INSECURITY, EXCHANGE RATE, INFLATION AND AGRICULTURAL PRODUCTIVITY IN NIGERIA: A VAR AND TODA-YAMAMOTO CAUSALITY APPROACH

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Abstract

This study examined the relationship between insecurity, exchange rate, inflation rate and agricultural productivity in Nigeria for the period of 1990 to 2024. The study employed the Augmented Granger causality test approach developed by Toda and Yamamoto (1995). The specific objectives of the study were to examine the individual effects of insecurity, exchange rate, consumer price index, agricultural credit guarantee scheme and interest rate on agricultural output in Nigeria. Data were sourced from World Bank Development Indicator and Central Bank of Nigeria Statistical Bulletin. The data were analyzed using the alternative causality testing approach of Toda-Yamamoto (1995). The results revealed that the current threat to security in Nigeria can be used to predict future outcome of agricultural productivity. Also, exchange rate affects agricultural production and can be used to predict future outcome of insecurity in Nigeria while the combined effects of inflation and agric credit guarantee scheme can be used to predict future outcome of agricultural productivity in Nigeria. Result from the impulse response function analysis revealed that the initial response of agricultural productivity to shocks in insecurity and other variables is slow and steady prior to increase towards the end of the 12-month period. The study concluded that there is potential threat to agricultural production if insecurity, exchange rate, inflation, and agric funding schemes are not adequately enhanced. It was recommended that government should improve on security and make farmers feel safe in their farms, liaise with the private sector to increase local production and boost exchange rate as well as implementing price control subsidies and promotion of agricultural innovation and efficiency.
Keywords: Agricultural Productivity, Exchange Rate, Inflation, Insecurity, Toda-Yamamoto

INTRODUCTION

One of Nigeria's most important industries is agriculture. It also helps third-world countries fight poverty and thrive economically. Nigeria relies heavily on the oil industry for its budgetary revenues, but 70% of the population still engages in subsistence agriculture, so agriculture's role in human development must be balanced. The agricultural sector is a significant economic contributor, producing goods, foreign exchange, and exports. Agriculture is essential to life and a nation's economic development, especially in providing adequate and nutritious food for human and industrial development. Nigeria produces a variety of crops, including cattle, fish, poultry, and timber, due to its varied climate and fertile soil. It has four subsectors: Crop Production, Livestock, Forestry, and Fishing.

According to World Bank Development Indices (2020), agriculture is Nigeria's most important economic sector, contributing 24% to the nation's GDP and employing 35% of the population, including 80% of the rural population. According to FAO (2020), the sector is the country's most significant employer of employment. Nigeria's economy relies on agriculture despite oil. It is most Nigerians' primary income. Due to the sector's importance, successive governments have proposed monetarily and otherwise to revitalise agriculture in Nigeria since 1960. All programs aim to increase agricultural output for consumption and export, provide inputs and subsidies to small-scale farmers, make credit facilities accessible to a large segment of rural farmers, eradicate poverty, create employment, and raise economic standards. The 1959 Farm Settlement Scheme, 1972's National Accelerated Food Production Programme (NAFPP), 1974 and 1989's Agricultural Development Programme (ADP), 1976's Operation Feed the Nation (OFN), 1976's River Basin Development Authorities (RBDAs), and 1980's Green Revolution (GR) were among these programs. Directorate for Food Roads and Rural Infrastructure (DFRRI) launched in 1986; Better Life Programme (BLP) for Rural Women introduced in 1987; National Agricultural Land Development Authority (NALDA) launched in 1992; Family Support Programme (FSP)/ Family Economic Advancement Programme (FEAP) launched in 1994 and 1996, National Fadama Development Project (NFDP) of the early 1990s, National Economic Empowerment and Development Stra

Other recent government agriculture initiatives include the 2014 Action Against Desertification (AAD) Programme and the 2016–2020 Agriculture Promotion Policy (APP), designed to unlock sector potential and reduce crude oil dependence. Nigeria—Africa Trade and Investment Promotion Programme, Presidential Economic Diversification Initiative launch in July 2017, Economic and Export Promotion Incentives and Zero Reject Initiative in 2017, REDD+ 2015, NEWMAP in 2018. The above strategies and programs are linked to macroeconomic policy to create a stable economic climate supporting strong and sustainable economic growth. With oil discovery and the 1970s oil boom, the sector was neglected, reducing its GDP contribution to 21.91% in 2019 from 65.7% in 1957, causing food insecurity and poverty. Population growth exceeded economic growth in 2019, causing poverty to climb slowly. Nearly half the population lives below the international poverty line ($2 per day), while unemployment peaked at 33.30% in the fourth quarter of 2020 (World Bank 2020). Nigeria's agricultural sector contributes to the economy but confronts various productivity issues. A country's agricultural production and balance of payment are affected by its currency's appreciation or depreciation relative to other economies. Exchange rate swings affect export revenues, imported input costs, food price inflation, investment and production options, and government policies. Exchange rate swings may hurt Nigeria's agricultural exports. When the

naira weakens against major currencies like the US dollar, Nigerian agricultural exports become more competitive (Akinbode & Ojo, 2018). If international purchasers can buy more Nigerian food for the same currency, farmers' export revenues may rise. Nigeria's agricultural industry is vulnerable to price changes in herbicides, equipment, and fertilisers because it imports them. Imported items cost more; therefore, local currency depreciation may affect input costs (Onyeagocha et al., 2021). Higher production costs may hurt farmers' profits and competitiveness. Nigerian food prices may be affected by naira fluctuations. Imported items cost more when the local currency rises (Onwuka & Oyewumi, 2019). Consumers, especially low-income ones, need help from time to time in getting affordable meals. Currency uncertainty may affect agriculture output and investment decisions. If the currency rate continues to fluctuate, farmers and agribusinesses may refrain from engaging in long-term projects or increasing output (Onyeagocha *et al.,* 2021). Slow sector growth and reduced agricultural production are possible. Currency fluctuations can hurt the agriculture business. Thus, governments sometimes intervene to stabilise the market. The Central Bank of Nigeria may use capital controls or currency interventions to stabilise the naira (Onwuka & Oyewumi, 2019). These bills provide stability and support to ensure the agriculture sector's long-term prosperity and growth.

Another worrisome trend affecting agricultural production in Nigeria is insecurity as noted by Eneji, Babagario and Agri (2019). Insecurity and conflict among groups in Nigeria have increased, killing 77,000 people and displacing 2.6 million in the past five years, affecting agricultural development. Fulani herders, kidnappers, robbers, and Boko Haram in Nigeria have uprooted farming villages, wrecked marketplaces, and increased agricultural food loss as most farmers fled for safety. Farmers now have limited access to regional marketplaces and fear being kidnapped or assassinated when visiting their land. Some unemployed farmers may commit crimes to escape poverty (Onyeagocha *et al.,* 2021). Boko Haram insurgency has killed 32.8 thousand people in Borno State, Nigeria. Borno State produces the most wheat in the nation and contributes about 30% of the national wheat production total (Onwuka & Oyewumi, 2019). Fulani herders's violent harassment of farmers in Benue, Gombe, and Taraba States of Nigeria has also threatened Nigeria's food output thereby reducing access to food-production, contributing to Nigeria's agricultural food loss (Onyeagocha et al., 2021).

Problem Statement/Justification

According to the International Trade Administration (2023), Nigeria imports $10 billion to satisfy its food and agricultural output deficiencies, mainly wheat, rice, poultry, fish, food services, and consumer-oriented foods. European, Asian, US, South American, and South African agricultural imports dominate. Nigeria has launched agricultural projects for

diversification away from oil, including the Anchor Borrowers Program (ABP). In October 2021, the government adopted the "National Agricultural Technology and Innovation Plan" (NATIP) for 2022 at the Council on Agriculture and Rural Development Regular meeting. COVID-19 economic recovery plan for Nigeria over four years. This will replace the 2016 Agriculture Promotion Policy (APP) that expired in December 2020. In December 2022, food inflation reached 23.75% according to Statistics from the National Bureau of Statistics (2024). Food prices rose for grains, yams, pork, fish, and fruits. Devaluations of the native currency (naira) since 2021 provide upward pressure. As transportation costs rise, gasoline prices and insecurity have also raised food prices. There is strong indication of insufficient government funding of agricultural sector with less than 1% annual allocation going to the sector (CB, 2024).

Food security is crucial to the country's growth and development and the fragility of food production is a significant issue for the government and stakeholders. Food security is essential for development, yet worldwide experience shows that more needs to be improved. Development needs include nutritional diversity, food quality, prenatal and paediatric dietary education, health services, water, sanitation, and other public health interventions. Agriculture only gained 1.3% in Q3 2022. The agriculture industry is hindered by low productivity, inaccessible or expensive inputs, and rising post-harvest loss due to inadequate logistics and insecurity nationwide. The North-East is safer in 2022, with fewer farmer attacks. Grain production is booming as security improves. State governors are clearing land for farmers, especially IDP households returning home, to boost productivity. Insecurity has returned after easing significantly, and most farmers are returning to IDP camps, which will lead to food insecurity in the country.

Russia's invasion of Ukraine may threaten Nigeria's food security. Russia and the Black Sea nations supply Nigeria with low-quality wheat. The deepening of the issue could raise imported wheat and wheat-based product prices. Nigerian food and agricultural imports to the US rose 50% to $92 million in 2021 from $58 million in 2020. US imports of Nigerian cocoa, tea/herbal goods, feeds and fodder, cashew/tree nuts, spices, and seafood are significant. Nigeria has struggled to maximise trade preference gains under the Africa Growth and opportunity Act (AGOA). These worrying issues raises a critical concern for agricultural policies. Understanding the linkages between insecurity, exchange rate, inflation and agricultural development in Nigeria using an alternative causality testing approach of Toda-Yamamoto (1995) and VAR stability analysis will solve the quagmire of problem identification which will be bedrock for sound policy formulation that will set the agricultural sector in Nigeria to positive trends in the long run.

Objectives of the Study

The broad objective of the study is to examine the relationship between insecurity, exchange rate, inflation rate, and agricultural development in Nigeria using vector auto regression and Toda-Yamamoto alternative causality approach. Specifically, the study tries to:

1. examine the effect of insecurity on agricultural output in Nigeria;

2. determine the relationship between exchange rate fluctuations and agricultural output in Nigeria;

3. investigate the relationship between consumer price index and agricultural output in Nigeria;

4. analyze the effect of the Agricultural Credit Guarantee Scheme on agricultural output in Nigeria;

5. ascertain the relationship between interest rate and agricultural output in Nigeria.

This study spans the period 1990 through 2024 and it incorporates data on insecurity, exchange rate, inflation, agricultural credit and interest rate. The 39-year period is considered long enough to fit the T-Y causality analysis.

LITERATURE REVIEW

There has been several literature linking insecurity, exchange rate, inflation, agricultural credit and interest rate to agricultural production in Nigeria and outside of Nigeria. One of such studies is the research work of Ilesanmi and Odefadehan (2022) where-in they used 2011–2020 time series data to study how insecurity affects agricultural food loss in Nigeria. The dependent variable was agricultural GDP, which represents agricultural food production. The independent variables were poverty rate, unemployment, crime rate, unemployment rate and federal government internal security spending were negatively connected to agricultural productivity (AGDP), contributing to food loss.

Usman (2022) examined how insecurity affects food production in Igabi LGA, Kaduna State, Nigeria. Using a sample of 399 farmers to answer questions on how insecurity affects food production in the research area, chi-square analysis found that kidnapping, banditry, and livestock rustling accounted for 96.4 per cent of insecurity in the study area, causing food shortages and high food prices of 63.5 per cent and 34.1 per cent, respectively.

Ijeomah and Wonah (2022) explored how insecurity affects Delta State peasant farmers' food production. The study adopted theoretical approach of the Marxian political economy, which states that political and historical events are the outcome of social forces colliding and can be viewed as contradictions and their resolves. Material wealth and access may be the cause of the conflict. Thus, the theory examined how humans value material goods and how an

undefined grazing route caused conflicts between farmers and herders over acreage and grazing rights. They concluded that rising food prices in Delta State Nigeria is a result of peasant farmers' declining productivity.

Odunsi-Oyewole (2022) examined insurgency's impact on Nigeria's agricultural production. They adopted the Toda and Yamamoto VAR approach and found that insurgency causes agricultural output and can be used to predict its future. The study concluded that diminishing insurgency by providing funds and implementing practical and efficient programs to revitalise the economy and create jobs may boost agriculture.

Agri, Babagario, and Eneji (2019) studied the impact of insecurity on agricultural productivity in Nigeria. GDP was the dependent variable, poverty, unemployment, crime rate, and federal government recurrent expenditures on internal security were the independent variables. Ordinary Least Squares multiple regression result showed that crime rate and unemployment were adversely connected to agricultural productivity.

Furthermore, Eniekezimene, Wodu, and Anda-Owei (2024) used the Dutch Disease Syndrome theoretical framework and the non-linear autoregressive distributed lag (NARDL) method for Nigeria to examine how naira-dollar exchange rates affect agricultural production from 1981 to 2021. They found that exchange rate has a symmetrical long-term effect on Nigerian agricultural output but an asymmetrical short-term effect. The long-term symmetrical effect of the currency rate showed that exchange rate appreciation raised real agricultural GDP by 8.8%, while depreciation only increased it by 0.11 per cent.

Omotunde, Zakari, Alexander, Ndatsu, and Adeshina (2023) evaluated how currency rate and inflation affected Nigeria's agricultural output from 1981 to 2020. Autoregressive Distributed Lag (ARDL) result showed that in the long term, exchange rate and inflation have a negative and insignificant effect on agricultural output (AGDP), but commercial bank loans to agriculture have a positive and insignificant effect. Short-term results also showed that exchange rate, inflation rate, and commercial bank credit negatively affect agricultural output. The short-term results also demonstrated that exchange rate and inflation rate positively correlated with agricultural sector output.

Olayide (2022) used annual time series data from the Central Bank of Nigeria Statistical Bulletin (2021) to study how exchange rate fluctuations affect the Nigerian agricultural sector. The autoregressive distributed lag (ARDL) technique showed that the exchange rate negatively affected agricultural output in the short term, but the effect was statistically negligible. It was statistically significant that the exchange rate increased agricultural output over time. Thus, the study found that exchange rate fluctuations affect Nigerian agricultural output over time.

Chukwuemeka and Ibekwe (2020) investigated the exchange rate and Nigerian agricultural sector output from 1987 to 2019. The study used Ordinary Least Square. Regression showed that the nominal exchange rate and money supply positively and significantly affect agriculture sector production, but interest rate and inflation rate negatively affected agricultural output.

Since inflation is a variable that can possibly affect agricultural output, empirical work of Mekonen (2020) used the Autoregressive Distributed Lag model to study Ethiopia's agriculture sector growth and inflation. They found that long-term inflation negatively and significantly affects agriculture sector growth, suggesting the severe effect of inflation on the agricultural sector. Fang and Zibo (2019) examined world food price determinants from 1964 to 2013. They concluded that agricultural productivity, food production, and currency rates negatively and considerably affect the world food price. The study showed no substantial effect of world food stock or crude oil prices on world food prices.

Obasaju and Baiyegunhi (2019) used VECM and Variance Decomposition to examine macroeconomic policies' short- and long-term effects on Nigerian agricultural output (1980: Q1 – 2014: Q4). Their long-term analysis found that inflation and money supply explain variations in actual agricultural output, with inflation having a more significant impact. Onakoya *et al.* (2018) examined long-term and short-term agricultural value addition from 1970 to 2016. VECM analysis found that in the long run, inflation, exchange, and agricultural employment rates positively correlated and predicted agricultural production value added.

A recent study by Agbeyeke and Chukwugoziem (2025) provided three important insights. First is that depreciation of the exchange rate has a strong positive correlation with agricultural export competitiveness while raising the cost of inputs. The second is that monetary policy interest rates reveal a strong negative effect on sector performance via channels of credit availability; and trade has a doubly sensitive effect, with short-run adverse effects but long-run positive contributions to agricultural growth. Tuaneh and Doodei (2025) found varying significant but negative effects of exchange rate on agricultural performance in different exchange rate regimes. The forecast variance result further showed that agricultural performance was more exogenous.

Mufutau *et al.* (2025) found a positive relationship between the GDP of Livestock, cattle, fishery and other livestock, with agricultural credit scheme. Ojo and Oluwaseun (2025) concluded that proves that Agricultural Financing Scheme such as the agricultural credit scheme has the tendency of enhancing macroeconomic development when properly managed and harnessed. Zakari *et al.* (2025) investigated how the Agricultural Credit Guarantee Scheme Fund (ACGSF) influences rice production in Kura Local Government Area, Nigeria. Ordinary

Least Squares (OLS) regression result revealed that ACGSF positively impacts rice output significantly. Key factors such as farm size, fertilizer use, labor input, and seed quality exhibited strong statistical significance in influencing rice production post-ACGSF intervention. However, the study concludes that credit accessibility remains a challenge.

Summary/Gap in Literature

This study analysed empirical and theoretical literature on the effects of insecurity, exchange rate, and inflation on agricultural output. Authors have varied opinions. Some gaps were in methodology, some in scope, and some found a positive relationship between variables and agricultural output, such as Chukwuemeka and Ibekwe (2020), Onakoya et al. (2018), and Adisu (2019). However, no previous study has captured the long-term and short-term effects of insecurity, exchange rate, and inflation on agriculture sector output in Nigeria using the approach proposed for the study. Furthermore, the intervening effects of interest rate and agric credit scheme have not been considered in studies relating insecurity to agricultural production in Nigeria. To fill these gaps identified, this study will use the Vector Auto-Regressive and alternative causality testing approach of Toda-Yamamoto to show the relationship between insecurity, exchange rate, inflation and Nigeria's agricultural sector development.

METHODOLOGY

Theoretical Framework

The theoretical foundation of this research was the Cobb Douglas model. Numerous studies make use of the Cobb Douglass production function. The Cobb Douglass production function defines the connection between the cost of production inputs and the value of final goods and services. In order to boost output, the Cobb Douglass model highlights the value of capital investment in agriculture and efficient worker utilisation. Cobb Douglass production function is represented as follows:

$$Q = AK^{\beta 1}L^{\beta 2} \tag{1}$$

Where, Q is the product or Agricultural output, K is the amount of capital used, and L is the number of hours worked. The constant term A is multiplied by the capital coefficient $\beta 1$ and the labour coefficient $\beta 2$. To simplify the analysis, we will use the total value of fixed assets to stand in for the capital component of the model, while headcount will represent the labour component. Therefore, when the theoretical framework is linearized, a mathematical specification can be made as follows:

$$logQ = A + \beta_1 logK + \beta_2 logL \tag{2}$$

Equation (2) could further be specified econometrically as;

$$\log Q = A + \beta_1 \log K + \beta_2 \log L + \mu \qquad (3)$$

Where: μ is the error term. Since the Cobb Douglass production function is a fundamental theory of output and production activities and has been used in numerous researches to analyse both firm behavior and other production activities especially in the agricultural sector, it is an appropriate choice for this investigation. As such, this investigation rests on the theoretical foundation provided by this connection.

Model Specification

The theoretical foundation of this research was the Cobb Douglas model. Numerous studies make use of the Cobb Douglass production function. The Cobb Douglass production function defines the connection between the cost of production inputs and the value of final goods and services. In any case, the model modifies the empirical work of Ilesanmi, and Odefadehan, (2022), the model is formulated thus:

$$AGOT = f(X_i) \qquad (4)$$

Where; AGOT = Agricultural Output, and X_i = set of chosen explanatory variables.

The chosen variables are reflected in the model as

$$AGOT = f(INS, EXR, CPI, ACGS, INT) \qquad (5)$$

In equation (3), AGOT = Agricultural output, INS = Insecurity index, EXR = Exchange rate, CPI = Consumer price index, ACGS = Agricultural credit guarantee scheme, and INT = Interest Rate

Furthermore, the work set out to present a Vector Autoregressive (VAR) and Toda-Yamamoto (1995) causality test model to test the fluctuations of insecurity index, exchange rate, inflation and other components on agricultural output in Nigeria.

The VAR Form of the Model is shown below:

$$AGP_t = \alpha_1 + \alpha_{1i} \sum_{i=1}^{n} AGP_{t-1} + \sum_{i=1}^{n} \beta_{1i} INS_{t-1} + \sum_{i=1}^{n} \partial_{1i} EXR_{t-1} + \sum_{i=1}^{n} \gamma_{1i} CPI_{t-1} + \sum_{i=1}^{n} \vartheta_{1i} ACGS_{t-1}$$
$$+ \sum_{i=1}^{n} \sigma_{1i} INT_{t-1} + \varepsilon_{it} \quad \dots (6)$$

$$INS_t = \alpha_2 + \alpha_{2i} \sum_{i=1}^{n} INS_{t-1} + \sum_{i=1}^{n} \beta_{2i} AGP_{t-1} + \sum_{i=1}^{n} \partial_{2i} EXR_{t-1} + \sum_{i=1}^{n} \gamma_{2i} CPI_{t-1} + \sum_{i=1}^{n} \vartheta_{2i} ACGS_{t-1}$$
$$+ \sum_{i=1}^{n} \sigma_{2i} INT_{t-1} + \varepsilon_{2t} \quad \dots (7)$$

$$EXR_t = \alpha_3 + \alpha_{3i} \sum_{i=1}^{n} EXR_{t-1} + \sum_{i=1}^{n} \beta_{3i} INS_{t-1} + \sum_{i=1}^{n} \partial_{3i} AGP_{t-1} + \sum_{i=1}^{n} \gamma_{3i} CPI_{t-1} + \sum_{i=1}^{n} \vartheta_{3i} ACGS_{t-1}$$

$$+ \sum_{i=1}^{n} \sigma_{3i} INT_{t-1} + \varepsilon_{3t} \quad ...(8)$$

$$CPI_t = \alpha_4 + \alpha_{4i} \sum_{i=1}^{n} CPI_{t-1} + \sum_{i=1}^{n} \beta_{4i} INS_{t-1} + \sum_{i=1}^{n} \partial_{4i} EXR_{t-1} + \sum_{i=1}^{n} \gamma_{4i} AGP_{t-1} + \sum_{i=1}^{n} \vartheta_{4i} ACGS_{t-1}$$

$$+ \sum_{i=1}^{n} \sigma_{4i} INT_{t-1} + \varepsilon_{4t} \quad ...(9)$$

$$ACGS_t = \alpha_5 + \alpha_{5i} \sum_{i=1}^{n} ACGS_{t-1} + \sum_{i=1}^{n} \beta_{5i} INS_{t-1} + \sum_{i=1}^{n} \partial_{5i} AGP_{t-1} + \sum_{i=1}^{n} \gamma_{5i} EXR_{t-1} + \sum_{i=1}^{n} \vartheta_{5i} CPI_{t-1}$$

$$+ \sum_{i=1}^{n} \sigma_{5i} INT_{t-1} + \varepsilon_{5t} \quad ...(10)$$

$$INT_t = \alpha_6 + \alpha_{6i} \sum_{i=1}^{n} INT_{t-1} + \sum_{i=1}^{n} \beta_{6i} INS_{t-1} + \sum_{i=1}^{n} \partial_{6i} AGP_{t-1} + \sum_{i=1}^{n} \gamma_{6i} EXR_{t-1} + \sum_{i=1}^{n} \vartheta_{6i} CPI_{t-1}$$

$$+ \sum_{i=1}^{n} \sigma_{6i} ACGS_{t-1} + \varepsilon_{6t} \quad ...(11)$$

Where, j is the lag length, K is the maximum distributed lag length, and the constant terms are independent and identically distributed error terms.

Following Sinha and Sinha (2007) and Rambalg and Doran (1996) as cited in Agu and Chukwu (2008), the Toda-Yamamoto (1995) causality test is valid for series that integrated or cointegrated and serves also as an augmented Granger causality test and is formulated as follows:

Let d_{max} = maximum order of integration in the VAR system below: The VAR $(_{K + dmax})$ shall be estimated to use the modified WALD test for linear restrictions on the coefficients of VAR which follows an asymptotic X^2-distribution. Using the Akaike Information Criteria (AIC), the maximum lag order for the model is determined.

To increase the number of lags in the WALD model up to the maximum cointegration level of variables entered in the model is crucially fundamental in opting for the Toda-Yamamoto causality testing procedure. The Toda-Yamamoto approach is an alternative causality testing approach based on the Granger causality equation but augmented with extra lags determined by the potential order of integration of the series causally tested.

Methods of Data Analysis

This study used several statistical methods to examine the data, including the unit root test, cointegration, and the Vector Auto-Regression (VAR) Model. We analysed the impact of insecurity, exchange rate and inflation on agricultural development by computing the impulse response function (IRF) analysis and using the econometric statistical programme E-views 13.0. The Impulse reaction in the VAR paradigm represents stress caused by exogenous causes.

Unit Root Test using ADF

The ADF unit root test verifies or rejects the presence of a unit root in a time series dataset. In addition, the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test for statioarity is also carried out to cross-check the ADF test result. The uit root test is crucial to determine whether or not a series is stationary before adding it to a VAR model. If the sequence isn't stationary, we next look to see if there is divergence. This is determined based on the outcome of the ADF test. We conclude that the variable under study is stable at the 5% level if the probability value of the ADF test statistic is less than the 0.05 critical value threshold.

Estimation of Toda-Yamamoto Causality Test

The study test for the Block Exogeneity/Granger causality by estimating the following VAR model:

$$Y_t = a_0 + a_1Y_{t-1} + ... + a_pY_{t-p} + b_1X_{t-1} + ... + b_pX_{t-p} + u_t \qquad (12a)$$
$$X_t = c_0 + c_1X_{t-1} + ... + c_pX_{t-p} + d_1Y_{t-1} + ... + d_pY_{t-p} + v_t \qquad (12b)$$

Then, testing $H_0: b_1 = b_2 = ... = b_p = 0$, against H_A: 'Not H_0 ', is a test that X does not Granger-cause Y.

Similarly, testing $H_0: d_1 = d_2 = ... = d_p = 0$, against H_A: 'Not H_0 ', is a test that Y does not Granger cause X.

Theoretically, the Toda-Yamamoto procedure is outlined below according Giles (2011):

Test the data for stationarity to determine the integration order. This is done using the ADF and KPSS stationarity tests.

If the data are I(1), it means that the maximum order of integration m = 1. However, the data is not differenced.

Estimate the VAR model and in level form and determine the maximum lag length using the Akaike Info criterion (AIC).

Estimate the preferred VAR model and include in 'm' number of lags for each of the variables. Also, the pre-existing lag is increased by the maximum order of integration (k + d_max) in order to estimate the T-Y causality.

In each case, a probability value that is less than 0.05 critical value implies rejection of the null hypothesis and the conclusion that there is Granger causality.

Impulse Response Function (IRF)

It is useful to use the Impulse Response Function (IRF) to predict how a time sequence of data would react to various system disturbances (Enders, 1995). The IRF graphic illustrates the impact of an innovation shock of one standard deviation on the present and future values of the endogenous variables. The impulse response demonstrates how external shock affects insecurity, exchange rate, inflation and agricultural output -related variables. In this work, the Impulse Response Function (IRF) was modified by Cholesky's degree of freedom.

Rationale for the Model

VAR models outperform simultaneity bias-prone models. It detects limited exogeneity and parameter constraints. It also implies unidirectional causation between components. VAR models analyze the dynamic relationship between research elements. Simple latency structures simplify the delayed response (Agenor, 2005). A combined F-test on the lagged variables may illuminate the effect of the anticipated component of the independent variables when reading the predicted variables is challenging. VAR innovations, which use just delayed variables on the right-hand side, eliminate the requirement to establish whether current variables are exogenous. Thus, each variable is dependent. Greenwood, Jovanovic (1990).

Sources of Data

Table 1: Sources of Data

Variables	Role in the model	Description	Data source
Agricultural Output (AGP)	Dependent Variable	This is the ratio of agricultural GDP to total GDP expressed as an index.	Central Bank of Nigeria Statistical Bulletin, 2024
Security threat index (INS)	Independent Variable	This is an index that measures the level of insecurity from 1 = Low to 10 = High	www.theglobaleconomy.com
Exchange rate (EXR)	Independent Variable	The rate at which one US dollar is exchange for the local currency unit (naira)	CBN Statistical Bulletin, (2024)

Consumer price index, a proxy for inflation (CPI)	Independent Variable	This is a proxy for inflation rate. It effectively determines the index of price changes within a basket of prices	CBN Statistical Bulletin, (2024)	Table 1....
Agricultural Credit Guarantee Scheme (ACGS)	Independent Variable	This is a funding scheme advanced to farmers with the full guarantee of the Federal Government of Nigeria.	CBN Statistical Bulletin, (2024)	
Interest Rate (INT)	Independent Variable	This is the rate of interest on agricultural loans.	CBN Statistical Bulletin, (2024)	

ANALYSIS

Stylized Analysis

The data are analyzed using econometric procedures earlier discussed. However, trend analysis precedes the main data analysis in order to ascertain the direction of movement of each of the variables. Fig. 1 shows the trend of security threat index for Nigeria from 1990 to 2024.
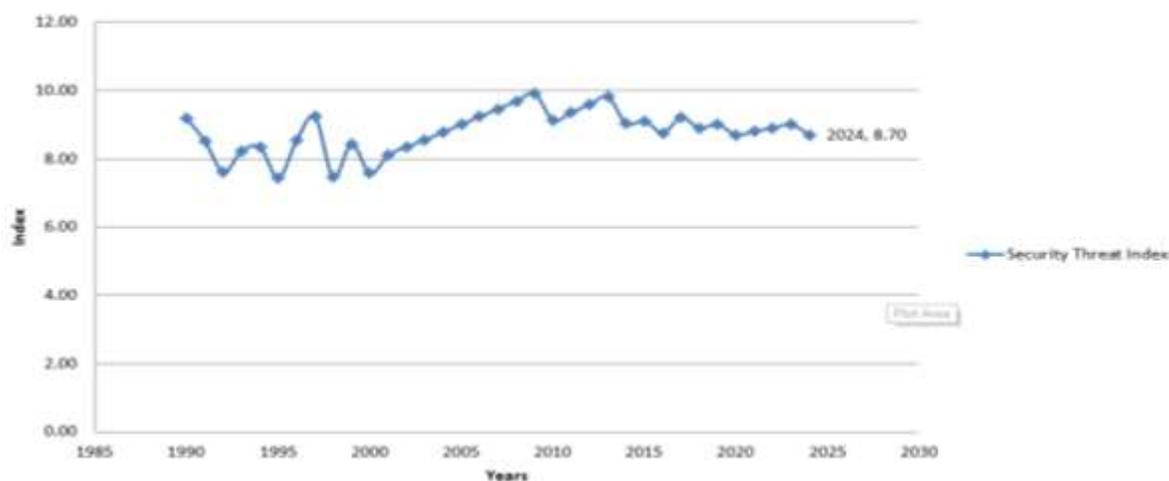

Figure 1: Trend of Security Threat Index for Nigeria, 1990 – 2024 (Note: 0 = Low; 10 = High)
(Data Source: CBN, 2024)

Trend analysis of security threat for Nigeria shows that Nigeria's security situation has always been precarious with an average index of 8.61 from 1990 through 2010. The index reached a period high of 9.91 in 2009 and the lowest index was 7.43 in 1995. The period after 2011 to 2024 saw Nigeria's security threat index averaging 9.06 which is closer to the 10-point mark. This shows that Nigeria's security situation is on the increase given the recent threat of terrorism, herdsmen, bandits and kidnapping which are known to have severe negative

consequences on several key sectors of the economy including the agricultural sector. However, how the agricultural productivity has been impacted by this increasing threat of security is yet to be ascertained in this research.
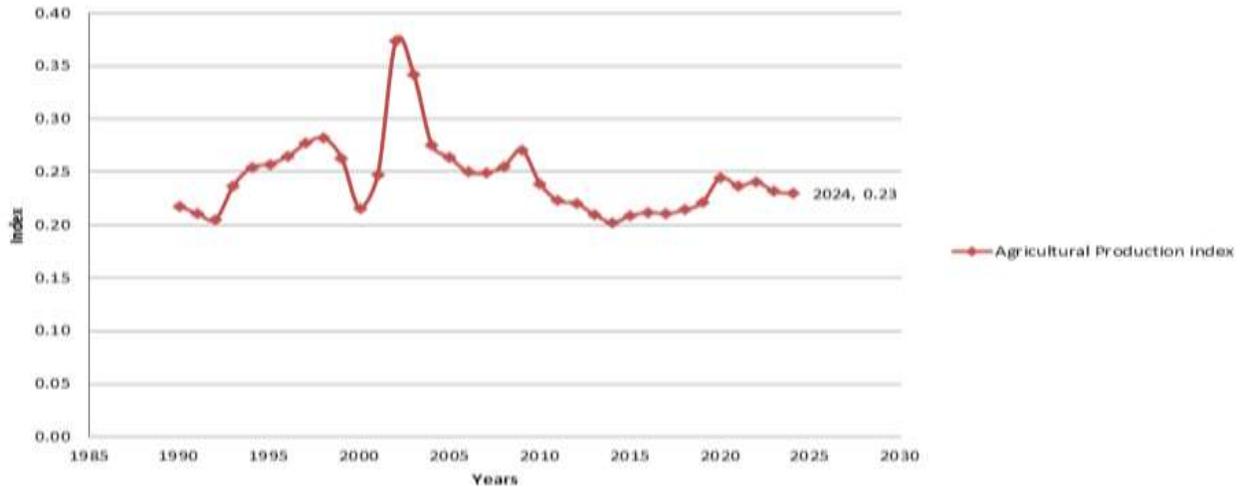

Figure 2: Trend of Agricultural Production Index for Nigeria, 1990 – 2024

(Data Source: CBN, 2024)

Figure 2 shows the trend analysis of Nigeria's agricultural production index. It is evident that Nigeria achieved highest agricultural production in 2002 with an index of 0.37. The lowest for the period was 2014 with an index of 0.20. It is intuitive to note that Nigeria has been championing reversal to an agro-based economy but it appears that the spate of insecurity and other macro-economic factors have hindered further development of agricultural sector in Nigeria. This will be determined in the subsequent analysis.
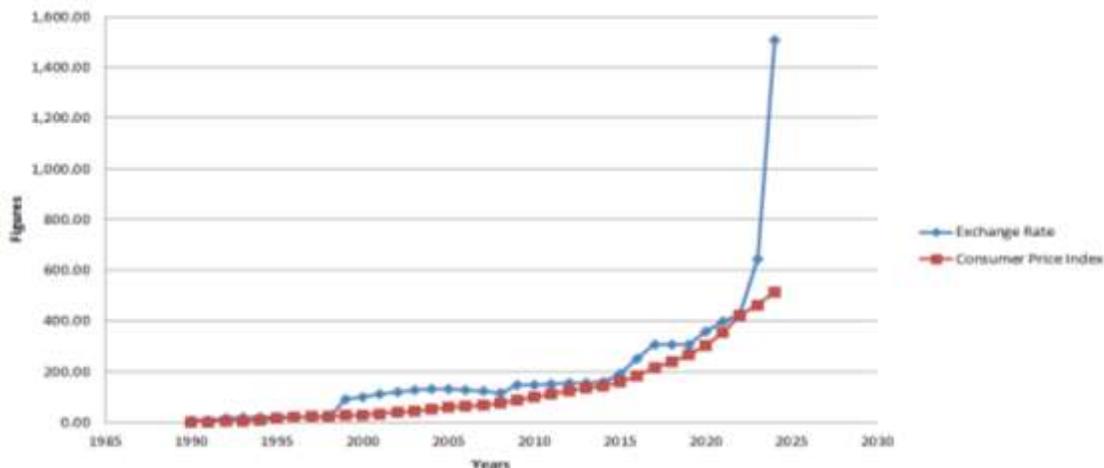

Figure 3: Trend of Exchange Rate and Consumer Price Index for Nigeria, 1990 – 2024

(Data Source: CBN, 2024)

Figure 3 shows that Nigeria's exchange rate has been on a steady rise from N8.04 to $1 in 1990 to N102.11 to $1 in 2000 and rising further to N159.3 to $1 in 2010. The year 2024 marked a significant turn-around for exchange rate in Nigeria as it rose sharply to N1506 to $1 signalling potential consequences for export trade especially agro-based products.

Consumer price index also showed steady rise through the years 1990-2024 rising from an index point of 2.41 in 1990 to 29.6 in 2000 and 100 points in the base year 2000. Consumer price index for Nigeria rose to 302.9 in 2020 and reached 515.7 in 2024. What this possibly implies is that there is rising prices in Nigeria which means the prevalence of inflationary trends and this has the potential of exerting pressure on agricultural products. Therefore, the threat of insecurity and other macro-economic factors can possibly affect agricultural production which might lead to inflation of prices of agro-based products. The inter-relationship between these economic variables will be determined subsequently in this analysis.
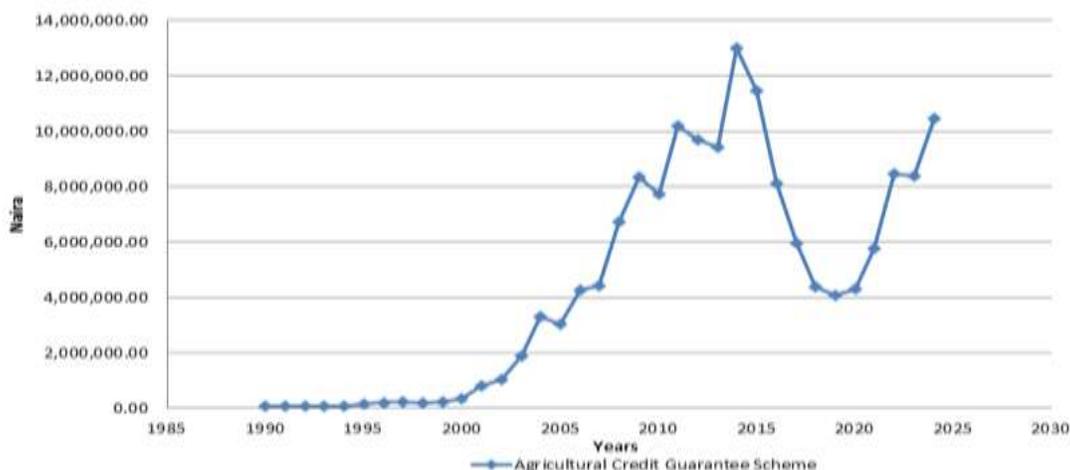

Figure 4: Trend of Nigeria's Agricultural Credit Scheme, 1990 – 2024
(Data Source: CBN, 2024)

Nigeria's agricultural credit scheme is a deliberate action by the Nigerian government to finance agricultural production through the provision of loans to farmers. The scheme had guaranteed funding to the tune of N12.9bn in 2014 which is the highest for the period under review. However, there was a sharp fall in funding under the scheme which was witnessed in the subsequent years after 2015. Funding under the scheme started on gradual increase afterwards and at end of 2024, the scheme guaranteed loan of N10.48bn in Nigeria according to statistics from the Central Bank of Nigeria.

The stylized facts presented in the figures has shown trend of the variables to be used in the model analysis in this research. It is evident that there will be an interesting linkage between

the variables as security threat, exchange rate fluctuations and inflation dynamics have not been favorable for Nigeria. Therefore, the reaction of agricultural sector to changes in these variables will engender proper policy decisions especially at this time that the Nigerian government is channeling efforts towards economic diversification.

Pre-Estimation Tests

The Augmented Dickey Fuller unit root test is carried out to ensure that the time series are stationary series. This is necessary in order to avoid a spurious result and ensure that the data are good for predictive purposes. Additionally, the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test for stationarity is used to check-mate the ADF unit root test for consistency. This cross-check is good because the two tests have different null hypothesis hence giving the estimates a more robust assessment of stationarity and remove any form of inconsistencies in the final outcome. Both tests are summarized in Table 2.

Table 2: ADF Unit Root and KPSS Stationarity Test Results (Eviews 13 output)

	ADF Test Stat. (*p-value in parenthesis*)			KPSS Test Stat (5% level = 0.4630)		
	@Level	@1st diff.	Decision	@Level	@1st difference	Decision
AGP	-1.8972 (0.3294)	-6.3443 (0.0000)	Stationary at 1st difference, I(1)	0.5557	0.4053	Stationary at 1st difference, I(1)
INS	-1.4443 (0.5483)	-9.0520 (0.0000)	Stationary at 1st difference, I(1)	0.7903	0.0799	Stationary at 1st difference, I(1)
EXR	-0.6404 (0.8482)	-4.5303 (0.0010)	Stationary at 1st difference, I(1)	0.7740	0.1159	Stationary at 1st difference, I(1)
CPI	-3.9856 (0.0041)	-3.0129 (0.0443)	Stationary at Level, I(0) and 1st diff.	0.6966	0.3418	Stationary at 1st difference, I(1)
ACGS	-1.3714 (0.5845)	-3.9279 (0.0049)	Stationary at 1st difference, I(1)	0.5931	0.2161	Stationary at 1st difference, I(1)
INT	-3.2992 (0.0228)	-5.7539 (0.0000)	Stationary at Level, I(0) and 1st diff.	0.6423	0.3157	Stationary at 1st difference, I(1)

The result shows that the variables have mixed order of integration. That is to say that based on the ADF unit root test, agric productivity (AGP), security threat index (INS), exchange rate (EXR) and agric credit scheme (ACGS) achieved stationarity after first differencing. Hence they are said to be integrated of order I(1). The other variables consumer price index (CPI) and interest rate are stationary at level i.e. I(0).

However, looking at the KPSS stationarity test, agric productivity (AGP), security threat index (INS), exchange rate (EXR) and agric credit scheme (ACGS) were also stationary at first difference while the stationarity for consumer price index (CPI) and interest rate differed from the ADF by being stationary only at first difference but not at level. Thus, the stationarity order fo the variables is I(1) and I(0) hence we have a maximum order of integration for the group of time-series be *m=1*. The next step in the analysis is to determine the maximum lag length for the model which is summarized in Table 3.

Table 3: Lag Selection Criteria (Eviews 13 output)

Lag	LogL	LR	FPE	AIC	SC	HQ
0	45.55901	NA	3.14e-09	-2.552194	-2.274648	-2.461721
1	205.8204	248.1467	1.09e-12	-10.56906	-8.626239	-9.935749
2	273.4457	78.53260	1.87e-13	-12.60940	-9.001305	-11.43325
3	338.0934	50.04980	7.09e-14	-14.45764	-9.184266	-12.73865
4	572.1209	90.59129*	2.48e-18*	-27.23360*	-20.29496*	-24.97178*

Table 3 shows that the maximum lag order for the model is 4 based on the Akaike Info criterion (AIC). Intuitively, all the criteria are in agreement that the maximum lag length should be 4. Thus, the appropriate maximum lag length *p* for the variables in the VAR model is *p=4*. Additionally, we confirmed the existence of long run relationship between the variables using the Johansen cointegration test result shown in Table 4.

Table 4: Johansen Cointegration Test (Eviews 13 output)

Hypothesized No. of CE(s)	Trace Statistic	*p-value*	Max-Eigen Statistic	*p-value*	*Decision*
None *	171.0876	0.0000	66.69891	0.0000	Cointegrated
At most 1 *	104.3887	0.0000	36.22223	0.0258	Cointegrated
At most 2 *	68.16646	0.0002	31.24622	0.0161	Cointegrated
At most 3 *	36.92024	0.0064	21.89771	0.0390	Cointegrated
At most 4	15.02253	0.0588	14.03515	0.0543	Not Cointegrated
At most 5	0.987380	0.3204	0.987380	0.3204	Not Cointegrated

There is evidence of cointegration based on the Johansen cointegration test at 5% level. In other words, there is long run relationship amongst the variables. This is a clear indication that insecurity, exchange rate and inflation have long run effect on agricultural development in

Nigeria. Having cross-checked the validity of the results through the stationarity, lag selection and cointegration tests, the study proceeds with the Toda-Yamamoto causality analysis.

Toda-Yamamoto Causality Test Analysis

The Toda-Yamamoto causality test summarized in Table 5 tries to overcome the shortcomings of the conventional Granger causality test which is based on F-statistics. Since the F-statistics follows a standard normal distribution, it implies that the integrated variables may not give us robust result (Giles, 2011). Thus, the Toda-Yamamoto causality test generates an augmented VAR model (k + d_max) which gives us the asymptotic test statistic which is the Chi-square statistic. This T-Y test summarized in Table 5 does not require variables to be integrated and it considers both the short run and long run dynamics of security threat index, exchange rate and inflation on agricultural development in Nigeria for the period under review.

Table 5: Toda-Yamamoto Causality Test Summary (Eviews 13 output)

Variables	AGP	INS	EXR	CPI	ACGS	INT
AGP	--	1.103950	0.077428	1.501064	**10.30306**	3.846796
		(0.8936)	(0.9993)	(0.8265)	**(0.0356)***	(0.4271)
INS	**17.13587**	--	**27.15772**	7.127016	2.067488	4.102303
	(0.0018)*		**(0.0000)***	(0.1293)	(0.7233)	(0.3923)
EXR	**29.15766**	7.747175	--	2.775358	1.897532	**11.55440**
	(0.0000)*	(0.1013)		(0.5961)	(0.7546)	**(0.0210)***
CPI	**13.57550**	**15.87428**	**11.59808**	--	0.796139	4.611865
	(0.0088)*	**(0.0032)***	**(0.0206)***		(0.9390)	(0.3295)
ACGS	**21.61865**	0.440523	5.117146	5.847379	--	3.278059
	(0.0002)*	(0.9790)	(0.2755)	(0.2108)		(0.5124)
INT	4.453670	2.811096	**11.88599**	0.862506	3.824380	--
	(0.3481)	(0.5899)	**(0.0182)***	(0.9299)	(0.4303)	

The result shows that security threat index has unidirectional causal relationship with agricultural productivity in Nigeria (*p=0.0018*). This means that the current threat to security in Nigeria can be used to predict future outcome of agricultural productivity. Also, security threat index can be used to predict future outcome of exchange rate in Nigeria. The implication of this is that with rising insecurity in Nigeria, there is high likelihood of displacement and disruption of farming activities, thereby leaving vast areas of fertile land uncultivated. This can be easily predicted given the fact that farmers are usually housed in remote areas where there may be threats to life by terrorists and bandits. Just as Ilesanmi and Odefadehan (2022) asserted, crime

rate and other forms of insecurity are negatively connected to agricultural productivity contributing to food loss. Also, Usman (2022) found that kidnapping, banditry, and livestock rustling accounts for 96.4 per cent of insecurity in Kaduna State Nigeria causing food shortages. Other studies also found negative effect of insecurity on agricultural productivity (Ijeomah and Wonah, 2022; Odunsi-Oyewole, 2022; Agri *et al.,* 2019).

The prediction of the outcome of exchange rate using the current state of insecurity in Nigeria is also confirmed in this present study. By implication, rising security challenges heightens the pressure on local manufacturing (agricultural production) and this can lead to reduced production. In effect, there will be preferences for importation in order to augment local production which is insufficient. By so doing, there will be heightened pressure on exchange rate which is needed for import trade and as a result, this can make exchange rate to surge as was the case I the study of Omotunde *et al.* (2023). On the contrary, this situation can make exchange rate to drop depending on the level of commitment of the government towards ensuring abundance of goods and services for consumption (Olayide, 2022; Chukwuemeka & Ibekwe, 2020). Thus, if the government chooses to encourage local production for internal sufficiency and export, it will potentially drive exchange rate down and vice versa. Thus, the dynamism of insecurity can effectively be used to predict future outcome of exchange rate and its fluctuations.

Furthermore, the result shows that the combined effects of inflation and agric credit guarantee scheme can be used to predict future outcome of agricultural productivity in Nigeria. Thus, the rise in prices can exert severe effect on agricultural productivity as was found in the study of Fang and Zibo (2019). By implication, increasing costs is a direct effect of inflation and this decreases farmers' profits and investments through increased cost of inputs such as fertilizers, seeds, machinery, fuel etc. (Mekonen, 2020). The significant causal relationship between agric credit guarantee scheme and agricultural productivity signals a positive outcome because it is expected that increased funding of the agricultural sector should increase agricultural production. This corroborates the finding of Onakoya *et al.* (2018) where-in they held that agricultural production value added is enhanced through funding of agricultural inputs.

Further analysis revealed that inflation has unidirectional causal relationship with both security threat index for Nigeria and exchange rate. The current level of agricultural production can be used to predict future outcome of agricultural credit scheme in Nigeria based on the results in Table 5. Also, exchange rate and interest rate have bidirectional causal relationship thus cementing the close relationship of the two monetary variables in determining agricultural productivity in Nigeria.

Response to Cholesky One S.D. (d.f. adjusted) Innovations
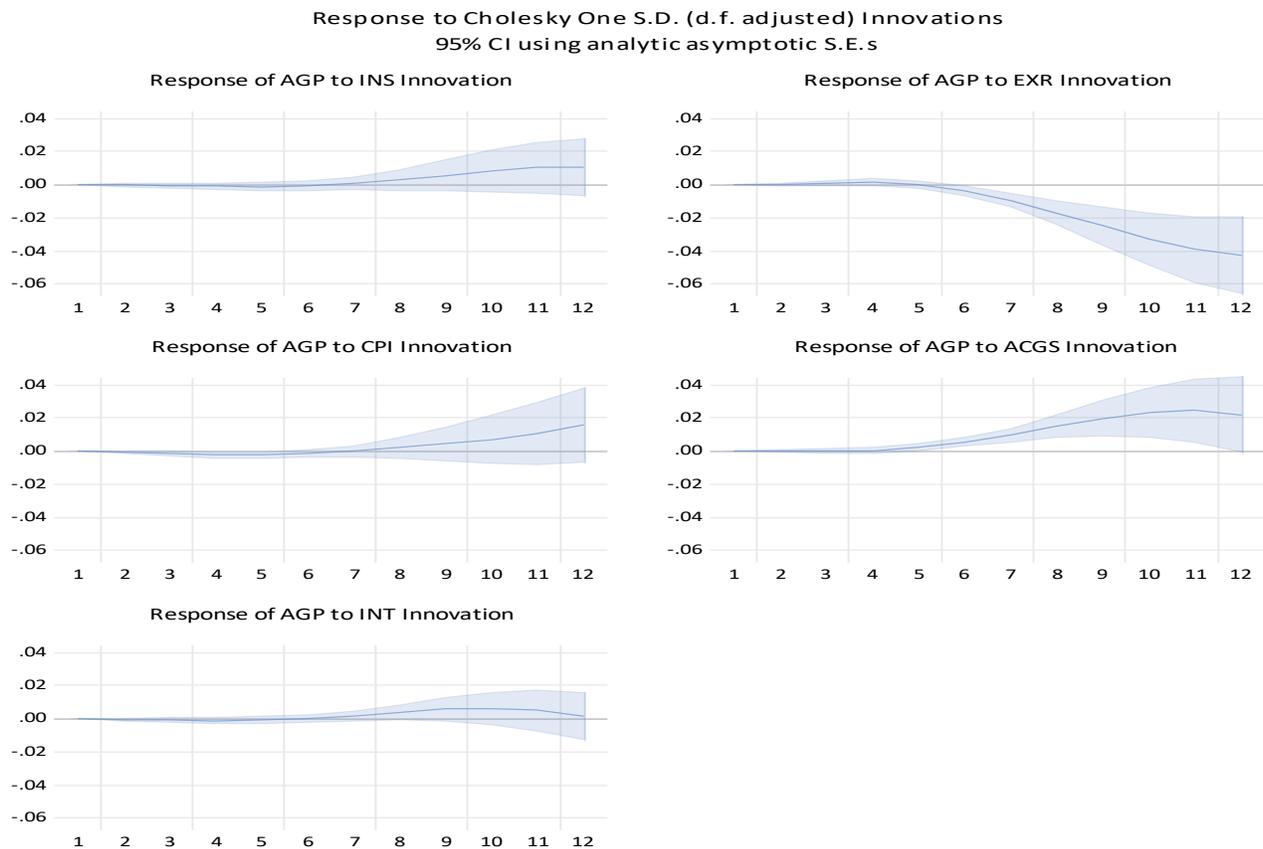95% CI using analytic asymptotic S.E.s

Figure 5: Impulse Response Analysis

Figure 5 shows the response of agricultural productivity to impulses or shocks to insecurity index, exchange rate, inflation, interest rate and agric credit scheme. The results show that the response of agricultural productivity is most severe when there is shock to exchange rate. There is an observed negative slope in agricultural productivity which implies negative effect of exchange rate fluctuations on agricultural productivity. Other effects have positive trends. However, one core observation is that the initial response of agricultural productivity is slow and steady along the zero mean line prior to initial rise and stabilization towards the end of the 12-month period.

CONCLUSION AND RECOMMENDATIONS

Nigeria being a developing nation strives to develop the agricultural sector which has suffered from years of neglect. The preference for oil resources has led to increased depletion of agricultural yield. In recent years, the agricultural has come under close scrutiny following the diversification drive of the government. However, there is a new threat to agricultural productivity which is the threat of insecurity, exchange rate and inflation pressure. This study analyzed these the effect of these variables on agricultural production using the Toda-

Yamamoto approach and the analysis led to the conclusion that the current spate of insecurity of Nigeria can be used to predict the outcome of agricultural production which is likely to be negative. Thus, there is a potential threat to agricultural production if insecurity, exchange rate, inflation, and agric funding schemes are not adequately enhanced. The estimates showed significant causal relationship between insecurity index and agricultural production which confirmed the initial fear. Also, the study concludes that the current trend of movement in Nigeria's exchange rate, inflation and agricultural credit guarantee scheme can be used to predict future outcome of agricultural production. There is a predicted negative outcome of agricultural productivity given changes in exchange rate, inflation and agricultural credit guarantee scheme. The monetary variables – exchange rate and interest rate showed strong positive and significant effects on agricultural productivity thus signaling a possible policy decision that can potentially enhance agricultural productivity. Given the conclusions drawn from the analysis, the following suggestions are made:

1. The Nigerian government should urgently tackle the increasing insecurity in Nigeria which has displaced farmers and is currently threatening food security in the country. The current state of security in Nigeria can obviously predict future depletion of agricultural productivity. Thus, government needs to reverse this trend by ensuring that the indices of security are improved upon in order to make farmers feel safe in their farms.

2. Government should liaise with the private sector to increase local production of agricultural products so as to boost the country's exchange rate and stabilize other monetary variables such as interest rate. This can be done by way of encouraging funding of farmers and intensifying the agric credit guarantee scheme funding.

3. Inflation can be checked by implementing price control subsidies and promotion of agricultural innovation and efficiency.

4. The dynamic interaction between insecurity, exchange rate and inflation is a complex and serious one and the government need to take adequate note of these three macro-economic variables in order to effectively develop the agricultural sector in Nigeria. One way of taking adequate cognizance of these variables is through sound research and development (R & D) in order to develop strategies that will ensure optimal agricultural production. This present research comes in handy at this time in this regard.

SCOPE FOR FURTHER STUDIES

There is need to acknowledge that this present research does not exhaust knowledge of the relationship between insecurity, exchange rate, inflation and agricultural productivity in Nigeria. There is always room for improvement in further studies. Thus, further studies can

study the dynamic impact of insecurity on food security in Nigeria using primary data approach. Additionally, the effect of other macro-economic variables (such as interest rate, employment, trade balance, climate condition, etc.) on agricultural productivity can be explored. Also, qualitative research approach can be explored in further studies as this will further highlight how insecurity has affected agricultural productivity in Nigeria.

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