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The Evolution of Drivers of Food Inflation in Nigeria: A Time-Varying Analysis

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Abstract

This study examines the time-varying drivers of food inflation in Nigeria over the period 2010 to 2024, using the time-varying Granger causality (TVGC) framework of Shi et al. (2020) within a Lag-Augmented VAR model. The empirical analysis incorporates food inflation, exchange rate, money supply, and an insecurity index as the core variables of interest. The results show that exchange rate depreciation and money supply growth are the dominant monetary drivers of food inflation, with their predictive influence strengthening markedly during the post-COVID-19 period and following the 2023 foreign exchange reforms. Insecurity exerts a time-varying structural influence on food prices, most prominently from 2019 onward, coinciding with intensified conflict in major food-producing regions. Robustness checks using a Time-Varying Parameter Structural VAR with Stochastic Volatility (TVP-SVAR-SV) confirm the exchange rate and monetary channels as persistent positive drivers of food inflation, while showing that insecurity operates mainly through macroeconomic volatility amplification rather than as a direct linear price shock. The findings call for a coordinated policy response combining exchange rate stability, monetary discipline, and structural reforms in agriculture and security to address Nigeria's persistent food inflation challenge.

Keywords: food inflation, Time-varying parameter models, Nigeria, exchange rate pass-through, demand and supply, monetary policy, supply chain shocks

JEL Classification: C32, E31, Q11, E64[*†]

[*] Authors are staff of the Central Bank of Nigeria. The views expressed in this paper are those of the authors and do not represent the position of their affiliated institution.

1. Introduction

The management of inflationary pressures remains a significant challenge for policymakers. Although several studies attribute these pressures to a blend of monetary and structural factors (Ndikumana et al., 2023; Rapu et al., 2016; Maitra, 2016; Bane, 2018), there are evidences that also suggest that the recent surge in food inflation reflects a more pronounced influence of structural factors (Algieri, Kornher, & von Braun, 2024; Ndikumana et al., 2023; Bhattacharya & Sen Gupta, 2018; Alper, Hobdari, & Uppal, 2017). Given the substantial weight of food prices in the consumer goods basket, they have consistently applied considerable pressure on headline inflation. Therefore, the determinants of food inflation are anticipated to have a nearly direct impact on aggregate prices within the economy (Nakorji et al., 2023; Bawa et al., 2020; Ekpeyong, 2023).

In recent years, Nigeria has witnessed significant increases in food inflation, posing serious threats to food security while simultaneously intensifying poverty and inequality. Food inflation reached a peak of 40.87 per cent in June 2024, a stark rise from 9.78 percent in May 2015, which marked the last instance of single-digit inflation in the food index. It is crucial for policymakers, stakeholders, and researchers to comprehend the complex factors driving food inflation in Nigeria in order to alleviate its detrimental impacts. Various interconnected factors contribute to this inflationary trend, including disruptions in supply chains, fluctuations in exchange rates (Umar & Umar, 2022; Akanni, 2020), changes in climate, and inadequacies in policy frameworks (Iliyasu, Mamman & Ahmed, 2023). Before the implementation of strategic measures by the Central Bank of Nigeria aimed at returning to orthodox practices, food inflation was primarily addressed through unconventional approaches, such as direct interventions in agricultural sectors (Obiora et al., 2023; Lawrence, 2023). Nevertheless, as part of the recalibration of monetary policy, it is imperative to reassess the primary drivers of food inflation in Nigeria and investigate how the Bank can effectively utilize its conventional tools to mitigate the pressures exerted on food prices.

Food production and the corresponding prices are significantly affected by a variety of factors, including environmental conditions like severe weather events. Additionally, the depreciation of the naira against major currencies presents a considerable risk to the costs of imported food and agricultural inputs, thereby exacerbating the challenges faced by the domestic food supply. Beyond these economic and environmental influences, socio-political factors, including conflicts and security issues in agricultural regions, as well as regulatory hurdles, are instrumental in shaping the landscape of food inflation (Obiora, 2023; Adekunle et al., 2024; Kah, 2017; Nnaji et al., 2022). The interaction among these elements creates a multifaceted environment in which increasing food prices not only mirror market trends but also reveal deeper structural weaknesses within the Nigerian economy. The persistent issue of food inflation presents significant challenges, necessitating a thorough examination of its underlying causes to formulate effective policies aimed at ensuring food accessibility and affordability in Nigeria. This study intends to investigate these causes comprehensively, offering insights into the key drivers of food inflation and proposing possible policy measures that could be implemented by both the monetary and fiscal authorities to address the pressures.

Several studies have explored food inflation in Nigeria using ARDL (Umar and Umar, 2022), VAR (Rapu et al., 2016), SVAR (Ndikumana et al., 2023), and Bayesian VAR frameworks (Shuaibu et al., 2025). While these identify important monetary and structural drivers, they assume time-invariant relationships, which is inconsistent with Nigeria's history of multiple structural breaks across distinct policy regimes. A time-varying approach is preferable because the relative dominance of monetary versus structural channels shifts across episodes such as the 2016 oil price shock, the COVID-19 pandemic, and the 2023 exchange rate unification, none of which can be adequately captured in a single full-sample estimate.

The novelty of this paper lies in its application of a unified time-varying framework to simultaneously test the dynamic predictive influence of exchange rate, money supply, and insecurity on food inflation in Nigeria, a combination not previously examined in the existing literature on Nigeria. While prior studies such as Nwosu, Akpan, and Etudaiye (2024) apply TVGC methods to the inflation-insecurity nexus and Akpan and Abubakar Sani (2024) examine geopolitical risks, neither integrates all three channels in a single framework. Furthermore, existing studies employing ARDL, VAR, SVAR, and factor models assume time-invariant relationships, a restriction that is inconsistent with Nigeria’s multiple structural breaks across policy regimes. This paper addresses three explicit research questions: first, do the drivers of food inflation in Nigeria change over time, and during which episodes does each driver dominate? Second, does exchange rate pass-through to food prices vary across different foreign exchange market regimes? Third, does insecurity influence food inflation in Nigeria, and through what channel, whether direct price transmission or amplification of macroeconomic volatility? The remainder of the paper is structured as follows: Section 2 reviews the relevant literature, Section 3 presents the data and methodology, Section 4 discusses the stylized facts, Section 5 reports the empirical and robustness results, and Section 6 concludes with policy recommendations.

2. Literature Review

2.1 Theoretical Framework

The analysis of food inflation in Nigeria draws on several complementary theoretical traditions, each pointing to different but interacting transmission channels. The monetarist theory holds that sustained price increases are ultimately driven by excess monetary growth relative to output. In Nigeria’s context, this channel operates through money supply expansion that fuels aggregate demand, raises input costs, and depreciates the exchange rate, transmitting inflationary pressure into the food sector (Rapu et al., 2016; Lawrence, 2023). The structuralist or cost-push view emphasises supply-side constraints as primary drivers of food price increases, including inadequate rural infrastructure, high post-harvest losses, climate-induced agricultural disruptions, and insecurity in food-producing regions (Iliyasu, Mamman, and Ahmed, 2023; Nwosu, Akpan, and Etudaiye, 2024). The demand-pull theory attributes food price increases to rising real incomes, urbanisation, and shifts toward more expensive food commodities (Abbott et al., 2011; Mishra and Roy, 2012). The New Keynesian framework highlights the role of monetary policy credibility in anchoring inflation expectations; where credibility is weak, as has historically been the case in Nigeria, adverse

supply shocks generate second-round effects through expectations, producing food price persistence that outlasts the original shock (Bhattacharya and Sen Gupta, 2018). These theoretical perspectives are not mutually exclusive. Their relative importance varies over time and across economic regimes, providing the principal motivation for the time-varying empirical approach adopted in this study.

2.2 Evidence from Nigeria and Sub-Saharan Africa

Nigeria's food inflation dynamics present a complex interplay of macroeconomic, structural, institutional, and policy-driven factors. Recent data indicates a technical decline in headline inflation to 23.18% in February 2025, primarily due to the rebasing of the Consumer Price Index (CPI) to 2024. However, underlying pressures persist, with food inflation remaining elevated at 23.51%, reflecting systemic challenges in agricultural production, currency volatility, and security crises.

In examining the factors contributing to food inflation in Nigeria, existing research has primarily attributed the rise in food prices to supply-side determinants (Thomas et al., 2023; Nguyen et al., 2017; Olasunkanmi & Oladipo, 2020; Gizaw & Myrland, 2025; Nsafoah & Ilori, 2024). These supply-side drivers can be broadly categorized into global and domestic factors. Global influences include the COVID-19 pandemic (Shuaibu et al., 2025; Omotayo et al., 2022; Agbugba et al., 2022; Andam et al., 2020; Ibukun & Adebayo, 2021), commodity price fluctuations (Tule, Salisu, & Chiemeke, 2019; Olasunkanmi & Oladele, 2018), geopolitical tensions (Akpan & Abubakar Sani, 2024), disrupted supply chains (Shuaibu et al., 2025), and the impact of climate change (Iliyasu & Ahmed, 2023; Onafeso, Akanni, & Badejo, 2015). As a small open economy, Nigeria is particularly vulnerable to these global shocks, which often lead to price volatility and persistence, shaped by the magnitude and duration of the shocks.

Moreover, the domestic landscape has been marked by policy responses that are often ineffective and, at times, inflationary (Karkare et al., 2022). Empirical investigations into these dynamics have employed traditional econometric techniques such as linear regression, Global Vector Autoregression (GVAR), Seasonally Adjusted Moving Average with Exogenous Regressors (SARIMA-X), panel data models, and Bayesian VAR frameworks with penalty function approaches. However, these methodologies tend to overlook the time-varying nature of the impulse responses among variables, thereby limiting their explanatory power in capturing the evolving dynamics of food inflation. This observation motivates the methodological framework employed in the present study.

On the domestic front, food inflation in Nigeria has also been influenced by a host of internal factors, including widespread insecurity (Nwosu, Akpan, & Etudaiye, 2024; Ajodo-Adebanjoko & Walter, 2014), energy costs (Bassey & Ekong, 2019; Ikue, 2024), labor union activities (Peter & Kwanashie, 2025), rising farm input costs (Thomas et al., 2023), and post-harvest losses. Despite numerous policy efforts aimed at addressing the structural constraints to food production, the challenges remain persistent and complex (Olasunkanmi & Oladipo, 2020).

Food inflation is driven by a complex interplay of factors. Rising demand due to economic growth and changing consumption patterns, particularly for animal-source foods and processed items, contributes significantly to price increases (Abbott et al., 2011; Mishra & Roy, 2012). Fuel inflation has a moderate impact, varying across commodities, while international prices mainly affect tradeable goods (Bhattacharya & Sen Gupta, 2018). Specific commodities driving food inflation include milk, fish, sugar, edible oils, fruits, vegetables, and cereals (Mishra & Roy, 2012). The effects of food inflation extend beyond the food sector, with significant pass-through to non-food and headline inflation (Bhattacharya & Sen Gupta, 2018). Understanding these drivers is crucial for developing effective policies to address food price volatility.

2.3 Time-Varying Econometric Approaches in Inflation Analysis

While most existing studies have examined food inflation at an aggregate level, this paper aims to disaggregate the index into its principal components,namely, farm produce and processed food. Furthermore, limited attention has been given to the time-varying properties of the covariates influencing food inflation, particularly within the context of contemporary time-series econometric methods (see Thoma, 1994; Swanson, 1998; Arora & Shi, 2016; Phillips et al., 2015a, 2015b; Psaradakis et al., 2005; Shi et al., 2020). This study adopts a time-varying framework that explicitly allows for unknown structural change points in the causal relationships among variables. Such an approach is preferable to traditional models that either ignore temporal heterogeneity or rely on arbitrary sub-sample divisions.

In summary, the literature reveals a persistent tension between monetary and structural explanations for food inflation in Nigeria, with no consensus on which channel dominates across different time periods. Studies relying on full-sample static estimators, including ARDL, standard VAR, and SVAR, are constrained by time-invariance assumptions that are difficult to justify in Nigeria's policy-volatile environment. The present study redresses this gap by allowing causal relationships to evolve endogenously over time, thereby producing findings that are more informative for policymakers navigating a shifting macroeconomic landscape.

3. Data and Methodology

In alignment with the primary aim of this study, we employ the Time-varying Granger Causality test to examine historical data concerning food inflation and its principal determinants. The dataset utilized in this research will cover the years 2010 to 2024, thereby encompassing significant events such as the fluctuations in commodity prices in 2016, the disruptions to the global supply chain caused by the COVID-19 pandemic in 2020, and the fiscal expenditures following the pandemic from 2021 to the present. Causal analyses, including Granger causality tests (Granger, 1988), fundamentally hinge on the notion of predictability. Traditionally, causality is assessed through a standard VAR model; however, the causal relationships may not always remain stable over time. To address this limitation, Shi et al. (2020) introduced time variation into Granger Causality tests, facilitating the analysis of non-stationary variables within the model (refer to Baum, Hurn, & Otero, 2021 for further details).

Consider the bivariate VAR(m) model:

$$y_{1t} = \phi_0^{(1)} + \sum_{k=1}^{m} \phi_{1k}^{(1)} y_{1t-k} + \sum_{k=1}^{m} \phi_{2k}^{(1)} y_{2t-k} + \varepsilon_{1t} \quad (1)$$

$$y_{2t} = \phi_0^{(2)} + \sum_{k=1}^{m} \phi_{1k}^{(2)} y_{1t-k} + \sum_{k=1}^{m} \phi_{2k}^{(2)} y_{2t-k} + \varepsilon_{2t} \quad (2)$$

Where y_{1t} and y_{2t}, respectively, represent the variables of interest. y_1 is said to Granger cause y_2 if the past values of y_1 have predictive power on the current value of y_2, conditional on the past values of y_2.

The null hypothesis of no Granger causality from variable y_1 to y_2 is $\boldsymbol{R}_{1\to2}\pi = 0$, where $\boldsymbol{R}_{1\to2}$ is the coefficient restriction matrix and $\pi = vec(\Pi)$ using row vectorization.

The heteroskedastic-consistent Wald statistic of the null hypothesis is denoted by $\boldsymbol{\mathcal{W}}_{1\to2}$ and is defined as

$$\boldsymbol{\mathcal{W}}_{1\to2} = T(\boldsymbol{R}_{1\to2}\hat{\pi})' \left[\boldsymbol{R}_{1\to2}\left(\widehat{\nabla}^{-1}\hat{\Sigma}\widehat{\nabla}^{-1}\right)\boldsymbol{R}'_{1\to2}\right]^{-1}(\boldsymbol{R}_{1\to2}\hat{\pi}) \quad (3)$$

Where $\hat{\nabla} = \mathbb{I}_n \otimes \hat{\boldsymbol{Q}}$ and $\hat{\boldsymbol{Q}} = T^{-1}\Sigma_t \mathbb{x}_t \mathbb{x}_t'$ and $\hat{\Sigma} = T^{-1}\sum_t \hat{\xi}_t \hat{\xi}_t'$ with $\hat{\xi}_t = \hat{\xi}_t \otimes \mathbb{x}_t$ and $\xi_t = \mathbb{y}_t - \hat{\Pi}\,\mathbb{x}_t$. Defining $\hat{\nabla}$, the subscript n in $\mathbb{I}_n$ refers to the number of variables in the VAR model. This framework applies to testing for Granger causality in the context of VAR model estimated on stationary variables. To accommodate integrated variables, we consider a Lag-Augmented VAR (LA-VAR) model, which is simply the original VAR(m) model augmented with additional d lags for the possible maximum order of integration. The model is therefore, specified as VAR(m + d) The Granger causality test would be conducted under the LA-VAR such that the coefficients associated to the additional d are not considered in the test restrictions.

To allow for time variation and date-stamping of the variables, recursive estimation methods are required to estimate the forward expanding, rolling, and recursive evolving window. Shi et al., (2020) proposed the use of three recursive testing algorithms for a data-driven discovery of the change points in the causal relationships. These include the forward expanding window (FE) earlier considered by Thoma (1994) in the (non-augmented) original VAR model, the recursive rolling window (RO) based on Swanson (1998) and Arora & Shi (2016), and a recursive evolving window (RE) algorithm described in Phillips et al, (2015a, 2015b), all of which utilize sub-sample tests of Granger causality within the LA-VAR framework.

Following Shi et al. (2020), consider a sample of $T + 1$ observations $\{y_0, y_0, \ldots y_T\}$. Let f_1 and f_2 be the starting and end points of the regression sub-samples and the Wald test statistic calculated from this subsample denoted by $W_{f_1 f_2}$. Furthermore, let $\tau_1 = [f_1 T]$, $\tau_2 = [f_2 T]$, where T represents the total number of observations. Assume $\tau_0 = [f_0 T]$ to represent the minimum number of observations required to estimate the LA-VAR model.

The FE algorithm, which is a standard forward recursion, first computes the Wald test statistic for a minimum window length, $\tau_0 = [f_0 T] > 0$ and then expand the sample size sequentially by one extra observation until the final Wald test statistic is computed using the entire sample size. The FE considers the first data point $(\tau_0 = 1)$ as the starting point of every sub-sample.

In the RO algorithm, a fixed window size (τ_0) is rolled through the sample, advancing one observation at a time, and a Wald Statistic computed for each window. In other words, given the fixed regression window size equals to τ_0, the start point of the calibration moves from the first observation $(\tau_1 = 1)$ to $T - \tau_0 + 1$ and the end point $\tau_2 = \tau_1 + \tau_0 - 1$. Alternatively, the starting and end point of the regression could be written as $\tau_1 = \tau_2 - \tau_0 + 1$ and $\tau_2 = \{\tau_0, \ldots, T\}$, respectively, where T is the last observation (see Shi, et al., 2020).

The RE algorithm combines the procedure of both FE and RO approaches, as a special case. Like the recursive rolling window (RO) algorithm, the endpoint of the regression window is still $\tau_2 = \{\tau_0, \ldots, T\}$. Howbeit, rather than maintaining a fixed distance, the regression procedure allows the distance between the starting point τ_1 and the endpoint τ_2 to vary and cover all possible values in the rolling window. Inference on Granger non-causality for each observation of interest, is then based on a sequence of the backward supremum Wald statistics, defined by Shi, et al., (2020) as:

$$\mathcal{SW}_f(f_0) = \underset{f_2 = f, f_1 \in [0, f_2 - f_0]}{Sup} \{\mathcal{W}_{f_1, f_2}\} \tag{4}$$

Where f is the fraction of the total sample, while $f_1 \, and \, f_2$ are the starting and ending points of the total sample, respectively.

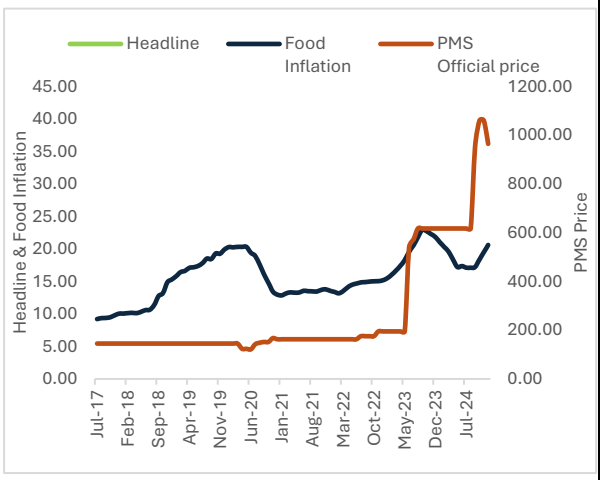
For full sample analysis, testing the null hypothesis that a given variables does not Granger cause another at any time during the sample, against the alternative that there is Granger causality at some time, required a single Wald test statistic. The maximal FE, RO, and RE statistic is the largest element of the first row of the upper triangular matrix, the main diagonal matrix and the entire upper triangular matrix of test statistics, respectively. Beyond these summary measures for the full sample, the sequence of FE, RO and RE statistics can also be graphed and compared with the bootstrap percentiles derived by the methods described in Shi, et al., (2020). Given these estimates, period(s) in which Granger-causal relationship exists can be identified, where the test statistic exceeds the corresponding critical value. Although Shi et al. (2020) have provided forward expanding window, rolling window and recursive evolving window algorithms to estimate the time-varying causality test, it has been proved that the recursive evolving window algorithm (which combines the features of the other two algorithms) provides the most reliable results with the highest power. For this reason, some authors have chosen to report only the RE window algorithm in their papers (e.g., Espoir et al., 2023). Hence, we would, in this paper, presents the results for all the three, but rely more on the sequence of the RE test statistics in adjudging the validity of the time-varying Granger causality results.

The empirical analysis is based on a four-variable VAR specification for monthly data on

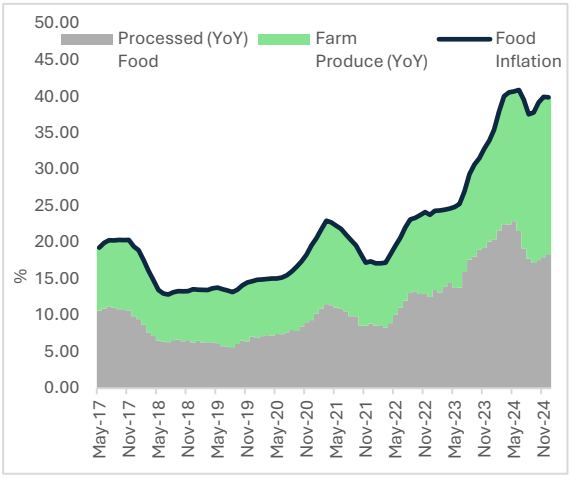
food inflation (pi), the exchange rate (exr), broad money supply (ms), and a security index (sec), sourced from the National Bureau of Statistics (NBS) monthly CPI publications and the CBN Statistical Bulletin. The insecurity index is constructed from conflict incident and fatality data sourced from the Armed Conflict Location and Event Data (ACLED) Project, normalised to a scale of 0 to 100. All series are seasonally adjusted prior to estimation to address the seasonal patterns that characterise monthly CPI data. Due to the nature of the LA-VAR Granger Causality tests, we examine the variables for unit root using Leybourne (1995) and Elliott et al. (1996). This class of test is preferable under the circumstance of examining both forward and reverse realizations of the time series of interest.

4. Stylized Facts

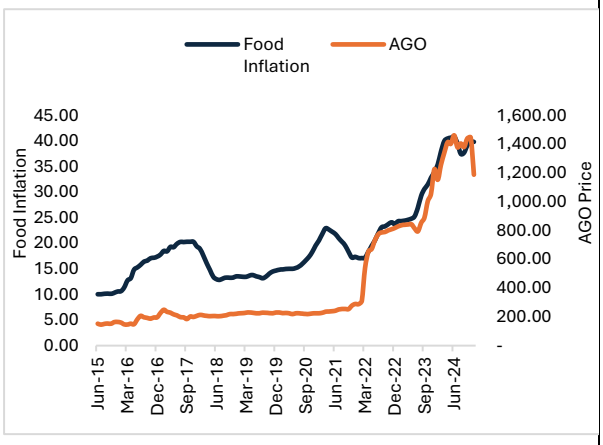
Inflation and PMS Price



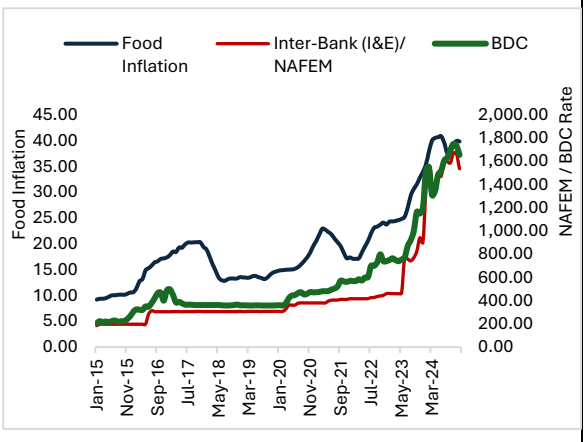
Components of Food Inflation



Food Inflation and AGO Price



Food Inflation and Exchange Rate



The graph illustrates the dynamic relationship between food inflation and Automotive Gas Oil (AGO) prices in Nigeria from June 2015 to December 2024. Over this nearly decade-long period, the data reveals distinct phases that reflect underlying economic and policy developments. From 2015 to mid-2022, both food inflation and AGO prices remained

relatively stable, albeit with periodic fluctuations. During this period, food inflation generally hovered between 10% and 20 per cent, while AGO prices remained below 300 naira. The chart shows occasional surges in food inflation, such as in early 2017 and again around early 2021, likely reflecting temporary supply shocks, currency depreciation, or seasonal agricultural shortfalls. AGO prices during this period were moderately stable, suggesting a degree of policy control over fuel pricing, possibly linked to subsidies.

A sharp structural break becomes evident around mid-2022. AGO prices surged dramatically, climbing from around N300 to over N1,200 within a short period. This coincided with a significant upward trend in food inflation, which breached the 20 per cent mark and eventually rose above 40 per cent by mid-2023. The synchrony in the rise of AGO prices and food inflation suggests a strong pass-through effect from energy costs to food prices. In a country where transportation and food distribution heavily rely on diesel-powered logistics, increases in AGO prices are quickly reflected in higher food prices, especially for staples.

Between mid-2022 and mid-2023, the chart displays a tight co-movement pattern between AGO and food inflation, implying that energy prices became a dominant driver of inflationary pressures during this period. This could be linked to domestic policy changes, such as the removal of fuel subsidies, or external shocks like higher global oil prices and exchange rate devaluation. The alignment of the peaks for both variables around the same period reinforces this narrative of interconnectedness.

In the final segment of the chart, covering late 2023 to August 2024, a divergence becomes noticeable. AGO prices show a sharp decline, falling from their peak of over 1,400 naira to around 1,200 naira. In contrast, food inflation, though starting to decelerate, does so at a slower pace. This divergence could reflect a lagged response of inflation to declining energy costs, suggesting that price stickiness or structural bottlenecks may be preventing an immediate reversal in food prices. It also indicates that inflationary pressures are not solely driven by fuel costs, but could also be influenced by broader macroeconomic factors such as exchange rate volatility, import dependency, or climatic disruptions to food supply.

In summary, the graph tells a story of Nigeria's shifting inflationary landscape, highlighting how fuel prices, particularly AGO, have become an increasingly important determinant of food inflation. The post-2022 period marks a critical inflection point, likely reflecting a new policy regime or external economic shocks. While the recent decline in AGO prices offers some relief, the persistence of high food inflation points to the need for structural reforms in agriculture, transportation, and energy sectors to sustainably address inflationary pressures.

In the trend of food inflation in Nigeria alongside two key exchange rate indicators , the Inter-Bank (I&E/NAFEM) rate and the Bureau de Change (BDC) rate , spanning from January 2015 to December 2024. Between 2015 and early 2022, food inflation exhibited a generally upward but moderate trend, fluctuating between 10 per cent and 20 per cent. Meanwhile, both the official interbank exchange rate (NAFEM/I&E) and the BDC rate showed relative stability, with the BDC rate remaining consistently above the interbank rate, indicating a persistent premium in the parallel market. This premium reflects foreign exchange shortages and capital control measures that pushed demand into the informal BDC market.

The turning point in the chart becomes evident around mid-2022, when both exchange rate lines , especially the BDC rate , began to rise steeply. The BDC rate surged from below 700 naira per USD to over N1,600 by early 2024, while the official rate (NAFEM) also climbed, though with a noticeable lag and less volatility. This period of exchange rate depreciation coincides with a dramatic increase in food inflation, which accelerated to over 40 per cent by mid-2023. The timing and co-movement suggest a strong exchange rate pass-through to food inflation , a well-documented phenomenon in import-dependent economies like Nigeria, where currency depreciation directly affects the cost of imported food, agricultural inputs, and transport.

From mid-2023 onward, the gap between the BDC and NAFEM rates narrowed slightly, suggesting some attempts at exchange rate convergence or improved supply in the official market. Nevertheless, both rates remained elevated, and food inflation, though showing signs of peaking, stayed at historically high levels. This indicates that the depreciation shock had a lingering impact on food prices, possibly compounded by structural rigidities in domestic food supply chains.

Interestingly, the chart shows that while exchange rates and food inflation move in tandem during periods of economic stress, there are phases (such as 2018 to 2020) where inflation rises even when exchange rates are relatively flat. This hints at other inflationary drivers during such periods, including supply shocks, insecurity affecting food production, or policy inefficiencies.

The chart illustrates a strong and growing link between exchange rate volatility and food inflation in Nigeria. The sharp depreciation of both the official and parallel exchange rates after 2022 appears to have been a key driver of the surge in food prices. The BDC rate emerges as a more responsive and volatile indicator, often leading the official rate and potentially serving as an early signal for inflationary pressures. The persistence of high food inflation, even as exchange rates stabilize, calls for deeper structural reforms in forex management, agricultural productivity, and supply chain resilience to break the inflation-exchange rate feedback loop.

5. Empirical Results

Table 1. Summary Statistics

Variable	Mean	Std. dev.	Min	Max
pi	16.62	7.56	7.9	40.87
exr	339.73	329.38	117.72	1670.47
ms	16.06	0.58	14.98	17.47
sec	22.23	22.13	0	100

Note: where pi, exr, ms, and sec represent food inflation, exchange rate, money supply and the security index, respectively. In addition, Std. dev, min, and max represent the standard deviation, minimum and maximum values of the variables.

The summary statistics indicate that the exchange rate and security index had the greatest degree of variance over the review period. It was also shown that, on average, price growth and money supply were in double digits, signifying potential inflationary pressures originating from the monetary sector. The average security index was 22.3 points on a scale of 0 to 100, with a maximum of 100 and a low of 0. The index's performance indicates that at specific periods, insecurity markedly intensified, perhaps contributing to inflationary pressures. To empirically determine causal behaviour, we evaluate the time-varying Granger causality among the variables.

Table 2. Stochastic Properties of the Data

Variable		ADF_{max}						DFGLS					
		Levels			Difference			Levels			Difference		
		P	Statistic		P	Statistic		P	Statistic		P	Statistic	
pi	AIC	14	0.79	[0.981]	14	-2.87	[0.022]	14	1.18	[0.936]	14	-0.57	[0.481]
	SIC	2	0.59	[0.977]	1	-7.19	[0.000]	0	2.24	[0.993]	13	-0.53	[0.504]
	GTSO5	14	0.79	[0.981]	14	-2.87	[0.025]	14	1.18	[0.943]	13	-0.53	[0.529]
exr	AIC	14	2.23	[0.999]	14	-5.90	[0.000]	14	2.57	[0.995]	14	-4.95	[0.000]
	SIC	14	2.23	[1.000]	14	-5.90	[0.000]	14	2.57	[0.997]	13	-4.64	[0.000]
	GTSO5	14	2.23	[1.000]	14	-5.90	[0.000]	14	2.57	[0.997]	13	-4.64	[0.000]
ms	AIC	1	2.38	[1.000]	2	-6.98	[0.000]	1	5.20	[1.000]	11	-0.69	[0.426]
	SIC	1	2.38	[1.000]	0	-15.90	[0.000]	1	5.20	[1.000]	5	-1.07	[0.252]
	GTSO5	1	2.38	[1.000]	11	-2.98	[0.019]	1	5.20	[1.000]	11	-0.69	[0.460]
sec	AIC	3	-2.48	[0.052]	2	-11.58	[0.000]	3	-1.91	[0.042]	2	-11.62	[0.000]
	SIC	2	-2.90	[0.014]	1	-14.46	[0.000]	2	-2.22	[0.014]	1	-14.52	[0.000]
	GTSO5	2	-2.90	[0.023]	2	-11.58	[0.000]	2	-2.22	[0.090]	2	-11.62	[0.000]

Note: ADFmax and dfgls are the unit-root tests of Leybourne (1995) and Elliott, Rothenberg, and Stock (1996), respectively. A and S indicate that p was determined using the Akaike (1974) and Schwarz (1978) information criteria, respectively; GTSO5 indicates that p was determined using the general-to-specific algorithm proposed by Campbell and Perron (1991) and Hall (1994) using a 5% significance level. The Pmax was set to 14 in the process of determining the optimal level of lag.

In the pre-estimation diagnostics, we assess the unit root of the variables following the methodologies established by Leybourne (1995) and Elliot, Rothenberg, and Stock (1996). The ADFmax test employs both forward and reverse iterations to assess unit root presence, utilising the maximum Augmented Dickey-Fuller (ADF) tau statistics. The Dickey Fuller approach utilising Generalised Least Squares (DFGLS) demonstrates greater power compared to the standard Augmented Dickey-Fuller (ADF) method. The results indicated mixed stationarity of the time series. Consequently, as the variables are integrated of order 1, we set the differences to 1 in the lag-augmented VAR model.

Table 3. Lag Length Selection Criteria

Lag	LR	Df	P	FPE	AIC	HQIC	SBIC
0				4.3E+07	28.93	28.96	28.99
1	2231.1	16	0.000	764.77	17.99	18.12*	18.32*
2	46.06	16	0.000	713.23	17.92	18.16	18.51
3	47.23*	16	0.000	661.52*	17.85*	18.19	18.70
4	21.63	16	0.155	697.17	17.89	18.34	19.01

Note: where LR, DF, P, FPE, AIC, HQIC, SBIC represent the likelihood ratio, degree of freedom, P-value, Final Prediction Error, Akaike Information Criterion, Hannan-Quinn Information Criterion, and Schwarz Bayesian Information Criterion, respectively.

The lag length selection criteria determined that a lag of three is optimal for the LA-VAR model. This analysis relies on the FPE, AIC, and LR statistics. The choice of lag 3 is demonstrated to be more efficient for the VAR model, considering the constraints of dimensionality related to the model's degrees of freedom.

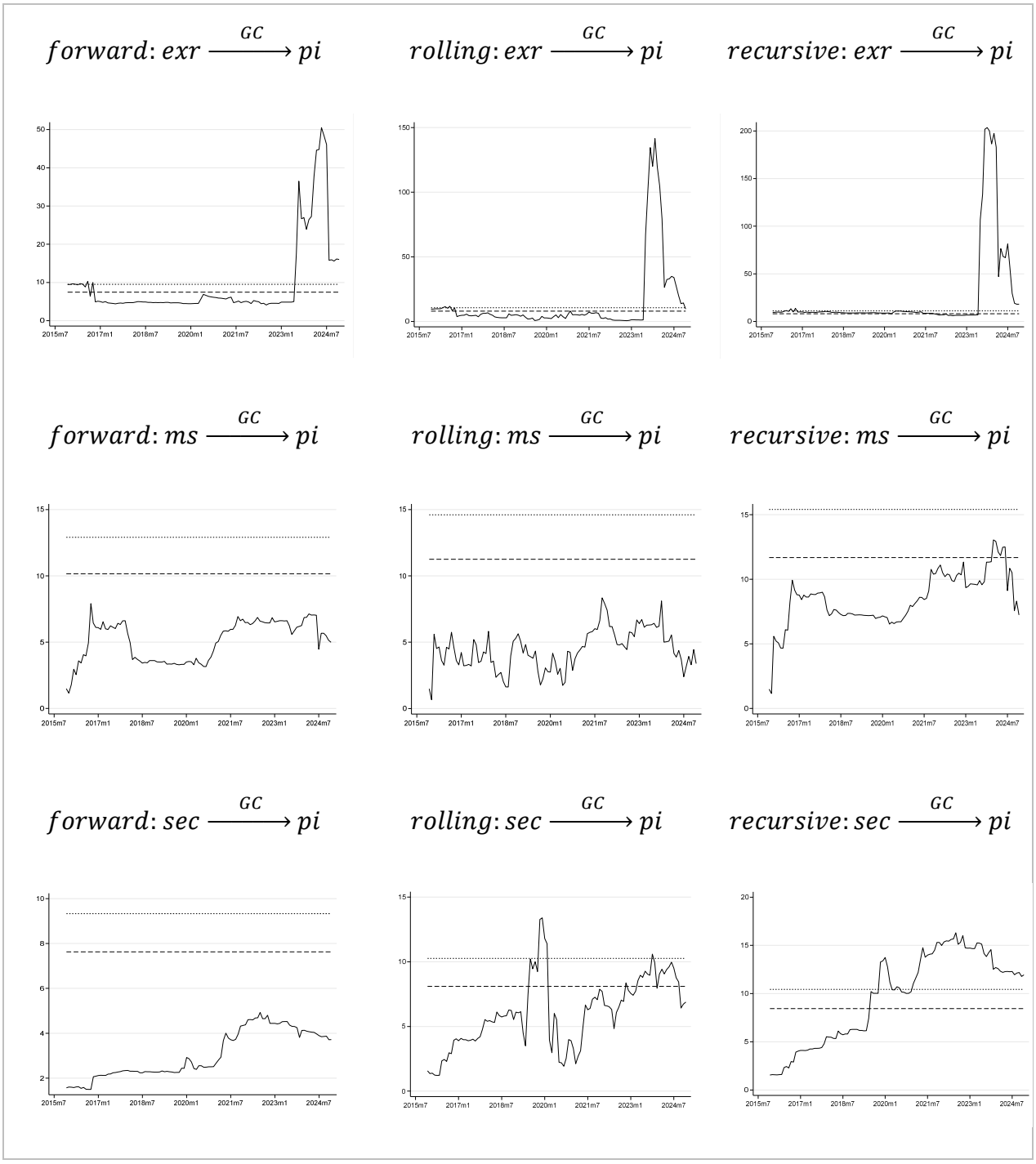


Figure 1. Time-varying Granger causality tests between inflation, money supply, exchange rate, and insecurity

Where indicates that the direction of Granger causality being tested runs from x to y. The test is reported with 90th (--) and 95th (-) percentiles of bootstrapped test statistics. The underlying VAR model is fit with p=3 lags as determined in the lag order test. The study spanned the period December 2008 to 2024, with a minimum window size of 96 observations. The bootstrapped critical values (the 90th and 95th percentiles) are based on 499 replications with a one-year period (twelve months) to control size. The Wald statistics are heteroskedasticity robust.

The time-varying Granger causality analysis indicated that the exchange rate and money growth significantly influenced inflation, particularly during the post-COVID-19 period and following the foreign exchange market reforms implemented after 2023. The forward and rolling windows similarly indicated this trend during the post-crisis period of 2016/2017. The recursive window indicated causality from the start of the sample through 2021, primarily at the 90th percentile. The recursive window analysis indicated that money supply exerted a causal influence on inflation during the post-COVID crisis period, highlighting the monetary and fiscal interventions implemented to mitigate the crisis's effects on households and businesses.

The analysis of rolling and recursive windows indicated that the security index Granger-caused inflation primarily from 2019 to the conclusion of the sample period. This coincides with the increased tension surrounding the 2019 elections, ongoing attacks in agricultural communities, and conflicts between herders and farmers.

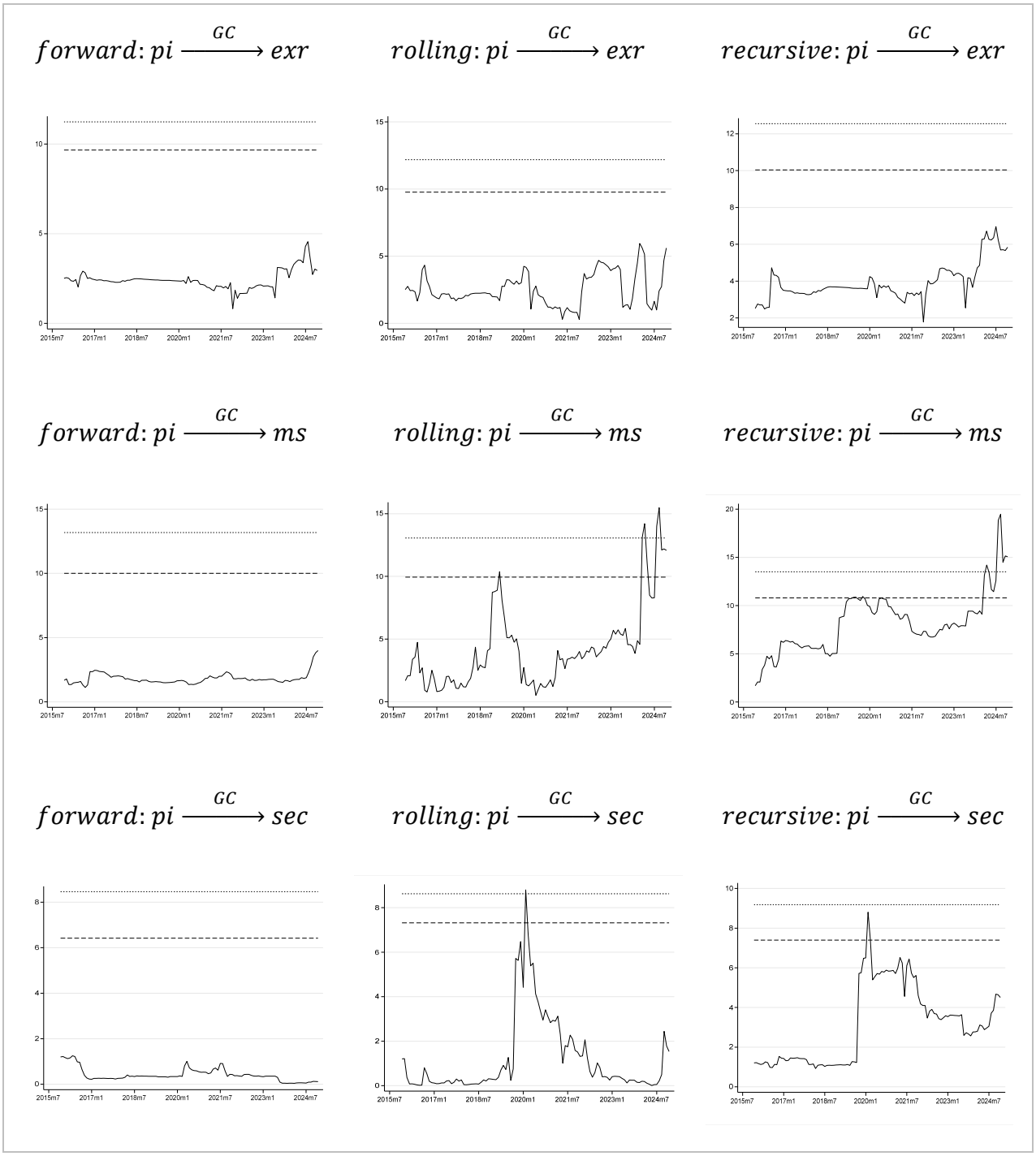


Figure 2. Time-varying Granger causality tests between inflation, money supply, exchange rate, and insecurity

Where indicates that the direction of Granger causality being tested runs from x to y. The test is reported with 90th (--) and 95th (-) percentiles of bootstrapped test statistics. The underlying VAR model is fit with p=3 lags as determined in the lag order test. The study spanned the period December 2008 to 2024, with a minimum window size of 96 observations. The bootstrapped critical values (the 90th and 95th percentiles) are based on 499 replications with a one-year period (twelve months) to control size. The Wald statistics are heteroskedasticity robust.

We conduct a reverse analysis of causality, estimating the influence of inflation on the selected variables. The findings indicate that inflation significantly influences money supply, particularly in the post-COVID-19 period, with a lesser effect observed following the oil shock of 2017/2018. Our analysis revealed a causal relationship between inflation and security during the election year of 2019, demonstrating a bi-directional causality between these two variables within the same time frame. In contrast, inflation did not demonstrate a causal effect on the exchange rate over the observed period.

Table 4. Tests of Granger Causality (Wald Statistics)

Direction of Causality	Max Wald FE	Max Wald RO	Max Wald RE
$pi \xrightarrow{GC} exr$	50.52 (7.45) [9.5]	141.53 (7.93) [10.62]	203.5 (8.08) [11.06]
$pi \xrightarrow{GC} ms$	7.91 (10.16) [12.9]	8.34 (11.25) [14.6]	13.04 (11.68) [15.39]
$pi \xrightarrow{GC} sec$	1.25 (6.42) [8.46]	8.8 (7.32) [8.63]	8.8 (7.39) [9.18]
$exr \xrightarrow{GC} pi$	4.55 (9.66) [11.24]	5.94 (9.76) [12.18]	6.96 (10.03) [12.55]
$ms \xrightarrow{GC} pi$	10 (13.17) [19.04]	9.94 (13.05) [19.17]	10.79 (13.49) [20.05]
$sec \xrightarrow{GC} pi$	7.63 (9.32) [13.44]	8.09 (10.25) [13.88]	8.44 (10.43) [13.89]

Note: Time-varying Granger causality tests between inflation, money supply, exchange rate, and insecurity. Where $x \xrightarrow{GC} y$ *indicates that the direction of Granger causality being tested runs from x to y. The test is reported with 95th () and 99th [] percentiles of bootstrapped test statistics. The underlying VAR model is fit with p=3 lags as determined in the lag order test. The study spanned the period December 2008 to 2024, with a minimum window size of 96 observations. The bootstrapped critical values (the 90th and 95th percentiles) are based on 499 replications with a one-year period (twelve months) to control size. The Wald statistics are heteroskedasticity robust.*

The estimates on table 4 show the bootstrap test statistics of the time varying granger causality. These test values support the graphical representation of the causality results. The variation in test statistics reveal that granger causal relationships among the variables are highly dynamic and the pattern of causality in the data varies with the algorithms.

5.1 Robustness Results

To assess the robustness of the TVGC results, we re-estimated the food inflation-driver relationship using a time-varying parameter structural VAR with stochastic volatility. This exercise is useful because the TVGC framework establishes whether predictive causal linkages evolve over time, while the TVP-SVAR with Stochastic Volatility framework provides complementary evidence on the dynamic response of food inflation to structural innovations in exchange rate, money supply, and insecurity. The robustness analysis therefore examines whether the broad conclusions from the original TVGC results remain valid when the relationships are modelled through time-varying impulse responses and stochastic volatility.

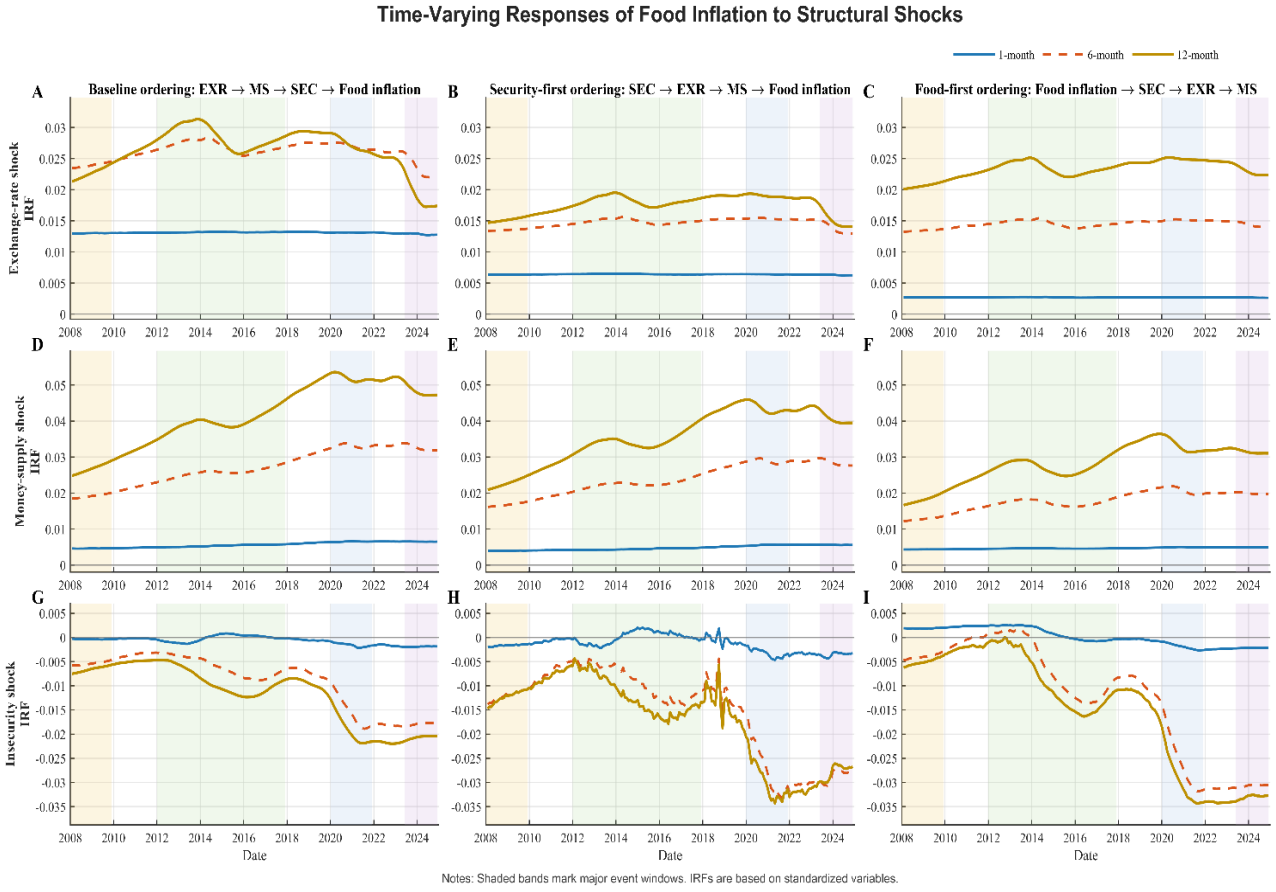


Figure 3. Time-varying impulse responses of food inflation to exchange-rate, money-supply, and insecurity shocks

The result in Figure 3 broadly supports the main findings of the paper. Across the baseline, of which the recursive ordering of variables prioritised security and food, exchange-rate shocks generate positive responses in food inflation. This is consistent with the original TVGC

evidence that the exchange-rate channel has become an important and time-varying driver of food inflation in Nigeria. The effect is especially visible around major adjustment periods, including the post-2012 period and the recent 2023-2024 exchange-rate reform and food-price surge. This reinforces the argument that exchange-rate depreciation affects food prices through imported food costs, imported agricultural inputs, transport costs, and broader pass-through into domestic prices. Importantly, the exchange-rate effect remains positive even when the contemporaneous ordering of insecurity and food inflation is changed, suggesting that the exchange-rate channel is not an artefact of the baseline structural ordering.

Money supply shocks also produce consistently positive responses in food inflation across all specifications. This strengthens the original paper's finding that monetary factors remain relevant, even though food inflation is often discussed mainly as a structural or supply-side problem. The TVP-SVAR-SV results show that the money-supply response rises over time and becomes more pronounced from the late 2010s into the COVID-19 and 2023-2024 periods. In the event-window summary, the money-supply shock has the largest positive 12-month response during the 2020-2021 and 2023-2024 windows. This is consistent with the TVGC results, which indicate that the importance of monetary variables is not constant but strengthens during episodes of macroeconomic stress. The implication is that liquidity conditions, exchange-rate pressures, and food-market disruptions may reinforce one another, making monetary policy relevant even when the immediate triggers of food inflation appear structural.

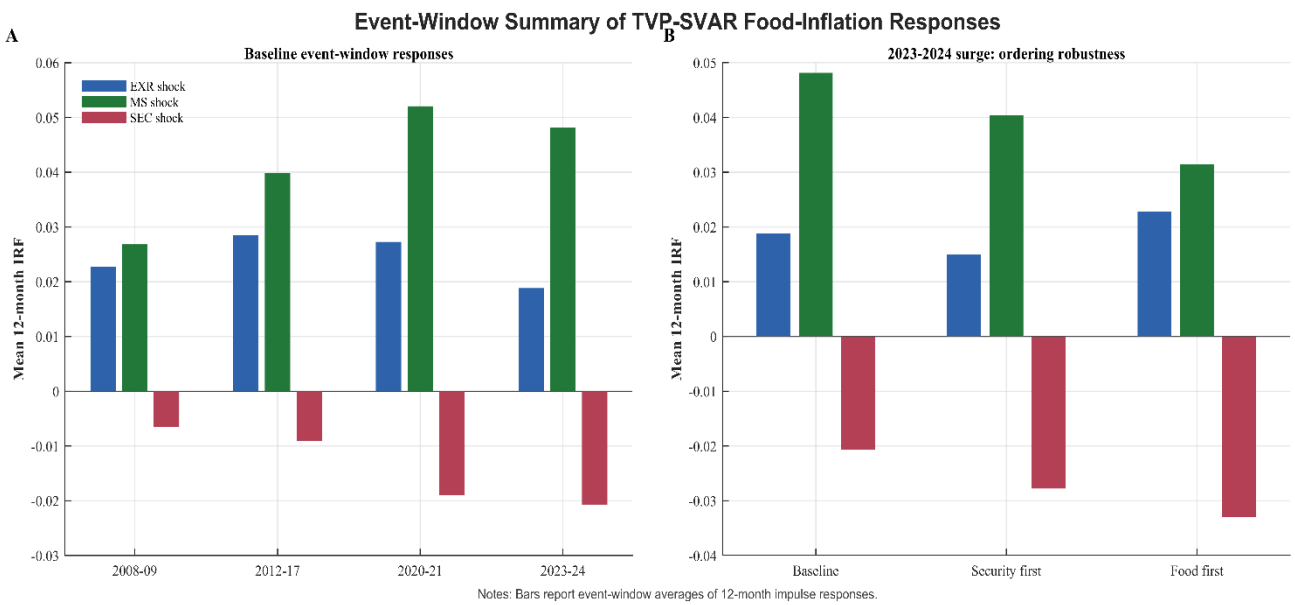


Figure 4. Ordering-robustness impulse responses for the insecurity channel

The third result concerns insecurity. The original TVGC analysis indicates that insecurity plays a time-varying role in the evolution of food inflation, especially through periods associated with conflict, displacement, supply-chain disruption, and reduced agricultural production. The TVP-SVAR-SV robustness results provide a more nuanced interpretation. In the impulse-response panels, the direct response of food inflation to an insecurity shock is negative

across the three recursive orderings. This should not be interpreted mechanically as evidence that insecurity lowers food inflation. Rather, it shows that once exchange rate and money supply are included in the same structural system, the recursive IRF does not isolate a stable positive direct price response from the insecurity index. The insecurity variable may be working through indirect channels, including exchange-rate pressure, fiscal responses, supply disruptions, expectations, and regional food-market fragmentation. It may also reflect measurement issues in the insecurity index, since security events can be episodic, geographically concentrated, and only imperfectly aligned with national monthly food inflation.

Stochastic volatility estimates.

The stochastic-volatility results provide stronger support for the insecurity channel. Under the security-first ordering, insecurity volatility rises sharply around 2011-2012, spikes again around 2020, and remains elevated around 2021. These periods correspond to episodes of heightened security stress and pandemic-related disruption. This supports the central message of the original TVGC results: insecurity matters most as a source of instability and time variation in the food-inflation environment, rather than as a simple linear shock with a constant positive effect. In other words, insecurity appears to amplify uncertainty and volatility in the system, while its direct impulse-response effect depends on how the structural model allocates contemporaneous interactions among insecurity, monetary conditions, exchange rates, and food inflation.

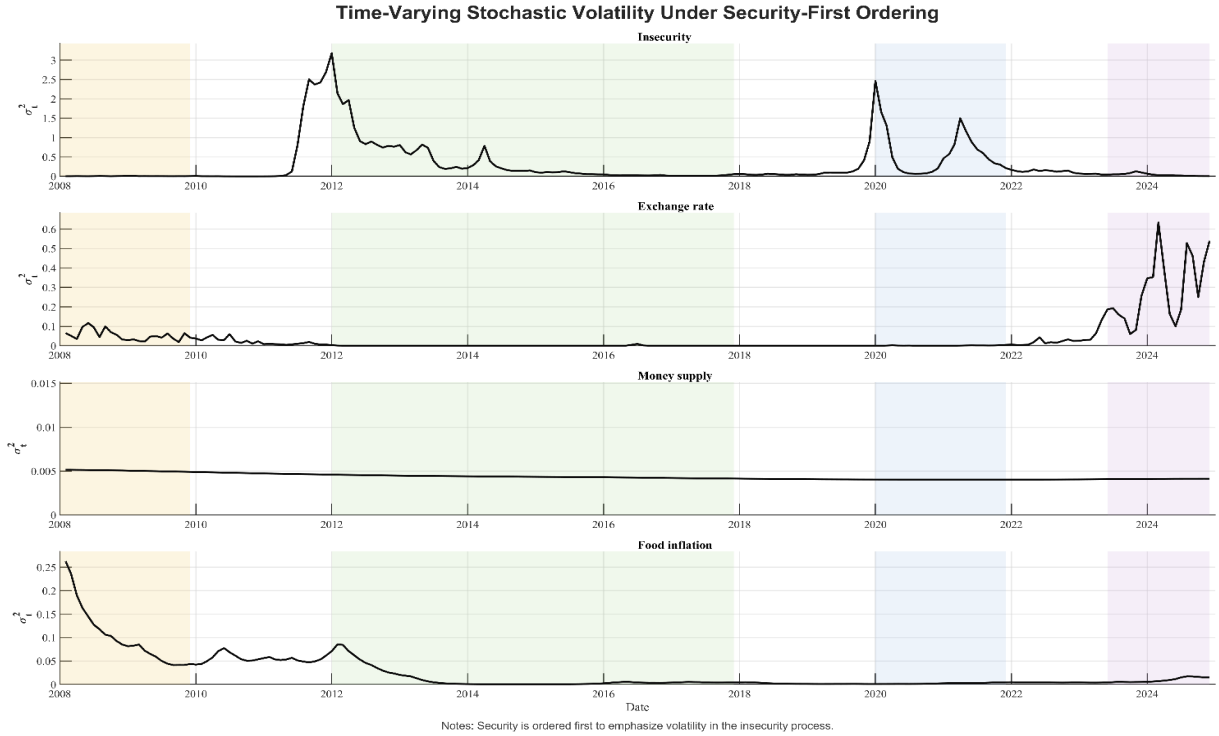


Figure 5. Stochastic volatility estimates

Overall, the TVP-SVAR-SV robustness analysis strengthens the paper's main conclusion that food inflation in Nigeria is driven by an evolving combination of external, monetary, and structural factors. The exchange-rate and money-supply channels are robust across alternative

orderings and remain positive drivers of food inflation. The insecurity channel is confirmed more through volatility and instability than through a stable positive structural impulse response. This distinction is important. It suggests that policy responses to food inflation should not treat insecurity merely as another linear determinant of prices, but as a destabilizing structural condition that weakens food supply systems, raises uncertainty, and interacts with macroeconomic pressures.

Thus, the robustness evidence aligns with the original time-varying Granger causality findings while adding an important layer of interpretation. The TVGC results show that the predictive importance of the drivers changes over time. The TVP-SVAR-SV results show that the magnitude and persistence of shocks also vary over time, with exchange rate and money supply producing robust positive food-price responses and insecurity contributing mainly through volatility. Together, the two approaches support the view that Nigeria's food inflation problem cannot be explained by a single static driver. Instead, it reflects a shifting policy environment in which monetary pressures, exchange-rate depreciation, and structural insecurity interact differently across episodes.

6. Conclusion

This study has examined the time-varying drivers of food inflation in Nigeria over the period 2010 to 2024 using the TVGC framework of Shi et al. (2020), within a four-variable LA-VAR model incorporating food inflation, exchange rate, money supply, and an insecurity index. The central finding is that the predictive influence of these drivers on food inflation is not constant but shifts significantly across macroeconomic regimes. Exchange rate depreciation and money supply growth are identified as the dominant monetary drivers, with their Granger-causal effects on food inflation intensifying during the post-COVID-19 period and following the 2023 foreign exchange market reforms. The insecurity index emerges as a significant time-varying predictor of food inflation from 2019 onward, coinciding with escalating conflict in agricultural communities, though the TVP-SVAR-SV robustness results indicate that insecurity operates primarily through macroeconomic volatility amplification rather than a direct and stable positive price effect.

Notably, the results indicate that exchange rate volatility and money supply growth exerted significant causal effects on inflation, particularly in the post-COVID-19 period and following foreign exchange market reforms after 2023. These effects mirror similar inflationary pressures observed in the aftermath of the 2016-2017 economic downturn, underscoring the cyclical nature of Nigeria's monetary vulnerabilities. Additionally, the influence of security-related disruptions, especially from 2019 onward, further highlights the critical role of internal instability and conflict in exacerbating food price volatility. This confirms that inflation in Nigeria, particularly food inflation, cannot be attributed solely to market trends but also reflects more profound structural and institutional weaknesses.

Given the significant weight of food in Nigeria's consumer price index and its direct impact on economic welfare, policymakers must adopt more deliberate and time-sensitive approaches in both fiscal and monetary responses. Relying solely on orthodox monetary policy tools may be insufficient without complementary structural reforms that address

security, logistics, and agricultural productivity. Therefore, a coordinated strategy that balances price stability with long-term investments in food systems and rural infrastructure is crucial for mitigating the persistent challenge of food inflation.

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The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

Data sharing statement

No additional data are available.

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