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ASSESSING THE SYMMETRIC INTERPLAY BETWEEN INSECURITY, CLIMATE CHANGE, AND FOOD INFLATION IN NIGERIA

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ABSTRACT---
Food inflation is one of the most regressive taxation dynamics globally; it affects the average person and is more detrimental to low-income consumers than to those in higher income brackets. The interrelated problems of insecurity and climate change, both of which have serious effects on food systems and economies worldwide, have become increasingly apparent to the world community in recent years. The study's goal is to determine whether climate change and insecurity contribute to higher food inflation in Nigeria. With time series data spanning 2011M1-2022M12, we use the ARDL approach to cointegration analysis. The findings provide very convincing evidence of a relationship between rising food prices, insecurity, and climate change. We discovered that climate change and the degree of insecurity play a significant role in explaining why food prices have increased in Nigeria. According to an estimate of the coefficient of error correction term (ECT), the rate of adjustment of food price inflation from the initial shock would be corrected by about 23 percent each month. The study also shows that there is a clear connection between climate change, insecurity, and food price inflation in Nigeria and that the independent parameters are important trigger variables for the food price inflation in Nigeria in the period under study. Therefore, this study suggests policy interventions inform of financial safety net to help households negatively impacted by insecurity. To address future needs and climate-related challenges, the Nigerian state should transition from a traditional agricultural system to climate-smart agriculture.

KEY WORDS: *Nigeria, Food Price Inflation, Insecurity, Climate Change, ARDL.*
JEL CLASSIFICATION: *E51, E52, G21*---

1.0 INTRODUCTION

Food inflation is considered as one of the most regressive forms of taxation, it affects the common man, and hurts poor consumers more than those in higher income groups. In recent years, the global community has witnessed the intertwining challenges of insecurity and climate change, both of which have significant implications for food systems and economies around the world. These challenges are particularly acute in countries like Nigeria, where the nexus between insecurity and climate change has been found to exacerbate the issue of food inflation (George, Adelaja and Awokuse; 2021). Nigeria is one of the most food insecure countries and highly affected not only by general insecurity across the six geo-political zones of the country but the climate change shocks. Around 48% of Nigeria's population lives below the poverty line (World Bank, 2020; World Poverty Clock, 2020). It is a major source of worry, particularly for developing nations where a larger proportion of the populace is a net buyer of food. Human health, nutrition, climate, and other factors are all closely related to food security, making it a crucial global issue (Murthy, 2022; Matemilola and Elegbede, 2017; Meybeck et al., 2017; Mc Carthy et al., 2018; Ben Abdallah et al., 2021). It is noted globally that Between about 720 to 811 million people are suffering from acute hunger, and another 3 billion population cannot afford a healthy diet due to rising costs, expanding poverty, and income disparities. Additionally, children's malnutrition is a significant issue in both Africa and Asia (FAO et al., 2021). A variety of factors, particularly the ongoing war between Russia and Ukraine and climate change, are contributing to the rising food prices globally. However, there are factors that are also peculiar to each country which have contributed significantly to the rising food prices. The main causes of food price inflation in Nigeria have been identified as farmer-herder clashes, kidnapping, banditry, the Boko Haram insurgency, general insecurity, and climate change shocks. The consumer price index (CPI), which measures the rate of change in prices of goods and services, surged 17-year high to 22.79 in June 2023, the highest since September 2005.The increase was recorded against the backdrop of food inflation, which rose to 25.25 percent in June 2023, which constitute about 60 per cent of the inflation basket. (NBS June 2023). The rising cost of food in recent past is caused by many factors but most notable among them is the incessant conflict for grazing space between farmers and herders, which has resulted in fewer farmers going to their farms and less food being produced and consequently high food prices across the land.

The purpose of this research is to evaluate the link between insecurity, climate change and their impact on food price inflation in Nigeria within the period under study. Nigeria serves as an intriguing case study due to its significant vulnerability to both armed conflicts and environmental changes, particularly within the African context (as noted by Raleigh et al. in 2015). According to the 2019 Global Terrorism Index, a substantial portion of the rise in fatalities can be attributed to violence between Nigerian farmers and herders, leading to the displacement of nearly 300,000 people in 2018. These conflicts between farmers and herders have far-reaching economic consequences, affecting both agricultural communities and pastoralists, thereby resulting in significant financial implications for all parties involved (as highlighted by Sulaiman et al. in 2021). Given the substantial negative impacts of these factors, Nigeria presents an ideal case study for this research.

The rest of the paper is structured as follows. The second section provides a review of related literature. Section three covers the methodology, while section four deals with estimation and analysis of the results. The final section summarizes the results and discusses policy implications.

3.0 METHODOLOGY

3.1 Data Sources

To ascertain if insecurity and climate change enhance food price inflation in Nigeria, the study employs monthly time-series data spanning 2011M1-2022M12. The data were sourced from the Central Bank of Nigeria (CBN) and National Bureau of Statistics (NBS) statistical databases, Climate Change Knowledge Portal and google trend. The variables used in the analysis are summarized as follows:

Variable	**Description**	**Source**
FPI	Food Price Inflation	NBS
Rainfall	Amount of Rainfall	Climate Change Knowledge Portal
PMI	Purchasing Manager Index	NBS
PMS	Petroleum Motor Spirit	CBN
Ins. index	Insecurity Index	Google Trend

3.2 Empirical Model and Econometric Method

Our model follows the format below in consistent with the work and the framework similar to the one adopted by Robert Becker Pickson, Elliot Boateng (2022).

$$(FPI_t) = \delta_0 + (\delta_1 INS.) + (\delta_4 PMI_t) + (\delta_2 PMS_t) + (\delta_3 RAINF_t) + \\ + \varepsilon_t \qquad (1)$$

Where FPI is the food price inflation (as the dependent variable), INS. is the insecurity index; PMI is the purchasing manager index (proxy for growth); PMS is the petroleum motor Spirit (proxy for transport cost); RAIN signifies average rainfall (proxy for climate change).

The coefficients in equation (1) encapsulate how food price inflation responds to alterations in its influencing factors outlined earlier. Based on our initial expectations, we anticipate that all these coefficients will exhibit positive associations with the dependent variable.

3.2 The ARDL Forms of the Model

The error correction version of the Auto Regressive Distributive Lag (ARDL) model, as stated by Pesaran and Shin in (1998), is a valuable tool for analyzing time series data, especially in small samples. It is used to determine long-run relationships among variables while efficiently addressing issues like unit roots and serial correlation in economic time series data. The model is particularly helpful when ordinary least squares (OLS) regression may produce spurious results. The error correction version of the ARDL model can be expressed as follows:

$$\Delta y_t = \varpi + \sum_{i=1}^{n-1} \Lambda_1 \Delta y_{t-i} + \sum_{i=0}^{n-1} \Pi_1 \Delta x_{t-i} + \Omega_1 y_{t-n} + \Omega_2 x_{t-n} + \varepsilon_t \qquad (2)$$

Equation (2) characterizes the error correction mechanism within the ARDL model framework. In this equation, ϖ represents the constant vector parameter, , Λ and Π denote the short-term parameters, y_t encompasses the endogenous vector variable, x_t is a vector containing the other explanatory variables as previously specified, Ω_1 *and* Ω_2 are the parameters related to the long-run relationship. ε_t is the error term, assumed to be serially uncorrelated and homoscedastic.

It is essential to underscore that when introducing the ARDL model, all variables must exhibit stationarity, either at the level or through first differencing. To ascertain this property before proceeding with the full ARDL model, this paper employs the Phillips-Perron (PP) test developed by Phillips and Perron (1988) and the Elliot et al. (1996) Dickey-Fuller Generalized Least Squares (DF-GLS) test. These tests are used to investigate the presence of unit roots in the coefficients. This precautionary step ensures that none of the variables possesses an integrated order of I(2)), as the use of ARDL would be inappropriate in such cases.

3.3 ARDL and Bounds testing procedure.

To estimate the long-term relationship between variables, Pesaran and Shin's cointegration technique uses a two-stage process. It first determines whether cointegration between the variables is present through bounds testing, typically using the Wald or Fisher F-test. The error-corrected version of the Autoregressive Distributed Lag (ARDL) model's lagged regressor coefficients being equal to zero in this first stage is the null hypothesis (This is shown in Equation 2). In symbolic notation, this null hypothesis can be expressed as: H_0:Ω_1=Ω_2=0

- H_0 represents the null hypothesis.
- $\Omega_1\Omega_1$ and $\Omega_2\Omega_2$ are coefficients within the ARDL model.
- The null hypothesis assumes that both $\Omega_1\Omega_1$ and $\Omega_2\Omega_2$ are equal to zero.

This test helps determine whether there is a cointegrating relationship among the variables in the model, which is an essential step in analyzing long-term relationships between them.

This null is tested against the alternative hypothesis of $H_1: \Omega_1 \neq \Omega_2 \neq 0.1$. The second stage of estimation can only proceed once cointegration has been established among the variables. At this stage, the short-run and long-run parameters are estimated2 using the following two equations:

Long-run equation:

$$\hat{\Omega}_1 y_t + \hat{\Omega}_2 x_t = 0;\ y_t = -\frac{\hat{\Omega}_2}{\hat{\Omega}_1} x_t. \qquad (3)$$

Obtained from a version of equation (2) where appropriate lags would have been selected for both the dependent and independent variables using any of the information criterion after confirming the existence of long-run relationship in stage one.

The short-run dynamic error correction equation for coefficients obtained from the equation below:

$$\Delta y_t = c + \textstyle\sum_{j=1}^{k} \chi_j \Delta y_{t-j} + \sum_{j=0}^{q} \gamma_{1j} \Delta x_{t-k} + \varpi ecm_{t-1} + \nu_t \quad (4)$$

Where $ecm_{t-1} = y_{t-1} - \frac{\hat{\Omega}_2}{\hat{\Omega}_1} x_{t-1}$ obtained from (3) above; y_t and x_t are as previously defined; γ_{1j} are the short-run parameters; ϕ measures the speed of adjustment to a new equilibrium whenever there is a shock. It also provides

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another means of validating the existence of cointegration or long-run relationship among the variables. It is expected to be negative and significant and less than one in absolute value for the model to be stable.

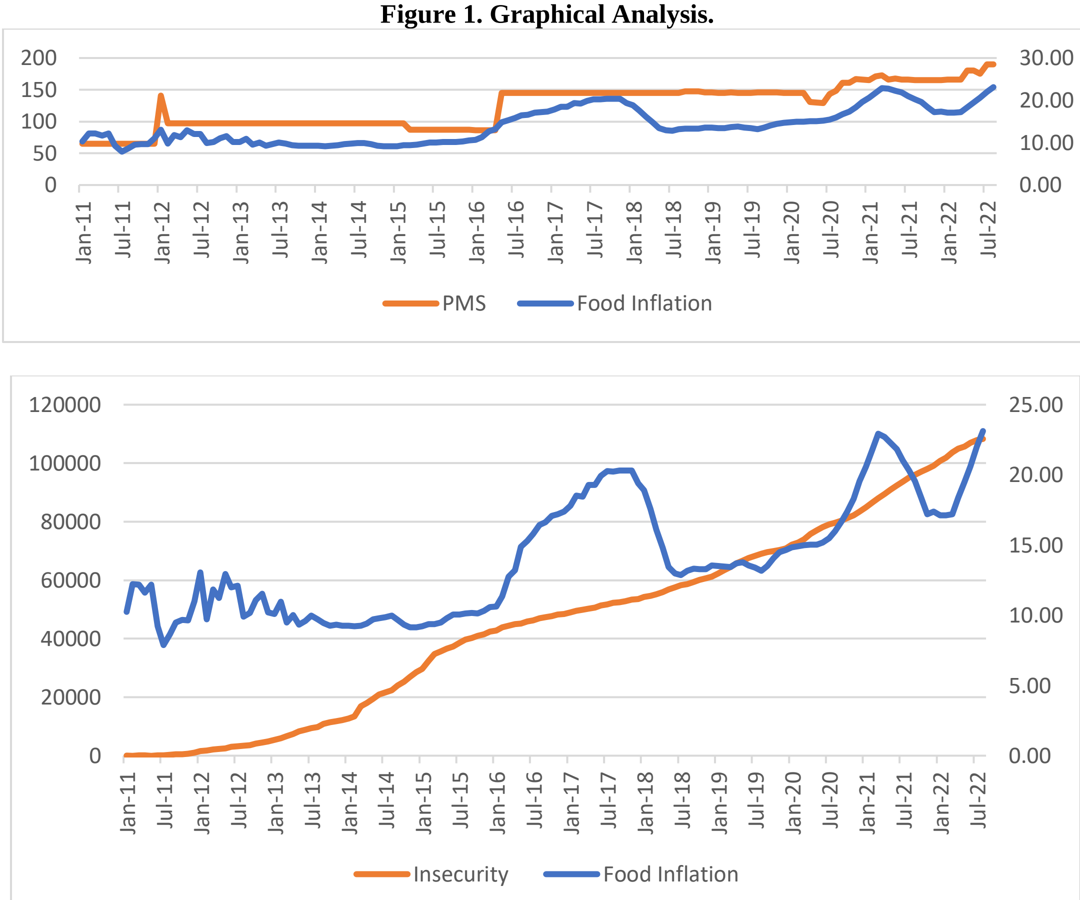
4.0 ESTIMATION AND DISCUSSION OF RESULTS

This section discusses the empirical results comprising of the graphical analysis, unit root tests, the bounds testing for cointegration, the long-run and short-run estimates of the model, error correction and finally, the stability and diagnostics test results.

4.1 Graphical Analysis

The graphical picture depicts the visual preview of the series under evaluation. This is what is popularly known in time series analysis as eyes ball test. The visual plot is an informal test that gives a glimpse of the behavior of the variables.

Figure 1. Graphical Analysis.



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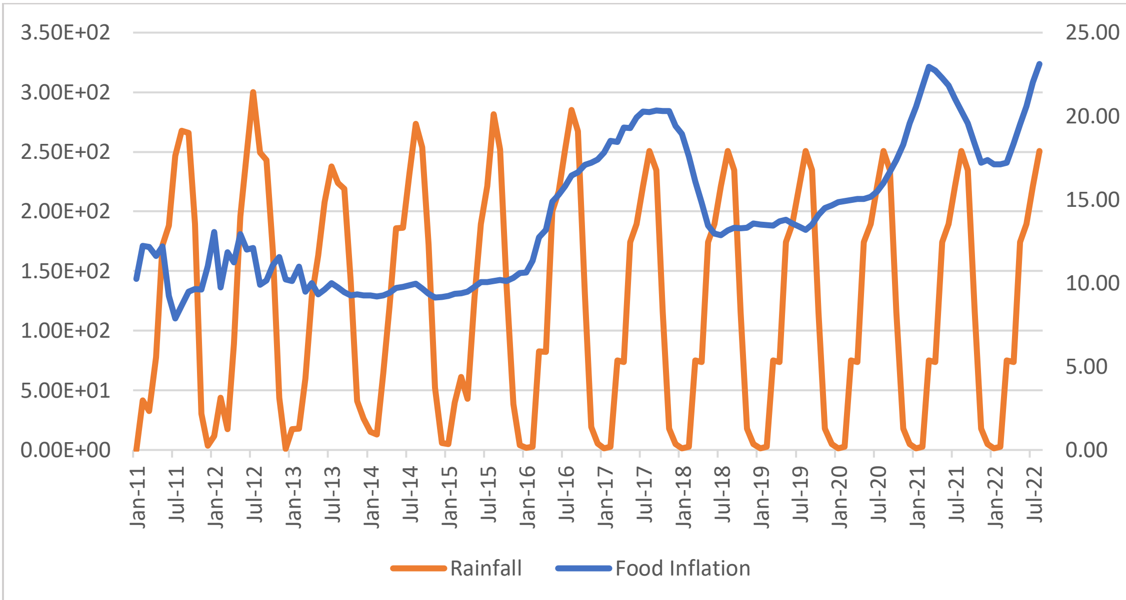

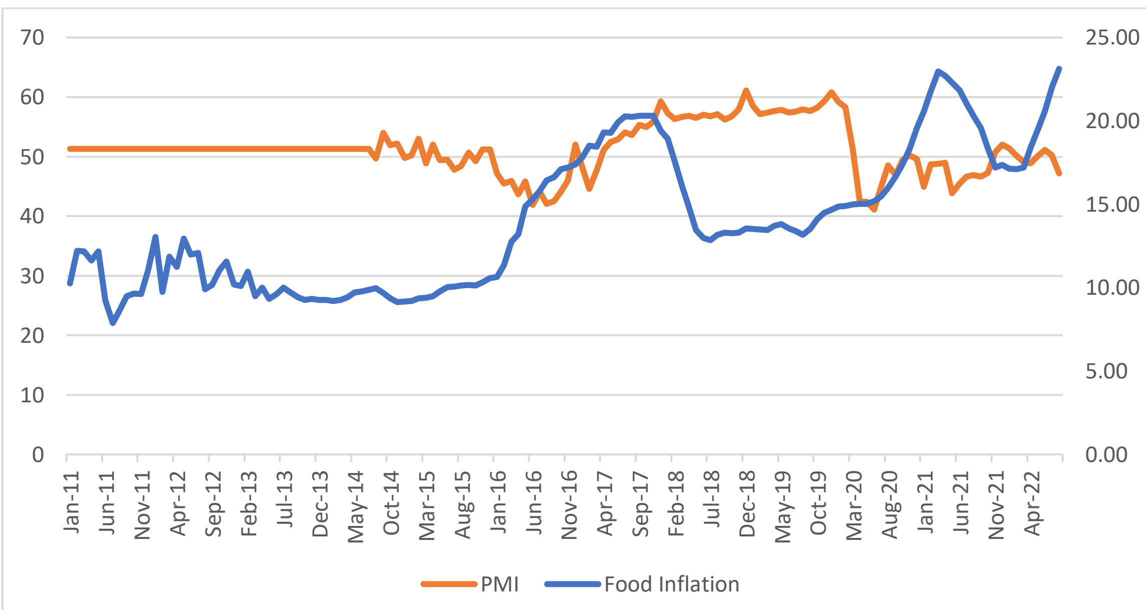

Source: Author's Computation September 2023.

The graphical representations above show that the variables contain trend and volatile and it's a pointer to the need to conduct further test in order to ascertain the stationarity status of the parameters for valid and reasonable econometric analysis. The graph also indicates that the parameters exhibit a positive relationship with food price inflation. This means that the variables are strong determinants of food inflation in Nigeria.

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4.2 Empirical Results

Table 1: Descriptive Analysis

	FOOD INFLATION	INSECURITY	PMI	PMS	RAINFALL
Mean	13.95589	45760.18	51.23643	123.6322	121.18
Median	13.30512	47905	51.3	145	115.8
Maximum	23.12082	108289	61.1	190.01	300.1
Minimum	7.876968	27	41.1	65	0.9
Std. Dev.	4.116085	32514.01	4.259905	34.16081	95.87584
Skewness	0.504508	0.132543	0.011171	-0.136228	0.143393
Kurtosis	2.047368	1.927707	2.881168	1.736881	1.49568
Jarque-Bera	11.23278	7.117152	0.085285	9.739931	13.68048
Probability	0.003638	0.028479	0.958254	0.007674	0.00107
Sum	1953.825	6406425	7173.1	17308.51	16965.2
Sum Sq. Dev.	2354.96	1.47E+11	2522.404	162207.5	1277712
Observations	140	140	140	140	140

Source: Author's Computation September 2023

Table 1 presents summary statistics for the individual time series data for the sample period including the mean, standard deviation, kurtosis, skewness, and the Jarque-Bera test for all the coefficients. From the table, estimates of the standard deviation indicate that the variables are generally volatile. The *P*-values associated with the Jarque–Bera statistics, a test for departure from normality, indicates that the series from all the coefficients actually deviate from normal distribution. The is consistent with the results of the parameters of their skewness and kurtosis. The results further show that most of the coefficients are positively skewed except PMS, which is negatively skewed. The result suggests in relative terms a one-to-one relationship between the series as insecurity variable has the highest average figure as compared to other parameters. The series also indicates relatively higher deviation from its mean value as revealed by the large standard deviations. Overall, the revelation indicates the need to further scrutinize the stability of the series individually in consistent with the earlier prescription for stationarity test.

4.3 Unit root test

The parameter is said to be stationary or has no unit root when its moments are time independent (Enders & Lee J. 2004). The preference for these two tests was because they have inbuilt mechanism to control for serial correlation when testing for unit roots. In addition, Dickey-Fuller Generalized Least Squares is an improved test with much better statistical properties with the best overall performance in terms of small-sample size and power. The tests are represented in table 2.

Table 2: Phillip-Perron P and Dickey-Fuller Generalized Least Squares

Variables	**Phillips-Parron**		**Remarks**	**DF-GLS**		**Remarks**
	Level	**1st Difference**	**Order of Integration**	**Level**	**1st Difference**	**Order of Integration**
FPI	-0.940720	-10.93935***	1(1)	-0.403847	-3.289330**	1(1)
RAINF	-5.100740***	-7.093340***	1(0)	-0.610432	-5.656923***	1(1)
PMS	-1.081601	-15.92516***	1(1)	-0.148126	-15.45715***	1(1)
PMI	-2.797670	-11.81010***	1(1)	-2.319280	-5.197712***	1(1)
INS.INDEX	-1.728737	-6.188434***	1(1)	0.942886	-3.051938**	1(1)

Source: *Authors' Computation* ***September 2023***

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The unit root property of the parameters of the model is examined in this section with the aid of ADF-GLS and PP test at both levels and first difference. For the PP test, it shows a mixture of stationarity at levels but stabilized at first difference and integrated at order 1(1). While the estimated figures of ADF-GLS test for all the variables could not be rejected at levels, the computed first difference figures demonstrate that the coefficients are stationary at 5% significant level and integrated at order 1(1). This automatically paves the way for the use of the ARDL bounds testing procedure to ascertain the existence of long-run relationship or otherwise of the parameters under study.

5.3 Bounds Test

The ARDL model uses a two-stage methodology to estimate the long-run relationship, as was already mentioned. The bounds test is used in the initial stage to determine whether long-run relationships exist. The F-statistic derived from the bounds test must be greater than the upper-bound critical values set at either the 5% or 10% significance level to prove the existence of a long-run relationship. The table below demonstrate the results of the test:

Table 3: Bound Test Result

Model	k	F-Statistic	Lower Bound Critical Value 1, 2.5, 5, & 10%	Upper Bound Critical Value 1, 2.5, 5 & 10%
$FPI = f(Rainfall, pmi, pms, Ins.Index)$	4	8.833271	3.06	4.15

Note *, **, *** and **** represent 10, 5, 2.5 and 1% level of significance, respectively.

The F-statistic critical values as observed above are higher when compared with the estimated value at the lower and upper bounds (1%, 5%, and 10%, respectively). Based on the results, we found very strong evidence for a cointegration relationship between food price inflation, insecurity, and climate change.

Table: 4 ARDL Short-Run Estimate

Short-Run Estimation	Coefficient	Std. Error	t-statistic	Prob.
RAINFALL	0.003035	0.001210	2.507178	0.0140
PMI	0.080401	0.026835	2.996116	0.0035
PMS	0.021016	0.004813	4.366050	0.0000
INSECURITY	0.000425	0.000203	2.095632	0.0389

Source: *Author's Computation September 2023*

R- Squared =0.9907 *Adjusted R-Squared = 0.9868*

F-Statistic = 248.5074 *Probability (F-Stat) = 0.0000*

Durbin -Waston Statistic: 2.0

In the short run, most of the recorded coefficients are statistically different from zero and complied with expected signs. The results suggest that a 1% increase in the amount of rainfall (climate change) will increase food price inflation by 0.003035%. Similarly, the food price inflation will increase by 0.080401% with a 1% rise PMI. In the same vein, a 1% increase in PMS, proxy for transportation cost will also raise food price inflation by 0.021016%. The results further indicate that a 1% increase in the level of insecurity in Nigeria tend to increase the food price inflation by 0.000425% in the short run.

According to the results, the overall significance of the model is demonstrated by the F-Statistic figure of 248.5074 which is way above the rule of thumb put at 2. The R-Squared of 0.9907 indicates that the variations in the model between the dependent and the explanatory parameters is explained to the tune of about 99%, meaning that the model is fit and well specified. It also shows that it does not suffer from serial correlation problem with DW Statistic figure of 2.0, approximately.

Table 5: ARDL Long-Run Estimate

Long-Run Estimation	Coefficient	Standard. Error	t-statistic	Probability
RAINFALL	0.009661	0.004341	2.225290	0.0286
PMI	0.400950	0.061403	-6.529860	0.0000
PMS	0.021016	0.005448	3.857209	0.0002
INSECURITY	0.009661	3.19E-05	4.245510	0.0001
C	30.40311	4.101211	7.413201	0.0000
*CointEq(-1)***	-0.230086	0.030762	-7.479575	0.0000

Source: *Author's Computation September 2023*

Table 5: The results of the long-run estimates indicate that the parameters follow a priori expectations and are statistically significant. The Rainfall, PMI, PMS, and Insecurity are statistically different from zero. The results suggest that a 1 per cent increase in climate change proxy by the amount of rainfall will raise food price inflation by 0.009661%, while a 1 per cent rise in PMI will also increase the food price inflation by 40%. Similarly, a 1% increase in PMS will raise food price inflation by 0.021016%. Food price inflation will also go up by 0.009661% if the level of insecurity in the country increases by 1% in the long-run.

In accordance with the error correction principle, the results for the estimated error correction term (ECT) show that the coefficient is not only negative but statistically significant with an absolute value between zero and one. It establishes a long-term convergence between climate change, insecurity, and rising food prices. This suggests that the model would still converge over time even if an external shock were to be added. However, it is estimated that the coefficient of error correction term is -0.230086 (roughly 23%), which means that the rate of error correction for the inflation of food prices from the initial shock would be corrected and converged at a rate of about 23% per month.

Table 6: Stability and Diagnostic Test

Stability Test	Stable	Unstable	**Diagnostic Test**	F-statistic	Prob. Value
CUSUM	Stable		Serial Correlation	0.011723	0.9883
CUSUM SQUARE	*Stable*		Heteroscedasticity	0.932591	0.5839

Source: *Author's Computation September 2023*

When constructing the error-correction term, which is combined with short-term dynamics, it is crucial to ensure the stability of long-run coefficients. An inadequate representation of the short-run dynamics that identify departures from the long-run relationship can frequently lead to instances of instability. As a result, it becomes essential to consider short-run dynamics in order to keep long-run parameters consistent. We use the CUSUM and CUSUMSQ tests, developed by Brown et al. (1975), to address this issue.

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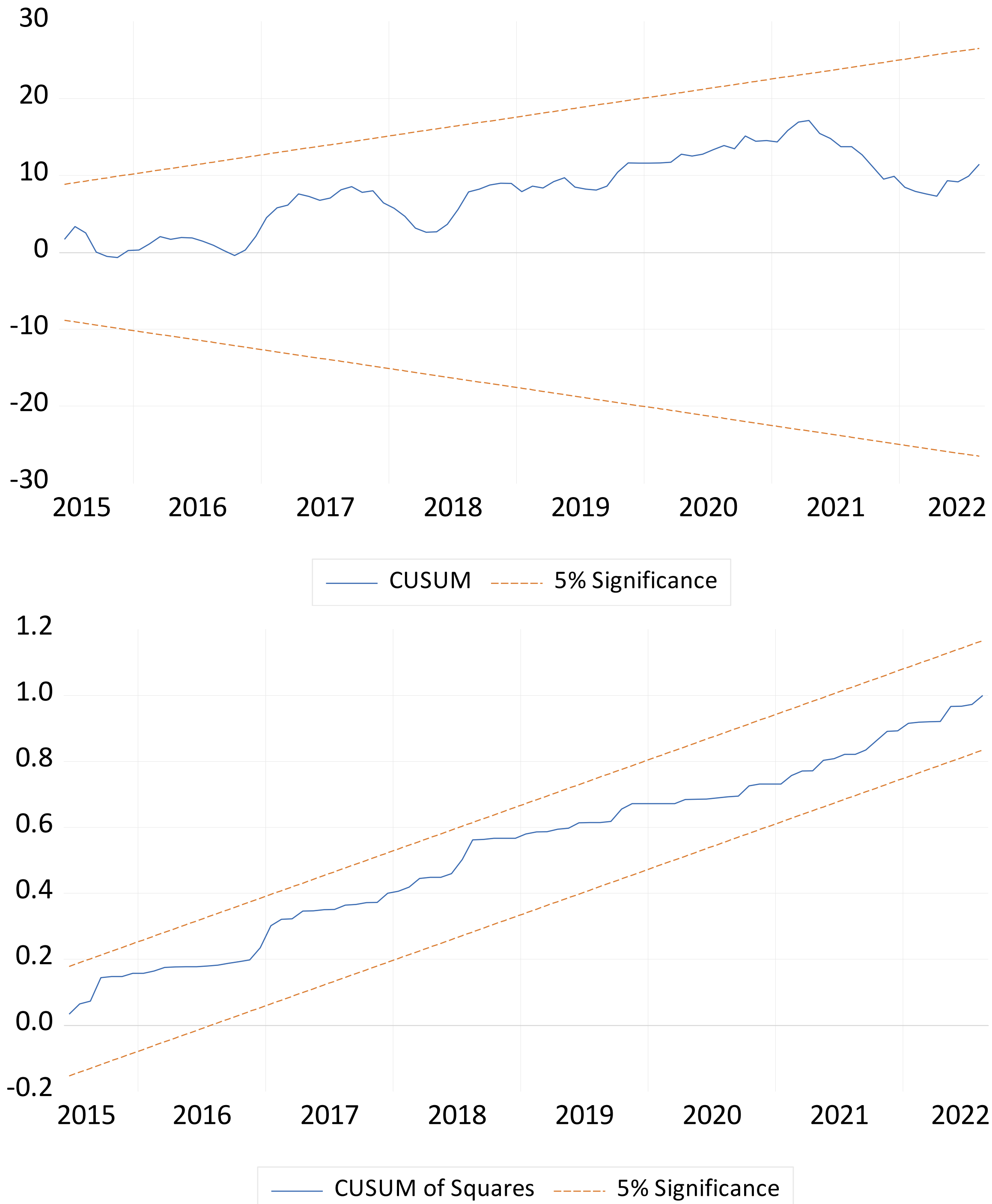

Figure 2: CUSUM and CUSUMSQ Stability Tests

In theory, the plots of the CUSUM and CUSUMSQ statistics must be within the 5% critical bounds for a model to be considered stable. In this instance, the CUSUM and CUSUM SQUARE stability tests pass the critical bounds and are consistent with the theory and its underlying principles. Similar to this, diagnostic tests were run on models that had serial correlation rejected, indicating a well-specified model, and were also determined to be homoscedastic based on the heteroskedasticity test. The diagnostic tests' findings and the CUSUM stability test's results demonstrate that the model describing the connection between rising food prices, insecurity, and climate change is adequate for guiding policymaking.

5. 0 CONCLUDING REMARKS AND POLICY RECOMMENDATIONS

While any form of conflict negatively affects food prices, it's worth noting that there is a shortage of studies exploring the impact of insecurity and climate change on food price inflation. To address this research gap, this study aimed to assess whether insecurity and climate change exacerbate food price inflation in Nigeria. The study employed the ARDL approach for co-integration analysis, utilizing monthly time series data spanning from January 2011 to December 2022.

The findings of this research strongly support the existence of a cointegration relationship between food price inflation, climate change, and insecurity. Notably, the study established that insecurity and climate change are significant determinants of food price inflation during the examined period. The estimated coefficient for the error correction term (ECT) is approximately -0.230086, indicating that the adjustment speed of food price inflation following an initial shock would correct and converge by approximately 23% each month in the long run.

Furthermore, the study underscores a clear association between food price inflation, insecurity, and climate change, highlighting that these independent variables serve as relevant triggers for food price inflation in Nigeria. The implications of these findings are far-reaching, suggesting that climate change poses a distressing challenge to the socioeconomic well-being of the Nigerian population and their access to food and nutritional security. This research underscores the significant impact of climate change on the agricultural and food sectors in Nigeria. These findings align with the conclusions drawn by (Antle and Capalbo, 2010; Wossen and Berger, 2015). The recent surge in flooding crises in Nigeria has had a profound impact on farmers who rely on the wet plains adjacent to the Niger and Benue Rivers. These flooding events have frequently led to the submergence and damage of substantial quantities of food crops. Consequently, they have disrupted the seasonal patterns of food availability and, in turn, have exerted pressure on food prices. Often, the early arrival of certain food commodities has been rendered impossible due to climate-related occurrences.

Considering these challenges, it is imperative for the Nigerian government to shift from traditional agricultural practices to the adoption of Climate-Smart Agriculture to meet future food demands. This transition should encompass alternative methods such as irrigation and the revitalization of diminishing water bodies in the Sudan and Sahel savannah regions. These measures, when undertaken by the government and relevant stakeholders, can facilitate the return of farmers to productive activities. Furthermore, as indicated by the study's results, insecurity persists as a formidable barrier preventing farmers, particularly in the northern regions and the middle belt of Nigeria, from effectively harvesting and processing their food crops.

This factor has had a detrimental impact on both livestock and crop production, leading to an increase in cattle rustling and subsequently driving up food prices (Ajibo et al., 2018; Awotokun et al., 2020; Ladan and Badaru, 2021). Our research findings further corroborate the positive relationship between insecurity and food price inflation. These findings underscore the urgency of implementing policy interventions to support households that have been adversely affected by insecurity. Effective policies could involve immediate safety measures, such as providing food aid to affected families, and planning for post-conflict rehabilitation programs for both farmers and herders in regions that have been severely affected by conflicts related to livestock and farming. To address the issue at its core, the government should consider establishing modern, publicly-owned ranches equipped with state-of-the-art technologies in the Sahel region. This initiative aims to discourage nomadic herding practices. However, to successfully implement this transition, the government should engage influential Northern leaders like the Sultan of Sokoto and various Emirs in promoting the adoption of ranching as a cultural and economic practice, emphasizing the significant economic and security benefits it offers. The findings also highlight the significant role played by transportation costs in driving food price inflation. The continuous escalation of transportation expenses, particularly when moving agricultural products from rural and farming areas to urban centers, has exacerbated the overall cost of essential food items in the market. The results further suggest that economic growth is a contributing factor to the inflationary pressures on food prices in Nigeria, as indicated by the outcomes of the empirical analysis. Consequently, there is a pressing need for policy interventions aimed at both stimulating and regulating activities within the sector. For instance, the government should consider allocating funding to the manufacturing sector to encourage local production rather than relying on the importation of foreign-manufactured goods. This shift towards domestic production can mitigate disruptions in the sector and help stabilize exchange rates, ultimately contributing to a more balanced and sustainable economic environment.

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