ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XV, Issue X, October 2026

Dynamic Spill-Overs and Frequency Connectedness among Monetary Policy, Investment and Sectoral Output in Nigeria: Evidence from a Time-Varying Parameter VAR Model

SALIU Mojeed Olanrewaju[a] & ADEBAYO Adedayo Omolade[b]

[a] Ekiti State University, Ado-Ekiti, Ekiti State, Nigeria

[b] Ekiti State University, Ado-Ekiti, Ekiti State, Nigeria

DOI: https://doi.org/10.51583/IJLTEMAS.2026.151000026

Received: 13 October 2026; Accepted: 18 October 2026; Published: 31 October 2026

ABSTRACT

This study investigates the dynamic spillovers and frequency connectedness among monetary policy, investment and sectoral output in Nigeria over the period 1990–2025. Employing the Frequency Time-Varying Parameter Vector Autoregressive (Frequency TVP-VAR) framework, the study examines the magnitude, direction and persistence of macroeconomic shock transmission across eight variables: GDP growth, foreign direct investment, gross fixed capital formation, money supply, interest rates, agricultural output, manufacturing output and crude oil production growth. The findings reveal substantial macroeconomic interdependence, with Total Connectedness Indices of 39.74% and 39.75% in the time and frequency domains, respectively. GDP growth, interest rates, manufacturing output and money supply emerge as net transmitters of shocks, while crude oil production growth, gross fixed capital formation, agricultural output and foreign direct investment are net receivers. Frequency decomposition indicates that medium-term fluctuations (4–10 years) account for the largest share of total connectedness (41.9%), followed by short-term (2–4 years; 36.0%) and long-term (above 10 years; 22.1%) fluctuations. Interest rates and money supply dominate short-term transmission, manufacturing output and GDP growth are prominent medium-term transmitters, while GDP growth and agricultural output lead long-term transmission. Pairwise and network analyses further reveal asymmetric and heterogeneous inter-sectoral spillovers. The study concludes that macroeconomic connectedness in Nigeria is time-varying, frequency-dependent and sectorally differentiated. It recommends coordinated monetary, investment and sectoral policies that integrate short-term stabilisation, medium-term productive expansion and long-term economic resilience.

Keywords: Frequency TVP-VAR; Dynamic spillovers; Monetary policy; Investment; Sectoral output; Nigeria.

INTRODUCTION

The interrelationship among monetary policy, investment and sectoral output constitutes a fundamental dimension of macroeconomic management, particularly in developing economies characterised by structural rigidities, financial market imperfections and vulnerability to domestic and external shocks. Monetary policy influences economic activities through adjustments in liquidity, interest rates, credit availability and financing costs, while investment facilitates capital accumulation, technological advancement and productive capacity expansion. However, the magnitude, direction and persistence of these relationships may differ across economic sectors and macroeconomic conditions. Bernanke and Gertler (1995) demonstrate that monetary policy operates through credit-market imperfections that amplify its effects on real economic activities, while Mishkin (1996) identifies interest rate, exchange rate, asset price and credit channels as important mechanisms of monetary transmission. Similarly, Solow (1956) establishes capital accumulation as a fundamental determinant of economic growth, while Borensztein et al. (1998) demonstrate that foreign direct investment can stimulate growth through technological diffusion, conditional on the absorptive capacity of the recipient economy. These theoretical contributions suggest that monetary policy, investment and productive

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XV, Issue X, October 2026

activities are interconnected through complex transmission mechanisms that may generate both immediate and persistent economic effects.

The effectiveness of these transmission mechanisms is particularly important in Nigeria, where macroeconomic management operates within an economy characterised by substantial agricultural activities, manufacturing potential and dependence on petroleum production. Despite successive monetary reforms, financial-sector restructuring and economic diversification initiatives, the economy continues to experience inadequate infrastructure, financing constraints, production bottlenecks and exposure to international commodity-market disturbances. The World Bank (2025) identifies insecurity, infrastructure deficiencies, high input costs and low agricultural productivity as important constraints on Nigeria's productive transformation. Similarly, the International Monetary Fund (IMF, 2025) emphasises the need to strengthen financial inclusion, improve electricity supply and expand access to private-sector credit to support sustainable growth. These structural challenges potentially weaken monetary policy transmission and generate heterogeneous responses across productive sectors.

Nigeria's macroeconomic experience between 1990 and 2025 further underscores the importance of examining evolving economic interdependencies. During this period, the economy experienced financial liberalisation, banking-sector reforms, exchange rate adjustments, petroleum-market disturbances, the global financial crisis, the COVID-19 pandemic and recent monetary and fiscal policy reforms. These developments altered financing conditions, investment expectations and production incentives. For instance, the Central Bank of Nigeria (CBN, 2025) maintained the Monetary Policy Rate at 27.50% during the early part of 2025 before reducing it to 27.00% in September. Furthermore, the World Bank (2025) reports that Nigeria's economy expanded by approximately 3.9% during the first half of 2025, compared with 3.5% during the corresponding period of 2024. Although these developments reflect changing macroeconomic conditions, aggregate growth conceals differences in the performance and adjustment mechanisms of individual productive sectors. Consequently, the transmission of monetary disturbances to investment and production cannot necessarily be assumed to remain stable across economic regimes.

The agricultural, manufacturing and petroleum sectors exhibit distinctive characteristics that may influence their responses to monetary and investment disturbances. Agriculture contributes significantly to employment, food security and rural livelihoods but remains vulnerable to seasonal fluctuations, insecurity, climate-related disturbances and inadequate production credit. Manufacturing provides opportunities for industrial diversification, technological advancement and value addition, although its performance is constrained by unreliable electricity supply, high financing costs and dependence on imported inputs. Petroleum production, meanwhile, influences export earnings, fiscal resources, foreign exchange availability and investment expectations but is susceptible to operational disruptions, infrastructure constraints and industry-specific investment conditions. These differences imply that disturbances originating from monetary policy or investment may be transmitted unevenly across sectors. Moreover, sectoral production shocks may generate feedback effects on financing conditions, investment behaviour and aggregate economic performance. The IMF (2025) identifies petroleum-sector developments, financing constraints and structural production bottlenecks as important determinants of Nigeria's macroeconomic prospects.

Investment represents a particularly important channel through which monetary conditions influence productive-sector performance. Gross fixed capital formation facilitates the acquisition of machinery, infrastructure and productive equipment, while foreign direct investment provides potential opportunities for capital inflows, technological transfer and managerial development. However, changes in interest rates and monetary liquidity may affect domestic and foreign investment differently, depending on financing conditions, macroeconomic uncertainty and sectoral profitability. Bernanke and Gertler (1995) argue that monetary disturbances influence firms through credit availability and external financing premiums, while Borensztein et al. (1998) emphasise the importance of domestic absorptive capacity in determining the growth effects of foreign investment. These relationships suggest that investment may simultaneously function as a recipient of monetary disturbances and a transmitter of shocks to productive sectors, making a system-wide investigation of macroeconomic interdependence particularly relevant.

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XV, Issue X, October 2026

Previous empirical studies have examined monetary policy transmission and sectoral output performance in Nigeria, providing important evidence of heterogeneous policy effects. Nwosa and Saibu (2012), employing vector autoregressive and Granger causality techniques, establish that monetary transmission differs across productive sectors, with the interest rate channel particularly relevant to agricultural and manufacturing activities. Similarly, Saibu (2011), using an autoregressive distributed lag framework, reports differences in the responsiveness of agricultural and manufacturing output to monetary policy variables. Ezeaku et al. (2018), applying cointegration and error-correction techniques, find that credit, interest rates and exchange rates significantly influence industrial-sector performance. Although these studies provide valuable evidence concerning monetary transmission, their principal emphasis is on estimating the effects of monetary variables on sectoral output rather than quantifying the evolving magnitude and direction of reciprocal spillovers among monetary policy, investment and multiple productive sectors. Consequently, the extent to which individual macroeconomic variables function as net transmitters or receivers of disturbances remains insufficiently established within the reviewed Nigerian literature.

An additional limitation concerns the treatment of macroeconomic relationships as stable or symmetric across changing economic conditions. Nigeria's repeated exposure to financial disturbances, petroleum-market instability, exchange rate adjustments and policy reforms suggests that monetary transmission mechanisms may evolve substantially over time. Goshit et al. (2022), employing nonlinear autoregressive distributed lag and asymmetric causality approaches, demonstrate that positive and negative monetary policy shocks have different effects on Nigeria's aggregate output growth. Similarly, Ogunjinmi and Adekunle (2025) identify asymmetric monetary policy effects on agricultural performance. While these studies recognise nonlinear transmission, they do not directly measure the continuous evolution of system-wide directional connectedness among monetary conditions, investment and sectoral production. Thus, identifying whether the strength and direction of macroeconomic spillovers change across different economic conditions remains an important empirical challenge.

Methodologically, conventional vector autoregressive, autoregressive distributed lag and error-correction models provide useful information about dynamic responses, equilibrium relationships and monetary transmission. Nevertheless, conventional fixed-parameter specifications may inadequately capture evolving relationships when structural changes alter economic interactions. Furthermore, conventional impulse-response analysis does not directly quantify total, directional and net connectedness within a unified macroeconomic system. Diebold and Yılmaz (2009, 2012) advance the connectedness literature by developing forecast error variance decomposition measures that identify the transmission and reception of shocks among interconnected variables. Antonakakis et al. (2020) subsequently extend dynamic connectedness analysis through a Time-Varying Parameter Vector Autoregressive (TVP-VAR) framework, permitting coefficients and covariance relationships to evolve without imposing arbitrary rolling-window restrictions. Although these methodological advances provide important analytical tools, their existence does not resolve the empirical question of how monetary policy, investment and productive-sector disturbances interact within Nigeria's changing macroeconomic environment.

Beyond time variation, another important research problem concerns the frequency composition of macroeconomic spillovers. Monetary policy adjustments may influence financing conditions relatively quickly, whereas investment projects, agricultural production decisions and manufacturing capacity expansion often require longer adjustment periods. Similarly, disturbances affecting crude oil production may generate immediate changes in export-related expectations alongside persistent consequences for investment and aggregate output. Baruník and Křehlík (2018) demonstrate that connectedness differs across frequencies and develop a spectral variance decomposition framework for distinguishing transitory and persistent shock transmission. However, the reviewed Nigerian monetary transmission studies, including Nwosa and Saibu (2012), Ezeaku et al. (2018) and the sectoral analysis of Adelowo and Saibu (2025), do not jointly examine time-varying directional spillovers and their frequency composition across monetary policy, investment and multiple productive sectors. Consequently, it remains unclear whether macroeconomic connectedness in Nigeria is predominantly driven by relatively short-lived disturbances or more persistent transmission mechanisms.

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XV, Issue X, October 2026

A further conceptual issue relates to the representation of petroleum-sector performance. While crude oil prices are frequently employed to capture petroleum-related macroeconomic disturbances, they primarily reflect international commodity-market conditions rather than the physical volume of domestic petroleum extraction. Accordingly, relying exclusively on oil prices may obscure the distinction between external price shocks and changes in domestic oil-sector production. The present study therefore employs crude oil production growth as a measure of physical petroleum output performance, alongside agricultural and manufacturing output indicators. This specification provides a more direct basis for examining production-related spillovers across Nigeria's major productive sectors, while recognising that crude oil production does not represent the entirety of oil and gas value added.

Against this background, the central research problem is that the evolving magnitude, direction and frequency composition of spillovers among monetary policy, investment and sectoral output in Nigeria remain insufficiently understood within the reviewed empirical literature. Specifically, it is unclear whether monetary policy variables predominantly transmit disturbances to investment and productive sectors or whether investment and sectoral production generate significant feedback effects. Furthermore, the relative importance of agriculture, manufacturing and crude oil production as transmitters or receivers of shocks, and whether these relationships vary across different frequency horizons, remains an important empirical question. To address these issues, this study investigates dynamic spillovers and frequency connectedness among monetary policy, investment and sectoral output in Nigeria over the period 1990–2025. It employs a Frequency TVP-VAR framework incorporating gross domestic product growth, foreign direct investment, gross fixed capital formation, money supply, interest rate, agricultural output, manufacturing output and crude oil production growth. By integrating time-varying relationships, directional connectedness and frequency decomposition within a unified empirical framework, the study seeks to provide evidence on macroeconomic shock transmission, investment financing, productive-sector interdependence and the design of coordinated policies for sustainable economic development in Nigeria.

REVIEW OF EMPIRICAL LITERATURE

The empirical literature on monetary policy transmission, investment, sectoral output and dynamic connectedness provides important insights into the interactions among macroeconomic variables. However, differences in methodological approaches, geographical coverage and variable selection have produced varying conclusions regarding the magnitude, direction and persistence of economic shocks.

Ezeaku et al. (2018) examined the effects of monetary policy transmission channels on industrial-sector growth in Nigeria using annual data spanning 1981–2014. The study employed Johansen cointegration analysis and an Error Correction Model (ECM) to investigate the short-run and long-run relationships between monetary policy indicators and industrial output. The findings indicated that private-sector credit, interest rates and exchange rates exerted negative effects on industrial output growth in both periods, with stronger effects in the long run. The authors also established a long-run equilibrium relationship between monetary transmission variables and industrial performance, with approximately 72.2% of disequilibrium corrected annually. These findings demonstrated the relevance of monetary and financial conditions to Nigeria's industrial development. However, the study concentrated primarily on industrial output and did not jointly examine agricultural production, petroleum output and investment within an interconnected system. Furthermore, the ECM framework did not quantify time-varying directional spillovers or decompose shock transmission across frequency horizons. The present study addresses these limitations by examining multiple productive sectors alongside monetary policy and investment variables.

Saliu (2024) examined the relationship between monetary policy transmission, labour force participation and real sector performance in Nigeria using annual time-series data covering 1991–2023. Employing the Johansen cointegration technique and an error-correction modelling framework, the study investigated the responses of agricultural and manufacturing outputs to money supply, interest rates, sectoral bank credit, government expenditure and labour force participation. The findings established significant long-run relationships among the variables in both sectoral models. Although the study provided useful evidence on sector-specific monetary transmission and equilibrium adjustment, its conventional cointegration and error-

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XV, Issue X, October 2026

correction framework did not investigate time-varying directional spillovers, bilateral shock transmission or the distribution of connectedness across different economic frequencies. The present study extends this evidence by employing the Frequency TVP-VAR connectedness framework to examine dynamic interdependence among monetary conditions, investment, aggregate economic growth and sectoral output in Nigeria, while distinguishing short-, medium- and long-term frequency components.

Ogunjinmi and Adekunle (2025) examined the asymmetric effects of monetary policy on agricultural performance in Nigeria over the period 1981–2021. The study employed a Nonlinear Autoregressive Distributed Lag (NARDL) model to investigate the effects of monetary policy rates, lending rates, liquidity ratios and agricultural credit on agricultural output. The findings revealed asymmetric responses to monetary policy changes. Positive changes in monetary policy rates significantly enhanced agricultural performance in the short run, whereas negative changes exerted stronger adverse effects in the long run. The study also established that lending rate increases and decreases had differing short-run effects, while long-run lending rate changes were associated with negative but statistically insignificant effects. Furthermore, liquidity conditions influenced agricultural output in the short run, while agricultural credit exhibited differing short-run and long-run relationships with production. Although the study provides recent evidence of nonlinear monetary transmission in agriculture, its sector-specific framework did not examine how agricultural disturbances interact with manufacturing, petroleum production and investment. It also did not identify frequency-specific directional spillovers, which constitute an important dimension of the present investigation.

Adelowo and Saibu (2025) investigated the responses of Nigeria's agricultural, manufacturing and services sectors to macroeconomic policy shocks using annual data covering 1985–2022. The study employed a Structural Vector Autoregressive (SVAR) model, supported by impulse response analysis and forecast error variance decomposition, to examine the effects of government expenditure, government revenue, inflation, interest rates, real exchange rates and crude oil prices on sectoral output growth. The findings revealed that sectoral responses differed according to the nature of macroeconomic disturbances. Manufacturing output was particularly responsive to inflation and government expenditure, while agricultural production was more sensitive to real exchange rate fluctuations. Services output was influenced by production costs and exchange rate movements. The authors concluded that sector-specific policy responses are necessary because productive sectors exhibit different sensitivities to macroeconomic disturbances. Despite its relevance, the study employed a conventional SVAR framework rather than a time-varying frequency-connectedness model. Furthermore, its use of crude oil prices as a macroeconomic shock variable differed from the present study's inclusion of crude oil production growth as a direct measure of petroleum output performance. The study also did not explicitly examine investment variables as potential transmitters and receivers of system-wide shocks.

Diebold and Yılmaz (2009) investigated return and volatility spillovers across 19 international equity markets using observations beginning in the early 1990s. The authors developed a spillover index based on forecast error variance decompositions within a Vector Autoregressive framework to quantify interdependence among financial markets. Their empirical findings revealed that return and volatility spillovers exhibited different dynamic characteristics. Return spillovers followed a gradually increasing trend without pronounced bursts, whereas volatility spillovers displayed substantial episodic increases associated with periods of financial instability. The study demonstrated that the intensity of interdependence changes over time and that different forms of shocks may exhibit distinct transmission patterns. Its major contribution lies in establishing a quantitative framework for measuring system-wide spillovers. However, the empirical application focused on international financial markets rather than the interconnected relationships among monetary policy, investment and productive-sector output. Moreover, the original framework did not explicitly distinguish frequency-specific transmission or continuously evolving TVP-VAR parameters. These limitations motivate the adaptation of more recent connectedness techniques to Nigeria's macroeconomic system.

Diebold and Yılmaz (2012) extended the empirical analysis of interconnected financial markets by developing total and directional volatility spillover measures using generalised forecast error variance decompositions within a VAR framework. Their study examined daily volatility interactions among United States stock, bond, foreign exchange and commodity markets from January 1999 to January 2010. The findings demonstrated that cross-market volatility spillovers were relatively limited before the global financial crisis but intensified

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XV, Issue X, October 2026

substantially as financial instability increased. The stock market emerged as an important transmitter of disturbances to other financial markets following the collapse of Lehman Brothers in September 2008. The study established the usefulness of distinguishing shocks transmitted to and received from other variables, thereby providing an empirical foundation for identifying net transmitters and receivers. Nevertheless, its application focused on financial-market volatility rather than macroeconomic production and investment relationships. Furthermore, the framework did not directly decompose directional connectedness into short-, medium- and long-frequency components. The present study builds on this contribution by examining directional spillovers within Nigeria's monetary policy–investment–sectoral output system.

Baruník and Křehlík (2018) investigated the frequency dynamics of financial connectedness and systemic risk by developing a spectral representation of forecast error variance decompositions. Their empirical application examined volatility connectedness among United States financial institutions across different frequency horizons. The findings demonstrated that the economic interpretation of connectedness depends considerably on the frequency at which disturbances are transmitted. High-frequency connectedness was associated with relatively rapid information processing and short-lived shock transmission, whereas lower-frequency connectedness indicated more persistent disturbances capable of affecting interconnected variables over longer periods. The study therefore established that aggregate connectedness measures may conceal important differences between transitory and persistent shocks. Although the framework provides a strong methodological foundation for frequency-specific analysis, its empirical application concentrated on financial institutions rather than monetary policy, investment and sectoral production in a developing economy. Furthermore, the study did not specifically examine the changing roles of agricultural, manufacturing and crude oil production within a Nigerian macroeconomic system. These limitations provide a rationale for integrating frequency decomposition with TVP-VAR estimation in the present study.

Despite the contributions of the above reviewed studies, they have not been able to jointly establish the evolving magnitude, direction and frequency composition of spillovers among monetary policy, investment, aggregate growth and agricultural, manufacturing and crude oil production in Nigeria. The present study addresses this specific gap by employing a Frequency TVP-VAR framework covering 1990–2025, thereby integrating dynamic connectedness, net shock transmission and frequency decomposition within a unified macroeconomic system.

DATA SET AND RESEARCH METHODS

The study employs annual secondary data spanning 1990–2025. Eight endogenous variables are incorporated into the connectedness system to capture aggregate economic performance, monetary policy conditions, investment activities and sectoral production.

The vector of endogenous variables is specified as:

$$Y_t = \begin{bmatrix} GDPGR_t \\ FDI_t \\ GFCF_t \\ MS_t \\ INT_t \\ AGO_t \\ MFO_t \\ COPGR_t \end{bmatrix} \quad \text{.....Eq 1}$$

Where GDPGR represents gross domestic product growth rate; FDI denotes foreign direct investment; GFCF represents gross fixed capital formation; MS denotes money supply; INT represents interest rate; AGO denotes agricultural output; MFO represents manufacturing output; and COPGR denotes crude oil production growth rate. The inclusion of GDPGR captures aggregate macroeconomic performance, while money supply and interest rate represent monetary conditions. FDI and GFCF measure foreign and domestic investment, respectively. Agricultural output, manufacturing output and crude oil production growth capture productive-sector performance. The variables are treated as jointly endogenous, allowing the estimation framework to

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XV, Issue X, October 2026

account for reciprocal relationships rather than imposing a predetermined direction of transmission. Data on all the macroeconomic variables are sourced from Central Bank of Nigeria (CBN) and National Bureau of Statistics (NBS), while data on crude oil production growth are sourced specifically from the OPEC statistical bulletin.

In order to investigate effectively the dynamic spillovers and frequency connectedness among monetary policy, investment and sectoral output in Nigeria, the study employs a Frequency Time-Varying Parameter Vector Autoregressive (Frequency TVP-VAR) connectedness framework, which integrates the dynamic connectedness approach of Diebold and Yılmaz (2012), the frequency-domain decomposition developed by Baruník and Křehlík (2018), and the TVP-VAR connectedness methodology advanced by Antonakakis, Chatziantoniou and Gabauer (2020). The framework is particularly appropriate because the relationships among monetary conditions, investment and productive activities may evolve over time and differ across frequency horizons. Unlike conventional fixed-parameter VAR models, the TVP-VAR allows the coefficients and innovation covariance matrix to change over time. The frequency connectedness extension further decomposes forecast error variance contributions into components associated with relatively transitory and persistent disturbances.

Time-Varying Parameter Vector Autoregressive Model

The TVP-VAR framework extends the conventional VAR by allowing the autoregressive coefficients and innovation covariance matrix to evolve over time. Following the general approach of Primiceri (2005) and Antonakakis et al. (2020), a TVP-VAR model of order p can be expressed as:

$$Y_t = C_t + \sum_{\ell=1}^{p} B_{\ell,t} Y_{t-\ell} + \mathfrak{E}_t \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots Eq\ 2$$

Where Y_t is an $N \times 1$ vector of endogenous variables, C_t is an optional time-varying intercept, $B_{\ell,t}$ represents the $N \times N$ coefficient matrix at lag ℓ, and $\mathfrak{E}_t$ denotes the vector of reduced-form innovations as:

$$\mathfrak{E}_t | \mathscr{F}_{t-1} \sim N(0, \Sigma_t) \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots Eq\ 3$$

Here, Σ_t is the time-varying positive-definite innovation covariance matrix. Given the limited annual sample and the eight-variable specification, the study adopts a parsimonious TVP-VAR(1) as:

$$Y_t = B_{1,t} Y_{t-1} + \mathscr{E}_t \dots\dots\dots\dots\dots\dots\dots Eq\ 4$$

This representation corresponds to the zero-intercept form of the implemented TVP-VAR specification.

Time variation in the coefficient parameters

The TVP-VAR coefficients are allowed to change over time according to a state evolution process. In general state-space notation states as:

$$\beta_t = \beta_{t-1} + \eta_t, \dots\dots\dots\dots\dots\dots\dots\dots Eq\ 5$$

Where

$$\beta_t = Vec(B_{1,t}) \dots\dots\dots\dots\dots\dots\dots\dots Eq\ 6$$

And η_t represents innovations in the coefficient states.

Equation 5 expresses the conceptual random-walk evolution of time-varying coefficients. In the implemented forgetting-factor TVP-VAR, state uncertainty is updated recursively rather than by independently estimating an unrestricted state-innovation covariance matrix. The forgetting-factor approach assigns greater weight to

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XV, Issue X, October 2026

recent observations while retaining information from the historical sample. The two forgetting factors are specified as:

$$K_1 = 0.99, \qquad K_2 = 0.96 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots Eq\ 7$$

The first controls the evolution of coefficient uncertainty, while the second governs the updating of the innovation covariance matrix. Their values follow commonly employed settings in TVP-VAR connectedness applications and are maintained in the empirical implementation.

Generalised Forecast Error Variance Decomposition

Following Pesaran and Shin (1998) and Diebold and Yılmaz (2012), the study employs the Generalised Forecast Error Variance Decomposition (GFEVD), which measures the contribution of innovations in one variable to the forecast error variance of another variable without requiring an arbitrary Cholesky ordering. For an H-step forecast horizon, the generalised variance decomposition is defined as:

$$\theta_{ij,t}^{g}(H) = \frac{\sigma_{jj,t}^{-1}\sum_{h=0}^{H-1}\left(e_i^{\prime}\Psi_{h,t}\Sigma_t e_j\right)^2}{\sum_{h=0}^{H-1} e_i^{\prime}\Psi_{h,t}\,\Sigma_t\,\Psi_{h,t}^{\prime} e_i} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots Eq\ 8$$

Where $\theta_{ij,t}^{g}(H)$ represents the contribution of shocks originating from variable *j* to the H-step forecast error variance of variable *i*; $\sigma_{jj,t}$ is the *j*-th diagonal element of Σ_t; and e_j and e_i are selection vectors. Because generalised variance contributions do not necessarily sum to unity across variables, row normalisation is applied:

$$\tilde{\theta}_{ij,t}^{g}(H) = \frac{\theta_{ij,t}^{g}(H)}{\sum_{j=1}^{N}\theta_{ij,t}^{g}(H)} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots Eq\ 9$$

Thus,

$$\sum_{j=1}^{N}\tilde{\theta}_{ij,t}^{g}(H) = 1 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots Eq\ 10$$

The resulting normalised variance decomposition matrix provides the basis for measuring connectedness within the eight-variable Nigerian macroeconomic system.

Total Connectedness Index

The Total Connectedness Index (TCI) measures the proportion of forecast error variance attributable to shocks originating from other variables in the system. It is specified as:

$$TCI_t(H) = 100\,\frac{\sum_{i=1}^{N}\sum_{\substack{j=1\\ j\neq 1}}^{N}\tilde{\theta}_{ij,t}^{g}(H)}{N} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots Eq11$$

A higher TCI indicates greater system-wide interdependence, while a lower value suggests that forecast uncertainty is explained more extensively by variables' own innovations. In the present study, the TCI provides an aggregate measure of the extent to which disturbances are transmitted among monetary conditions, investment, aggregate growth and productive-sector activities.

Directional Connectedness received from other Variables

Directional connectedness FROM other variables measures the proportion of variable *i's* forecast error variance attributable to innovations originating elsewhere in the system:

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XV, Issue X, October 2026

$$C_{i\leftarrow,t}(H) = 100 \sum_{\substack{j=1 \\ j\neq 1}}^{N} \tilde{\theta}_{ij,t}^{g}(H) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots Eq\ 12$$

A high FROM value indicates that the variable is relatively exposed to shocks originating from other components of the macroeconomic system.

Directional Connectedness Transmitted to other Variables

Directional connectedness TO other variables measures the total contribution of innovations originating from variable *i* to the forecast error variances of other variables:

$$C_{i\rightarrow,t}(H) = 100 \sum_{\substack{j=1 \\ j\neq 1}}^{N} \tilde{\theta}_{ij,t}^{g}(H) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots Eq\ 13$$

A high TO value indicates that the variable is an important source of disturbances within the system.

Net Directional Connectedness

Net connectedness is obtained by subtracting directional connectedness received from directional connectedness transmitted:

$$NET_{i,t}(H) = C_{i\rightarrow,t}(H) - C_{i\leftarrow,t}(H) \ldots\ldots\ldots\ldots\ldots\ldots Eq\ 14$$

The interpretation follows three possible outcomes:

$NET_{i,t} > 0$: Variable i is a net transmitter of shocks.

$NET_{i,t} < 0$: Variable i is a net receiver of shocks.

$NET_{i,t} = 0$: The variable has balanced transmitted and received connectedness

These classifications are central to determining whether monetary policy variables primarily transmit disturbances to investment and production or whether productive sectors generate stronger feedback effects.

Net Pairwise Directional Connectedness

The Net Pairwise Directional Connectedness (NPDC) between variables *i* and *j* is expressed as:

$$NPDC_{ij,t}(H) = 100\left[\tilde{\theta}_{ji,t}^{g}(H) - \tilde{\theta}_{ij,t}^{g}(H)\right] \ldots\ldots\ldots\ldots\ldots\ldots\ldots Eq\ 15$$

Under this sign convention, a positive $NPDC_{ij,t}$ indicates that variable *i* transmits more forecast variance to variable *j* than it receives from *j*. This measure is particularly relevant for identifying the dominant direction of transmission between money supply and manufacturing output, interest rates and investment, or crude oil production growth and aggregate economic growth.

Frequency-Domain Connectedness Framework

Although time-domain connectedness measures identify the magnitude and direction of shock transmission, but, they do not establish whether connectedness arises predominantly from relatively transitory or persistent disturbances. Baruník and Křehlík (2018) address this limitation by developing a frequency-domain decomposition of forecast error variance, building on spectral representations of stationary processes. The frequency response function corresponding to the time-varying moving average representation is defined as:

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XV, Issue X, October 2026

$$\Psi_t\left(\mathrm{e}^{-i\omega}\right) = \sum_{h=0}^{\infty} \Psi_{h,t}\, \mathrm{e}^{-ih\omega}, \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots Eq\ 16$$

Where ω denotes angular frequency and $i = \sqrt{-1}$. The corresponding spectral density matrix is:

$$S_t(\omega) = \Psi_t\left(\mathrm{e}^{-i\omega}\right) \Sigma_t \Psi_t^*\left(\mathrm{e}^{-i\omega}\right) \ldots\ldots\ldots\ldots\ldots\ldots\ldots Eq\ 17$$

Where the superscript * denotes the conjugate transpose. The spectral density describes how forecast variance is distributed across different frequencies.

Generalised Causation Spectrum

Following Baruník and Křehlík (2018), the generalised causation spectrum from variable *j* to variable *i* is defined as:

$$\mathscr{F}_{ij,t}(\omega) = \frac{\sigma_{ji,t}^{-1}\left|\mathrm{e}_i^{'}\Psi_t\left(\mathrm{e}^{-i\omega}\right)\Sigma_t \mathrm{e}_j\right|^2}{\mathrm{e}_i^{'} S_t(\omega)\mathrm{e}_i} \ldots\ldots\ldots\ldots\ldots\ldots\ldots Eq\ 18$$

This quantity measures the contribution of innovations in variable *j* to the spectrum of variable *i* at frequency . To account for the relative importance of different frequencies, the weighting function is specified as:

$$\Gamma_{i,t}\,(\omega) = \frac{\mathrm{e}_i^{'} S_t(\omega)\mathrm{e}_i}{\frac{1}{2\pi}\int_{-\pi}^{\pi} \mathrm{e}_i^{'}\, s_t(\lambda)\mathrm{e}_i d\lambda} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots Eq\ 19$$

The frequency-specific variance decomposition over a frequency interval *d = (a,b)* is then:

$$\theta_{ij,t}^{g}(d) = \frac{1}{2\pi}\int_a^b \Gamma_{i,t}\,(\omega)\, \mathscr{F}_{ij,t}(\omega) d\omega \ldots\ldots\ldots\ldots\ldots\ldots Eq\ 20$$

The decomposition is subsequently normalised using the total contribution across the complete frequency range:

$$\tilde{\theta}_{ij,t}^{g}(d) = \frac{\theta_{ij,t}^{g}(d)}{\sum_{j=1}^{N} \theta_{ij,t}^{g}(-\pi,\pi)} \ldots\ldots\ldots\ldots\ldots\ldots\ldots Eq\ 21$$

The normalised frequency contributions provide the basis for distinguishing the connectedness associated with different periodicities. The equations above express the population frequency-domain framework. In empirical implementation, the frequency contributions are approximated numerically using the estimated moving average coefficients and the selected forecast horizon.

Frequency-Band Specification

The empirical analysis adopts three frequency bands using the partition:

$$\mathrm{P} = \left(\pi + 0.00001, \frac{\pi}{2}, \frac{\pi}{5}, 0\right) \ldots\ldots\ldots\ldots\ldots\ldots Eq\ 22$$

For annual data, angular frequency and periodicity are related through:

$$\mathrm{P} = \frac{2\pi}{\omega} \ldots\ldots\ldots\ldots\ldots\ldots\ldots Eq\ 23$$

Where P is measured in years per cycle.

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XV, Issue X, October 2026

Consequently, the frequency partition corresponds to the following economic horizons:

Frequency component	Angular-frequency interval	Approximate periodicity
Higher frequency (Short-Term)	$(\pi/2, \pi)$	2–4 years
Intermediate frequency (Medium Term)	$(\pi/5, \pi/2)$	4–10 years
Lower frequency (Long-Term)	$(0, \pi/5)$	More than 10 years

EMPIRICAL FINDINGS

This section of the study first exhibits the descriptive statistics of monetary policy, investment and sectoral output in Nigeria.

Table 1: Descriptive Statistics of the Original Series

Variable	Mean	Median	SD	Minimum	Maximum
GDPGR	4.20	3.92	3.80	-2.04	15.33
FDI	2849743285.39	1916645305.65	2555950460.12	-186792428.93	8841062050.77
GFCF	10.86	5.25	15.75	0.12	65.23
MS	18.87	20.32	6.32	9.06	27.38
INT	2.93	4.95	9.71	-31.45	18.18
AGO	25.00	25.23	3.76	19.99	36.97
MFO	31.14	33.44	5.96	14.16	34.23
COPGR	-0.27	1.67	6.97	-16.53	12.04

Source: Author's computation, supplied R-software output.

The descriptive statistics table in table 1 depicts that real GDP growth averages 4.20%, ranging from −2.04% to 15.33%, indicating substantial variation in aggregate economic performance. FDI averages approximately 2.85 billion in the source data units, with a negative minimum of −0.187 billion, which supports the use of a transformation accommodating negative flows. Gross fixed capital formation has a mean of 10.86 and a large standard deviation of 15.75. Money supply averages 18.87, while the interest-rate series averages 2.93 and ranges from −31.45 to 18.18. The negative observations strongly suggest that INT may be a real rather than a nominal interest rate. Agriculture and manufacturing average 25.00 and 31.14 respectively in the supplied measurement units. Crude oil production growth averages −0.27%, with a range of −16.53% to 12.04%, reflecting considerable fluctuations in domestic petroleum extraction. The figures in this table refer to the raw data, not the transformed VAR inputs.

Table 2: Correlation Matrix of the Original Variables

Variable	GDPGR	FDI	GFCF	MS	INT	AGO	MFO	COPGR
GDPGR	1.00	0.30	-0.14	-0.19	0.33	0.30	0.17	0.13
FDI	0.30	1.00	-0.12	0.38	0.29	-0.17	0.27	-0.09
GFCF	-0.14	-0.12	1.00	0.66	0.05	0.13	0.28	-0.02
MS	-0.19	0.38	0.66	1.00	0.31	-0.20	0.31	-0.32
INT	0.33	0.29	0.05	0.31	1.00	-0.02	0.27	-0.07

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XV, Issue X, October 2026

AGO	0.30	-0.17	0.13	-0.20	-0.02	1.00	0.30	-0.05
MFO	0.17	0.27	0.28	0.31	0.27	0.30	1.00	-0.12
COPGR	0.13	-0.09	-0.02	-0.32	-0.07	-0.05	-0.12	1.00

Source: Author's computation, supplied R-software output.

The correlation results in table 2 reveal that the strongest positive bivariate association is between gross fixed capital formation and money supply (r = 0.657), consistent with co-movement between investment and monetary conditions. Money supply and FDI exhibit a moderate positive association (r = 0.384), while money supply and crude oil production growth have a negative association (r = −0.325). GDP growth correlates positively with interest rates (r = 0.333), agricultural output (r = 0.303) and FDI (r = 0.297). These contemporaneous correlations are descriptive only, they do not establish direction, temporal ordering or causality, and they are not substitutes for the connectedness estimates.

Table 3: Time-Domain TVP-VAR Connectedness Matrix

Variable	GDPGR	FDI	GFCF	MS	INT	AGO	MFO	COPGR	FROM
GDPGR	79.12	0.83	0.96	5.90	1.90	5.20	4.43	1.67	20.88
FDI	2.87	71.09	11.00	4.12	1.71	1.84	5.24	2.12	28.91
GFCF	8.12	7.89	60.42	5.77	9.33	3.17	4.21	1.09	39.58
MS	2.06	5.01	6.42	47.08	13.13	1.77	15.10	9.42	52.92
INT	8.59	1.01	2.35	13.89	48.36	5.84	15.04	4.93	51.64
AGO	6.77	3.07	2.44	0.79	7.71	69.42	3.23	6.58	30.58
MFO	4.51	4.78	5.31	11.00	18.29	1.94	49.31	4.85	50.69
COPGR	3.23	4.48	1.24	12.54	6.54	7.22	7.45	57.31	42.69
TO	36.14	27.07	29.72	54.01	58.61	26.98	54.70	30.66	317.90
Inc.Own	115.26	98.15	90.13	101.09	106.97	96.40	104.01	87.97	cTCI/TCI
NET	15.26	-1.85	-9.87	1.09	6.97	-3.60	4.01	-12.03	45.41/39.74
NPT	6.00	3.00	4.00	3.00	5.00	3.00	4.00	0.00	

Source: Author's computation, supplied R-software output.

The results in table 3 show that the total connectedness index (TCI) is 39.74%, indicating that approximately 39.74% of the system's forecast-error variance contributions arise from cross-variable shocks, with the remainder attributable to own innovations. The corrected TCI (cTCI) reported in the output is 45.41%; it is a rescaled measure and should not be confused with the conventional TCI. The largest FROM values occur for money supply (52.92%), interest rates (51.64%) and manufacturing (50.69%), indicating relatively high exposure to shocks originating elsewhere. The largest TO values occur for interest rates (58.61), manufacturing (54.70) and money supply (54.01). Because TO values are column sums, they can exceed the conventional 0–100 share interpretation for an individual receiving variable.

Net spillovers identify GDPGR (+15.26), INT (+6.97), MFO (+4.01) and MS (+1.09) as net transmitters. COPGR (−12.03), GFCF (−9.87), AGO (−3.60) and FDI (−1.85) are net receivers. This pattern suggests that aggregate growth and monetary conditions occupy important transmitting positions in the fitted predictive system, while crude oil production growth and capital formation are especially exposed to cross-variable innovations.

These results do not establish that GDP growth or interest-rate interventions structurally cause the other variables to change. Specific bilateral entries are also evident as the INT shock contributes 18.29% of MFO forecast variance, whereas the MFO shock contributes 15.04% of INT forecast variance. Similarly, MFO contributes 15.10% of MS forecast variance, and MS contributes 11.00% of MFO forecast variance. The MS-to-COPGR contribution is 12.54%, while the COPGR-to-MS contribution is 9.42%. These directional differences are predictive decompositions conditional on the eight-variable model.

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XV, Issue X, October 2026

Whereas time-domain TVP-VAR connectedness measures overall time-varying shock transmission, frequency-domain connectedness decomposes that transmission into distinct periodicity bands to distinguish relatively transitory from persistent interdependence.

For annual observations, the three bands are interpreted as short-term (higher-frequency, approximately 2–4-year periodicities), medium-term (intermediate-frequency, approximately 4–10 years), and long-term (lower-frequency, periodicities exceeding 10 years) connectedness. These labels refer to cyclical periodicities, not the short-run or long-run equilibrium effects estimated in cointegration models.

Table 4: Overall Frequency-Domain Connectedness (All Bands)

Variable	GDPGR	FDI	GFCF	MS	INT	AGO	MFO	COPGR	FROM
GDPGR	79.10	0.83	0.96	5.91	1.91	5.20	4.43	1.67	20.90
FDI	2.87	71.09	11.00	4.13	1.71	1.84	5.24	2.12	28.91
GFCF	8.15	7.89	60.38	5.77	9.34	3.17	4.21	1.09	39.62
MS	2.06	5.01	6.42	47.08	13.14	1.77	15.10	9.42	52.92
INT	8.62	1.01	2.35	13.89	48.34	5.84	15.03	4.93	51.66
AGO	6.77	3.07	2.44	0.79	7.71	69.41	3.23	6.58	30.59
MFO	4.52	4.78	5.31	11.01	18.29	1.94	49.30	4.85	50.70
COPGR	3.23	4.48	1.24	12.54	6.54	7.22	7.45	57.31	42.69
TO	36.22	27.06	29.72	54.03	58.64	26.97	54.69	30.67	318.00
Inc.Own	115.32	98.15	90.10	101.12	106.97	96.38	103.98	87.98	cTCI/TCI
Net	15.32	-1.85	-9.90	1.12	6.97	-3.62	3.98	-12.02	45.43/39.75
NPDC	6.00	3.00	4.00	3.00	5.00	3.00	4.00	0.00	

Source: Author's computation, supplied R-software output.

The full-spectrum frequency matrix in table 4 yields a conventional TCI of 39.75% and corrected TCI of 45.43%, almost identical to the time-domain benchmark (39.74% and 45.41%). GDPGR remains the strongest net transmitter (+15.32), while COPGR (-12.02) and GFCF (-9.90) remain the strongest net receivers.

This close agreement supports numerical consistency between the overall frequency and time-domain decompositions; it is not independent validation of model identification.

Table 5: Short-Term Frequency Connectedness (Approximately 2–4 Years)

Variable	GDPGR	FDI	GFCF	MS	INT	AGO	MFO	COPGR	FROM
GDPGR	16.08	0.25	0.19	1.67	0.19	2.47	2.44	0.78	7.99
FDI	0.62	59.79	10.61	2.60	1.12	0.66	2.12	0.86	18.56
GFCF	0.37	3.17	29.61	1.90	4.41	1.78	3.57	0.19	15.38
MS	1.15	0.67	0.67	16.34	5.15	0.08	3.01	3.38	14.11
INT	0.94	0.48	0.49	3.92	12.39	1.26	4.45	0.50	12.04
AGO	3.40	1.95	2.05	0.41	3.49	28.81	1.04	2.68	15.03
MFO	0.20	2.23	0.71	4.64	5.52	1.27	20.58	2.99	17.56
COPGR	1.11	4.32	1.05	3.67	0.72	1.41	1.60	23.31	13.89
TO	7.79	13.07	15.77	18.81	20.59	8.93	18.23	11.37	114.57
Inc.Own	23.88	72.85	45.38	35.15	32.99	37.74	38.82	34.68	cTCI/TCI
Net	-0.20	-5.50	0.39	4.70	8.55	-6.10	0.67	-2.52	16.37/14.32
NPDC	5.00	3.00	3.00	6.00	6.00	1.00	2.00	2.00	

Source: Author's computation, supplied R-software output.

The short-term frequency band in table 5 reports TCI = 14.32% and cTCI = 16.37%. Interest rates are the leading net transmitter (+8.55), followed by money supply (+4.70), manufacturing (+0.67) and GFCF (+0.39).

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XV, Issue X, October 2026

Agriculture (-6.10) and FDI (-5.50) are the largest net receivers. This points to an important role for monetary conditions in the relatively short-term frequency component of the estimated spillover system.

Table 6: Medium-Term Frequency Connectedness (Approximately 4–10 Years)

Variable	GDPGR	FDI	GFCF	MS	INT	AGO	MFO	COPGR	FROM
GDPGR	28.46	0.15	0.41	2.77	0.42	2.06	1.49	0.67	7.98
FDI	1.23	8.32	0.25	1.01	0.49	0.81	2.84	0.81	7.44
GFCF	2.35	3.78	24.11	3.77	2.90	0.80	0.60	0.79	14.99
MS	0.86	2.94	4.24	22.19	5.86	1.21	9.54	4.46	29.11
INT	2.32	0.27	1.61	4.51	18.68	2.18	7.93	1.85	20.68
AGO	3.24	0.97	0.29	0.20	4.20	34.37	1.66	3.67	14.23
MFO	1.31	1.76	3.84	3.51	7.26	0.44	23.62	0.98	19.11
COPGR	1.34	0.10	0.15	6.99	3.83	3.63	3.64	25.17	19.67
TO	12.65	9.98	10.79	22.76	24.96	11.14	27.71	13.23	133.21
Inc.Own	41.11	18.31	34.90	44.95	43.63	45.51	51.32	38.40	cTCI/TCI
Net	4.67	2.55	-4.20	-6.35	4.28	-3.09	8.60	-6.44	19.03/16.65
NPDC	5.00	3.00	2.00	2.00	5.00	2.00	6.00	3.00	

Source: Author's computation, supplied R-software output.

The medium-term frequency band in table 6 has TCI = 16.65% and cTCI = 19.03%, the largest contribution among the three reported bands. Manufacturing (+8.60) and GDPGR (+4.67) are leading net transmitters, followed by interest rates (+4.28) and FDI (+2.55). COPGR (-6.44) and MS (-6.35) are leading net receivers. This suggests that manufacturing-related and aggregate-growth innovations are especially relevant to medium-term frequency forecast uncertainty.

Table 7: Long-Term Frequency Connectedness (Periodicity Exceeding 10 Years)

Variable	GDPGR	FDI	GFCF	MS	INT	AGO	MFO	COPGR	FROM
GDPGR	34.55	0.43	0.36	1.47	1.30	0.66	0.50	0.22	4.93
FDI	1.03	2.98	0.14	0.52	0.10	0.38	0.29	0.46	2.91
GFCF	5.43	0.94	6.66	0.10	2.03	0.59	0.04	0.11	9.24
MS	0.04	1.40	1.51	8.55	2.13	0.48	2.54	1.59	9.69
INT	5.36	0.26	0.25	5.46	17.27	2.40	2.65	2.58	18.94
AGO	0.14	0.14	0.10	0.18	0.02	6.22	0.53	0.23	1.34
MFO	3.01	0.78	0.76	2.86	5.51	0.23	5.10	0.88	14.03
COPGR	0.78	0.06	0.04	1.88	1.99	2.17	2.21	8.83	9.12
TO	15.79	4.01	3.16	12.46	13.09	6.91	8.75	6.06	70.22
Inc.Own	50.34	6.99	9.82	21.02	30.35	13.13	13.84	14.89	cTCI/TCI
Net	10.85	1.10	-6.09	2.77	-5.86	5.57	-5.28	-3.06	10.03/8.78
NPDC	5.00	4.00	2.00	4.00	2.00	6.00	2.00	3.00	

Source: Author's computation, supplied R-software output.

The long-term frequency band in table 7 reports TCI = 8.78% and cTCI = 10.03%. GDPGR (+10.85) and AGO (+5.57) dominate net transmission, whereas GFCF (-6.09), INT (-5.86) and MFO (-5.28) are principal net receivers. This component is the smallest in aggregate magnitude but exhibits a different hierarchy of transmitters and receivers, demonstrating that variable roles depend on frequency.

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XV, Issue X, October 2026

The three frequency-band TCI contributions sum to 39.75% (14.32 + 16.65 + 8.78), matching the full-spectrum TCI subject to rounding. As shares of full-spectrum connectedness, the higher, intermediate and long-term frequency bands account for approximately 36.0%, 41.9% and 22.1%, respectively. Thus, the medium-term frequency band makes the largest contribution to aggregate connectedness. The band cutoffs used in the analysis correspond, for annual data, to approximate periodicities of 2–4 years, 4–10 years and longer than 10 years.

Figure 1: Dynamic Total Connectedness Index

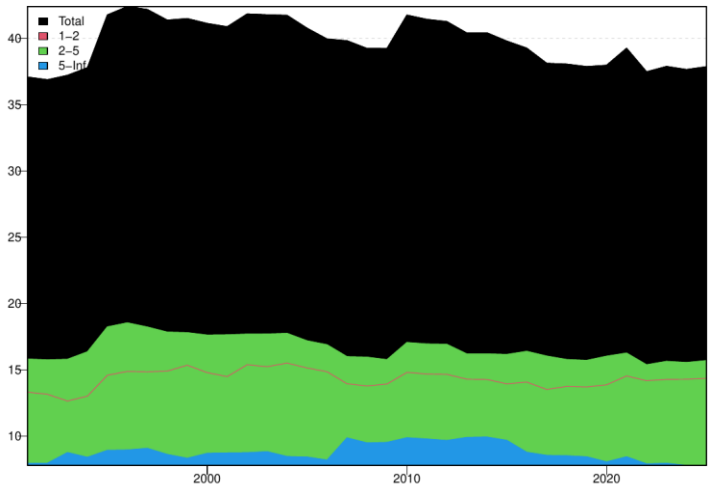


Figure 1 indicates that aggregate connectedness changes across the estimation period rather than remaining constant. The mean full-spectrum TCI is 39.75%, partitioned into 14.32 percentage points at short-term frequency (approximately 2–4-year periodicities), 16.65 at medium-term frequency (4–10 years), and 8.78 at long-term frequency (longer than 10 years). Thus, medium-term frequency fluctuations contribute the most (41.9% of the total), followed by short-term frequency (36.0%) and long-term frequency (22.1%) movements. The relatively persistent component remains economically relevant despite its smaller share.

Figure 2: Dynamic Directional Connectedness Received FROM Other Variables

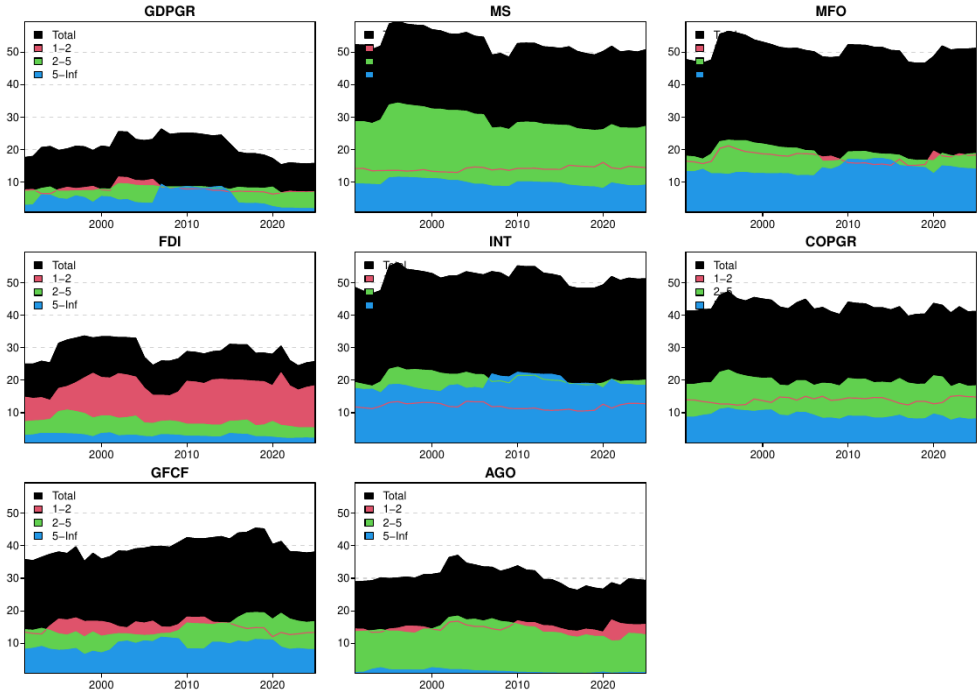


Figure 2 shows that money supply (MS), interest rates (INT), and manufacturing output (MFO) receive the largest average spillovers from the other variables, with full-spectrum FROM values of 52.92%, 51.66%, and

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XV, Issue X, October 2026

50.70%, respectively. At short-term frequency, the largest recipients are FDI (18.56), MFO (17.56), and GFCF (15.38), suggesting sensitivity of investment and production to relatively transitory disturbances. At medium-term frequency, MS (29.11) and INT (20.68) are the most exposed, followed by COPGR (19.67) and MFO (19.11). At long-term frequency, INT (18.94) and MFO (14.03) receive the most cross-variable uncertainty, while agriculture (AGO) receives only 1.34. Economically, the results imply that monetary conditions and manufacturing are especially interconnected, but their exposure is distributed unevenly across periodicities.

Figure 3: Dynamic Directional Connectedness Transmitted TO Other Variables

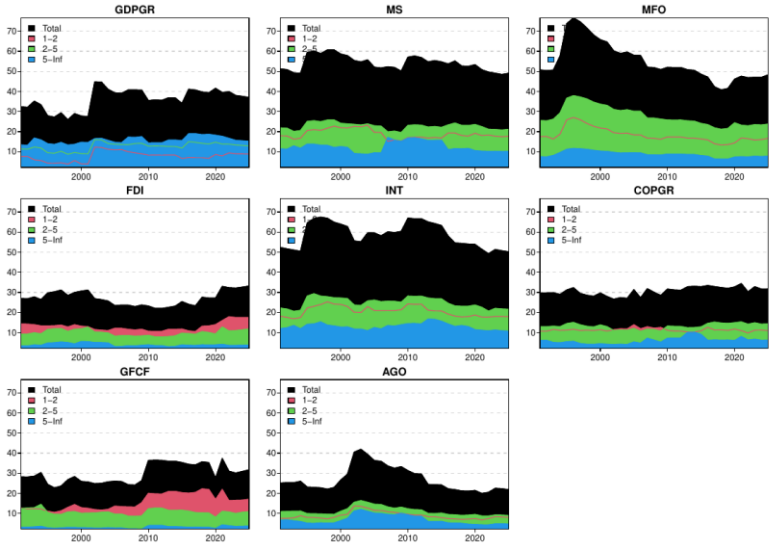


Figure 3 traces the time-varying capacity of each variable to transmit predictive uncertainty. In the full spectrum, INT (TO = 58.64), MFO (54.69), and MS (54.03) are the largest gross transmitters. At short-term frequency, INT (20.59) leads, followed by MS (18.81) and MFO (18.23), highlighting monetary and manufacturing links in relatively rapid fluctuations. At medium-term frequency, MFO (27.71) leads, followed by INT (24.96) and MS (22.76), indicating particularly strong production–monetary interdependence over 4–10-year periodicities. At long-term frequency, GDPGR (15.79), INT (13.09), and MS (12.46) dominate transmitted variance contributions. These differences imply that the identity of the main shock source depends on the frequency considered; a high TO score is not proof of an exogenous policy shock.

Figure 4: Dynamic Net Directional Connectedness

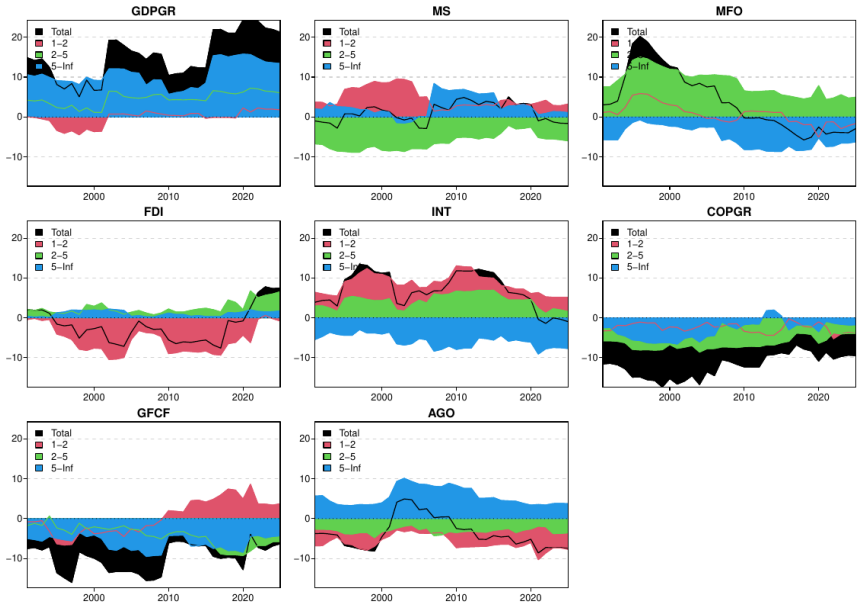


Figure 4 shows that net transmitting and receiving positions are not uniform across frequencies. Full-spectrum

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XV, Issue X, October 2026

net transmitters are GDPGR (+15.32), INT (+6.97), MFO (+3.98), and MS (+1.12), whereas COPGR (−12.02) and GFCF (−9.90) are major net receivers. At short-term frequency, INT (+8.55) and MS (+4.70) transmit net disturbances, while AGO (−6.10) and FDI (−5.50) receive them. At medium-term frequency, MFO (+8.60), GDPGR (+4.67), INT (+4.28), and FDI (+2.55) are net transmitters, whereas COPGR (−6.44) and MS (−6.35) are principal receivers. At long-term frequency, GDPGR (+10.85) and AGO (+5.57) lead transmission, while GFCF (−6.09), INT (−5.86), and MFO (−5.28) receive more than they transmit. Notably, INT switches from net transmitter in the first two bands to net receiver at long-term frequency; MS switches from transmitter at short-term frequency to receiver at medium-term frequency. These are predictive balances, not estimates of the sign of economic growth effects.

Figure 5: Net Pairwise Directional Connectedness

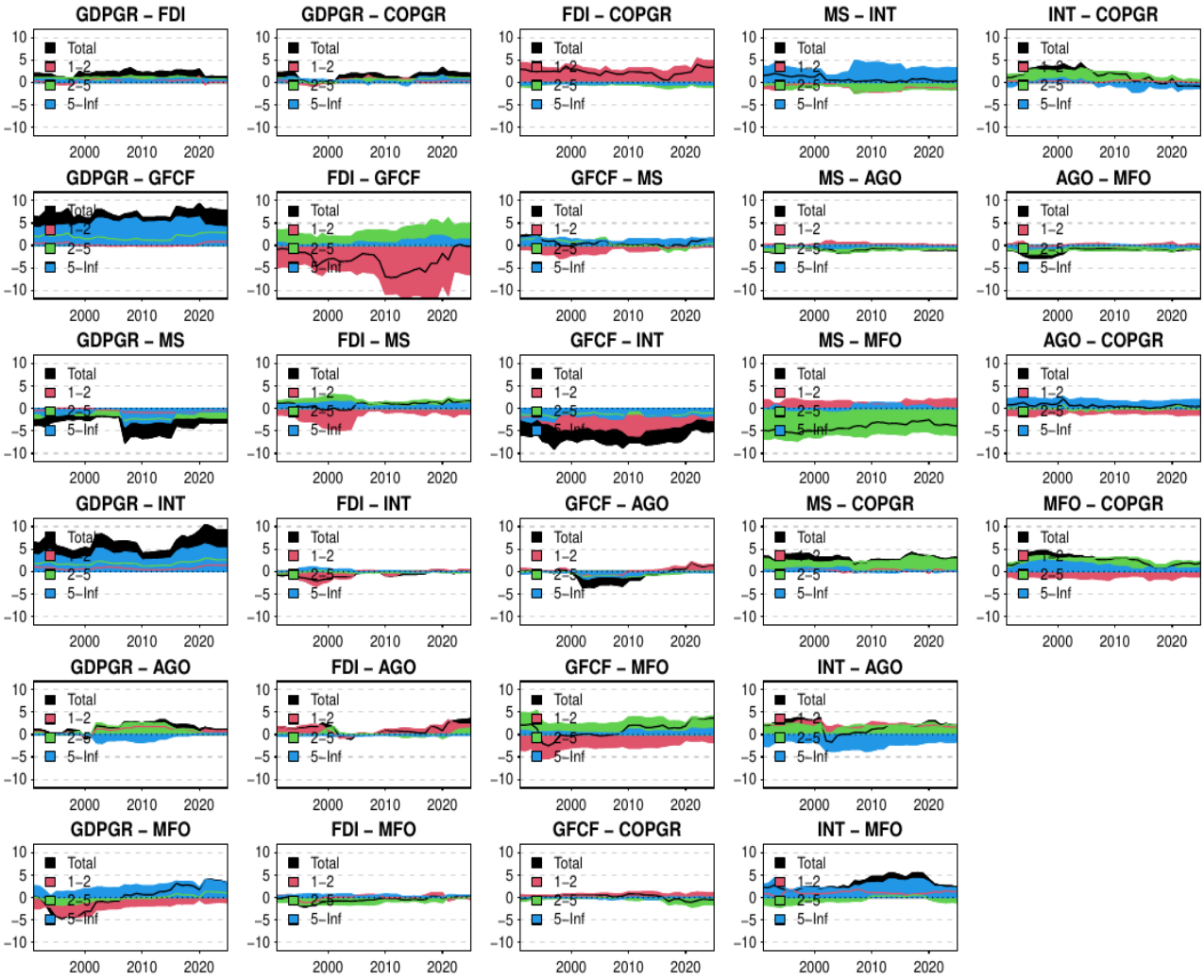


Figure 5 disaggregates the system into bilateral net transmission balances. The time-domain matrix indicates that GDPGR transmits more than it receives from GFCF (8.12 versus 0.96; net 7.16 percentage points), INT (8.59 versus 1.90; net 6.69), and AGO (6.77 versus 5.20; net 1.57). INT is a net transmitter to MFO because INT innovations account for 18.29% of MFO forecast variance, compared with 15.04% in the reverse direction (net 3.25); INT similarly transmits more to GFCF (9.33 versus 2.35; net 6.98). MFO transmits more to MS (15.10 versus 11.00; net 4.10). MS transmits more to COPGR (12.54 versus 9.42; net 3.12), and GFCF transmits more to FDI (11.00 versus 7.89; net 3.11). At short-term frequency, monetary links are prominent (INT net +8.55 and MS +4.70); at medium-term frequency MFO (+8.60) and GDPGR (+4.67) gain prominence; at long-term frequency GDPGR (+10.85) and AGO (+5.57) dominate. Hence the bilateral ordering in individual panels can vary with periodicity. Pairwise net values are differences between two directional variance shares, not positive or negative output responses.

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XV, Issue X, October 2026

Figure 6: Network of Net Pairwise Directional Connectedness

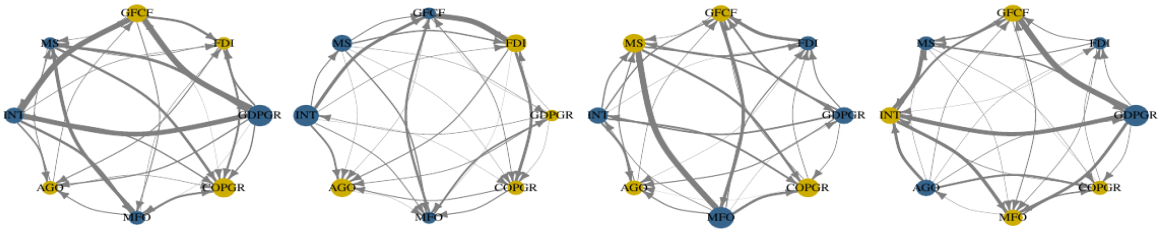


Figure 6 maps the direction of net bilateral connectedness. The underlying variance decomposition identifies GDPGR as the strongest overall net transmitter (+15.32) and COPGR as the strongest net receiver (−12.02), with GFCF also a pronounced receiver (−9.90). Illustrative bilateral directions include GDPGR toward GFCF (8.12 versus 0.96), GDPGR toward INT (8.59 versus 1.90), INT toward GFCF (9.33 versus 2.35), INT toward MFO (18.29 versus 15.04), MFO toward MS (15.10 versus 11.00), and MS toward COPGR (12.54 versus 9.42). Economically, these links suggest that aggregate activity, financing conditions and manufacturing occupy central positions in predictive shock redistribution, whereas investment formation and crude oil production growth are particularly exposed to system-wide fluctuations. Frequency results qualify the network: monetary indicators lead at short-term frequency, MFO and GDPGR at medium-term frequency, and GDPGR and AGO at long-term frequency. Network arrows express relative predictive dominance, not proven structural causal transmission.

DISCUSSION OF FINDINGS

The empirical findings reveal substantial, time-varying and frequency-dependent interrelationships among monetary policy indicators, investment and sectoral output in Nigeria during 1990–2025. The time-domain Total Connectedness Index (TCI) of 39.74% closely corresponds to the full-spectrum frequency-domain TCI of 39.75%, indicating that approximately 40% of aggregate forecast-error variance contributions originate from cross-variable innovations. The corrected indices of 45.41% and 45.43%, respectively, reinforce the importance of macroeconomic interdependence, although own-variable innovations remain dominant. This finding is compatible with the interconnected monetary transmission mechanisms emphasised by Bernanke and Gertler (1995) and Mishkin (1996), and extends the directional spillover framework of Diebold and Yılmaz (2012) to Nigeria's monetary, investment and productive-sector relationships.

In the time domain, GDP growth (GDPGR) is the largest net transmitter (+15.26), followed by interest rates (INT: +6.97), manufacturing output (MFO: +4.01) and money supply (MS: +1.09). Crude oil production growth (COPGR: −12.03), gross fixed capital formation (GFCF: −9.87), agricultural output (AGO: −3.60) and foreign direct investment (FDI: −1.85) are net receivers. Thus, aggregate growth and monetary conditions occupy important transmitting positions, whereas capital formation and domestic petroleum production are more exposed to innovations elsewhere in the system. The findings complement Nigerian evidence on monetary transmission to productive activities (Nwosa & Saibu, 2012; Ezeaku et al., 2018), while identifying the relative positions of variables within a unified predictive connectedness framework rather than estimating structural policy effects.

Monetary indicators are especially important in short-term frequency connectedness (approximately 2–4-year periodicities): INT (+8.55) and MS (+4.70) are the principal net transmitters, whereas AGO (−6.10) and FDI (−5.50) are leading net receivers. Across the full time-domain system, INT transmits 58.61 units of connectedness and receives 51.64, compared with 54.01 transmitted and 52.92 received by MS. The importance of financing and liquidity conditions is consistent with Bernanke and Gertler's (1995) credit-channel argument, Mishkin's (1996) monetary transmission framework and the Nigerian findings of Nwosa and Saibu (2012). Goshit et al. (2022) likewise highlight non-uniform monetary transmission. Nevertheless, these measures represent predictive variance contributions, not the causal effects of identified monetary policy shocks.

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XV, Issue X, October 2026

Investment variables exhibit heterogeneous transmission roles. GFCF is a substantial net receiver overall (−9.87) and remains a net receiver in the medium-term (−4.20) and long-term (−6.09) frequency components. FDI is a net receiver overall (−1.85) and in the short-term component (−5.50), but becomes a modest net transmitter at medium-term (+2.55) and long-term (+1.10) frequencies. These contrasts suggest that domestic capital formation and foreign investment are differently positioned within relatively transitory and persistent macroeconomic fluctuations. The findings are compatible with Solow's (1956) emphasis on capital accumulation and Borensztein et al.'s (1998) treatment of FDI as a potential channel of productive transformation; however, the model does not directly estimate the effects of investment on growth.

Sectoral connectedness is similarly heterogeneous. Manufacturing is a net transmitter overall (+4.01), with its strongest transmitting role in the medium-term frequency band (+8.60). Agriculture is a net receiver overall (−3.60) but becomes a net transmitter in the long-term band (+5.57). COPGR remains a net receiver in all three bands (−2.52, −6.44 and −3.06), indicating persistent relative exposure of domestic petroleum production growth to cross-variable innovations. These differences are consistent with the importance of sector-specific monetary transmission discussed by Saibu (2011), Nwosa and Saibu (2012) and Adelowo and Saibu (2025). Importantly, COPGR measures changes in physical crude oil production, not international crude oil prices; the results therefore should not be interpreted as oil-price shock estimates.

The frequency decomposition shows that short-term connectedness contributes 14.32 percentage points (36.0% of total connectedness), medium-term connectedness 16.65 points (41.9%), and long-term connectedness 8.78 points (22.1%). Medium-term fluctuations, corresponding approximately to 4–10-year periodicities, thus account for the largest share. MFO (+8.60), GDPGR (+4.67) and INT (+4.28) are prominent medium-term net transmitters, while COPGR (−6.44) and MS (−6.35) are leading receivers. In the long-term band (periodicities exceeding 10 years), GDPGR (+10.85) and AGO (+5.57) lead transmission, whereas GFCF (−6.09), INT (−5.86) and MFO (−5.28) become important receivers. These reversals reinforce Baruník and Křehlík's (2018) argument that aggregate connectedness conceals frequency-specific heterogeneity and the usefulness of the time-varying framework of Antonakakis et al. (2020). The short-, medium- and long-term labels denote periodicities, not conventional cointegrating adjustment horizons.

The net pairwise results identify asymmetric bilateral relationships. INT innovations explain 18.29% of MFO forecast variance, compared with 15.04% in the reverse direction, giving INT a net bilateral transmitting advantage of 3.25 percentage points. MFO innovations explain 15.10% of MS forecast variance versus 11.00% from MS to MFO, indicating a 4.10-point advantage for manufacturing. Likewise, MS contributes 12.54% to COPGR forecast variance, compared with 9.42% in the opposite direction. GDPGR dominates six of its seven bilateral comparisons and INT five, while COPGR dominates none in the overall summary. These differences reveal reciprocal but unequal predictive spillovers; the sign of net connectedness does not indicate whether a variable raises or lowers output.

CONCLUSION AND POLICY RECOMMENDATIONS

This study examined dynamic spillovers and frequency connectedness among monetary policy, investment and sectoral output in Nigeria from 1990 to 2025 using the Frequency TVP-VAR framework. The findings reveal substantial macroeconomic interdependence, with Total Connectedness Indices of 39.74% and 39.75% in the time and frequency domains, respectively. GDP growth, interest rates, manufacturing output and money supply emerged as net transmitters, while crude oil production growth, gross fixed capital formation, agriculture and foreign direct investment were net receivers. Frequency decomposition revealed that medium-term fluctuations contributed the largest share of connectedness (41.9%), followed by short-term (36.0%) and long-term (22.1%) fluctuations. The study concludes that macroeconomic spillovers in Nigeria are dynamic, asymmetric and frequency-dependent, underscoring the importance of coordinated, sector-sensitive economic management.

The findings suggest that the Central Bank of Nigeria should strengthen interest-rate and liquidity management while considering their interconnectedness with investment and productive activities. Government should prioritise investment-friendly macroeconomic conditions, infrastructure development and access to long-term financing to strengthen capital formation. Given manufacturing's prominent medium-term

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XV, Issue X, October 2026

transmitting role, industrial policies should promote affordable productive credit, reliable energy supply and domestic value addition. Agricultural modernisation and improved petroleum production infrastructure should also be prioritised to enhance sectoral resilience. Finally, policymakers should adopt a frequency-sensitive approach that integrates short-term stabilisation, medium-term industrial development and long-term structural transformation.

REFERENCES

1. Adelowo, A., & Saibu, O. (2025). Sectoral output growth responses to macroeconomic policy shocks: Evidence from Nigeria. Botswana Journal of Economics, 17(2), 14–26. https://doi.org/10.5897/BOJE2025.0021
2. Antonakakis, N., Chatziantoniou, I., & Gabauer, D. (2020). Refined measures of dynamic connectedness based on time-varying parameter vector autoregressions. Journal of Risk and Financial Management, 13(4), Article 84. https://doi.org/10.3390/jrfm13040084
3. Baruník, J., & Křehlík, T. (2018). Measuring the frequency dynamics of financial connectedness and systemic risk. Journal of Financial Econometrics, 16(2), 271–296. https://doi.org/10.1093/jjfinec/nby001
4. Bernanke, B. S., & Gertler, M. (1995). Inside the black box: The credit channel of monetary policy transmission. Journal of Economic Perspectives, 9(4), 27–48. https://doi.org/10.1257/jep.9.4.27
5. Borensztein, E., De Gregorio, J., & Lee, J.-W. (1998). How does foreign direct investment affect economic growth? Journal of International Economics, 45(1), 115–135. https://doi.org/10.1016/S0022-1996(97)00033-0
6. Central Bank of Nigeria. (2025). Monetary policy decisions. https://www.cbn.gov.ng/MonetaryPolicy/decisions.html
7. Diebold, F. X., & Yilmaz, K. (2009). Measuring financial asset return and volatility spillovers, with application to global equity markets. The Economic Journal, 119(534), 158–171. https://doi.org/10.1111/j.1468-0297.2008.02208.x
8. Diebold, F. X., & Yilmaz, K. (2012). Better to give than to receive: Predictive directional measurement of volatility spillovers. International Journal of Forecasting, 28(1), 57–66. https://doi.org/10.1016/j.ijforecast.2011.02.006
9. Ezeaku, H. C., Ibe, I. G., Ugwuanyi, U. B., Modebe, N. J., & Agbaeze, E. K. (2018). Monetary policy transmission and industrial sector growth: Empirical evidence from Nigeria. SAGE Open, 8(2), 1–12. https://doi.org/10.1177/2158244018769369
10. Goshit, G. G., Jelilov, G., Iorember, P. T., Celik, B., & Davd-Wayas, O. M. (2022). Asymmetric effects of monetary policy shocks on output growth in Nigeria: Evidence from nonlinear ARDL and Hatemi-J causality tests. Journal of Public Affairs, 22, Article e2449. https://doi.org/10.1002/pa.2449
11. International Monetary Fund. (2025). Nigeria: 2025 Article IV consultation—Press release; staff report; and statement by the executive director for Nigeria (IMF Country Report No. 25/157). https://doi.org/10.5089/9798229015127.002
12. Mishkin, F. S. (1996). The channels of monetary transmission: Lessons for monetary policy (NBER Working Paper No. 5464). National Bureau of Economic Research. https://doi.org/10.3386/w5464
13. Nwosa, P. I., & Saibu, M. O. (2012). The monetary transmission mechanism in Nigeria: A sectoral output analysis. International Journal of Economics and Finance, 4(1), 204–212. https://doi.org/10.5539/ijef.v4n1p204
14. Ogunjinmi, O. O., & Adekunle, E. A. (2025). Asymmetric effects of monetary policy on agricultural performance in Nigeria. African Journal of Economic Review, 13(1), 95–111. https://www.ajol.info/index.php/ajer/article/view/290599
15. Pesaran, M. H., & Shin, Y. (1998). Generalized impulse response analysis in linear multivariate models. Economics Letters, 58(1), 17–29. https://doi.org/10.1016/S0165-1765(97)00214-0
16. Primiceri, G. E. (2005). Time varying structural vector autoregressions and monetary policy. The Review of Economic Studies, 72(3), 821–852. https://doi.org/10.1111/j.1467-937X.2005.00353.x
17. Saibu, M. O., & Nwosa, P. I. (2011). Effects of monetary policy on sectoral output growth in Nigeria (1986 to 2008). Journal of Economics and Behavioral Studies, 2(6), 245–254.

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XV, Issue X, October 2026

18. Saliu, M. O. (2024). Monetary policy transmission, labour force participation and real sector performance in Nigeria. International Journal of Research and Innovation in Social Science, 8(7), 2970–2978. https://doi.org/10.47772/IJRISS.2024.807231
19. Solow, R. M. (1956). A contribution to the theory of economic growth. The Quarterly Journal of Economics, 70(1), 65–94. https://doi.org/10.2307/1884513
20. World Bank. (2025). From policy to people: Bringing the reform gains home (Nigeria Development Update). https://www.worldbank.org/en/news/press-release/2025/10/08/positive-economic-momentum-in-nigeria-now-time-to-bring-home-the-gains