

EFFECTS OF ASYMMETRIC MONETARY POLICY ON TARGETING INFLATION AND STABILIZING OUTPUT IN NIGERIA

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ABSTRACT

This paper proposes a non-linear approach to analysing monetary policy shocks. The Taylor rule is explored using non-linear techniques, namely the asymmetric vector autoregressive (AVAR) model from 1993Q1 to 2023Q4. The results reveal evidence of asymmetric shocks transmission among major macroeconomic variables, namely the monetary policy rate, inflation and the output. The threshold/asymmetric VAR impulse response functions confirm evidence of asymmetric shocks transmission among the variables. In particular, the results indicate that the huger preponderance of the shocks propagation in inflation and output is due to the changes in the monetary policy rate. This implies that the Central Bank needs to focus more on keeping inflation at the target level (low and stable) and, stabilizing the output around the desired trend through choosing an optimal rate that would help it achieve these macroeconomic targets.

Keywords: Monetary Policy, Taylor Rule, Asymmetric VAR

JEL classification: C22, E12, E52

1. Introduction

The major macroeconomic goal of the Central Bank is to keep inflation at the target level and to stabilize real GDP around its trend (Oni, 1966, Enders and

Li, 2015). Intuitively, at higher inflation rates spending is discouraged which prompts the Central Bank to hike the interest rate when inflation is above its target level and when the output gap is positive. This is termed the Taylor rule as it was introduced by John Taylor in 1993. However, a plethora of econometricians have cast a doubt on the linear form of the Taylor rule and argued that the Central Bank's policy reactions to inflation and output are best modelled as non-linear rather than linear. For example, it is likely that the Central Bank prefers inflation to be below the target than above it. Moreover, it is probable that the Central Bank prefers a positive output gap than a negative one. The intuition behind this is that interest rate changes are often more dramatic when inflation and/or output is low. Hence, the monetary policy formulation can be construed as asymmetric / non-linear where inflation or output could serve as the threshold variable (Irandoost, 2020).

Globally, it has been discovered that monetary policy is asymmetric in its ability to achieve output stabilization and inflation targeting; that is, expansionary and contractionary policies produce different macroeconomic reactions. Monetary tightening typically has greater and quicker effects on output and inflation than monetary easing (Cover, 1992; Karras, 1996). The literature is replete with both theoretical and empirical evidence on this imbalance in both developed and developing nations. According to the New Keynesians, nominal rigidities, credit frictions, and expectation dynamics are often the reason why prices and wages in advanced economies change upward more quickly than downward (Gali, 2015). It is often simpler for central banks that experiment with inflation-targeting regimes to reduce inflation through tightening than to increase output due to recessions (Mishkin & Schmidt-Hebbel, 2007).

Weaker financial systems, greater fiscal dominance, more volatile currency rates, shallower credit markets, and more frequent asymmetries are particularly noticeable in emerging and developing countries (Ikpeze, 1994, Gogo, 2019, Peersman & Smets, 2005; Loayza & Schmidt-Hebbel, 2002). Consequently, contractionary monetary policy greatly reduces output and expansionary monetary policy often increases inflation while leaving output constant. This global evidence underscores the importance of incorporating asymmetry into monetary policy analysis and modelling. Essentially, the idea of asymmetric effects is ingrained in models that assume price rigidity/asymmetric

information. A multitude of studies have found evidence of asymmetric effects, particularly with regard to monetary policy easing and tightening (Cover, 1992, Parker and Rothman, 2004; Hayford, 2006; Crawford, 2008; Sznajderska, 2014; Ülke and Berument, 2016). Some studies suggest that policy easing (lowering the interest rate) may have larger effects on prices but smaller effects on real activity, while policy tightening (raising the interest rate) tends to have larger real effects but smaller effects on prices (Olayiwola & Ogun, 2019). One good example of asymmetric effects includes their impact on output and inflation. Studies such as Cover (1992) and Romer and Romer (1994) suggest that expansionary monetary policy have a larger impact on output but a smaller impact on inflation while the reverse is true for a contractionary monetary policy.

Although monetary policy is a crucial tool for stabilizing output and controlling inflation in Nigeria, results have often been less than ideal. Inflation and erratic production growth continue, notwithstanding the Central Bank of Nigeria's frequent changes to the monetary policy rate and liquidity management (Adeoye, 2003, CBN, 2022). According to empirical data, monetary easing frequently causes inflation without corresponding growth, whereas monetary tightening has bigger contractionary consequences on output (Isedu, 2013). These unequal policy consequences are often further exacerbated by structural rigidities, fiscal dominance, exchange rate volatility, and inadequate financial intermediation, compromising macroeconomic stability and effective inflation targeting (Ajakaiye, 1985, Mishkin & Schmidt-Hebbel, 2007).

Therefore, recognizing the potential for asymmetric effects is crucial for policy making, particularly in a small open economy like Nigeria. It is against this backdrop that this paper seeks to examine the asymmetric effects of monetary policy on inflation and output in Nigeria using the asymmetric vector autoregressive model. Olayiwola and Ogun (2019) have examined the asymmetric effect of the monetary policy on output and price in Nigeria using the NARDL. This research however deviates from their study by using asymmetric VAR. The period covered by their study is from 1986 to 2016, but this study starts from the return of democratic rule in Nigeria in 1999 to 2024 using quarterly data. This period was chosen based on the observed behaviour of the variable of interest for the study.

2. Literature Review

The New Keynesian theory, developed by Fischer (1977), Mankiw (1985), Taylor (1993), Clarida et al. (1999), Woodford and Walsh (2005), and Galí (2015), emphasizes nominal rigidities, forward-looking expectations, and imperfect competition as key channels through which monetary policy affects inflation and output. However, the New Keynesian theory provides a theoretical basis for understanding why monetary policy might have asymmetric effects on inflation and output.

According to New Keynesian economics, the presence of nominal rigidities, particularly sticky prices and wages, causes monetary policy shocks to have real effects on output in the short run while influencing inflation in the long-run (Woodford & Walsh, 2005). In this framework, monetary policy transmission is assumed to be inherently non-linear, which implies that contractionary and expansionary policy actions might not generate equal and opposite responses in macroeconomic variables. Although the basic New Keynesian model suggests a divine coincidence whereby stabilizing inflation equally stabilizes the output gap, this result breaks down once real-world frictions such as imperfect competition, supply-side shocks, and financial market imperfections are introduced (Clarida et al., 1999). Consequently, central banks might face a trade-off between inflation targeting and output stabilization which could lead to asymmetric policy outcomes.

The notion of asymmetric effects of monetary policy shocks on output and prices started initially with the seminal work of Cover in 1992. According to Cover (1992), expansionary and contractionary monetary policies have different effects on macroeconomic variables (sign asymmetry). Several other researchers, like Morgan (1993), DeLong and Summers (1992), conclude that positive and negative monetary shocks have asymmetric effects. On the contrary, Ravn and Sola (2004) found that positive and negative monetary shocks have symmetric effects. This controversy has generated the issue of whether or not this symmetric effect of monetary policy shocks is with respect to the direction of policy action and size of policy shocks in the economy. Many studies have also claimed that positive and negative monetary policy shocks have asymmetric effects by providing empirical evidence for asymmetry between positive and negative (tight and loose) monetary policy shocks (Parker and Rothman, 2004; Hayford, 2006; Crawford, 2008; Sznajderska, 2014; Ülke

and Berument, 2016). In the same vein, Komlan (2013) argued that the effects of monetary policy in Canada revealed asymmetric preference and his results were in tandem with previous findings by Favero and Rovelli (2003) for the USA, and Rodriguez (2008) for Canada. However, a considerable amount of empirical research on this issue has emerged as case studies for different developing countries (Aye and Gupta, 2012; Notarpietro and Siviero, 2015; Zakir and Malik, 2013).

Irandoost (2020) examined the extent to which monetary policy has a long-run asymmetric effect on output in a number of countries in the Organization for Economic Co-operation and Development (OECD) by using a nonlinear cointegration analysis within a likelihood-based panel framework. His findings indicate that there is a long-run relationship between the real interest rate as an indicator of monetary policy and the growth rate of real output in five out of the nine countries reviewed. This lends more credence to the view that output responds asymmetrically to real interest rate changes. The economic implication of his results is that monetary policy affects positive and negative output fluctuations differently.

Kilinc and Tunc (2019) investigated the sector-level asymmetric effects of monetary policy shocks on economic activity in Turkey from 2006Q1 to 2014Q4 by employing the Markov Regime Switching Model. Using business cycles for the state of the economy, they found that monetary policy shocks have strong effects on aggregate GDP, services, and industrial production and its sub-sectors during recessionary periods. The results were found to be weaker for expansionary periods and monetary policy was more effective during credit slowdowns, with economically more feasible quantitative effects, compared to the business cycles. Jorda et al. (2019) constructed a quantitative medium-scale dynamic stochastic general equilibrium model with endogenous total factor productivity growth to understand the mechanisms at work. They used a panel of 17 countries spanning more than hundred years. They found that non-neutrality of monetary policy in the long run was not quite right. Moreover, the results revealed that exogenous variation in monetary policy influences capital accumulation and total factor productivity, thereby affecting output for a much longer period of time than is customarily assumed, and that monetary policy could have long-run effects.

Olayiwola and Ogun (2019) investigated the asymmetric effect of positive and negative monetary policy shocks on output and prices in Nigeria using non-linear autoregressive distributive lag (NARDL) econometric techniques. The results show that in the short run, negative shocks have more significant effects on output than do positive shocks, but the effects of positive and negative monetary policy shocks do not have significant effects on the price level; while in the long run, positive shocks have more significant effects than do negative shocks on both output and prices. This implies that monetary policy shocks have asymmetric effects on output and prices in Nigeria, both in the short and long run periods. Moran and Queralto (2018) have revealed how monetary policy influences business innovation and productivity growth. They found that significant total factor productivity losses were due to the zero-lower bound in the US.

Apanisile (2017) examined the long-run asymmetry effects of monetary policy shocks on output in Nigeria. The results reveal that both components of money supply have positive long-run effect on output in Nigeria and that the long run effects of monetary policy on output were symmetric as their coefficients were the same, albeit the study neglects the simultaneous effect of policy shocks on output and prices.

Tenreyro and Thwaites (2016) examined how the response of the US economy to monetary policy shocks depends on the state of the business cycle using nonlinear Romer regressions. They found that the effects of monetary policy were less powerful in recessions, especially for durables expenditure and business investment. They also found that contractionary policy shocks were more powerful than expansionary shocks. Santoro et al. (2014), employing the Markov Switching Rational Expectation Model, found that monetary policy influenced asymmetric effects on output over contractions and expansions in economic activity in the United States from 1982Q3 to 2009Q4.

From the literature so far reviewed, it becomes clear that the asymmetric effect of monetary policy on output and prices is well documented in the literature for developed countries. However, the literature on Nigeria on the subject matter is very scanty. The few studies conducted on Nigeria on the asymmetric effect of monetary policy in Nigeria include those of Apanisile (2017) and Olayiwola and Ogun (2019), where they used the nonlinear ARDL model. As distinct from these studies, this study uses the asymmetric VAR

model, which is a multi-equation technique rather than a single-equation technique, to examine the asymmetric effect of monetary policy on output and prices in Nigeria from 1999Q1 to 2024Q4. The rationale behind the choice of a multi-equation technique in this study is that examining the dynamics of inflation and output and the contemporaneous relationship between the two variables can be better captured using a system of equations rather than a single equation approach.

3. Methodology

3.1 Model specification

The asymmetric vector autoregressive (AVAR) model is one of the classes of VAR models developed through the Hatemi-J (2012) technique that allows for potential asymmetry in estimating impulse responses and variance decompositions, therefore decomposing the series into cumulative positive and negative changes so as to estimate the impulses to an asymmetric innovation. However, the AVAR is a restricted nonlinear version of the VAR model in which the identification restrictions are based on the underlying economic theory, and the reason for imposing the restriction is to limit the interaction/direction of causality among the variables of concern, in order to represent meaningful short-run or long-run relationships among the variables and the structural shocks (Ohiorhenuan, 1979, Abiona 2014). However, following the Hatemi-J (2012) technique, what differentiates the AVAR model from the VAR model is the asymmetric impulse response functions (IRFs) and the asymmetric variance decomposition (VDC); hence, the asymmetry is the only difference. The model can be specified in the form of VAR and then developed into asymmetric form by decomposing the variables into positive and negative forms. The model can first be specified as follows:

$$Ae_t = B\mu_t \quad (1)$$

where: A is an $n \times n$ matrix of structural coefficients, e_t is a $n \times 1$ vector of the original shocks in the model with a covariance matrix $\sum e$, B is an $n \times n$ variance-covariance matrix and μ_t is an $n \times 1$ vector of the structural errors or shocks, which is a white noise process with zero mean and time-invariant variance-covariance matrix $\sum \mu$.

However, following Ülke and Berument (2015), Yalcin et al. (2015), and Ozcelebi (2019), we in this paper test for the presence of asymmetry by adopting the two different methods of Kilian and Vigfusson (2011), namely the slope-based test and the impulse response-based test. The tests' set of equations which encapsulate both the censored variables and the nonlinear VAR model, can be stated as follows:

$$X_t = a_0 + \sum_{i=1}^p a_1 y_{t-i} + \sum_{i=1}^p a_2 X_{t-i} + \mu_{1,t} \tag{2}$$

$$X_t = \beta_0 + \sum_{i=1}^p \beta_1 y_{t-i} + \sum_{i=1}^p \beta_2 X_{t-i} + \sum_{i=1}^p g_2 X_{t-1}^+ + \mu_{2,t} \tag{3}$$

where: equation (2) is a linear VAR model which captures the impacts of X_t on y_t , while equation (3) integrates the effects of both X_t and the censored variable X_t^+ on y_t , and $i = 1, \dots, p$ indexes the lag order in the equations.

In this veneration, the dynamic responses of y positive and negative innovations in X_t can be computed. The replacement of negative values of X_t with zero leads to the representation of a censored variable X_t^+ , and this variable can be defined as:

$$X_t^+ \begin{cases} X_t, & \text{if } X_t > 0 \\ 0, & \text{if } X_t \leq 0 \end{cases} \tag{4}$$

Furthermore, the Kilian and Vigfusson (2011) slope-based test is built on statistical testing of the censored variables where the null hypothesis of the test states that $H_0: g_{2,0} = \dots = g_{2,p} = 0$ against $H_1: g_{2,0} \neq \dots \neq g_{2,p} \neq 0$.

Moreover, the impulse response-based test for asymmetry is conducted by gathering the impulse response of equation (4), where the impacts of positive and negative shocks at the same period are compared and tested statistically irrespective of whether they are the same or not. The null hypothesis of this test is $H_0: I_y(h, \delta) = -I_y(h - \delta)$ or $H_0: I_y(h, \delta) + I_y(h - \delta) = 0$ against $H_a: \text{not } H_0$ where $I_y(h, \delta)$ and $I_y(h - \delta)$ are responses of X_t at period $h = 1, 2, \dots, H$ to shock δ . This test has an asymptotic X_{H+1}^2 distribution, and it depends on the impact of the shock.

The asymmetric IRFs and VDCs are represented by the following specifications:

$$y_t^+ = v + Ay_{t-1}^2 + \dots + A_p y_{t-1}^+ + \mu_t^+ \tag{5}$$

$$y_t^- = vv + AAy_{t-1}^- + \dots + AA_p y_{t-1}^- + \mu_t^- \tag{6}$$

where: y_t^+ and y_t^- denote a 2×1 vector of variables and the constant terms of the model are contained in the 2×1 vectors v and vv . For simplicity without any loss of generality, trend and exogenous variables are ignored in the equations in contrast to the VAR model specification in equation (1). Therefore, the matrix A in equation (7) can be stated as follows:

$$A = \begin{pmatrix} 1 & a_{12} & a_{13} & a_{14} & a_{15} \\ a_{21} & 1 & a_{23} & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 \\ 0 & a_{42} & a_{43} & 1 & a_{45} \\ a_{51} & 0 & 0 & 0 & 1 \end{pmatrix} \tag{7}$$

The variance-covariance (B) matrix can be specified as:

$$B = \begin{pmatrix} b_{11} & 0 & 0 & 0 & 0 \\ 0 & b_{22} & 0 & 0 & 0 \\ 0 & 0 & b_{33} & 0 & 0 \\ 0 & 0 & 0 & b_{44} & 0 \\ 0 & 0 & 0 & 0 & b_{55} \end{pmatrix} \tag{8}$$

Now the equation in matrix form for retrieving the structural shocks from the reduced form errors/shocks can be stated as:

$$\begin{pmatrix} \mu_t^Y \\ \mu_t^{M2} \\ \mu_t^{MPR} \\ \mu_t^{INF} \\ \mu_t^{EXR} \end{pmatrix} = \begin{pmatrix} 1 & a_{12} & a_{13} & a_{14} & a_{15} \\ a_{21} & 1 & a_{23} & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 \\ 0 & a_{42} & a_{43} & 1 & a_{45} \\ a_{51} & 0 & 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} e_t^Y \\ e_t^{M2} \\ e_t^{MPR} \\ e_t^{INF} \\ e_t^{EXR} \end{pmatrix} \tag{9}$$

However, the asymmetric vector autoregressive (AVAR) model specification is given by the matrix:

$$\begin{pmatrix} \mu_t^Y \\ \mu_t^{M2^+} \\ \mu_t^{M2^-} \\ \mu_t^{MPR^+} \\ \mu_t^{MPR^-} \\ \mu_t^{INF^+} \\ \mu_t^{INF^-} \\ \mu_t^{EXR^+} \\ \mu_t^{EXR^-} \end{pmatrix} = \begin{pmatrix} 1 & a_{12}^+ & a_{13}^- & a_{14}^+ & a_{15}^- & a_{16}^+ & a_{17}^- & a_{18}^+ & a_{19}^- \\ a_{21}^+ & 1 & a_{23}^+ & a_{24}^+ & a_{25}^+ & a_{26}^+ & 0 & 0 & 0 \\ a_{31}^- & a_{32}^- & 1 & a_{34}^- & a_{35}^- & a_{36}^- & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & a_{45}^+ & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & a_{54}^- & 1 & 0 & 0 & 0 & 0 \\ 0 & a_{62}^+ & a_{63}^+ & a_{64}^+ & a_{65}^+ & 1 & a_{67}^+ & a_{68}^+ & a_{69}^+ \\ 0 & a_{72}^- & a_{73}^- & a_{74}^- & a_{75}^- & a_{76}^- & 1 & a_{78}^- & a_{79}^- \\ a_{81}^+ & 0 & 0 & 0 & 0 & 0 & 0 & 1 & a_{89}^+ \\ a_{91}^- & 0 & 0 & 0 & 0 & 0 & 0 & a_{98}^- & 1 \end{pmatrix} \begin{pmatrix} e_t^Y \\ e_t^{M2^+} \\ e_t^{M2^-} \\ e_t^{MPR^+} \\ e_t^{MPR^-} \\ e_t^{INF^+} \\ e_t^{INF^-} \\ e_t^{EXR^+} \\ e_t^{EXR^-} \end{pmatrix} \tag{10}$$

3.2 Estimation techniques and data

3.2.1 Non-Linearity Test

The nonlinearity test developed by Brock et al. (1996) is employed in order to avoid mis-specification / wrong functional form in the model. This test can be used for testing against a variety of possible deviations from independence, including linear dependence, nonlinear dependence or chaos. It is shown in Brock et al. (1996) that $(\sqrt{n - m + 1}) \frac{b_{m,n}(\epsilon)}{\delta_{m,n}(\epsilon)} \rightarrow N(0,1)$

where: $\sigma_{m,n}^2(t) = 4(k^m + 2 \sum_{j=1}^{m-1} k^{m-j} c_1^{2j} + (m - 1)^2 c_1^{2m} - m^2 k c_1^{2m-2}$

Here, c_1 can be estimated using $c_{1,n}$. The k is the probability of any triplet of points lying within (ϵ) of each other, and is estimated by counting the number of sets satisfying the sample condition:

$$k_n(\epsilon) = \frac{2}{n(n-1)(n-2)} \sum_{t=1}^n \sum_{s=t+1}^n \sum_{r=s+1}^n \tag{11}$$

The hypothesis is that: H_0 : the series follows linear dependence
 H_1 : the series follows nonlinear dependence

3.2.2 Non-linear Unit Root Tests

The Kapetanios et al. (2003) nonlinear unit root test was availed to test for stationarity of the variables prior to estimation. This also was to avoid mis-specification and spurious regression using the index of the transfer function to test nonlinear adjustment characteristics (Kapetanios et al., 2003). Anoruo and

Murthy (2014) emphasize that the nonlinear behaviour of the data generating process follows symmetric adjustments for deviations above and below the equilibrium level. The test is based on the Exponential Smooth Transition Autoregressive model:

$$\Delta y_t = \delta y_{t-1} \{1 - \exp(-\theta y_{t-1}^2)\} + \varepsilon_t \quad (12)$$

where: y_t is the detrended time series of interest, δ is an unknown parameter, the term $\{1 - \exp(-\theta y_{t-1}^2)\}$ is the variance exponential transition function adopted in the test to represent the nonlinear adjustment, ε_t is the stochastic term that is assumed to be normally distributed with a zero mean and a constant variance.

3.2.3 Momentum Threshold Autoregressive (M-TAR) Model

After testing for unit root in the series, the paper proceeds to test for nonlinear cointegration among the series, the momentum threshold autoregressive model given as:

$$\Delta \mu_t = \rho_1 I_t \mu_{t-1} + \rho_2 (1 - I_t) \mu_{t-1} + v_t \quad (13)$$

$$I_t = \begin{cases} 1 & \text{if } \mu_{t-1} \geq \gamma \\ 0 & \text{if } \mu_{t-1} < \gamma \end{cases} \quad (14)$$

where: I_t denotes the Heaviside indicator, ρ_1 and ρ_2 represent the speed of adjustment coefficients in the two regimes, μ is the series of residuals from the co-integrating equation, v is the error term which is independent of $\mu(j < t)$, and γ is the value of the threshold.

The consistently estimated value of γ which is called attractor since $\Delta \mu_t$ has an expected value of zero when $\mu_{t-1} = \gamma$, this can be searched for in equation (14). The adjustment in the series is said to be symmetric if $\rho_1 = \rho_2$, otherwise it is asymmetric. Nevertheless, it is noteworthy that from equation (14), the TAR model allows μ_t to display differing amounts of autoregressive decay depending on whether its previous value μ_{t-1} is greater or smaller than the threshold value.

Enders and Siklos (2001) argue that a convenient way is to augment equation (13) with lagged changes in the μ_t sequence and this gives rise to the momentum threshold autoregressive (M-TAR) model with the following specification:

$$\Delta\mu_t = \rho_1 m_t \mu_{t-1} + \rho_2 (1 - m_t) \mu_{t-1} \sum_{i=1}^k y_i \Delta\mu_{t-1} + v_t \tag{15}$$

$$\text{where: } m_t = \begin{cases} 1 & \text{if } \mu_{t-1} \geq \Gamma \\ 0 & \text{if } \mu_{t-1} < \Gamma \end{cases} \tag{16}$$

where: m_t represents the Heaviside indicator and the M-TAR adjustment, i.e. ρ_1 and ρ_2 , can be especially useful when policy makers are viewed as attempting to smoothen out any large changes in series under investigation (Enders and Siklos, 2001).

The data used in this study was obtained from the Central Bank of Nigeria (CBN) database.

4. Results and Discussion of Findings

4.1 Non-linearity tests

Table 1 reports the BDS test for nonlinearity which was conducted on the variables, namely real GDP, money supply, monetary policy rate, inflation and the exchange rate. The results reveal that the variables are nonlinear at 1% level of significance, which implies that the nonlinear model is more appropriate to use than the linear model.

Table 1: Non-Linearity Test

Variables	Dimension	BDS Statistic	Std. Error	z-Statistic	Prob.	Remarks
RGDP	2	0.175017	0.003936	44.47739	0.0000*	Non-Linearity
MS	2	0.190048	0.008203	23.16925	0.0021*	Non-Linearity
MPR	2	0.162634	0.010713	15.18104	0.0000*	Non-Linearity
INF	2	0.186558	0.013262	14.06670	0.0000*	Non-Linearity
EXCR	2	0.195637	0.008737	22.39107	0.0000*	Non-Linearity

Note: * indicates non-linearity at 1% level of significance.

Source: Researchers' computation, 2025.

4.2 Nonlinear unit root test

Afterwards, we proceed to apply the nonlinear unit root test of Kapetanios et al. (2003) to test for stationarity of the series. The test was conducted with both a constant and a trend, using Akaike Information Criteria (AIC) and the results are reported in Table 2.

Table 2: Kapetanios et al. (2003) Nonlinear Unit Root Test

Variable	Criteria	Lags	KSS stat.	p-value	1% cv	5% cv	10% cv
RGDP	AIC	0	-5.682	0.000*	-4.018	-3.436	-3.144
MS	AIC	0	-4.301	0.000*	-3.983	-3.406	-3.117
MPR	AIC	0	-5.971	0.000*	-4.032	-3.446	-3.152
EXCR	AIC	1	-3.497	0.031**	-4.018	-3.436	-3.144
INF	AIC	0	-6.895	0.000*	-4.032	-3.446	-3.152

Source: Researchers' computation 2025

From the table it can be observed that all the p-values associated with the KSS statistic are less than 0.05% which validates the rejection of the null hypothesis of a unit root which signifies that the time series are nonlinearly stationary at level.

4.3 The asymmetric cointegration test

In order to allow for the possibility of nonlinearity in the adjustment process, the study uses the F-joint test from the M-TAR model to examine asymmetric cointegration between the variables (Table 3). Asymmetric cointegration among the variables was tested and no evidence of existence of any cointegrating vector was found. Therefore, the null hypothesis of no cointegration cannot be rejected.

Table 3: The Asymmetric Cointegration Test

Variable	Coefficient	Std. Error
Above Threshold	-0.097307	0.049836
Below Threshold	-0.100139	0.070322
Differenced Residuals(t-1)	-0.124473	0.089083
Differenced Residuals(t-2)	-0.189075	0.086751
Differenced Residuals(t-3)	-0.146921	0.084989
Differenced Residuals(t-4)	0.696863	0.08654
Threshold value (tau):	0.000000	
F-equal:	0.001225	
T-max value:	-1.424007	
F-joint (Phi):	2.611293	

Source: Researchers' computation, 2025.

A more careful examination of the table shows that, the null hypothesis $\rho_1 = \rho_2 = 0$ of no asymmetric cointegration cannot be rejected at 5% level. This implies that the variables are not cointegrated, which validates the use of the asymmetric VAR model rather than the momentum threshold error correction model (M-TECM).

4.4 Asymmetric VAR estimation

In order to examine the asymmetric effects of monetary policy in targeting inflation and stabilizing output in Nigeria, the asymmetric VAR model was employed, as all the series were found to be nonlinear. The results of the asymmetric impulse response functions (IRFs) are presented in Figures 1 and 2 while the results of the asymmetric variance decompositions (VDCs) are presented in tables 4 and 5.

The result of asymmetric impulse response in Figure 1 shows that the response of inflation to a one-unit standard deviation shock to itself is positive throughout the period.

However, the response inflation to a one-unit standard deviation shock to a positive RGDP, negative money supply, negative monetary policy rate and positive exchange rate is negative throughout the periods. The results also indicate that the response of inflation to a one-unit standard deviation shock to

a negative RGDP, positive money supply, positive monetary policy rate and negative exchange rate has been observed to be positive throughout the periods.

A careful look at Figure 2 shows that the response of output to a one-unit standard deviation shock to itself is positive throughout the periods, while the response of output to a one-unit standard deviation shock to positive inflation (INF_P), negative money supply (MS_N) shock, and negative monetary policy rate (MPR_N) is negative throughout the periods. Furthermore, the response of output to a one-unit standard deviation shock to negative inflation (INF_N), positive money supply (MS_P), and positive monetary policy rate (MPR_P) is positive throughout the periods except for negative inflation in the 1st period which was found to exhibit a negative response. Nevertheless, the response of output to a one-unit standard deviation shock to a positive exchange rate (EXCR_P) shock (appreciation) is positive throughout the periods, with exceptions in the 3rd, 4th, and 5th periods; while the response of output to a one-unit standard deviation shock to a negative exchange rate (EXCR_N) shock (depreciation) is positive, with exceptions observed in the 1st, 2nd, and the last three periods.

However, Tables 4 and 5 report the asymmetric variance decomposition of inflation and output due to variations in the monetary policy variables. The results in Table 4 show that inflation accounts for higher variation in itself, followed by positive RGDP, followed by positive money supply, and finally positive monetary policy rate. These variables account for the huge preponderance of fluctuations/variations in inflation as particularly observed from the 4th period horizon to the 10th.in

The results in Table 5 show that the real GDP (RGDP) accounts for the highest variations which came from inflation itself, followed by positive MS and positive MPR, which also account for higher variations in output. However, positive and negative EXCR, negative MS and negative MPR account for lower variation in inflation in the country. The results also show that positive and negative inflation account for moderate variation in output in Nigeria.

Accumulated Response to Generalized One S.D. Innovations

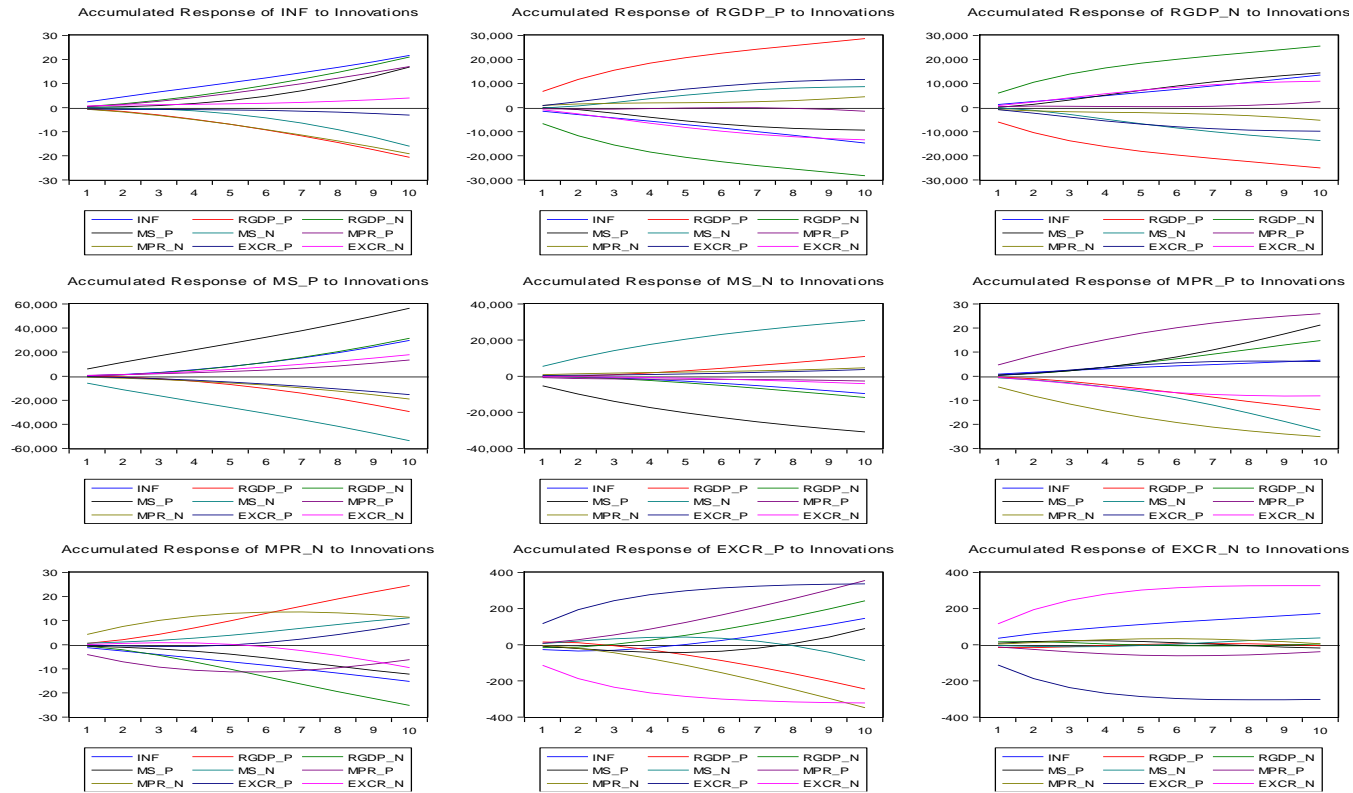


Figure 1: Asymmetric Response of Inflation

Source: Researchers' computation, 2025.

Accumulated Response to Generalized One S.D. Innovations

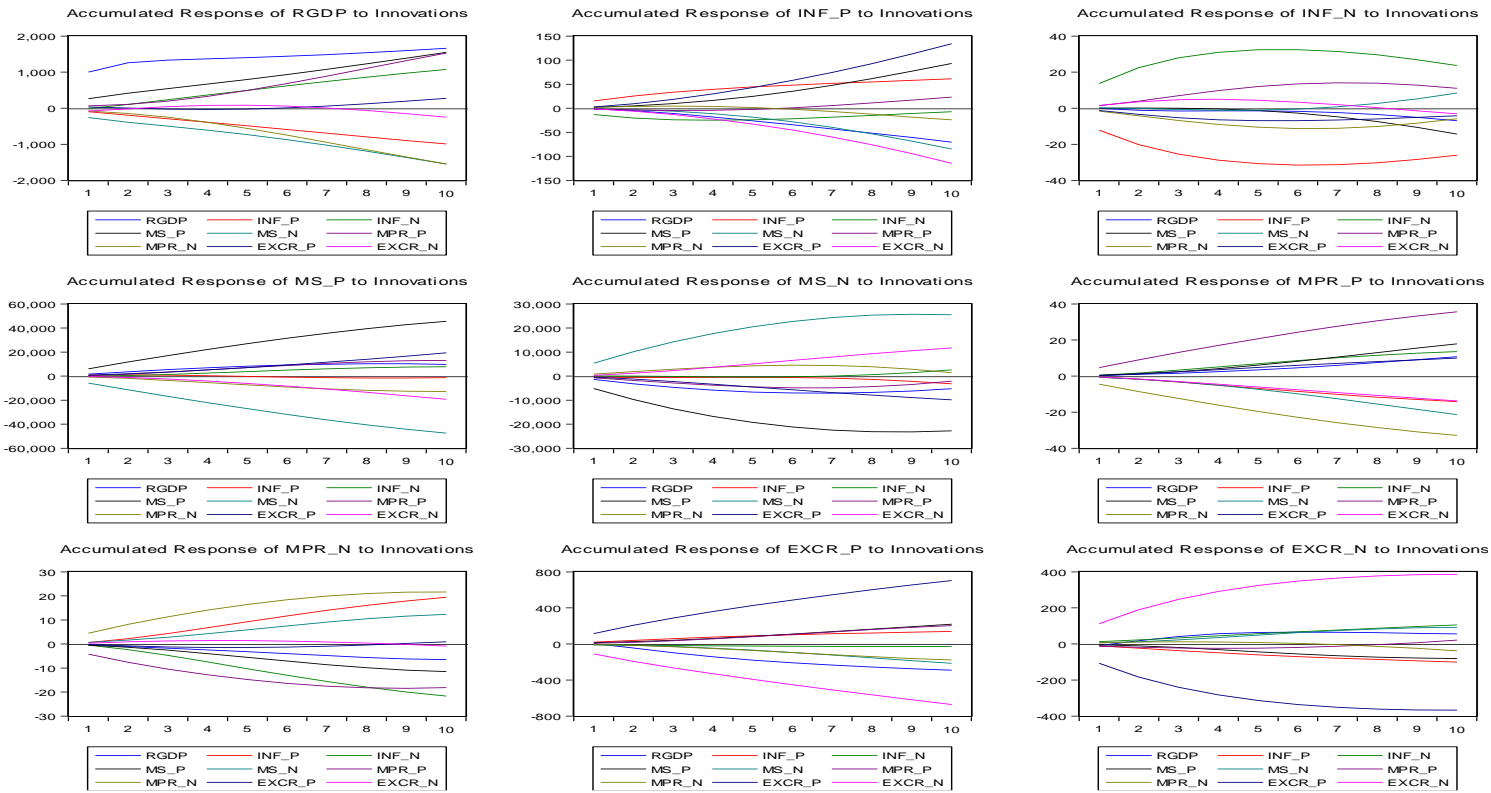


Figure 2: Asymmetric Response of Output

Source: Researchers' computation, 2025.

Table 4: Asymmetric Variance Decomposition of INF

Period	S.E.	INF	RGDP_P	RGDP_N	MS_P	MS_N	MPR_P	MPR_N	EXCR_P	EXCR_N
1	2.347375	100.0000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
2	3.279369	93.15538	3.464202	0.017152	0.155437	0.027330	2.345847	0.040273	0.761528	0.032847
3	4.123138	82.44085	8.905275	0.128908	1.004064	0.089803	5.825981	0.112855	1.407788	0.084472
4	4.989582	71.52814	14.12225	0.395309	2.923149	0.172908	8.878013	0.194288	1.650395	0.135548
5	5.911874	61.84204	18.18837	0.818979	5.923274	0.259462	10.92060	0.269581	1.601011	0.176679
6	6.906788	53.69638	20.96440	1.359738	9.746778	0.336056	11.94999	0.331305	1.410817	0.204535
7	7.986098	47.01254	22.64253	1.960654	14.02840	0.394852	12.18566	0.376982	1.179353	0.219029
8	9.158970	41.60543	23.50407	2.567688	18.41751	0.433134	11.88599	0.407102	0.957290	0.221794
9	10.43294	37.27760	23.81341	3.139625	22.64159	0.451855	11.27191	0.423723	0.765014	0.215275
10	11.81482	33.84742	23.78128	3.650323	26.52201	0.454040	10.50609	0.429508	0.607211	0.202112

Source: Researchers' computation, 2025.

Table 5: Asymmetric Variance Decomposition of RGDP

Period	S.E.	RGDP	INF_P	INF_N	MS_P	MS_N	MPR_P	MPR_N	EXCR_P	EXCR_N
1	1001.254	100.0000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
2	1050.552	96.82759	0.521313	0.984970	0.431318	0.499577	0.129507	0.034636	0.303460	0.267632
3	1075.239	92.91027	1.190615	2.082768	1.159213	0.784406	0.748493	0.063803	0.544201	0.516227
4	1098.895	89.06130	1.856200	2.940831	2.038833	0.818046	1.962785	0.074395	0.608352	0.639258
5	1124.207	85.18319	2.501214	3.553518	3.028280	0.782251	3.628351	0.073267	0.585696	0.664235
6	1152.146	81.21338	3.111718	3.960567	4.106846	0.818718	5.502389	0.070110	0.576026	0.640242
7	1182.700	77.21926	3.663181	4.198249	5.247232	1.008987	7.345631	0.072537	0.635733	0.609186
8	1215.219	73.32969	4.130169	4.299637	6.412287	1.387697	8.974891	0.085091	0.780425	0.600116
9	1248.715	69.67391	4.494714	4.296751	7.559247	1.955682	10.27998	0.109516	1.000879	0.629318
10	1282.086	66.34952	4.749696	4.220221	8.645384	2.691128	11.21861	0.145468	1.277472	0.702502

Source: Researchers' computation, 2025.

4.5 Diagnostic checks

Residual diagnostic tests were carried out to examine the statistical robustness of the results. Accordingly, the serial correlation and heteroskedasticity tests were conducted and the results are reported in Tables 6 and 7.

Table 6: Serial Correlation Test

Null hypothesis: No serial correlation at lag h						
Lag	LRE* stat	Df	Prob.	Rao F-stat	Df	Prob.
1	77.18644	49	0.0962	1.63563	(49, 375.0)	0.0964
2	69.27406	49	0.1298	1.45302	(49, 375.0)	0.1303
3	57.45689	49	0.1905	1.186953	(49, 375.0)	0.1924
4	56.92405	49	0.204	1.175141	(49, 375.0)	0.2059
5	66.2921	49	0.0504	1.385155	(49, 375.0)	0.0512
6	60.47434	49	0.126	1.254144	(49, 375.0)	0.1275
7	42.51049	49	0.732	0.861536	(49, 375.0)	0.7338
8	37.84484	49	0.8764	0.762429	(49, 375.0)	0.8774
9	36.8465	49	0.8994	0.741372	(49, 375.0)	0.9002
10	34.28341	49	0.9451	0.687554	(49, 375.0)	0.9456

Source: Researchers' computation, 2025.

Table 7: Residual Heteroskedasticity Tests

Dependent	R-squared	F(56,58)	Prob.	Chi-sq(56)	Prob.
res1*res1	0.539877	1.215236	0.2315	62.08585	0.2683
res2*res2	0.55636	1.29887	0.1627	63.98142	0.2167
res3*res3	0.532218	1.178383	0.2682	61.20511	0.2946
res4*res4	0.333867	0.519102	0.9926	38.3947	0.9652
res5*res5	0.614104	1.648206	0.0306	70.62194	0.0903
res6*res6	0.328445	0.506547	0.9942	37.77112	0.9707
res7*res7	0.586358	1.468178	0.0747	67.43121	0.1409

Source: Researchers' computation, 2025.

Table 6 shows that the null hypothesis of no serial correlation cannot be rejected at all lags. Therefore, the residuals are serially independent. Similarly, from Table 7, the test for heteroskedasticity indicates that the residuals are homoscedastic as the p-values are all greater than 0.05.

Table 8 reports the results of the Jarque-Bera test for normality of the residuals. The test reveals that the errors are not normally distributed as the p-value associated with the JB statistic value is less than 0.05, which validates rejection of the null hypothesis of normality.

Table 8: VAR Residual Normality Tests

Component	Jarque-Bera	Df	Prob.
1	305.311	2	0.0000
2	41.86118	2	0.0000
3	390.2336	2	0.0000
4	8727.397	2	0.0000
5	225.905	2	0.0000
6	1731.2	2	0.0000
7	268.3529	2	0.0000
Joint	11690.26	14	0.0000

Source: Researchers' computation, 2025.

The results obtained in this study, namely the asymmetric impulse response functions and variance decomposition align with the earlier works of Morgan (1993) on inflation and output in Nigeria which found evidence dynamics, DeLong and Summers (1998), Komlan (2013), Sznajderska (2014); Ülke and Berument (2016) but contrast with the findings of Ravn and Sola (1996). First, the impulse response results for inflation indicate evidence of asymmetries in the output and inflation as the results revealed stronger persistence, and the response of inflation to a unit shock to itself was found to be positive and significant throughout the period. This suggests that inflationary pressures in Nigeria tend to be self-reinforcing, reflecting structural rigidities, adaptive expectations, and weak price adjustment mechanisms. Such persistence implies that inflation, once not properly targeted, could affect output.

The results further show that positive output shocks due to contractionary monetary policy measures (negative money supply and monetary policy rate shocks), and exchange rate appreciation exerted a negative effect on inflation. This aligns with theoretical expectations, as higher output improves supply conditions, while tighter monetary policy measures and currency appreciation reduce demand-side pressures and imported inflation. Conversely, negative output shocks, expansionary monetary policy (positive money supply and interest rate shocks) and exchange rate depreciation resulted in higher inflation throughout the periods. This confirms the vulnerability of Nigeria's inflation to demand expansion and exchange rate pass-through, thereby reinforcing the asymmetric nature of inflation dynamics. The finding is in tandem with those of Moran and Queralto (2018), Kilinc and Tunc (2019), Irandoust (2020) and contrasts with those of Jorda et al. (2019) and Moran and Queralto (2018).

The variance decomposition results reinforce these findings, shedding more light on the fact that inflation shocks explain the largest proportion of inflation variability, followed by positive shocks to RGDP, money supply, and monetary policy rate. This suggests that expansionary macroeconomic policy measures trigger inflation more than contractionary ones, which underscores the non-linear inflationary response to the CBN monetary policy measures. Exchange rate shocks, particularly in both positive and negative directions, contribute relatively less to inflation variability, implying that whilst the exchange rate movements affect inflation, domestic factors play a more dominant role.

Regarding output dynamics, the impulse response analysis indicates that output is largely self-driven, with its own shocks accounting for sustained positive responses. However, positive inflation shocks, contractionary money supply, and contractionary interest rate shocks negatively affected output, reflecting the growth-dampening effects of inflationary pressures and tight monetary policy. Interestingly, expansionary monetary policy shocks (positive money supply and monetary policy rate shocks) stimulated output, while negative inflation shocks also supported output growth after the initial period. These results suggest that output in Nigeria responds more favourably to accommodative monetary conditions, although such policies risk fuelling inflation. These findings align with those of Apanisile (2017), Aye and Gupta

(2012), Notarpietro and Siviero (2015), Zakir and Malik (2013), and contrast with the findings of Tenreyro and Thwaites (2016) and Ravn and Sola (1996).

The variance decomposition of output confirmed that output shocks dominate output variability, with positive money supply and monetary policy rate shocks contributing significantly. Inflation shocks exerted a moderate influence on output, indicating a trade-off between inflation control and output stabilization.

The paper highlights some policy implications of the results obtained. First, policymakers in Nigeria should adopt a cautious and forward-looking monetary policy framework, prioritizing inflation control due to its persistence and strong feedback effects. Contractionary monetary policy measures appear to be more effective in curbing inflation than expansionary policy measures. This implies that Nigeria faces a clear inflation–output trade-off, with asymmetric restraint in monetary expansion. Additionally, since output responds positively to accommodative policy and inflation responds more significantly to expansionary shocks, monetary authorities should complement monetary policy with structural and supply-side reforms to enhance productive capacity. Finally, maintaining exchange rate stability remains important, but greater emphasis should be placed on domestic macroeconomic discipline to achieve effective inflation control and output growth in Nigeria.

5. Conclusion

This paper proposes a non-linear approach to analysing monetary policy shocks in Nigeria. The Taylor rule has been explored using non-linear techniques, namely the asymmetric vector autoregressive (AVAR) model from 1999Q1 to 2024Q4. The findings provide strong evidence that monetary policy and macroeconomic shocks exert nonlinear and asymmetric effects on both inflation and output. Inflation in Nigeria was found to be highly persistent, with its own shocks accounting for the larger proportion of the variations in inflation. This underscores the structural nature of inflationary pressures in the economy and highlights the difficulty often encountered in stabilizing prices once inflation expectations become entrenched. The results further reveal that expansionary monetary policy shocks exert stronger inflationary pressures than contractionary policies in dampening inflation. Conversely, contractionary

monetary policy measures were shown to be more effective in reducing inflation, albeit at the cost of output contraction. On the output side, accommodative monetary policy supports economic growth, while high inflation and tight monetary conditions negatively affect output performance. These findings confirm the existence of a clear trade-off between inflation control and output stabilization in Nigeria, thereby invalidating the notion of a divine coincidence in the Nigerian context.

Given the persistence and self-reinforcing nature of inflation, the Central Bank of Nigeria (CBN) should prioritize price stability over output stabilization as its primary policy objective. Early and decisive monetary tightening is recommended when inflationary pressures emerge to prevent inflation from becoming entrenched. While expansionary monetary policy can stimulate output growth, the study shows that such policy generates disproportionately higher inflationary effects. Therefore, monetary expansion should be used cautiously, particularly during periods of weaker output performance lest it fuel inflation further. This implies that stronger coordination between monetary and fiscal authorities is essential in reducing excessive reliance on monetary expansion and in ensuring macroeconomic stability.

Overall, the study concludes that monetary policy in Nigeria does not affect inflation and output symmetrically but rather asymmetrically. The asymmetric responses suggest that uniform policy prescriptions may be ineffective, and that the effectiveness of monetary policy depends largely on the direction, magnitude, and prevailing macroeconomic conditions under which policy actions are implemented.

It is noteworthy that this study relies mainly on aggregate macroeconomic data rather than disaggregated sectoral contributions. However, inflation and output responses may vary across sectors of the economy, such as Agriculture, Manufacturing, and Services. Finally, the study focuses on a limited set of monetary policy variables, namely money supply, monetary policy rate, and exchange rate and leaves out other relevant transmission channels due to lack of access to data. The exclusion of these components might lead to an incomplete representation of the full monetary policy transmission mechanism.

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