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VOLATILITY OF AGRICULTURAL COMMODITIES IN MUBI AND DAWANAU MARKETS IN ADAMAWA AND KANO STATES IN NIGERIA

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ABSTRACT: *In this paper, we examined the volatility of agricultural commodities like Maize (White), Cowpeas (Brown) and Sorghum (White) in Adamawa and Kano state markets from 2015 – 2022 using data obtained from World Food Programme (WFD) food prices nga. We also compared the volatilities of these agricultural commodities in the Adamawa (Mubi) market with the volatilities of the same agricultural commodities in the Kano (Dawanau) market to study the evolution of the price of these agricultural commodities in the Adamawa (Mubi) and Kano (Dawanau) markets.*

KEYWORDS: Price, Price volatility, Agricultural markets, Agricultural commodity, Derivatives.

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INTRODUCTION

Financial derivatives enable parties to trade specific financial risks such as interest rate risk, currency, equity and commodity price risks, credit risk, etc., to other entities who are more willing, or better suited, to take or manage these risks, typically, but not always, without trading in a primary asset or commodity. The risk associated with a financial derivative contract can be determined either by trading the contract itself with options, say, or by creating a new contract which embodies risk characteristics that match those of the existing contract owned (IMF, 1998).

Volatility can be defined as the variation (amplitude and frequency) of commodities price changes around their mean value (Huchet–Bourdon, 2011). As can be seen in (the European Commission, 2009; and Matthews, 2010), we have two kinds of volatility; historical and implicit volatilities. Historical volatility considers data from the past (past commodities prices). It shows the uncertainty in the price of commodities in the past while implicit volatility is the future markets' expectation on volatility of the price of the commodities. In our work, we will consider only historical changes in the price of agricultural commodities in the Nigerian market. As in the Organization for Economic Cooperation and Development (OECD) (OECD, 2009), agriculture has exposure to some risks which are; production risk, market risk, institutional risk, and personal and financial. It is obvious that the market risk is related to the volatility of prices of the agricultural commodities in the Nigeria market and these uncertainties in prices are important determinants of how much a farmer would be willing to invest in a particular commodity.

Policymakers and participants along the food supply chain are interested in the volatility of agricultural commodities and to better understand the expected future evolution in the prices of these agricultural commodities (Matthews, 2010). Therefore, the study of the price volatility of agricultural commodities in the Nigerian market is very important. Borawski *et al*., (2018), also examined the price volatility of some agricultural commodities like beef, pork and wheat in Poland using 650 weekly observations from 2003 to 2015. In their work, they found that the global market situation impacted Polish agricultural markets, with the integration of Polish into the EU, the global financial crisis in 2008 and EU zone problems having the strongest impact on the Polish agricultural market.

Volatility in prices of agricultural commodities over the years has given people concern about the condition of food and nutrition in emerging nations' impoverished people (Minot, 2014). As a result of price volatility in agricultural commodities, a lot of programmes have been set up in sub–Saharan Africa to react to the growing food prices in the region. (Smith and Abraham, 2016). For instance, the Nigeria federal government in 2012 launched a scheme called the Growth Enhancement Support Scheme (GESS) to find better ways to deliver agricultural inputs, improve yields, stimulate food security and enhance economic progress in the rural part of Nigeria (Adesina, 2012). Therefore, agricultural commodities price volatility can create serious economic problems in Africa (Arezki and Bruckner, 2016). Besides, approximately 60% of the human population in sub–Saharan Africa earns their livelihood from agriculture with about 28% making use of agricultural land that is less than two hectares (Alper *et al*., 2016).

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It is widely accepted that the agricultural sector of a nation's economy can contribute immensely to the nation's economic growth and development. Therefore, it is very important for such a country to develop its agricultural sector. Therefore, the work of Osabohien, *et al*., (2018), uses the Autoregressive Distributive Lag (ARDL) to study the contribution to food production and export in Nigeria. The study pointed out that the major determinants in studying the effective performance of the agricultural sector are technology and institutional framework. Since the use of modern agricultural activities can increase agricultural production (Osabohien, *et al*., 2018). Besides, agriculture can be viewed as a backbone for a developing nation like Nigeria. Therefore, the price volatility of agricultural commodities is a very important component in such a developing economy. The work of Adeyemi *et al*., (2019), discussed the macroeconomic impact of price volatility of agricultural commodities in Nigeria from 1970 to 2017 using Autoregressive Distributive Lag (ARDL) cointegration and Impulse – Response Function (IRF) analysis where they found that there is evidence of persistent fluctuation in the macroeconomic variables observed. Hence, agriculture is very important for sustaining development and reducing poverty in a nation like Nigeria. It can also be a source of livelihood and economic growth (WBR, 2023; Adebayo, *et al*., 2016).

Nigeria to some extent depends on agricultural commodities export for foreign earnings and for financing its budget. Therefore, changes in the price of agricultural commodities could have a negative effect on the overall nation's development. This study examines the volatility of selected agricultural commodities in selected Nigeria markets and we utilize the data obtained from the World Food Programme (2015 – 2022) for our analysis in Mubi and Dawanau markets in Adamawa and Kano states.

The Constant Elasticity of Variance (CEV) Model

We assume that the price of the agricultural derivative follows the following stochastic differential equation:

$$dX_t = rX_t dt + \sigma X_t^{\alpha} dW_t, \qquad X_0 > 0 \tag{1}$$

where r is the percentage drift, σ is the percentage volatility, with restriction

$r \in R, \sigma > 0$. Furthermore, α is the Elasticity of Variance (CEV), which is considered to be the CEV parameter that is considered to be in the interval $[0,1]$. The initial price is $X_0 = X > 0$.

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Estimation of the Parameters of the Agricultural Derivative Model

Discrete Maximum Likelihood Method

Here, we investigate parameter estimation procedures where the diffusion process X is strictly observed at discrete points. One of the major problems encountered in the discrete maximum likelihood parameter estimation framework is finding a closed-form expression that involves the unknown parameters that approximate the transition probability density function (PDF). To overcome this problem, we will consider the Gaussian transition density function (Danjuma and Dange, 2022). The idea behind the maximum likelihood method is to find the parameter values so that the actual outcome has the maximum probability. **The exact maximum likelihood estimation for constant elasticity of variance model parameters.**

Alternatively, let $\{X(t): t \geq 0\}$ be a stochastic process that satisfies Markov's property. Assume that we observe this process at a discrete collection of time points $\{t_0, t_1, \ldots, t_n\}$, where $t_0 = 0, t_i = \frac{i\tau}{n}\ for\ i = 1,2,\ldots,n$. Let $\{X(t_0), X(t_1), \ldots, X(t_i)\}$ be the available data. For simplicity, we use $X_i = X(t_i)$. Let θ be the parameters defining the process $\{X(t): t \geq 0\}$. Then likelihood function can be defined as

$$L(\theta|X_1, X_2, \ldots, X_n) = \prod_{i=1}^{n} p(X_{t_i}|X_{t_{i-1}};\theta)$$

Where $p(X_{t_i}|X_{t_{i-1}};\theta)$ is called the transition density? For the Geometric Brownian Motion (GBM) process the transition density is:

$$p\left(X_{t_i}|X_{t_{i-1}};\theta\right) = \frac{1}{\sigma X_i\sqrt{2\pi\Delta t}} exp\left[-\frac{\left(log\left(\frac{X_i}{X_{i-1}}\right) - \left(r - \frac{\sigma^2}{2}\right)\Delta t\right)^2}{2\sigma^2\Delta t}\right]$$

Thus, the likelihood function is:

$$L(\theta|X_1, X_2, \ldots, X_n) = \prod_{i=1}^{n} \frac{1}{\sigma X_i\sqrt{2\pi\Delta t}} exp\left[-\frac{\left(log\left(\frac{X_i}{X_{i-1}}\right) - \left(r - \frac{\sigma^2}{2}\right)\Delta t\right)^2}{2\sigma^2\Delta t}\right]$$

$$= \prod_{i=1}^{n} \left(\frac{1}{\sqrt{2\pi\Delta t}}\frac{1}{\sigma X_i} exp\left[-\frac{\left(log\left(\frac{X_i}{X_{i-1}}\right) - \left(r - \frac{\sigma^2}{2}\right)\Delta t\right)^2}{2\sigma^2\Delta t}\right]\right) \qquad (2)$$

Therefore, taking the natural logarithm of both sides of (2) results in the log-likelihood function of the form:

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$$l(\theta|X_1, X_2, \dots, X_n) = log\ log\ L(\theta|X_1, X_2, \dots, X_n)$$
$$= -\frac{n}{2} log\ log\ (2\pi\Delta t) - \sum_{i=1}^{n} \square\ log\ log\ (\sigma X_i)$$
$$-\frac{1}{2}\sum_{i=1}^{n} \square \frac{\left(log\left(\frac{X_i}{X_{i-1}}\right) - \left(r - \frac{\sigma^2}{2}\right)\Delta t\right)^2}{\sigma^2 \Delta t} \quad (3)$$

Now,

$$\frac{\partial l}{\partial r} = -0 - 0 - \frac{1}{2}\sum_{i=1}^{n} \square \frac{log\left(\frac{X_i}{X_{i-1}}\right) - \left(r - \frac{\sigma^2}{2}\right)\Delta t}{\sigma^2 \Delta t}(-2\Delta t) \quad (4)$$

Equating (4) to zero gives:

$$\sum_{i=1}^{n} \square \frac{log\left(\frac{X_i}{X_{i-1}}\right) - \left(r - \frac{\sigma^2}{2}\right)\Delta t}{\sigma^2} = 0$$

$$\sum_{i=1}^{n} \square\ log\left(\frac{X_i}{X_{i-1}}\right) - \sum_{i=1}^{n} \square \left(r - \frac{\sigma^2}{2}\right)\Delta t = 0$$

$$Let\ \underline{X} = \left(r - \frac{\sigma^2}{2}\right)\Delta t, then$$

$$\sum_{i=1}^{n} \square\ log\left(\frac{X_i}{X_{i-1}}\right) - n\underline{X} = 0$$

$$\underline{X} = \frac{1}{n}\sum_{i=1}^{n} \square\ log\left(\frac{X_i}{X_{i-1}}\right)$$

Similarly,

$$\frac{\partial l}{\partial \sigma} = -0 - \sum_{i=1}^{n} \square \frac{1}{\sigma X_i}(X_i) - \frac{1}{2}\sum_{i=1}^{n} \square \frac{\left(log\left(\frac{X_i}{X_{i-1}}\right) - \underline{X}\right)^2}{\sigma^4 (\Delta t)^2}(-2\sigma\Delta t)$$

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$$= -\frac{n}{\sigma} + \sum_{i=1}^{n} \frac{\left(log\left(\frac{X_i}{X_{i-1}}\right) - \underline{X}\right)^2}{\sigma^3 \Delta t} \quad (5)$$

Equating Equation (5) to zero gives:

$$\frac{n}{\sigma} = \sum_{i=1}^{n} \frac{\left(log\left(\frac{X_i}{X_{i-1}}\right) - \underline{X}\right)^2}{\sigma^3 \Delta t}$$

$$n\Delta t\sigma^2 = \sum_{i=1}^{n} \left(log\left(\frac{X_i}{X_{i-1}}\right) - \underline{X}\right)^2$$

$$\sigma^2 = \frac{1}{n\Delta t}\sum_{i=1}^{n} \left(log\left(\frac{X_i}{X_{i-1}}\right) - \underline{X}\right)^2$$

$$\underline{\sigma} = \sqrt{\frac{1}{n\Delta t}\sum_{i=1}^{n} \left(log\left(\frac{X_i}{X_{i-1}}\right) - \underline{X}\right)^2} \quad (6)$$

Since,

$$\underline{X} = \left(r - \frac{\sigma^2}{2}\right)\Delta t$$

$$r\Delta t = \underline{X} + \frac{\sigma^2}{2}\Delta t$$

$$\underline{r} = \frac{1}{\Delta t}\left(\underline{X} + \frac{\sigma^2}{2}\Delta t\right) = \frac{\underline{X}}{\Delta t} + \frac{\sigma^2}{2} \quad (7)$$

Numerical Results and Discussion

Here, applying equation (6), the volatilities of some agricultural commodities like Maize (White), Cowpeas (Brown) and Sorghum (White) in Adamawa and Kano markets have been evaluated to gain some insight into how the prices of these commodities evolved in these markets annually and compared the volatilities of these agricultural commodities in the Adamawa with Kano markets.

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Table 1

Commodity Category: Cereals and Tubers

Sources: WFD (World Food Programme) food prices in nga (2023)

Commodity: Maize (White) State: Adamawa Market: Mubi

Year	2015	2016	2017	2018	2020	2021	2022
Volatility	0.2405	0.4538	0.3893	0.2996	0.4332	0.2735	0.1176

Commodity Category: Cereals and Tubers

Sources: WPF (World Food Programme) food prices in nga (2023)

Commodity: Maize (White) State: Kano Market: Dawanau

Year	2015	2016	2017	2018	2020	2021	2022
Volatility	0.1334	0.3006	0.4938	0.2664	0.4137	0.4070	0.0377

Table 2

Commodity Category: Pulses and Nuts

Sources: WFP (World Food Programme) food prices in nga (2023)

Commodity: Cowpeas (Brown) State: Adamawa Market: Mubi

Year	2015	2016	2017	2018	2020	2021	2022
Volatility	0.2144	0.3061	0.4815	0.3029	0.3659	0.4384	0.0723

Commodity Category: Pulses and Nuts

Sources: WFP (World Food Programme) Food Prices in NGA (2023)
Commodity: Cowpeas (Brown) State: Kano Market: Dawanau

Year	2015	2016	2017	2018	2020	2021	2022
Volatility	0.2199	0.3143	0.6101	0.2626	0.4256	0.3704	0.0712

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Table 3

Commodity Category: Cereals and Tubers

Sources: WFP (World Food Programme) food prices in NGA (2023)

Commodity: Sorghum (White) State: Adamawa Market: Mubi

Year	2015	2016	2018	2020	2021	2022
Volatility	0.1542	0.6077	0.1740	0.3738	0.1767	0.0276

Commodity Category: Cereals and Tubers

Sources: WFP (World Food Programme) food prices in nga (2023)

Commodity: Sorghum (White) State: Kano Market: Dawanau

Year	2015	2016	2018	2020	2021	2022
Volatility	0.1638	0.4613	0.2393	0.4702	0.3976	0.1181

From Table 1, we observed that out of the seven years, we considered, in 2017 and 2021 the annual price volatilities of Maize (White) in the Dawanau market are greater than the annual price volatilities of Maize (White) in the Mubi markets. Therefore, we can conclude that the price of Maize (White) in the Dawanau market is fairly stable compared to the price of Maize (White) in the Mubi market.

Also, From Table 2 we can see that in 2018, 2021 and 2022, the annual price volatilities of Cowpeas (Brown) in the Mubi Market are greater than the annual price volatilities of Cowpeas (Brown) in the Dawanau market out of the seven years we considered. Hence, we can hardly say which of the markets the price of Cowpeas (Brown) is more stable in respect of the seven years considered.

Finally, from Table 3, it is obvious that out of the six years under consideration, only in 2016 that the annual price volatility of Sorghum (White) in the Mubi market is greater than the annual price volatilities of Sorghum (White) in the Dawanau market. Therefore, we may conclude that the price of Sorghum (White) in the Mubi market is more stable compared to the price of Sorghum (White) in the Dawanau market for the period under consideration.

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CONCLUSION

We have examined the annual volatilities of some agricultural commodities like Maize (White), Cowpeas (Brown) and Sorghum (White) in the Mubi market and Dawanau market to gain some insight into the changes in these agricultural commodity prices in these markets. We then compare the price volatilities of the agricultural commodities in Mubi market with the price volatilities of the same agricultural commodities in Dawanau market and concluded that the price of Maize (White) in Dawanau market is more stable compared to that of Mubi market and the price of Sorghum (White) is more stable in Mubi market compared to Dawanau market. Our future work will cover more markets and agricultural commodities in all the different geo-political zones.

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