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Agricultural Commodities Volatility in Some Selected Markets in the Northern and Western States in Nigeria

T. Danjuma, N. M. Ike-Muonso, H. C. Chinwenyi

***Abstract*—**The price volatility of agricultural commodities in Nigeria market is very essential and understanding its future evolution is important for informed decision making to policymakers. In this paper, we examined the volatilities of some agricultural commodities such as maize (white), cowpeas (brown) and sorghum (white) in Mubi and Dawanau markets in the Northern part of the country and compared its volatilities with the same agricultural commodities from Lagos and Ibadan markets in the Western part of Nigeria.

***Keywords*—**Agricultural commodity, agricultural market, derivatives, volatility, price.

I. Introduction

THE study of price volatility of agricultural commodities in Nigeria market is very important as it relates to policymakers and participants along the food supply chain. This is so because a clear understanding of this concept will enhance and guide their informed policy decision making in the country [1]. Reference [2] 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 on Polish agricultural markets, with the integration of Poland into EU with the global financial crisis in 2008 and the EU zone problems having the strongest impact on Polish agricultural market. Reference [3] studied the price volatility transmission of perishable agricultural product. Volatility transmission is the price phenomenon that influences upstream production and downstream consumption in agricultural commodity markets. Their work examined the relationship between product perishability and price volatility transmission along the agricultural market chain. They adopted data from litchi and apple markets in China to investigate how price volatilities are transmitted across the farm, wholesale and retail stages using high – frequency data. Some evidence of price transmission is also found in [4]-[7].

In international agricultural commodity market, the existing price volatility can present a food security threat around the world. For instance, for a lot of people around the globe whose survival depends on small scale farming, the price volatility is beginning to present more challenges [8]. Volatility in prices of agricultural commodities over the years has given people concern about the state of food and nutrition in emerging impoverished nations in the world [9]. The uncertainty in prices of agricultural commodities in Nigeria market can adversely affect the achievement of the targeted economic growth and standard of living [10]. As also evidenced in [11] and [12], uncertainty in food price in the market is one of the pressing challenges for policy makers in trying to solve the problems associated with food security and economics. As a result of price volatility in agricultural commodities, a lot of programmes have been set up in sub-Saharan African to react to this growing food prices in the region [13]. For instance, the Nigeria federal government in 2012, launched the scheme called Growth Enhancement Support Scheme (GESS) for the purpose of finding better ways in delivery of agricultural inputs, improve yields, stimulate food security and enhance economic progress in the rural part of Nigeria [14]. Therefore, agricultural commodities price volatility can create serious economic problems in Africa [15]. Besides, approximately 60% of human population in sub-Saharan Africa earn their livelihood from agriculture with about 28% making use of agricultural land that is less than two hectares [16].

Agriculture can be viewed as a backbone for a developing nation like Nigeria. Therefore, price volatility of agricultural commodities is a very important component in such a developing economy. The work of [17] focuses on determinant of agricultural commodities price volatility in Pakistan, where they investigated the price volatility of agricultural commodities and food products in Pakistan using data ranging from June 1983 to June 2018. The work of [18] also 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 sources of livelihood and economic growth [19], [20].

It is widely accepted that agricultural sector of nation's economy can contribute immensely to the nation's economic growth and development. Therefore, it is very important for such country to develop its agricultural sector. Hence the work

T. Danjuma is with the Department of Mathematical Science, Federal University Gusau, Zamfara State, Nigeria (e-mail: tdanjuma@fugusau.edu.ng).
N. M. Ike-Muonso is with the Raw Materials Research and Development Council, Maitama, Abuja, Nigeria.
H. C. Chinwenyi is with the Raw Materials Research and Development Council, Maitama, Abuja, Nigeria (e-mail: chinwenyi@yahoo.com).

of [21] used 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 agricultural sector are technology and institutional framework, since the use of modern agricultural activities can increase agricultural production [21].

Changes in price of agricultural commodities can have some effects on the overall nation's development. This study examines the volatility of selected agricultural commodities in some selected markets in Nigeria over the past six years to eleven years period and utilizes data obtained from world food programme Nigeria for analysis.

II. The Constant Elasticity of Variance 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 $r \in \mathbb{R}, \sigma > 0$. Furthermore, α is the elasticity of variance, which is considered to be the CEV parameter that is considered to be in the interval $[0,1]$. The initial price is $X_0 = X > 0$.

III. Estimation of the Parameters of the Agricultural Derivative Model

A. Discrete Maximum Likelihood Method

Here, we investigate the 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 to find a closed form expression that involves the unknown parameters that approximates the transition probability density function (PDF) [22]. We will consider the Gaussian transition density function. The idea behind the maximum likelihood method is to find the parameter values so that the actual outcome has the maximum probability.

B. 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 the Markov's property. Assume that we observe this process at a discrete collection of times points $\{t_0, t_1, \dots, t_n\}$, where $t_0 = 0, t_i = {}^{i\tau}/_{n}\ for\ i = 1,2,\dots,n.$ Let $\{X(t_0), X(t_1), \dots, X(t_i)\}$ 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

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

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:

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

Thus, the likelihood function is:

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

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

$$l(\theta|X_1, X_2, \dots, X_n) = \log L(\theta|X_1, X_2, \dots, X_n)$$

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

Now,

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

Equating (4) to zero gives:

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

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

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

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

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

Similarly,

$$\frac{\partial l}{\partial \sigma} = -0 - \sum_{i=1}^{n}\frac{1}{\sigma X_i}(X_i) - \frac{1}{2}\sum_{i=1}^{n}\frac{\left(log\left(\frac{X_i}{X_{i-1}}\right)-\bar{X}\right)^2}{\sigma^4(\Delta t)^2}(-2\sigma\Delta t)$$
$$= -\frac{n}{\sigma} + \sum_{i=1}^{n}\frac{\left(log\left(\frac{X_i}{X_{i-1}}\right)-\bar{X}\right)^2}{\sigma^3\Delta t} \tag{5}$$

Equating (5) to zero gives:

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

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

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

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

Since,

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

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

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

IV. Numerical Results

We applied (6) to some data obtained from [23] to evaluate the volatilities of some agricultural commodities like Maize (White), Cowpeas (Brown) and Sorghum (White) in Lagos, Ibadan, Mubi and Dawanau markets to gain some understanding of how the prices of these commodities evolved in the markets annually and compared the volatilities of these agricultural commodities in these markets.

TABLE I
COMMODITY CATEGORY: CEREALS AND TUBERS [23]

Commodity: Maize (White), State: Lagos Market: Lagos								
Year	2015	2016	2017	2018	2019	2020	2021	2022
Volatility	0.3362	0.4252	0.3827	0.1322	0.0654	0.3056	0.2533	0.0379
Commodity: Maize (White) State: Oyo Market: Ibadan								
Year	2015	2016	2017	2018	2019	2020	2021	2022
Volatility	0.3154	0.3713	0.3911	0.2186	0.2565	0.3823	0.5767	.000
Commodity: Maize (White) State: Adamawa Market: Mubi								
Year	2015	2016	2017	2018	2019	2020	2021	2022
Volatility	0.2405	0.4538	0.3893	0.2996	0.3411	0.4332	0.2735	0.1176
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 II
COMMODITY CATEGORY: PULSES AND NUTS [23]

Commodity: Cowpeas (Brown) State: Lagos Market: Lagos								
Year	2015	2016	2017	2018	2020	2021	2022	
Volatility	0.2114	0.2278	0.1429	0.2966	0.3112	0.4633	0.0684	
Commodity: Cowpeas (Brown) State: Oyo Market: Ibadan								
Year	2015	2016	2017	2018	2019	2020	2021	2022
Volatility	0.0595	0.5723	0.2588	0.1628	0.0978	0.1919	0.3311	0.0300
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: Cowpeas (Brown) State: Kano Market: Dawanau								
Year	2015	2016	2017	2018	2019	2020	2021	2022
Volatility	0.2199	0.3143	0.6101	0.2626	0.3947	0.4256	0.3704	0.0712

TABLE III
COMMODITY CATEGORY: CEREALS AND TUBERS [23]

Commodity: Sorghum (White) State: Lagos Market: Lagos								
Year	2015	2016	2017	2018	2019	2020	2021	2022
Volatility	0.1814	0.2921	0.1659	0.0823	0.0721	0.6127	0.2108	0.0353
Commodity: Sorghum (White) State: Oyo Market: Ibadan								
Year	2015	2016	2017	2018	2019	2020	2021	2022
Volatility	0.1222	0.6297	0.3449	0.1178	0.0695	0.5634	0.2558	0.0052
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: Sorghum (White) State: Kano Market: Dawanau								
Year	2015	2016	2017	2018	2019	2020	2021	2022
Volatility	0.1638	0.4613	0.3914	0.2393	0.3380	0.4702	0.3976	0.1181

From Table I, we compared price volatilities of Maize (White) from Lagos market with the price volatilities of Maize (White) from Mubi and Dawanau markets. From the comparison, we obtained that:

i. It is only in 2015, that the annual price volatilities of Maize (White) in Lagos Market is greater than annual price

volatilities of Maize (White) in Mubi market. Therefore, price of Maize (White) is more stable in Lagos market compared to Mubi market.

ii. Also, comparing Lagos market with Dawanau market, one can hardly say which of the market the price of Maize (White) is more stable in respect to the number of years in the period considered.

iii. From the comparison of Ibadan market with Mubi market, one can say that the price of Maize (White) in Ibadan market is fairly stable compared to the price of Maize (White) in Mubi market.

iv. Similarly, comparing Ibadan market with Dawanau market, one can hardly say which of the market the price of Maize (White) is more stable in respect to the number of years for the period considered.

In Table II, we can see that:

i. It is only in 2021, that the annual price volatilities of Cowpeas (Brown) in Lagos market area greater than price volatilities of Cowpeas (Brown) in Mubi market. Hence the price of Cowpeas (Brown) in Lagos market is more stable compared to that of Mubi market for the period under consideration.

ii. Also, comparing Lagos market with Dawanau market, we can see that in 2018 and 2021, the price volatilities of Cowpeas (Brown) in Lagos market are greater than that of Dawanau market. Thus, we can also conclude that the price of Cowpeas (Brown) in Lagos market is more stable compared to that of Dawanau market.

iii. Furthermore, comparing Ibadan market with Mubi market, we also observed that price of Cowpeas (Brown) is more stable in Ibadan market compared to Mubi market since it is only in 2016 that the annual price volatilities of Cowpeas (Brown) in Ibadan market is greater than that of Mubi market for the period considered.

iv. Similarly, comparing Ibadan market with Dawanau market, we can also see that the price of Cowpeas (Brown) in Ibadan market is more stable compared to that of Dawanau market.

From Table III, we compared the annual price volatilities of Sorghum (White) in Lagos and Ibadan markets with that of Mubi and Dawanau markets. We can see that:

i. The price of Sorghum (White) in Mubi market is more stable compared to Lagos market.

ii. Furthermore, comparing Lagos market with Dawanau market, one cannot say which market for which the price of Sorghum (White) is more stable with respect to the number of years under consideration.

iii. Also, from comparing Ibadan market with Mubi market, one cannot say which market the price of Sorghum (White) is more stable for the period considered.

iv. The price of Sorghum (White) in Ibadan market is more stable compared to Dawanau market.

V. Conclusion

We have evaluated the volatilities of some agricultural commodities like Maize (White), Cowpeas (Brown) and Sorghum (White) in Dawanau, Mubi, Lagos and Ibadan markets in Kano, Adamawa, Lagos and Oyo States in Nigeria respectively. We also compared the volatilities of these commodities in the Northern markets (Dawanau, Mubi) with that of Western markets (Lagos, Oyo) to gain some insight into which of the markets the price of the commodities is more stable.

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