Asymmetric Effects of Monetary Policy on Agricultural Performance in Nigeria

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Abstract
This study investigates the asymmetric effects of monetary policy on agricultural performance in Nigeria from 1981 to 2021, employing the Nonlinear Autoregressive Distributed Lag (NARDL) model. The analysis reveals an asymmetric relationship between monetary policy rates and agricultural output. In the short run, positive changes in the monetary policy rate significantly enhance agricultural performance, whereas negative changes have a less pronounced effect. Conversely, in the long run, negative changes in the monetary policy rate significantly hinder agricultural performance, underscoring the critical role of maintaining lower policy rates to support agricultural growth. Further, the positive changes in lending interest rates directly influence agricultural output, while negative changes exert indirect effects. However, long-run variations in lending rates, whether positive or negative, negatively impact agricultural performance, though insignificantly. Additionally, the liquidity ratio shows short-run significance, with positive changes enhancing and negative changes constraining agricultural performance. In the long term, liquidity ratio variations are not statistically significant. Finally, the study uncovers a counterintuitive finding: deposit money banks' credit to agriculture negatively affects agricultural performance in the short run but exhibits a significant positive impact in the long run during periods of reduced credit. The findings suggest the maintenance of low monetary policy rates, improvement in credit allocation mechanisms, stabilization of financial institutions' liquidity management, and implementation of targeted interventions such as subsidizing lending rates and strengthening agricultural credit schemes to drive sustainable agricultural growth in Nigeria.

Keywords: Agriculture output; monetary policy rate; liquidity ratio; lending rate; domestic credit
JEL Classification Codes: E43, E52, O13, Q11.

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1. Introduction

Agriculture has long been recognized as a cornerstone of economic development, particularly in developing nations, where it plays a pivotal role in poverty reduction and sustainable growth (Agbugba and Binaebi, 2018). Investments in agriculture are often viewed as a pathway to economic emancipation, offering key contributions to national development through product, factor, market, and foreign exchange contributions (Adekunle and Ndukwe, 2018). Despite recent growth in African economies, including a real production increase from 3.6% in 2017 to 4.1% in 2018 (African Development Bank, 2018), challenges remain in achieving systemic changes that address poverty and expand agricultural value chains, highlighting the need for targeted policy interventions (Ajudua, Davis, and Okonkwo, 2015).

Monetary policy significantly influences economic sectors, including agriculture, through mechanisms such as interest rates, credit availability, and exchange rates (Ezihe, Agbugba, and Idang, 2017). In Nigeria, the Central Bank's monetary policy framework, encompassing instruments like open market operations, discount rates, and credit directives, is critical for facilitating agricultural investments and productivity (Ademola, 2019). However, sectoral responses to monetary policy shocks vary, underlining the importance of understanding its transmission mechanisms and differential impacts on sectors like agriculture (Khan, 2011). Addressing these disparities is vital for crafting policies that enhance agricultural growth and economic stability.

Historically, agriculture has been central to Nigeria's economy, providing livelihoods, exports, and raw materials for industries (Ekwe *et al.*, 2017). However, the sector has faced significant challenges since the 1960s, including declining agricultural exports and increasing dependence on food imports, which accounted for approximately one-fourth of the 2017 national budget (Emenuga, 2019). Farmers face difficulties in securing financing for equipment, technologies, and market strategies due to inadequate credit facilities and high collateral demands (Athanasius, 2017). Consequently, commercial banks allocate only 5–10% of their loan portfolios to agriculture, favoring sectors perceived as safer, such as oil and gas (Ezihe, Agbugba, & Idang, 2017). This trend contributes to Nigeria's alarming food import bill, estimated at $5–7 billion annually, which accounts for a significant portion of the national budget (Emenuga, 2019).

Furthermore, structural issues such as limited access to credit, inadequate infrastructure, and inconsistent policies have exacerbated these challenges, underscoring the need for effective monetary interventions to revitalize the sector and address pressing economic issues. Despite efforts to direct affordable credit to agriculture, such as stipulating lower interest rates for the sector (Omorogbe, Jelena, & Ademoh, 2014), farmers continue to face significant barriers in accessing financial services. These challenges limit their ability to invest in land, equipment, and innovative practices, further stifling growth (Athanasius, 2017). Addressing these financial constraints through well-targeted monetary policies could unlock the sector's potential to drive economic development and improve livelihoods.

While many studies have explored the symmetric effect of monetary policy on Nigeria's economy, they often focus on linear effects, neglecting the possibility of asymmetries. For instance, Enimu, Eyo, and Ajah (2017) and Aremu *et al.* (2019) emphasize general economic shocks but fail to address how monetary tightening and easing differently affect agriculture. This study adds to the existing body of knowledge by examining the asymmetric effects of monetary policy on agricultural performance in Nigeria from 1981 to 2021, utilizing a Non-linear Autoregressive Distributed Linear (NARDL) approach.

The remainder of this study is organized as follows. Section 2 presents the review of related literature. Section 3 discusses the methodology part of the study. The results and discussion of findings were presented in section 4, while the last section concludes and proffers policy recommendations.

2. Literature Review

There is a growing concern in the literature about the intricate relationship between monetary policy and agricultural performance, particularly in developing nations, where agriculture remains a critical driver of economic growth and food security. Scholars argue that the effectiveness of monetary policy in stimulating agricultural productivity is constrained by structural challenges, such as limited access to credit, high interest rates, and inflationary pressures, which disproportionately affect this sector. Considering these concerns, this section of the study reviews existing research evidence to shed light on the complexities of this relationship, highlighting the roles of policy instruments such as credit supply, interest rate adjustments, and inflation control. The review critically examines the findings of key studies, focusing on the gaps in addressing the asymmetric impacts of monetary policy changes, which this study aims to explore further.

Ajudua *et al*. (2015) provide a broad review of monetary policy's effectiveness in enhancing agricultural sector performance in Nigeria, using a historical perspective. The researchers utilized a descriptive analysis approach supported by regression to review historical data. The study concluded that while monetary policy plays a crucial role, its impact is often limited by poor policy implementation and infrastructural deficits in Nigeria. Ekine and Nwaokedibe (2018) focus on the effects of monetary policies on Nigeria's agricultural output from 1981-2016. They employed OLS techniques on macroeconomic variables such as interest rates and inflation. Findings showed that while monetary policy instruments have a measurable effect, inflation and interest rate volatility often offset potential gains in Nigeria. Also, Chinedu and Ezekwe (2021) focus on how monetary policy influences commercial banks' ability to supply credit to the agricultural sector in Nigeria. The study relied on Ordinary Least Squares (OLS) regression to examine the responsiveness of agricultural credit to monetary policy changes. They found that monetary policy significantly affects commercial banks' credit supply to agriculture, highlighting the importance of favorable credit terms for boosting the sector.

Athanasius (2017) analyzes the relationship between banks' credit and agricultural output in Nigeria over the period 1980-2014. This employed co-integration and error correction techniques to establish a long-run relationship between banks' credit and agricultural output. The study emphasized that consistent and adequate credit supply is a major driver of agricultural output in Nigeria, but policy inconsistencies hinder long-term benefits. More so, Oboh and Tule (2019) examine the direct impact of monetary policy on the agricultural sector in Nigeria, identifying channels through which policy affects agricultural performance. They used the Auto-Regressive Distributed Lag (ARDL) model to explore short- and long-term effects of monetary policy on agricultural performance. Findings revealed that monetary policy tools, particularly interest rates and credit availability, significantly impact agricultural output, but their effectiveness is constrained by structural bottlenecks in Nigeria.

Mashinini *et al*. (2019) expand the scope to Eswatini, evaluating the effects of monetary policy on agricultural output. They used a Vector Autoregression (VAR) model to study the monetary policy impact on agriculture in Eswatini. The result revealed that monetary policies such as reduced interest rates positively influenced agricultural output, suggesting similar potential for other African nations. Also, Emenuga (2019) investigates the effect of commercial banks' credit facilities on agricultural productivity in Nigeria. It applied a panel data regression model to analyze the effect of credit on productivity. It confirmed that increased agricultural credit from commercial banks positively correlates with higher productivity in the sector. The studies collectively highlight that monetary policy plays a vital role in the performance of the agricultural sector. While credit availability emerges as a common determinant of agricultural productivity, structural challenges such as implementation inefficiencies and infrastructure deficits limit the efficacy of monetary interventions. Notably, findings from Eswatini by Mashinini *et al*. (2019) resonate with Nigerian studies, underscoring the universal challenges of linking monetary policy to agricultural outcomes in African economies.

The reviewed studies provide extensive insights into the relationship between monetary policy and agricultural performance in Nigeria and Eswatini, but they predominantly assume linear effects, leaving a significant gap in understanding asymmetric impacts. Studies such as Oboh and Tule (2019) and Chinedu and Ezekwe (2021) focus on how monetary policy influences credit availability and agricultural outcomes but do not explore how positive and negative policy changes might have differing impacts on the sector. Similarly, works like Ajudua *et al*. (2015) and Ekine and Nwaokedibe (2018) rely on linear models like OLS and ARDL, which cannot capture nonlinear dynamics, potentially overlooking the complexities of monetary policy's effects on agriculture. Thus, this study fills the identified gaps by investigating the asymmetric effects of monetary policy on agriculture performance in Nigeria. It employs the Non-linear ARDL (NARDL) model, which is particularly suited for capturing the differential impacts of positive and negative changes in monetary policy instruments.

3. Methodology

3.1 Data sources and measurements

This study examines the asymmetric effect of monetary policy on agricultural performance in Nigeria using annual time-series data spanning 1981 to 2021. Agricultural performance is represented by agricultural output as a percentage of Gross Domestic Product (GDP). Monetary policy is measured through the monetary policy rate, lending interest rate, liquidity ratio, and deposit money bank credit to agriculture (as a percentage of GDP). Control variables include government expenditure (as a percentage of GDP) and inflation (annual percentage change in consumer prices). Data for the monetary policy rate, lending interest rate, and liquidity ratio were obtained from the Central Bank of Nigeria (CBN) Statistical Bulletin (2022). Other variables, including deposit money bank credit to agriculture, government expenditure, and inflation, were sourced from the World Development Indicators (WDI) database (2022). This diverse dataset ensures robust analysis of the relationship between monetary policy and agricultural performance in Nigeria.

3.2 Model specification

Adapting the empirical models of Ajudua *et al*. (2015), Ekine and Nwaokedibe (2018), Oboh and Tule (2019) and Chinedu and Ezekwe (2021), the study modifies the models and specifies the links between monetary policy and agricultural performance as:

$$agdp_t = \phi_0 + \phi_1 mpr_t + \phi_2 \operatorname{int}_t + \phi_3 lr_t + \phi_4 dma_t + \mathrm{B}Z_t + \upsilon_t \tag{1}$$

Where: agdp is agriculture output as a ratio of GDP; mpr denotes monetary policy rate; int represents lending interest rate; lr is liquidity ratio; dma represents deposit money bank credit to agriculture as a ratio of GDP; Z denotes the vector of control variables which are government expenditure as a percentage of GDP and inflation rate; ϕ_{1-4}, B are parameters; ϕ_0 is constant; t is time; and υ is error term.

The study employs the Nonlinear Autoregressive Distributed Lag (NARDL) model to capture the asymmetric effects of monetary policy on agricultural performance. The model decomposes monetary policy variables into their positive and negative components to assess their differential impacts. The standard ARDL model incorporates the Unrestricted Error Correction Mechanism (UECM), which is represented as follows:

$$\begin{aligned} agdp_t = {} & \varphi_0 + \sum_{i=0}^{n_1} \varphi_{1i} agdp_{t-i} + \sum_{i=0}^{n_2} \varphi_{2i} mpr_{t-i} + \sum_{i=0}^{n_3} \varphi_{3i} \operatorname{int}_{t-i} + \sum_{i=0}^{n_4} \varphi_{4i} lr_{t-i} + \sum_{i=0}^{n_5} \varphi_{5i} dma_{t-i} \\ & + \sum_{i=0}^{n_6} \Theta'_{6i} Z_{t-i} + \pi_1 agdp_{t-1} + \pi_2 mpr_{t-1} + \pi_3 \operatorname{int}_{t-1} + \pi_4 lr_{t-1} + \pi_5 dma_{t-1} + \Phi Z_t + \upsilon_t \end{aligned} \tag{2}$$

Here, n_1 denotes the lag order of the dependent variable (regressand), while the other n_s represent the lag orders of the independent (explanatory) variables. The short-run elasticities, combined with the error correction mechanism, can be derived using the following approach:

$$\begin{aligned} agdp_t = {} & \varphi_0 + \sum_{i=0}^{n_1} \varphi_{1i} agdp_{t-i} + \sum_{i=0}^{n_2} \varphi_{2i} mpr_{t-i} + \sum_{i=0}^{n_3} \varphi_{3i} \operatorname{int}_{t-i} + \sum_{i=0}^{n_4} \varphi_{4i} lr_{t-i} + \sum_{i=0}^{n_5} \varphi_{5i} dma_{t-i} \\ & + \sum_{i=0}^{n_6} \Theta'_{6i} Z_{t-i} + \vartheta ECM_{t-1} + \upsilon_t \end{aligned} \tag{3}$$

The ARDL method does not account for the possibility of asymmetric relationships between variables, as it assumes that positive and negative changes in the independent variables have identical effects on the dependent variable. This limitation makes it less suitable for examining the potentially asymmetric links between monetary policy variables and agricultural performance. To address this, we adapted the NARDL model by Shin, Yu, and Greenwood-Nimmo (2014), which offers the advantage of testing for hidden cointegration, enabling differentiation between linear, nonlinear, and absent cointegration. The NARDL framework is particularly suited for capturing asymmetric long-run relationships (Mesagan, Alimi, and Vo, 2022), making it a more appropriate choice for this study.

$$agdp_t = \alpha^+ mpr_t^+ + \alpha^- mpr_t^- + \gamma^+ \operatorname{int}_t^+ + \gamma^- \operatorname{int}_t^- + \lambda^+ lr_t^+ + \lambda^- lr_t^- + \rho^+ dma_t^+ + \rho^- dma_t^- + e_t \tag{4}$$

The equation showed that the equilibrium link between monetary policy variables and agricultural performance is distributed in positive $\alpha^{+}mpr_t^{+}, \gamma^{+}\text{int}_t^{+}, \lambda^{+}lr_t^{+}, \rho^{+}dma_t^{+}$ and negative $\alpha^{-}mpr_t^{-}$, $\gamma^{-}\text{int}_t^{-}, \lambda^{-}lr_t^{-}, \rho^{-}dma_t^{-}$ effects, while the stochastic term e_t denotes the possible deviation from the long-run equilibrium. The NARDL is thereby estimated as:

$$\begin{aligned}\Delta agdp_t &= \sigma + \varpi agdp_{t-1} + \alpha^{+}mpr_{t-1}^{+} + \alpha^{-}mpr_{t-1}^{-} + \gamma^{+}\text{int}_{t-1}^{+} + \gamma^{-}\text{int}_{t-1}^{-} + \lambda^{+}lr_{t-1}^{+} + \lambda^{-}lr_{t-1}^{-} \\ &+ \rho^{+}dma_{t-1}^{+} + \rho^{-}dma_{t-1}^{-} + \Psi Z_t + \sum_{j=0}^{n-1}\eta_j \Delta agdp_{t-j} + \sum_{j=0}^{n-1}\left(\tau_j^{+}\Delta mpr_{t-j}^{+} + \tau_j^{-}\Delta mpr_{t-j}^{-}\right) \\ &+ \sum_{j=0}^{n-1}\left(\omega_j^{+}\Delta \text{int}_{t-j}^{+} + \omega_j^{-}\Delta \text{int}_{t-j}^{-}\right) + \sum_{j=0}^{n-1}\left(\psi_j^{+}\Delta lr_{t-j}^{+} + \psi_j^{-}\Delta lr_{t-j}^{-}\right) + \sum_{j=0}^{n-1}\left(\delta_j^{+}\Delta dma_{t-j}^{+} + \delta_j^{-}\Delta dma_{t-j}^{-}\right) \\ &+ \sum_{j=0}^{n}\Upsilon'_j \Delta Z_{t-j} + \varepsilon_t\end{aligned} \tag{5}$$

Thus, the short-run NARDL elasticities with the error correction mechanism is stated as:

$$\begin{aligned}\Delta agdp_t &= \sigma + \sum_{j=0}^{n-1}\eta_j \Delta agdp_{t-j} + \sum_{j=0}^{n-1}\left(\tau_j^{+}\Delta mpr_{t-j}^{+} + \tau_j^{-}\Delta mpr_{t-j}^{-}\right) + \sum_{j=0}^{n-1}\left(\omega_j^{+}\Delta \text{int}_{t-j}^{+} + \omega_j^{-}\Delta \text{int}_{t-j}^{-}\right) \\ &+ \sum_{j=0}^{n-1}\left(\psi_j^{+}\Delta lr_{t-j}^{+} + \psi_j^{-}\Delta lr_{t-j}^{-}\right) + \sum_{j=0}^{n-1}\left(\delta_j^{+}\Delta dma_{t-j}^{+} + \delta_j^{-}\Delta dma_{t-j}^{-}\right) + \sum_{j=0}^{n}\Upsilon'_j \Delta Z_{t-j} + \varepsilon_t\end{aligned} \tag{6}$$

4. Empirical Results

4.1 Descriptive statistics and correlation analysis

In Table 1, the summary statistics of the variables in the table shows that the average of agriculture contribution to GDP stood at 22.87%. This implies that the actual economic activities of the agricultural sector have increased and consequently improvement in income generation has also been recorded over the years as it grows at an average of 22.87%. This is also evident that the average monetary policy rate of 13% has grown from minimum value of 6% to maximum value 26%. The average annual lending interest rate of 17.45% showed that it has a maximum rate of 31.65% and a minimum of 8.92% in Nigeria. Additionally, the interval growth rates of monetary policy rate and lending interest rate of 1.6% and 0.62% from 1981 to 2021 respectively show low growth rates which has influenced the interval growth of agriculture expenditure to GDP at 1.59% indicates that the two monetary policy variables have been the major contributors to improved agricultural productivity in Nigeria.

As for liquidity ratio and deposit money bank credit to agriculture sector as a ratio of GDP were 49.067 and 0.59% respectively. The maximum and minimum values of liquidity ratio were 104.2 and 26.393 whereas that of deposit money bank credit to agriculture sector as a ratio of GDP were 1.00% and 0.163% correspondingly. Concerning other co-founding factors, the mean of government expenditure as a ratio of GDP and inflation rate were 8.41% and 18.95% respectively. Meanwhile, their respective maximum values are 17.29% and 5.39%, whereas the minimum values are 5.87% and 5.31% respectively. Also, the standard deviation of the variables is low in relations to their mean values. More so, all the variables are positively skewed, implying rightward skewed variables.

Table 1: Descriptive statistics

Signs	Variable Measurements	Mean	Std. Dev.	Max.	Min.	Kurtosis	Skewness	Jarque-Bera	Prob.
agdp	Agriculture expenditure (% of GDP)	22.866	4.589	36.965	12.240	4.741	0.450	6.564	0.038
mpr	Monetary policy rate (%)	13	3.959	26	6	4.543	0.734	7.751	0.021
int	Lending interest rate (%)	17.446	4.811	31.65	8.917	3.646	0.319	1.409	0.494
lr	Liquidity Ratio	49.067	14.668	104.20	26.393	6.402	1.465	34.429	0.000
dma	Deposit money bank credit to agriculture (% of GDP)	0.593	0.223	1.0040	0.163	2.189	0.114	1.212	0.546
ge	Government expenditure (% of GDP)	8.408	2.532	17.286	5.089	5.872	1.533	30.145	0.000
inf	Inflation, consumer prices (annual %)	18.949	16.659	72.836	5.388	5.307	1.854	32.581	0.000

Note: Std. Dev. – standard deviation; Max. – maximum; Min. – minimum; Prob. – probability.
Source: Author's computation (2024).

Of all the variables, the kurtosis showed that average of deposit money bank credit to agriculture sector as a ratio of GDP is less than three, indicating a platykurtic form of distribution, while other variables agriculture expenditure as a ratio of GDP, monetary policy rate, lending interest rate, liquidity ratio, government expenditure as a ratio of GDP (ge), and inflation rates were higher than three and they displayed leptokurtic form in distribution. Thus, this means that all of the variables are not normally distributed. More so, the Jarque-Bera statistics revealed that five variables are significant at 0.05 critical values while others are not. The implication is that there is presence of outliers in the values of some variables, indicating some level of asymmetry and discreteness in the data sets.

The correlation analysis of monetary policy variables and agricultural performance between 1981 and 2022 is reported in Table 2. The magnitude of the various relationships of the economic performance and overall behaviour of monetary policy variables are moderate but none of them is up to 0.8. Monetary policy indices have positive correlation with agricultural performance except deposit money bank credit to agriculture to GDP which has negative coefficient. Similarly, the level of associations between the variables of agricultural performance was reported in the table. Summarily, the correlation values suggest the absence of perfect multicollinearity among the predictive variables, as positive and negative relationships were reported among the variables of interest in varying magnitudes and signs.

Table 2: Correlation matrix

	agdp	*mpr*	*int*	*lr*	*dma*	*ge*	*inf*
agdp	1						
mpr	0.3339	1					
int	0.5640	0.7988	1				
lr	0.0211	0.0653	-0.1897	1			
dma	-0.1369	0.4166	0.1411	-0.1015	1		
ge	0.2509	0.6665	0.6101	-0.1433	0.3501	1	
inf	0.0510	0.3608	0.3744	-0.2540	0.5088	0.2224	1

Note: agdp - agriculture output to GDP; mpr - monetary policy rate; int - interest rate; lr – liquidity ratio; dma - deposit money bank credit to agriculture; ge – government expenditure; inf - Inflation rate.
Source: Author's computation (2024).

4.2 Unit root and cointegration tests

This test is necessary to examine the stationarity level of individual variables. It indicates whether the variables are stationary or non-stationary. Shocks in stationary time series will be temporary and its effects over time eliminated as the series revert to their long run mean values. Meanwhile, non-stationary time series contain permanent components of shocks and its means and variances depend on time. In this current study the conventional Augmented Dickey-Fuller unit root test was employed to carry out the test and the result is reported in Table 3.

Table 3: Conventional Unit Root Test for the time series data, 1981 - 2021

Variables	**Level**	**First Difference**	***I*(d)**
	ADF	**ADF**	
agdp	-2.5686(3)[-3.6156]	-6.9636(1)[-3.6156]***	*I*(1)
mpr	-3.3346(0)[-2.9369]**	-	*I*(0)
int	-2.3074(0)[-3.6056]	-6.8439(0)[-3.6105]***	*I*(1)
lr	-3.5639(0)[-2.9369]**	-	*I*(0)
dma	-1.4900(0)[-3.6056]	-6.0883(0)[-3.6105]***	*I*(1)
ge	-1.8646(1)[-3.6105]	-10.1222(0)[-3.6105]***	*I*(0)
inf	-4.1023(1)[-3.5298]**	-	*I*(0)

Note: *** significant at 1%; ** significant at 5%; Calculated at trend and intercept and lag lengths selected automatically using the Schwarz Info Criterion. agdp - agriculture output to GDP; mpr - monetary policy rate; int - interest rate; lr – liquidity ratio; dma - deposit money bank credit to agriculture; ge – government expenditure; inf - Inflation rate.
Source: Author's computation (2024).

The ARDL bounds test is based on the assumption that the variables are I(0) or I(1). So, before applying this test, we determine the order of integration of all variables using the unit root tests.

The objective is to ensure that the variables are not I(2) so as to avoid spurious results. The ADF unit root tests under the conventional methods revealed the following decision on stationary level of variables of interest at varying significant levels for monetary policy rate, liquidity ratio and inflation rate which were found to reject the null hypothesis "not stationary at level" at 5% McKinnon significance levels. It shows that monetary policy rate, liquidity ratio and inflation rate stationary and integrated of order zero. However, the time series variable of agricultural performance, interest rate, deposit money bank credit to agriculture, and government expenditure were found not to reject the null hypothesis "unit root at level" but reject the null hypothesis of "unit root at first difference" at 5% significance level. This indicates that at first difference, the time series agricultural performance, interest rate, deposit money bank credit to agriculture, and government expenditure were stationary at first difference and integrated of order one.

In order to empirically analyse the non-linear long-run relationships and short run dynamic interrelationship among the variables of interest (agriculture expenditure as a ratio of GDP, monetary policy rate, lending interest rate, liquidity ratio, deposit money bank credit to agriculture as a ratio of GDP, government expenditure as a ratio of GDP, and inflation rates), we apply the linear and non-linear autoregressive distributed lag (ARDL) cointegration technique. Table 4 shows the symmetric cointegration between monetary policy and agricultural performance. At 5% significance level, the estimated F-statistics of the normalized equations were found to be greater than the lower but less than the upper critical bound. It means that the null hypothesis of no long-run relationship is not rejected at the 5% level of significance. This suggests that the symmetric cointegration is inconclusive.

Table 4: Symmetric cointegration test results using ARDL bound test

Models	AIC Lags	Functions						F-statistics	Decision
ARDL Model (1, 3, 2, 3, 1, 3, 3)	2	$F_{agdp}(agdp \mid mpr, \text{int}, lr, dma, ge, \text{inf})$						3.2279	No Cointegration
Significance Level		**1%**		**5%**		**10%**			
Upper and Lower Bounds		I(0)	I(1)	I(0)	I(1)	I(0)	I(1)		
Critical bound values		1.99	2.94	2.27	3.28	2.88	3.99		

Note: ***, ** and * denote rejection of null hypothesis at 1%, 5% and 10% significance levels respectively). agdp - agriculture output to GDP; mpr - monetary policy rate; int - interest rate; lr – liquidity ratio; dma - deposit money bank credit to agriculture; ge – government expenditure; inf - Inflation rate. [see] results in appendix for details.
Source: Author's computation (2024).

Table 5 also shows the asymmetric long run cointegration among the regressors and regressand. The Akaike Information Criterion is used to select the appropriate lag structure of the NARDL framework (AIC). The table results show that the asymmetric bound F-statistics values in Nigeria exceed the upper bound values at 5% critical levels for the asymmetric relationship between monetary policy and agricultural performance. As a result, we reject the null hypothesis and conclude that the variables have a non-linear long-run equilibrium cointegration relationship at the conventional level. Furthermore, the NARDL bound results support an asymmetric long-run relationship between Nigerian monetary policy and agricultural performance.

Table 5: Asymmetric cointegration test results using NARDL bound test

Models	AIC Lags	Functions						F-statistics	Decision
ARDL Model (2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 1)	2	$F_{agdp}(agdp \mid mpr^{+}, mpr^{-}, \text{int}^{+}, \text{int}^{-}, lr^{+}, lr^{-}, dma^{+}, dma^{-} ge, \text{inf})$						8.7856	No Cointegration
Significance Level		**1%**		**5%**		**10%**			
Upper and Lower Bounds		I(0)	I(1)	I(0)	I(1)	I(0)	I(1)		
Critical bound values		2.41	3.61	1.98	3.04	1.76	2.77		

Note: ***, ** and * denote rejection of null hypothesis at 1%, 5% and 10% significance levels respectively). agdp - agriculture output to GDP; mpr - monetary policy rate; int - interest rate; lr – liquidity ratio; dma - deposit money bank credit to agriculture; ge – government expenditure; inf - Inflation rate. [see] results in appendix for details.
Source: Author's computation (2024).

4.3 Asymmetric ARDL estimates of monetary policy on agricultural performance

The section presents the asymmetric estimates of monetary policy and agricultural performance in Nigeria between 1981 and 2021. The error correction mechanism that measures the speed or degree of adjustment are reported in the short-run estimation results in Table 6. It is the rate of adjustment at which the dependent variable changes due to changes in the independent variables. The ARDL test automatically choose the lag length on all variables as the model was set at two to ensure sufficient degree of the freedom based on automatic selection of Akaike Information Criterion (AIC). The coefficients of the error correction term (ECT) were found to be negative and statistically significant for the models of average agriculture performance. Correspondingly, the ECT values implied that the models correct its short-run disequilibrium by 71.66% speed of adjustment to return to the long run equilibrium.

Table 6: Short-run asymmetric estimates of monetary policy and agricultural performance

NARDL Error Correction Regression
Dependent Variable: Δ(agdp)
Selected Model: ARDL(2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 1)
Sample: 1981 2921
Included observations: 38

ECM Regression				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
Δ(agdp(-1))	0.713821	0.052192	13.67677	0.0000
$\Delta(mpr^{+})$	0.672814	0.104117	6.462090	0.0007
$\Delta(mpr^{+}(-1))$	0.726350	0.115833	6.270670	0.0008
$\Delta(mpr^{-})$	-0.822311	0.125115	-6.572463	0.0006
$\Delta(mpr^{-}(-1))$	1.915841	0.138056	13.87725	0.0000
$\Delta(int^{+})$	-0.226530	0.143623	-1.577259	0.1658
$\Delta(int^{+}(-1))$	2.183414	0.163494	13.35472	0.0000
$\Delta(int^{-})$	-0.170143	0.168304	-1.010922	0.3511
$\Delta(int^{-}(-1))$	-1.957567	0.154804	-12.64547	0.0000
$\Delta(lr^{+})$	0.051626	0.016108	3.204996	0.0185
$\Delta(lr^{+}(-1))$	0.154141	0.022753	6.774576	0.0005
$\Delta(lr^{-})$	-0.115288	0.034524	-3.339315	0.0156
$\Delta(lr^{-}(-1))$	-0.338508	0.026917	-12.57578	0.0000
$\Delta(dma^{+})$	-5.838382	3.911401	-1.492657	0.1861
$\Delta(dma^{+}(-1))$	-42.79661	3.994970	-10.71262	0.0000
$\Delta(dma^{-})$	-22.42302	2.564404	-8.743950	0.0001
$\Delta(dma^{-}(-1))$	-26.01512	3.339829	-7.789358	0.0002
Δ(ge)	0.653633	0.091524	7.141687	0.0004
Δ(ge(-1))	-1.040338	0.095204	-10.92746	0.0000
Δ(inf)	-0.092715	0.011777	-7.872480	0.0002
ECT(-1)	-0.716613	0.070393	-10.18917	0.0000
R-squared	0.876291	F-Statistics(Prob.)		14.294(0.0015)
Adjusted R-squared	0.848398	Durbin-Watson stat		2.008899

Diagnostic Tests			
Serial Correlation	2.1847(0.2284)	Heteroskedasticity test	0.8751(0.6385)
Normality Test	1.9424(0.3786)	Ramsey RESET Test	2.3291(0.0803)

Note: ***,**&* denotes rejection of the hypothesis at the 0.01, 0.05 and 0.1 level respectively.
Source: Author's computation (2024).

In Table 6, the short run estimate revealed that the lag one of agriculture output to GDP positively drive agricultural productivity in Nigeria. Concerning the monetary policy determinants of agricultural performance, the positive change of monetary policy rate at current and lag 1 directly and significantly impacted short run agricultural performance. When monetary policy rate witnessed a negative change, its current and lag one coefficient indirectly and directly influenced agricultural performance. This shows that the positive changes of monetary policy rate have higher influence on agricultural performance than the negative change in monetary policy rate. As to lending interest rate, its positive and negative change at lag one has positive and negative impact on agricultural performance in the short run. The study showed that agricultural performance is directly influenced by positive changes in liquidity ratio and indirectly affected by the negative changes in liquidity ratio at 5% significance level. Concerning deposit money bank credit to agriculture, all the coefficients for positive and negative changes are negative and statistically significant at 5% except its current positive change which is insignificant. The current government expenditure has a direct and significant impact on agricultural performance but its lag one adversely impacted agricultural performance in the short run. Inflation rate at the current level was found to negatively and significantly influence agricultural performance at the conventional level.

As for the long-run estimates presented in Table 7, the coefficient of positive change in monetary policy rate was positive and insignificant for the agricultural performance model but the negative change of monetary policy rate has negative and statistical impact on agricultural performance. It implies that negative changes in monetary policy rate indirectly influences agricultural performance in the long run. As for the positive and negative changes in lending interest rate, they negatively and significantly impacted on long run agricultural performance. Meanwhile, the positive and negative change in liquidity ratio has indirect and direct effect on agricultural performance. It was shown in the table that both positive and negative changes in deposit money bank credit to agriculture positively influence agricultural performance in the long run. For the controlling variables, government expenditure positively impacted agricultural performance. The inflation rate is found to negatively impacted on agricultural performance in the long run.

Table 7: Long-run asymmetric estimates of monetary policy and agricultural performance

Variables	**Dependent Variable:** Agricultural Performance (agdp)			
	Coefficient	Std. Error	t-Statistic	Prob.
Monetary policy rate^{+}	0.450021	0.633644	0.710211	0.5042
Monetary policy rate^{-}	-1.519951	0.456928	-3.326453	0.0159
Interest rate^{+}	-0.676213	0.592838	-1.140637	0.2975
Interest rate^{-}	-0.266036	0.571525	-0.465485	0.6580
Liquidity ratio^{+}	-0.120463	0.088942	-1.354394	0.2244
Liquidity ratio^{-}	0.085699	0.189993	0.451065	0.6678
Deposit money bank credit to agriculture^{+}	13.97014	13.67639	1.021478	0.3464
Deposit money bank credit to agriculture^{-}	26.55842	7.368758	3.604191	0.0113
Government expenditure	0.980271	0.426332	2.299316	0.0612
Inflation	-0.169465	0.045489	-3.725428	0.0098
Constant	10.39414	3.692165	2.815187	0.0305

Note: ***,**&* denotes significance at 0.01, 0.05 and 0.1 level respectively.
Source: Author's computation (2024).

The regression for the underlying ARDL equation of average agricultural performance fits very well and the model is significant at 1% level. It also passes all the diagnostic tests against serial correlation (Breusch-Godfrey test, heteroscedasticity, White Heteroskedasticity Test, and normality of errors (Jarque-Bera test). The Ramsey RESET test also suggests that the model is well specified. Their results are reported in Table 6. The stability of the long-run coefficient is tested by the short-run dynamics. Once the ECM model given by agricultural performance equation has been estimated, the cumulative sum of recursive residuals (CUSUM) and the CUSUM of square (CUSUMSQ) tests are applied to assess the parameter stability. Figure 1 plots the average agricultural performance. The results for CUSUM and CUSUMSQ test results for average agricultural performance indicates the absence of any instability of the coefficients because the plot of the CUSUM and CUSUMSQ statistic fall inside the critical bands of the 95% confidence interval of parameter stability. By implication, this model is not suffering from structural change.

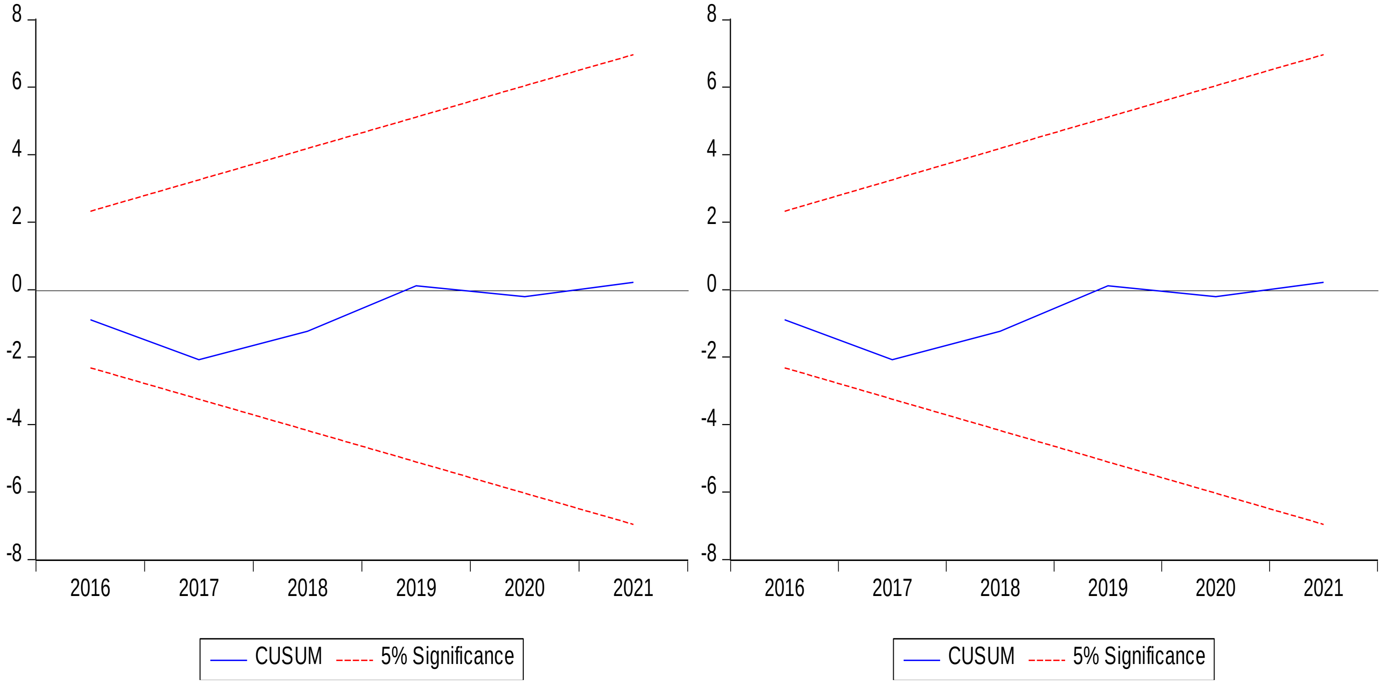

Figure 1: Cumulative Sum (CUSUM) and Cumulative Sum of Square (CUSUMSQ)

5. Discussion of Findings

The study examines the asymmetric impact of monetary policy on agricultural performance in Nigeria from 1981 to 2021, utilizing the Nonlinear Autoregressive Distributed Lag (NARDL) model. The findings highlight an asymmetric relationship, with short-run positive changes in the monetary policy rate significantly boosting agricultural performance compared to negative changes. Conversely, in the long run, only negative changes in the monetary policy rate significantly and adversely affected agricultural output. This suggests that lower monetary policy rates foster greater agricultural performance, aligning with existing literature emphasizing the role of low-interest financial credit in agricultural development (Ajudua, Davis, and Okonkwo, 2015; Athanasius, 2017; Emenuga, 2019; Mashinini *et al*., 2019; Oboh and Tule, 2019; Chinedu and Ezekwe, 2021). Regarding lending interest rates, the study reveals that short-run positive changes directly influence agricultural performance, while negative changes have an indirect impact. In the long run, both positive and negative changes in lending rates negatively affect agricultural performance, though these effects are not statistically significant at the 5% level. This finding contrasts with studies suggesting that higher lending rates positively drive long-term agricultural performance (Ajudua, Davis, and Okonkwo, 2015; Athanasius, 2017; Emenuga, 2019). The lack of significant impact might reflect a shift in government strategy, where lending rates are no longer a primary tool for enhancing agricultural sector growth.

The study also identifies the liquidity ratio as a critical factor influencing agricultural performance. Positive changes in liquidity ratio positively affect agricultural output in the short run, while negative changes have an adverse impact. This underscores the importance of financial institutions' solvency in providing credit to the agricultural sector. However, in the long run, both positive and negative liquidity ratio changes show no significant influence on agricultural performance, suggesting that liquidity constraints may not be a decisive factor over understudied period. Interestingly, both positive and negative changes in deposit money banks’ credit to agriculture negatively affect agricultural performance in the short run. In the long run, however, negative changes in credit to agriculture exhibit a significant positive impact on agricultural output. This finding diverges from previous studies asserting that bank credit is a crucial driver of agricultural development (Ekine & Nwaokedibe, 2018; Emenuga, 2019). The discrepancy may indicate inefficiencies in the credit allocation process or shifts in agricultural financing mechanisms.

6. Conclusion

This paper investigates the asymmetric effects of monetary policy on agricultural performance in Nigeria from 1981 to 2021. Employing the Nonlinear Autoregressive Distributed Lag (NARDL) model, the findings reveal an asymmetric link, wherein short-term positive changes in the monetary policy rate significantly enhance agricultural performance compared to negative changes. In contrast, over the long term, only negative changes in the monetary policy rate significantly and negatively impacted agricultural output. The study indicates that short-term positive changes in loan interest rates directly affect agricultural performance, whereas negative changes exert an indirect influence. Ultimately, both positive and negative changes in lending rates adversely impact agricultural performance, although these impacts are statistical insignificance at the 5% level. The research identifies the liquidity ratio as a pivotal factor affecting agricultural production. The positive changes in the liquidity ratio enhance agricultural output in the short term, whilst the negative changes exert an adverse effect. Nonetheless, over the long term, changes in liquidity ratios, whether positive or negative, exhibit no significant impact on agricultural production. Notably, both positive and negative fluctuations in deposit money banks' loan to agriculture adversely impact agricultural performance in the short term. Finally, negative changes in agricultural credit financing have a significant positive effect on agricultural output.

To enhance agricultural performance in Nigeria, policymakers should prioritize maintaining low monetary policy rates to facilitate affordable access to credit for farmers, aligning with evidence that reduced rates significantly boost agricultural output in the long term. The Central Bank of Nigeria should strengthen mechanisms for effective credit allocation, ensuring that deposit money banks provide adequate and accessible financing to the agricultural sector. Additionally, financial institutions should improve their liquidity management to stabilize short-term credit provision, which is critical for supporting agricultural investments. Lastly, targeted interventions, such as subsidizing lending rates and enhancing the Agricultural Credit Guarantee Scheme, are recommended to address structural inefficiencies in agricultural financing and boost productivity sustainably.

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