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The Causal and Dynamic Interactions between Petrol and Food Prices in Nigeria: A Toda-Yamamoto Causality Approach and Impulse Response Analysis

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ABSTRACT

This study explores the causal and dynamic interactions between petrol prices and food prices in Nigeria using monthly time series data from January 1995 to January 2025. Specifically, first, the study ascertained if changes in petrol prices can significantly predict food prices using the Toda-Yamamoto causality approach. Second, the study examined the dynamic response of food prices to price shocks or impulse in petrol prices using the impulse response function of the vector autoregression. It was discovered that a significant bi-directional causality relationship exists between petrol price and food prices in Nigeria. It was also discovered that increases in petrol prices lead to increases in food prices, suggesting a significant impact of petrol price shocks on food prices. The study concluded that petrol prices significantly predict food prices; and food prices respond positively to changes in petrol prices.

Keywords: Petrol, Food, Prices, Toda-Yamamoto, Impulse Response, Causality

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1. Introduction

Nigeria is a resource-rich nation where the government formulate and implement policies to harness the resources to enhance the welfare of the citizens. A crucial resource that is beneficial and is contributing to the total revenue of the Nigeria economy is crude oil. Crude oil alone accounts for 40% of the country's GDP, 70% of budget revenues, and 95% of foreign exchange earnings (World Bank, 2004). The discovery of crude oil has been a game changer for the wealth of the Nigeria economy. In fact, the earnings from the sale of crude oil affect government's planning decisions on ways to fulfill its obligations to initiate and implement sound economic policies for the welfare of people and the stability of the economy overtime (Ubi-Abai & Bosco, 2017; Udonwa & Ubi-Abai, 2018).

Crude oil is refined into different petroleum products that makes much of the modern world possible. Notably, the petroleum product that is created with around a half of every barrel of crude oil is petrol (SciMed, 2024). Petrol, referred to as Premium Motor Spirit (PMS) is resourceful to every sector of the economy. Petrol is used by nearly everyone, including small businesses and households (Okwa et al., 2024). The demand for petrol is termed inelastic because there are no adequate substitutes for petrol as sources of power for both public and private sectors coupled with the inability of the government to protect the economy from global oil shock (Azeez 2018).

Petrol prices have fluctuated over the years. A five-year interval analysis of petrol prices before the President Bola Ahmed Tinubu-led administration shows that petrol price increased from ₦0.60 in the year 1990 to ₦11 in the year 1995. It further increased to ₦30 in the year 2000 and ₦65 in the years 2005 and 2010. The upward trend in petrol price continued as the it reached an average of ₦87 in the year 2015. In the year 2020, the average price of petrol hits ₦148.02. The first quarter of the year 2023 saw the prices of petrol at ₦263.29, ₦254.06, ₦238.11 in January, February and March respectively (NBS, 2023). Economic activities are invariably affected because of the dependence on petrol as a source of energy, especially the prices of food. Moreover, rising petrol prices elevate production and transportation expenses, creating downstream effects on agricultural output costs and ultimately impacting farm profitability (Dillon & Barrett, 2016).

Over the years, the general and continuous rise in food prices depict the volatile nature of food prices. Inflation (Consumer prices) reduced from to 7.4% in the year 1990 to 6.9% in the year 2000 after reaching peak of 72.8% in the year 1995. It further increased to 13.7% and 13.2% in the year 2010 and the year 2020 respectively. Inflation has since maintained upward fluctuations (WD1, 2024). A better understanding of the country's food price dynamics is explained using an index, the Food Price Index (FPI). The food price index mirrors food price volatilities that are sensitive to local price shocks. It covers various food products, including bread, cassava meal, cowpeas, garri, groundnuts, maize, millet, rice, sorghum, and yam. Data collected from 53 markets shows that there was a 243% increase in nine food items which comprise bread, cassava meal, cowpeas, garri, groundnuts, maize, millet, rice, and sorghum from May 2010 to January 2023 (World Bank, 2024).

The data from the Food and Agriculture Organisation (2023) indicated the level of fluctuations in food prices. The annual food price index decreased from 76.3 in the year 1990 to 67.1 in the year 2000. It increased to 106.8 in the year 2010 and further increased to 125.1 and 145.5 in the year 2021 and the year 2022 respectively. Probably, the level of fluctuations in petrol prices aside the political, economic and social dynamics of Nigeria (Eruaga et al., 2023) can affect the prices of goods and services across the country, making it difficult for people to afford necessities (Okwa et al., 2024).

The Nigeria government had initiated and implemented the petrol subsidy policy in 1977 to ameliorate the possible impacts of fluctuating petrol prices on the welfare of people and businesses. The petrol subsidy policy mandated regulated pricing for essential commodities, including petrol, prohibiting sales above government-approved rates. Subsequent governments have made attempts to end the petrol subsidy policy due to some reasons that seem important, while putting in place some compensation mechanisms for the people (Adeoti et al, 2016). McCulloch et al. (2021) were of the view that the attempts by successive Nigerian governments to end petrol subsidy met stiff resistance by the citizens. Despite series of protests against the end of the petrol subsidy policy, the Federal Government under the President Bola Ahmed Tinubu-led administration ended the petrol subsidy policy in the year 2023. These actions signaled the end of the controversial petrol subsidy removal policy previous Administrations struggled with since the 1980s (Amadi, 2023; Suleiman et al., 2023)

Sadly, the removal of petrol subsidy altered the petrol and price dynamics which can affect the welfare of people. Petrol prices increased by almost 200% from ₦238.11 per litre in the month of March 2023 to ₦626.7 per litre in the month of July 2023. It continued its upward fluctuations to ₦696.79 per litre in January 2024, and increased to ₦1030.46 litre in July 2024 (NBS, 2024). The prices of petrol differed in different zones: ₦747.9 per litre in North Central;

₦815.34 litre in the North East; ₦820.1 litre in North West; ₦786.78 per litre in South-East; ₦678.3 per litre in South-South; ₦773.06 per litre in South West (Statista, 2024). The average prices of petrol after the petrol subsidy removal were ₦830.46 per litre for August 2024, ₦1030.46 per litre for September 2024, ₦1184.83 per litre for October 2024, ₦1060 per litre for November 2024 and ₦1030 per litre for December 2024 (NBS, 2023). Since petrol prices significantly influence Nigeria's cost of living, the volatilities of food prices reached levels that seemed unbearable. Inflation rapidly grew from 22.04% in May 2023 to 25.80% in August 2023 and 28.92% in December 2023. The upward fluctuation continued in June 2024 as headline inflation grew to 34.20% month on month and food inflation rose to 40.9% year on year. In October, headline inflation was 33.88% month on month and food inflation grew to 39.16% year on year (NBS 2024). By November 2024, Nigeria's inflation had risen for the third straight month advancing to 34.60% in annual terms (Ohuocha, 2024).

It is based on these observations that the study seeks to, first, examine the causal effects of changes in petrol prices on changes in food prices in Nigeria; and second, examine the dynamic response of changes in food prices to price shocks or impulse in petrol prices in Nigeria.

Many studies have analyzed effects of oil price on changes in Nigeria's food price. Few studies such as Nwoko et al., (2016) and Ngare and Derek (2021) analyzed the causal effects using pairwise granger causality for stationary variables – variables where the original data had been altered by differencing. Hence, this study seeks to use a better causality approach, the Toda and Yamamoto causality procedures, because it uses data in their original state. Kyarem and Dodo (2023) adopted the Toda and Yamamoto causality but did not present the procedures giving way to doubt the end results. This study presents a step-by-step appropriate procedure to undertake the Toda and Yamamoto causality.

Following the introduction, the study presents the review of related literature in section two. Section three presents the materials and method. Section four analyzes the data and discusses the findings; and section 5 concludes the study with appropriate recommendations.

2. Literature Review

2.1 Cost-Push Inflation Theory

The cost-push inflation theory examines how resources (input materials) used in the production, labour, capital and raw materials, affect the cost of producing goods and services which may influence prices and output. Petrol and its derivatives are used in agricultural production, such as operating machinery and irrigation systems. Hence, higher petrol prices can increase the cost of these inputs and vice versa. Moreover, increased production cost for farmers lead to higher prices for agricultural products, which are eventually reflected in food prices.

2.2 Transportation Cost Theory

Transportation cost theory focuses on how the costs of moving goods or services impact economic activities. Petrol, as a key input for transportation, tends to affect the prices of food in that when petrol price rises, the cost of transporting food from farms to processing facilities, warehouses and retail outlets increases. Definitely, higher transportation costs are often passed on to consumers in the form of higher food prices.

2.3 Theory of Consumer Behaviour (Income and Substitution Effects)

The income effect refers to the change in consumption of a good or service resulting from a change in the consumer's real income. The substitution effect refers in the theory of consumer behaviour to the change in consumption of a good or service resulting from a change in its relative price. Applicably, higher petrol prices reduce disposable income for consumers, as they spend more on fuel. This can lead to changes in consumption patterns, with consumers shifting focus to cheaper food options. While some food prices may decrease due to reduced demand, others may increase as consumers substitute away from more expensive options.

2.4 Empirical Literature Review

Some researchers have undertaken studies on petrol and food price fluctuations. Nwoko et al. (2016) examined the impact of oil price fluctuations on food price volatility in Nigeria. Annual data on oil price and individual prices of maize, rice, sorghum, soya beans, and wheat spanning from 2000 to 2013 were used. The unit root tests showed that all variables stationary at first difference; the Johansen co-integration test indicated no long-run relationship between oil price and any of the individual food price volatility. The VAR model result as well as the impulse response functions revealed positive and significant short-run relationships between oil price and each of the selected food price volatility with exception of rice and wheat price volatility. The Granger causality test indicated a unidirectional causality from oil price to maize, soya bean, and sorghum price volatilities but does not show such relationship for rice and wheat price volatilities.

Akpaeti et al. (2018) examined the relationship between petrol pump price fluctuations and agricultural productivity from 1970 to 2016, using the ordinary least squares and a multivariate vector error correction model. Their study found that while a positive growth rate of 7.86% was observed, it adversely affected the economy in the long term. Additionally, the VECM analysis indicated that petrol prices had a significant negative influence on agricultural productivity and key macroeconomic policy variables in both the short and long run. The researchers attributed this to reduced agricultural output and elevated interest rates, which deterred investment during the period under review.

Olasunkanmi and Oladele (2018) examined how oil price fluctuations influenced agricultural commodity prices in Nigeria, using monthly data from 1997 to 2016 on crude oil prices, maize, wheat, soybean, and exchange rates. The study incorporated dummy variables to account for structural breaks in commodity price trends. They used both linear and nonlinear autoregressive distributed lag models. Wald test results confirmed asymmetric effects, indicating that positive and negative oil price shocks of equal magnitude did not produce proportional impacts on agricultural prices. The findings revealed that rising oil prices consistently had a significant positive effect on agricultural commodity costs, suggesting that higher fuel prices drive up food prices.

Azeez (2018) employed a generalized autoregressive conditional heteroscedasticity framework to analyze how oil price volatility spills over into food prices across urban and rural areas, comparing the pre-crisis and the post-crisis periods. The study assessed impulse response functions and variance decomposition to measure these effects. Findings revealed that aggregate food prices and urban food prices exhibited a positive response to oil price shocks in both the full sample and post-crisis periods. In contrast, rural food prices responded negatively to the shocks. Notably, urban areas demonstrated heightened sensitivity to oil price fluctuations during the post-crisis phase, experiencing more pronounced impacts compared to rural regions.

Kanu (2019) analyzed the correlation between petroleum product prices and consumer goods prices in Nigeria from the timeframe 1996 to 2018. Utilizing the multiple ordinary least squares regression analysis, the research used secondary data such as prices of automotive gas oil (diesel), premium motor spirit (petrol), dual-purpose kerosene (household kerosene), and the consumer price index, sourced from the National Bureau of Statistics and Central Bank of Nigeria's Statistical Bulletin. The empirical results demonstrated statistically significant positive relationships between petroleum product prices (automotive gas oil, premium motor spirit, and dual-purpose kerosene) and consumer goods prices. The study concluded that fluctuations in these key petroleum products substantially influence the pricing of consumer commodities in the Nigerian market

Fasanya and Odudu (2020) conducted an investigation on return and volatility transmission patterns among Nigeria's primary agricultural commodities. They analyzed cross-market dynamics for five key crops - wheat, rice, soybeans, groundnut, and palm oil, using monthly price data from January 1980 to June 2017. The study employed the spillover approach and the rolling sample analysis to capture the inherent secular and cyclical movements in the Nigerian agricultural commodities market. The analysis revealed significant market interdependence among Nigeria's primary agricultural commodities. The research identified distinct behavioral patterns, with return spillovers demonstrating persistent trends while volatility transmissions occurred through intermittent bursts. Furthermore, the investigation pinpointed specific crisis periods that served as catalysts for the observed fluctuations in both returns and volatility within Nigeria's agricultural commodities markets.

Nwosu and Vincent (2020) evaluated the influence of price fluctuations on consumption behaviours for petrol, rice, and beans in Owerri, Imo State, Nigeria. Survey results revealed that 90% of respondents strongly agreed or agreed that prices for these commodities were highly unstable. Using the a**nalysis of variance**, the study found that **70% of consumers** acknowledged price as a significant factor affecting their purchasing decisions, regardless of necessity. Regression analysis indicated a **positive but statistically insignificant relationship** between price and consumption levels for all three commodities. This study revealed that **necessity** emerged as a more decisive factor than price sensitivity, underscoring the inelastic demand for these essential goods in the study area.

Ngare and Derek (2021) investigated the relationship between fuel and food prices by analyzing monthly data on diesel, maize, beans, cabbage, and potatoes from the year 2010 to the year 2018 using granger causality and cointegration tests. Their findings showed that diesel prices granger-caused price changes in perishable vegetables (cabbage and potatoes) but not in staple crops (maize and beans), while cointegration analysis confirmed a long-run equilibrium relationship between diesel and vegetable prices. The study revealed that the increase in diesel price significantly raised cabbage and potato prices, prompting the recommendation for implementing tax relief policies to help stabilize food costs.

Okereke and Obinna (2022) studied the relationship between petroleum product prices, exchange rates, and food inflation in Nigeria using monthly data from the year 2010 to the year 2021. Their findings revealed that premium motor spirit (petrol) prices and exchange rate fluctuations exerted statistically significant positive effects on food prices in both short-term and long-term periods. However, the study found no significant impact of automotive gas oil (diesel) prices on food item costs. These results suggested that petrol prices and currency exchange rates were influential drivers of food price inflation in Nigeria's economic landscape. They attributed petrol's substantial impact to its widespread usage across multiple sectors including agriculture, transportation, industry, and household consumption. Additionally, the study confirmed the critical role of exchange rate volatility in price instability, particularly given Nigeria's dependence on imported refined petroleum products and numerous food commodities.

Kyarem and Dodo (2023) used the autoregressive distributed lag estimation technique to analyze the dynamic relationship between fuel prices and food inflation in Nigeria from 1991 to 2021. Their empirical results revealed distinct temporal effects: PMS prices exerted a statistically significant positive influence on food prices in the short-run, while demonstrating a positive but insignificant long-run impact. The causality analysis yielded two important directional relationships: a unidirectional causal flow from food prices to PMS prices; and another unidirectional relationship where exchange rate movements granger-caused food price fluctuations. The findings suggested that fuel price shocks immediately affected food costs, but the inflationary effects diminished over extended periods. Moreover, exchange rate volatility emerged a more persistent determinant of food price dynamics in Nigeria.

Ozili (2023) used the discourse analysis methodology to examine the macroeconomic and microeconomic effects of Nigeria's 2023 fuel subsidy removal. Positively, it frees up financial resources for other sectors, boosts domestic refinery production, reduces fuel imports, creates jobs, and lowers budget deficits while curbing corruption and exchange rate pressure. However, negative impacts include short-term economic slowdown, higher inflation, increased poverty, fuel smuggling, crime, and job losses in the informal sector. To mitigate these effects, the study recommended the government should assess the policy's impact on citizens and businesses. The study also recommended to implement palliatives and relief programs to ease the hardship on individuals and firms.

Okwa et al. (2024) examined how fuel subsidy removal in Nigeria affected consumer goods, transportation, and house rent, with varying consequences. While some political economists and analysts argue that subsidy removal frees up resources, others contend it worsens poverty. Using the rentier state theory and a descriptive survey design with cross-sectional data, the research analyzed the policy's impact on consumer goods through frequency distribution, simple percentages, and the Wilcoxon rank test at a 5% significance level. Findings confirmed that subsidy removal raised the cost of consumer goods due to increased transportation and housing expenses, ultimately lowering Nigerians' standard of living.

Omotosho (2019) examined how oil price shocks and fuel subsidies impact Nigeria's economy using a new Keynesian dynamic stochastic general equilibrium model. Results showed oil shocks significantly influenced output, contributing to 22% of its fluctuations over four years. With subsidies, negative oil shocks reduced overall GDP but boost non-oil GDP, raise inflation, and weaken the exchange rate. Without subsidies, GDP contraction is milder, inflation falls, but exchange rate depreciation worsens short-term. Removing subsidies increased macroeconomic instability and affected monetary policy responses. The study recommended that subsidy reforms must include safety nets and sustainable adjustments to minimize negative consequences.

Ogwuche et al. (2024) investigated the impact of Nigeria's fuel subsidy payments on economic growth from 2005 to 2023 using quarterly data series. Analyzing GDP growth rate as the dependent variable against fuel subsidy expenditure, exchange rate, and inflation, the Johansen co-integration and vector error correction techniques revealed a significant negative relationship between subsidy spending and economic growth. The findings suggested redirecting subsidy funds to more productive sectors to stimulate economic growth. The study recommended policy shifts to optimize government expenditure for long-term economic benefits.

Umoru and Onishowo (2024) explored the impact of fuel subsidy removal on the performance of small and medium enterprises in Edo North, Nigeria. Specifically, it aimed to assess how the rising costs of production, supply chain, and finance influenced market share, profitability, and survival rates among SMEs. A descriptive survey research design was employed, with a sample of 288 SMEs selected randomly using Cochran's sample size formula. Data collected through structured questionnaires were analyzed using descriptive statistics and pearson product moment correlation at a 5% significance level. The findings showed a positive but insignificant relationship between production costs and SMEs' market share. Additionally, a negative correlation was observed between supply chain costs and profitability, while a significant negative correlation was found between financing costs and the survival rate of SMEs.

In summary, the literature reveals a complex relationship between fuel price fluctuations and food prices in Nigeria, with varying impacts across different commodities, regions, and timeframes. Studies such as Nwoko et al. (2016), Akpaeti et al. (2018), and Olasunkanmi and Oladele (2018) highlighted short-term positive effects of oil price shocks on food prices, though long-term cointegration is often absent. Urban areas tend to be more sensitive to fuel price changes than rural areas, as seen in Azeez (2018), while perishable vegetables like cabbage and potatoes are more affected than staple crops (Ngare & Derek, 2021). Fuel subsidy removal, examined by Ozili (2023) and Okwa et al. (2024), has mixed macroeconomic effects—freeing up fiscal resources but increasing inflation, poverty, and production costs, particularly for SMEs (Umoru & Onishowo, 2024). Additionally, exchange rate volatility and petrol prices are key drivers of food inflation (Okereke & Obinna, 2022; Kyarem & Dodo, 2023), while subsidy payments negatively impacted economic growth as observed by Ogwuche et al. (2024). The studies also collectively emphasized the asymmetric and multifaceted nature of fuel price impacts, with short-term volatility transmission (Fasanya & Odudu, 2020) and varying consumer responses (Nwosu & Vincent, 2020). While fuel price hikes generally elevate food costs, the extent depends on commodity type, market structure, and policy interventions.

Building upon existing literature, this study makes two key methodological contributions: First, it develops a systematic implementation framework for the Toda-Yamamoto causality test that addresses and eliminates potential serial correlation in errors. Second, it enhances the analysis through comprehensive shock examination via impulse response functions within a Vector Autoregression (VAR) framework. These methodological innovations aim to provide more robust empirical evidence on the dynamic relationships between the examined variables while overcoming common econometric limitations present in previous studies.

3. Materials and Methods

The *ex post* research design was appropriate for the study. It implies analyzing and understanding the consequences of a particular event after it occurred. It is fitting that the study seeks to analyze the consequences of the fluctuations of petrol price on changes in food prices in Nigeria.

3.1 Data and Sources

The data obtained are the Food Agricultural Organisation's (FAO) monthly data on Food Price Index and the National Bureau of Statistics' (NBS) monthly data of petrol prices. The time frame of the data is from January 1995 to January 2025.

3.2 Toda and Yamamoto Causality Analysis

The Toda and Yamamoto causality (1995) is built on the granger causality, which assesses whether one time series can predict another time series, without the need for pre-testing for cointegration or requiring variables to be of the same order of integration. Notably, it is useful when dealing with time series data in their original state (non-stationarity) unlike the traditional granger causality that deals with time series data that have been altered through differencing (stationarity)

The Toda-Yamamoto causality uses a modified Wald test within a Vector Autoregressive (VAR) model. A VAR model is a system of equations that describes how multiple time series evolve over time, allowing for interactions between them. The Toda-Yamamoto approach augments the VAR model with extra lags ($m + d_{max}$) and then tests the coefficients of those lags to determine if X can significantly predict Y.

The study uses a bivariate VAR ($m + d_{max}$) comprised of Food Price Index (FPI) and Petrol Price (PETROL) displayed in equation 1 and equation 2.

$$\mathrm{FPI} = \propto + \sum_{i-1}^{m} \beta\, \mathrm{FPI}_{t-i} + \sum_{i=m+1}^{m+dmax} \gamma\, \mathrm{FPI}_{t-i} + \sum_{i-1}^{m} \delta\, \mathrm{PETROL}_{t-i} + \sum_{i=m+1}^{m+dmax} \partial\, \mathrm{PETROL}_{t-i} + \mu_{1t} \quad (1)$$

$$PETROL = \emptyset + \sum_{i-1}^{m} \rho\, PETROL_{t-i} + \sum_{i=m+1}^{m+dmax} \varphi\, PETROL_{t-i} + \sum_{i-1}^{m} \tau\, FPI_{t-i} + \sum_{i=m+1}^{m+dmax} \omega\, FPI_{t-i} + \mu_{2t} \quad (2)$$

Where $\beta, \gamma, \delta, \emptyset, \rho, \sigma, \tau, \varphi, \omega, and \propto$ are parameters in equation 1 and 2; *m* is the lag length; d_{max} is the maximum order of integration; μ_{1t} and μ_{2t} are the residuals in both equations. The null hypothesis of non-causality between food price index and petrol price can be expressed as H_0: $\delta_i = 0, \forall\, i=1, 2, \ldots, m$.

Three steps are involved to implement the Toda-Yamamoto causality procedures. First, the test for unit root using the Augmented Dickey-Fuller (ADF) test to ensure the data is in its original state without alteration (differencing) for stationarity. This is important to avoid spurious regression, where results appear statistically significant even when no true relationship exists. Moreover, neglecting the stationarity of variables can lead to unknown maximum order of integration for variables which can lead to incorrect lag selection and present potentially invalid results. Equation 3 and equation 4 presents the Augmented Dickey-Fuller specifications:

$$\Delta\mathrm{FPI} = \propto + \beta t + \delta \mathrm{FPI}_{t-1} + \sum_{i-1}^{m} \theta\, \Delta\mathrm{FPI}_{t-i} + \varepsilon_t \quad (3)$$

$$\Delta\mathrm{PETROL} = \gamma + \varphi t + \omega \mathrm{PETROL}_{t-1} + \sum_{i-1}^{m} \vartheta\, \Delta\mathrm{PETROL}_{t-i} + \varepsilon_t \quad (4)$$

Second, the determination of the lag length (*m*). This is important to ensure a correctly specified VAR model to avoid misspecification errors. Moreover, choosing too few lags (underfitting) can leave out important dynamics, leading to omitted variable bias and invalid causality results. Choosing too many lags (overfitting) reduces degrees of freedom, increases estimation uncertainty, and may introduce false significance. There are many measures to determine lag length. The study presents the Akaike Information Criterion (AIC) in equation 5 and the Schwarz Information Criteria (SC) in equation 6

$$\mathrm{LogAIC} = \frac{2K}{n} + \mathrm{Log}\left(\frac{\mathrm{RSS}}{n}\right) \quad (5)$$

$$\mathrm{LogSC} = \frac{K}{n}\mathrm{Log}(n) + \mathrm{Log}\left(\frac{\mathrm{RSS}}{n}\right) \quad (6)$$

Where $\sum \mu_i^2$ is the Residual Sum of Squared (RSS) and K is the number of parameters including intercept and *n* is the number of observations.

Third, check for the presence of autocorrelation in the selected lag length, *m*. This ensures that the residuals are white noise, which confirms the VAR is well-specified; the causality results are reliable; and policy conclusions are trustworthy. Hence, it is recommended to increase the selected lag length from m, if serial correlation does exist, to a preferred lag length p that rejects the null hypothesis of no serial correlation.

Strictly following these three steps presents the Toda and Yamamoto causality procedures where the results are expected not to be spurious, the residuals are white noise leading to valid inferences and trustworthy policy recommendations. Aside ascertaining the predictive effect of petrol prices and food prices, the study seeks to trace how a shock to one variable affects the other variable over time.

3.3 The Impulse Response Function (IRF) Analysis

The impulse response function is a tool used in time series analysis to examine the response of a variable to a shock or impulse in another variable. The impulse response function is often used in conjunction with VAR models to reveal the dynamic relationships between variables over time. The study computes the impulse response functions between petrol prices and food prices to trace the impact of one-unit shock across time horizons.

4. Data Analysis and Discussion

Having explained some data in the introductory section, Figure 1 shows the trends in the food prices and petrol prices during the period under study.

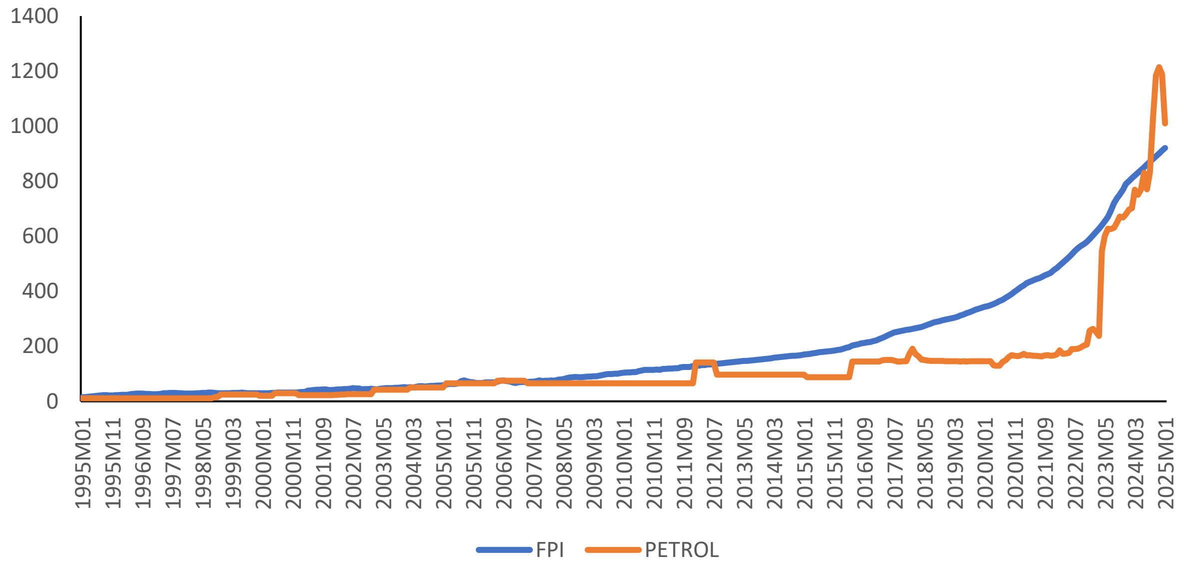

Figure 1: Trend in monthly data on petrol prices and food prices in Nigeria, 1995-2025

The trend in food price index shows a gradual upward trend in food prices from January 1995 which continued to November 2007. The trend in food prices continue unabatedly till January 2025. The trend in petrol prices is similar to that of food prices from January 1995 until August 2011 when it started showing tremendous increases in prices. Trend in petrol prices reached peak in 2023 with the fuel-subsidy removal policy which serves as a shock to critical subsectors of the economy especially, changes in food prices. Figure 1 shows that subsequent reductions in petrol prices have insignificant effect on the unbearable increase in food prices. Perhaps, an unbiased and valid causal relationship between petrol prices and food prices is necessary.

4.1 The Toda-Yamamoto Causality Analysis

The study tested for causality relationship between monthly petrol prices and monthly food prices using the Toda-Yamamoto approach. First, the monthly data were subjected to unit root tests to determine if the variables were non-stationary at their levels (the original data are not altered). Table 1 shows the unit root test of the data on petrol prices and food prices.

Table 1: Augmented Dickey-Fuller and Phillips Perron Unit Root Test

Augmented Dickey-Fuller (ADF)					
SN	Variables	Levels (I_0)	1st Diff. (I_1)	2nd Diff. (I_2)	Remark
1	FPI	1.0000	0.3851	0.0000	(I_2)
2	PETROL	1.0000	0.8568	0.0000	(I_2)
Phillips-Perron (PP)					
SN	Variables	Levels (I_0)	1st Diff. (I_1)	2nd Diff. (I_2)	Remark
1	FPI	1.0000	0.0360		(I_1)
2	PETROL	1.0000	0.0000		(I_1)

Note: Values are Probability Values (P-value)

Table 1 present the level of stationarity of the two variables, petrol price and food price. For the ADF test, FPI and PETROL are both stationary at second difference; while they were both stationary at the first difference using the PP test. Notably, the Toda-Yamamoto causality procedures use time series data that are non-stationary, that is, variables that are not altered in their original state. Table 1 confirms that both FPI and PETROL are not stationary at their levels (1.000 respectively). In other words, the data on FPI and PETROL are in their original state.

The next step was to select appropriate lag length using the Akaike Information Criteria (AIC) and the Schwarz Information Criteria (SC). Table 2 shows the appropriate lag for the two variables.

Table 2: Lag Length Selection

Lag	**LogL**	**LR**	**FPE**	**AIC**	**SC**	**HQ**
0	-4438.766	NA	3.34e+08	25.30351	25.32551	25.31227
1	-2365.319	4111.450	2530.159	13.51179	13.57779	13.53806
2	-2258.510	210.5762	1408.430	12.92598	13.03598	12.96976
3	-2252.966	10.86707	1396.102	12.91718	13.07117	12.97847
4	-2231.967	40.92001	1267.237	12.82033	13.01831	12.89912
5	-2212.711	37.30512	1161.751	12.73340	12.97538*	12.82971
6	-2209.730	5.742022	1168.545	12.73920	13.02518	12.85302
7	-2208.172	2.982091	1184.964	12.75312	13.08310	12.88445
8	-2193.639	27.65757	1115.993	12.69310	13.06708	12.84194
9	-2179.841	26.10272	1055.457	12.63727	13.05525	12.80362
10	-2166.561	24.97101*	1001.172*	12.58439*	13.04637	12.76826*

Source: E-views 13

Table 2 shows that the maximum selected lags of 10 was selected by the AIC, while the maximum selected lags for the SC is 5. It is important to know that the acceptance of the selected lag lengths for either AIC and SC depends on the absence of serial correlation in errors. This makes the model valid. Hence, the autocorrelation LM residual test was undertaken to ensure the selected lag lengths are devoid of serial correlation of errors. Table 3 presents the VAR residual serial correlation LM test.

Table 3: VAR Residual Serial Correlation LM Tests

LAG	LRE* STAT	DF	PROB.	RAO F-STAT	DF	PROB.
1	11.07715	4	0.0257	2.787250	(4, 702.0)	0.0257
2	6.885370	4	0.1421	1.727339	(4, 702.0)	0.1421
3	16.16135	4	0.0028	4.081323	(4, 702.0)	0.0028
4	24.81270	4	0.0001	6.304964	(4, 702.0)	0.0001
5	10.41577	4	0.0340	2.619596	(4, 702.0)	0.0340
6	12.59057	4	0.0135	3.171480	(4, 702.0)	0.0135
7	11.52149	4	0.0213	2.899974	(4, 702.0)	0.0213
8	16.57889	4	0.0023	4.188016	(4, 702.0)	0.0023
9	44.30962	4	0.0000	11.41769	(4, 702.0)	0.0000
10	19.49365	4	0.0006	4.934579	(4, 702.0)	0.0006
11	9.421673	4	0.0514	2.367900	(4, 702.0)	0.0514
12	4.500475	4	0.3425	1.127122	(4, 702.0)	0.3425
13	6.274076	4	0.1796	1.573298	(4, 702.0)	0.1796
14	23.35162	4	0.0001	5.927504	(4, 702.0)	0.0001
15	18.76806	4	0.0009	4.748445	(4, 702.0)	0.0009

Source: E-views 13

Table 3 shows that there were serial correlations in the residuals for selected AIC lag length of 10, which is 0.0006, and the selected SC lag length of 5, which is 0.0340. The null hypothesis of no serial correlation was accepted in both AIC and SC. In order to ensure an appropriate lag length with no serial correlation in the residuals, the lag length was extended to lag 12 where the null hypothesis of no serial correlation in residuals was rejected because the p-value is 0.3425. Hence, the study selected 12 lags as the appropriate lag length for the VAR model.

Having ascertained the appropriate lags, the next step was to estimate the bivariate VAR with 12 lags, and determine the Toda-Yamamoto causality between food prices and petrol prices. Table 4 presents the results of the causality procedures.

Table 4: Toda-Yamamoto Causality Test

Dependent Variable: FPI			
Excluded	Chi-square	df	P-value
Petrol	112.2886	12	0.0000
All	112.2886	12	0.0000
Dependent Variable: PETROL			
Excluded	Chi-square	df	P-value
FPI	67.05898	12	0.0000
All	67.05898	12	0.0000

Source: E-views 13

Table 4 shows that petrol prices significantly granger causes food prices and food prices significantly granger causes petrol prices. Hence, there is a significant bi-directional causality relationship between petrol price and food price, flowing from petrol price to food price and food price to petrol price which suggests a close level of interconnectedness.

With respect to petrol prices granger causing food prices, transportation cost, production cost and inflationary spillover are significant factors. Petrol is a major input for transportation in Nigeria, where most goods (including food) are moved by road. Higher petrol prices increase the cost of transporting agricultural produce from rural farms to urban markets, raising food prices. Many farmers rely on petrol-powered machinery and generators due to unreliable electricity. Higher fuel costs raise the cost of cultivation, processing, and storage, which is passed on to consumers. Petrol price hikes often trigger broader inflation, as businesses adjust prices to cover increased logistics and operational expenses, indirectly affecting food prices.

With respect to food prices granger causing petrol prices, demand for biofuel and wage-price spiral are significant factors. Food prices have likely surged due to supply shortages emanating from conflicts in the mostly agrarian Northern Nigeria or through climate shocks. Hence, the government as well as the private sector, through the Nigerian Biofuel Policy and Initiatives, implemented in 2007 which aim to reduce reliance on imported petrol and create sustainable biofuels industry. These initiatives have led to increasing demand for petrol-derived inputs (like fertilizers or fuel for processing), indirectly pushing up petrol prices. Also, high food prices can lead to demands for higher wages, including refinery workers or transporters in the petroleum sector. These acts have led to increased labour costs which raises petrol production and distribution costs.

4.2 The Impulse Response Function Analysis

The study sought to analyze the dynamic relationship between food prices and petrol prices by seeking to understand and analyze how food prices respond to unexpected changes in petrol prices. Figure 2 present the impulse response analysis between food prices and petrol prices in Nigeria during the period under study.

Figure 2 shows the food price response to petrol price shock, food price response to food price shock, petrol price response to food price shock and petrol price response to food price shock. These scenarios have implications for each variable, the economy and policy makers.

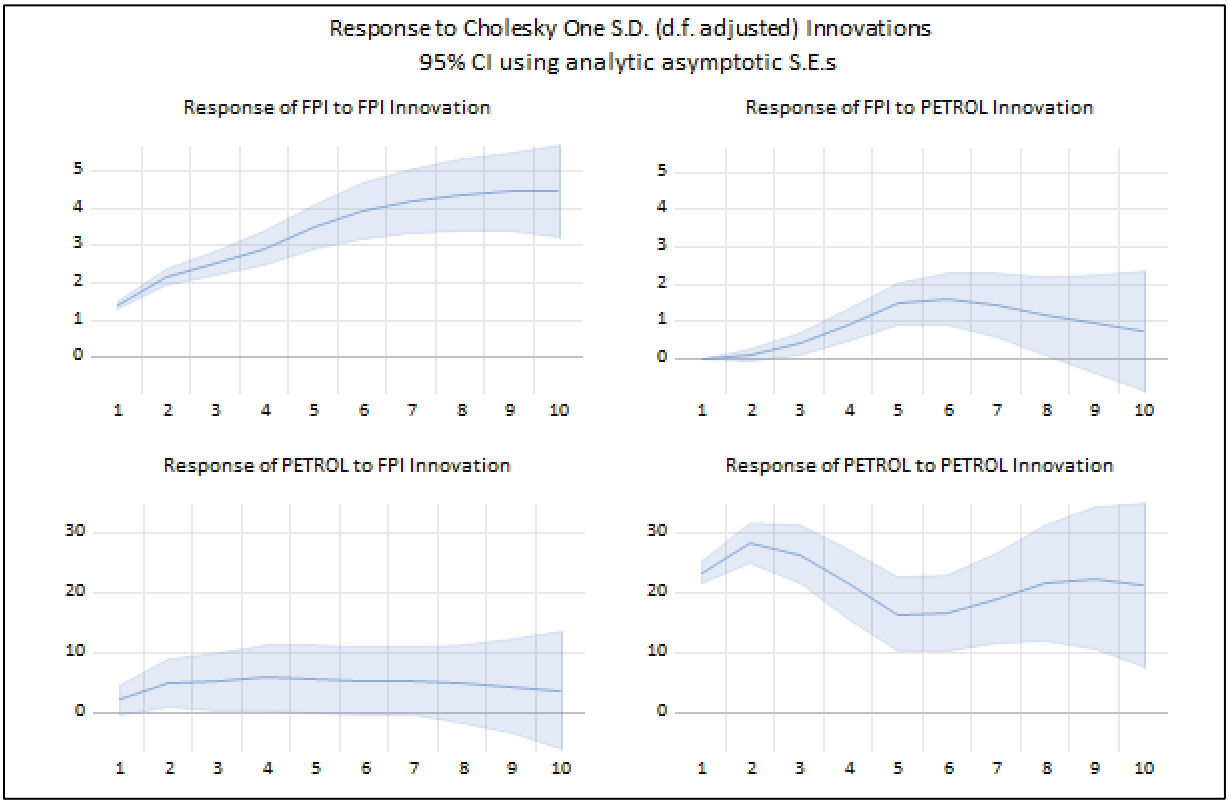

Figure 2: Impulse Response Function between Food Prices and Petrol Prices

4.2.1 Food Price Response to Petrol Price Shock

The response is positive, indicating that an increase in petrol prices leads to an increase in food prices. The response rises from 0 and peaks at 1.7, suggesting a significant impact of petrol price shocks on food prices. The response then declines to 0.7, indicating that while the impact diminishes over time, it remains positive and significant. The possible interpretations are that increased petrol prices led to higher transportation costs for food, contributing to food prices increase. Moreover, petrol price shocks affected production costs, particularly for agricultural products, leading to higher food prices.

4.2.2 Food Price Response to Food Price Shock

The response is positive, indicating that a shock to food prices leads to further increases in food prices. The response ranges from 1.4 to 4.5, suggesting a significant and persistent impact of food price shocks on themselves. The positive response could indicate price momentum, where changes in food prices tend to persist or even amplify over time. This finding might reflect market dynamics, such as supply and demand imbalances, that contribute to food price volatility. The findings suggest that food price shocks can have lasting impacts on food price levels.

4.2.3 Petrol Price Response to Food Price Shock

The response is positive which indicates that an increase in food prices leads to an increase in petrol prices. The response magnitude is between 0 and 10, suggesting a moderate to significant impact. This implies that increased food prices might lead to higher transportation costs, contributing to petrol price increases. The positive response could reflect the interconnectedness of economic variables, where changes in one sector (food prices) affect another (petrol prices).

4.2.4 Petrol Price Response to Petrol Price Shock

The response is positive, indicating that a shock to petrol prices leads to further increases in petrol prices. The response rises from 20 and peaks at 27, suggesting a significant initial impact. It then declines to 15, indicating a temporary adjustment. It further rises again to 22 and reduces to 21, showing some persistence and fluctuation. The findings suggest that petrol price shocks can lead to significant and persistent price fluctuations. This response pattern might reflect market dynamics, such as supply and demand imbalances, speculation, or external factors influencing petrol prices.

5. Conclusion and Recommendation

The study concludes that changes in petrol prices have significant predictive effects on food prices in Nigeria. The bidirectional Granger causality between petrol and food prices in Nigeria highlights the interconnectedness of the energy and agricultural sectors, necessitating integrated policy approaches. The study concludes that changes in petrol price can contribute to increasing food prices. Moreover, changes in food prices can have lasting impacts on food price levels. The findings highlight most importantly the challenges in maintaining petrol price stability as interventions in one market may have unintended consequences in the other.

The study gives the following recommendations:

To stabilize prices, the government could prioritize reducing dependence on imported petroleum products by investing in domestic refining capacity, such as operationalizing the Dangote Refinery and rehabilitating state-owned refineries. This would mitigate fuel price volatility caused by exchange rate fluctuations and global oil market shocks, indirectly stabilizing food prices by lowering transportation and production costs. Simultaneously, targeted subsidies or price controls on essential food items during periods of sharp inflation could provide short-term relief, though these measures must be carefully designed to avoid market distortions and fiscal strain.

Long-term strategies should focus on improving agricultural productivity and reducing post-harvest losses to decouple food prices from energy inputs. Policies such as expanding access to affordable renewable energy for irrigation and processing, promoting climate-smart agriculture, and upgrading rural infrastructure would enhance supply chain resilience. The government could also establish strategic grain reserves and buffer stocks to dampen price spikes during supply disruptions. On the energy side, accelerating the transition to renewable energy sources for agricultural value chains, such as the solar-powered cold storage, would reduce the sector's exposure to petrol price volatility while aligning with climate goals.

Macroeconomic reforms are equally critical to address the structural drivers of price instability. A managed float of the naira, combined with monetary policies to curb inflation, could reduce the pass-through effect of petrol prices on food costs. Cross-sectoral coordination through a dedicated "Energy-Food Price Stability Task Force" could enable real-time monitoring and rapid response to emerging crises. Moreover, International partnerships, such as the African Continental Free Trade Area, could be leveraged to secure stable food and energy supplies during domestic shortfalls. These measures must be accompanied by social protection programs, such as cash transfers, to shield vulnerable populations during transitional periods, ensuring that stabilization efforts do not exacerbate poverty.

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