustering has been widely observed in storable agricultural commodity prices. According to Stigler (2011), low price volatilities tend to follow low price volatilities and high price volatilities tend to follow high price volatilities. This occurrence can be precisely described by the Autoregressive Conditional Heteroskedastic (ARCH) model, first introduced by Engel (1982) and was later generalized by Bollerslev (1986) giving rise to the GARCH model. The main idea is to allow the conditional variance to depend on values of previous shocks and on its own past values. Stigler (2011) further maintained that it is possible that positive and negative shocks have different effects on price volatility of storable agricultural commodities.

Studies using the ARCH model and its extensions are frequently employed to measure volatilities of market prices. Jordaan *et al.* (2007), using the ARCH or GARCH approach, measured conditional volatilities for the prices of various crops traded on the SAFEX, Figiel and Hamulczuk (2010) tested for conditional volatility by investigating monthly wheat procurement prices in Poland, Pop and Ban (2011) used EGARCH for modeling the price of wheat in order to estimate volatility and price risk, both on the Romanian and international markets and Pop *et al.* (2013) used GARCH approach to measure commodity price volatility during and after the Economic Crisis (Implications for Romania). Baharom *et al.* (2009), examined the volatility of Thai rice price using GARCH model. Sukati (2013) examined the volatility of maize price in Swaziland using ARCH/GARCH approach.

The soaring agricultural commodity prices in recent years have increased the question of whether or not volatility is rising and leading to more frequent extreme price swings (Huchet-Bourdon, 2011). It is of great importance to measure food price volatility because variations in prices can create a level of insecurity which increases risks for producers, traders, consumers as well as governments. Recurrent variations in food prices will make it difficult for the government to implement control measures for food market. It is crucial for policy makers to be aware of the degree of price volatility so as to adopt suitable strategies that will reduce volatility in the market given that food volatility is closely related to food production and food security. Thus, measuring maize price volatility is particularly important for Nigeria in that maize is one the staple foods of majority of the population and has implications for both farmers and market participants. This study examined price volatility in the Nigerian maize market using the ARCH and GARCH approaches.

MATERIALS AND METHODS

Data Collection

The study employed average monthly data on real wholesale prices of maize obtained from Food Security Portal data dashboard (2017). The prices of maize in Nigeria currency unit (Naira) per kilogram between November, 2010 and October, 2017 were used for the analysis.

Estimation Techniques

The unit root property of the variable was investigated to avoid spurious regression. The Augmented Dickey Fuller (ADF) test (Dickey and Fuller, 1981) for the presence of unit was employed. The ADF test is based on the following regression given in equation 1:

$$\Delta Y_t = \beta_1 + \beta_2 t + \delta Y_{t-1} \sum_{i=1}^m \lambda_i \Delta Y_{t-i} + \varepsilon_t \quad \dots(1)$$

where;

ε_t = pure white noise error term and

$$\Delta Y_{t-1} = (Y_{t-1} - Y_{t-2}).$$

The number of lagged difference terms to include is often determined empirically. The ADF test that the series is not stationary is shown by the null hypothesis ($H_0 : \beta = 0$) whereas the alternative hypothesis ($H_1 : \beta < 0$) shows that the series is stationary. The rule is that if the computed ADF statistics is greater than the critical at the specified level of significance, then the null hypothesis of unit root is accepted otherwise it is rejected.

Autoregressive Conditional Heteroskedascity (ARCH) method and its other extensions such as GARCH and TGARCH were used to test the volatility of maize price. The ARCH-LM test proposed by Breusch-Pagan (Breusch and Pagan, 1979), which is also consistent with Engle (Engel, 1982) was used to test for the ARCH effect so as to determine the existence of volatility in maize price. The ARCH model model suggests that the variance of the residuals

at time t (ε_t) depends on the square of error terms from past periods hence the variance is not constant. In developing an ARCH model, two distinct specifications are considered - one for the conditional mean and the other for the conditional variance. An ARCH (1) model is thus specified in equation 2 and 3:

$$Y_t = X_t^1 \theta + \varepsilon_t \quad \dots(2)$$

The variance equation is thus:

$$\delta^2 = \alpha + \beta \varepsilon_{t-1}^2 + \mu_t \quad \dots(3)$$

Also, considered in this study is the General Autoregressive Conditional Heteroskedascity (GARCH) model developed by Bollerslev (1986). It is an extension of Engle's ARCH model. It captures the effect of variance on volatile time series which ARCH model does not. The GARCH model allows for the conditional variance to depend upon past information and consequently vary over time. It allows for a more flexible lag structure than the ARCH model of Engle (1982). In the GARCH model the conditional variance is predicted by past forecast errors and past variances. The mean equations in both ARCH and GARCH are the same but the conditional variance equations differ. The estimation procedure for GARCH is the same in ARCH model; the only difference is the conditional variance equation which is stated below in equation 4.

$$\delta_t^2 = \alpha_0 + \beta_1 \varepsilon_{t-1}^2 + \beta_2 \delta_{t-1}^2 + \mu_t \quad \dots(4)$$

where;

ε_{t-1}^2 = ARCH term and δ_{t-1}^2 is the GARCH term. The closer the sum of the coefficients is to 1, the slower the mean reverting and the closer the sum to 0, the faster the mean reverting.

The Threshold GARCH (TGARCH) introduced by Zakoian (1994) was also considered for estimation in this study. This model captures asymmetric or leverage effect not accounted for by ARCH and GARCH models. This asymmetric relationship is called leverage effect and describes how a negative shock causes volatility to rise more than if a positive shock with the same scale had occurred. The specification for the TGARCH model is thus stated as shown in equation 5:

$$\delta_t^2 = \varphi + \sum_{i=1}^p \beta_i \varepsilon_{t-i}^2 + \sum_{h=1}^q \beta_h \delta_{t-h}^2 + \sum_{j=1}^k \gamma_j \varepsilon_{t-j}^2 \bar{I}_{t-j} \quad \dots(5)$$

where;

$\bar{I}_t = 1$ if $\varepsilon_t = 0$ and 0 otherwise. Good news has an impact of β_i while bad news has an impact of $\beta_i + \gamma_i$. If $\gamma_i > 0$, bad news increases volatility and that means there is leverage effect.

RESULTS AND DISCUSSION

The result of the unit root test is presented in Table 1. The Augmented Dickey Fuller (ADF) test revealed that the variable is stationary at first difference. That is, the variable is integrated of order one $I(1)$.

Table 1: ADF Test of Maize Prices in Nigeria, 2010M11 to 2017M10

Variables	Levels		First Difference		Order of integration
	<i>t</i> -statistic	Probability	<i>t</i> -statistic	Probability	
Ln Maize price	- 0.7374	0.8308	-8.7027***	0.0000	$I(1)$

Note: ***significance at 1% level. Lag length selection was automatic based on Schwarz information criterion (SIC).

Source: Author's computations using E-views

The ARCH-LM test was performed to determine the existence of volatility in maize prices. The ARCH-LM test result is presented in Table 2. The results show that the probability values for both F-statistics and R^2 indicate the existence of ARCH effect in maize price which means that maize price was volatile. The null hypothesis (H_0) of no ARCH effects is rejected if the probability value of this test is less than any of the convention statistical significance levels ($P < 0.01$; $P < 0.05$; and $P < 0.1$). The Lagrange Multiplier (LM) test shows a p value of 0.0000, which is well below 0.05, and consequently the null hypothesis of no ARCH (1) effects is strongly rejected. The rejection of the null hypothesis shows the presence of ARCH effect. The presence of volatility in maize price required estimations of ARCH-family models. The presence of ARCH effect means that maize price volatility is time varying and thus agreeable to GARCH Approach.

Table 2: ARCH-LM Test

Variable	Coefficient	Probability
F-Statistics	434.049	Prob. F (0.0000)
Observed R^2	69.9469	Prob. Chi-Square (0.0000)

Source: Author's computations using E-views

Following the establishment of the existence of volatility in maize price, GARCH and TGARCH models were estimated and the results are presented in Table 3 and Table 4. In the estimated (GARCH (1, 1), γ_1 and δ_1 measures the short-run dynamics of the time series. Given that the coefficient of γ_1 (0.8003) is large and significant, implies that maize price volatility responds strongly to market dynamics. However, because the coefficient of δ_1 (0.1809) is small and not statistically significant, implies that maize price volatility is not continual. Furthermore, given that γ_1 is larger than δ_1 suggests that volatility in maize price have a tendency to be spiky. This result is similar to the findings of Sukati (2013). The sum of the coefficients of ARCH and GARCH is 1.12 which points to the existence of ARCH and GARCH effect, indicating that a shock to the conditional variance will be very persistent. This also indicates that, maize prices are very volatile. This could be attributed to the seasonality in maize production.

Table 3: Results of GARCH (1, 1) Model

Variables	Coefficient	Standard error	z-Statistics	Prob.
Mean Equation				
Constant ϕ	4.053663	0.019998	202.7004	0.0000***
Variance equation				
Constant - ϕ	0.005522	0.004038	1.367483	0.1715
ARCH (1) - γ_1	0.800259	0.375836	2.129276	0.0332**
GARCH (1) - δ_1	0.180993	0.323870	0.558844	0.5763

Source: Author's computations using E-views

To determine the presence of asymmetry effect, the TGARCH was estimated (Table 4). Results show that thresholds are not significant in the determination of asymmetric effect in the volatility of maize price in Nigeria. In the estimated TGARCH (1, 1) model, the coefficient of leverage effect is negative (-0.296394) and insignificant, suggesting that there are no asymmetry effects on the maize price movements to succeeding movements. This means that the model merely slips back to the standard GARCH specification. This finding is in line with

(Sukati, 2013). Following Sukati (2013), since the leverage effect is insignificant, the EGARCH extension as proposed by Nelson (1991) was not estimated.

Table 4: Results of TGARCH (1, 1) Model

Variables	Coefficient	Standard error	z-Statistics	Prob.
Mean Equation				
Constant ϕ	4.053987	0.019455	208.3817	0.0000***
Variance equation				
Constant $-\phi$	0.006157	0.004825	1.276038	0.2019
ARCH (1) $-\gamma_1$	0.905231	0.519764	1.741619	0.0816*
GARCH (1) $-\delta_1$	0.157976	0.405837	0.389259	0.6971
TGARCH (1) $-\sigma$	-0.296394	0.595462	-0.497754	0.6187

Source: Author's computations using E-views

CONCLUSION AND RECOMMENDATIONS

The study examined maize price volatility and its impact on food security in the Nigeria by means of ARCH model and its extensions (GARCH and TGARCH) using monthly real wholesale prices of maize from November, 2010 to October, 2017. It is evident from the results of this study that maize price is volatile. There is no evidence of leverage effect in the price of maize in Nigeria. The study concludes that maize price volatility can be adequately modeled by GARCH models. Given the persistent price volatility in the maize market, this study recommends that strategies to deal with price volatility be strengthened by buying buffer stock at competitive prices, provision of input subsidy, investments in reducing post harvest losses and storage facilities and establishing market information scheme to give participants' better information about prices.

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