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Impact of Cereal Production on Food Inflation in Nigeria: A Time Series Analysis

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Abstract

This research investigates how the production of cereal commodities affects the rise in food prices in Nigeria by analyzing quarterly time series data from 2008 to 2022. The focus is to study the link between cereal production (such as maize, rice, wheat, sorghum, millet and soybeans) and food inflation. Additionally, the study investigates the factors influencing cereal output in Nigeria. Data, for this research were gathered from the Food and Agriculture Organization (FAO), the Central Bank of Nigeria (CBN), and the National Bureau of Statistics (NBS). Various analytical methods are used such as the Augmented Dickey Fuller (ADF) Philip Perron Unit Root tests ARDL model (ARDL) Vector Error Correction Model (VECM) Impulse Response Function analysis, Wald Test and Granger Causality test. The findings show that cereal production has a one-way impact on food price increases; this means that fluctuations in cereal output play a role in shaping food price trends over time. Maize rice and wheat production were identified as the drivers of food inflation changes, whereas millet and soybeans had little effect on food prices. The VEC Model estimation suggests that corrections to deviations from the long-term balance in food inflation occur slowly at 5% which means only a small portion of any imbalance is rectified each quarter. The impulse response analysis also reveals that corn (maize) rice, sorghum, and wheat have an impact on food inflation trends whereas millet shows a negative impact, in the short term. The analysis of variance breakdown shows that 83 percent of the fluctuations in food prices can be attributed to factors within the food market itself; specifically, rice, wheat, soybeans and millet collectively contribute to 13.94 percent of the long-term fluctuations. The research underscores the importance of Nigeria's Federal Ministry of Agriculture and Rural Development (FMARD) focusing on enhancing cereal production methods by ensuring access to quality seeds, fertilizers, machinery and irrigation systems. Additionally tackling security challenges in all regions is vital for stabilizing food costs and achieving food security.

Keywords: Inflation, Cereal Commodity, Cereal Price, Food Inflation, Cereal Production, Agricultural Policy, Price Stability, Nigeria.

Introduction

Food inflation, an aspect of inflation, refers to the consistent rise in prices of food items over time. When analyzing food inflation, it is important to delve into the factors that influence markets and households. At the core of the analysis lies the interplay between supply and demand. In terms of food inflation, supply side elements encompass productivity, weather conditions and technological advancements in farming. Any disruption in the supply chain like disasters or bottlenecks can result in reduced supply and higher prices. On the demand side, factors such as changes in consumer preferences, population growth and income levels play a role. For example, a global population increase or rising incomes can lead to demand for food products exerting upward pressure on prices.

Production cost is another critical factor that impacts on the price of food items. Costs associated with inputs like seeds, fertilizers and energy influence decisions made by producers. If these costs increase due to factors like rising oil prices or disruptions in the supply chain, producers may transfer these expenses to consumers thereby contributing to food inflation.

Understanding consumer behaviour is another aspect of microeconomics when it comes to analyzing food inflation. The concept of elasticity helps us understand how changes in price impact the quantity demanded. Goods that are considered essential like foods may still be in demand when their prices increase due to their necessity. This can contribute to food inflation.

Access to food is crucial for survival. However, the overall rise in food prices poses a threat to low-income earners' ability to fulfill this need. In households on average, staple foods derived from cereals such as wheat, corn, rice, millet, soybean and sorghum play a role in sustaining their health and wellbeing. The proportion of household income spent on these food items has steadily risen from 26.4% in 2011 to 56.5% in 2019 (NBS, 2020). This increase can be attributed to the rise in food inflation rates which reached an average of 22.12 percent in 2022 compared to 13.43 percent in 2016 (*Ejechi, 2023; Sasu, 2022*). The first half of 2022 witnessed a rise in prices of food, fuel and fertilizer. This increase can be largely attributed to the aftermath of the conflict in Ukraine and subsequent sanctions imposed on Russia (*Hebebrand & Laborde, 2022; Arndt, et al, 2023*) as ongoing supply chain disruptions caused by Covid-19. A scholar suggests that if expenditure on food exceeds total family income it indicates underlying issues with economic and political conditions within that country (*Njegovan & Simin, 2020*).

Some scholars have connected the surge in food prices to factors such as currency exchange rates, interest rates, oil prices, money circulation, yearly rainfall patterns and costs related to inputs. Other studies point out that the global spike in food costs can be attributed to elements like weather conditions, speculative activities, high petroleum prices and export limitations imposed by different nations. The hike in food prices not only diminishes households buying power but also affects their consumption habits leading to a decline in the consumption of well-rounded meals. This situation sets the stage for health hazards (*Uddin et al., 2014; Ahmed & Singla, 2015; Qayyum & Sultana, 2018; Akinbode et al., 2020; Sefa & Ozbugday, 2021; Wellington, 2021; Durevall et al., 2013*).

Staple grains like rice, maize, wheat, millet and sorghum are basic food components for a large portion of Nigerians. Nonetheless Nigeria heavily relies on importing over half of these staples to make up for its production levels (*FAO, 2021*). The yearly output of maize, rice, wheat and sorghum falls short of the country's demand. For instance, Nigeria's rice production rose from 3.7 million tons in 2017, to 5.0 million tons in 2019. Despite this growth, 57% of the 6.7 million tons of rice consumed in Nigeria annually is produced within the country resulting in a shortfall of, around 3 million tons that are either brought in or smuggled into Nigeria. Similarly, there has been a rise in wheat production in Nigeria from 50,000 tons in 2015 to 60,000 tons in the period of 2021/2022. However, this quantity only meets 2% of the nation's demand for 5.6 million tons of wheat (*FAO, 2021*).

Since cereals are ingredients for food products like flour and animal feeds, an increase in cereal prices can result in inflationary pressures affecting almost all sectors within the food industry. For instance, the recent hike in bread prices, in Nigeria was primarily linked to rising wheat costs. The increasing costs of soybean and corn have an impact on the price of poultry feed, which in turn affects the prices of chicken, beef and eggs. One of the goals set forth in Sustainable Development Goal number 2 is to eliminate hunger by 2030. Meanwhile, reports from the United Nations indicate that around 720 million to 811 million people were experiencing hunger in 2020 while over 2.4 billion individuals, accounting for more than 30 percent of the population, were dealing with varying levels of food insecurity.

Problem Statement

Empirical evidence highlights the relationship between cereal production and food inflation. However, existing studies have either focused on broader agricultural supply shocks or have examined cereal price volatility without adequately addressing the direct impact of cereal production on food inflation. Additionally, the role of specific cereals in driving food inflation in Nigeria remains unclear.

This study addresses these gaps by investigating the impact of cereal production on food inflation in Nigeria using quarterly time series data from 2008 to 2022. Employing robust econometric techniques such as the Vector Error Correction Model (VECM), Impulse Response Analysis, and Variance Decomposition, this research seeks to provide empirical insights into the causal link between cereal production and food inflation. The study also explores the determinants of cereal production to identify the structural and policy-related factors that hinder domestic cereal output.

By addressing these research gaps, this study aims to provide evidence-based recommendations to policymakers, particularly the Federal Ministry of Agriculture and Rural Development (FMARD), for improving cereal production strategies, stabilizing food prices, and enhancing Nigeria's food security framework. Ultimately, the research contributes to the broader discourse on sustainable agricultural practices to mitigate inflationary pressures and promote economic stability in Nigeria.

Research Objectives

The main goal of this research is to examine how cereal production influences food inflation in Nigeria. The specific objectives are:

i. to examine the existence and direction of causality between food inflation and quantity of cereal produced in Nigeria.
ii. to Examine the Effect of Cereal Production on Food Inflation in Nigeria.
iii. to investigate the determinants of cereal production in Nigeria.

The goals outlined aim to investigate the connection, between cereal output and rising food prices while offering insights, for policymakers and supporting efforts to enhance food security and economic equilibrium in Nigeria.

This study is organized into five (5) sections. The first section is the introduction which covers the background to the study, statement of the problem and the objectives of the study. The second section is the literature review and theoretical framework, which contains the conceptual literature, theoretical literature, empirical literature as well as gaps in the literature. The third section presents the methodology of the study, which include research design, nature and sources of data, and methods of data analysis. The results are presented in section four while the last section contains summary, conclusion, and recommendations.

Literature Review

Conceptual Clarification

(i) Food Prices

Food prices refer to the monetary value of food that humans consume, and many factors impact food prices, from supply and demand, developmental costs and strategies (Saliu, 2021), to infrastructural distribution channels and exchange rates. Thus, from an economic perspective, food prices affect family consumption habits and family food expenditure, resource allocation, and equity of access to various nutritional alternatives. Food prices impact household expenditures and entrepreneurial activities since, in developing nations, food represents a significant component of total household income (Onwusiribe et al., 2021).

In addition to the rise and fall of food prices, food inflation is the rise in food prices as related to other price increases over time under a unified currency (Diaz-Bonilla, 2016). According to DiGiovanni (2014), food inflation is manifested directly within the grocery store receipts of people who see their assigned food prices rising due to no added value. Thus, countries must change their food considerations and policies so that continuous food inflation does not diminish real income and raise poverty levels. Therefore, food prices are essential features of economic existence that reflect social realities and dictate socioeconomic quality of life—especially in agricultural or net food importing nations.

(ii) Cereals Commodities

Cereal crops are defined as staple grains that belong to a larger grain family correlating to the Poaceae family. The primary examples include maize, rice, wheat, sorghum, millet, barley, rye, oats, and triticale (Akanni & Adeniyi, 2020). They are quality sources of carbohydrates and, for many years, serve as their caloric intake, primarily in developing countries. Cereals are also valued for ease of low production, storage capabilities, and potential to be processed for human/animal feed (Idem & Showemimo, 2004).

Some ancient cereals in Africa include African rice, finger millet, fonio (acha), and pearl millet, which have significant potential for food sovereignty and resilience to climate change in sub-Saharan Africa (National Research Council, 1996). The agricultural economy and consumption patterns in Nigeria support the findings of Macauley (2015) and Ellah and Emeh (2020), as maize, rice, sorghum, and millet are the staples from which most people's daily caloric intake is derived. "Cereal commodity prices" refer to the price of cereals (grains) generally measured in metric tons. Pricing is measured through domestic and international supply and demand, input costs (fertilizer, seeds, labor), weather, transportation and export restrictions, and tariffs (World Bank, 2021). For example, if a drought or a flood happens in one of the world's or nation's major growing areas, supply shocks can create slippery increases. If international grain exports are halted through war or restrictions on export, this creates a shock-wave effect on both international and national/local markets (FAO, 2022). For Nigeria and the Nigerian market, cereal prices are even more vulnerable to external shocks based on exchange rates and fuel prices as fuel is needed for transportation and many of the agricultural inputs are imported. This means that an understanding of cereal commodity prices is imperative for effective agricultural policies and inflation-targeting strategies.

Theoretical Literature

i. Cobb-Douglas Production Function

The Cobb-Douglas production function is a theoretical equation of level and factor inputs generated in 1928 by economists Charles Cobb and Paul Douglas, representative of the expected relationship between factor inputs (courses of production) and expected levels of output (total goods or services) of the economy at large. The production function is written as:

$$Q = AK^{\propto}L^{1-\propto}$$

Where A = advancement; K = level of capital input; L = level of labour input; and α = level of capital share of production. Thus, 1 - α = level of labour share of production. The higher α, the more capital is involved in the process; the lower α, the more important the role of labour.

This function has been utilized in empirical analyses to determine the output of firms and industries based on deviations from expected inputs of capital and labour and expected output. This function has also been utilized as part of a theoretical framework to explain an economy's development over time.

ii. Institutional Theory of Agricultural Production

The institutional theory of production relates to how society composes and regulates agricultural production and whether or not, and to what extent, agricultural production occurs as a byproduct of social considerations. It is a powerful theory based on the institutional power over farmer behavior and market creation. It comes from the works of Meyer and Rowan (1977) and DiMaggio and Powell (1983) in subsequent years.

Essentially, this means that production is more or less effective relative to social context. Institutions are government intrusions, legislation, social expectations, and value systems. These factors influence the mitigation of farmer choices, resource availability, and exposure to vulnerability. For example, through subsidization efforts, market price interventions, protectionist efforts, and free trade policy agreements, farmers may be mandated to cultivate specific crops at specific outputs. Furthermore, land use regulations, sustainable development initiatives, and agricultural safety efforts will influence how farmers tend to their crops.

Also, the institutional theory suggests that institutions may also be devils with an adjustment to environments that leads to adjustments to the systems of agricultural production. Thus, it needs to be assessed how policies and institutions impact production and subsequently arrange them to ensure the most effective sustainable and resilient systems of operation in agriculture.

iii. Structuralist View of Inflation

Structural inflation theory is the acknowledgment of the source of inflation relative to an ongoing system instead of only supply/demand inflation. This is a structural theorization that recognizes inflation as a byproduct of increased costs of production. Increases in wages, increased energy and material costs, and legislative actions of governments (*Sunkel, 1960*) increase price hikes when they do not necessarily need to occur, even with nominal demand pressures.

This theory of inflation challenges the monetarist theory, which holds that inflation arises only from an increase or decrease in the money supply. Rather, the impetus for inflation is complicated and does not stem solely from money supply changes. Furthermore, it's essential to know what causes the problem to implement effective measures to remedy it. This theory gives a framework for assessing the inflationary situation within a nation and implies that control efforts should focus on wages, energy costs, and political engagements.

iv. Demand Pull Inflation

The principle of demand-pull inflation asserts that inflation occurs in the event that demand rises so high that goods and services become limited due to an increase in the cost itself. This principle is based upon the notion that should desired goods and services come to fruition, the producers will raise prices to ensure greater profit margins, thereby raising the overall price level of the economy.

Thus, demand pull inflation is caused by an increase in demand over what supply can provide, resulting in increased prices. Demand pull inflation can occur due to excessive consumer demand, increased governmental expenditures, or overall investment beyond average. For instance, the government may increase its expenditure on public projects by seeking to create more roads and bridges. Public demand for such projects increases where supply in the form of materials and labor must be had. As materials and labor become more limited in availability, demand increases for such items and hourly wages. Thus, demand pull inflation inflates the price of such materials and construction-based wages.

The Demand-Pull theory of inflation connects to the Cost Push theory of inflation, which claims that inflation happens due to an increase in enterprise costs, like wages or materials, not inflation due to an increase in demand. These two theories are not mutually exclusive - both areas of concern can contribute to an economy's condition at one time and create inflation; however, there are other factors at play that drive an economy as well.

Critics of demand-pull theory say that it oversimplifies the causes of inflation by saying demand is merely one piece of the puzzle when it comes to the pricing factor. In addition, they argue that inflation does not occur from just increased demand unless no increased supply happens in conjunction, meaning that inflation can be avoided. However, the Demand-Pull theory has been championed throughout history as a theory of inflation in an economy because policymakers believe it to be true and use levels of aggregate demand to formulate monetary and fiscal policy to reduce inflation.

New Keynesian inflation theory is the New Keynesian explanation of how inflation occurs. It builds upon a specific economic theory that denotes a need for governmental intervention to maintain economic balance. Thus, this inflation theory relies upon supply/demand equilibrium and the notion that goods/services will cost more down the line. The principles involved focus on "prices and wages," meaning prices/wages are not flexible relative to supply/demand changes due to time or length of time. Thus, the resultant price changes from increased aggregate demand will reflect more changes in output and employment.

The New Keynesian Phillips Curve (NKPC) relates to the New Theory conversation. NKPC is the relationship between an economy's inflation and its unemployment levels. It is an extension of the Phillips Curve by A.W. Phillips from the 1950s, which stated that unemployment and inflation had an inverse relationship. Yet the NKPC expands the conversation to state that not only is there a relationship with unemployment, but also those years in advance of knowing how much inflation there will be can be determined by the actions of businesses and households to determine inflation.

It is suggested that the level of pressure in an economy is influenced by factors such as anticipated inflation rate, current and future output levels and real interest rates. In the context of the NKPC model, inflation is depicted as a function of expected output gap (the variance between potential output) and a measure of real production costs (like labor expenses). The concept of the output gap reflects the extent of slack while the real production cost factor indicates the pressure on businesses to raise prices due to cost escalations. The NKPC has played a role in shaping policies across various nations by providing a structure, for central banks to predict inflation trends and adjust interest rates accordingly. Moreover, it underscores the significance of managing inflation expectations, ensuring that inflation remains aligned with the bank's objectives.

Theoretical Linkage

There are a variety of classical theories of causes of inflation which correlate with one another in causation assessment. These are the quantity theory of money, the monetary theory of inflation, the demand-pull theory, the cost-push theory, and the structural inflation theory. The quantity theory of money suggests that fluctuations in the general price level happen mostly based upon fluctuations in the amount of money in circulation in an economy. The theory's earliest proponents are David Hume (1711-76) and David Ricardo (1772-1823). Subsequent proponents include Irving Fisher (1876-1947) whose equation of exchange (MV=PT) is famous, and Arthur Cecil Pigou (1877-1959) who demonstrated that in a fractional reserve banking system, control over a given exogenously determined stock of high-powered money can affect monetary control (*Totonchi*, *2011*).

To the Monetarists led by Milton Friedman (1912-2006), the money supply is the key—but not the only—determinant of output and price levels in the short run and price level in the long run (*Jalil, 2011*). The demand-pull inflation was made significant via support of the demand-driven increase from the works of John Maynard Keynes (1883-1946). "When the value of aggregate demand exceeds the value of aggregate supply at the full employment level, the inflationary gap arises" (Ibid). The cost-push inflation occurs as a by-product of wage increases to employees without increases in productivity. This can occur whenever trade unions call for increases in worker salaries to offset increases in the cost of living. Thus, union demand for salary increases naturally creates a situation of increased cost of production which the producer must pass onto the end-consumer of goods.

Therefore, the theoretical evaluation of inflation is in five blocks of causational elements: monetary shocks, demand elements, supply-side (or real) shocks, structural and political elements (or institutional determinants). It's these five aggregate causational elements that infer that inflation is an aggregate and institutionally connected event. It's an aggregate and institutional phenomenon, everywhere and always. (*Jalil, 2011*).

For this investigation, which intends to model the food inflationary trend in Nigeria, we would invoke theoretical considerations of inflation such as the structuralist view, demand-pull inflation, and the New Keynesian Phillips curve. The nature of the economic substructure of Nigeria is riddled with so many structural rigidities: faulty government policies, high local production, and cost of doing business, making it difficult to achieve equilibrium national output with the available capital.

Hence, for this investigation, we use the supply-side (or real) shocks causational element as the emphasis to ascertain food inflation. Specifically, the study sought to determine the effect of the quantity of grains produced on general food inflation.

Empirical Literature

This empirical review is done in 5 parts: the first part considers global studies on cereal production and food inflation; the second examines evidence from developing and developed countries; the third part looks at regional studies in sub-Saharan Africa; the fourth part considers comparative insights from countries with similar economic structures; while the fifth part reviews Nigeria-specific empirical studies.

i. Global Studies on Cereal Production and Food Inflation

Studies emerge across the globe that connect cereal pricing and food inflation shocks. For example, in a study of the international cereal market, Bellemare (2015) credits climate shocks with a great deal of price variability and inflation in the cereal market, meaning the findings attribute to international markets. In Brazil, Barros et al. (2021) find cereal price shocks in 2020 - especially shocks to rice and maize - drive excess price variance in inflation movements in the 2020 inflation index. Using a Bayesian VAR, Peersman et al. (2021) find that World Oil supply shocks drive more and more food price changes and cereal inflation changes over time. In contributions to 2021 studies, Ting-Ting et al. assess China for bidirectional causality between agricultural commodity prices and inflation and find that there are positive impacts of inflation on grain prices as well as a negative impact of agricultural commodities on grains in inflation findings, suggesting a complicated path. What these studies hold in common is a top-down approach, where metrics exist for an overall inflation index or overall agricultural commodity index and findings are compiled without proper differentiation for inventory. Many, too, fail to recognize the learned levies that would prevent international shocks from impacting domestic pricing by national interventions.

ii. Evidence from Developing and Developed Countries

Samal, et al. (2022) tested the impact of macroeconomic variables on food price inflation in India based on a monthly series from January 2006 to March 2019. An ARDL bounds testing approach to co-integration found that the series were cointegrated. The coefficients of long-run estimates indicated that per capita income, money supply, world food price index, and agricultural wages positively and significantly impacted food price inflation in the short-run and long-run. However, food grain availability negatively and significantly impacted food price inflation in the short-run and long-run. In addition, a unidirectional causality existed from the world food price index to food price inflation. Still, there is no causal direction to food price inflation from money supply and agricultural wages in the short run. This article will help understand the country's inflation trends. The advantages include that it's based on monthly data, meaning a more focused time-series analysis can be done. The disadvantage of this study is that it only focuses on food grains and not tubers or cash crops and/or cereal crops.

Barros et al. (2021) assess whether agriculture contributes to inflation in Brazil. The research question revolves around how unexpected price shocks to three types of goods influence Brazil's inflation index (IPCA). Additionally, the authors analyze supply shocks to the energy market, foreign exchange rates, and prices of agricultural commodities in the world market. The New Keynesian Philip Curve serves as the theoretical framework, and Impulse Response Functions (IRF), the Forecast Error Variance Decomposition (FEVD), and Historical Decomposition of Forecast Errors (HDFE) serve as the means of analysis. The results suggest that the costs driving the most variance in IPCA were expected inflation, grain prices, and diesel prices, and the exchange rate, respectively. The conclusion is supported by properly applied techniques, although one variable overlooked is gas prices since it fuels transportation costs. Furthermore, one variable lacking in Barros et al. (2021)'s analysis is that it looked at Brazil's general inflation index, not necessarily the food inflation index. Thus, the grains-related effect might be less relevant based on the more critical impact of the other independent variables tested.

Ting-Ting et al. (2021) investigates the mutual influence between agricultural commodity prices (ACP) and inflation (INF) in China by employing the bootstrap full- and sub-sample rolling-window Granger causality tests. The study found that ACP has positive effects on INF, indicating that agricultural commodities play a significant role in stabilizing general price levels, but the higher ACP may create inflationary pressures. However, the negative effects suggest that under the shock of external uncertainty, the rise of ACP is not always regarded as the prime driver of INF. The results are not consistent with Hypothesis 1, which highlights that INF is positively affected by ACP. In turn, the study also found positive and negative impacts of INF on ACP, showing that the level of INF can affect the supply and demand of agricultural commodity markets, it can be considered as a factor affecting ACP. This study ought to have captured money supply as one of the explanatory variables. Also, for policy purpose, aggregating agricultural commodity prices will not bring out the major issues imbedded in the price dynamics. This is why this current study focus on cereal production.

Ozurak (2021) assesses the primary determinants of volatility of food prices in Turkey for the time frame 1 January 2000 - 31 December 2020. Through a Vector Autoregressive (VAR) approach, Volatility Spillover and Volatility Spillover analyses between the Turkey Food Price Index (in Turkey), the Dollar-TL exchange rate, and the Turkey Food Price Index (World) were performed. The results indicate that there is a volatility spillover effect between the Turkey Food Price Index and the World Food Index, which is stronger than return spillover effects. Ultimately, short-run results indicate statistically significant volatility spillover between the Food Price Index in Turkey, the world, and exchange rates, and this does not carry over into the long run. Yet in the long run, the biggest determinant of Turkey Food Price Indexes is the Production Price Index of Agricultural Products, which becomes the breakpoint for the increase of the food price index over time after 2016. This analysis does not consider volatility and changes in oil prices and exchange rates as the major determinants of food prices.

In contrast, Baek and Koo (2010) analyzed U.S. food inflation using VAR models and showed how energy prices and demand shocks propagate through cereal markets, affecting retail food prices. In Indonesia, Farandy (2020) emphasized the influence of international cereal prices and oil prices on domestic food inflation, reinforcing the argument for stronger domestic supply chains.

However, these studies often neglect the socio-economic vulnerability of poorer households in rural settings, which is more pronounced in developing countries.

iii. Regional Studies in Sub-Saharan Africa

Kuma & Gata (2022) investigated factors affecting food price inflation in Ethiopia using data from 1990 to 2021 employing an Autoregressive Distributed Lag (ARDL) approach. The findings revealed that variables such as real GDP, world food price, rainfall amount, population number, money supply, exchange rate, and interest rate were co-integrated in the long run. The long run result revealed that real GDP and world food price at first lag affected food price inflation negatively and significantly whereas domestic food price, annual rainfall, interest rate and money supply affected food price inflation positively and significantly. The time frame is adequate, however, the series of rainfall and population number seems not to have a theoretical underpinning, rather the study ought to have include other relevant variables like oil price, and money supply.

Okou, et al. (2022) analyzed the domestic and external drivers of local staple food prices in Sub-Saharan Africa. Using data on domestic market prices of the five most consumed staple foods from 15 countries, the study found that external factors drove food price inflation, with domestic factors capable of acting as mitigants to these vulnerabilities. On the external side, the estimations showed that Sub-Saharan African countries were highly vulnerable to global food prices, with the pass-through from global to local food prices estimated close to unity for highly imported staples. On the domestic side, staple food price inflation was lower in countries with greater local production and among products with lower consumption shares. Also, adverse shocks such as natural disasters and wars contributed 1.8 and 4 per cent to rises in the prices of staple foods respectively beyond generalized price increases. Food inflation is not driven by staple food commodity alone. This is the major defect of this study. There is need for further study in sub-Saharan African countries on food inflation.

Jerumeh (2022) assessed the pattern and determinants of food price volatility in Nigeria. He used annual and monthly time series data between January 2000 to December 2020 and conducted descriptive statistics, Coefficient of Variation, Autoregressive Conditional Heteroscedasticity (ARCH) model, Generalized Autoregressive Conditional Heteroscedasticity (GARCH) model, and Exponential GARCH (EGARCH) to analyze. There was food price volatility from 2000 to 2012; after 2012, the increase in food prices was almost nonexistent. There was an increase in the price of food from 2000 to 2006 and from 2007 to 2012, meaning that by 2000, rice almost tripled in price relative to its price at the beginning of 2000. Since we know what is going on in the next years (2013-2020) of the research, this means that food prices were excessively high since 2013 relative to where they started at 2013-2020 and thereafter. The results indicated that the causes of food price volatility emerged from return on the consumer price index, interest rates, exchange rates, and food price rate. This is a solid article because it assesses an issue with monthly time series data that is not often collated and the correct means of assessment relative to the course of the study (dealing with volatility).

Yet many of the above studies, including Jerumeh (2022), despite solid empirical application, either focus too much on descriptive statistics or do not render cereal production a statistically significant factor. Moreover, those that found geographies founded a vulnerability to shocks from outside failed to distinguish inflation variables by crop, which restrains policymaking capabilities to certain avenues.

iv. Comparative Insights from Countries with Similar Economic Structures

Tanzania and Uganda have similar configurations to Nigeria. Ngulugulu (2020) determined that Tanzania experienced cereal prices and transportation costs as inflation determinants. Mawejje and Lwanga (2015) assessed inflation in Uganda and found that inflation for food - with the most critical cereal being maize - was driven by agricultural supply shocks. Finally, Damba et al. (2019) examined food prices in Ghana using ARDL, which found sorghum and millet crises as inflationary determinants.

Many of these articles referenced quarterly/monthly data and strong econometric assessments, which complicates the reliability of the data as well as varying definitions in markets from country to country. Regardless, their conclusions will provide a comparison against which to measure the significance of Nigeria's cereal/inflation relationship.

v. Nigeria-Specific Empirical Studies

Muhammad, et al. (2021) examined the effect of macroeconomic factors, output and prices of selected cereal grains in Nigeria using OLS technique and quarterly data from 2006 to 2016. The estimated outcome from the output model for rice reveals that quarterly interest rate and money supply increases rice output, while oil price reduced rice output. However, exchange rate and inflation had no effect on rice output. The estimated outcome for maize output model showed that inflation rate rose with maize output in Nigeria. The result also indicated that exchange rate increased sorghum output level. Nevertheless, interest rate, inflation, and money supply were not determinants of the level of sorghum output. The outcome showed that interest rate had no effect on the price of maize. Furthermore, exchange rate, inflation and oil price were contributory factors to rises in the price of sorghum in the nation. Nonetheless, interest rate and money supply did not determine the price level of sorghum. The inclusion of interest rate in this analysis is inconsequential, rather other prices of cereals such as wheat, rice and millet should have been featured in the model. Notwithstanding, this current study built on this gap by examining the aggregated impact of cereal production on food inflation.

Abiodun, et al. (2022) interrogated in Nigeria a sampled households from Oyo State. A multi-stage sampling procedure was used to select 174 households for the study. Primary data were obtained on types of rice, frequency and quantity bought, reasons for demand, price variations and coping strategies. Descriptive statistics and Quadratic Almost Ideal Demand System (QUAIDS) that considered the non-linear impact of income changes was used for data analysis. Over 70 per cent of households' demand was for imported long grain rice, as against local brown and wet grain rice and local brown and dry grain rice. The expenditure elasticities of both Local Short Brown Wet Rice (LSBWR) and Imported Short Grain Rice (ISGR) was positive and <1 indicating that they were normal and necessary food items. Strategies mainly used to cope with rice price and households' income changes include: substitution of rice with other food types, preparation of rice with other foods to reduce quantity of rice in meals and reduction of rice demand. Even though price intervention might not lead to a significant effect on rice demand, an improvement in technology would lead to reduction in the cost of rice production and eventually reduce the price of local rice, enhancing high demand while encouraging producers to increase production. Price variations which is the focus of this study is not limited to category of rice, but other determinants play a major role in food inflation in Nigeria. This study ought to have incorporated transportation cost that is subject to oil price. This insight has prompted this current study to include oil price in our model.

Mbah, et al. (2022) examined the effect of agricultural productivity on food prices, asserting whether such effect could be transmitted into inflation. Time series data for Nigeria between 1981 and 2021 were used; calibrated on a 3-variable Structural Vector Autoregressive model (SVAR). Results indicated that the transmission of agricultural productivity to inflation in Nigeria is a long-run phenomenon. Increased agricultural productivity induced a positive change in food prices while an increase in food prices was accompanied by a fall in inflation in the long run. When dealing with prices, studies have shown that monthly or quarterly data produces better results than annual time series data, this is the major shortcoming of this study. This current study builds on this using quarterly time series data.

Ojo and Akinyemi (2021) employed ARDL models and established that maize and rice significantly influence food inflation. Eze and Okafor (2020) confirmed a long-run relationship between cereal production and inflation, with sorghum and maize playing dominant roles. Abiodun et al. (2022), using household-level data in Oyo State, highlighted strong consumer sensitivity to imported rice price volatility.

Toyin, et al. (2020) interrogated the measurement of volatilities in prices of important staple foods using the GARCH approach, investigating the factors that drove it over the period 1970 to 2019. The result revealed persistent volatility in food prices over the estimated period. It was further revealed that insurgency, political stability in neighboring countries, trade liberalization, GDP per capita, inflation rate, government effectiveness, crop production, crude oil price and exchange rate were prominent drivers of volatility in food commodity prices. Studies use political stability/instability index to account for the degree of insurgency, thus both series in the same model render the model defect.

However, many Nigerian studies focus on single crops or macroeconomic aggregates, limiting comprehensive policy guidance. Others, like Jerumeh (2022), though rich in descriptive insights, fall short in using robust econometric modeling for causal inference.

vi. Data-Driven Insights from Time Series Models

The most popular time series methods are ARDL, VECM, and Johansen cointegration. For instance, in Nigeria, Mbah et al. (2022) examined the long-run association between agricultural output and food inflation via SVAR and found causality operating in both directions. Muhammad et al. (2021) used OLS to review their regression findings, but they too did not find any lagged effects. Yet those who did find lagged effects were from more recent endeavors, specifically Barros et al. (2021), who used Impulse Response Functions.

The omission of exchange rate as a determinant of food commodity price was not established in this study but later. For instance, Peersman et al. (2021) found with a structural time-varying-parameter Bayesian Vector Autoregression (TVP-BVAR) that increases in oil prices due to oil supply shocks did not drive food commodity prices before 2000 but after. Furthermore, global food commodity supply shocks due to bad yields had positive effects on crude oil prices since 2000 but not before. They conclude through their econometric analysis that this is not due to the trending biofuels story but, much more importantly, information frictions related to the global business cycle and information discovery in the increasingly financialized commodity markets. Thus, exchange rate, in addition to annual rainfall, should have been included as a determinant of food commodity price. Falling from this gap, this study included exchange rate in the model. Therefore, the revelation from this research that requires future research is the application of time series models with a lag structure (ARDL, VAR). These more accurately assess the impact of cereal production on inflation both in the short and long term. However, this might be compounded by the availability of data during select years—only in those where quarterly data was available.

vii. Policy Interventions and their Impact

Akpan and Udoh (2009) evaluated the effect of Nigeria's agricultural policies and found that input subsidies had short-term positive impacts on cereal output, but these effects diminished without sustained investment. Alao and Oloni (2015) critiqued commodity price regulations for distorting market signals. The Federal Ministry of Agriculture and Rural Development (2011) emphasized the need for market-oriented reforms in its Agricultural Transformation Agenda. Akanni and Adeniyi (2020) projected cereal output under policy reform scenarios and found significant inflation-reducing potential from seed and fertilizer subsidies.

Despite these findings, empirical evaluations of Nigerian policy interventions often lack rigorous counterfactual analysis. There is also limited evidence on the effectiveness of tariffs and import bans on domestic cereal price stabilization.

Gaps in Literature

However, despite optimistic results from past research regarding food inflation and food production through agricultural yield, there are still gaps in the research. For example, although agricultural studies exist, a search has not been conducted for Nigeria's grains—maize, rice, wheat, sorghum, and millet as a block of dependent variables - and their impact on the food inflation rate.

Moreover, much of the research was conducted pre-Covid-19 and pre-Russia-Ukraine war. These two geopolitical events have made global food sourcing more difficult for many; thus, any findings based solely on preexisting annual standards could be outdated. Additionally, some studies utilize poor methodology to only seek annual data - which fails to account for how temporary price increases - which could better apply based on quarter or monthly assessed data - play into the overall annual results. Thus, this study seeks to remedy the inadequacies by using quarterly time series data in conjunction with the VECM Impulse Response Analysis and Variance Decomposition to determine what happens to the inflation rate of food in Nigeria when cereal yield increases.

Research Design

The research design employed in this study is the ex post facto research design. The study obtains data from secondary sources, namely Central Bank of Nigeria, Food and Agricultural Organization, and the National Bureau of Statistics data portals. Visual models and statistical techniques are adopted in examining and analyzing the parameter estimates and their interactions. Visual models include charts, graphs and tables while analytical techniques include the use of Autoregressive Distributed Lag (ARDL), Granger Causality model, impulse response test along with other appropriate econometric diagnostics tests. Other econometric diagnostic tools such as stability diagnostic test, lag selection criteria test and unit root test are utilized to ascertain that the data is stationary and adequate for use and to mitigate against obtaining spurious results. The results are presented in a logical manner so as to address the objectives of the study.

The study employs quarterly time series data covering the period of 14 years, that is 2008-2022. The data needed for the study was obtained from two main sources: the National Bureau of Statistics (NBS) online portal and the Food and Agricultural Organization data portal. Data on food inflation was sourced from the NBS; Cereals Production (E.g. Sorghum, Millet, Soyabeans, Rice, Maize, and Wheat) was obtained from Food and Agricultural Organization (FAO) data portal.

i. Food Inflation (FOI)
ii. Maize in Metric Tons (MAZ)
iii. Rice in Metric Tons (RCE)
iv. Sorghum in Metric Tons (SGH)
v. Soyabeans in Metric Tons (SYB)
vi. Wheat in Metric Tons (WHT)
vii. Millet in Metric Tons (MIL)

This study employs both descriptive and analytical techniques to analyze the objectives of the study. Descriptive statistics and graphical methods are used to present a detailed analysis of the various properties of the variables under study. In addition to the descriptive statistics, the Augmented Dickey-Fuller and Philip-Perron Unit Root Test, Autoregressive Distributed Lag (ARDL) are used to estimate short-run and long-run relationship among the variables. The study also estimates the pair-wise granger causality as a complementary tool of analysis. Pre and Post estimation tests are also conducted to give direction on the appropriate technique to adopt and also to check if the estimates the are reliable.

The study proceeded to ascertain the existence and direction of causality between cereal production and food inflation in Nigeria. In this case, this study considers a bi-variate model involving cereals commodity and food inflation. The choice of this technique was determined by the outcome of the stationarity test. Thus, the pairwise Granger causality test was employed. The pairwise Granger causality test equations are stated in equations 3.1 to 3.7:

$$FOI_t = \sum_{t=1}^{n} MAZ_{t-i} + \sum_{t=1}^{n} MIL_{t-i} + \sum_{t=1}^{n} RCE_{t-i} + \sum_{t=1}^{n} SGH_{t-i} + \sum_{t=1}^{n} SYB_{t-i} + \sum_{t=1}^{n} WHT_{t-i} + U_{1t}$$ Eqn. 3.1

$$MAZ_t = \sum_{t=1}^{n} FOI_{t-i} + \sum_{t=1}^{n} MIL_{t-i} + \sum_{t=1}^{n} RCE_{t-i} + \sum_{t=1}^{n} SGH_{t-i} + \sum_{t=1}^{n} SYB_{t-i} + \sum_{t=1}^{n} WHT_{t-i} + U_{1t}$$ Eqn. 3.2

$$MIL_t = \sum_{t=1}^{n} MAZ_{t-i} + \sum_{t=1}^{n} FOI_{t-i} + \sum_{t=1}^{n} RCE_{t-i} + \sum_{t=1}^{n} SGH_{t-i} + \sum_{t=1}^{n} SYB_{t-i} + \sum_{t=1}^{n} WHT_{t-i} + U_{1t}$$ Eqn. 3.3

$$RCE_t = \sum_{t=1}^{n} MAZ_{t-i} + \sum_{t=1}^{n} MIL_{t-i} + \sum_{t=1}^{n} FOI_{t-i} + \sum_{t=1}^{n} SGH_{t-i} + \sum_{t=1}^{n} SYB_{t-i} + \sum_{t=1}^{n} WHT_{t-i} + U_{1t}$$ Eqn. 3.4

$$SGH_t = \sum_{t=1}^{n} MAZ_{t-i} + \sum_{t=1}^{n} MIL_{t-i} + \sum_{t=1}^{n} RCE_{t-i} + \sum_{t=1}^{n} FOI_{t-i} + \sum_{t=1}^{n} SYB_{t-i} + \sum_{t=1}^{n} WHT_{t-i} + U_{1t}$$ Eqn. 3.5

$$SYB_t = \sum_{t=1}^{n} MAZ_{t-i} + \sum_{t=1}^{n} MIL_{t-i} + \sum_{t=1}^{n} RCE_{t-i} + \sum_{t=1}^{n} SGH_{t-i} + \sum_{t=1}^{n} FOI_{t-i} + \sum_{t=1}^{n} WHT_{t-i} + U_{1t}$$ Eqn. 3.6

$$WHT_t = \sum_{t=1}^{n} MAZ_{t-i} + \sum_{t=1}^{n} MIL_{t-i} + \sum_{t=1}^{n} RCE_{t-i} + \sum_{t=1}^{n} SGH_{t-i} + \sum_{t=1}^{n} SYB_{t-i} + \sum_{t=1}^{n} FOI_{t-i} + U_{1t}$$ Eqn. 3.7

The direction of causality running from cereals commodity (MAZ, MIL, RCE, SGH, SYB, and WHT) to food inflation (FOI) and from food inflation to cereals commodity can be established through rejecting the null hypothesis of no causality.

On the model specification for effects of cereal production on food inflation, this study utilized the model of Muhammad et al., (2021), which is a transformed model by Danlami (2016) for the analysis of this objective which centers on effects of cereal commodities on food inflation in Nigeria. The functional form of the Muhammad *et al.*, (2021) model is expressed in equation 3.8 and 3.9:

$$LOT = \alpha + \beta_1 LIF_t + \beta_2 LER_t + \beta_3 LPO_t + \beta_4 LIR_t + \beta_5 LMST_t + \varepsilon_t$$ Eqn. 3.8

$$LPR_t = \alpha + \beta_1 LIF_t + \beta_2 LER_t + \beta_3 LPO_t + \beta_4 LIR_t + \beta_5 LMST_t + \varepsilon_t$$ Eqn. 3.9

Where, OT and PR represent the output and price of selected cereal grain (Rice, Maize, and Sorghum), IF Illustrates the Inflation rate, ER represents the Exchange rate, PO is the Price of Crude oil, IR denotes interest rate, MS Shows Money Supply and ε denotes error term. Hence, the study done by Shu'aib & Abdu (2021) employs Ordinary least squares (OLS) technique for the long-run estimate of the model. The variables used in the models are changed to their natural log.

This present study adopted Vector Error Correction Model (VECM) to estimate the effect of cereal commodity production on food inflation in Nigeria for the period from 2008 to 2022 quarterly data. The suitability of VECM is accentuated by Sim (1980) and Hill, Griffiths & Lim's (2012) argument that it is designed for use with non-stationary series that are known to be co integrated, and it as offered a coherent way to combine the long-and short-run effects.

To achieve this objective, the model by Muhammad *et al.* (2021) was modified with the incorporation of cereal commodity in metric tons disaggregated into maize, millet, rice, sorghum, soybeans, and wheat. The functional form of the model is expressed below:

$FOI = f(MAZ, MIL, RCE, SGH, SYB, WHT)$ Eqn. 3.10

Where, FOI = Food Inflation, MAZ = Maize in Metric tons, MIL = Millet in Metric Tons, RCE = Rice in Metric Tons, SGH = Sorghum in Metric Tons, SYB = Soybeans in Metric Tons, WHT = Wheat in Metric Tons,

Assuming $y_t = (y_{it}, y_{2t}, \cdots, y_{kt})'$ as k-dimensional stochastic time series, $t = 1,2,\cdots,T$ and $y_t \sim \mathrm{I}(1)$, each $y_{it} \sim I(1), i = 1,2,\cdots,k$ is affected by exogenous time series of d-dimension $x_t = (x_{1t}, x_{2t}, \cdots, x_{dt})'$ then the VAR model can be established as follows:

$y_t = A_1 y_{t-1} + A_2 y_{t-2} + \cdots + A_p y_{t-p} + Bx_t + \mu_t, t = 1,2,\dots,T$ Eqn.3.11

If y_t is not affected by exogenous time series of d-dimension $x_t = (x_{1t}, x_{2t}, \cdots, x_{dt})'$, then the VAR model of formula (3.11) can be written as follows:

$y_t = A_1 y_{t-1} + A_2 y_{t-2} + \cdots + A_p y_{t-p} + \mu_t, t = 1,2,\dots,T$ Eqn.3.12

With cointegration transformation of formula (3.11), we can express as follows:

$\Delta y_t = \prod y_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta y_{t-i} + \mu_t$ Eqn. 3.13

Where

$\prod = \sum_{i=1}^{p} A_i - \boldsymbol{I}, \quad \Gamma_i = -\sum_{j=i+1}^{p} A_j$ Eqn. 3.14

If y_t has cointegration relationship, then $\prod y_{t-1} \sim I(0)$ and formula (3.13) can be written as follows:

$\Delta y_t = \alpha\beta' y_{t-1} + \sum_{i-1}^{p-1} \Gamma_i \Delta y_{t-i} + \mu_t$ Eqn. 3.15

where $\beta' y_{t-1} = ecm_{t-1}$ is the error correction term, which reflects long-term equilibrium relationships between variables, and the above formula can be written as follows:

$\Delta y_t = \alpha ecm_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta y_{t-i} + \mu_t$ Eqn. 3.16

Formula (3.16) is the vector error correction model (VECM), in which each equation is an error correction model. In order to proceed with the above estimation technique, the study first carried out Augmented Dickey Fuller unit root test to determine the level of stationarity of the time series data. For the post-test, the study applied vector autoregressive stability test to ensure that results obtained achieve some level of stability within the study period.

The ARDL model is expressed in mathematical form in equation 3.17 below.

$$\Delta LFOI_t = \delta_o + \delta_1 LFOI_{t-1} + \delta_2 LMAZ_{t-1} + \delta_3 LRCE_{t-1} + \delta_4 LWHT_{t-1} + \delta_5 LMIL_{t-1} + \delta_6 LSGH_{t-1} + \delta_7 LSYB_{t-1} + \sum_{i=0}^{p} \varphi_1 \Delta LFOI_{t-1} + \sum_{i=0}^{q} \varphi_2 \Delta LMAZ_{t-1} + \sum_{i=0}^{q} \varphi_3 \Delta LRCE_{t-1} + \sum_{i=0}^{q} \varphi_4 \Delta LWHT_{t-1} + \sum_{i=0}^{q} \varphi_5 \Delta LMIL_{t-1} + \sum_{i=0}^{q} \varphi_6 \Delta LSGH_{t-1} + \sum_{i=1}^{q} \varphi_7 \Delta LSYB_{t-0} + +\lambda ECM_{t-1} + \varepsilon_t$$

Eqn. 3.17

where $\delta_1 - \delta_7$ are the long-run parameters; $\varphi_1 - \varphi_7$ are the short-run parameters; δ_o and ε are the intercept term and the white noise stochastic term respectively; λ is the parameter of the error correction mechanism (ECM); ln is the natural logarithm of the variables, and; Δ is the difference operator. A shock to any of the regressors may not result in an immediate long-run effect on food inflation (LFOI), which creates disequilibrium in the system and requires that the short-run adjusts to its long-run equilibrium through the error correction mechanism (ECM_{t-1}). The ECM_{t-1} is a one lag error correction term that accounts for the speed of adjustment to the long-run equilibrium.

Variable Description and Justification

This study adopted the ARDL model because the available data achieved stationarity at a mix of level and first difference. Starting with the ADF unit root test, the results show that irrespective of whether the unit root testing is based on the model with constant only or with constant and trend, the null hypothesis of unit root tends to hold for food inflation (FOI), maize (MAZ), rice (RCE), soyabeans (SYB), wheat (WHT), the only exception being sorghum (SGH) and millet (MIL). Again, irrespective of whether the ADF includes constant only or constant and trend, the order of integration appears to be mixed.
Data presentation and analysis are the focus of the next section.

Data Presentation

Quarterly data of cereals (Wheat, Millet, Rice, Maize, Millet and Sorghum) output measured in metric tons were utilized for the study's analysis for a quarterly period of 14 years (2008-2022). The quantity of cereal produced was sourced from the Food and Agriculture Organization's data portal. The raw data set is presented in the Appendix to this study.

Data Analysis and Results

Trend Analysis

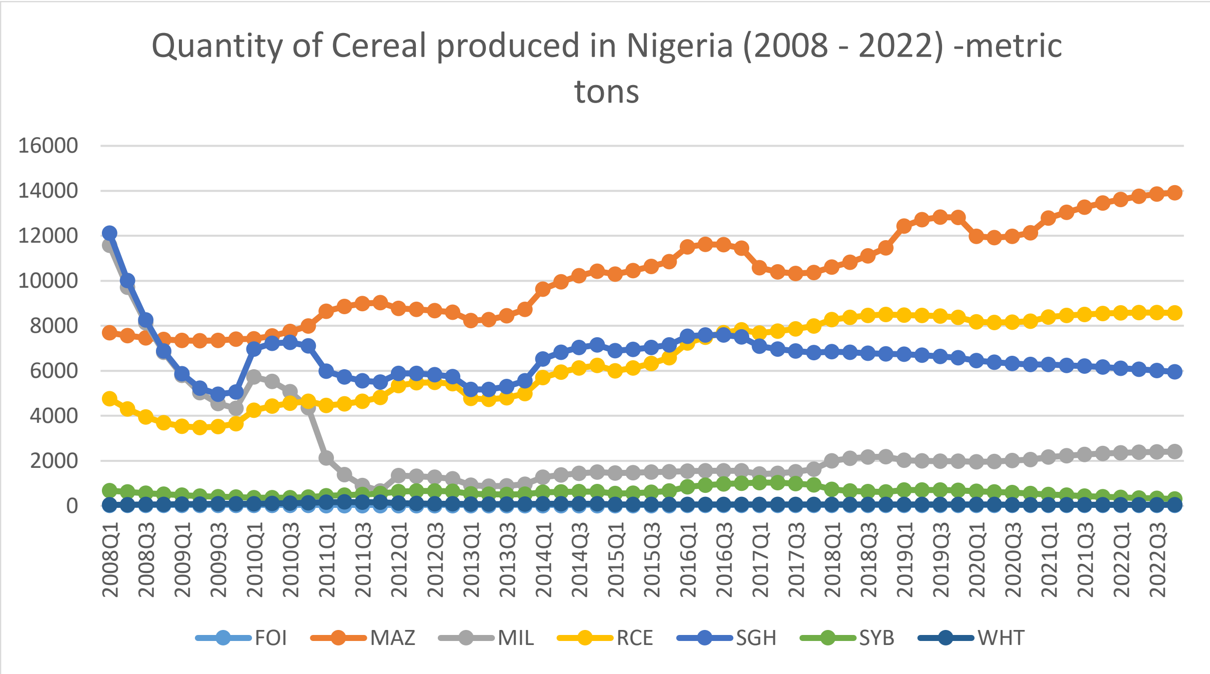

Figure 4.1: Trends in Maize, Millet, Rice, Sorghum, Soyabeans, and Wheat, in Metric Tons.
Source: *Food Agriculture Organization, 2022*

Figure 4.1 represent the quarterly time series data of disaggregated cereal commodity production variables, covering period of 2008q1 to 2022q4. Maize, in metric tons, witnessed relative growth trajectory with the maximum rate in 2022q4 while the minimum or negative growth rate recorded was in 2009q2. In terms of the difference in the production output across the quarters, the value did not vary significantly, even during the 2016 and 2020 recession. Millet varies across quarters with the highest growth value recorded in 2008q1 while the minimum was in 2011q4. Although there are variances across the various quarters, this could be associated with government policy inconsistency, which might have affected millet farmer's output. Also, the trends of rice recorded the highest metric tons growth in 2022q3 while the minimum growth was in 2008q2, which might be on the account of little commitment from the government side and the temporary ban paced on rice importation. The series of sorghum witnessed the highest metric tons growth in 2008q1 while the minimum growth was in 2009q3. However, there are little or no traces of significant difference across quarterly values essentially due to a myriad of factors including climate variability, pest and diseases, limited access to improved seeds and other inputs, limited mechanization, post-harvest losses and inadequate extension services.

Table 4.1: ADF Unit Root Test Results

AUGMENTED DICKEY FULLER UNIT ROOT					
Variable	Level	Prob.	First Difference	Prob.	I(d)
FOI	-1.820221	0.3673	-5.900302	0.0000	I(1)
MAZ	-0.648203	0.8511	-4.044017	0.0124*	I(0)
RCE	-1.019619	0.7407	-4.877603	0.0002	I(1)
MIL	-3.675250	0.0070	-4.496262	0.0006	I(0)
SGH	-4.443881	0.0007	-4.862168	0.0002	I(0)
SYB	-1.884750	0.3371	-4.060300	0.0023	I(1)
WHT	-2.109840	0.2417	-4.073010	0.0022	I(1)

Note: The exogenous lags are selected based on SIC while *implies the series is stationary at level with constant and trend. The null hypothesis for ADF is that an observable time series is not stationary.

Starting with the ADF unit root test, the results in Table 4.1 shows that irrespective of whether the unit root testing is based on the model with constant only or with constant and trend, the null hypothesis of unit root tends to hold for food inflation (FOI), rice (RCE), Soybean (SYB) and Wheat (WHT). Maize (MAZ), millet (MIL), and sorghum (SGH), been exceptions. Again, irrespective of whether the ADF includes constant only or constant and trend, the order of integration appears to be mixed.
From the VAR result, this study chooses to conduct its analysis with lag 1 under the SC. The major requirement in conducting Johansen (1992, 1995) co-integration tests and estimation of a VAR function - either in its unrestricted or restricted Vector Error Correction (VEC) framework - is the choice of an optimal lag length. And the choice of an optimal lag length depends on multivariate versions of information criteria, which include the LR, AIC, HQ, FPE and SICS (Brooks, 2002). The optimal lag of 1 is chosen for the empirical model based on SC. The VAR result reveals a long run association among the series since some of the statistical value is greater than their respective critical values for the cointegrating equations.

Causality Between Cereal Production and Food Inflation in Nigeria

The analysis, in Table 4.2 revealed a relationship between cereal production and food inflation in Nigeria. The findings indicate that maize production influences food inflation significantly while food inflation in turn impacts output. Moreover, changes in rice and wheat production play roles in affecting food inflation dynamics. Additionally, there is a connection between food inflation and sorghum well as soybean output at a certain level of significance. These results suggest an interplay between cereal production and food inflation dynamics, in the context of Nigeria.
Based on the findings this research concluded that fluctuations, in food inflation in Nigeria are primarily attributed to maize, rice and wheat. Conversely it was observed that variations in millet, sorghum and soybeans output in tons are influenced by changes, in food inflation.

Table 4.2: Pairwise Granger Causality Tests

Null Hypothesis:	Obs	F-Statistic	Prob.
MAZ does not Granger Cause FOI	58	5.92756	0.0048
FOI does not Granger Cause MAZ		0.53435	0.5892
MIL does not Granger Cause FOI	58	0.48516	0.6183
FOI does not Granger Cause MIL		2.81269	0.0690
RCE does not Granger Cause FOI	58	2.61535	0.0426
FOI does not Granger Cause RCE		0.49690	0.6112
SGH does not Granger Cause FOI	58	0.68012	0.5109
FOI does not Granger Cause SGH		3.20530	0.0485
SYB does not Granger Cause FOI	58	0.16780	0.8460
FOI does not Granger Cause SYB		3.29383	0.0448
WHT does not Granger Cause FOI	58	2.53017	0.0492
FOI does not Granger Cause WHT		0.61465	0.5446

Source: *Extract from EViews 12 Output*

Effects of Cereal Production on Food Inflation in Nigeria

Following the unit root test result, the study conducted the Johansen cointegration test to ascertain the presence of a linear combination among the variables. This is contained in Table 4.3 below.

Table 4.3: Result of Unrestricted Cointegration test

Result of Unrestricted Cointegration Test

Unrestricted Cointegration Rank Test (Trace)				
Hypothesized		**Trace**	**0.05**	
No. of CE(s)	**Eigenvalue**	**Statistic**	**Critical Value**	**Prob.****
None *	0.588054	154.7730	125.6154	0.0003
At most 1 *	0.442502	103.3350	95.75366	0.0136
At most 2	0.398744	69.44580	69.81889	0.0535
At most 3	0.285638	39.93916	47.85613	0.2247
At most 4	0.190061	20.42995	29.79707	0.3941
At most 5	0.099481	8.203747	15.49471	0.4439
At most 6	0.035996	2.126259	3.841466	0.1448
Trace test indicates 2 cointegrating eqn(s) at the 0.05 level				
* denotes rejection of the hypothesis at the 0.05 level				
**MacKinnon-Haug-Michelis (1999) p-values				

Source: *Extract from E-view 12 output, 2023*

From the result on table 4.3 above, there are at least 2 cointegration equations. Also, the result shows that there is a long-run relationship among the variables since the trace statistics values are greater than the critical values (0.05).

The hypotheses for the cointegrating test are: H0: There is no cointegration and H1: There is cointegration. Since the calculated F-statistics is greater than the critical value for the upper bound I(1), then we conclude that there is co-integration. That is, there is presence of long-term relationship. This analysis is followed by estimation of the long run model which is Error Correction Model.

Table 4.4: ARDL Regression Result

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
FOI	0.638399	0.262857	2.524738	0.0282
MAZ	0.045260	0.018125	2.497103	0.0297
MIL	-0.090334	0.042521	-2.124451	0.0571
RCE	0.026729	0.009724	-2.748680	0.0189
SGH	0.087711	0.040620	2.159327	0.0538
SYB	-0.007703	0.033617	-0.229124	0.8230
WHT	1.131614	0.575142	-1.967538	0.0748
R-SQUARED = 0.994832 ADJUSTED R-SQUARED = 0.975099 F-STATISTICS = 50.41 PROB(F-STATISTIC) = 0.0000 DURBIN-WATSON STAT = 2.50				

Source: Author's analysis, E-views10.

From the regression result, maize production has a positive effect on food inflation in Nigeria within the period under study (2008 – 2022). This means if the quantity of maize produced increases, there is a tendency that this leads to downward trend in food inflation. Same argument goes for rice, wheat and sorghum. Only millet and soyabean hold a contrary result. Furthermore, F-Statistics (50.41) shows that the overall hypothesis is statistically significant for this regression analysis. The Durbin-Watson (2.50) statistic, which is a negative, shows there is absence of serial correlation.

The result of the estimated error correction model is presented on table 4.5 below

Table 4.5: Vector Error Correction Model Prediction Results

Error Correction:	D(FOI)	D(MAZ)	D(MIL)	D(RCE)	D(SGH)	D(SYB)	D(WHT)
CointEq1	-0.046	-0.001	0.008	0.002	0.004	-0.001	-0.002
	(0.049)	(0.001)	(0.006)	(0.001)	(0.002)	(0.002)	(0.002)
	[-0.943]	[-1.139]	[1.529]	[1.751]	[2.320]	[-0.033]	[-1.151]

Source: *Extract from E-view 12 output, 2023*

The estimated Vector Error Correction Model (VECM) without any restrictions indicated that MAZ, MIL, RCE, SYB, WHT, and SGH, congregate to the long-run equilibrium given the co integrating equation. Importantly, the result of the short-run dynamic coefficients associated with the long-run relationships obtained from the VECM equation is given in Table 4.8. A value of (-0.046) for the VECM coefficients suggests a slow speed of adjustment strategy of about 5%. Though the theoretical nature of this model does not allow meaningful explanation of the VECM estimates, the study relies on the impulse response functions and forecast error variance decompositions for insightful interpretation as recommended by Sim (1980) in Balcilar et al., (2020). The results of impulse response and forecast error variance decomposition are presented in Table 4.6 and 4.7 below.

Table 4.6: The Impulse Response

Period	FOI	MAZ	MIL	RCE	SGH	SYB	WHT
1	1.473011	0.099804	0.077036	0.174304	0.143470	0.240316	0.030620
2	3.401084	0.143454	0.249615	0.489059	0.512726	0.664539	0.040080
3	5.485081	0.180653	0.335578	0.808856	0.934400	1.165715	0.097333
4	7.610069	0.274978	0.302213	1.136210	1.361769	1.747475	0.222183
5	9.735076	0.450010	0.160470	1.482142	1.781756	2.427031	0.425106
6	11.83783	0.708021	-0.068700	1.852413	2.195400	3.200233	0.696790
7	13.90921	1.037996	-0.366704	2.242283	2.603475	4.045644	1.022034
8	15.94808	1.424861	-0.716159	2.645349	3.006684	4.940010	1.385276
9	17.95847	1.853758	-1.101407	3.056720	3.406081	5.864933	1.773490
10	19.94650	2.311999	-1.509468	3.473391	3.803105	6.807652	2.176673

Source: *Extract from E-view 12 output, 2023*

The impulse response function of the VAR framework measures the responsiveness of a variable in the estimated equation of interest to an innovation or shock from other parameters. The impulse response function reveals that food inflation respond positively to innovations from maize (MAZ), rice (RCE), sorghum (SGH), soya beans (SYB), and wheat (WHT) across the selected horizons. However, FOI responds negatively to innovations from MIL. This implies that MAZ, RCE, SGH, SYB, and WHT will jointly cause increase in food inflation if the quantity produced decreases over time. On the other hand, a reduction in the quantity of MIL produced does not cause increase in FOI significantly.

Domestic activities around these crops production is still not adequate that can guarantee self-sufficiency of these cereals to meet local demand, thus merchants result to importation of these crops. Recall that in recent time, advanced economies are also experiencing high inflation rate which could be a pass-through effect to Nigeria's rising food inflation.
The positive innovations from the crops could be attributed to instability particularly 2008/09 global financial crisis, 2016 recession, Covid-19 pandemic coinciding with Russia-Ukraine war resulting to Nigeria slipping into another recession in 2020 thereby rendering many food farmers and food-producing companies incapacitated in the production of adequate food. In addition, the ravaging insecurity in the northern part of Nigeria has forced farmers to abandon their farms, and the Nigeria's border closure has also contributed to rising cost of food items.

Table 4.7: Variance Decompositions

Period	S.E.	FOI	MAZ	MIL	RCE	SGH	SYB	WHT
1	1.473011	100.0000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
2	2.476001	96.03049	0.123993	0.077270	0.398897	0.399086	0.959173	0.148672
3	3.306236	93.58785	0.168945	0.049872	0.833290	0.774190	1.610832	0.367235
4	4.003311	92.00915	0.130687	0.167994	1.336621	0.953354	2.026393	0.748223
5	4.612537	90.53371	0.102997	0.425714	1.882493	0.987437	2.383668	1.240400
6	5.159761	88.95675	0.132682	0.763627	2.436798	0.955539	2.717765	1.810376
7	5.659729	87.32892	0.223052	1.135343	2.956937	0.905750	3.016216	2.405990
8	6.121220	85.75195	0.356549	1.506836	3.417624	0.857165	3.268222	2.984513
9	6.550493	84.30025	0.511910	1.855155	3.811088	0.815403	3.473896	3.518787
10	6.952526	83.00908	0.671977	2.167463	4.140611	0.781208	3.639544	3.996740

Source: *Extract from E-view 12 output, 2023*

The Forecast Error Variance Decomposition (FEVD) of the VAR captures the effect of the exogenous variables in the model of interest in the system. In the medium term, there was a steady decline in the influence of own shock from food inflation accounting for the variations with marginal declines in the values of other parameters in the model. This trend persisted all through the medium term and beyond with exception of sorghum in the 10th quarter. In the furthest forecasted period, approximately 83 per cent of the variations in food inflation can be accrued to its own shocks. Respectively, rice, wheat, soyabeans, and millet accounting for approximately 4.14 percent, 3.99per cent, 3.64 percent and 2.17 per cent of the variations in food inflation. This implies that in the country, the rising output of these crops in metric tons would drag down food inflation in the long-run, while fall in the productivity of these crops would induce food inflation in Nigeria. In other words, innovations from rice, wheat, soyabeans, millet would bring about possible effect on food inflation in Nigeria.
For diagnostic test, Table 4.8 failed to ascertained serial correlation.

Table 4.8: VEC Multicollinearity Test

	FOI	MAZ	MIL	RCE	SGH	SYB	WHT
FOI	1.000	0.068	0.052	0.118	0.097	0.163	0.021
MAZ	0.068	1.000	-0.031	0.520	0.276	0.561	0.454
MIL	0.052	-0.031	1.000	0.629	0.603	0.036	-0.524
RCE	0.118	0.520	0.629	1.000	0.855	0.485	0.091
SGH	0.097	0.276	0.603	0.855	1.000	0.181	-0.073
SYB	0.163	0.561	0.036	0.485	0.181	1.000	0.572
WHT	0.021	0.454	-0.524	0.091	-0.073	0.572	1.000

Source: *Extract from E-view 12 output, 2023*

An assumption that there is no multicollinearity among the explanatory variables induced in the regression model. It refers to the existence of more than one exact (or inexact) linear relationship. Multicollinearity test is carried out in order to verify the possibility of this assumption using the correlation matrix. It has been suggested that if the pair-wise correlation coefficient is in excess of 0.8, then multicollinearity is present and may pose serious estimation problem (Gujarati & Porter, 2006). From the correlation matrix above, we can confirm that there is no pair-wise correlation coefficient that is in excess of 0.80 (Gujarati & Porter, 2006). Hence, the variables cannot be said to be collinear. MAZ is 0.06, MIL is 0.05, RCE is 0.12, with SGH, SYB, and WHT having 0.09, 0.16, and 0.02 respectively. Therefore, we conclude that there is no multicollinearity among the repressors.

Table 4.9: Diagnostic Test for Model Two

Diagnostic and Post-Estimation Results				
Adj. R^2	***F-statistics***	***Linearity Test***	***Autocorrelation Test***	***Heteroscedasticity test***
		Ramsey RESET	**LM Test**	**ARCH**
0.668548	4.000686	2.134636 (0.1386)	0.527012 (0.4741)	0.739443 (0.3936)

Source: *Extract from EViews 12 Output*

Note that probability values for the post-estimation test are in parentices

Table 4.9 presents the diagnostic and post-estimation results for model two. F-statistics specifies whether the independent variable(s) are jointly significant in explaining the dependent variable. R^2 measures how well the estimates have explained the actual dependent variable – it is a measure of the strength of the model. Adjusted R^2 is particularly used to assess if the addition of an independent variable has contributed to increased strength of the model. The null hypothesis of linearity is maintained and the model is appropriately stated as the Linearity RESET test verifies that the model is stable. The presence of autocorrelation and the rejection of the serial correction null hypothesis, which appears to be consistent with the food inflation model, were further investigated in this

work. Also, this study discovered that the food inflation model's null hypothesis of heteroscedasticity was repeatedly rejected. This among others is an indication that the empirical estimates obtained from the estimated model are efficient and robust for policy inference.
The stability diagnostics tests in the form of CUSUM and CUSUM squares diagrams are presented in Figure 4.2a and Figure 4.2b. The diagrams revealed that the variables of interest employed in this model for analysis are all stable and thus appropriate for inclusion in the model for analysis and forecasting. This is because the movement of the recursive residual resolves within the critical bounds.

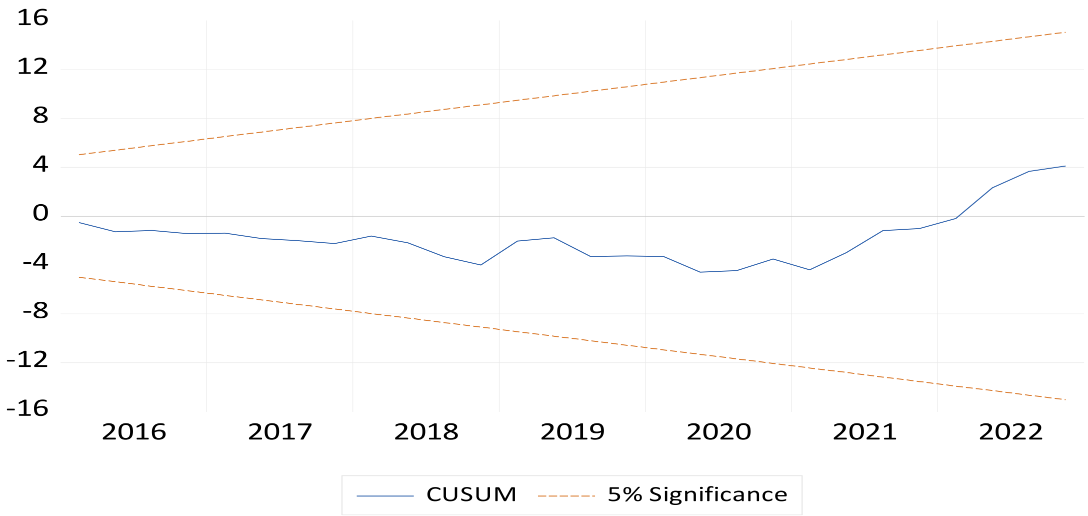

Figure 4.2a: CUSUM

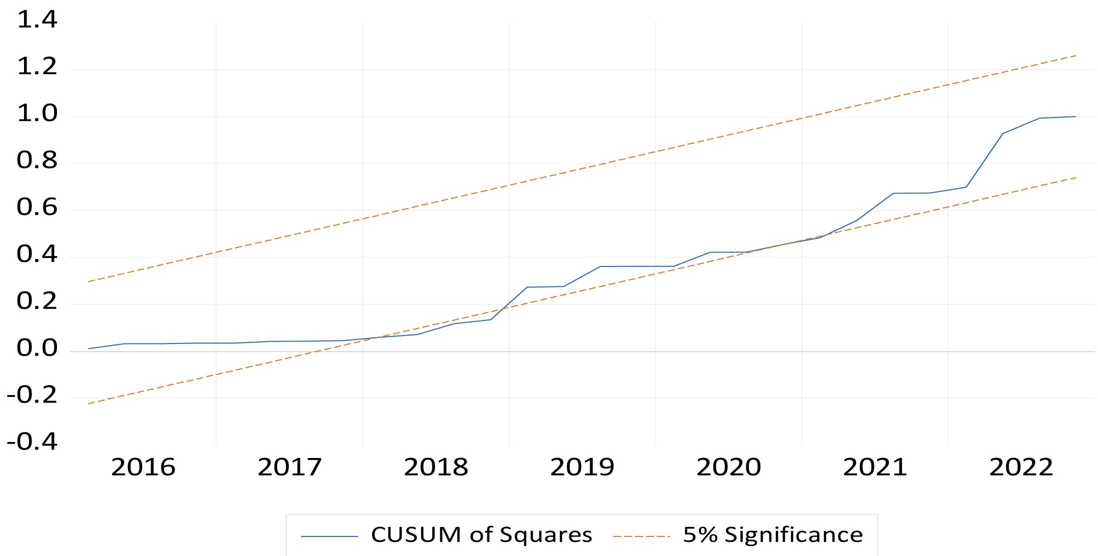

Figure 4.2b: CUSUM of square

Determinants of Cereal Production in Nigeria

Cereal production in Nigeria is part of the agricultural sector and is dependent upon many structural and non-structural factors with respect to environmental, economic, agricultural, institutional, and socio-political productivity variables. The cereal subsector - comprised of maize, rice, millet, sorghum, and wheat - has barely leveled over the years due to such factors on a sectoral basis and interconnectedness - intentionally or unintentionally - with other sectors.

The most relevant factors of production for yields in Nigeria include climate and ecology. Changes in rainfall, temperature, and the incidence of freak weather events overly impact suggested planting times and decrease yields (Kumara & Sharma, 2020). Cereal farming is mostly rain-fed, which indicates that more projects should focus on irrigation systems as well as drought-resistant seeds (Ojo et al., 2021).

Access and affordability of inputs continue to pose major constraints. Limited access to quality seeds, fertilizers, and agrochemicals, as well as the rising price of inputs, limit smallholder output just like with smallholder farmers in Nigeria (Mbah et al., 2022). This is compounded by findings that input markets with subsidy and government intervention significantly increase cereal yield, but such findings are also mediated by access to extension agents and farmer sensitization efforts (Olagunju et al., 2020).

Access to markets and related infrastructure are constraints to agriculture as well. Poor rural roads and dearths of storage and high transportation costs increase post-harvest losses, prevent production above subsistence, and disincentivize producers (Abiodun & Omotayo, 2021). Intra-season and inter-season price variations call for value chain infrastructure improvements - storage and processing - that would provide supply response and price stabilization.

Institutional and Policy Frameworks are other considerations that impact cereal output. The reliability of government-mediated programs such as Anchor Borrowers' Programme (ABP) and Growth Enhancement Support Scheme (GESS) is average, exacerbated by bureaucratic delays and non-focusing on smallholder farmers (Ayinde et al., 2021). Land tenure is a contentious issue, and low-interest loans are almost nonexistent, preventing any formulation for sustainable participation that could involve productivity-increasing investments (Omodara & Alarima, 2022).

Insecurity and socio-political instability are the last developments. Unfortunately, many of the farmers in northern regions' cereal belts are most prone to armed conflict, banditry, and farmer-herder issues. Consequently, thousands of farmers now have no choice but to relocate, and many have abandoned their farms - either out of fear or a lack of resources to continue (Yusuf & Bello, 2021). For those remaining, determination must contend with fragmented input and output markets. Thus, without security, sustainable participation is futile; peace efforts and resilience must come first before any policy intervention can be effective.

Ultimately, the variables affecting Nigeria's cereal output are connected. Only a systems, multilateral, and cross-disciplinary approach spanning everything from climate-resilient agriculture to infrastructure development, policy and political change, access to finance, and conflict mitigation will raise the possibility of productivity within the cereal sector.

Discussion of Findings

The first objective seeks to examine the existence and direction of causality between food inflation and quantity of cereal produced in Nigeria. The study employs the granger causality test and established that there is a unidirectional causality running from maize, rice, wheat and sorghum to food inflation withing the period under consideration (2008 – 2022). These food items actually granger cause rise in food inflation, ceteris paribus. On the other hand, the result also shows that millet and soyabean do not granger cause food inflation withing the same period. Infact, the study found that causality runs from food inflation to millet between the first to sixth quarter of the period covered.

The second objective is to Examine the Effect of Cereal Production on Food Inflation in Nigeria. First, cointegration result demonstrate existence of long run relationship between cereal production and food inflation in Nigeria, which conformed to the finding by Geetha, et al., (2015). Based on the impulse response function, it reveals that food inflation respond positively to innovations from maize (MAZ), rice (RCE), sorghum (SGH), soya beans (SYB), wheat (WHT) across the selected horizons, this agrees with the findings of Okou, et al. (2022), Mbah, et al. (2022), Barros, Carrara, Castro and Silva (2021). For instance, the rising food prices are associated with dangers of imported inflation partially resulting from importing raw materials for the agro-industry processing (Ngulugulu, 2020) alongside weak exchange rate and high cost of finished and semi-finished importation. However, food inflation responds negatively to innovations from millet only in the 1st to 5th quarter while 6th to 10th demonstrate positive innovations to food inflation. This outcome has demonstrated that cereal production account for the rise in food inflation in Nigeria.

Sequel to the second objective, variance decomposition reveals that all variations in food inflation are caused by internal variations, with the share of variation decreasing in the fourth period to approximately 92 percent, even as the share of variation in other parameters increases. Rice and soybeans are each responsible for about 1.33 percent and 2.03 percent of the variations in food inflation, respectively, this is in line with the finding of Farandy (2020). Essentially, in the 10th quarter, fluctuations in food inflation were accounted for, respectively, by rice, wheat, soyabeans, and millet, at about 4.15 percent, 3.99 percent, 3.64 percent, and 2.17 percent, this agrees with the outcome of Tule, et al., (2019). This suggests that food inflation in Nigeria would increase if the productivity of these crops decreased, whereas increased output of these crops in metric tons would reduce food inflation over time. In other words, improvements in production and supply of maize, rice, wheat, soybeans, and sorghum could reduce the price of food in Nigeria.

The third objective is to investigate the determinants of cereal production in Nigeria. In line with extant literature, the study avers that determinants of cereal production include climate change, soil fertility, pest and diseases affecting crops, lack of access to finance,

lack of access to quality agricultural inputs, lack of access to markets, government policy, conflict and insecurity issues.
The study concluded from the following that maize, rice, and wheat account for variations in food inflation in Nigeria, whereas the converse situation suggests that changes in food inflation influence changes in millet, sorghum, and soyabean output in metric tons.

Recommendations
Based on the results of this study, the following specific and policy recommendations are achievable and actionable:

(i) A National Cereal Production Policy should be created and monitored: The Federal Ministry of Agriculture and Rural Development (FMARD) in consultation with the Institute for Agricultural Research, the National Agricultural Seeds Council, the Central Bank of Nigeria, and various development partners should establish a National Cereal Production Policy to set expectations for maize, rice, sorghum, soybeans, and wheat as the highest relative producers of food inflation within Nigeria. This policy should aim at increased yield, technology development, technology adoption, and expanded production regionally.

(ii) Ensure that critical agricultural value chain constraints identified are addressed: This requires investment by policymakers in:

- Improved access to affordable, quality agricultural inputs such as seeds, fertilizers, herbicides, and insecticides.
- Extension and improvement of irrigation systems to stop dependence on rainfall for farming.
- Construction and rehabilitation of rural feeder roads to connect farms to market.
- Establishment of grain post-harvest processing and storage facilities to ensure no losses occur while prices are stabilized.
- Implementation of access to working capital policies and insurance facilities for smallholder grain farmers.

(iii) Reduce Non-Technical Barriers but make Insecurity a Priority: Insecurity is one of the non-technical barriers affecting sustainable grain production, and the following should be addressed by the government:
- Increase security in agricultural regions where banditry and insurgency impact operations.
- Provide aid to displaced farmers through reallocation and farming input distribution.
- Promote the use of community policing and other local security efforts to protect farmlands and the agricultural supply chain.

(iv) Institutionalize a Monitoring and Evaluation Process: Form a national cereal M&E task force to monitor policy compliance, measure increases in productivity, and gauge the success of all activities undertaken to prevent food price inflation. This will ensure accountability, provide access to places of policy failure based on M&E activities, and create long-term sustainability.

These recommendations will strengthen Nigeria's cereals production industry, if successfully executed, stabilize the economy from food inflation shocks, and enhance national food security.

Study Limitations

Despite its strengths, the study has limitations that should be acknowledged. First, the study's reliance on secondary data may introduce potential inaccuracies due to data collection inconsistencies. Additionally, while the model effectively captures the link between cereal production and food inflation, it may not fully account for external factors such as currency fluctuations, global food prices, and political instability, which can significantly influence inflation patterns.

Future research could explore these dimensions by integrating broader macroeconomic variables to enhance model robustness and deepen insights into Nigeria's food inflation dynamics.

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