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Analysing the Impact of Macroeconomic Variables on Food Inflation: A Robust Regression Model Approach

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Abstract

This study investigates the influence of macroeconomic variables on food inflation using a robust regression modeling approach. The period of study was from 2004 to 2023. Data on macroeconomic variables and food inflation rates were collected from the Nigeria Bureau of Statistics (NBS) and the Central Bank of Nigeria (CBN). The data were analyzed to quantify the impact of each factor on food inflation dynamics. The regression model derived from the analysis reveals that the positive coefficient of 0.631 indicates that an increase in the interest rate is associated with higher food inflation rates. Crude oil price influence with a coefficient of 0.084 has a modest positive effect on food inflation, highlighting the interconnectedness of energy costs and food pricing. Further, the coefficient of 0.020 suggests that changes in the exchange rate also contribute to food inflation variations, reflecting the impact of currency fluctuations on import costs and food prices.

Keywords: Food Inflation, Macroeconomic variables, Robust regression model, Interest rates, Crude oil prices, Exchange rates, Economic Analysis, Price Dynamics.

1. Introduction

Food inflation, a crucial component of overall inflation, directly impacts consumers purchasing power and economic stability. Understanding the factors that drive food price fluctuations is essential for policymakers, economists, and businesses to make informed decisions and develop effective strategies. Through a regression model analysis, this study investigates the relationship between food inflation rates and key macroeconomic variables:- specifically, interest rates, crude oil prices, and exchange rates. Interest rates are pivotal in shaping borrowing costs, investment decisions, and overall economic activity. Changes in interest rates can have ripple effects on consumer spending, production costs, and inflation influencing food prices. Crude oil prices are fundamental to various aspects of the food supply chain, affecting transportation costs, production expenses, and packaging materials. Fluctuations in crude oil prices can directly impact the costs of producing and delivering food products, ultimately influencing food price inflation rates.

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Exchange rates, reflecting the value of one currency compared to another, are critical for international trade and can impact the prices of imported food items. Changes in exchange rates can affect the cost of imported food products, influencing overall food inflation levels. By examining the interactions between interest rates, crude oil prices, exchange rates, and food inflation rates, this study aims to uncover the drivers of food price dynamics and provide insights into the complex relationship between macroeconomic variables and food price inflation. Through this analysis of the formulated regression model, the study seeks to shed light on how variations in interest rates, crude oil prices, and exchange rates directly affects food price inflation rates. The findings of this study have the potential to offer valuable insights for policymakers and stakeholders in managing food price volatility, enhancing economic stability and promoting informed decision-making in the realm of food economics and finance.

2. Review of Related Literature

Asharami et al., (2022) investigated the impact of macroeconomic factors on food price inflation in India, they utilized the monthly time series from 2006 to 2019. It was reported from their study that the coefficient of long-run estimates shows that per-capital income, money supply, global food prices, and agricultural wages are positively and significantly impacted on food price inflation. The depreciation of the real exchange rate increases food price inflation by expanding the cost of importing petroleum products, fertilizer, and other finished products relating to agricultural commodities, leading to rising domestic market prices. In other words, the depreciation of the exchange rate directly affects the agricultural sectors. Changing the prices of tradable and non-tradable goods resulted in a change in the prices of agricultural products in favour of the farmer. Taylor and Spriggs (1989). Bhattacharya and Jain (2020) submitted that an unexpected monetary tightening induces food price inflation in emerging and developed countries. Akinbode et al., (2021) reported that food production, exchange rate, money supply, and crude oil prices were significant in the short run while all of these except food production were significant in the long run. Akinbobola, (2012) reported that in the long run, money supply and exchange rate have significant inverse effects on inflationary pressure, while real output growth and foreign price changes have direct effects on inflationary pressure. Chinezelum et al., (2023) employed a non-linear auto-regressive distributed lag model to investigate the relationship between Nigeria's monetary policy and food inflation and reported that the exchange rate negatively affects food prices, while both the money supply and monetary policy rate, positively influence food inflation. Amanuel and Amsalu, (2022) investigated the dynamics of food price inflation and its determinants in Ethiopia, and the auto-regressive distributed lag (ARDL) co-integration model was employed for data analysis,. They reported that food price inflation was significantly influenced by previous food prices in the short run but showed a negative relationship in the long run. Further, their findings indicate that money supply and exchange rates positively affect food price inflation in both the short and long run, while real GDP negatively impacts it. Teena and Shivakumar, (2022) results revealed a long- run co-integration relationship between variables, with three co integration equations. From the study of Saini et al., (2020), there was a food - wage

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spiral in which changes in food prices and agricultural wages are anticipated to affect each other. Bhattacharya and Sen Gupta, (2018) reported that agricultural wage inflation is a universal cause of food inflation. Their analysis also indicated a minor impact on fuel and international prices in India. In kenya, crude oil prices significantly impact food inflation Lidiema, (2020). Malhortra and Maloo (2017), and Gupta (2014) found that international prices performed a limited role in explaining variations in domestic food prices.

3. Materials and Methods

Data Sources:

Food Inflation Rate Data: Quarterly data on food inflation rates from 2004 to 2023 were sourced from NBS and CBN.

Macroeconomic Variables Data: Data on Interest rates, Crude oil prices, and exchange rates were collected from NBS and CBN.

Variable Selection:

Dependent Variable: The dependent variable in the regression model was the food inflation rate.

Independent Variables: The independent variables include interest rates, crude oil prices, and exchange rates.

Regression Model:

Model Specification: The regression model used in the analysis was formulated as

Food Inflation Rate $= \beta_0 + \beta_1 (Inflation\ Rate) + \beta_2 (Crude\ Oil\ Price) + \beta_3 (Exchange\ Rate) + \epsilon.$

Statistical Analysis: Robust regression analysis was conducted to estimate the coefficients of the independent variables and assess their significance.

Statistical software: Statistical software, R - programming language was used for data analysis.

Data Processing:

* Data cleaning: Data cleaning techniques were employed to handle missing values, outliers, and inconsistencies in the dataset.

* Normalisation: Variables were standardized or normalised to ensure comparability and mitigate scale effects during regression analysis.

Model Evaluation:

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* Goodness of fit: The goodness of fit of the regression model was assessed using metrics such as R- Squared, adjusted R - Squared, and F - Statistic.

* Heteroskedasticity and Multicollinearity: Diagnostic tests were conducted to check for issues such as heteroskedasticity and multicollinearity.

Limitations:

* Data Limitations: Potential limitations related to data quality, availability, and measurement errors were acknowledged.

* Model Assumptions: Assumptions underlying the regression model, such as linearity and independence of errors were considered.

4. Data Analysis and Discussion

Diagnostic Checks:

Table 1. Test for normality

Variables	Kolmogorov-Smirnov			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Food Inflation Rate	0.323	80	<0.001	0.460	80	<0.001
Interest Rate	0.428	80	<0.001	0.298	80	<0.001
Crude Oil Price	0.175	80	<0.001	0.799	80	<0.001
Exchange Rate	0.261	80	<0.001	0.788	80	<0.001

Employing Kolmogorov-Smirnov and Shapiro-Wilk tests, the hypotheses that the variables are normally distributed were rejected ($p<0.05$) as shown in Table 1. Hence, the data violated the assumption of normality.

Table 2: Model Summary (Autocorrelation test)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	0.971[a]	0.942	0.940	5.340	0.642

a. Predictors: (Constant), Exchange Rate, Crude Oil Price, Interest Rate
b. Dependent Variable:
Food Inflation Rate

Durbin-Watson shows values between 0 and 4. Ideally, its value should near 2. Values greater than 3 or less than 1 are strong indicators of correlated residuals. Table 2 reveals a Durbin-Watson value of 0.642, meaning that the residuals are auto correlated.

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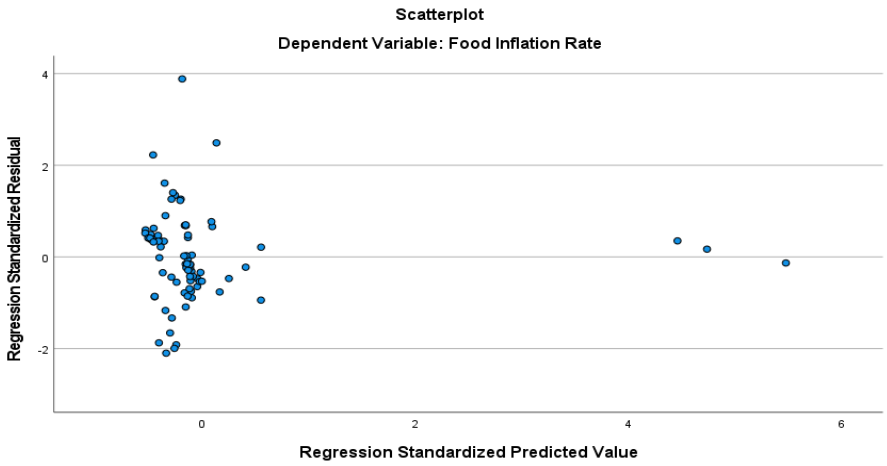
Table 3: Coefficients (Multi-collinearity test)

	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	-7.172	2.018		-3.554	0.001	-	-
Interest Rate	0.597	0.032	0.777	18.594	<0.001	0.434	2.305
Crude Oil Price	0.111	0.023	0.197	4.766	<0.001	0.445	2.249
Exchange Rate	0.022	0.004	0.161	5.756	<0.001	0.963	1.038

a. Dependent Variable: Food Inflation Rate

Variance Inflated Factors (VIF) greater than 5 are strong indicators of multicollinearity. Table 3 shows the VIF of the dependent variables are all less than 5, this implies that multicollinearity does not exist among the independent variables.

Fig 1: Residual versus Predicted plot (Heteroscedasticity test)



A scatter plot of residual against the predicted value should show a random rectangular shape, pattern or funnel shape means an indicator of heteroscedasticity. Figure 1 shows a funnel shape, that is, the assumption is violated.

Robust Regression Model

Since three of the assumptions of the traditional regression are violated, this suggests a robust regression model so that the violated assumptions can be taken care of.

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Table 4: Coefficients of Bi-Square Weighting function

Coefficients	Estimate	SE	t value	p value	Sig
Intercept	-5.425	1.754	-3.093	<0.001	***
Interest Rate	0.631	0.028	22.623	<0.001	***
Crude Oil Price	0.084	0.020	4.119	<0.001	***
Exchange Rate	0.020	0.003	6.200	<0.001	***
Residual Standard Error = 3.573					

a. Dependent Variable: Food Inflation Rate

The results of the Bi-Square Weighting function robust regression are presented in Table 4. The results reveal that interest rate, crude oil price, and exchange rate significantly contributed to the food inflation rate.

The model is given as: Food Inflation Rate

$$= -5.425 + 0.631(\text{Interest Rate}) + 0.084(\text{Crude Oil Price}) + 0.020(\text{Exchange Rate}) + \epsilon.$$

A unit change in interest rate will result in an additional 0.631 in inflation rate keeping all other variables constant. Likewise, a unit change in crude oil price and the exchange rate will bring about an additional 0.084 and 0.020 respectively to the food inflation rate. The residual standard error of 3.573 (Table 4) makes this model better compared to the residual standard error of 5.340 (Table 2) from the traditional regression.

Findings

The model suggests that changes in the inflation rate, crude oil prices, and exchange rates have varying impacts on food inflation rates.

Interest Rate (IR) Impact: The positive coefficient of 0.0631 indicates an increase in the interest rate, suggesting a potential link between monetary policy decisions and food price dynamics.

Crude Oil Price (COP) Influence: With a coefficient of 0.084, crude oil price fluctuation has a modest positive effect on food inflation, highlighting the interconnectedness of energy costs and food pricing.

Exchange Rate (ER) Effect: The coefficient of 0.020 suggests that changes in the exchange rate also contribute to food inflation variations, reflecting the impact of currency fluctuations on import costs and food prices.

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4. Conclusion

In conclusion, this study has delved into the intricate relationships between food inflation rates and significant macroeconomic variables, interest rates, crude oil prices, and exchange rates. Through a robust regression model analysis, valuable insights have been uncovered regarding the direct impacts of these variables on food price dynamics.

The findings of this study reveal that interest rates, crude oil prices, and exchange rates have distinct influences on food inflation rates. The positive coefficient associated with interest rates suggests that changes in interest rates are positively correlated with food inflation, indicating that fluctuations in borrowing costs can impact food prices. Similarly, the positive coefficients for crude oil prices and exchange rates highlight the direct effects of these factors on food price inflation, reflecting the importance of transportation costs, production expenses, and international trade dynamics in shaping food prices.

These results underscore the complexity of factors influencing food price inflation and emphasize the interconnected nature of macroeconomic variables within the food supply chain. Understanding these relationships is crucial for policymakers, economists, and stakeholders in formulating effective strategies to manage food price volatility and promote economic stability.

The implications of this study extend to decision-making processes in economic policy formulation, market forecasting, and risk management strategies. By recognizing the significant role of interest rates, crude oil prices, and exchange rates in shaping food price inflation dynamics, stakeholders can make informed decisions to mitigate risks, enhance consumer welfare, and foster sustainable economic growth.

Moving forward, further research and analysis in this area could explore additional variables, consider dynamic relationships over time, and investigate the potential for policy interventions to mitigate the impacts of macroeconomic fluctuations on food prices. By our understanding of these dynamics, we can contribute to more resilient and efficient food systems in the face of evolving economic landscapes.

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Future studies on food price inflation could consider incorporating additional macroeconomic variables to provide a more comprehensive understanding of the factors influencing food inflation price dynamics. For instance:

1. GDP Growth: The overall economic performance, as indicated by GDP Growth rates, can impact consumer's purchasing power and demand for food products, influencing food price inflation.
2. Unemployment Rate: Changes in unemployment rates can affect household incomes and consumer spending patterns, thereby influencing food consumption and prices.
3. Wage Growth: The rate of growth in wages can impact consumers' ability to afford food items and may influence demand side inflationary pressures.
4. Money Supply: Fluctuations in the money supply can impact aggregate demand, potentially affecting food prices through changes in consumer purchasing power.
5. Government Policies: Fiscal and monetary policies, such as taxation, subsidies, and interest rate decisions, can have direct and indirect effects on food price inflation rates.
6. Commodity Prices: Beyond crude oil prices, the prices of other commodities like grains, meats, and dairy products can also impact food price inflation rates, especially for specific food categories.
7. Weather conditions: Weather patterns and natural disasters can significantly affect agricultural production, crop yields and food supply, influencing food prices.
8. Supply Chain Disruptions: Disruptions in global supply chains, such as trade barriers, transportation issues, or geopolitical events, can impact on food prices through changes in supply and distribution costs.
9. Consumer Sentiment: Consumer confidence and sentiment can influence spending behaviours and overall demand for food products, thereby affecting food price inflation.
10. Technology and Innovation: Advancements in technology and agricultural practices can impact production efficiencies, supply chain management, and ultimately food prices.

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