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Maize and Rice Prices Instability in Northeast, Nigeria.

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ABSTRACT
The study examines maize and rice price instability in Northeast, Nigeria. Secondary data on monthly basis for wholesale maize and rice price per kilogram obtained from National Bureau of Statistics website for period of 7 years (2017 – 2023) were used for the study. Purposive sampling techniques were used. Inferential statistics were used to analyze the data of the study. The use of inferential statistics involved the use of Augmented Dickey Fuller (ADF) Test, Cuddy-Della Valle index, and Autoregressive Integrated Moving Average (ARIMA). The study maize and rice price instability in Northeast, Nigeria. Secondary data on monthly basis for wholesale maize and rice price per kilogram obtained from National Bureau of Statistics website for period of 7 years (2017 – 2023) were used for the study. Purposive sampling techniques were used. Inferential statistics were used to analyze the data of the study. The use of inferential statistics involved the use of Augmented Dickey Fuller (ADF) Test, Cuddy-Della Valle index, and Autoregressive Integrated Moving Average (ARIMA). The study revealed that at first difference all the price series were stationary. The study indicates that rice market price instability in all the states were average (medium), while maize market price instability in all the states were high since their respective CDVI is greater than 30% CDVI threshold across the study period. The study also indicated that GOMM has the highest price instability (44.31%) in the study area. The analysis of maize and rice price forecast in Northeast Nigeria revealed that, there will be upward trend of cowpea prices from the month of January to December, 2024 in all the states under observation. The study concluded that Nigeria's maize and rice markets, particularly Gombe State, had the highest levels of price unpredictability. The month with the highest maize and rice price, from January to December, is December and recommended that policymakers should implement price stabilization mechanisms, such as subsidies or buffer stocks, to reduce extreme price fluctuations and protect farmers and consumers from economic shocks.

Keywords*:* Maize, Rice, Prices, Instability

I. INTRODUCTION

In sub-Saharan Africa about 208 million people eat maize, a staple crop that is essential to their economic and food security. In Eastern and Southern Africa (ESA), it makes up over half of the calories and protein consumed, and in West Africa, it makes up one-fifth. Over 33 million hectares of land are used for maize cultivation, but low average yields make it difficult to meet the anticipated rise in demand (Harold, 2015). In Africa, rice is an essential food staple that is consumed quickly as a result of population increase, urbanization, and shifting dietary preferences. After the food crisis of 2007–2008, domestic production increased, but demand did not keep up, forcing Africa to rely more on imports to meet its growing demands (Seck *et al.*, 2013 and Harold, 2015).

Unprecedented volatility in the price of agricultural commodities has been connected to the affordability of food, especially during the COVID-19 epidemic. Nigeria, which produces the most cereal crops in West Africa (an average of 3.2 million tons yearly), is experiencing negative effects on its production and marketing activities as a result of rising demand from both urban and rural populations (Food and Agriculture Organization, 2017). Cereals, such as rice, maize, millet, and wheat, account for 70% of Nigeria's total acreage used for food crops, according to the Global Information and Early Warning System on Food and Agriculture (GIEWS). Cereals are essential for food security, spending, and revenue in South-South Nigeria (Central Bank of Nigeria (CBN), 2010), most Nigerians depends on cereals for their daily dietary needs and the prices of these grains are factorial to the determination of the extent to which Nigerians can pay for these food commodities.

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The degree and rate at which the prices of products and services deviate from predicted ranges is known as price volatility. This could be otherwise called price fluctuation in the marketplace (Ekakitie, 2010). In Nigeria, volatility has a significant impact on grain productivity. In contrast, a lack of demand for maize has deterred many farmers from growing the crop, which has raised the price of corn in 2018 and beyond. Due to a strong demand for local rice in Nigeria, particularly in the South-South area, and a lack of supply, the Buhari administration's prohibition on the importation of foreign rice has resulted in higher local rice prices.

Most farm goods have prices that follow predictable seasonal trends rather than being constant throughout the season. According to Akinseye (2011) and Onubogu (2020), market imperfections and potential inefficiencies in the food distribution system between surplus and deficient areas have been linked to the increase in commodity market prices in certain parts of Nigeria. These imperfections are known to cause local food supply shortages in some parts of the country while there are surpluses in others, which raise serious concerns. This has brought about price volatility, food inflation, poverty and hunger. Coupled with inadequate market price transmission, high food prices has increased the levels of food deprivation, droved millions of people into food insecurity, worsening conditions of many and threatening long term global food security.

II. MATERIALS AND METHODS

The Study Area

The study was conducted in Northeast Nigeria located between the Sudan Savannah and Sahel Savannah vegetation (Akinyemi, *et al.*, 2022). With a land area that makes up over one-third of Nigeria, the Northeast is the country's biggest geopolitical zone. The semi-desert Sahelian savanna and the tropical West Sudan savanna eco-regions make up the majority of the zone's environmental divisions (Akinyemi, *et al.*, 2022). Approximately 26 million people live in the region, making up 12% of the nation's overall population. It is well-known for its cattle and agricultural growth, both of which have a significant impact on the national economy. The region is not as densely populated as compared to the southern region of the country (Akinyemi, *et al.*, 2022).

Sampling Procedure/Techniques

Purposive sampling technique was used for the selection of northeast geopolitical zone so as get which gives a total of five (5) states. The selected states were Adamawa, Born, Gombe, Taraba and Yobe States.

Method of Data Analysis

The use of inferential statistics involved the use of Augmented Dickey Fuller (ADF) Test, Cuddy-Della Valle index, and Autoregressive Integrated Moving Average (ARIMA).

Augmented dickey fuller test

Augmented Dickey Fuller test was used in testing stationarity of variables. Augmented Dickey-Fuller (ADF) was performed to test the stationarity series in the data for theoretical and practical reasons. The ADF tests can be expressed as

$$\Delta P_t = \alpha_0 + \delta_1 t + \beta_1 P_{t-1} + \sum_{j=0}^{q} \beta_1 \Delta P_{t-j} + \varepsilon_t \quad (1)$$

Where

$\Delta P_t = P_t - P_{t-1}$, $\Delta P_{t-1} = P_{t-1} - P_{t-2}$, $\Delta P_{n-1} = P_{n-1} - P_{n-2}$ etc.

P = the price in each state

α_0 = constant or drift

t = time trend variable

q = number of lag length selected based on Schwartz information criterion (SIC)

ε_t = pure white error term

The test for a unit root in the price series was carried out by testing the null hypothesis that β_1 (coefficient of P_{t-1}) is zero. The alternative hypothesis is that β_1 is less than 0. A non-rejection of the null hypothesis suggests that the time series under consideration is non-stationary (Gujarati, 2004).

If the unit root test confirms the presence of a unit root (at level) in the price series, it has to be differenced to make it stationary which is termed as the order of integration, I (d). The regressions provide a t-statistic of the estimated δ. The t-statistic is then compared to the critical value t-statistic, If the computed absolute value of the tau statistics (τ) exceeds the ADF critical tau values at the conventional significant level (usually the five percent significant level) we will reject the hypothesis that δ=0, in which case the time series is stationary. On the other hand, if the tau statistics is less than ADF critical tau values at 5%, we will accept the null hypothesis, were the time series is non-stationary.

Cuddy-Della Valle index

The coefficient of variation (CV) measures instability, but the CV over-estimates the level of time series data characterized by long-term trends (Nimbrayan and Bhatia 2019). This limitation is overcome by the Cuddy-Della Valle index (CDVI), a modification of CV that de-trends and shows the exact direction of the instability (Anuja, *et al.*, 2013). Cuddy-Della Valle index was used to achieve objective (i).

$CV = \frac{std.dev.}{mean} \times 100$ (2)

$CDVI = CV\sqrt{1} - R^2$ (3)

Where;
CV = Coefficient of variation
CDVI = Cuddy-Della Valle index
R^2 = Coefficient of determination
According to Sihmar (2014) CDVI ranges from < 15 (low instability), 15–30 (medium instability), and >30 (high instability).

Autoregressive integrated moving average (ARIMA) model

Autoregressive integrated moving average (ARIMA) was used to forecast future price of maize and rice. In time series analysis, an ARIMA model is a generalization of an ARMA model. These models are fitted to time series data either to better identify with the data or to predict future points in the series. They are applied in many cases where data illustrate evidence of non-stationarity, whereas differencing step can be applied to reduce the non-stationarity. Non-seasonal ARIMA models are generally denoted ARIMA (p, d, q) where parameters are non-negative integers then p, d, q refer to the autoregressive, differencing, and moving average terms for the non-seasonal component of the ARIMA model. Seasonal ARIMA models are usually denoted ARIMA (p, d, q) (P, D, Q)$_m$, where m refers to the number of periods in each season, and P,D,Q refer to the autoregressive, differencing, and moving average terms for the seasonal component of the ARIMA model (Box and Jenkins, 1970). ARIMA models form an important area of the Box – Jenkins approach to time-series modeling. It is also known as Box-Jenkins method. A non-seasonal stationary can be modeled as a combination of the past values and the errors which can be denoted as ARIMA (p, d, q) are can be expressed as

$Y_t = c + \phi_1 y_{t-1} + \phi_2 y_{t-2} + ... + \phi_p y_{t-p} + e_t - \theta_1 e_{t-1} - \theta_2 e_{t-2} - ... - \theta_q e_{t-q}$ *(4)*

Where
Y_t, y_{t-1} --- y_{t-p} = are original series;
$\phi_1 ... \phi_p$ (phis) = are the regressive parameters to be estimated;
θ_1 ---- θ_p (thetas) =are the moving average to be estimated;
e_t ---- e_{t-q} = are a series of unknown random error
The Box-Jenkins (ARIMA) methodology for analyzing and modeling time series is characterized by four steps

- Identification
- Estimation
- Diagnostic checking
- Forecast (2)

Identification The identification stage, finding the time series data is stationary or not and compare the estimated Autocorrelation Function (ACF) and Partial Autocorrelation Function (PACF) to find a match. We choose, as a tentative model, the ARMA process whose theoretical ACF and PACF best match the estimated ACF and PACF.

Estimation Estimating the parameters for Box–Jenkins models is a rather complicated non–linear estimation problem. The main approaches for fitting Box - Jenkins models are non-linear least squares and maximum likelihood estimation. Parameter estimates are usually obtained by maximum likelihood, which is asymptotically correct for time series. Estimators are always sufficient, efficient, and consistent for Gaussian distribution and which are asymptotically normal with efficient for several non-Gaussian distribution (Box and Jenkins, 1970).

Diagnostic Checking The diagnostic checking is necessary to test the appropriateness of the selected model. Model selection can be made based on the values of certain criteria like log likelihood, Akaike Information Criteria (AIC), Bayesian Information Criteria (BIC) and Schwarz-Bayesian Information Criteria (SBC).

$$AIC = \{n(1 + \log 2\pi) + n \log \sigma^2 + 2m\}$$
$$BIC = -2\log(L) + k\log(n)$$
$$SBC = \log \sigma^2 + (m \log n)/n \quad (5)$$

If the model selection is done, it is necessary to verify the satisfactoriness of the estimated model. This is done by studying the pattern among the residuals, if there is any. The estimated residuals can be computed as $\hat{e} = Y_t - \hat{y}_t$.
Where $\hat{y}_t$ is the estimated observation at time t.
The values of $\hat{e}_t$ which are either less than -3 or greater than 3, indicate that the corresponding residuals are outliers. The values of ADF may be studied to verify whether the series of residuals is white-noise. After tentative model has been fitted to the data, it is important to perform diagnostic checks to test the satisfactoriness of the model. It has been found that it is effective to measure the overall adequacy of the chosen model by examining the significant level of the ADF test. Therefore, if the diagnostic checking is fulfilled effectively and the model is found adequate, the fitted model can be used for forecasting purpose. (4)

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Forecasting is the prediction of values of a variable based on identified past values of that variable or other associated variables. Forecasting also may be based on expert judgments, which in turn are based on chronological data and experience. In analysis part, the appropriate model is found satisfactory, and the fitted model can be used for forecasting purpose (Box and Jenkins, 1970).

III. RESULTS AND DISCUSSION

Unit Root Test

Table 1 show that maize and rice market prices at first difference were not stationary at the 5% level, indicating they are influenced by earlier prices. Because the variables were non-stationary at levels, any attempt to utilize them will lead to false regression, which is not ideal for policy making and cannot be used for long-term prediction. But the P-value for the coefficients is significant at the 5% level, indicating the price series is stationary at the first difference I(1). This study is in line with that of Adekunle (2015) who indicates that the price series of food grains markets in Southwest Nigeria were stationary at first difference. This showed that the price series were integrated of order one I(1) and Dorothy *et al.* (2017) who reported that were non-stationary at respective levels.

Table 1: Results of Augmented Dickey Fuller (ADF) Test

	AT LEVELS AT 5%							AT FIRST DIFFERENCE AT 5%						
States	Intercept		intercept & trend		None			Intercept		intercept & trend		None		
	ADF	P-value	ADF	P-value	ADF	P-value	Remark	ADF	P-value	ADF	P-value	ADF	P-value	Order of integration
RICE														
ADR	-2.9862	0.0416	-3.6032	0.0097	-1.9550	0.6156	Non-stationary	-2.9918	0.0001	-3.6122	0.0006	-1.9556	0.0000	I(1)
BORR	-2.9862	0.3066	-3.6032	0.3456	-1.9550	0.4824	Non-stationary	-2.9919	0.0002	-3.6121	0.0016	-1.9557	0.0000	I(1)
GOMR	-2.8968	0.9566	-3.4649	0.5022	-1.9448	0.9786	Non-stationary	-2.9862	0.0312	-2.9918	0.0000	-3.6122	0.0000	I(1)
TAR	-2.8968	0.9605	-3.4649	0.3589	-1.9448	0.9783	Non-stationary	-2.8972	0.0001	-3.4655	0.0000	-1.9448	0.0000	I(1)
YOR	-2.8968	0.8339	-3.4649	0.3998	-1.9448	0.9053	Non-stationary	-2.8972	0.0000	-3.4655	0.0000	-1.9448	0.0000	I(1)
MAIZE														
ADM	-2.8968	0.9923	-3.4649	0.9195	-1.9448	0.9845	Non-stationary	-2.8972	0.0000	-3.4655	0.0000	-1.9448	0.0000	I(1)
BORM	-2.8968	0.9623	-3.4649	0.8505	-1.9447	0.9502	Non-stationary	-2.8972	0.0001	-3.4655	0.0000	-1.9448	0.0000	I(1)
GOMM	-2.8968	0.9848	-3.4648	0.9112	-1.9448	0.9821	Non-stationary	-2.8972	0.0000	-3.4655	0.0000	-1.9448	0.0000	I(1)
TAM	-2.8968	0.9724	-3.4649	0.8178	-1.9448	0.9612	Non-stationary	-2.8972	0.0001	-3.4655	0.0000	-1.9448	0.0000	I(1)
YOM	-2.8968	0.9684	-3.4655	0.8984	-1.9448	0.9700	Non-stationary	-8.4958	0.0000	-3.4655	0.0000	-1.9448	0.0000	I(1)

Source Output from E-views

Note: ADR= Adamawa State rice market price, BORR= Borno State rice market price, GOMR= Gombe State rice market price, TAR= Taraba State rice market price, YOR= Yobe State rice market price, ADM = Adamawa State maize market, BORM= Borno State maize market, GOMM= Gombe State maize market TAM= Taraba State maize market and YOM= Yobe State maize market price .

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Degree of Price Instability

When prices fluctuate throughout time and space, it's referred to as price instability. Price instability is considered high according to the Cuddy Della Valle index (CDVI) if the CVDI value is more than 30%; moderate (medium) price instability is present if the value is between 15% and 30%; and low price instability is present if it is less than 15%. Table 1 reveals that, the value of CDVI of ADR was 25.77%, BORR was 24.83%, GOMR was 29.24%, TAR was 28.61%, YOR was 26.45%, ADM was 36.61%, BORR was 37.91%, GOMM was 44.31%, TAM was 36.78% and YOM was 33.39%. This indicates that rice market price instability in all the states were average (medium), while maize market price instability in all the states were high since their respective CDVI is greater than 30% CDVI threshold across the study period. The study also indicated that GOMM has the highest price instability (44.31%) in the study area as revealed by Patrick (2018) that the Kasama groundnut market in Zambia had the worst price fluctuation (85%) whereas Lusaka had the lowest price variability (50%) across the study period. The difference in groundnut prices between the highest and lowest variations was 35%. High price instability could be caused by disparities in supply and demand, shifts in consumer employment and income trends, and changes in market sentiment. It follows that it might be detrimental to the economy overall and the marketing system in particular. It can lead to inefficient resource allocation between buyers and sellers and encourage poverty among the socially disadvantaged as reported by (Akpan *et al.* 2014).

Table 2: Degree of Price Instability

State markets	Minimum	Maximum	Mean	Std. Deviation	CV	CDVI
ADR	211.33	503.40	328.02	87.76	26.75	25.77
BORR	234.66	515.54	350.09	83.35	23.81	24.83
GOMR	193.58	520.94	319.27	96.48	30.22	29.24
TAR	210.30	513.86	331.69	98.18	29.59	28.61
YOR	179.87	495.12	316.71	86.88	27.43	26.45
ADM	75.86	274.03	154.98	56.72	36.59	35.61
BORM	79.13	270.53	156.39	60.82	38.89	37.91
GOMM	70.36	333.41	171.56	77.70	45.29	44.31
TAM	70.36	258.75	151.39	57.16	37.76	36.78
YOM	80.31	266.22	161.13	55.37	34.37	33.39

Source Output from E-views
CV = Coefficient of variation and CDVI = Cuddy Della Valle index
Note: ADR= Adamawa State rice market price, BORR= Borno State rice market price, GOMR= Gombe State rice market price, TAR= Taraba State rice market price, YOR= Yobe State rice market price, ADM = Adamawa State maize market, BORM= Borno State maize market, GOMM= Gombe State maize market TAM= Taraba State maize market and YOM= Yobe State maize market price

Price Forecasts of Rice and Maize in Nigeria

Identification of ARIMA Models

The best ARIMA model projection for predicting maize and rice prices from January to December of 2024 is determined by comparing the forecasts. Due to the close values of price forecasts to real maize values, the ARIMA model is preferred (Table 3). Based on the values of several factors, including number of significance, R^2, sigma, Akaike Information factors (AIC), and Schwarz-Bayesian Information Criteria (SIC), ARIMA models were chosen. Therefore ARIMA (0,3,1), (0,1,1), (1,1,0), (1,1,0), (1,1,2), while (1,1,0), (4,1,1), (1,1,0), (1,1,1) and (1,1,1) for Adamawa, Born, Gombe, Taraba and Yobe states maize markets, while Adamawa, Born, Gombe, Taraba and Yobe states rice markets respectively were identified the best models.

Table 3: Identification of ARIMA Models

States	Models		
ADM	**ARIMA (3,1,0)**	**ARIMA (0,3,1)**	**ARIMA (3,1,1)**
Number of significance	1	2	1
Sigma square	424.7095	411.1321	422.6294
R^2	0.0374	0.04644	0.0203
Akaike info criterion	7.9506	7.9472	7.9483
Schwarz criterion	8.0467	8.1755	8.0447
BOM	**ARIMA (0,1,0)**	**ARIMA (1,1,0)**	**ARIMA (0,1,1)**
Number of significance	1	1	1
Sigma square	848.00501	879.8336	884.3369
R^2	0.0486	0.0164	0.0229
Akaike info criterion	3.3595	8.8103	8.8147
Schwarz criterion	3.3277	8.9056	8.8556
GOMM	**ARIMA (0,1,0)**	**ARIMA (1,1,0)**	**ARIMA (0,1,1)**
Number of significance	1		2
Sigma square	0.0000	531.8581	272.6343
R^2	0.0000	0.0228	0.0119
Akaike info criterion	0.4745	8.5280	8.5193
Schwarz criterion	0.5064	8.6236	8.6142
TAM	**ARIMA (0,1,0)**	**ARIMA (1,1,0)**	**ARIMA (0,1,1)**
Number of significance	0	0	0
Sigma square	0.0000	788.4767	792.4037
R^2	0.0000	0.0218	0.0178
Akaike info criterion	4.0048	8.7115	8.7158
Schwarz criterion	4.9729	8.8066	8.7538
YOM	**ARIMA (1,1,0)**	**ARIMA (0,1,2)**	**ARIMA (1,1,2)**
Number of significance	1	1	2
Sigma square	215.6552	190.2103	178.4396
R^2	0.0074	0.0873	0.1242
Akaike info criterion	7.6494	7.5958	7.5827
Schwarz criterion	7.7131	7.91431	7.7104
ADR	**ARIMA (1,1,0)**	**ARIMA (0,1,1)**	**ARIMA (1,1,1)**
Number of significance	0	0	0
Sigma square	2435.844	2446.100	2428.483
R^2	0.0396	0.0230	0.0341
Akaike info criterion	9.2550	9.3800	9.2830
Schwarz criterion	9.3551	9.3017	9.4103
BORR	**ARIMA (0,1,4)**	**ARIMA (4,1,0)**	**ARIMA (4,1,1)**
Number of significance	1	1	1
Sigma square	777.2365	757.2851	767.3514
R^2	0.0288	0.0507	0.06900

Akaike info criterion	8.6116	8.6114	8.6214
Schwarz criterion	6.8070	8.8458	9.7968
GOMR	**ARIMA (1,1,0)**	**ARIMA (0,1,1)**	**ARIMA (1,1,1)**
Number of significance	0	0	0
Sigma square	274.2545	280.3624	280.0271
R^2	0.029	0.0124	0.0128
Akaike info criterion	7.8470	7.8350	7.8624
Schwarz criterion	7.9425	7.8984	7.9580
TAR	**ARIMA (1,1,0)**	**ARIMA (0,1,1)**	**ARIMA (1,1,1)**
Number of significance	1	1	1
Sigma square	811.5098	810.6440	807.2916
R^2	0.0018	0.0016	0.032
Akaike info criterion	8.6365	8.6366	8.8622
Schwarz criterion	8.7321	8.7322	8.7896
YOR	**ARIMA (1,1,0)**	**ARIMA (0,1,1)**	**ARIMA (1,1,1)**
Number of significance	0	0	0
Sigma square	455.2297	455.1638	445.6560
R^2	0.0012	0.0013	0.0223
Akaike info criterion	9.0432	9.0431	9.0508
Schwarz criterion	9.1388	9.1387	9.0783

Source Output from E-views

Model Estimation

The data was subjected to an ARIMA model test as well. The findings presented in Table 4 demonstrate that plots of the partial auto correlation function (PACF) and auto correlation function (ACF) were produced, displaying stationary series due to the delays falling inside the 95 percent confidence interval of the PACT and ACF bounds. As a result, the prices of for Adamawa, Born, Gombe, Taraba, Yobe states maize and rice markets were estimated using the ARIMA models mentioned above.

Table 4: Results for model estimation

Autocorrelation	Partial Correlation	Serial No.	AC	PAC	Q-Stat	Prob
. |*. |	.*| . |	1	0.186	-0.179	66.405	0.3801
.*| . |	.**| . |	2	-0.115	-0.285	67.492	0.6141
.**| . |	.*| . |	3	-0.350	-0.149	77.721	0.7533
.**| . |	. |*. |	4	-0.384	0.194	90.190	0.9668
.**| . |	. | . |	5	-0.328	0.009	99.411	0.2808
.**| . |	.*| . |	6	-0.248	-0.094	104.79	0.5043
.*| . |	. | . |	7	-0.127	-0.044	106.22	0.9137
.*| . |	.**| . |	8	-0.069	-0.209	106.64	0.5150
.*| . |	.*| . |	9	-0.110	-0.195	107.74	0.2240
.*| . |	. |*. |	10	-0.112	0.105	108.91	0.0645
.*| . |	. | . |	11	-0.109	-0.001	110.02	0.1860
.*| . |	. | . |	12	-0.115	-0.021	111.28	0.7280
.*| . |	. | . |	13	-0.077	-0.057	111.86	0.5816
. | . |	.*| . |	14	-0.026	-0.178	111.92	0.0116
. | . |	. | . |	15	0.039	0.071	112.08	0.3238
. |*. |	. | . |	16	0.105	0.072	113.20	0.9320

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<tr><td>. |*. |</td><td>. | . |</td><td>17</td><td>0.142</td><td>-0.022</td><td>115.29</td><td>0.8498</td></tr>
<tr><td>. |*. |</td><td>. | . |</td><td>18</td><td>0.146</td><td>0.028</td><td>117.53</td><td>0.6199</td></tr>
<tr><td>. |*. |</td><td>. | . |</td><td>19</td><td>0.135</td><td>-0.056</td><td>119.50</td><td>0.7907</td></tr>
<tr><td>. |*. |</td><td>. | . |</td><td>20</td><td>0.119</td><td>-0.019</td><td>121.07</td><td>0.7094</td></tr>
<tr><td>. | . |</td><td>. | . |</td><td>21</td><td>0.068</td><td>-0.006</td><td>121.58</td><td>0.3841</td></tr>
<tr><td>. | . |</td><td>. | . |</td><td>22</td><td>0.027</td><td>0.023</td><td>121.67</td><td>0.9201</td></tr>
<tr><td>. | . |</td><td>. | . |</td><td>23</td><td>-0.002</td><td>0.026</td><td>121.67</td><td>0.9517</td></tr>
<tr><td>. | . |</td><td>. | . |</td><td>24</td><td>-0.025</td><td>0.018</td><td>121.74</td><td>0.6773</td></tr>
<tr><td>. | . |</td><td>. | . |</td><td>25</td><td>-0.029</td><td>-0.025</td><td>121.84</td><td>0.2052</td></tr>
<tr><td>. | . |</td><td>. | . |</td><td>26</td><td>-0.034</td><td>-0.045</td><td>121.98</td><td>0.7607</td></tr>
<tr><td>. | . |</td><td>. | . |</td><td>27</td><td>-0.059</td><td>-0.054</td><td>122.43</td><td>0.6207</td></tr>
<tr><td>.*| . |</td><td>. | . |</td><td>28</td><td>-0.084</td><td>-0.029</td><td>123.33</td><td>0.8973</td></tr>
</table>

Source Output from E-views

Models Diagnostics

To determine whether the models that were chosen are appropriate, diagnostic checking is required. Once the models have been chosen, the estimated models' satisfactoriness must be confirmed. Analyzing the residuals' pattern allows for this. Forecasting is possible because, according to the model diagnostics shown in Table 5, the models for every state that was chosen were all stationary at the 1% level.

Table 5: Time series model diagnostics

		At level		
States	**T-statistics**	**5% critical values**	**P-values**	**Remark**
ADM	-7.5319	-2.7041	0.0000***	Stationary
BORM	-7.4085	-2.7025	0.0000***	Stationary
GOMM	-7.3404	-2.7025	0.0000***	Stationary
TAM	-7.5734	-2.7025	0.0000***	Stationary
YOM	-7.3727	-2.7025	0.0000***	Stationary
ADR	-6.0824	-2.7025	0.0000***	Stationary
BORR	-7.1784	-2.7025	0.0000***	Stationary
GOMR	-7.3473	-2.7025	0.0000***	Stationary
TAR	-7.1607	-2.7025	0.0000***	Stationary
YOR	-7.7490	-2.7326	0.0000***	Stationary

Source Output from E-views
Note *** denote 1% significant level

Forecasted price of maize and rice in Nigeria

According to an examination of Nigeria's maize price estimate, prices in the states of Adamawa, Born, Gombe, Taraba and Yobe states would be rising between Januarys to December 2024. In Adamawa, Born, Gombe, Taraba and Yobe states, respectively, the prices of maize would be lowest (₦276.3931, ₦272.258, ₦337.5687, ₦260.9784 and ₦268.6883) in January and highest (₦303.8308, ₦291.3065, ₦386.8446, ₦286.7755 and ₦297.4049) in December (Table 6). Based on a study of the Nigerian rice market projection, prices in the states of Adamawa, Born, Gombe, Taraba and Yobe are expected to rise between Januarys to December 2024. In the states of Adamawa, Born, Gombe, Taraba and Yobe, the prices of rice would be lowest in January (₦506.863, ₦518.8358, ₦526.5868, ₦523.0267 and ₦467.2192) and highest in December (541.4453, 556.5358, 592.9247, 552.2017, and 507.2349) respectively. The study's analysis showed that prices for maize and rice will be rising in Adamawa, Born, Gombe, Taraba and Yobe states between January and December 2024. The analysis of maize and rice price forecast in Nigeria revealed that, there will be upward trend of maize and rice prices from the month of January to December, 2024 in all the states under observation. This study is in line with the findings of Tareq *et al.* (2010) who reported that the price of Aman-Hybrid in Bangladesh showed a steady upward trend from 2010 to 2012 and also Jonah *et al*. (2014) who revealed that monthly price of maize marketing in Nigeria increased between 1998 and 1999 and between 2001 and 2002.

Table 6: Forecasted price of Maize and rice in Naira/kg form January –December, 2024

Period/States	Adamawa	Borno	Gombe	Taraba	Yobe
			MAIZE		
January	276.3931	272.2581	337.5687	260.9784	268.6883
February	278.7815	273.9898	341.7761	263.2244	271.1801
March	281.1906	275.7214	346.0359	265.4898	273.695
April	283.6205	277.4531	350.3488	267.7746	276.2332
May	286.0714	279.1848	354.7155	270.0791	278.7949
June	288.5434	280.9164	359.1366	272.4034	281.3805
July	291.0368	282.6481	363.6127	274.7477	283.9899
August	293.5518	284.3798	368.1447	277.1122	286.6236
September	296.0885	286.1115	372.7332	279.4971	289.2817
October	298.6471	287.8431	377.3788	281.9024	291.9645
November	301.2278	289.5748	382.0824	284.3285	294.6721
December	303.8308	291.3065	386.8446	286.7755	297.4049
			RICE		
January	506.863	518.8358	526.5868	523.0267	467.2192
February	513.1131	522.1548	532.2976	525.4968	473.3111
March	523.6666	525.4951	538.0703	524.4111	475.1177
April	520.5142	528.8567	543.9056	528.469	474.4943
May	520.5877	532.2399	549.8041	535.2054	475.1863
June	519.6779	535.6447	555.7667	535.6199	479.8524
July	518.9547	539.0713	561.7939	535.7365	487.881
August	523.1049	542.5198	567.8865	539.8024	496.1788
September	528.5517	545.9903	574.0451	544.6782	501.5553
October	531.3592	549.4831	580.2705	545.8225	503.4935
November	533.3986	552.9982	586.5635	547.1694	504.3222
December	541.4453	556.5358	592.9247	552.2017	507.2349

Source Output from E-views

Forecast performance measurement

Projected Based on the values of specific criteria, including Thail inequality coefficient (TIC), mean absolute percent error (MAPE), mean absolute square error (RMSE), and mean absolute error (MAE), the performance of the rice and maize markets in the states of Adamawa, Born, Gombe, Taraba, and Yobe was measured. Table 7 illustrates that the minimum values of RMSE and MAE for the rice market in Taraba State (80.1577 and 61.1204, respectively) and the smallest values of MAPE and TIC for the maize market in Yobe State (14.2741 and 0.1126, respectively) were observed compared to all other states. As a result, Taraba State rice market was minimum (80.1577, and 61.1204 respectively) and the values of MAPE and TIC of Yobe state maize market forecast were the best forecast because they met two of the criteria respectively.

Table 7: Forecast Performance Measurement

States	RMES	MAE	MAPE	TIC
ADM	118.3499	88.297	21.1159	0.1066
BORM	182.8783	155.2137	66.5321	0.2614
GOMM	166.4827	84.6568	28.8.6568	0.1318
TAM	110.5729	183.6084	43.8595	0.4459
YOM	118.0015	97.4916	14.2741	0.1126
ADR	101.7496	82.7144	33.8331	0.1599
BORR	105.2553	80.0842	33.2174	0.1498

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GOMR	94.8703	74.3578	21.3828	0.1075
TAR	80.1577	61.1204	25.1302	0.1239
YOR	159.1870	128.9516	53.7081	0.2204

Source Output from E-views
Note: Root mean square error (RMSE), mean absolute error (MAE), mean absolute % error (MAPE and Thail inequality coefficient (TIC)

Post Estimation Diagnostics

Test for normality

The result of Jaeque-Bera test show that the F-statistic value is 0.4296 and the T-value of the test is 0.8067. This show that the probability of Jaeque-Bera is greater than 0.05 (5% level of significant). In this case the null hypothesis which state that residuals are normally distributed is accepted.

Test for autocorrelation

The Jaeque-Bera test result indicates that the residuals are normally distributed, and the null hypothesis is accepted. The F-statistic value is 0.4173, and the test's T-value is 0.8125. These values indicate that the probability of a Jaeque-Bera is greater than 0.05 (5% level of significance).

Test for misspecification error

The F-statistic and likelihood ratio P-values, respectively, are greater than 0.05, according to the results of the Ramsey RESET test. This indicates that there are no problems in misspecification.

Test for heteroskedasticity

The probability value of the F-Statistic and chi-square is greater than the 5% crucial value, according to the Breusch-Pagan-Godfrey test. Therefore, the null hypothesis which states that the model has no heteroskedasticity is accepted.

Table 8: Results of post estimation diagnostics

Test name	Test statistics	P-values	Test result
Jarque-Bera	JB = 0.4173	0.8125	H_o is accepted
Breusch-Godfrey Serial	F= 0.7312	0.5548	H_o is accepted
Correlation LM Test	chi-squared = 1.698153	0.5452	
Ramsey RESET	F= 1.6540	0.1351	H_o is accepted
	T= 2.3181	0.2457	
	Likelihood ratio= 2.852165	0.1614	
Breusch-Pagan-Godfrey	F=1.5137	0.2483	H_o is accepted
	Chi-squared = 16.42088	0.2661	

Source output of E-views

Test for stability

The results of the Cusum test for stability show that the blue line is within the red lines, or within the 5% crucial line, indicating that the residual variations as shown in figure 1 below.

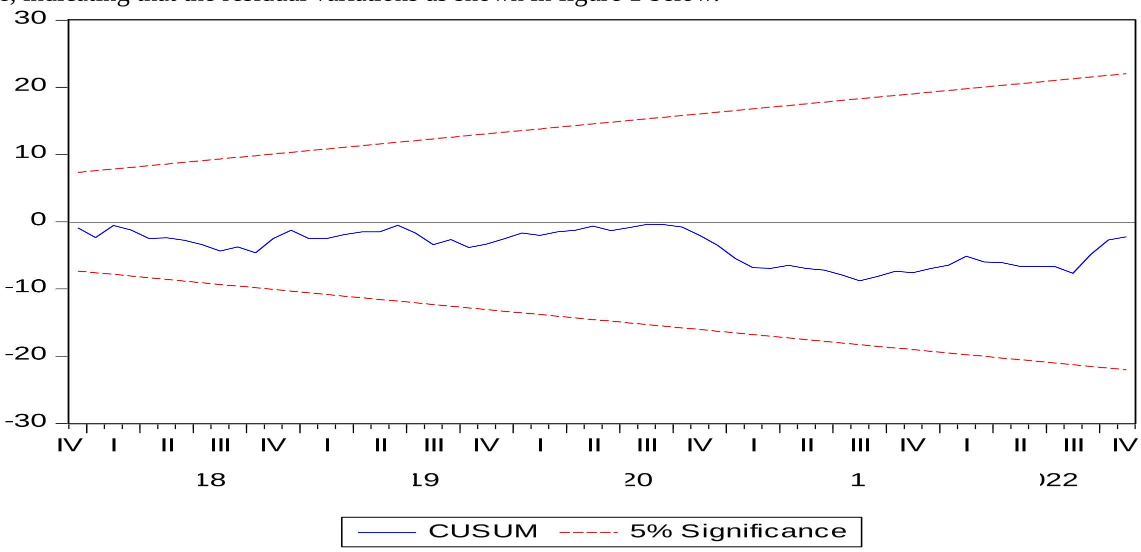

Figure 1 Cusum test for stability

Test for multicolinearity

The centered VIF values of all the variables are less than 10, confirming the analysis of variance inflation factors in Table 9 below, which indicates that multicolinearity is not an issue in the model.

Table 9: Variance Inflation Factors

Variance	Coefficient Variance	Uncentered VIF	VIF
ADM	480.00	16.36	3.58
BORM	0.03	648.85	5.61
GOMM	2.63	7.49	2.96
TAM	0.11	727.25	7.10
YOM	5.09	4.16	1.56
ADR	0.31	436.18	6.52
BORR	0.21	401.71	6.89
GOMR	1.24	11.69	6.38
TAR	419.63	22.20	7.52
YOR	549.28	1.96	1.22
ADM	0.01	147.28	7.60
C	174.50	9.56	NA

Source output of E-views

IV. Conclusion

The study arrived at the conclusion that Nigeria's maize and rice markets, particularly Gombe State, had the highest levels of price unpredictability. The month with the highest maize and rice price, from January to December, is December. Nigerian farmers would therefore be paid fairly for their products in December. In addition, if all else is equal, December would be the ideal time for maize and rice farmers to sell their excess crop and get paid well for it.

V. Recommendations

based on the conclusion of the study several recommendations could be made to farmers, policymakers, and traders based on this conclusion:

1. For area like Gombe State with high price volatility, policymakers could implement price stabilization mechanisms, such as subsidies or buffer stocks, to reduce extreme price fluctuations and protect farmers and consumers from economic shocks.
2. Farmers should explore different market opportunities, both locally and regionally, to spread risk. If price instability in Gombe State is problematic, finding alternative destinations with more stable prices could provide a more balanced income stream throughout the year.
3. Farmers and traders should plan to sell their maize and rice in December, when prices are highest, to maximize their income. Stockpiling maize and rice until December can provide a significant advantage, as demand typically drives prices up during this period.
4. Since stockpiling until December offers the best price, investment in better storage facilities would be critical. Proper storage techniques can reduce post-harvest losses and ensure that the quality of maize and rice remains intact, allowing sellers to capitalize on the high prices in December.
5. Farmers and traders need access to real-time market data and price forecasting tools to track price trends and make informed decisions. Establishing or improving local and regional information networks could help in monitoring market prices and adjusting sales strategies.
6. Encouraging farmers to form cooperatives can enhance their bargaining power in markets and secure better prices. Cooperatives can also help with bulk purchasing of inputs and collective storage solutions to better manage stockpiling until favorable selling times

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Conflict of Interest Disclosure
No conflict of interest exists.

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