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MODELING THE ASYMMETRIC RELATIONSHIP BETWEEN MONETARY POLICY FLUCTUATIONS AND AGRICULTURAL SECTOR'S KEY CROP PRODUCTIVITY IN NIGERIA

By

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Abstract

The study focused on examining the asymmetric relationship between Agricultural output and monetary policy variables in Nigeria. The key monetary policy variables used include liquidity ratio, commercial bank credit to agriculture, treasury bills, and exchange rate assessing the asymmetric impact on the output of cocoa, rice and cereals within the period of 1981 to 2023. The study employed asymmetric form of ARDL and the following findings revealed that cocoa output in Nigeria is highly sensitive to both the direction and magnitude of shocks in monetary policy variables particularly the exchange rate, liquidity ratio, and commercial bank lending, short-run fluctuations in key monetary policy indicators do not have a statistically significant effect on rice output in Nigeria. This could imply that rice production is more influenced by structural or long-term factors, or that monetary policy tools operate with longer lags in this particular agricultural sub-sector. The results also show that cereal output in Nigeria responds weakly and inconsistently to short-run changes in monetary policy instruments. While some delayed effects from credit and liquidity shocks are evident. Finally, there exist asymmetric relationship between monetary policy variables and the outputs of cocoa, cereals, and rice. This asymmetry means that the agricultural outputs do not adjust linearly to changes in these monetary variables. The study recommend among others that observed asymmetric and inconsistent responses of cocoa, cereal, and rice outputs to monetary policy variables suggest that monetary tools alone are insufficient. Therefore, coordinated policies that combine targeted fiscal incentives (such as input subsidies or tax reliefs for agribusinesses) with favorable monetary interventions (e.g., concessional lending rates for agriculture) are essential to stimulate sustained growth in the agricultural sector.

Key Words: monetary policy dynamics, agricultural sector outputs
JEL Classification: C32, E52, Q10

1 Introduction

Monetary policy encompasses a broad range of strategies used by governments to regulate the money supply with the goal of achieving key macroeconomic objectives. According to the Central Bank of Nigeria (CBN, 2011), the core focus of monetary policy lies in regulating the supply of money and credit within the economy, with the overarching aims of ensuring price stability, fostering output growth, and achieving full employment. Consequently, the effective management of monetary policy remains a crucial driver of macroeconomic growth. Omolade and Mukolu (2018) observed that the Central Bank of Nigeria has employed diverse tools and frameworks of monetary policy, including inflation targeting, monetary targeting, exchange rate targeting, and interest rate targeting. Similarly, Romer (1996) and Jorda and Salyer (2002) affirmed that these approaches underscore the complex dynamics of monetary policy transmission mechanisms.

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The CBN (2013) categorizes Nigeria's monetary policy trajectory into three major eras: the Pre-SAP era, the Structural Adjustment Programme (SAP)/Deregulation era, and the Bank Consolidation era. The Pre-SAP era, covering periods such as 1967–1971 and 1973–1980, was characterized by a monetary policy framework that primarily supported fiscal operations of the government. During this era, monetary control was administratively driven, with lending and deposit rates, credit growth, and exchange rates determined by fiat. Capital flows were tightly regulated. In contrast, the SAP and Deregulation era witnessed a strategic shift toward a more market-oriented financial system. This new approach was aimed at improving financial savings mobilization and enabling more efficient allocation of resources (Tallroth, 1987). The introduction of the Structural Adjustment Programme in 1986 ushered in liberalization and a gradual departure from administrative controls.

A notable transformation occurred during the Bank Consolidation era, beginning in 2004. This period emphasized the need for a robust financial system capable of supporting an effective monetary policy framework (CBN, 2013). The monetary authority adopted a more market-based approach, introducing the Monetary Policy Rate (MPR) in 2006 to replace the Minimum Rediscount Rate (MRR). This change was accompanied by tools such as Open Market Operations (OMO), stabilization measures for liquidity control, and exchange rate management through securitized and collateralized instruments.

Recent developments in Nigeria's monetary policy landscape reflect frequent adjustments to respond to prevailing macroeconomic conditions. The Monetary Policy Rate (MPR) has undergone several revisions in the past few years. For instance, in December 2022, the MPR stood at 16.5%, with the NAFEX exchange rate at ₦461.33/$. It was raised to 17.5% in January 2023, with a parallel exchange rate of ₦635.23/$. By mid-2023, the MPR reached 18%, and was further increased to 18.75% in Q4 2023 (CBN, 2023). In Q2 2024, the rate was increased again by 150 basis points to 26.25%, accompanied by an asymmetric corridor of +100/-300 basis points and an official exchange rate of ₦1,517.02/**$** (CBN, 2024). These continuous changes reflect the adaptive role of monetary policy in shaping macroeconomic outcomes. Notably, monetary policy dynamics have significant implications for various sectors of the economy, especially agriculture. The transmission of monetary policy operates through several channels including interest rates, credit availability, bank lending, asset prices, and exchange rates which influence economic activities such as production, investment, and trade (Bernanke & Blinder, 1992).

The key monetary policy variables examined in this study, monetary policy rate (MPR), liquidity, and exchange rate are instrumental in determining macroeconomic performance. Freund and Weintraub (2002) explained that the money supply, which includes both currency in circulation and bank deposits, plays a crucial role in determining liquidity levels in the economy. The MPR, which is the policy interest rate set by the Central Bank, influences borrowing costs and thereby affects investment behavior. Rose (2000) further emphasized that exchange rates, by affecting the relative prices of domestic and foreign goods, significantly impact the trade balance and the performance of export-oriented sectors such as agriculture. According to Ezihe, Agbugba, and Idang (2017), the agricultural sector plays a fundamental role in Nigeria's economy, contributing significantly to GDP and serving as a key source of non-oil exports. The sector is widely regarded as a potential catalyst for poverty reduction and sustainable growth, particularly in developing countries. Given its interconnections with other economic sectors, agriculture serves as an important engine of inclusive growth and rural development.

Among the major sub-sectors, cocoa, cereals, and rice production stand out for their strategic importance. Cocoa is a vital cash crop and a major export commodity for Nigeria and other tropical countries, earning significant foreign exchange and providing rural livelihoods (Giller et al., 2019). Cereals and rice, on the other hand, are essential for domestic food security and remain central to agricultural policy interventions. Given the complexity of economic systems, different sectors tend to respond asymmetrically to monetary policy shocks. The agricultural sector, due to its structure and exposure to both domestic and international dynamics, is particularly sensitive to monetary conditions. The CBN (2008) acknowledges that its monetary policy significantly influences credit availability to the agricultural sector, which is crucial for input procurement, mechanization, and productivity. Moreover, Enders (2010) highlighted the growing recognition of asymmetric responses in economic research. It is now widely accepted that economic agents react differently to positive and negative shocks, thus challenging traditional linear assumptions. In the context of agriculture, this asymmetry suggests that the impact of monetary policy may vary depending on whether the policy stance is expansionary or contractionary.

Therefore, this study seeks to rigorously analyze the asymmetric effects of monetary policy on selected agricultural outputs in Nigeria, specifically focusing on cocoa, cereal, and rice production. By doing so, the research aims to contribute to a deeper understanding of the nuanced interaction between monetary policy dynamics and agricultural productivity in an emerging economy like Nigeria. Following the introduction, section two provides a review of relevant theories and literatures. Section three describes the research methodology and addresses data-related concerns. Section four presents the analysis of data and interpretation of results, and Section five concludes the study with appropriate policy recommendations.

2 Literature Review

Theoretical Perspectives

The Quantity Theory of Money (QTM) provides a classical framework that explains the relationship between the volume of monetary aggregates in an economy and the general price level. Although originally formulated to explain the effects of money supply on prices and output, the theory can be

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extended to incorporate liquidity ratio as a proxy for monetary conditions, especially in the context of monetary policy tools used by central banks to influence credit availability and sectoral outputs. The theory, primarily advanced by Irving Fisher (1922), is expressed through the identity: MV= PT Where: M = Quantity of money, V = Velocity of circulation, P = General price level, T = Volume of transactions or output. The central idea of the QTM is that, if V and T are constant, any change in M (money stock or liquidity) results in a proportional change in the price level (P). Although Fisher's original formulation focused on money supply, the liquidity ratio which represents the proportion of liquid assets held by banks relative to their liabilities is a key monetary policy instrument that affects the availability of credit and liquidity in the economy.

In the context of modern monetary policy, changes in the liquidity ratio influence the credit-creating capacity of commercial banks, which indirectly affects the effective liquidity available in the economy. A lower liquidity ratio typically allows banks to lend more, thereby increasing liquidity in the system, while a higher liquidity ratio restricts lending and contracts liquidity. Thus, although not identical to money supply, the liquidity ratio serves as a regulatory tool to influence liquidity conditions, and therefore can be theoretically aligned with the monetary quantity in Fisher's model.

As argued by Gali (2008) and Mankiw and Taylor (2007), under the QTM framework, monetary tools such as liquidity ratios, if used to alter the effective money base in the economy, are assumed to have direct and proportional effects on nominal variables such as prices. The theory assumes that velocity (V) and output (T) are constant, implying that any expansion in liquidity (through reduced liquidity ratios) would lead to inflationary pressure and influence production costs. Moreover, under the QTM framework, monetary aggregates such as the liquidity ratio are treated as exogenous, meaning their values are set independently by the monetary authority and not directly affected by changes in output or income. Thus, the theory presumes a unidirectional causality from liquidity conditions to nominal income and sectoral output.

In contrast, Keynesian economics especially via the Liquidity Preference Theory and the IS-LM framework (Hicks, 1937) views liquidity as endogenously determined, influenced by income levels and interest rates. In the Keynesian framework, the demand for liquidity (i.e., holding of liquid assets) is a function of transactional needs, precautionary motives, and speculative behavior, all of which are linked to economic activity and monetary policy signals. Within this view, a change in the liquidity ratio, which alters bank lending ability, has implications for the interest rate, which in turn affects investment, aggregate demand, and output. Therefore, in the short run, monetary policy interventions that manipulate the liquidity ratio can have significant real effects on sectoral productivity, particularly in interest-sensitive sectors like agriculture.

The Quantity Theory of Money, when interpreted through the lens of liquidity ratio, provides a useful theoretical foundation for assessing how monetary policy instruments affect agricultural productivity in Nigeria. This study examines the impact of three key monetary policy variables liquidity ratio, monetary policy rate (MPR), and exchange rate on the output of selected agricultural commodities, namely cocoa, cereals, and rice. Specifically adjustments in the liquidity ratio affect the availability of credit to the agricultural sector by influencing how much banks can lend. A reduction in liquidity ratio increases bank lending potential, thus possibly enhancing access to credit for farmers. This increase in liquidity can lead to increased investment in agricultural inputs, greater productivity, and higher output in crops like cocoa and rice. Conversely, a tightening liquidity stance (i.e., raising the liquidity ratio) may reduce access to credit, raising borrowing costs, and constraining agricultural investment and production. Furthermore, inflationary effects resulting from excess liquidity can also affect the cost of agricultural inputs (e.g., fertilizer, seeds, machinery), especially in an economy with weak infrastructure and dependency on imports. These effects are particularly pronounced in the Nigerian context, where inflationary pressures often accompany monetary expansion. Hence, the study leverages the Quantity Theory of Money to theoretically explain how changes in monetary condition, mediated may influence agricultural output, either through credit constraints, input price adjustments, or investment incentives.

Empirical Review

Several empirical studies have explored the influence of macroeconomic and monetary policy variables on agricultural performance across different economies, including Nigeria. Omojimite (2012) examined the relationship between public institutions and agricultural productivity in Nigeria using time series data from 1970 to 2008. Applying the Fully Modified Ordinary Least Squares (FMOLS) technique, the study found a positive and significant relationship between institutional credit and agricultural growth. The institutional dummy variable was also significant, indicating that institutional support programs contributed meaningfully to sectoral output and growth. Similarly, Olanrewaju and Makinde (2012) analyzed the implications of monetary policy management on agricultural prices in Nigeria using OLS estimation. Their findings indicated that money supply significantly impacted agricultural prices, which were less sensitive to monetary changes than aggregate prices. Money supply and exchange rate together accounted for 86.2% of the variation in agricultural prices. Ajudua, Davis, and Okonkwo (2015) employed the Ordinary Least Squares (OLS) method to evaluate the effects of monetary policy on agricultural output. They reported that while money supply had a positive effect on output, interest rates negatively impacted agricultural productivity. Their Granger causality test revealed a unidirectional causal link from interest rates to agricultural GDP, emphasizing the influence of interest rates on sectoral performance.

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Imoughele and Ismaila (2014) examined the manufacturing sector in relation to monetary policy variables such as exchange rate, interest rate, broad money supply, and inflation. Their findings, though not agriculture-specific, revealed a long-run equilibrium relationship between these macroeconomic variables and output, indicating the systemic influence of monetary dynamics across sectors. Muftaudeen and Hussainatu (2014) utilized a multivariate Vector Error Correction Model (VECM) to investigate macroeconomic policy effects on Nigerian agricultural output from 1978 to 2011. The results indicated that government expenditure significantly enhanced agricultural productivity, while agricultural credit negatively affected productivity in the short run. Expanding the scope to Malaysia, Kadir and Tugaal (2015) used the Autoregressive Distributed Lag (ARDL) model to assess macroeconomic influences on agricultural output. Their findings revealed that, in the long run, exchange rate negatively affected agricultural output. In the short run, however, agricultural output responded positively to lagged output and interest rates, while agricultural expenditure had a negative effect. In South Africa, Chisasa and Makina (2015) examined the relationship between bank credit and agricultural output from 1970 to 2011 using an Error Correction Model (ECM). The results showed a positive long-run relationship between credit and agricultural output but a negative short-run effect, reflecting credit uncertainty and volatility. Granger causality analysis suggested a unidirectional relationship from credit to output and from output to capital formation.

Ekine & Nwaokedibe (2018) investigated the effectiveness of monetary policy measures in driving agricultural output in Nigeria between 1981 and 2016. They examined the impact of money supply, prime lending rate, deposit money bank credits to agriculture and inflation rate on agricultural output, using static and dynamic regression models. Dynamic error correction model formed the basis for the data analysis. It was found from the parsimonious ECM that one period lag of money supply and deposit money bank credits to agriculture have a significant positive impact on agricultural output.

Oboh, Tule, & Ebuh (2019) examined the impact of monetary policy on agricultural sector performance in Nigeria. The study employed the Autoregressive-Distributed Lag (ARDL) approach and established a long-run relationship between agriculture value added and some monetary policy variables. In the same year, Oboh, Tule, and Ebuh investigated the influence of monetary policy on the performance of the agricultural sector in Nigeria. The research used the Autoregressive-Distributed Lag (ARDL) methodology to ascertain a durable association between agricultural value added and certain monetary policy variables. More precisely, the results indicated that over a prolonged period, changes in the money supply and the maximum lending rate had notable impacts on the value added in the agricultural sector. However, the exchange rate and inflation do not have substantial effects. The article suggests implementing an expansionary monetary policy that does not cause inflation in order to enhance the value added to the agricultural sector of the Nigerian economy, recognizing the significant impact of money supply on agricultural sector performance.

Olorunsogun (2020) investigated the influence of monetary policy on agricultural production. The Vector Error Correction Method (VECM) was used for analysis. The analysis uncovered a persistent statistical correlation between monetary policy instruments and agricultural production. The research further determined that changes in monetary policy tools lead to modifications in agricultural production.

Abiola, Rotdelmwa, Adedoyin, Inegbedion & Olabisi (2021) In examining the impact of monetary policy channels on agricultural performance in Nigeria, used output, employment, and export as metrics for agricultural performance, and the channels of monetary policy considered were credit, interest rate, money and exchange rate. Structural Vector Autoregression (SVAR) and dynamic ordinary least squares (DOLS) were employed. The SVAR variance decomposition findings show that the forecast error shocks of monetary policy channels affect agricultural performance. Likewise, the long-run equations from the DOLS show that output has a positive relationship with money supply, a negative relationship between employment and interest rate, and a negative relationship between exchange rate and export.

Arigor and Asuquo (2021) analyzed the effects of monetary policy on Agricultural Gross Domestic Product performance in Nigeria, 1970-2018. The co-integration and error correction models (ECM) technique was employed in the analysis. The results revealed that in the long run; exchange rate and credit to the agricultural sector were positively signed and significant at the 1 & 5 % levels respectively, while inflation rate was significant at 10 %. In the short run, there exist a negative relationship with respect to lending rate, monetary policy rate and credit to the agricultural sector and are significant at 1%, 10%, and 10% respectively while inflation was positively related to Agric. GDP and is significant at 5%.

Abiola, Rotdelmwa, Adedoyin, Inegbedion, and Olabisi (2021) conducted a study to analyze how different aspects of monetary policy affect agricultural performance in Nigeria. The researchers measured agricultural performance using indicators such as output, employment, and export. The specific channels of monetary policy that were examined included credit, interest rate, money supply, and exchange rate. The study used Structural Vector Autoregression (SVAR) and dynamic ordinary least squares (DOLS) as analytical methods. The SVAR variance decomposition analysis reveals that the shocks in prediction errors of monetary policy channels have an impact on agricultural performance. Similarly, the long-term equations derived from the Dynamic Ordinary Least Squares (DOLS) analysis indicate that there is a positive correlation between production and money supply, a negative correlation between employment and interest rate, and a negative correlation between exchange rate and export.

Using Auto regressive Distributed Lag (ARDL) model Momoh, Isere and Al-Hassan (2023) investigated effect of monetary Policy on the agricultural output in Nigeria. The study used ratio of Agricultural output to GDP (AGRGDP) as the dependent variable and Monetary Policy Rate (MPR), Treasury Bill Rate (TBR), Money supply (MS), Lending Rate (LENR) and Agricultural Credit Guarantee Scheme Fund (ACGSF) as independent variable. The results revealed that there is a long run relationship between dependent and the independent variables. It was observed that money supply, lending rate, Treasury bill rates and monetary policy rate are important drivers of agricultural output.

Research Gap

Despite the breadth of empirical literature on the relationship between monetary policy and agricultural output in Nigeria, several critical gaps persist both in terms of theoretical coverage and methodological innovation. Firstly, the majority of prior studies have focused on conventional monetary policy instruments such as money supply, interest rate, and exchange rate, often overlooking the liquidity ratio, a vital but underexplored regulatory tool employed by central banks to modulate credit availability and systemic liquidity. In a credit-constrained agricultural economy like Nigeria, where farmers and agribusinesses heavily rely on institutional financing, changes in the liquidity ratio can have significant implications for agricultural productivity. The scant attention to this policy instrument leaves an important knowledge gap regarding how liquidity-driven credit tightening or expansion impacts different agricultural outputs**.** Secondly, the existing body of literature tends to treat agricultural output as an aggregate, thereby masking the sectoral heterogeneity in response to monetary policy changes. This approach overlooks the fact that agricultural sub-sectors such as cocoa, rice, and cereals differ in their sensitivity to credit access, input requirements, and policy shocks. There is a notable paucity of disaggregated studies that evaluate the differential impact of monetary policy on specific agricultural sub-sectors that are crucial to food security and export earnings in Nigeria. Thirdly, most empirical studies adopt linear econometric models such as Ordinary Least Squares (OLS), Vector Error Correction Models (VECM), and traditional ARDL frameworks that presume symmetrical effects of monetary policy changes. However, such linear approaches may fail to capture the potential asymmetries in the response of agricultural output to positive and negative shocks in liquidity conditions. For instance, a tightening of the liquidity ratio may constrain agricultural financing more severely than an equivalent loosening might enhance it. This possibility calls for a nonlinear modelling framework such as the Nonlinear Autoregressive Distributed Lag (NARDL) model, which can uncover and quantify these asymmetric relationships.

3 Methodology

In carrying out this study, we adopted use of time series secondary data. The secondary data will be obtained from central bank of Nigeria statistical bulletin 2023. The study covered the period of 1981 to 2023. This study will adopt the Non-linear Autoregressive Distributed Lag (NARDL) model as recently developed by Shin et al. (2014). The NARDL model is an asymmetric modification of the conventional linear ARDL model of Pesaran, Shin, and Smith (2001).

Model Specification

The functional and econometric forms of the models can be specified as follows:

Model 1

$$CoaOUTPT = f\left(LQR,\ CBLA, MPR, EXR\right)$$

$$lnCoaOUTPT = \beta_0 + \beta_1 lnLQR + \beta_2 lnCBLA + \beta_3 MPR + \beta_4 EXR + \varepsilon_1 t \ \ldots\ldots\ldots\ldots(3.1)$$

Model 2

$$RicOUTPT = f\left(LQR,\ CBLA, MPR, EXR\right)$$

$$lnRicOUTPT = \beta_0 - \beta_1 lnLQR + \beta_2 lnCBLA + \beta_3 MPR + \beta_4 EXR + \varepsilon_2 t \ \ldots\ldots\ldots\ldots(3.2)$$

Model 3

$$CerOUTPT = f\left(LQR,\ CBLA, MPR, EXR\right)$$

$$lnCerOUTPT = \beta_0 \,{}_{-}\beta_1 lnLQR + \beta_2 lnCBLA + \beta_3 MPR + \beta_4 EXR + \varepsilon_3 t \ldots\ldots\ldots\ldots(3.3)$$

Where: CoaOUTPT –Cocoa Output, RicOUTPT –Rice output, CerOUTPT –Cereal output, EXCHR – Exchange rate, LQR– Liquidity ratio, MPR – Monetary Policy Rate, while CBLA- Commercial Bank Lending to Agriculture Sector is added as control variable to avoid variable omission. εt is the term describing the error and is expected to be broadly distributed with the mean of zero and unchanged variance; β0 is the Constant term/intercept whereas β_1 and β_5 are the Slope coefficients. Further, the work set out to present an Autoregressive Distributed Lag (ARDL) model of the effects of exchange rate movements on foreign capital inflow in Nigeria. The generalized form of ARDL (p, q) model is stated as:

$$\Delta Y_t = a_0 + a_i \sum_{i=1}^{p} \Delta Y_{t-i} + \beta_i \sum_{i=0}^{q} \Delta X_{t-i} + \beta_i \sum_{i=0}^{n} X_{t-i} + \mu_t \ldots\ldots(3.7)$$

Applying the variables of this study, the ARDL models are specify explicitly as

Model 1

$$lnCoaOUTPT_t = \sum_{i=1}^{p} \beta_1 lnCoaOUTPT_{t-1} + \sum_{i=1}^{p} \beta_2 lnLQR_{t-1} + \sum_{i=1}^{p} \beta_3 lnCBLA_{t-1} + \sum_{i=1}^{p} \beta_4 MPR_{t-1} + \sum_{i=1}^{p} \beta_5 EXR_{t-1} + \varepsilon_1 t \ \ldots\ldots\ldots\ldots(3.5)$$

Model 2

$$lnRicOUTPT_t = \sum_{i=1}^{p} \beta_1 lnRicOUTPT_{t-1} + \sum_{i=1}^{p} \beta_2 lnLQR_{t-1} + \sum_{i=1}^{p} \beta_3 lnCBLA_{t-1} + \sum_{i=1}^{p} \beta_4 MPR_{t-1} + \sum_{i=1}^{p} \beta_5 EXR_{t-1} + \varepsilon_2 t \ \ldots\ldots\ldots\ldots(3.6)$$

Model 3

$$lnCerOUTPT_t = \sum_{i=1}^{p} \beta_1 lnCerOUTPT_{t-1} + \sum_{i=1}^{p} \beta_2 lnLQR_{t-1} + \sum_{i=1}^{p} \beta_3 lnCBLA_{t-1} + \sum_{i=1}^{p} \beta_4 MPR_{t-1} + \sum_{i=1}^{p} \beta_5 EXR_{t-1} + \varepsilon_3 t \ldots\ldots\ldots\ldots(3.7)$$

Where Y and X denote the dependent and independent variables respectively. Extending the model to the non-linear ARDL (NARDL) model in order to capture the asymmetric effect of exchange rate movements on foreign capital inflow in line with Shin *et al* (2014), we specify the NARDL.

The NARDL Model

The NARDL model has advantage over ARDL as it permits the evaluation of asymmetric short run and long run effect of explanatory variable on the explained variable. According to Shin et al (2014), the asymmetric cointegration relationship with NARDL model decomposed the exogenous variables into positive and negative sum of squares.

$$Y_t = \alpha_t^+ X_t^+ + \alpha_t^- X_t^- + \mu_t \qquad (3.8)$$

Where Y = CoaOUTPT, RicOUTPT , CerOUTPT and X stands for EXCHR, LQR, MPR, CBLA. The "+" and "-" as superscript denote the threshold variable coefficient showing positive and negative responses of the explanatory variables of the dependent variables for the three (3) models. The NARDL model exhibiting the long run and short-run asymmetry is specified in generalized form in equation 3.9

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$$Y_t = \sum_{i=1}^{p} \alpha_i Y_{t-i} + \sum_{i=1}^{q} (\alpha_i^+ X_{t=i}^+ + \alpha_i^- X_{t-i}^-) + \mu_t \quad (3.9)$$

Therefore, the conditional error correction model for equation 11 with respect to positive and negative partial sum can be specified as

$$\Delta Y_t = \sum_{i=1}^{p} \alpha_i \Delta Y_{t-i} + \sum_{i=0}^{q} \Delta(\alpha_i^+ X_{t=i}^+ + \alpha_i^- X_{t-i}^-) + \varphi^+ X_t^+ + \varphi^- X_t^- + \mu_t \quad (3.10)$$

Where α represents the short run asymmetric effect and φ measures the long run asymmetric monetary policy on agricultural sub-sector output in Nigeria. Shin et al (2014) posited that the above equation sufficiently corrects for the potential feeble endogeneity of non-stationarity variable in a non-linear ARDL model.

According to Shin et al. (2014), the asymmetric cointegrating relationship in NARDL framework starts by splitting the exogenous variables in Equations (3.5), (3.6) and (3.7) into a partial sum process as summarized and presented below:

$$y_t = \varphi_t + \varphi_1^+ X_{1t}^+ + \varphi_1^- X_{1t}^- + \mu_t \quad (3.15)$$

Where y_t is k x1 vector of agricultural outputs at time t; X_t is a k x 1 vector of multiple regressors specified such that $X_t = X_o + X_t^+ + X_t^-$ indicating natural logarithm the regressors; $\varphi^+ and \varphi^-$ are the corresponding asymmetric cointegrating parameters, which shows that CoaOUTPT, RicOUTPT and CerOUTPT respond asymmetrically as EXCHR, LQR, MPR, CBLA show fluctuating movement; μ_1 is the stochastic error terms. The (+) and (-) are superscripts showing the negative and positive reactions circulating a zero threshold, which defines and sets boundaries for the regressors, implying that the first difference of the series is assumed to be normally distributed with zero mean. A nonlinear model which exhibits both long run and short run asymmetries can be modeled as follows:

$$y_t = \sum_{i=0}^{q} \psi_t y_{t-1} + \sum_{i=0}^{r} (\partial_i^{+1} X_{t-i}^{+1} + \partial_i^{-1} X_{t-i}^{-1}) + \mu_t \quad (3.18)$$

We will proceed to specify the conditional error correction model for equation (3.18) which contain the negative and positive partial sums as:

$$Y_t = \pi y_{t-1} + \lambda^+ X_{t-1}^+ + \lambda^- X_{t-1}^- + \sum_{i=1}^{q-1} \gamma_i \Delta y_{t-1} + \sum_{i=1}^{r-1} (\sigma_i^+ X_{t-1}^+ + \sigma_i^- X_{t-1}^-) + \phi ECM_{t-1} + \mu_t \quad (3.19)$$

Shin et al. (2014) noted that equation (3.19) adequately corrects for the potentially weak endogeneity of non-stationary explanatory variables adequately in a nonlinear ARDL model. The relationship $-\varphi_t^+ = \lambda^+ / q$ and $-\varphi_t^- = \lambda^- / q$ are applied while determining the long run coefficients. The null hypothesis which states that no long run relationship exists within the levels of y_t, X_t^+ and X_t^- this gives $q = \lambda^+ = \lambda^- = 0$ will be tested using the bound testing technique proposed and applied by Pesaran et al. (2001). This approach is valid no matter the time series properties of *X*t.

We shall proceed to determine the direction of causality between the variables of the model using Granger causality test. The optimal lag lengths will be selected using Akaike information criteria.

Tests for Asymmetry

The Wald test which has the null hypothesis of no asymmetry in the long run coefficients $(\varphi_1^+ = \varphi_1^-)$ for model as well as $(\sigma_i^+ = \sigma_i^-)$ for the short run coefficients will be estimated. If the result proves otherwise, we reject the null hypothesis. Wald test for asymmetry (for short-run and long-run) which is crucial to this study will be tested. This test is based on the null hypothesis that positive and negative variations in monetary policy variables have direct opposite influence on agricultural sector outputs in Nigeria. The decision rule states that if the probability of the Wald test is above conventional significance level of 1% or 5% significant level, conclusion of no asymmetry is accepted. Conversely, if the probability is below the 1% or 5% significant level, we reject the null hypothesis and conclude that there exists asymmetric effect of monetary policy variables on agricultural sector outputs in Nigeria.

4 Results and Discussion

4.1 Unit Root Test Result

The stationarity features of the series were examined to ascertain the series order of integration. It adopted both the conventional stationarity test approach (ADF and PP) and the regime shift approach (Zivot-Andrews and Min-Dickey-Fuller). The summary of the result is shown in Table 4.1.

Table 4.1: Unit Roots Test Result

	Conventional Approach						**Breakpoint Approach**							
	ADF			**Phillip-Perron**			**Min Dickey-Fuller**				**Zivot-Andrews**			
Variable	Lev	1st diff	I (d)	Lev	1st diff	I(d)	Lev	1st diff	BP	I (d)	Lev	1st diff	BP	I (d)
CoaOUTPT	-0.8	-4.3**	I(1)	-0.8	-4.2**	I(1)	-1.3	-5.5**	2022	I(1)	-1.5	-5.5**	2022	I(1)
RicOUTPT	-1.9	-6.2**	I(1)	-2.2	-6.1**	I(1)	-4.0	-7.3**	1999	I(1)	-4.0	-7.3**	1999	I(1)

*Corresponding Author: **Ndubuisi Eme UGURU..**

CerOUTPT	2.4	-2.4**	I(1)	-2.3	-6.3**	I(1)	-2.9	-6.4**	1988	I(1)	-2.9	-6.4**	1988	I(1)
EXCHR	-1.7	-5.9**	I(1)	-1.9	-5.9**	I(1)	-2.8	-7.8**	1999	I(1)	-2.8	-7.8**	1999	I(1)
LQR	-3.3**	N/A	I(0)	-3.5*	N/A	I(0)	-4.5*	N/A	2006	I(0)	-4.5*	N/A	2006	I(0)
MPR	-3.2**	N/A	I(0)	-3.1	N/A	I(0)	-4.2	-8.4**	2011	I(1)	-3.6	-8.5**	2011	I(1)
CBLA	-3.7**	N/A	I(0)	-3.5	N/A	I(0)	-5.2*	N/A	1986	I(0)	-5.1*	N/A	1986	I(0)

Authors' computation. ** (*) shows the variable is stationary at 1% (5%) level of significance. BP denotes break period, I(d) represents order of integration of the series.

Table 4.1 presents the conventional and breakpoint approaches to unit root test. Augmented Dickey Fuller (ADF) and Philip-Perron (PP) Unit Root Tests revealed that the variables are stationary at different order, at level and after their first differences (i.e *I*(0) and *I*(1)*)*. The the conventional approach agreed that monetary policy rate liquidity ratio and commercial banks lending rate are stationary at level while cocoa output, rice output, cereal output, and exchange rate are all stationary after their first differences. The breakpoint approach (Min- Dickey- Fuller and Andrew-Zivot Unit root tests) also agreed with ADF and PP test on all the variables except MPR which they proved to be stationary after the first difference.

Thus, we conclude that the variables under investigation were integrated at level (*I*(0)) and after first difference (*I*(1)). This implies that we have a combination of order of integration. The breakpoints observed in the series for different periods justified the appropriateness of the asymmetric for of ARDL.

Next is to test the cointegration relationship among the variables using NARDL bound test for the 3 models as shown in the Table 4.2 for model one below;

4.2 Cointegration Test

Table 4.2: NARDL Model Bounds Test for model one

Test Statistic	Values	K	Significant level	Lower bound(I0)	Upper bound (I1)	Conclusion
F-statistic	3.568205	5	10% 5% 1%	2.63 3.1 4.13	3.35 3.87 5.0	cointegration inconclusive inconclusive

Source: Author's computation

From Table 4.2, the long run relationship between cocoa output and other explanatory variables is conintegrate at 10% significance level because the calculated F-statistc value (3.568205) is greater than the upper bound (3.35) but at 5% and 1% level of significance, the result is inconclusive because the F-statistic is in-between the upper and the lower bounds values. Thus there is evidence of cointegration in the first model

Table 4.3: NARDL Model Bounds Test for Model Two

Test Statistic	Values	K	Significant level	Lower bound(I0)	Upper bound(I1)	Conclusion
F-statistic	2.634775	5	10% 5% 1%	2.26 2.63 4.13	3.35 3.87 5	inconclusive No cointegration No cointegration

Source: Author's computation

From Table 4.3, illustrate the long run between rice output and other explanatory variables is not cointegrated at 1%, and 5% significant level because the calculated F-statistc value (2.634775) is below the upper bound and the lower bound critical value, however, at 10% the result is inconclusive. Therefore, there is no evidence of conitegration between the variables in the second model.

Table 4.4: NARDL Model Bounds Test for Model Three

Test Statistic	Values	K	Significant level	Lower bound(I0)	Upper bound(I1)	Conclusion
F-statistic	2.634775	5	10% 5% 1%	2.63 3.1 4.13	3.35 3.87 5	Inconclusive No cointegartion No cointegartion

Source: Author's computation

Table 4.4, illustrate that the long run between cereals output and other explanatory variables is inconclusive at 10% significance level because the calculated F-statistc value (2.307364) is in-between the upper bound (3.57) and the lower bound (2.26) critical value but at 5% and 1% level of significance, there is no evidence of conitegration between the variables in the first model.

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4.3 **Result NARDL**

The research will proceed to estimate the models as shown below

Table 4.5: Estimated NARDL short run and long run results for model one (dependent variable: LNCOAOUTPT)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Short Run Panel				
D(LNEXR_NEG)	-12.682991	6.753771	-1.877912	0.0871
D(LNEXR_NEG(-1))	-13.662880	6.389323	-2.138392	0.0558
D(LNEXR_POS)	1.106182	0.256435	4.313700	0.0012
D(LNEXR_POS(-1))	-0.646114	0.293620	-2.200506	0.0500
D(LNLQR_NEG)	-1.921984	0.709054	-2.710631	0.0203
D(LNLQR_NEG(-1))	-0.940714	0.638707	-1.472840	0.1688
D(LNLQR_NEG(-2))	0.414502	0.508543	0.815077	0.4323
D(LNLQR_POS)	0.295364	0.438254	0.673955	0.5143
D(LNLQR_POS(-1))	-2.448692	0.851419	-2.876014	0.0151
D(LNLQR_POS(-2))	2.039148	0.788492	2.586137	0.0253
D(LNMPR_NEG)	-2.882477	0.930620	-3.097373	0.0102
D(LNMPR_NEG(-1))	-0.087294	0.545148	-0.160129	0.8757
D(LNMPR_NEG(-2))	3.249675	0.935387	3.474150	0.0052
D(LNMPR_POS)	0.931073	0.536378	1.735853	0.1105
D(LNMPR_POS(-1))	1.586703	0.410898	3.861548	0.0026
D(LNCBLA_NEG)	0.642519	0.746612	0.860579	0.4078
D(LNCBLA_NEG(-1))	-1.113344	0.712612	-1.562342	0.1465
D(LNCBLA_POS)	0.276395	0.688931	0.401194	0.6960
CointEq(-1)	-2.651174	0.556315	-4.765600	0.0006
Long Run Coefficients				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
LNEXR_NEG	11.039479	3.327900	3.317251	0.0069
LNEXR_POS	1.057161	0.130218	8.118395	0.0000
LNLQR_NEG	-0.706215	0.378134	-1.867632	0.0887
LNLQR_POS	-0.534609	0.194231	-2.752433	0.0188
LNMPR_NEG	-1.679439	0.608232	-2.761180	0.0185
LNMPR_POS	-0.589598	0.244536	-2.411092	0.0345
LNCBLA_NEG	1.487590	0.593252	2.507518	0.0291
LNCBLA_POS	0.880756	0.361542	2.436108	0.0330
C	10.267732	0.218574	46.976071	0.0000

The estimated Nonlinear ARDL (NARDL) results provide insights into the asymmetric short-run and long-run effects of selected monetary policy variables on cocoa output (LNCOAOUTPT) in Nigeria. In the short run, both negative and positive shocks in the exchange rate have significant effects on cocoa output. A positive shock (i.e., depreciation) in exchange rate significantly increases cocoa output, while a negative shock (i.e., appreciation) reduces it. This suggests that depreciation of the naira may encourage export-oriented cocoa production, whereas appreciation discourages it. The effects are particularly strong in the current and one-period lag of both exchange rate shocks. Regarding the liquidity ratio, the results indicate a mixed short-run effect. A one-period lag of a positive liquidity shock (i.e., increase in liquidity ratio) has a significant negative impact on cocoa output, while a two-period lag of the same variable shows a significant positive effect. This suggests that increasing liquidity requirements initially constrains credit flow to the cocoa sector, but may adjust over time. Conversely, negative shocks (reductions in liquidity ratio) initially have a significant negative effect but turn insignificant in later periods, indicating short-term credit tightening effects.

The monetary policy rate (MPR) also exhibits asymmetry. A negative shock (reduction in MPR) significantly reduces cocoa output in the short run, although its two-period lag turns positive and significant. Positive MPR shocks (increases in interest rates) show delayed but significant positive effects at one lag, possibly reflecting adjustment in financing behavior or delayed responses in the agricultural sector. With respect to commercial bank lending to agriculture (CBLA), neither positive nor negative shocks produce statistically significant short-run effects. This implies that changes in agricultural credit do not immediately translate into changes in cocoa output within the short-term horizon. The error correction term (ECT(-1)) is negative and statistically significant, confirming the existence of a long-run equilibrium relationship between the variables, and indicating that about 265% of deviations from equilibrium are corrected annually, suggesting a rapid speed of adjustment.

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In the long run, both positive and negative shocks in the exchange rate significantly influence cocoa output, with depreciation (positive shock) having a stronger effect than appreciation. This underscores the export sensitivity of cocoa to currency fluctuations. The liquidity ratio, both when increased or decreased, has a statistically significant negative long-run effect on cocoa output, suggesting that higher liquidity requirements tend to reduce funding availability for the cocoa sector, regardless of the direction of change. The monetary policy rate similarly has a negative long-run effect whether it increases or decreases, indicating that fluctuations in interest rates either way can dampen long-term investment or planning in cocoa production, possibly due to uncertainty or cost-of-funds considerations. Conversely, both negative and positive changes in commercial bank lending to agriculture significantly boost cocoa output in the long run. This indicates that sustained access to institutional credit supports cocoa production over time, regardless of whether the credit level is increasing or recovering from a decrease. The NARDL results reveal that cocoa output in Nigeria is highly sensitive to both the direction and magnitude of shocks in monetary policy variables particularly the exchange rate, liquidity ratio, and commercial bank lending.

Table 4.6: Estimated NARDL results model two (dependent variable: LNRICOUTPT)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.018278	0.011029	1.657323	0.1485
D(LNRICOUTPT(-1))	-0.015133	0.024107	-0.627742	0.5533
D(LNEXR_NEG)	-0.030897	0.199409	-0.154943	0.8819
D(LNEXR_NEG(-1))	0.019099	0.235636	0.081052	0.9380
D(LNEXR_NEG(-2))	0.389676	0.333885	1.167097	0.2875
D(LNEXR_NEG(-3))	0.444977	0.264678	1.681201	0.1437
D(LNEXR_POS)	0.001689	0.015700	0.107564	0.9178
D(LNEXR_POS(-1))	0.009460	0.028528	0.331607	0.7515
D(LNEXR_POS(-2))	-0.017353	0.018195	-0.953685	0.3771
D(LNEXR_POS(-3))	-0.016437	0.016631	-0.988349	0.3611
D(LNEXR_POS(-4))	-0.022760	0.018651	-1.220274	0.2681
D(LNMPR_NEG)	-0.046719	0.042276	-1.105107	0.3114
D(LNMPR_NEG(-1))	-0.035595	0.036305	-0.980429	0.3647
D(LNMPR_NEG(-2))	-0.032448	0.034993	-0.927249	0.3896
D(LNMPR_NEG(-3))	-0.014052	0.038877	-0.361438	0.7302
D(LNMPR_NEG(-4))	0.012857	0.042833	0.300160	0.7742
D(LNMPR_POS)	-0.015687	0.025397	-0.617660	0.5595
D(LNMPR_POS(-1))	-0.016021	0.037319	-0.429313	0.6827
D(LNMPR_POS(-2))	0.000871	0.031732	0.027461	0.9790
D(LNMPR_POS(-3))	-0.016769	0.022418	-0.748040	0.4827
D(LNMPR_POS(-4))	-0.025581	0.026466	-0.966573	0.3711
D(LNCBLA_NEG)	0.026231	0.054664	0.479869	0.6483
D(LNCBLA_NEG(-1))	0.042142	0.066933	0.629622	0.5521
D(LNCBLA_NEG(-2))	0.096402	0.046201	2.086559	0.0820
D(LNCBLA_NEG(-3))	0.056433	0.039651	1.423261	0.2045
D(LNCBLA_NEG(-4))	-0.022420	0.038962	-0.575434	0.5859
D(LNCBLA_POS)	0.029224	0.040896	0.714588	0.5017
D(LNCBLA_POS(-1))	0.075417	0.054708	1.378526	0.2172
D(LNCBLA_POS(-2))	-0.004709	0.028767	-0.163701	0.8753
D(LNCBLA_POS(-3))	0.013606	0.031836	0.427366	0.6840
D(LNCBLA_POS(-4))	0.039440	0.034326	1.148984	0.2943

The NARDL model results for cocoa output, with LNRICOUTPT as the dependent variable, show that most of the short-run dynamics between rice production and the monetary policy variables including exchange rate (LNEXR), liquidity ratio (LNLQR), monetary policy rate (LNMPR), and commercial bank lending to agriculture (LNCBLA) are statistically insignificant within the sample period from 1987 to 2023. Specifically, both negative and positive shocks in the exchange rate have no significant impact on rice output in the short run, as indicated by the low t-statistics and high p-values across all lags. This implies that fluctuations in exchange rate, whether appreciation or depreciation, do not significantly alter rice output over the observed period. Similarly, changes in the monetary policy rate whether increases or decreases show no

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meaningful short-run influence on rice output. None of the coefficients for the negative or positive changes in the MPR are statistically significant, suggesting that interest rate adjustments by the central bank do not immediately translate into changes in rice production.

Commercial bank lending to the agricultural sector also presents mostly insignificant short-run effects. Although the second lag of negative credit shocks shows a moderately significant positive impact on rice output, this result is isolated and does not reflect a consistent pattern across the other lags. Positive credit shocks are likewise statistically insignificant, suggesting that increases in lending do not produce immediate changes in rice production levels within the time frame considered. This model reveals that short-run fluctuations in key monetary policy indicators do not have a statistically significant effect on rice output in Nigeria. This could imply that rice production is more influenced by structural or long-term factors, or that monetary policy tools operate with longer lags in this particular agricultural sub-sector.

Table 4.7: Estimated NARDL results model three (dependent variable: LNCEROUTPT)

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
D(LNCEROUTPT(-1))	-0.539645	0.336182	-1.605220	0.1837
D(LNEXR_NEG)	20.43468	10.26456	1.990801	0.1173
D(LNEXR_NEG(-1))	-12.91485	7.518449	-1.717754	0.1610
D(LNEXR_NEG(-2))	11.63352	9.367578	1.241892	0.2821
D(LNEXR_NEG(-3))	-20.19909	10.10038	-1.999835	0.1161
D(LNEXR_POS)	0.324393	0.368735	0.879744	0.4287
D(LNEXR_POS(-1))	0.692337	0.529172	1.308341	0.2609
D(LNEXR_POS(-2))	-0.484320	0.262542	-1.844736	0.1388
D(LNEXR_POS(-3))	-0.807761	0.428063	-1.887013	0.1322
D(LNLQR_NEG)	-0.570207	0.868091	-0.656852	0.5471
D(LNLQR_NEG(-1))	3.021013	1.028501	2.937297	0.0425
D(LNLQR_NEG(-2))	-0.006232	0.794618	-0.007843	0.9941
D(LNLQR_NEG(-3))	2.084328	1.184838	1.759168	0.1534
D(LNLQR_POS)	1.636350	0.838353	1.951863	0.1227
D(LNLQR_POS(-1))	-1.736656	0.815058	-2.130715	0.1001
D(LNLQR_POS(-2))	0.120600	0.823611	0.146429	0.8907
D(LNLQR_POS(-3))	1.305398	0.904107	1.443853	0.2223
D(LNMPR_NEG)	1.277649	1.284928	0.994335	0.3763
D(LNMPR_NEG(-1))	-2.103488	0.967566	-2.173998	0.0954
D(LNMPR_NEG(-2))	-1.731315	0.810300	-2.136636	0.0995
D(LNMPR_NEG(-3))	-1.513584	0.825779	-1.832918	0.1408
D(LNMPR_POS)	-1.571822	0.798818	-1.967684	0.1205
D(LNMPR_POS(-1))	0.630722	0.698246	0.903294	0.4175
D(LNMPR_POS(-2))	-0.681855	0.576258	-1.183247	0.3022
D(LNMPR_POS(-3))	-0.449020	0.484124	-0.927490	0.4062
D(LNCBLA_NEG)	1.184450	1.086916	1.089734	0.3371
D(LNCBLA_NEG(-1))	-0.463500	1.059326	-0.437542	0.6843
D(LNCBLA_NEG(-2))	-1.270845	0.996297	-1.275569	0.2712
D(LNCBLA_NEG(-3))	2.077741	0.934382	2.223652	0.0902
D(LNCBLA_POS)	3.046162	1.337943	2.276749	0.0851
D(LNCBLA_POS(-1))	0.732576	0.786728	0.931168	0.4045
D(LNCBLA_POS(-2))	2.822059	0.992396	2.843683	0.0467
D(LNCBLA_POS(-3))	-1.173301	0.585397	-2.004282	0.1156
C	0.140848	0.353811	0.398087	0.7109

The estimated NARDL model results for cereal output in Nigeria reveal complex short-run dynamics between cereal production and key monetary policy indicators namely, exchange rate, liquidity ratio, monetary policy rate, and commercial bank lending to agriculture over the sample period from 1986 to 2023. The impact of exchange rate fluctuations, whether depreciation (negative shocks) or appreciation (positive shocks), appears to be statistically insignificant overall, as shown by the high p-values. Although some individual coefficients, like the third lag of negative exchange rate shocks and the second and third lags of positive shocks, are relatively large in magnitude, their statistical

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insignificance suggests that short-run changes in the exchange rate do not have a strong or consistent effect on cereal output.

For liquidity ratio shocks, the result indicates that a negative shock in the previous period has a significant positive effect on cereal output, implying that a tightening of liquidity conditions in the past may have supported cereal production, possibly through more efficient credit allocation. Other positive and negative shocks to liquidity are largely insignificant, suggesting the effect is not consistent across time. Regarding the monetary policy rate, both negative and positive shocks yield mixed and mostly insignificant results in the short run. However, the first and second lags of negative shocks are marginally significant with negative signs, suggesting that a loosening of monetary policy (i.e., reductions in interest rate) might slightly stimulate cereal output after a lag. Positive interest rate shocks generally show no clear effect.

The role of commercial bank lending to agriculture shows slightly more influence on cereal output. Notably, positive shocks in credit particularly at the second lag have a statistically significant positive effect, implying that increases in lending to the agricultural sector can enhance cereal production, although the impact is not immediate. A negative shock at the third lag is also marginally significant and positive, suggesting some delayed effects of credit tightening as well. The results suggest that cereal output in Nigeria responds weakly and inconsistently to short-run changes in monetary policy instruments. While some delayed effects from credit and liquidity shocks are evident, the overall pattern points to a limited and lagged sensitivity of cereal production to monetary policy dynamics in the short term.

Tests for Asymmetry

Table 4.20 to 4.28 shows the Wald test. Wald test has the null hypothesis that monetary policy variables have no asymmetric effect on agricultural output in Nigeria. The result are shown in the tables below

Table 4.8A: Wald Test for Asymmetry for the model one (long run)

Test Statistic	Value	df	Probability
t-statistic	-0.764954	155	0.4455
F-statistic	0.585155	(1, 155)	0.4455
Chi-square	0.585155	1	0.4443

The p-values are above the conventional 5% significance level, suggesting that the null hypothesis cannot be rejected at strict conventional levels but is very close to statistical significance. The results indicate a moderate level of asymmetry, though the evidence is not strong enough for firm conclusions. From the results the null hypothesis, cannot be rejected at the conventional 5% level of significance in the long run.

Table 4.8B: Wald Test for Asymmetry for the model one (short run)

Test Statistic	Value	df	Probability
t-statistic	3.140152	155	0.0020
F-statistic	9.860552	(1, 155)	0.0020
Chi-square	9.860552	1	0.0017

The p-values are below the conventional 5% significance level, suggesting that the null hypothesis is rejected. The results indicate the presence of asymmetry, with enough for firm conclusions. From the results the null hypothesis, is rejected 5% level of significance in the short run and we conclude that there is asymmetric relationship in the model.

Table 4.9: Wald Test for Asymmetry for the model two (short run)

Test Statistic	Value	df	Probability
t-statistic	4.144682	155	0.0001
F-statistic	17.17839	(1, 155)	0.0001
Chi-square	17.17839	1	0.0000

The p-values fall below the standard 5% significance threshold, leading to the rejection of the null hypothesis. The findings confirm the existence of asymmetry, providing sufficient evidence for firm conclusions. At the 5% significance level in the short run, the null hypothesis is rejected, indicating an asymmetric relationship within the model.

Table 4.10 Wald Test for Asymmetry for the model three (short run)

Test Statistic	Value	df	Probability
t-statistic	-8.525869	154	0.0000
F-statistic	72.69044	(1, 154)	0.0000
Chi-square	72.69044	1	0.0000

Since the p-values are below the conventional 5% significance level, the null hypothesis is rejected. The results provide strong evidence of asymmetry, supporting firm conclusions. At the 5% significance level in the short run, the rejection of the null hypothesis confirms the presence of an asymmetric relationship in the model.

Diagnostic Tests

The diagnostic tests were carried out to ensure that the regression models passed all necessary econometric

*Corresponding Author: **Ndubuisi Eme UGURU..**

conditions such as serial correlation, heteroskedasticity and normality, the results are presented in Table 4.29 to 4.37 below.

Table 4.29: Diagnostic Tests for Model One

Variable Coefficient	Coefficient	Prob
Jarque-Bera normality test	0.325693	0.8497
Breusch-Godfrey serial correlation LM test	0.910116	0.3626
ARCH: heteroscedasticity test	1.214030	0.3817
Ramsey Reset test	3.784287	0.0804

Source: Author's computation

Results of diagnostics test show that the model residuals are not normally distributed as indicated by Jarque- Bera statistic (p = 0.0000), it also indicated that the model does not suffer from autocorrelation (p = 0. 0.7781) and there is no evidence of heteroscedasticity (p = 0.7978). The Ramsey stability test signifies that the model is correctly specified.

Table 4.12: Diagnostic Tests for Model Two

Variable Coefficient	Coefficient	Prob
Jarque-Bera normality test	7.352722	0.0253
Breusch-Godfrey serial correlation LM test	0.062806	0.8121
ARCH: heteroscedasticity test	0.378257	0.9647
Ramsey Reset test	4.756942	0.0810

Source: Author's computation

Results of diagnostics test show that the model residuals are abnormally distributed as indicated by Jarque- Bera statistic (p = 0.0253), it also indicated that the model does not suffer from autocorrelation (p = 0.8121) and there is no evidence of heteroscedasticity (p = 0.9647). Also the model is well specified and stable as indicated by Ramsey stability test with pro-value of 0.0810 which is not less than the conventional 5% level of significance.

Table 4.13: Diagnostic Tests for Model Three

Variable Coefficient	Coefficient	Prob
Jarque-Bera normality test	5.947258	0.0511
Breusch-Godfrey serial correlation LM test	6.981145	0.1253
ARCH: heteroscedasticity test	0.305304	0.9771
Ramsey Reset test	1.101209	0.3711

Source: Author's computation

Results of diagnostics test show that the model residuals are normally distributed as indicated by Jarque- Bera statistic (p = 0.0511), it also indicated that the model does not suffer from autocorrelation (p = 0.1253) and there is no evidence of heteroscedasticity (p = 0.9771). Also the model is well specified and stable as indicated by Ramsey stability test with pro-value of 0.3711 which is not less than the conventional 5% level of significance.

Discussion of Results

The NARDL (Nonlinear Autoregressive Distributed Lag) model estimation reveals important insights into the responsiveness of agricultural outputs particularly cocoa and cereal production to monetary policy instruments in Nigeria. The findings underscore the nuanced and asymmetric nature of this relationship, especially in the context of developing economies where monetary transmission mechanisms are often weakened by structural inefficiencies and institutional rigidities.

For cocoa output, the results suggest a strong sensitivity to both the direction and magnitude of shocks in monetary policy variables such as the exchange rate, liquidity ratio, and commercial bank lending to the agricultural sector. This implies that fluctuations in these variables whether appreciation or depreciation in exchange rates, tightening or loosening of liquidity, or increases and decreases in credit availability do not impact cocoa output uniformly. Instead, positive and negative shocks produce different outcomes, reflecting an asymmetric adjustment path. For example, depreciation in the exchange rate might stimulate cocoa exports and hence increase output due to improved producer incentives, whereas an appreciation might suppress competitiveness, leading to a decline in production. This is in line with the findings of Adeniran and Yusuf (2021), who observed that exchange rate shocks have a nonlinear effect on agricultural exports in Nigeria, particularly for cash crops like cocoa.

However, despite this apparent sensitivity, the model further reveals that in the short run, fluctuations in these monetary policy indicators do not have a statistically significant effect on cocoa output. This suggests that cocoa production, being a perennial crop with long gestation periods, is less responsive to immediate monetary shocks. Instead, its output is more likely shaped by long-term structural factors, such as infrastructure availability, land tenure systems, access to improved seedlings, and extension services. Additionally, this outcome may reflect the lagged effect of monetary policy tools, which do not instantly transmit to the agricultural sector. This aligns with the observations of Nwosa (2020), who found that monetary policy transmission to the real agricultural sector in Nigeria is weak and operates with significant lags, especially for tree crops.

Similarly, the results show that cereal output which includes crops such as maize, millet, and sorghum responds weakly and inconsistently to short-run changes in monetary policy instruments. Though cereals are annual crops and theoretically more sensitive to seasonal monetary interventions (such as changes in credit availability during planting seasons), the findings suggest that such responsiveness is neither uniform nor immediate. Nonetheless, some delayed effects from credit and liquidity shocks are evident, pointing to a partial lagged

*Corresponding Author: **Ndubuisi Eme UGURU..**

transmission. These observations resonate with the study by Oji-Okoro et al. (2019), who emphasized that while liquidity and credit support policies can stimulate cereal production, the effect is often realized with a delay due to bureaucratic bottlenecks in fund disbursement and implementation inefficiencies.

In general, the NARDL results highlight an asymmetric relationship between monetary policy variables namely the exchange rate, monetary policy rate (MPR), liquidity ratio, and commercial bank lending to agriculture and the outputs of cocoa, cereals, and rice. This asymmetry means that the agricultural outputs do not adjust linearly to changes in these monetary variables. A unit increase in the MPR, for instance, may suppress output more than a unit decrease stimulates it, due to issues such as credit rationing, market frictions, or farmer risk aversion. The asymmetry observed is consistent with the theoretical framework of asymmetric monetary transmission proposed by Bernanke and Gertler (1995), which argues that credit markets in developing countries often amplify the effects of monetary tightening more than they do for monetary easing.

5 Conclusion and Recommendation

Agriculture remains a critical sector in Nigeria, contributing significantly to employment, food security, and economic stability. Despite its importance, the sector faces numerous challenges, including fluctuating monetary policies that impact its stability and growth. Monetary policy, encompassing measures like interest rate adjustments, liquidity ratio, and inflation targeting, is a powerful tool for managing a nation's economic activity. The study employed the NARDL (Nonlinear Autoregressive Distributed Lag) and the findings revealed that that cocoa output in Nigeria is highly sensitive to both the direction and magnitude of shocks in monetary policy variables particularly the exchange rate, liquidity ratio, and commercial bank lending, short-run fluctuations in key monetary policy indicators do not have a statistically significant effect on rice output in Nigeria. This could imply that rice production is more influenced by structural or long-term factors, or that monetary policy tools operate with longer lags in this particular agricultural sub-sector. The results also show that cereal output in Nigeria responds weakly and inconsistently to short-run changes in monetary policy instruments. While some delayed effects from credit and liquidity shocks are evident. Finally, there exist asymmetric relationship between monetary policy variables and the outputs of cocoa, cereals, and rice. This asymmetry means that the agricultural outputs do not adjust linearly to changes in these monetary variables.

Recommendation

Based on the findings from the NARDL analysis, the following three recommendations are proposed:

1. Since cocoa output is more influenced by long-term structural factors rather than short-run monetary policy fluctuations, government and stakeholders should prioritize infrastructure development (e.g., rural roads, storage facilities), secure land tenure systems, and increased access to extension services. These measures will improve the resilience and productivity of cocoa farmers, making them less vulnerable to policy and market shocks.
2. Given that the effects of commercial bank lending and liquidity ratios on cereal output are weak and delayed, policymakers should ensure that agricultural credit schemes are not only adequately funded but also efficiently disbursed to farmers, especially during critical periods of the planting season.
3. The observed asymmetric and inconsistent responses of cocoa, cereal, and rice outputs to monetary policy variables suggest that monetary tools alone are insufficient. Therefore, coordinated policies that combine targeted fiscal incentives (such as input subsidies or tax reliefs for agribusinesses) with favorable monetary interventions (e.g., concessional lending rates for agriculture) are essential to stimulate sustained growth in the agricultural sector.

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