The Neutral Interest Rate and Monetary Policy Stance in the West African Monetary Zone: A DSGE Approach.

Williams Anthony Oscar[a], Benedict Ndubisi Akanegbu[b]

a Central Bank of Nigeria, Plot 33, Abubakar Tafawa Balewa Way Central Abuja, Federal Capital Territory, Nigeria

b Nile University of Nigeria, Plot 681, Cadastral Zone C, OO, Research & Institution Area, Abuja, Nigeria

Abstract

While the subject of the neutral interest rate has gained significant attention by the Advanced economies in recent periods, owing to the post-crises economic stabilisation, the emerging economies, especially in the WAMZ region are lagging. Accordingly, this paper attempts to estimate the neutral interest rate for two key economies in the West African Monetary Zone (WAMZ): Nigeria and Ghana using an open-economy Dynamic Stochastic General Equilibrium Model. The findings indicated that monetary policy stance in the WAMZ region was largely loose between 2010 (post-gfc) and 2024 (post-COVID 19), with marked expansions during post-crises periods such as the commodity price dip in 2016 and the COVID-19 pandemic in 2020. The findings further revealed that Ghana being an inflation targeting country showed a stronger commitment to price stability than Nigeria where monetary targeting is practiced. The paper, therefore, identified the need for countries in the WAMZ region to implement mechanisms that could absorb post-crises shocks to inflation as it has a significant risk to monetary policy.

Keywords: Neutral Interest Rate, Monetary Policy, DSGE.

Introduction

Prior to the implementation of monetary policy rules, the determination of monetary policy rates was predominantly based on the level of short-term and long-term real interest rates. (Borio, 2024). Nonetheless, this approach has been criticized for various reasons, including the inherent delay in the policy response attributable to the data reflecting actual inflation (Holston et al., 2017) and the inadequacy of real interest rates to adequately encapsulate the anticipations of economic agents (Borio, 2021). In light of these considerations, the neutral interest rate, as an indicator of the monetary policy stance, has garnered significant global attention.

Borio (2024) showed that from 2015, there has been a substantial increase in the frequency with which central bank discourses reflect the natural or neutral interest rate. This phenomenon first reached double-digit levels in 2015, thereby coinciding with the timeframe during which the Federal Reserve initiated an initial “lift-off” from a prolonged period of zero nominal rates, a situation that has persisted in the aftermath of the Global Financial Crisis (Armelius et al, 2018; Mansilla & Togores, 2024). Regrettably, the focus on Emerging Markets and Developing Economies (EMDEs) has remained exceedingly limited, with nearly no attention afforded to the developing nations within sub-Saharan Africa and West Africa (Amoetey et al, 2024). This paper aims to examine the major economies within the West African Monetary Zone (WAMZ), primarily in light of the convergence criteria established to ensure the initiative's viability.

The West African Monetary Zone (WAMZ) embodies a pivotal initiative designed to promote economic integration among its constituent nations, particularly illustrating a collective aspiration for monetary stability and mutual economic advancement. Comprising The Gambia, Ghana, Guinea, Nigeria, Liberia, and Sierra Leone, the WAMZ serves as a framework for harmonized monetary policy, with profound ramifications for the economic stability of West Africa. Since its establishment in 2000, however, the WAMZ has yet to effectively realize its primary convergence criterion of maintaining single-digit inflation (Olowofeso et al, 2023; Mogaji, 2017), thereby jeopardizing the attainment of a cohesive monetary policy within the region. This circumstance has prompted the objective of this study, which is to critically reassess the monetary policy stance in the region by evaluating factors beyond maintaining a positive real interest rate, delineated as a secondary convergence criterion, and consequently endeavour to investigate the intricacies of neutral interest rates in the area.

The methodology employed in this paper to ascertain the neutral interest rate is predominantly derived from an open-economy structural model due to the influence of global economic activities on the domestic economy (Tüzün, 2024). Within the current body of literature, numerous investigations have endeavoured to estimate the neutral interest rate. Noteworthy among these investigations is the work of Laubach & Williams (2003), which utilized the conventional IS and Phillips curves to align empirical data and derive the neutral interest rate (rstar). This methodology consequently constrained the rstar estimations to the dynamics of potential output, thereby neglecting the fundamental priorities of price stability as emphasized by central banks.

Time series methodologies for estimating the rstar (Lubik & Mattes, 2015; Ferreira & Shousha, 2021; Roberts, 2018; Sánchez, 2016) have faced substantial critique for their deficiency in theoretical underpinnings and the idiosyncrasies associated with time series models in general. To circumvent related time-series constraints, Kang & Do (2024) adopted a methodology for the Korean economy, wherein they integrated a Bayesian econometric framework, alongside a structural identification of shocks to enhance the theoretical robustness of their model. Segura-Rodriguez (2024) combined both the HLW and VAR methodologies, with the latter's rstar estimates predicated on an AR (1) process. This paper is not bound by these constrains due to the choice of a structural model.

There are existing studies regarding the application of structural models that pertain to open-economy dynamic stochastic general equilibrium (DSGE) frameworks for the estimation of the neutral interest rate. The pioneering contributions include those by Galí & Monacelli (2005), who formulated a structural DSGE model tailored for a small open economy, aiming to maintain an optimal monetary policy framework. Although their examination encompassed aspects related to trade and international risk sharing via the uncovered interest rate parity, the monetary policy reaction function within their model did not integrate the neutral interest rate. Other innovative studies in the domain of open-economy DSGE, such as Smets & Wouters (2003; 2007), employed the lagged nominal interest rate within the monetary policy reaction function, whereas Woodford (2003) incorporated the natural interest rate into the structural model; however, he limited its estimation to an autoregressive process. In contrast, this paper

delineates a more representative identity of the neutral interest rate that aligns with established theoretical foundations.

The existing body of literature regarding open economy Dynamic Stochastic General Equilibrium (DSGE) models pertaining to African economies has not extensively integrated the concept of the neutral interest rate within their frameworks. Noteworthy contributions to this field include Gupta and Steinbach (2013); Omotosho & Yang (2024); Ben Salem et al. (2024); Adjalala & Dissou (2023); Iyer (2020); Chuku (2020); Rasaki & Malikane (2015); and Balcilar et al. (2015). The body of peer-reviewed research specifically addressing open-economy DSGE models within the West African Monetary Zone (WAMZ) remains remarkably sparse. Consequently, this study endeavours to investigate the monetary dynamics prevalent in this region, with particular emphasis on the cases of Nigeria and Ghana. This selection is predicated upon various considerations, including the magnitude of their respective Gross Domestic Products (GDP) (Tsangarides & Qureshi, 2008), as well as notable similarities that exist between the two economies.

In terms of economic stature, Nigeria is ranked as the foremost economy within the WAMZ, boasting a GDP of $550.65 billion in 2023. Following Nigeria, Ghana ranks second with a GDP of $70.51 billion (World Development Indicators, 2023). The aggregate of these GDP figures represents an economic magnitude encompassing 95.43 percent of the total GDP within the region. Furthermore, comprehensive, and reliable economic data are more accessible for Nigeria and Ghana in comparison to other member states of the WAMZ. Considering this, the Central Bank of Nigeria and the Bank of Ghana are integral to the formulation and stance of monetary policy within the region. Given their substantial economic influence, the monetary decisions taken by these institutions are capable of shaping interest rate trajectories and ensuring financial stability throughout the WAMZ. An examination of these two countries yields significant insights into the monetary dynamics of the zone.

Monetary policy in Nigeria is implemented under the monetary targeting framework, wherein the monetary base serves as the operating target, while the broad money and inflation are the intermediate and ultimate targets, respectively. This framework was adopted in 1974 and fundamentally predicated on the assumption that inflation constitutes a monetary phenomenon within the country. The surge in money supply at the period was attributed to the oil boom of the 1970s (Nnanna, 2002). Notably, even in contemporary times, unprecedented expansion of money supply continues to pose significant challenges for policymakers, given the resource-abundant nature of the Nigerian economy and the resulting monetization of oil revenues (Ariweriokuma, 2008; Nwaoha & Wood, 2014). Consequently, under the prevailing framework, the Bank does not adhere to a rule-based monetary policy that is characterized by strict adherence to a defined inflation target. This, together with other constraints contribute to the loose stance of monetary policy and overall monetary conditions in Nigeria.

The Bank of Ghana, conversely, implemented an inflation targeting framework in 2007 mainly to mitigate the challenges posed by elevated and persistent inflation; depreciation of the exchange rate; pronounced fiscal dominance characterized by the financing of widening fiscal deficits primarily through monetary financing (Ghartey, 2001; Quartey & Afful-Mensah,

2014); the inadequacy of the nominal anchor; and de-anchoring of inflation expectations among economic agents (Odu et al, 2024). Notably, among the countries under review, Ghana exhibits a rule-based and forward-looking monetary policy framework that includes a clearly defined inflation target of 8 percent (with a permissible deviation of +/-2 percentage points). Consequently, the maintenance of inflation within this targeted range is important for the Bank of Ghana, in contrast to Nigeria, where the existing framework does not accommodate such a robust commitment. Although the Central Bank of Nigeria has recently announced its reversion to orthodox monetary policy in anticipation of transitioning to an inflation-targeting regime, the level of commitment to monetary policy targets still appears to be relatively weak, considering the prevailing inflationary trends.

This phenomenon is not entirely unexpected within the region, especially when considering the level of monetary and fiscal stimuli that were injected to the economy in the post-COVID 19 period. The Ghanian government spent about 2.1 percent of GDP to support the reopening of the economy while in Nigeria, there was liquidity injection of N3.6 trillion (2.4 percent of GDP) into the banking system, including N100 billion to support the health sector, N2 trillion to the manufacturing sector, and N1.5 trillion to the real sector to impacted industries (IMF, 2020). Hence, in this study, we seek to examine the monetary policy stance within the zone, considering these injections and other measures that were implemented during post-crises periods. We incorporate the neutral interest rate into the policy rules applicable to both central banks to establish a benchmark for evaluating the stance of monetary policy. The subsequent sections of the paper are organized as follows: Section 2 delineates the empirical methodology, Section 3 encompasses the stylized facts, Section 4 presents the results and discussion, while Section 5 encapsulates the findings and concludes the study.

2.0 Empirical Methodology

This study employs a structural model to ascertain the neutral interest rate pertinent to the specified nations within the West African Monetary Zone. The methodology is predominantly derived from the New Keynesian macroeconomic paradigm. The micro-founded open-economy Dynamic Stochastic General Equilibrium (DSGE) model is encapsulated by equations 4, 6, 8, 9, and 10.

2.1 Model Specification

The representative household is assumed to have constant preferences in their substitution of different consumption goods. In relation to the neutral interest rates, we specify household intertemporal utility maximisation to depict the linkage between the steady state interest rate at period t and equilibrium output.

$$r^* = \frac{1}{\sigma} g_c + \theta \qquad (1)$$

Where r^* represents the neutral interest rate, σ is the coefficient of the elasticity of substitution by the household, g_c represents the growth of consumption, usually proxied with output growth, and θ is the indicator of time preference in the equation. In the household model, labour productivity at its trend level and adjustments to monetary policies are considered factors

driving persistent changes in the neutral interest rate (Ademmer & Rush, 2024; Kang & Do, 2024). Population (Obstfeld, 2023; Holston et al, 2017), level of savings & investment (Ruch, 2021; Carrillo et al, 2018), and level of government debts (Ferreira, 2022) are other sources of persistent changes in the neutral interest rate. Although this paper considers mainly the annualized expected inflation and trend interest rate.

We examine an open-economy model where inflation and aggregate demand dynamics are summarised theoretically as follows:

$$\pi_{H,t} = \beta E_t\left[\pi_{H,t+1}\right] + \varkappa \tilde{y}_t \qquad (2)$$

The aggregate demand function takes the following form:

$$\tilde{y}_t = E_t[\tilde{y}_{t+1}] - \sigma^{-1}(i_t - E_t\left[\pi_{H,t+1}\right] - e_t^n \qquad (3)$$

In equations 2 and 3, $\pi_{H,t}$ represents the growth rate of the domestic prices, $\tilde{y}_t$ is the output gap, and i_t is the nominal interest rate at time t. The intertemporal elasticity of substitution, household preferences for domestic and foreign goods, as well as the price adjustment rigidities are represented by parameters σ and $\varkappa$. Therefore, they both generally represent household preferences and productivity backed by technology (Gabaix, 2020). The variable e_t^n represents the stochastic term of shocks to inflation and output gap in the model, while $i_t - E_t\left[\pi_{H,t+1}\right]$ represents the real interest rate gap deflated to zero periodically by e_t^n , to stabilize both the output gap and inflation.

Specifically, in this study, we specify the linearised aggregate demand equation, measuring the relationship between the output gap and its determinants as follows:

$$\tilde{y}_t = \beta_1 \tilde{y}_{t-1} - \beta_2 MCI + \beta_3 \tilde{y}_t^* + \epsilon_t^{\tilde{y}} \qquad (4)$$

Equation 4 shows that aggregate demand $\tilde{y}_t$ is a function of its lagged value $\tilde{y}_{t-1}$, monetary conditions MCI, foreign output gap ($\tilde{y}_t^*$), and the shock to aggregate demand $\epsilon_t^{\tilde{y}}$.

Where, $\tilde{y}_t = y_t - \bar{y}_t$, implying that the output gap is derived as the difference between the observed output y_t and its potential $\bar{y}_t$. The potential output for the domestic economy and other trend variables is recovered through estimating unobserved state variables using multivariate Kalman filtering (Mansilla Roca de Togores, 2024).

From equation (4), we define the monetary conditions index as a combination of the real interest rate gap $\hat{r}_t$ and the real exchange rate gap $\hat{z}_t$. this is shown in equation (5):

$$MCI = \beta_4 \hat{r}_t + (1 - \beta_4)(-\hat{z}_t) \qquad (5)$$

For the firms' pricing behaviour, we adopt the Hybrid New Keynesian Phillips Curve (HNKPC) to capture the forward and backward-looking features of inflation in the domestic economy, to reflect a more dynamic nature of inflationary dynamics in the economy. The HNKPC model is, therefore, as follows:

$$\pi_t = \alpha_1 \pi_{t-1} + (1 - \alpha_1)\mathbb{E}_t[\pi_{t+1}] + \alpha_2 RMC + \epsilon_t^{\pi} \qquad (6)$$

Where inflation π_t is sensitive to its lagged π_{t-1} and expected $\mathbb{E}_t[\pi_{t+1}]$ values as well as the real marginal cost RMC. The equation for RMC is as follows:

$$RMC = \alpha_3 \tilde{y}_t + (1 - \alpha_3)\hat{z}_t \tag{7}$$

We further specify the monetary policy reaction function based on a Taylor rule:

$$i_t = g_1 i_{t-1} + (1 - g_1)\{i_t^n + g_2(\mathbb{E}_t[\pi_{t+n}^4] - \pi_{t+n}^T) + g_3 \tilde{y}_t\} + \epsilon_t^i \tag{8}$$

Where i_t represents the nominal interest rate adjusted by the central bank, in response to the neutral rate interest rate i_t^n, deviation of annualised inflation from its target ($\mathbb{E}_t[\pi_{t+n}^4] - \pi_{t+n}^T$), and aggregate demand $\tilde{y}_t$. The lagged value of the policy rate and its parameter g_1 represents the smoothing in policy adjustments, which entails how much weight the central bank places on its "wait-and-see" approach to monetary policy. The monetary policy shock is represented by ϵ_t^i.

The neutral interest rate i_t^n is estimated thus:

$$i_t^n = \bar{r}_t + \mathbb{E}_t[\pi_{t+1}^4] \tag{9}$$

Where the neutral interest rate depends on the trend of real interest rate $\bar{r}_t$ and the annualized expected inflation $\mathbb{E}_t[\pi_{t+1}^4]$.

As an open economy, we also specify an Uncovered Interest Rate Parity (UIP) to the dynamics in the foreign exchange market between the domestic WAMZ economies and the global international market. Therefore, the UIP condition is specified thus:

$$s_t = (1 - e_1)\mathbb{E}_t[s_{t+1}] + e_1(s_{t-1} + 0.5 * (\pi_{t+n}^T - \pi_t^{*SS} + \bar{z}_t)) + (-i_t + i_t^* + prem)/4 + \epsilon_t^s \tag{10}$$

Where the nominal exchange rate s_t depends on its expected $\mathbb{E}_t[s_{t+1}]$ and lagged s_{t-1} values, the difference between the domestic inflation target π_{t+n}^T (annualised) and the steady state of global inflation π_t^{*SS} as well as the trend of real exchange rate $\bar{z}_t$. In the UIP condition we add a risk premium $prem$ to the difference between domestic nominal interest rate i_t and the foreign nominal interest rate i_t^*. (Dabrowski & Janus, 2024). We add the risk premium variable also because Kumar (2019) showed that in the absence of risk premium, UIP failure is more prominent in emerging countries relative to advanced countries.

Definitions

The definitions of identities in the summarised equations are as follows:

$$r_t = i_t - \mathbb{E}_t[\pi_{t+1}^4] \tag{11}$$

Where in equation (11) real interest rate r_t is estimated as the difference between the nominal interest rate i_t and expected annualised inflation $\mathbb{E}_t[\pi_{t+1}^4]$.

$$z_t = s_t + \log(cpi_t^*) - \log(cpi_t) \tag{12}$$

Equation (12) is the real exchange rate z_t, defined as the difference between nominal exchange rate s_t and the gap between domestic $\log(cpi_t)$and foreign $\log(cpi_t^*)$ consumer price indexes.

$$\mathbb{E}_t[\bar{z}_{t+1}] = \bar{r}_t - \bar{r}_t^* - prem \quad (13)$$

The long-term trend real exchange rate is defined in equation (13) as the difference between the trend values of the domestic real interest rate $\bar{r}_t$, foreign real interest rate $\bar{r}_t^*$ and risk premium $prem$.

$$\hat{r}_t = r_t - \bar{r}_t \quad (14)$$

$$\hat{z}_t = z_t - \bar{z}_t \quad \text{s} \quad (15)$$

The domestic real interest rate and real exchange rate gaps: $\hat{r}_t$and $\hat{z}_t$ are estimated by subtracting the trend values from the actual values as shown in equations (14) and (15).

The trend variables are specified as AR (1) processes as follows:

$$\bar{x}_{it} = \rho_{\bar{x}_{it}}\bar{x}_{it-1} + \left(1 - \rho_{\bar{x}_{it}}\right)\bar{x}_{it}^{SS} + \epsilon_t^{\bar{x}} \quad (16)$$

Equation (16) represents the condition for a vector of trend variables $\bar{x}_{it}$, which includes the inflation target, real exchange rate trend, real interest rate trend, and domestic potential output. This is due to the persistency associated with economic variables in a structural model (DeJong & Dave, 2007)

In the foreign equation block, we define the foreign output gap to depend on its past values $\tilde{y}_{t-1}^*$ and foreign demand shock $\epsilon_t^{\tilde{y}_t^*}$ as shown in equation (17).

$$\tilde{y}_t^* = \rho_{\tilde{y}_t^*}\tilde{y}_{t-1}^* + \epsilon_t^{\tilde{y}_t^*} \quad (17)$$

$$\pi_t^* = \rho_{\pi_t^*}\pi_{t-1}^* + \left(1 - \rho_{\pi_t^*}\right)\bar{\pi}_t^{*SS} + \epsilon_t^{\pi_t^*} \quad (18)$$

$$i_t^* = \rho_{i_t^*}i_{t-1}^* + \left(1 - \rho_{i_t^*}\right)(\bar{\imath}_t^{*SS} + \pi_t^*) + \epsilon_t^{i_t^*} \quad (19)$$

$$\bar{r}_t^* = \rho_{\bar{r}_t^*}\bar{r}_{t-1}^* + \left(1 - \rho_{\bar{r}_t^*}\right)\bar{r}_t^{*SS} + \epsilon_t^{\bar{r}_t^*} \quad (20a)$$

$$r_t^* = i_t^* - \pi_t^* \quad (20b)$$

$$\hat{r}_t^* = r_t^* - \bar{r}_t^* \quad (20c)$$

Equations (18) to (20c) are the AR (1) processes of foreign inflation, nominal interest rate, and trend real interest rate. The superscript '*ss*' distinguishes the steady state variables.

2.2 Model Parameters

2.2.1 Steady state parameters

The steady states incorporated within the structural model serve to facilitate the return of the modelled macroeconomic system to a state of equilibrium over the long term. Among these steady state parameters is the domestic inflation target $\pi_t^{T(SS)}$, which represents the projected long-term convergence point for inflationary measures. In the formulation of the trend real exchange rate $\bar{z}_t^{SS}$, the steady state signifies the anticipated rate of appreciation or depreciation of the domestic currency when evaluated in real terms. Likewise, the trend real interest rate $\bar{r}_t^{SS}$

is defined by its steady state parameter, which denotes the level toward which the real interest rate is expected to converge. Furthermore, the steady state of output growth $\bar{y}_{it}^{SS}$ is introduced to ensure the alignment of potential real GDP with its equilibrium counterpart. On the international front, the steady state of foreign inflation $\pi_t^{*ss}$and the foreign trend real interest rate $\bar{r}_t^{*ss}$ are incorporated into the model to promote the convergence of their respective actual values toward equilibrium values.

2.2.2 Business Cycle Parameters

In the IS curve (the aggregate demand equation), parameters $\beta_1, \beta_2, \beta_3$ represent the sensitivity of aggregate demand to its lagged value, monetary conditions, and foreign demand, respectively. The parameters β_4 in the monetary conditions index equation represents the relative weights of interest rate and exchange rate in the determination of monetary conditions.

The Hybrid New Keynesian Phillips Curve (HNKPC) parameter $\alpha_1 and\ 1-\alpha_1$ represent the relative weights allotted to the backward-looking and forward-looking elements of inflation. Parameter α_2 indicates the weight of real marginal cost in explaining the dynamics of domestic inflation. Parameter α_3 is used to apportion weights to the components of real marginal cost, which include the domestic output and real exchange rate gaps.

2.2.3 Policy Parameters

In the monetary policy reaction function, the policy parameter g_1 represent the level of importance the central bank places on either policy persistence or forward guidance. Similarly, parameters $g_2\ and g_3$ represent the sensitivity of the policy rate to the deviation of annualised inflation from its target and the output gap. In the Uncovered Interest rate Parity condition Parameter $e_1$represents the sensitivity of nominal exchange rate to its lagged and expected values.

2.2.4 Persistency Parameters

The model incorporated various persistency parameters that assess the stability of the annualized inflation target, the trajectory of the real exchange rate, the trend of real interest rates, output trends, the foreign output gap trend, the foreign inflation trend, as well as the trends of foreign nominal and real interest rates. These parameters were utilized to illustrate the rate at which the associated variables approach their equilibrium states.

2.3 Filtration process

The trend variables for the domestic economy were estimated using a Kalman filtration process due to its ability to incorporate time-varying properties of an economic data (Kim & Bang, 2018). In addition, its state-space structure suits the dynamic and recursive nature of economic trend variables used in this paper (Pasricha, 2006). However, the trend variables in the foreign sector were seasonally adjusted using HP-filter with Judgement applied to output gap based on available data on (same is applied in Pang & Shiamptanis, 2024).

In the filtration process, we specify a model of state-space form consisting of the measurement and unobserved state equations. The measurement equation is specified thus:

$$Y_t = CX_t + v_t \tag{21}$$

where Y_t is a vector of observed variables C is a matrix of known parameters, X_t is a vector of state variables which will be estimated using the Kalman filter, and v_t is a vector of measurement errors that are independent identically distributed. Furthermore, we specify the unobserved state in its dynamic form explained by the A vector of known parameters and independent and identically distributed errors ε_t.

$$X_t = AX_{t-1} + \varepsilon_t \tag{22}$$

Since, we introduce some forward-looking variables such as expected inflation in the neutral interest rate model, we modify the state equation to:

$$FE_t[X_{t+1}] + GX_t + HX_{t-1} + M\eta_t = 0 \tag{23}$$

where, F, G, H, M are matrices of structural parameters, E_t is the expectations operator, and η_t is the vector of structural shocks. Transforming the equation 7 to a state-space form involves solving for rational expectations, where the equation needs to have a unique stable solution of the form:

$$X_t = AX_{t-1} + P\eta_t \tag{24}$$

where A and P are matrices of the coefficients that are functions of F, G, H, M. We therefore substitute equation (8) into (7) and take expectations to enable the matrices satisfy the identity:

$$F[A(AX_{t-1} + P\eta_t) + P(S\eta_t)] + G[AX_{t-1} + P\eta_t] + HX_{t-1} + M\eta_t = 0 \tag{25}$$

For possible values of X_{t-1} and η_t, A and P are the solutions of equations:

$$FA^2 + GA + H = 0, \quad FAP + FPS + GP + M = 0 \tag{26}$$

Further, we update the estimate of the state variable using the data at period t. The Kalman filter uses the differences between the actual data Y_t and the model prediction Y_{t-1} to update the estimate of the unobserved states using the Kalman gain (matrix K).

$$X_{t/t} = X_{t/t-1} + K_t\left(Y_t - Y_{t/t-1}\right) \tag{27}$$

In this process, we specify the prediction error variance $F_{t/t-1}$ of the observed variable Y_t, given the observed values up to period $t-1$. We, therefore, have:

$$F_{t/t-1} = VAR_{t-1}\left[\left(Y_t - Y_{t/t-1}\right)\right] \tag{28}$$

In the updating phase of the Kalman recursion, the prediction error $P_{t/t-1}$ of the state variable X_t is also considered using the same specification in equation (12). The multivariate distribution for $Y_t \; and \; X_t$ takes the following form:

$$\begin{pmatrix} Y_t \\ X_t \end{pmatrix} \Big| \, Y_{t,\dots,} Y_{t-1} \sim N\left(\begin{pmatrix} Y_{t/t-1} \\ X_{t/t-1} \end{pmatrix}, \begin{pmatrix} F_{t/t-1} & CP_{t/t-1} \\ P_{t/t-1}C' & P_{t/t-1} \end{pmatrix}\right) \tag{29}$$

Based on equation (10), the conditional distribution of X_t given Y_t takes the form:

$$X_t|Y_t, Y_{1,\ldots,}Y_{t-1} \sim N(X_{t/t-1} + P_{t/t-1}C'F_{t/t-1}{}^{-1}[Y_t - Y_{t/t-1}], P_{t/t-1} - P_{t/t-1}C'F_{t/t-1}{}^{-1}CP_{t/t-1}) \quad (30)$$

From equation (11), it follows that:

$$X_{t/t} = X_{t/t-1} + P_{t/t-1}C'F_{t/t-1}{}^{-1}[Y_t - Y_{t/t-1}] = X_{t/t-1} + K_t\,[Y_t - Y_{t/t-1}], \quad (31)$$

$$P_{t/t} = P_{t/t-1} - P_{t/t-1}C'F_{t/t-1}{}^{-1}CP_{t/t-1} = (1 - K_tC)\,P_{t/t-1}, \quad (32)$$

The Kalman gain, which is quite important in determining how much weight is placed on the prior (predicted) state variable is stated as:

$$K_t = P_{t/t-1}C'F_{t/t-1}{}^{-1} \quad (33)$$

From equations (15 to 17) the Kalman filter algorithm is as follows:

$$K_t = P_{t/t-1}C'(CP_{t/t-1}C' + R)^{-1} \quad (34)$$

$$X_{t/t} = X_{t/t-1} + K_t[Y_t - Y_{t/t-1}] \quad (35)$$

$$P_{t+1|t} = A(1 - K_tC)P_{t/t-1}A' + Q \quad (36)$$

Where K_t depends positively on $P_{t/t-1}$ and negatively on the measurement equation variance R.

Replacing X_t with the potential output notation $\bar{y}_t$, we obtain estimates of the smoothed states by the following.

$$\bar{y}_{t/T} = \bar{y}_{t/t} + K_t[\bar{y}_{t+1/T} - \bar{y}_{t+1/t}] \quad (37)$$

Where, $\bar{y}_{t/T}$is the updated state estimate at time k, $\bar{y}_{t+1/T}$ is the actual measurement and $\bar{y}_{t+1/t}$ is the predicted measurement of potential output.

2.4 Calibration Strategy of Parameters and Shocks

The calibration of parameters in this manuscript was conducted in accordance with empirical evidence, theoretical postulations, accessible data, and expert evaluations. The Bayesian methodology is utilized in the allocation of prior values to the model parameters, thereby facilitating the model's alignment with both theoretical anticipations and the economic realities of the chosen economies. The preference for the Bayesian methodology over maximum likelihood estimation arises from the limitations of MLEs when analysing intricate structural models that encompass latent variables (Kang & Do, 2024). Furthermore, the prior calibration of the parameters is also critical in enhancing the sample size of the investigation, which encompasses the period from 2010 to 2025.

The parameters pertaining to the steady state were calibrated to encapsulate the values towards which the selected economies are anticipated to converge in their long-term equilibrium trajectory. The steady state of potential output was derived from the GDP forecasts for Nigeria and Ghana projected for the year 2024, as detailed in the International Monetary Fund's World Economic Outlook (IMF, WEO, 2024). Consequently, the potential output has been fixed at 3.3 and 2.8 percent for Nigeria and Ghana, respectively. The target for domestic inflation in

Nigeria has been set at 15.0, aligning with the budgetary framework outlined in Nigeria's 2025 Appropriation Bill. For the Ghanian economy, the inflation target was set at 10.0 per cent in line with their inflation targeting framework. The target for foreign inflation is established at 2.0 percent, which corresponds to the inflationary objectives set forth by the Federal Reserve Bank in the United States. The depreciation of the equilibrium real exchange rate serves as a mechanism for determining the calibrated value of the equilibrium exchange rate, whereby a gradual depreciation of 0.05 is recommended (de Resende et al, 2022); this long-term depreciation rate is informed by the Balassa-Samuelson effect as it pertains to emerging markets (Choudri & Khan, 2005). The real interest rate has been designated at 0.5 percent to reflect the stance of a central bank that prioritizes the mitigation of inflation by sustaining a positive real interest rate.

In the IS curve, the persistency parameter β_1 is set at 0.80 percent (the regression results of output and its lagged value). The impact of monetary conditions on demand β_2 was set at 0.3 to reflect a lower impact of monetary conditions on aggregate demand. The parameter β_3 was assigned 0.3 percent, reflecting a small open economy which depends fairly on foreign demand.

The MCI, an integral component of the aggregate demand framework, comprises the gaps of real interest rate and the real exchange rate. The effective parameter values representing the aggregate demand's responsiveness to variations in the real interest rate and real exchange rate gaps were set at 0.5 percent each, to capture a baseline behaviour of monetary conditions (de Resende et al, 2022).

The inflation model was specified following the New Keynesian approach. Due to persistent increase in Nigeria's CPI, we allocate a higher weight to the backward-looking component of the Phillips curve, due to evidence of inflation persistence (Tule et al, 2020). Consequently, parameter α_1 is set at 0.7 percent. The parameter for the real marginal costs (RMC) is set at 0.3 percent, while the share of output gap and real exchange rate gap were set at 0.7 and 0.3 percent, respectively, to reflect a greater impact of demand on inflation.

The policy parameters were calibrated to reflect a less forward-looking central bank that also considers the impact of policy rate adjustments on the banking system. The policy rate persistence parameter g_1 was set at 0.6 percent reflecting the high persistence usually associated with central banks in emerging markets (Nautz & Scheithauer, 2011). Parameter g_2 was tuned to 0.5 percent, reflecting a lower weight on the reaction of the Bank to the deviation of inflation from its long-run target. For the Ghanian economy, the reverse was calibrated to reflect the inflation-targeting nature of the Bank of Ghana. The policy response to the output gap, reflected by parameter g_3 was set at 0.4 percent, to reflect a lower sensitivity of the Taylor rule to aggregate demand concerns. Collectively, $1 - g_1$ would capture the weight of the Bank's response to developments to the neutral interest rate, inflation deviation, and the output gap.

The UIP condition was calibrated to reflect more sensitivity of the exchange rate to its expected nominal rate of changes. Parameter $e_1$was set at 0.6 percent to reflect persistence in the exchange rate together with an increased sensitivity of the exchange rate to other factors including inflation and interest rate differentials as well as the risk premium.

The other trend parameters which include the persistence of annualised inflation target, real exchange rate trend, trend of real interest rate, output trend, foreign output gap trend, foreign inflation trend, trend of foreign nominal interest rate, and foreign real interest rate trend were set at 0.8 percent to reflect the speed to which these variables converge to their steady states.

The variance of shock to aggregate demand was calibrated at 1.0 percent, encapsulating the frequent fluctuations observed in aggregate demand across both WAMZ economies. Within the context of the Phillips curve, the cost-push shock was delineated at 0.75, signifying sporadic alterations in cost-related determinants of inflation. The variances associated with the shocks in exchange rates and interest rates were established at 3.0 and 1.0 percent, respectively, to represent the more pronounced volatility in exchange rates compared to interest rates. The variance concerning the inflation target was calibrated at 2.0 percent to reflect the short-term periodic adjustments of the target within Nigeria's annual budgetary framework. For the Ghanaian economy, this figure was set at 1.5 percent, consistent with their erratic modifications to the inflation target as dictated by their prevailing monetary policy structure. The shocks impacting real interest rates and real exchange rate depreciation were assigned moderate values of 0.2 and 0.5 percent, respectively. In the foreign block, the shocks to potential output growth and the foreign output gap were calibrated at 0.4 and 1.0 percent, respectively, to mitigate the extent of cyclicality in potential output and facilitate its stability over time. The shocks to foreign nominal interest rates, inflation, and real interest rates were established at 1.0, 2.0, and 0.3 percent, respectively, to accurately reflect the relatively higher volatility in inflation and the systematic adjustments in nominal interest rates in accordance with the Taylor rule. This approach would ensure a moderate variation in the real interest rate, thereby justifying the low calibrated value.

The variables analysed for both countries include real GDP, Consumer Price Indices (CPI), interest rates, exchange rates, and inflation targets. In the case of Nigeria, the data were obtained from the National Bureau of Statistics and the Central Bank of Nigeria's database, whereas the data for Ghana were retrieved from the Ghana Statistical Services website. Regarding the foreign variables, which include the output gap, CPI, and interest rates, all data pertaining to the U.S. economy were sourced from the IMF database, except for the output gap, which was from the U.S. Bureau of Economic Analysis.

Table1: Summary of the Calibrated Parameters

Symbol	Description	Nigeria	Ghana
β_1	Persistence of output growth	0.8	0.8
β_2	Passthrough of monetary policy to the real economy	0.3	0.3
β_3	Sensitivity of output to external demand	0.5	0.5
β_4	Weights of real interest rate and real exchange rate in the monetary conditions index	0.5	0.5
α_1	Inflation persistence	0.7	0.7
α_2	Passthrough of marginal costs to inflation	0.2	0.2
α_3	Ratio of domestic costs in firms' aggregate costs	0.7	0.7
e_1	Weight of the backward-looking component in the UIP condition	0.4	0.4
g_1	Monetary policy persistence	0.6	0.6
g_2	Weight on inflation in the monetary policy rule	0.5	0.5
g_3	Weight on output gap in the monetary policy rule	0.5	0.5
$\rho_{\pi_t^T}$	Persistence in inflation target adjustment to the medium-term target	0.5	0.5
$\rho_{\bar{z}_t}$	Persistence in real exchange rate trend adjustment to its steady state	0.8	0.8
$\rho_{\bar{r}_{it}}$	Persistence in real interest rate trend adjustment to its steady state	0.8	0.8
$\rho_{\bar{y}_{it}}$	Persistence in domestic potential output growth adjustment to its steady state	0.8	0.8
$\rho_{\tilde{y}_t^*}$	Persistence in foreign potential output growth adjustment to its steady state	0.8	0.8
$\rho_{i_t^*}$	Persistence in foreign potential output growth adjustment to its steady state	0.8	0.8
$\rho_{\pi_t^*}$	Persistence in foreign potential output growth adjustment to its steady state	0.8	0.8
π_t^{TSS}	Steady state of inflation target	15	10
$\bar{r}_t^{SS}$	Steady state of domestic trend real interest rate	0.5	0.5
$\bar{z}_t^{SS}$	Steady state of the trend real exchange rate	0.5	0.5
$\bar{y}_t^{SS}$	Steady state of potential output growth	3.3	2.8
π_t^{*SS}	Steady state of annualised foreign inflation	2.0	2
$\bar{r}_t^{*SS}$	Steady state of foreign trend real interest rate	0.75	0.75

Notes: The summary of shock variances were omitted from table 1 due to space constraint. A detailed explanation of the calibrated shocks has been provided in the last paragraph of section 2.4. due to dearth of studies on WAMZ countries, we do a significant part of the calibration using expert belief.

3.0 Stylised Facts

As a precursor to the empirical analysis, we examine the behaviour of the observed variables over time by tracing the seasonal properties of the variables.

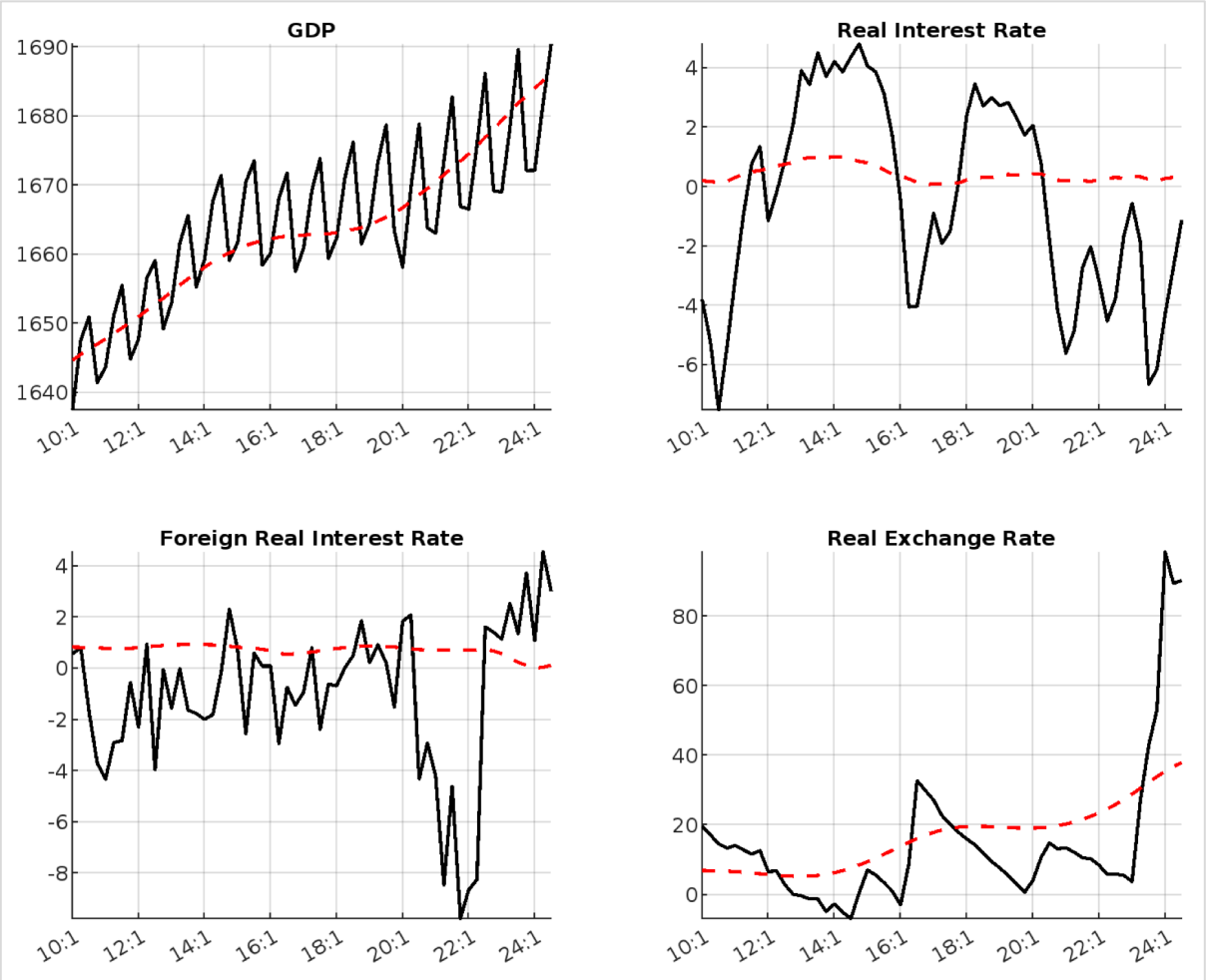


Figure 1: Panel of actual and trend variables observed for the Nigerian economy.
Note: the black lines represent the observed movements in the data while the red broken lines represent the trend behaviour of the variables. The seasonal properties of the variables were extracted using the Kalman filter and some element of expert judgement, except for the foreign real interest rate, which was filtered using the HP filter, as earlier explained in the methodology section. The GDP was measured in its log form while other variables were in their rates.

Figure 1 illustrates that the growth rate of real GDP experienced a relative deceleration from 2015 until the onset of the COVID-19 pandemic in 2020, a period characterized by positive real interest rates. Additionally, the real exchange rate appreciated during this timeframe, indicating an enhanced inflow of foreign currency. In the aftermath of the COVID-19 crisis, the real interest rate predominantly remained negative, falling below its trend value, largely as a result of inflationary pressures stemming from the fiscal and monetary measures implemented in response to the pandemic. These monetary interventions appeared to exert a more significant influence on inflation than on economic growth, as anticipated inflation rates contributed to maintaining interest rates in the negative territory throughout this period. This negative stance subsequently impacted the real exchange rate, leading to a substantial and sustained

depreciation of the naira. Despite the Central Bank of Nigeria's decision to increase the nominal interest rate by a total of 800 basis points by the third quarter of 2024, this adjustment had yet to be reflected in the real interest rate.

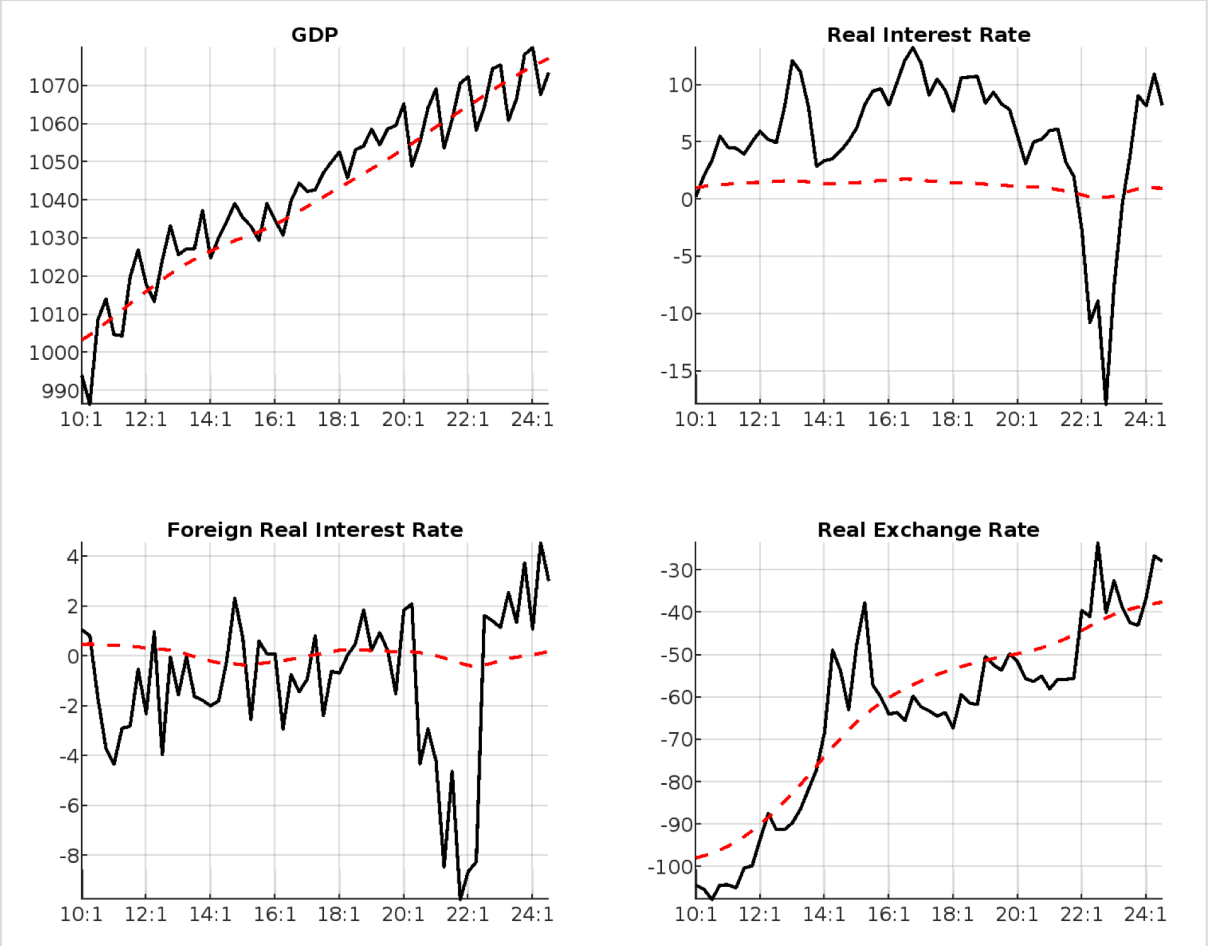


Figure 2: Panel of actual and trend variables observed for the Ghanaian economy.
Note: the black lines represent the observed movements in the data while the red broken lines represent the trend behaviour of the variables. The seasonal properties of the variables were extracted using the Kalman filter and some element of expert judgement, except for the foreign real interest rate, which was filtered using the HP filter, as earlier explained in the methodology section.

The data presented in Figure 2 indicates that prior to the onset of the COVID-19 pandemic in 2020, the real Gross Domestic Product (GDP) was consistently exceeding its potential trend. This period was characterized by predominantly positive real interest rates, which were influenced by the prevailing expectations among economic agents regarding sustained low inflation. Following 2020, a notable decline in real interest rates was observed, continuing until 2022, when these rates fell into negative territory, driven by deteriorating inflation expectations and a decline in the real exchange rate. In response, the Bank of Ghana adopted a hawkish stance, particularly from the fourth quarter of 2023, maintaining elevated nominal interest rates, which subsequently enhanced the real interest rate environment. Although this approach has imposed additional constraints on economic growth, it is noteworthy that a real appreciation of the exchange rate began around the same time that the increases in nominal interest rates were initiated.

4.0 Results and Discussion

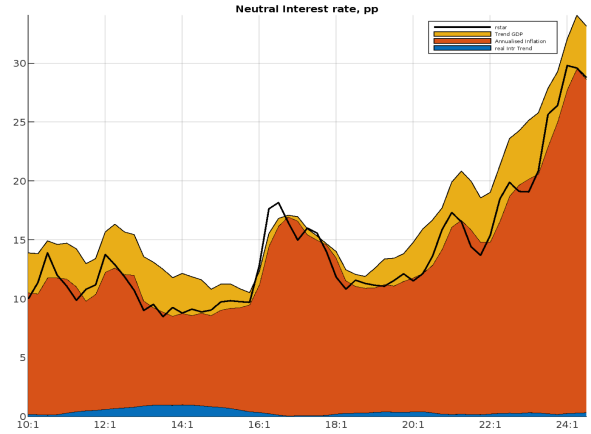


Figure 3: Neutral Interest Rate, trend real GDP, expected annualised inflation, and trend for real interest rate in Nigeria

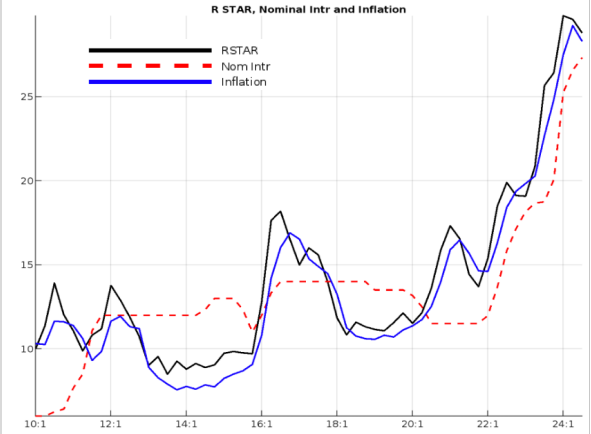


Figure 4: Neutral Interest Rate, nominal interest rate, and inflation in Nigeria

Note: In figure 3, rstar, trend GDP, real intr trend and annualised inflation represent the neutral interest rate, the potential of real GDP, and expected annualised inflation (logCPI). In figure 4, RSTAR and nom intr represent the neutral interest rate, and nominal interest rate.

The estimates of the neutral interest rate for Nigeria suggest that from the post-COVID 19 period, monetary policy stance have remained large loose. At the beginning of the period, the rstar stood at 9.99 percent in the first quarter of 2010 and dropped to 8.49 percent in the third quarter of 2013. This trend was driven by decline in annualised inflation expectations and a stable trend interest rate during the period. We observe keenly, that during post-crisis periods, monetary policy stance in Nigeria remained largely loose to facilitate economic recovery. This was evident in 2011, relating to the post global financial crisis and post-2016 which was the period of commodity price shock, and post-2020 period of COVID-19 pandemic. We also note that the period of loose stance was in the first two periods of crises were short-lived (8 quarters each on the average), however, the post-COVID 19 period stance have remained loose for a prolonged period. Compared with the estimates of Advanced economies, the estimated neutral rate has been quite high. For instance, neutral rates for the US and the ECB were estimated at a range of 0.9 to 0.6 percent between 2010 to 2023, while Canada's rate trended between 1.9 and 1.29 percent in the same period (Booker et al, 2023). Similarly, Kang & Do (2024) showed that the neutral interest rate in Korea tends to fall sharply during downturns, such as the global financial crisis and COVID-19 pandemic.

In a subsequent evaluation, the real interest rate differential and the output differential exhibited indications of co-movement during specific intervals yet displayed counteractive tendencies during alternative periods. Prominent among those intervals of counteraction were the years 2010, 2021, and 2023, which predominantly characterize post-crisis epochs that were primarily driven by demand. Considering these parameters, the crisis of 2016 was regarded as exhibiting interest rate inelasticity, as notwithstanding the presence of a negative real interest rate during this timeframe, aggregate demand remained significantly suppressed. This phenomenon is analogous to the experiences of other resource-abundant economies that were adversely impacted by the commodity price shock in 2016; while Mlachila & Ouedraogo (2020) provided

evidence indicating that these price shocks had repercussions on the financial sectors of such economies, Arigoni (2020) elucidated that the insufficiency of energy exports is responsible for the ramifications of commodity price shocks on the domestic economy.

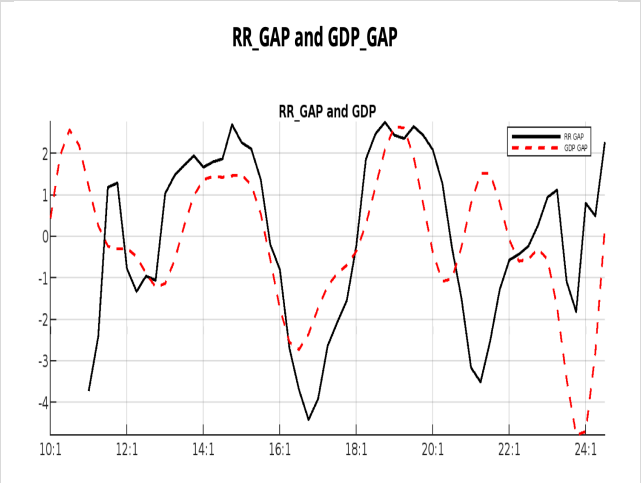


Figure 5: Real interest Rate Gap and Output Gap in Nigeria

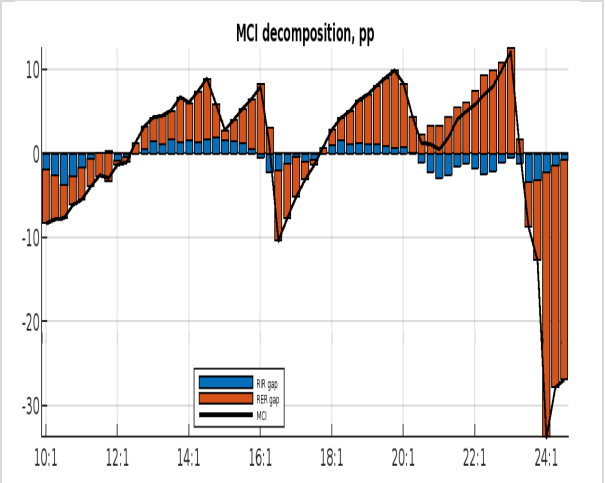


Figure 6: Monetary Conditions Index in Nigeria

Note: Figures 5 and 6 represent the interaction between the real interest rate gap (RR_GAP) and output gap (GDP_GAP) as well as the decomposition of Monetary Conditions Index (MCI). The MCI is decomposed to show the contribution of real interest rate gap and real exchange rate gap to monetary conditions.

The monetary conditions index was included in the analysis for a robustness check on the monetary policy stance earlier assessed using the neutral interest rate. The behaviour of the MCI showed a marked loosening in monetary conditions from 2023 to the end of the sample period. The monetary conditions at the period were driven by dip in the value of the naira to the US dollar occasioned by liberalisation of the foreign exchange market (Babagana, 2024).

Neutral Interest Rate in Ghana

As an inflation-targeting economy, monetary policy stance in Ghana was mostly in line with an economy facing serious inflationary episodes, particularly since the post-COVID 19 period.

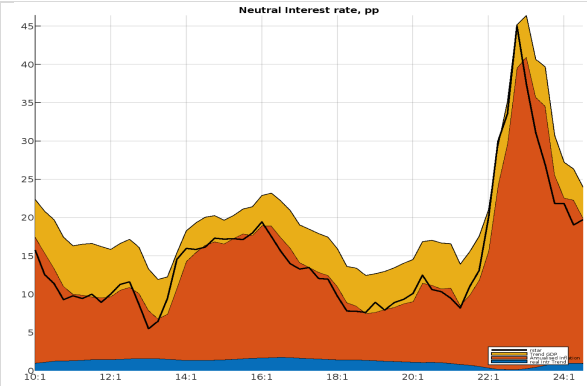


Figure 7: Neutral Interest Rate, trend real GDP, expected annualised inflation, and trend for real interest rate in Ghana

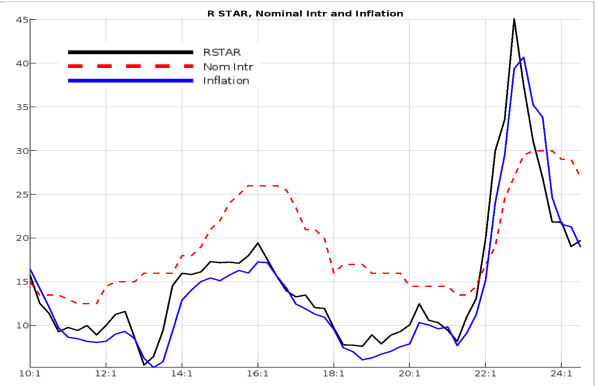


Figure 8: Neutral Interest Rate, nominal interest rate, and inflation in Ghana

Note: In figure 7, rstar, trend GDP, real intr trend and annualised inflation represent the neutral interest rate, the potential of real GDP, and expected annualised inflation (logCPI). In figure 8, RSTAR and nom intr represent the neutral interest rate, and nominal interest rate.

Figure 7 revealed that monetary policy stance in Ghana was tight for a majority of the sample period, as the nominal interest rate was above its neutral level, implying that the Bank of Ghana

was strongly responsive to inflation during the sample period. Apparently, when comparing both economies in figures 7 and 3, it is revealed that the trend of real interest rate contributed more to the neutral rate than the contribution of Nigeria's trend of real interest rate to the neutral rate (observe the blue fill in figure 7). Nevertheless, the annualised inflation expectation contributed more to the neutral interest rate dynamics in Ghana. On the average, neutral interest rate in Ghana stood at 14.86 per cent ranging from 6.46 percent in Q2 2013 to 45.08 percent in Q4 2022. This significant increase was on account of pessimistic expectations of annualised inflation. Figure 8 revealed that throughout the sample period except from Q2 2022 to the end-period, the nominal policy rate of the Bank of Ghana was above the neutral interest rate. This suggests a tight monetary policy stance which has drastically constricted aggregate demand over time. The increase in the neutral rate above the nominal rate from Q2 2022 was due to worsening annualised inflation expectations and thus, decrease in the trend of real interest rate.

The tight monetary policy stance inadvertently led to series of economic downturns in Ghana, as shown in figure 9. In Q1 2010, output gap was negative, aligning with global economic conditions that prevailed during the post GFC crisis period.

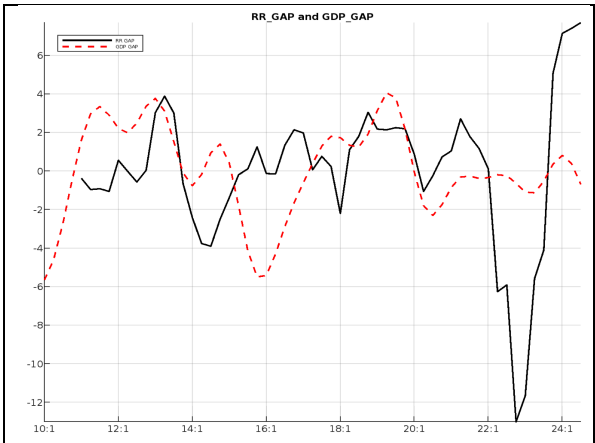


Figure 9: Real interest Rate Gap and Output Gap in Nigeria

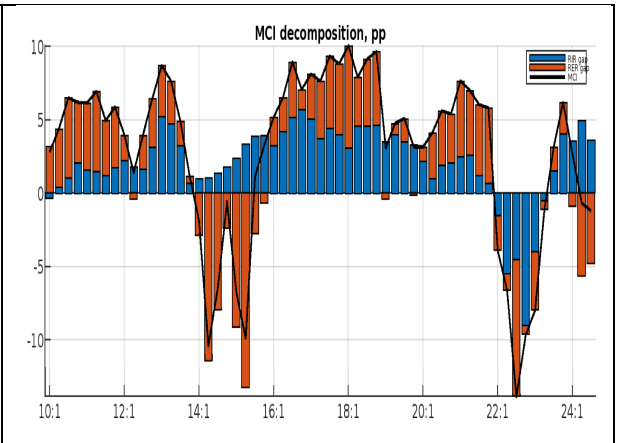


Figure 10: Monetary Conditions Index in Nigeria

Note: Figures 9 and 10 represent the interaction between the real interest rate gap (RR_GAP) and output gap (GDP_GAP) as well as the decomposition of Monetary Conditions Index (MCI). The MCI is decomposed to show the contribution of real interest rate gap and real exchange rate gap to monetary conditions.

Notably, the commodity price dip in 2016 and the COVID-19 pandemic and its lingering impact was revealed in the behaviour of the output gap, while the real interest rate gap strongly reflected the impact of a high level of expected annualised inflation. Real interest rate gap widened to -18.08 percent in Q4 2022 from a positive position of 11.62 percent in Q4 2015. This was strongly related with the 54 percent 2022 annual inflation recorded in Ghana, an inflationary episode attributed to the post COVID-19 pandemic spending (Nsafoah et al, 2024; Woblesseh, 2022), although Pessey (2023) attributes this increases in inflation to the deregulation in the petroleum sector and consequent rise in domestic prices of energy goods. To support this, Figure 10 shows that monetary conditions were equally loose in the same period reaching -13.88 percent in Q3 2022. The real interest rate gap contributed more to this negative index than the real exchange rate gap.

The striking finding among the Nigerian and Ghanian economies is that despite the divergence in their monetary policy frameworks, the monetary conditions across both economies were

loose during periods of economic crises. Although monetary policy stance between them were a slightly divergent, as shown in the comparison of the nominal and neutral interest rates, annualised inflation expectations remained high. A closer examination equally showed that inflation expectations in Ghana is somewhat more anchored compared with Nigeria's.

5.0 Conclusion

The main objective of this study was to estimate the neutral interest rate for two major countries in the West African Monetary Zone region - Nigeria and Ghana. The findings of the study suggested that monetary policy stance in the WAMZ region remained largely loose in the sample period, with marked expansions during post-crises periods such as the GFC in 2010, commodity price dip in 2016 and the COVID-19 pandemic in 2020. The findings further revealed that annualised inflation expectations exert a significant influence on the neutral rate in the zone. Alternatively, the neutral rate in the region is marginally affected by the trend of aggregate demand. The finding therefore implies that while monetary expansion boosted aggregate demand in post-crises periods for short-term recovery, it led to longer-term risks to monetary policy, due to the lack of automatic stabilisers. Therefore, there is need for countries in the WAMZ region to implement mechanisms that could absorb post-crises shocks to inflation as it has a significant impact on the monetary policy stance.

It also appears that in the WAMZ region, policymakers face significant challenges in maintaining economic stability using their traditional monetary policy tools as inflation expectations are largely impacted by inflation persistence. This necessitates the need for increased monetary policy communication and a stronger commitment towards keeping inflation at its target level.

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