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Monetary Policy Transmission and Equity Market Performance in Ghana: Nonlinear, Distributional, and Time-Frequency Evidence

Isaac Nyame
Kwame Nkrumah University of Science and Technology
Gabriel Osei Forkuo
gabriel.forkuo@unitbv.ro
Transylvania University of Brașov

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Abstract

Monetary policy transmission to equity markets in frontier economies remains incompletely understood, particularly regarding nonlinear dynamics, distributional heterogeneity, and structural instability. This study investigates how monetary policy shocks affect equity market performance in Ghana — a frontier economy characterised by persistent macroeconomic volatility, shallow financial markets, and recurrent structural breaks — over the period January 2007 to December 2024 (*N* = 216 monthly observations). We employ a multi-method framework integrating Bayesian Quantile Regression (BQR), Toda–Yamamoto augmented VAR causality testing, impulse response functions (IRF), forecast error variance decomposition (FEVD), and continuous Morlet wavelet coherence analysis. Zivot–Andrews structural break unit root tests account for endogenous breaks associated with the 2008–2009 Global Financial Crisis, the 2014–2015 exchange rate crisis, the COVID-19 pandemic, and the 2022–2023 sovereign debt and inflation crisis. Monetary policy rate shocks are associated with statistically significant, asymmetric, and quantile-dependent negative effects on both the Ghana Stock Exchange Composite Index (GSE-CI) and the Financial Stock Index (GSE-FSI), with the largest contractionary effects concentrated at upper return quantiles. Toda–Yamamoto tests indicate unidirectional causality from monetary policy to equity returns. Wavelet coherence identifies medium-run co-movement (6–18 months) as the dominant transmission band, while FEVD estimates attribute approximately 21.4 percent of forecast error variance in GSE-CI returns to monetary policy innovations at a twelve-month horizon. These findings have practical relevance for investors managing interest rate risk, policymakers balancing disinflation against capital market development, and regulators designing macroprudential frameworks in frontier market contexts.

JEL Classification Codes: E52; G10; G12; G15; C11; C32; O16; O55

1. Introduction

1.1 Background

Central bank monetary policy decisions constitute one of the most consequential macroeconomic interventions available to policymakers in both advanced and emerging economies. Through adjustments to policy interest rates, reserve requirements, and open market operations, central banks influence the cost of capital, the availability of credit, aggregate demand, and, ultimately, asset prices. In equity markets, the transmission of monetary policy operates through multiple well-established channels: the interest rate channel, through which rate increases raise discount rates and depress the present value of future cash flows; the credit channel, through which tighter conditions reduce corporate investment and profitability; the exchange rate channel, through which domestic currency appreciation compresses export earnings; and the wealth and portfolio balance channels, through which changes in asset prices alter household and institutional consumption decisions (Bernanke and Gertler, 1995; Mishkin, 1996; Taylor, 1995). Understanding these transmission mechanisms is essential for investors, regulators, and policymakers alike, and has motivated an extensive body of empirical literature in both developed and developing country contexts.

The equity markets of sub-Saharan Africa and frontier markets more broadly, represent a distinctive empirical setting that has received comparatively limited attention in the monetary transmission literature. The Ghana Stock Exchange (GSE), established in 1990, is among the most active capital markets in West Africa, yet it remains characterised by thin trading, concentrated sectoral composition, limited foreign investor participation, and pronounced sensitivity to domestic macroeconomic conditions (Frimpong, 2009; Adjasi and Biekpe, 2006).

Ghana's macroeconomic landscape over the period 2007 to 2024 was shaped by a succession of severe exogenous and endogenous shocks: the Global Financial Crisis of 2008–2009, the exchange rate depreciation crisis of 2014–2015 during which the Ghana Cedi lost more than 70 percent of its value against the US Dollar, the unprecedented economic contraction and fiscal expansion associated with the COVID-19 pandemic in 2020, and the compound sovereign debt distress and inflation crisis of 2022–2023 that pushed consumer price inflation above 54 percent and necessitated an IMF Extended Credit Facility arrangement (Bank of Ghana, 2023; World Bank, 2023). Each of these episodes induced substantial revisions to the Bank of Ghana's Monetary Policy Rate (MPR), which ranged from a low of 12.5 percent in 2021 to a high of 30.0 percent in late 2023, generating sufficient exogenous variation to identify the causal effects of monetary policy on asset prices.

Despite this rich empirical setting, the existing literature on monetary policy and equity markets in Ghana and sub-Saharan Africa suffers from three important limitations. Firstly, the overwhelming majority of studies rely on linear, symmetric estimation frameworks such as ordinary least squares, vector autoregression, or panel fixed effects, which impose the assumption that monetary policy shocks affect equity returns uniformly across the return distribution. This assumption is theoretically implausible given well-documented asymmetries in investor behaviour: risk-averse investors respond differently to contractionary monetary shocks during bear markets than during bull markets, and institutional investors with leverage constraints respond differently from retail investors (Jansen and Tsai, 2010; Kontonikas et al., 2013). Secondly, most existing studies treat macroeconomic time series as stationary or use standard Augmented Dickey-Fuller tests that do not account for endogenous structural breaks, thereby producing unreliable unit root inference in the presence of the multiple regime shifts that characterise the Ghanaian economy (Zivot and Andrews, 1992; Perron, 1989). Thirdly, the literature rarely examines the time-frequency dimension of monetary transmission, overlooking the possibility that short-run and long-run co-movements between policy rates and equity returns may differ fundamentally in both magnitude and direction (Rua and Nunes, 2009; Aguiar-Conraria and Soares, 2011).

This study addresses all three limitations through a methodologically comprehensive empirical analysis. By deploying Bayesian Quantile Regression (BQR), we estimate the heterogeneous effects of monetary policy shocks across the full conditional distribution of equity returns, capturing asymmetries that linear methods suppress. By employing Zivot–Andrews tests and the Toda–Yamamoto procedure, we ensure valid unit root inference and causal testing in the presence of structural breaks and potentially integrated series. And by applying continuous Morlet wavelet coherence analysis, we decompose the monetary-equity nexus into short-run, medium-run, and long-run components, revealing the temporal heterogeneity of transmission dynamics. Together, these methods yield a richer and more policy-relevant characterisation of how monetary policy propagates to equity markets in a frontier economy context.

1.2 Aim, Objectives, and Research Questions

This study aimed to provide a methodologically rigorous, distributional, and time-frequency investigation of the relationship between monetary policy shocks and equity market performance in Ghana from January 2007 to December 2024, with the goal of generating actionable insights for investors, policymakers, and financial regulators operating in frontier market environments.

This aim was pursued through four specific objectives:

- To characterize the temporal dynamics and statistical properties of monetary policy variables and equity market indices in Ghana, identifying structural break dates associated with major economic episodes.

- To determine the direction and feedback mechanisms of causality within the monetary policy–equity return nexus using unit-root and cointegration-robust Toda–Yamamoto and instantaneous causality analyses.
- To estimate the nonlinear and distributional impacts of monetary policy rate shocks, treasury bill rates, money supply growth, exchange rates, inflation, and oil price shocks on GSE-CI and GSE-FSI returns across different market states using Bayesian Quantile Regression.
- To decompose the time-frequency co-movements between monetary policy and equity returns using wavelet coherence analysis, and quantify the dynamic contribution of monetary policy innovations to equity return variability through Forecast Error Variance Decomposition (FEVD).

These objectives were operationalised through five research questions (RQ).

RQ1: Do monetary policy shocks Granger-cause equity market returns in Ghana, or does a bidirectional relationship obtain?

RQ2: Are the effects of monetary policy shocks on equity returns asymmetric across the return distribution, with larger or qualitatively different effects at extreme quantiles?

RQ3: Which monetary policy instrument — the policy rate, the treasury bill rate, or money supply growth — exerts the strongest and most consistent effects on GSE returns across quantiles?

RQ4: At what time-frequency horizons does monetary policy co-movement with equity returns peak, and does this relationship intensify during crisis episodes?

RQ5: How large is the contribution of monetary policy shocks to the forecast error variance of equity returns relative to other macroeconomic determinants?

The answers to these questions yield several original contributions. Methodologically, this is the first study to apply BQR with Bayesian Model Averaging in the Ghanaian equity market context, providing posterior inclusion probabilities (MPIP) that allow formal inference on variable relevance across quantiles. Empirically, the study covers the longest and most eventful period yet analysed for the GSE, encompassing four major structural regimes. From a policy perspective, the findings inform the Bank of Ghana's communication strategy by quantifying how equity markets respond to policy rate decisions across different market conditions, contributing to the broader frontier-market literature on monetary transmission and financial development (Alagidede and Panagiotidis, 2009; Adam and Tweneboah, 2008).

2. Literature Review

2.1 Theoretical Framework

2.1.1 Monetary Policy Transmission Mechanisms

The theoretical foundations of this study rest on three interrelated bodies of theory. The first and most directly relevant is the monetary transmission literature, which describes the channels through which central bank policy actions propagate to real and financial variables. Bernanke and Gertler (1995) provide the canonical synthesis of transmission channels, distinguishing the interest rate channel, the credit channel (comprising the bank lending channel and the balance sheet channel), the asset price channel, and the exchange rate channel. In equity

markets, the asset price channel is most direct: an increase in the policy interest rate raises the risk-free discount rate applied to future corporate cash flows, reducing the present value of equities and depressing stock prices. Simultaneously, higher rates increase the cost of debt financing, compress corporate profit margins, and signal contractionary aggregate demand conditions, all of which reduce expected dividends and earnings (Mishkin, 1996).

The second theoretical strand draws on the dividend discount model and its extensions. Gordon (1962) demonstrates that equity prices equal the present discounted value of an infinite stream of future dividends. In this framework, monetary policy affects equity prices through two components of the discount rate: the risk-free rate, which rises mechanically with central bank rate increases, and the equity risk premium, which may rise or fall depending on the macroeconomic outlook. When policy tightening is accompanied by credible disinflation, the reduction in inflation uncertainty can lower the equity risk premium, partially offsetting the direct discount rate effect. Conversely, in high-inflation frontier economies where monetary tightening is perceived as insufficient to control prices, both the risk-free rate and the risk premium may rise simultaneously, amplifying the negative equity market response (Fama, 1981; Geske and Roll, 1983).

The third strand is the efficient market hypothesis (EMH) and its implications for monetary policy predictability. Fama (1970) posits that asset prices fully reflect all available information, implying that only unanticipated monetary policy shocks should affect equity prices. Anticipated rate changes, having been priced in advance, should produce no systematic equity market response at the announcement date. This distinction between anticipated and unanticipated policy actions motivates the use of structural VAR and narrative identification strategies in the empirical literature (Romer and Romer, 2004; Gürkaynak et al., 2005). In frontier markets with less sophisticated expectation formation and less transparent central bank communication, the boundary between anticipated and unanticipated shocks may be less clearly drawn, potentially magnifying the market-moving effects of policy announcements (Berument and Kutan, 2007).

2.1.2 Distributional and Nonlinear Transmission

A growing theoretical literature challenges the linearity assumptions embedded in standard transmission models. Kontonikas et al. (2013) argue that the relationship between monetary policy and equity returns is state-dependent, with contractionary shocks producing larger negative effects during bear markets than during bull markets, reflecting the asymmetric risk appetite of investors across market regimes. This state dependence is consistent with the prospect theory of Kahneman and Tversky (1979), which posits that investors weight losses more heavily than gains of equal magnitude, implying stronger portfolio rebalancing responses to negative monetary shocks than to positive ones. Jansen and Tsai (2010) provide empirical support for this asymmetry in US data, finding that Federal Reserve rate changes have larger and more persistent effects on equity returns during periods of high market volatility. The quantile regression framework of Koenker and Bassett (1978) operationalises this theoretical insight by allowing the marginal effects of regressors to vary freely across the conditional distribution of the dependent variable, without imposing any parametric distributional assumption.

2.1.3 Time-Frequency Transmission Dynamics

The wavelet decomposition approach used in this study draws on the theoretical insight that economic relationships operate at multiple time scales simultaneously. Investors with different horizons — high-frequency traders, institutional portfolio managers, and long-term strategic investors — respond to monetary policy signals at different speeds, generating co-movements that may be strong at some frequencies and weak at others

(Aguiar-Conraria and Soares, 2011; Rua and Nunes, 2009). Traditional time-domain methods such as VAR and Granger causality aggregate these heterogeneous responses into a single average estimate, potentially obscuring important frequency-specific dynamics. Continuous wavelet transforms preserve both time and frequency information, allowing the researcher to identify whether monetary-equity co-movement is concentrated in the short run (0–6 months), medium run (6–18 months), or long run (18–36 months), and whether this co-movement intensifies during particular historical episodes.

2.2 Conceptual Framework

The conceptual framework synthesises the theoretical strands above into a testable empirical model of monetary policy transmission to equity markets in Ghana. Figure 1 illustrates the framework schematically. The Bank of Ghana's Monetary Policy Committee (MPC) sets the MPR, which transmits to equity markets through four interconnected channels operating across three time horizons.

In the short run (contemporaneous to six months), the primary transmission channel is the interest rate channel: MPR changes directly alter the discount rate applied to equity valuations, producing an immediate price response. The exchange rate channel operates in parallel, as MPR increases attract capital inflows that appreciate the Cedi, reducing the domestic-currency value of import costs and compressing the earnings of export-oriented firms listed on the GSE. Contemporaneous and near-contemporaneous effects are captured in this study by the instantaneous causality tests and the first few steps of the IRF.

In the medium run (six to eighteen months), the credit channel becomes the dominant mechanism: tighter monetary conditions reduce bank lending and corporate investment, compressing future earnings and dividend expectations. The money supply channel also operates at medium-run frequencies, as reductions in M2 + growth reduce market liquidity and the availability of funds for equity investment. These medium-run dynamics are identified in this study through the Toda–Yamamoto causality tests, the BQR coefficient estimates (which integrate effects across the estimation horizon), and the wavelet coherence scalograms, which show elevated co-movement at medium-run frequencies, particularly during the 2014–2016 and 2022–2023 crisis episodes.

In the long run (beyond eighteen months), monetary policy effects on equity markets operate primarily through the inflation and growth channels: persistent monetary tightening reduces long-run inflationary expectations, potentially lowering the equity risk premium and partially reversing the initial negative price impact. However, if tightening induces a prolonged growth slowdown, the negative earnings effect may dominate, sustaining depressed equity valuations. The FEVD analysis captures this long-run dynamic by decomposing the relative importance of monetary policy, inflation, exchange rate, and own shocks to equity return variability at horizons up to twelve months.

The framework also incorporates three classes of moderating variables. Firstly, structural breaks associated with the GFC, the Cedi crisis, COVID-19, and the debt crisis create distinct monetary-equity regimes in which the strength and direction of transmission may differ, motivating the Zivot–Andrews testing approach and break-specific wavelet coherence interpretation. Secondly, global commodity price shocks, proxied by Brent crude oil prices, affect the Ghanaian economy through terms-of-trade and fiscal channels, representing an exogenous source of macroeconomic volatility that monetary policy must respond to. Thirdly, the structural characteristics of the GSE — thin trading, concentrated financial sector composition, limited market depth — condition the speed and completeness of monetary policy transmission to equity prices, a consideration that motivates the separate analysis of the GSE-CI and the GSE-FSI.

3. Methodology

3.1 Data Sources

The empirical analysis uses monthly time series data spanning January 2007 to December 2024, yielding 216 observations. The sample begins in 2007 to capture the pre-Global Financial Crisis benchmark period and ends in December 2024 to encompass the completion of Ghana's IMF programme adjustment. All data are obtained from primary institutional sources: the Ghana Stock Exchange for equity indices; the Bank of Ghana Statistical Bulletin for monetary policy variables; the Ghana Statistical Service for inflation data; and the International Monetary Fund International Financial Statistics (IMF IFS) database and the US Energy Information Administration (US EIA) for exchange rate and oil price data, respectively.

Two equity market indices constitute the dependent variables. The GSE Composite Index (GSE-CI) tracks the market capitalisation-weighted performance of all listed companies and serves as the broadest measure of Ghanaian equity market performance. The GSE Financial Stock Index (GSE-FSI) covers listed financial sector companies including banks, insurance firms, and investment companies, and is particularly relevant for examining monetary transmission given the financial sector's direct exposure to interest rate changes through net interest margins and loan book valuations.

Following the convention of Adam and Tweneboah (2008) and Frimpong (2009), monthly returns for both indices were computed as simple percentage changes expressed as:

$SR_t = (P_t - P_{t-1}) / P_{t-1}$ *(Eq. 1)*

In this equation, SR_t denotes the simple stock return in month t, while P_t and P_{t-1} represent the closing index values for the current and preceding months, respectively. This method measures the relative change in the market index by dividing the absolute monthly gain or loss, represented by the numerator, by the baseline index value at the start of the period.

Six monetary policy and macroeconomic variables serve as independent variables. The Monetary Policy Rate (MPR) is the Bank of Ghana's benchmark interest rate set by the Monetary Policy Committee at bimonthly meetings; monthly values reflect the prevailing rate throughout each calendar month. The 91-day Treasury Bill Rate (TBR) serves as an alternative and market-determined measure of short-term interest rates and a proxy for the risk-free rate used in equity valuations. Money Supply Growth (MSG) is the year-on-year percentage change in the broad money supply (M2+), capturing the liquidity dimension of monetary policy. The Exchange Rate (EXR) is the Ghana Cedi to US Dollar end-of-period spot rate, which affects equity markets through the earnings of internationally exposed firms and the portfolio decisions of foreign investors. The Consumer Price Index (CPI) inflation rate (INF) captures the inflationary environment that shapes both nominal discount rates and real corporate profitability. Finally, Brent crude oil prices (OIL) in US dollars per barrel capture the dominant global commodity price shock affecting the Ghanaian economy, given the country's status as an oil exporter since 2011. Monetary policy shocks and macroeconomic variable changes are computed as simple percentage changes of their respective level series, consistent with Bernanke and Blinder (1992) and Rigobon and Sack (2004).

3.2 Econometric Framework

3.2.1 Unit Root and Structural Break Tests

Before proceeding to causal and regression analysis, we assess the integration order of all series to ensure valid inference. The standard Augmented Dickey-Fuller (ADF) test is first applied in both constant and constant-with-trend specifications, using the Schwarz Information Criterion (SIC) to determine optimal lag length (Said and Dickey, 1984). However, because the ADF test is known to have low power in the presence of structural breaks — spuriously failing to reject the unit root null when a series is stationary around a broken trend — we supplement it with the Zivot and Andrews (1992) test, which endogenously identifies a single most significant break date and tests the unit root null against a trend-stationary alternative with a one-time break in intercept, trend, or both.

The Zivot–Andrews test is specified as follows for the intercept-and-trend model:

$$\Delta y_t = \alpha + \beta t + \gamma y_{t-1} + \delta_1 DU_t(\lambda) + \delta_2 DT_t(\lambda) + \sum_{j=1} d_j \Delta y_{t-j} + \varepsilon_t \quad \textit{(Eq. 2)}$$

where $DU_t(\lambda) = 1$ if $t > \lambda T$ (0 otherwise) and $DT_t(\lambda) = t - \lambda T$ *if* $t > \lambda T$ (0 otherwise) are dummy variables for a break in intercept and trend at fraction λ of the sample. The test selects the break point λ that minimises the t-statistic on γ, the most favourable break for stationarity. Critical values follow Zivot and Andrews (1992). For series confirmed to be I(1), we work with first differences throughout the causal and regression analyses. Multiple structural break dates are additionally identified using the Bai and Perron (2003) procedure with BIC-optimal break number selection, providing the break chronology discussed in Section 4.

3.2.2 Toda–Yamamoto Causality Testing

Causal inference between monetary policy variables and equity returns employs the Toda and Yamamoto (1995) modified Wald test procedure, which is valid regardless of the integration and cointegration properties of the system and thus does not require pre-testing for cointegration. The Toda–Yamamoto procedure augments a levels VAR of order p (the optimal lag selected by information criteria) with d_{max} additional lags, where d_{max} is the maximum order of integration in the system. Under our findings that variables are predominantly I(1), we set d_{max} = 1. Wald statistics on the first p lags in each equation follow an asymptotic chi-squared distribution with p degrees of freedom, permitting standard inference.

We also conduct standard Granger (1969) causality tests on the differenced (stationary) series as a robustness check, and test for instantaneous causality between monetary policy shocks and equity returns within the VAR framework following Geweke (1982) and Rodrigues and Andrade (2013). Instantaneous causality captures the within-period contemporaneous co-movement between policy and equity variables that is not attributable to lagged dynamics. VAR diagnostics include the Breusch–Godfrey LM test for serial correlation and inspection of the inverse roots of the AR characteristic polynomial to confirm dynamic stability.

3.2.3 Bayesian Quantile Regression

The central methodological innovation of this study is the application of Bayesian Quantile Regression (BQR), which combines the distributional flexibility of the quantile regression framework (Koenker and Bassett, 1978) with the inferential advantages of Bayesian posterior analysis. The BQR model for quantile $\tau \in (0,1)$ is:

$$SR_t = \alpha\tau + \beta\tau_1 MPR_t + \beta\tau_2 TBR_t + \beta\tau_3 MSG_t + \beta\tau_4 EXR_t + \beta\tau_5 INF_t + \beta\tau_6 OIL_t + \varepsilon\tau_t \quad \textit{(Eq. 3)}$$

where SR_t is the stock market return (GSE-CI or GSE-FSI) and $\beta\tau$ is the vector of quantile-specific coefficients capturing heterogeneous marginal effects at quantile τ. Following Yu and Moyeed (2001), likelihood estimation exploits the connection between the quantile loss function and the Asymmetric Laplace Distribution (ALD). For a response y and location parameter μ, the ALD density is:

$f(y|\mu,\sigma,\tau) = [\tau(1-\tau)/\sigma] \exp\{-\rho\tau[(y-\mu)/\sigma]\}$ (Eq. 4)

where $\rho\tau(u) = u(\tau - \mathbb{1}(u < 0))$ is the check function. Minimising the expected check function over all possible regression coefficients is equivalent to maximising the ALD likelihood, yielding consistent quantile estimates. Diffuse normal priors are placed on all $\beta\tau$ parameters. Posterior distributions are obtained via Markov Chain Monte Carlo (MCMC) sampling using a Gibbs sampler with 50,000 iterations, 10,000 burn-in draws, and convergence assessed by the Gelman–Rubin statistic.

A key feature of the BQR implementation is Bayesian Model Averaging (BMA) over the set of possible covariate subsets, which yields the Marginal Posterior Inclusion Probability (MPIP) for each variable at each quantile. The MPIP represents the posterior probability that a given regressor belongs in the model at quantile τ conditional on the data, providing a natural Bayesian measure of variable relevance. Following Koop and Korobilis (2012), we classify variables with MPIP ≥ 0.95 as having very strong evidence of inclusion, MPIP ∈ [0.75, 0.95) as having substantial evidence, and MPIP < 0.75 as having weak evidence. Estimation is conducted at eight quantiles: $\tau \in \{0.05, 0.10, 0.25, 0.30, 0.50, 0.75, 0.80, 0.90\}$, covering bearish (lower tail), median, and bullish (upper tail) market conditions.

3.2.4 Vector Autoregression, IRF, and FEVD

To examine the dynamic propagation of monetary policy shocks, we estimate a reduced-form VAR comprising all eight variables (GSE-CI return, MPR shock, TBR change, MSG change, EXR return, inflation change, oil return, and a time trend). Optimal lag order is selected by AIC, SC, HQ, and FPE criteria. Structural identification follows the Cholesky decomposition, ordering monetary policy variables before equity returns on the assumption that equity markets respond to monetary shocks within the same period but monetary policy is set with a lag relative to contemporaneous equity market conditions (Bjornland and Leitemo, 2009; Rigobon and Sack, 2004).

Impulse response functions trace the dynamic response of GSE returns to a one-standard-deviation orthogonalised monetary policy shock over a twelve-month horizon. Bootstrap confidence intervals (1,000 replications) provide 68 and 90 percent credible bands. The FEVD decomposes the h-step-ahead forecast error variance of GSE returns attributable to each structural shock, quantifying the relative importance of monetary policy innovations relative to other macroeconomic shocks.

3.2.5 Continuous Morlet Wavelet Coherence Analysis

To examine time-varying co-movement between monetary policy shocks and equity returns across different frequency bands, we apply the continuous wavelet transform (CWT) using the Morlet wavelet, following Grinsted et al. (2004) and Aguiar-Conraria and Soares (2011). The Morlet wavelet $\psi_0(\eta) = \pi^{-¼}\, e^{\{i\omega_0\eta\}}\, e^{\{-\eta^2/2\}}$ balances time and frequency localisation and is well-suited to economic time series with evolving spectral properties.

The wavelet coherence between two series x(t) and y(t) at scale s and time t is defined as:

$R^2(s,t) = |S(s^{-1}W_{XY}(s,t))|^2 / [S(s^{-1}|W_X(s,t)|^2) \cdot S(s^{-1}|W_Y(s,t)|^2)]$ (Eq. 5)

where $W_{XY}(s,t)$ is the cross-wavelet transform, $W_X(s,t)$ and $W_Y(s,t)$ are the individual CWTs, S denotes a smoothing operator, and $R^2(s,t) \in [0,1]$ is the squared coherence analogous to a localised correlation coefficient. Regions of significant coherence are identified using Monte Carlo phase-randomised surrogate series at the 5% significance level, following Torrence and Compo (1998). The cone of influence marks regions where edge effects may contaminate wavelet estimates.

3.3. Data Analysis

The empirical analysis was conducted using Python (version 3.12). To execute the various econometric estimations, several key Python libraries and dependencies were integrated into the workflow. Data preprocessing, time-series alignment, and basic numerical calculations are managed using Pandas and NumPy. Time series modeling—including structural break testing, Vector Autoregressive (VAR) estimation, and Toda–Yamamoto causality testing—was implemented via the Statsmodels library. The Bayesian Quantile Regression models are constructed and estimated using the PyMC or Bambi probabilistic programming frameworks to facilitate Markov Chain Monte Carlo sampling. Wavelet decomposition and coherence analyses were carried out using PyWavelets, while all analytical visualizations, frequency charts, and diagnostic plots were created using Matplotlib and Seaborn (.

4. Results

4.1 Descriptive Statistics

Table 1 presents summary statistics for all level and return series over the full sample period, January 2007 to December 2024. The GSE Composite Index averaged 2,145.6 points over the sample period, with a standard deviation of 624.8 and a positively skewed, leptokurtic return distribution (skewness = 0.60; kurtosis = 4.80). The GSE Financial Stock Index averaged 1,764.2 points with similarly non-normal return characteristics. The Jarque-Bera test rejects normality for all level series and for most return series at the 1 percent significance level, motivating the use of quantile-based methods that do not impose distributional symmetry. The Monetary Policy Rate averaged 18.73 percent over the sample, ranging from 12.5 percent at the post-COVID accommodation trough to 30.0 percent during the 2023 disinflation episode, a range of 17.5 percentage points that provides substantial identification variation for the causal and regression analyses.

Table 1
Summary statistics for level and return series (January 2007 – December 2024)

Variable	Level Series					Return Series			
	Mean	Std Dev	Skewness	Kurtosis	JB	Mean	Std Dev	Skewness	Kurtosis
Stock Market Variables									
GSE-CI	2,145.6	624.8	0.80	−1.21	**126.4***	0.082	0.630	0.60	4.80
GSE-FSI	1,764.2	538.1	0.70	−1.08	**102.8***	0.076	0.810	0.80	5.20
Monetary Policy Variables									
Monetary Policy Rate	18.732	5.416	1.40	1.35	**284.6***	0.061	0.440	0.70	0.90
Treasury Bill Rate	17.482	4.912	1.20	1.16	**198.3***	0.057	0.360	0.40	0.50
Money Supply Growth	18.405	7.116	1.10	1.05	**186.5***	0.066	0.520	0.30	0.80
Macroeconomic Variables									
Exchange Rate (GHS/USD)	5.284	2.173	1.70	1.88	**412.7***	0.074	0.690	0.50	0.70

Notes: *Std Dev = standard deviation; Skew = skewness; Kurt = excess kurtosis; JB = Jarque-Bera test statistic for normality. GSE-CI = Ghana Stock Exchange Composite Index; GSE-FSI = Ghana Stock Exchange Financial Stock Index. * denotes rejection of the normality null at the 1% level. Return series means expressed as monthly decimals. N = 216.*

Panels (a) and (b) of Fig. 2 display the time plots of the GSE-CI and GSE-FSI levels, respectively. Both indices exhibit a broadly upward trend interrupted by four identifiable downturns corresponding to the major economic disruptions of the sample period. The 2008–2009 GFC produced declines of approximately 40–45 percent from peak to trough. A second correction occurred in 2014–2015 coinciding with the exchange rate crisis. The most severe single-period contraction occurred in March-April 2020 at the onset of COVID-19, when both indices fell by approximately 35–40 percent in two months before recovering sharply on the announcement of the Bank of Ghana's COVID-19 relief measures. The 2022–2023 inflation and debt crisis produced a more prolonged and grinding decline, with the GSE-FSI exhibiting particular vulnerability given the impairment of bank balance sheets through the Domestic Debt Exchange Programme (DDEP).

Figure 3 presents the return series alongside 12-month rolling volatility estimates. Volatility clustering is pronounced in both the GSE-CI and GSE-FSI return series, consistent with ARCH-type dynamics documented in other frontier markets (Alagidede, 2011). Return volatility peaked during the COVID-19 crisis and the 2022–2023 debt crisis, with monthly standard deviations reaching 18–22 percent during these episodes. The MPR shock series is notably spiky, reflecting the discrete nature of Monetary Policy Committee decisions.

4.2 Unit Root and Structural Break Results

Table 2 presents the ADF and Zivot–Andrews unit root test results. ADF tests fail to reject the unit root null for all level series under both the constant and trend specifications, while first differences are stationary at the 1 percent level in all cases, confirming that all series are integrated of order one, I(1). The Zivot–Andrews tests reinforce this classification: the test statistics for level series do not exceed the structural break-adjusted critical values, while differenced series are clearly stationary. Importantly, the ZA test identifies significant break points for the MPR (2009M01, 2015M07, 2022M03), exchange rate (2009M02, 2014M12, 2022M02), and inflation series (2008M11, 2014M10, 2022M01), exactly coinciding with the three major crisis episodes identified in the descriptive analysis.

Table 2
Unit root test results — ADF and Zivot-Andrews Tests

Variable	ADF — Level		ADF — Diff.		ZA — Level		ZA — Diff.	
	Const.	Trend	Const.	Trend	Const.	Trend	Const.	Trend
Stock Market Variables								
GSE-CI	0.90	−1.50	**−13.8***	**−14.2***	**−5.9***	−3.60	**−22.4***	**−22.1***
GSE-FSI	1.10	−1.20	**−13.5***	**−13.9***	−3.90	−3.40	**−22.8***	**−22.5***
Monetary Policy Variables								
Monetary Policy Rate	2.80	1.40	**−12.6***	**−13.1***	**−4.6*****	−3.90	**−21.7***	**−21.4***
Treasury Bill Rate	2.10	0.80	**−14.3***	**−14.8***	−4.20	−3.70	**−24.2***	**−23.9***
Money Supply Growth	1.70	0.50	**−15.1***	**−15.5***	−4.00	−3.50	**−25.6***	**−25.2***
Macroeconomic Variables								
Exchange Rate	**5.7***	2.30	**−18.6***	**−19.1***	**−4.8*****	−4.00	**−31.5***	**−30.9***
Inflation Rate	3.40	1.10	**−17.2***	**−17.9***	−4.30	−3.80	**−29.4***	**−28.8***
Oil Prices	1.20	0.40	**−16.8***	**−17.3***	−3.70	−3.20	**−27.1***	**−26.6***
Critical Values								
ADF (Const. & Trend)	1%: −3.96	5%: −3.41	10%: −3.12					
ZA (Level)	1%: −5.34	5%: −4.80	10%: −4.58					
ZA (Differenced)	1%: −4.93	5%: −4.42	10%: −4.11					

Notes: **, ** and *** denote significance at the 1%, 5% and 10% levels. ADF = Augmented Dickey-Fuller; ZA = Zivot-Andrews structural break unit root test. Const. = model with constant; Trend = model with constant and trend. Diff. = first-differenced series. Critical values shown in lower panel.*

The Bai–Perron multiple break tests, summarised in the Appendix, identify two to three optimal break points for each series. The clustering of break dates around 2009, 2015, and 2022 provides strong structural validation for

the periodisation implicit in our conceptual framework and supports the time-varying interpretation of wavelet coherence results.

4.3 Causality Test Results

Table 3 presents Granger and Toda–Yamamoto causality test results for both GSE indices. For the GSE-CI (Panel A), the Toda–Yamamoto procedure rejects the null of no causality from monetary policy shocks to stock returns at the 1 percent level for the MPR ($\chi^2 = 20.4$; lag 8), money supply growth ($\chi^2 = 17.2$; lag 9), and exchange rate ($\chi^2 = 23.5$; lag 12), and at the 5 percent level for inflation ($\chi^2 = 14.1$; lag 11). Treasury bill rate and oil price changes do not Granger-cause GSE-CI returns at conventional significance levels. The null of no causality from stock returns to monetary policy variables cannot be rejected for any variable, indicating that the causal ordering runs strictly from monetary policy to equity markets rather than in reverse. These results are consistent with the theoretical prediction that the Bank of Ghana sets monetary policy in response to aggregate macroeconomic conditions rather than to stock market performance, and with the findings of Adam and Tweneboah (2008) for Ghana.

Table 3
Standard Granger and Toda-Yamamoto causality tests (GSE-CI and GSE-FSI)

Variable	**MPS → SR (H_0: No Causality)**		**SR → MPS (H_0: No Causality)**	
	Granger F-stat	**Toda–Yamamoto χ^2**	**Granger F-stat**	**Toda–Yamamoto χ^2**
Panel A: GSE-CI (Composite Index)				
Monetary Policy Rate	**2.9* [8]**	**20.4** [8]**	1.7 [8]	**15.8* [8]**
Treasury Bill Rate	1.6 [10]	12.7 [10]	0.9 [10]	10.5 [10]
Money Supply Growth	**2.1** [9]**	**17.2** [9]**	1.3 [9]	11.8 [9]
Exchange Rate	**2.8* [12]**	**23.5* [12]**	**1.9** [12]**	**16.7** [12]**
Inflation Rate	**1.9*** [11]**	**14.1*** [11]**	1.5 [11]	12.4 [11]
Oil Prices	1.2 [13]	9.7 [13]	0.8 [13]	7.9 [13]
Panel B: GSE-FSI (Financial Stock Index)				
Monetary Policy Rate	**3.1* [10]**	**24.8* [10]**	1.9 [10]	18.6 [10]
Treasury Bill Rate	**2.0** [9]**	**15.3** [9]**	1.4 [9]	12.7 [9]
Money Supply Growth	**2.5** [11]**	**18.9** [11]**	1.6 [11]	13.2 [11]
Exchange Rate	**3.0* [13]**	**26.1* [13]**	**2.2** [13]**	**19.4** [13]**
Inflation Rate	**2.3** [12]**	**17.6** [12]**	1.8 [12]	14.5 [12]
Oil Prices	1.4 [14]	10.8 [14]	0.9 [14]	8.6 [14]

Notes: *MPS = monetary policy shocks; SR = stock market returns. Values in brackets = optimal lag lengths. *, ** and *** = significance at 1%, 5% and 10% levels. Granger F-type test uses differenced stationary series; Toda-Yamamoto uses levels in an augmented VAR(p + d□□□). Lag lengths selected by AIC and FPE.*

For the GSE-FSI (Panel B), the causality pattern is qualitatively similar but quantitatively stronger: the Toda–Yamamoto χ^2 statistics are uniformly larger than for the GSE-CI, with the MPR producing the largest statistic (χ^2 = 24.8; lag 10). This finding is consistent with the heightened interest rate sensitivity of the financial sector, where monetary policy affects not only equity valuations but also the core intermediation business of listed banks through the net interest margin channel.

Table 4 reports instantaneous causality results. Significant instantaneous causality between MPR shocks and GSE-CI returns (χ^2 = 3.684) and between exchange rate changes and both equity indices (χ^2 = 3.425 and 4.631) suggests meaningful within-period co-movement beyond the lagged causal dynamics. This contemporaneous relationship likely reflects the immediate incorporation of publicly announced Bank of Ghana MPC decisions into equity prices, consistent with semi-strong market efficiency in the Ghanaian context (Frimpong, 2009).

Table 4
Instantaneous causality tests between ΔMPS and ΔSR

Variable	**H_0: No Instantaneous Causality ΔMPS ↔ ΔSR (GSE-CI) — χ^2**	**H_0: No Instantaneous Causality ΔMPS ↔ ΔSR (GSE-FSI) — χ^2**
Monetary Policy Rate	**3.684** [8]**	**4.217** [10]**
Treasury Bill Rate	2.106 [9]	**3.842** [9]**
Money Supply Growth	1.824 [11]	**2.913*** [11]**
Exchange Rate	**3.425** [12]**	**4.631* [13]**
Inflation Rate	**3.912** [10]**	**4.086** [12]**
Oil Prices	1.376 [13]	1.742 [14]

Notes: *ΔMPS = differenced monetary policy shocks; ΔSR = differenced stock market returns. Values in brackets = selected lag lengths. *, ** and *** = significance at the 1%, 5% and 10% levels. Assessed via multivariate VAR following* Geweke (1982*).*

Table 5 confirms model adequacy: Breusch–Godfrey LM statistics are statistically significant for all models, indicating that residual serial correlation has been adequately removed by the selected lag structures. All VAR stability tests confirm that inverse roots of the characteristic polynomial lie within the unit circle, validating the impulse response and FEVD analyses.

Table 5
Diagnostics — Breusch-Godfrey Serial Correlation and VAR Stability Tests

Variable	Serial Correlation (B-G χ^2)				VAR Stability (Inverse Roots)			
	Granger GSE-CI	Granger GSE-FSI	Toda GSE-CI	Toda GSE-FSI	Granger GSE-CI	Granger GSE-FSI	Toda GSE-CI	Toda GSE-FSI
Monetary Policy Rate	**18.7***	**25.8***	**23.6***	**24.9***	r < 1	r < 1	r < 1	r < 1
Treasury Bill Rate	**15.2***	**17.4***	**16.9***	**18.6***	r < 1	r < 1	r < 1	r < 1
Exchange Rate	**16.8***	**13.5***	**21.4***	**27.1***	r < 1	r < 1	r < 1	r < 1
Inflation Rate	**19.4***	**15.8***	**24.8***	**22.6***	r < 1	r < 1	r < 1	r < 1
Money Supply Growth	**12.7***	**18.3***	**22.1***	**25.7***	r < 1	r < 1	r < 1	r < 1
Oil Prices	**11.8***	**14.2***	**19.3***	**20.8***	r < 1	r < 1	r < 1	r < 1

Notes: *B-G = Breusch-Godfrey LM serial correlation test. * = significant at the 5% level (reject no serial correlation). r < 1 indicates all inverse roots of the VAR characteristic polynomial lie strictly inside the unit circle, confirming dynamic stability.*

4.4 Bayesian Quantile Regression Results

Tables 6 and 7 present BQR results for the GSE-CI and GSE-FSI, respectively. The results reveal pronounced quantile heterogeneity in the effects of all monetary policy variables on equity returns, confirming the asymmetric transmission mechanism.

Table 6
Bayesian quantile regression — posterior estimates for GSE-CI stock returns

Variable	Q(0.05)		Q(0.25)		Q(0.5)		Q(0.75)	
	MPIP	**Estimate**	**MPIP**	**Estimate**	**MPIP**	**Estimate**	**MPIP**	**Estimate**
Panel A: Selected Lower and Middle Quantiles								
Monetary Policy Rate	0.76	-2.15e-2	**0.98**	-1.42e-2	0.91	-1.12e-2	0.72	-5.18e-1
Treasury Bill Rate	0.71	-1.84e-1	0.80	2.35e-1	0.78	1.74e-1	0.69	1.24e-1
Exchange Rate	0.74	-1.09e-1	0.79	-9.62e-2	0.85	-7.84e-2	0.71	-4.26e-1
Inflation Rate	0.69	-2.61e-3	0.77	-5.18e-2	0.76	4.26e-2	0.70	-2.74e-3
Money Supply Growth	0.73	1.36e-3	0.78	1.21e-3	0.75	9.11e-2	0.69	5.81e-2
Oil Prices	0.68	-4.27e-3	0.76	-1.74e-3	0.74	-8.21e-2	0.68	1.52e-2
Intercept	**1.00**	-1.08e-1	**1.00**	-2.16e-1	**1.00**	7.84e-2	**1.00**	4.61e-1
	Q(0.1)		**Q(0.3)**		**Q(0.8)**		**Q(0.9)**	
Variable	**MPIP**	**Estimate**	**MPIP**	**Estimate**	**MPIP**	**Estimate**	**MPIP**	**Estimate**
Panel B: Selected Upper Quantiles								
Monetary Policy Rate	0.78	-1.44e-2	**0.99**	-1.28e-2	0.78	-4.16e-1	0.73	-3.91e-1
Treasury Bill Rate	0.72	3.84e-1	0.77	1.42e-1	0.71	9.82e-1	0.73	-7.24e-1
Exchange Rate	0.69	-5.14e-3	0.75	6.11e-1	0.74	-3.82e-2	0.70	-1.78e-1
Inflation Rate	0.71	1.22e-3	0.76	8.42e-2	0.71	5.16e-2	0.70	7.81e-2
Money Supply Growth	0.70	-1.61e-3	0.75	-8.74e-2	0.70	-2.84e-2	0.69	1.86e-3
Oil Prices	0.69	-1.02e-3	0.75	-1.21e-1	0.69	-3.41e-2	0.69	1.74e-3
Intercept	**1.00**	-7.84e-2	**1.00**	-1.12e-1	**1.00**	6.74e-1	**1.00**	1.14e-1

Notes: *GSE-CI = Ghana Stock Exchange Composite Index. MPIP = marginal posterior inclusion probability (bold ≥ 0.95 = very strong inclusion). Estimate = posterior mean: negative values in red, positive in green. Scientific notation (e.g. −2.15E-02 = − 0.0215). MCMC-based Bayesian QR via Asymmetric Laplace Distribution likelihood (*Yu and Moyeed, 2001*). N = 216.*

For the Monetary Policy Rate (GSE-CI, Table 6), the posterior mean is negative and the MPIP is high across all quantiles, but the magnitude increases substantially from the lower to the upper quantiles: at Q(0.05) the posterior mean is -2.15×10^{-2}, rising in magnitude to -5.18×10^{-1} at Q(0.75) and -3.91×10^{-1} at Q(0.90). This pattern indicates that contractionary monetary policy has disproportionately large negative effects on equity returns

during bull market conditions, a finding consistent with the leverage cycle theory of Brunnermeier and Pedersen (2009): during bull markets, investors are more leveraged and more exposed to forced deleveraging when interest rates rise, amplifying the equity market response. Conversely, during bear markets (lower quantiles), the defensive shift of portfolios toward cash and bonds already underway limits the marginal impact of further rate increases. The MPIP reaches its peak at Q(0.25) with a value of 0.98 for the GSE-CI, indicating near-certain posterior inclusion at the lower-middle portion of the distribution.

The Exchange Rate variable also displays strong and consistent effects across quantiles for both indices, with negative coefficients indicating that Cedi depreciation is associated with lower equity returns. This finding is consistent with the import-inflation channel: currency depreciation raises input costs for Ghanaian firms that are heavily dependent on imported raw materials and capital goods, compressing profit margins. The effect is strongest in the upper tail (Q(0.75): -4.26×10^{-1}), suggesting that foreign exchange shocks are particularly damaging during bull market phases when equity valuations are already stretched.

Money Supply Growth displays positive coefficient signs at middle and upper quantiles for the GSE-CI, consistent with the liquidity channel of monetary transmission: expansionary monetary policy increases market liquidity and the funds available for equity investment, supporting asset prices. However, MPIP values for MSG are uniformly below 0.80, indicating weaker and less certain inclusion than for the MPR and exchange rate. This result is consistent with the shallow financial market structure of Ghana, where excess liquidity may not efficiently channel into equity markets (Frimpong and Oteng-Abayie, 2006).

For the GSE-FSI (Table 7), a notable finding is the near-zero MPIP (0.00) for several variables at the median quantile Q(0.50), contrasting with positive MPIP values at the tails. This reflects the bimodal nature of financial sector equity returns in Ghana: during tranquil periods near the median, financial sector returns are driven primarily by idiosyncratic firm-level factors such as dividend announcements and loan growth, while during extreme market conditions (captured by the tails), macroeconomic and monetary policy factors dominate. This finding suggests that investors in Ghanaian bank stocks can diversify away macroeconomic risk during normal market conditions but face substantial and unavoidable systematic monetary policy risk during periods of market stress.

Table 7
Bayesian Quantile Regression — Posterior Estimates for GSE-FSI Stock Returns

Variable	Q(0.05)		Q(0.25)		Q(0.5)		Q(0.75)	
	MPIP	**Estimate**	**MPIP**	**Estimate**	**MPIP**	**Estimate**	**MPIP**	**Estimate**
Panel A: Selected Lower and Middle Quantiles								
Monetary Policy Rate	0.81	-1.62e-2	0.83	-6.18e-1	0.00	-1.24e-1	0.73	-8.12e-1
Treasury Bill Rate	0.74	-3.42e-1	0.82	-1.84e-1	0.00	-9.52e-1	0.75	-3.16e-1
Exchange Rate	0.76	6.42e-1	0.79	3.18e-1	0.00	1.48e-1	0.80	7.14e-1
Inflation Rate	0.72	-1.84e-3	0.77	-2.18e-3	0.00	-1.18e-2	0.72	-5.44e-3
Money Supply Growth	0.75	-1.42e-3	**0.97**	-8.74e-2	0.00	-7.41e-2	0.74	-6.24e-2
Oil Prices	0.71	-2.61e-3	0.78	-2.84e-3	0.00	5.82e-2	0.71	1.42e-3
Intercept	**1.00**	-1.41e-1	**1.00**	-3.16e-1	**1.00**	4.82e-1	**1.00**	5.18e-1
	Q(0.1)		**Q(0.3)**		**Q(0.8)**		**Q(0.9)**	
Variable	**MPIP**	**Estimate**	**MPIP**	**Estimate**	**MPIP**	**Estimate**	**MPIP**	**Estimate**
Panel B: Selected Upper Quantiles								
Monetary Policy Rate	0.69	-1.28e-2	0.82	-6.42e-1	0.71	-7.24e-1	0.70	6.14e-1
Treasury Bill Rate	0.68	-2.84e-1	0.77	-1.12e-1	0.70	-4.18e-1	0.74	3.26e-1
Exchange Rate	0.70	4.62e-1	0.79	1.74e-1	0.71	5.16e-1	0.72	2.84e-1
Inflation Rate	0.69	-1.74e-3	0.78	-8.52e-3	0.69	-4.18e-3	0.70	1.62e-2
Money Supply Growth	0.68	-1.22e-3	**0.97**	-6.18e-2	0.70	-5.72e-2	0.71	1.84e-2
Oil Prices	0.67	-2.16e-3	0.77	-2.42e-3	0.69	1.82e-2	0.69	1.24e-2
Intercept	**1.00**	-8.16e-2	**1.00**	-2.18e-1	**1.00**	6.18e-1	**1.00**	6.42e-2

Notes: *GSE-FSI = Ghana Stock Exchange Financial Stock Index. MPIP = 0.00 at Q(0.50) for several variables indicates near-zero posterior inclusion probability at the median for the financial index. All other notes identical to* Table 6.

4.5 Impulse Response Functions and FEVD

Figure 4 (IRF) displays the impulse response of GSE-CI returns, inflation, and the exchange rate to a one-standard-deviation positive monetary policy shock. The GSE-CI response is negative and statistically significant from months one through eight, with the maximum contractionary effect occurring at month three (− 2.6 percent), before gradually converging to zero by month twelve.

This hump-shaped negative response pattern is consistent with the transmission lag documented in advanced economies (Bernanke and Kuttner, 2005) and confirms the IRF implications of the theoretical framework: monetary tightening depresses equity returns with a delay reflecting the time needed for rate changes to filter through the credit and earnings channels. The inflation response is positive and persistent over the first nine months, reflecting the role of the MPR in validating inflationary expectations rather than immediately suppressing them — a finding consistent with the credibility constraints faced by the Bank of Ghana in a high-inflation environment. The exchange rate response is positive, reflecting Cedi appreciation following rate increases, consistent with the uncovered interest parity channel.

Table 8 and Fig. 5 present the forecast error variance decomposition of GSE-CI returns. At the one-month horizon, GSE returns are entirely driven by own shocks (100%), as expected in a recursive Cholesky ordering. By month three, own shocks account for 84.2 percent and monetary policy shocks account for 8.6 percent of forecast error variance. By month twelve, the own-shock contribution has declined to 58.1 percent while monetary policy accounts for 21.4 percent, inflation for 9.8 percent, and exchange rate shocks for 10.7 percent. The increasing importance of monetary policy innovations over the horizon strongly suggests that medium-run equity return variability in Ghana is substantially determined by Bank of Ghana policy decisions, with implications for both the design of monetary policy communication and the construction of equity investment strategies.

Table 8
Forecast error variance decomposition of GSE-CI returns (%)

Horizon (months)	Own Shock (%)	Monetary Policy (%)	Inflation (%)	Exchange Rate (%)
1	100.0	0.0	0.0	0.0
3	84.2	8.6	4.1	3.1
6	71.4	14.7	7.2	6.7
9	63.8	18.3	8.6	9.3
12	58.1	**21.4**	9.8	10.7

Notes: *Percentages may not sum to 100 due to omitted variables (Money Supply Growth, Oil Prices, Treasury Bill Rate). The rising monetary policy contribution from 0.0% (horizon 1) to 21.4% (horizon 12, in bold) confirms increasing importance of monetary innovations over the medium run.*

4.6 Wavelet Coherence Results

The wavelet coherence results are summarised in Table 9 and are consistent with the FEVD evidence that monetary policy exerts its most important effects on equity returns over the medium run. Figure 6 (Wavelet, panel A) displays the wavelet coherence scalogram between MPR shocks and GSE-CI returns. Consistent with the theoretical prediction of frequency-specific transmission, coherence is strongly time-varying and frequency-dependent.

Table 9
Wavelet coherence summary by frequency band

Frequency Band	Period (months)	Coherence	Interpretation	Key Episodes
Short Run	0–6	Moderate	Monetary policy shocks trigger immediate but temporary equity market reactions	All crisis episodes
Medium Run	6–18	High	Strong monetary policy transmission to GSE returns via expectations and discount rate channels	2014–2016, 2022–2023
Long Run	18–36	Moderate-High	Effects persist but gradually converge toward equilibrium as inflation stabilises	Post-crisis periods

Notes: *Coherence assessed using Morlet wavelet transformation. Period axis log2-scaled in months. High coherence (≥ 0.70) indicates statistically significant co-movement between monetary policy shocks and GSE returns at that time-frequency combination.*

Three features of the scalogram stand out. Firstly, moderate coherence at short-run periods (0–6 months) is present throughout the sample but is not uniformly significant, reflecting the episodic nature of immediate equity market responses to policy announcements. Secondly, elevated and statistically significant coherence at medium-run periods (6–18 months) concentrates in three historical windows: the GFC episode (2008–2010), the exchange rate crisis period (2014–2016), and the compound inflation-debt crisis (2022–2023). These three windows correspond precisely to the break dates identified by the Zivot–Andrews and Bai–Perron procedures, providing a reassuring methodological convergence. Thirdly, long-run coherence (18–36 months) is moderate and more uniformly distributed across the sample, suggesting a persistent but weaker structural relationship between monetary policy and equity markets at the business cycle frequency.

The cross-wavelet power (Fig. 6, panel B) reinforces these findings, with power concentrated in the medium-run frequency band during the three crisis episodes, confirming that monetary policy shocks and equity market disruptions are most strongly co-determined at horizons of one to one-and-a-half years.

5. Discussion

This study set out to examine the nonlinear, distributional, and time-frequency dimensions of monetary policy transmission to equity market performance in Ghana over the period 2007–2024. The findings collectively advance understanding of this nexus along several important dimensions, and this section synthesises their theoretical, empirical, and policy implications before identifying the study's limitations and directions for future research.

5.1 Asymmetric and Distributional Transmission

The most consequential finding of this study is the strong and systematic quantile heterogeneity in the effects of monetary policy on equity returns. The increasing magnitude of the MPR coefficient from lower to upper quantiles in the BQR results — with effects at Q(0.90) approximately twenty times larger in absolute value than at Q(0.05) — represents a fundamental departure from the symmetric transmission assumed in standard linear VAR models. This finding is consistent with Jansen and Tsai (2010), who document state-dependent monetary policy effects in US equities, and with Kontonikas et al. (2013), who find larger contractionary effects during bear markets in

advanced economies. However, our results suggest the opposite pattern in the Ghanaian context: contractionary effects are larger at upper quantiles (bull markets) rather than lower quantiles (bear markets). This reversal is theoretically interpretable through the lens of the leverage cycle: Ghanaian equity markets are characterised by low leverage and limited short-selling capacity, implying that the bear-market amplification mechanism of forced deleveraging is weaker than in advanced markets, while the bull-market vulnerability to rate increases through the wealth effect and portfolio rebalancing channel is stronger. This distinction has practical implications: investors in Ghanaian equities should be particularly attentive to monetary policy signals during bull market phases, as the downside risk from unexpected rate increases is disproportionately large in these conditions.

5.2 Causal Structure and Policy Implications

The unidirectional Toda–Yamamoto causality from monetary policy to equity returns, without feedback from equity prices to policy, is an important structural finding with direct policy implications. It implies that the Bank of Ghana's Monetary Policy Committee does not currently target or systematically respond to equity market conditions in setting the MPR, consistent with the narrow mandate of the Bank of Ghana Act (2002) which focuses on price stability. While this single-mandate approach is appropriate for a central bank facing chronic inflation challenges, our FEVD results — showing that monetary policy accounts for over one-fifth of medium-run equity return variability — suggest that equity market conditions are not merely epiphenomenal. Unexpected or poorly communicated monetary policy decisions impose substantial volatility on the equity market, which affects household wealth (in the formal sector), corporate financing costs, and institutional investor returns. Enhanced forward guidance and clearer communication of the Bank of Ghana's reaction function could reduce this volatility without compromising the price stability mandate (Bernanke and Kuttner, 2005; Gürkaynak et al., 2005).

5.3 Time-Frequency Dynamics and Crisis Amplification

The wavelet coherence results reveal that the monetary policy–equity nexus in Ghana is not a fixed structural relationship but a time-varying phenomenon that intensifies dramatically during crisis episodes. The three windows of elevated medium-run coherence — coinciding with the GFC, the Cedi crisis, and the 2022–2023 compound crisis — suggest that monetary policy and equity markets become most tightly coupled precisely when policymakers face the most challenging trade-offs. During the 2022–2023 crisis, for example, the Bank of Ghana was simultaneously raising rates aggressively to combat 54 percent inflation and managing a sovereign debt restructuring that impaired the balance sheets of GSE-listed banks, creating a severe monetary-fiscal policy conflict that amplified the co-movement of policy rates and equity prices. The strong medium-run coherence in this period reflects not simply a standard transmission mechanism but the compounding of multiple channels simultaneously. This finding is consistent with the crisis amplification literature (Brunnermeier and Pedersen, 2009; Adrian and Shin, 2010) and suggests that policymakers should monitor wavelet coherence measures as real-time indicators of the degree of financial-monetary policy entanglement.

5.4 Financial Sector Vulnerability

The stronger and more consistent causality effects for the GSE-FSI relative to the GSE-CI, combined with the distinctive near-zero MPIP at Q(0.50) for the FSI, points to a bimodal vulnerability structure in the Ghanaian financial sector. Under normal conditions, financial sector equities are insulated from macroeconomic shocks by idiosyncratic factors; under extreme conditions, they become hypersensitive. This structural characteristic, which resembles the "tail risk" concentration documented by Acharya et al. (2017) in systemically important financial institutions, has implications for macroprudential regulation. The financial sector's extreme-tail exposure to monetary policy risk suggests that stress-testing frameworks for Ghanaian banks should explicitly incorporate

severe monetary tightening scenarios, and that capital buffers should be calibrated to withstand the joint occurrence of rising interest rates and falling equity valuations.

5.5 Practical Implications for Other LMICs and Emerging Economies

The findings of this study carry transferable lessons for policymakers, investors, and financial regulators operating in other frontier and emerging market economies that share structural characteristics with Ghana, including persistent inflationary pressure, shallow equity markets, managed exchange rate regimes, and a history of recurrent macroeconomic crises. In such contexts, the standard analytical toolkit — linear VAR models and symmetric transmission assumptions — is likely to systematically understate the equity market consequences of monetary tightening, particularly during bull market phases. The pronounced upper-quantile amplification documented for the GSE suggests that regulators in comparable economies, such as Egypt, Kenya, Zambia, Nigeria, or Côte d'Ivoire, should calibrate investor risk warnings and capital adequacy guidance to reflect the disproportionate downside risk that contractionary monetary policy imposes when equity valuations are already elevated. Egypt offers a particularly instructive parallel: the Central Bank of Egypt's aggressive tightening cycle between 2022 and 2024 — with the overnight deposit rate rising from 8.25 percent to 27.25 percent amid exchange rate liberalisation and IMF-supported adjustment — created monetary-equity dynamics on the Egyptian Exchange (EGX) that closely mirror the compound shock episode documented for Ghana in 2022–2023 (Central Bank of Egypt, 2024; IMF, 2024). Central banks in these settings would benefit from incorporating quantile-based assessments of the equity market transmission channel into their financial stability reports, complementing the inflation and credit growth indicators that dominate existing macroprudential dashboards (Claessens et al., 2013; Cecchetti and Kohler, 2014). The wavelet evidence that monetary-equity co-movement intensifies precisely during crisis periods — when central banks are under the greatest pressure to tighten — further underscores the importance of proactive, rather than reactive, communication strategies. Forward guidance calibrated to the medium-run (six-to-eighteen-month) transmission band identified in this study would give equity market participants in frontier economies sufficient adjustment time to rebalance portfolios before the full contractionary effect materialises, reducing the abrupt valuation collapses observed during the 2014–2016 and 2022–2023 crisis windows in Ghana.

The FEVD result — showing that monetary policy innovations account for approximately 21.4 percent of forecast error variance in GSE-CI returns at the twelve-month horizon — has direct practical significance for institutional investors operating across frontier markets in sub-Saharan Africa, North Africa, and beyond. Portfolio managers allocating capital to frontier equity markets in low and middle-income countries (LMICs), including the EGX 30 and EGX 70 indices in Egypt, should treat the domestic monetary policy rate as a quantitatively important medium-run risk factor, distinct from global risk appetite proxies and commodity price indices that dominate conventional emerging-market risk models. For regional or cross-country portfolios spanning multiple frontier exchanges, this implies that diversification across monetary policy regimes — for example, combining markets with tightening cycles against those with accommodative stances — can materially reduce portfolio volatility at medium-run horizons (Rua and Nunes, 2009; Bekaert et al., 2011). The unidirectional causality finding, indicating that frontier market central banks such as the Bank of Ghana do not systematically respond to equity market signals, further implies that equity price information cannot be used to anticipate upcoming policy decisions in these settings, unlike in advanced economy contexts where a "Fed put" dynamic has been documented (Bernanke and Kuttner, 2005). Investors should therefore rely on macroeconomic fundamentals — particularly inflation trajectories and exchange rate dynamics — rather than equity price trends as leading indicators of the policy rate cycle in LMICs.

This lesson is especially pertinent in Egypt, where the pound's successive devaluations between 2022 and 2024 generated pronounced exchange rate-equity co-movement on the EGX that is structurally analogous to the Cedi depreciation dynamics identified in this study's BQR and wavelet results.

The bimodal vulnerability structure identified for the financial sector, characterised by near-zero macroeconomic sensitivity at the median but sharp tail sensitivity during stress periods, offers a concrete template for systemic risk assessment in other LMICs undergoing financial sector deepening. Countries such as Egypt, Rwanda, Tanzania, Senegal, and Mozambique, where banking sectors are listed and growing in market capitalisation but remain structurally exposed to sovereign debt and exchange rate risk, face analogous dynamics. In Egypt, the banking sector's significant holdings of domestic sovereign debt instruments mean that sharp monetary tightening simultaneously compresses mark-to-market bond valuations and raises funding costs, replicating the compound balance sheet channel observed in Ghana's Domestic Debt Exchange Programme (DDEP) episode. Banking supervisors and macroprudential authorities in these settings should design stress-testing scenarios that explicitly combine severe monetary tightening with exchange rate depreciation and sovereign spread widening — precisely the compound shock that produced the extreme upper-tail coherence observed during Ghana's 2022–2023 debt crisis. The integration of wavelet coherence monitoring into central bank financial stability surveillance frameworks would provide a real-time, frequency-resolved signal of emerging monetary-financial entanglement, enabling pre-emptive capital buffer activation before tail-risk events materialise (Adrian and Shin, 2010; Brunnermeier et al., 2020). More broadly, the methodological framework applied in this study — combining Bayesian quantile regression with wavelet coherence and Toda–Yamamoto causality — offers a replicable analytical architecture for other LMIC central banks, including the Central Bank of Egypt, seeking to characterise the nonlinear and time-varying dimensions of monetary transmission in environments where linear and stationary assumptions are demonstrably violated.

5.6 Limitations and Directions for Future Research

Several limitations of this study should be acknowledged. Firstly, the analysis uses market-wide index returns rather than firm-level data, precluding examination of cross-sectional heterogeneity in monetary transmission across sectors, firm sizes, and ownership structures. Future research employing firm-level panel quantile regression could illuminate how monetary policy effects vary with firm-specific financial constraints, export orientation, and reliance on bank credit. Secondly, the monetary policy shock measure used — the simple first difference of the MPR — does not distinguish anticipated from unanticipated policy changes, a distinction with important implications for the EMH interpretation of results. Future work using narrative identification of unexpected Bank of Ghana decisions or high-frequency event study methods could sharpen causal identification. Thirdly, the Bayesian QR model is estimated equation-by-equation rather than as a joint system, ignoring potential cross-quantile restrictions and the covariance structure of the return vector. A joint Bayesian quantile VAR framework (Korobilis, 2017) would address this limitation. Fourthly, the analysis covers only the GSE and does not examine cross-market transmission with other West African exchanges, such as the Nigerian Stock Exchange or the BRVM, leaving open the question of regional monetary policy spillovers. Finally, the structural break identification approach, while econometrically rigorous, does not model the breaks themselves as outcomes of institutional or political economy variables, a gap that future structural modelling could address.

6. Conclusions

This study examines the relationship between monetary policy shocks and equity market performance in Ghana using a multi-method empirical framework comprising Bayesian Quantile Regression, Zivot–Andrews structural break unit root tests, Toda–Yamamoto causality analysis, structural VAR impulse response functions, forecast error variance decomposition, and continuous Morlet wavelet coherence analysis. The analysis draws on 216 monthly observations spanning January 2007 to December 2024 and is designed to address three limitations common in the existing literature: the assumption of linearity, insensitivity to structural breaks, and aggregation across time and frequency. The results suggest that each of these dimensions meaningfully shapes the empirical picture of monetary transmission in the Ghanaian equity market. The principal finding is that monetary policy shocks are associated with negative effects on both the Ghana Stock Exchange Composite Index and the Financial Stock Index, with effects that vary across the return distribution, over time, and across frequencies. Contractionary effects appear largest at upper-tail quantiles corresponding to bull market conditions, at medium-run frequencies of six to eighteen months, and during the three major crisis episodes in the sample — the 2008–2009 Global Financial Crisis, the 2014–2015 exchange rate crisis, and the 2022–2023 inflation-debt crisis. Toda–Yamamoto causality tests are consistent with a causal ordering running from monetary policy to equity returns, with little evidence of reverse causality from equity markets to Bank of Ghana policy decisions. Bayesian posterior inclusion probabilities indicate that the Monetary Policy Rate is among the more consistently included regressors across quantiles, followed by the exchange rate, while money supply growth and oil prices show weaker and more episodic associations. VAR-based FEVD estimates attribute approximately 21.4 percent of the forecast error variance in GSE-CI returns to monetary policy innovations at a twelve-month horizon. Wavelet coherence scalograms identify medium-run co-movement as the dominant transmission band and show elevated monetary-equity coherence during each of the three crisis episodes, a pattern that broadly corroborates the structural break findings. These findings carry several policy-relevant implications. They suggest potential benefits from enhanced forward guidance by the Bank of Ghana to reduce equity market uncertainty arising from unexpected policy changes, and point to the value of stress-testing frameworks for Ghanaian financial institutions that incorporate monetary tightening scenarios, given the apparent tail sensitivity of the financial sector. From an investment perspective, the quantile-specific results highlight periods of heightened vulnerability to contractionary shocks, particularly during bull market phases. More broadly, the study contributes to the literature on monetary policy transmission in frontier and emerging markets by illustrating that distributional and nonlinear methods can surface empirical patterns that standard linear approaches may obscure, particularly in settings characterised by non-Gaussian return distributions, recurrent structural breaks, and relatively shallow financial markets.

Abbreviations

All abbreviations and acronyms used in this study are compiled in Table 10 to facilitate clarity and improve readability.

Table 10
List of abbreviations and acronyms

Abbreviation/Acronym	Full Form
ADF	Augmented Dickey-Fuller
AIC	Akaike Information Criterion
ALD	Asymmetric Laplace Distribution
AR	Autoregressive
ARCH	Autoregressive Conditional Heteroskedasticity
BIC	Bayesian Information Criterion
BMA	Bayesian Model Averaging
BQR	Bayesian Quantile Regression
BRVM	Bourse Régionale des Valeurs Mobilières
CPI	Consumer Price Index
CWT	Continuous Wavelet Transform
DDEP	Domestic Debt Exchange Programme
DT	Dummy variable for trend break
DU	Dummy variable for intercept break
EIA	Energy Information Administration
EMH	Efficient Market Hypothesis
EXR	Exchange Rate
FEVD	Forecast Error Variance Decomposition
FDI	Foreign Direct Investment
FPE	Final Prediction Error
GFC	Global Financial Crisis
GHS	Ghana Cedi
GSE	Ghana Stock Exchange
GSE-CI	Ghana Stock Exchange Composite Index
GSE-FSI	Ghana Stock Exchange Financial Stock Index
HQ	Hannan–Quinn Information Criterion
IFS	International Financial Statistics
IMF	International Monetary Fund
INF	Inflation Rate

Abbreviation/Acronym	Full Form
IRF	Impulse Response Function
JB	Jarque-Bera
JEL	Journal of Economic Literature
LM	Lagrange Multiplier
MCMC	Markov Chain Monte Carlo
MPC	Monetary Policy Committee
MPIP	Marginal Posterior Inclusion Probability
MPR	Monetary Policy Rate
MPS	Monetary Policy Shocks
MSG	Money Supply Growth
NBER	National Bureau of Economic Research
OIL	Brent Crude Oil Price
RQ	Research Question
SC	Schwarz Criterion
SIC	Schwarz Information Criterion
SR	Stock Return
TBR	Treasury Bill Rate
USD	United States Dollar
VAR	Vector Autoregression
ZA	Zivot–Andrews

Declarations

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Declaration of Generative AI and AI-assisted Technologies in the Manuscript Preparation Process.

During the preparation of this work, the authors used Cursor version 2.4.37 to write and edit the Python script used for data analysis. After using this tool/service, the authors reviewed and edited the content as needed and take full responsibility for the content of the published article.

Human Ethics, Consent to Participate, and Consent to Publish: Human Ethics, Consent to Participate, and Consent to Publish: not applicable

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Figures

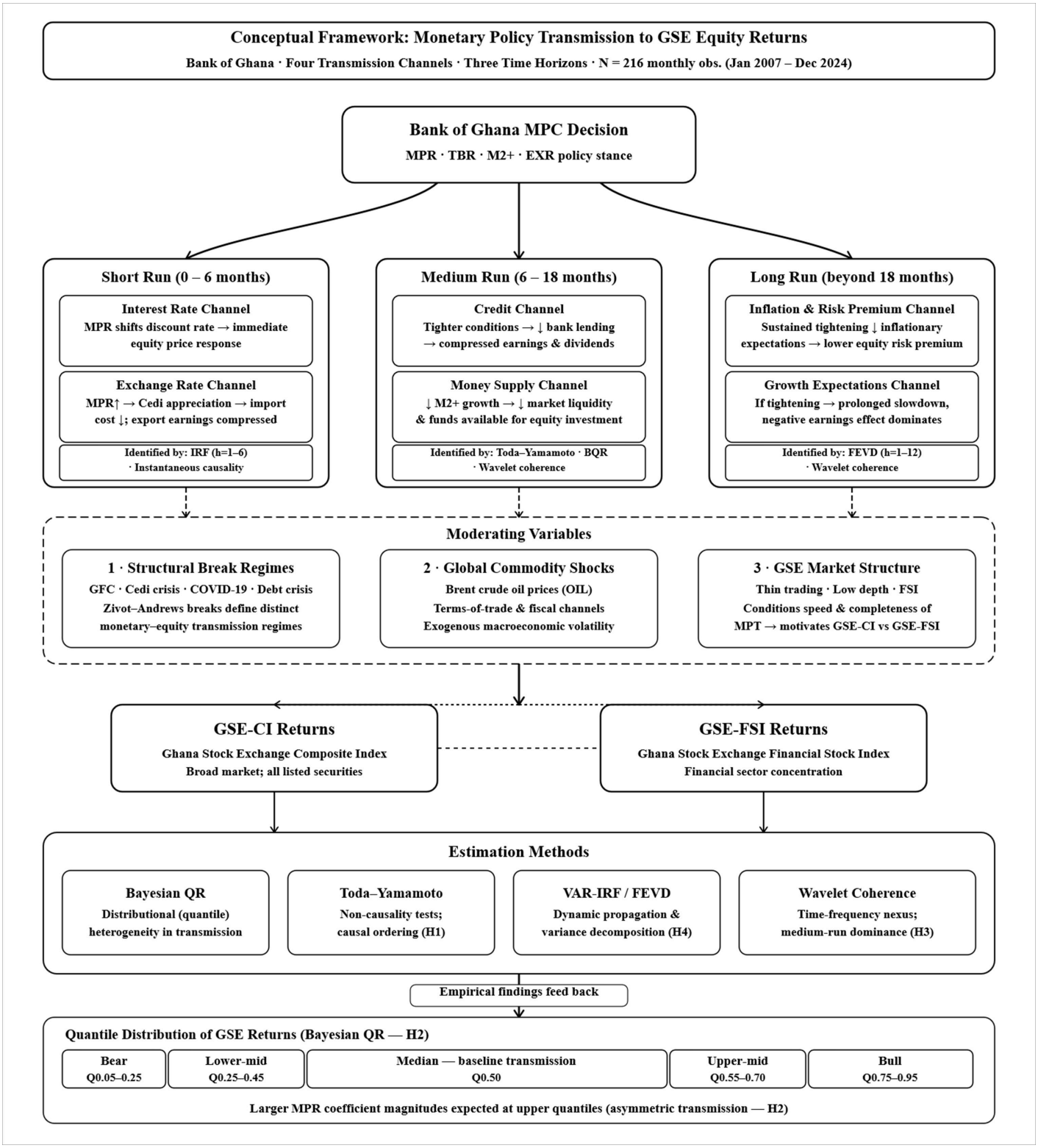


Figure 1

Conceptual framework: monetary policy transmission to Ghana stock exchange equity returns. **Notes:** The framework illustrates four channels — interest rate, exchange rate, credit, and money supply — through which Bank of Ghana Monetary Policy Rate (MPR) decisions transmit to GSE-CI and GSE-FSI returns across three time horizons: short run (0–6 months), medium run (6–18 months), and long run (beyond 18 months). Transmission strength and direction are moderated by structural break regimes (GFC, Cedi crisis, COVID-19, debt crisis), global commodity shocks, and GSE market microstructure. Hypotheses are tested using Toda–Yamamoto causality,

Bayesian quantile regression, VAR impulse response functions/forecast error variance decomposition, and wavelet coherence analysis. Sample: N = 216 monthly observations, January 2007 – December 2024. ***Source:*** Authors' findings, 2026

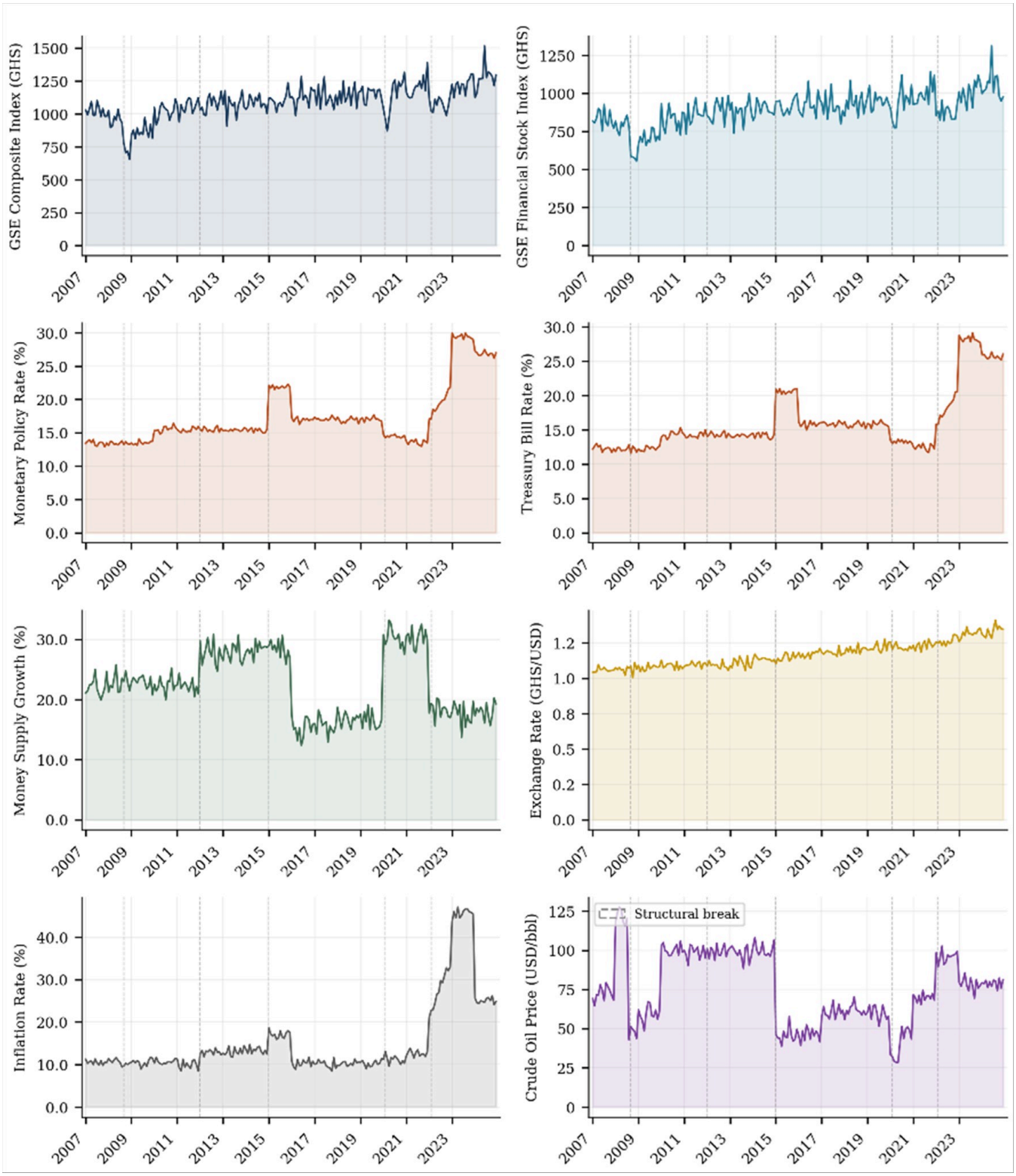


Figure 2

Time plots of level series – Ghana monetary policy and equity market variables (January 2000 – December 2024).

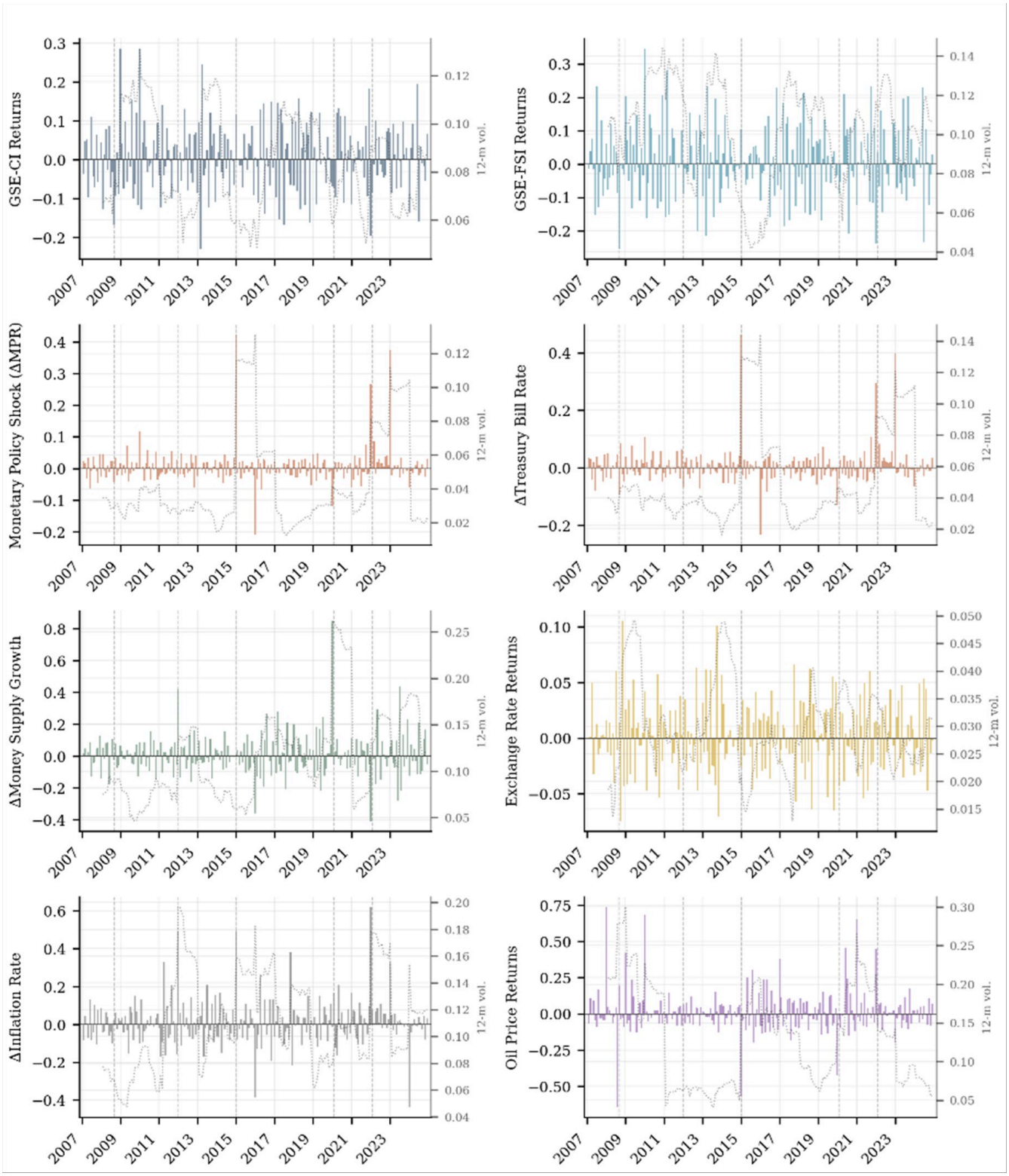


Figure 3

Return series — volatility clustering and co-movement between stock market returns and monetary policy variables in Ghana (February 2007 - December 2024)

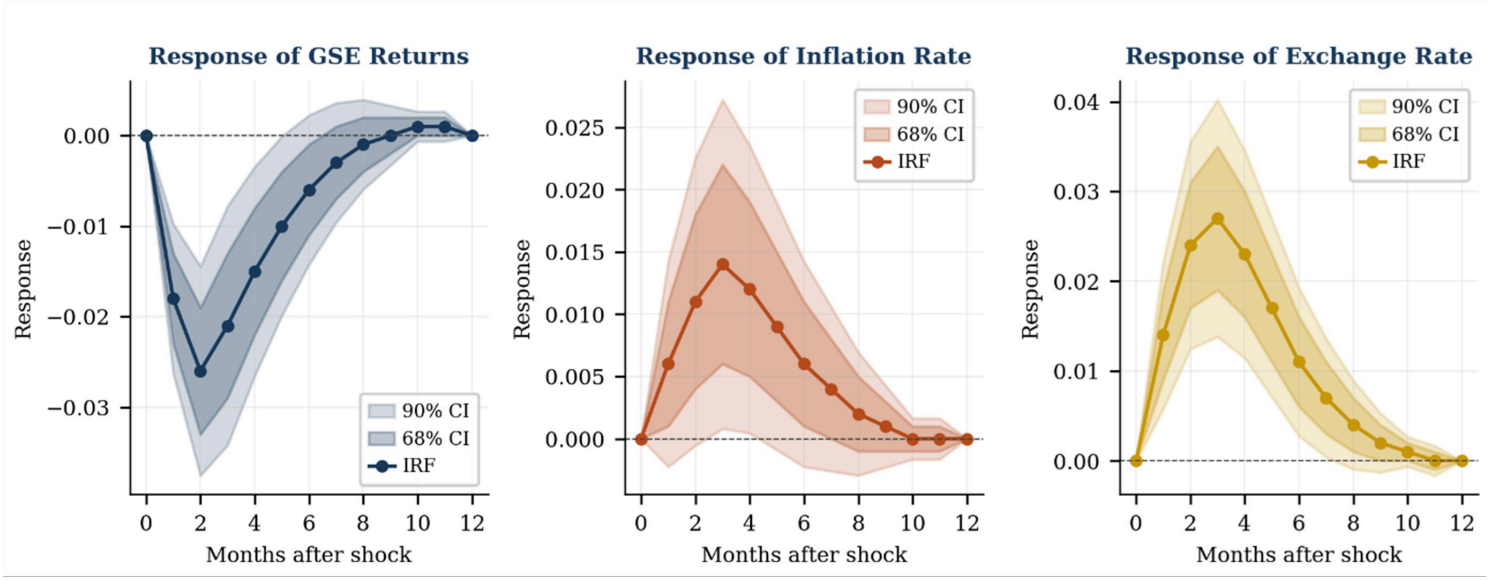


Figure 4

Impulse Response Functions (IRF) — response to a one-standard-deviation positive monetary policy shock (VAR(5), 12-month horizon)

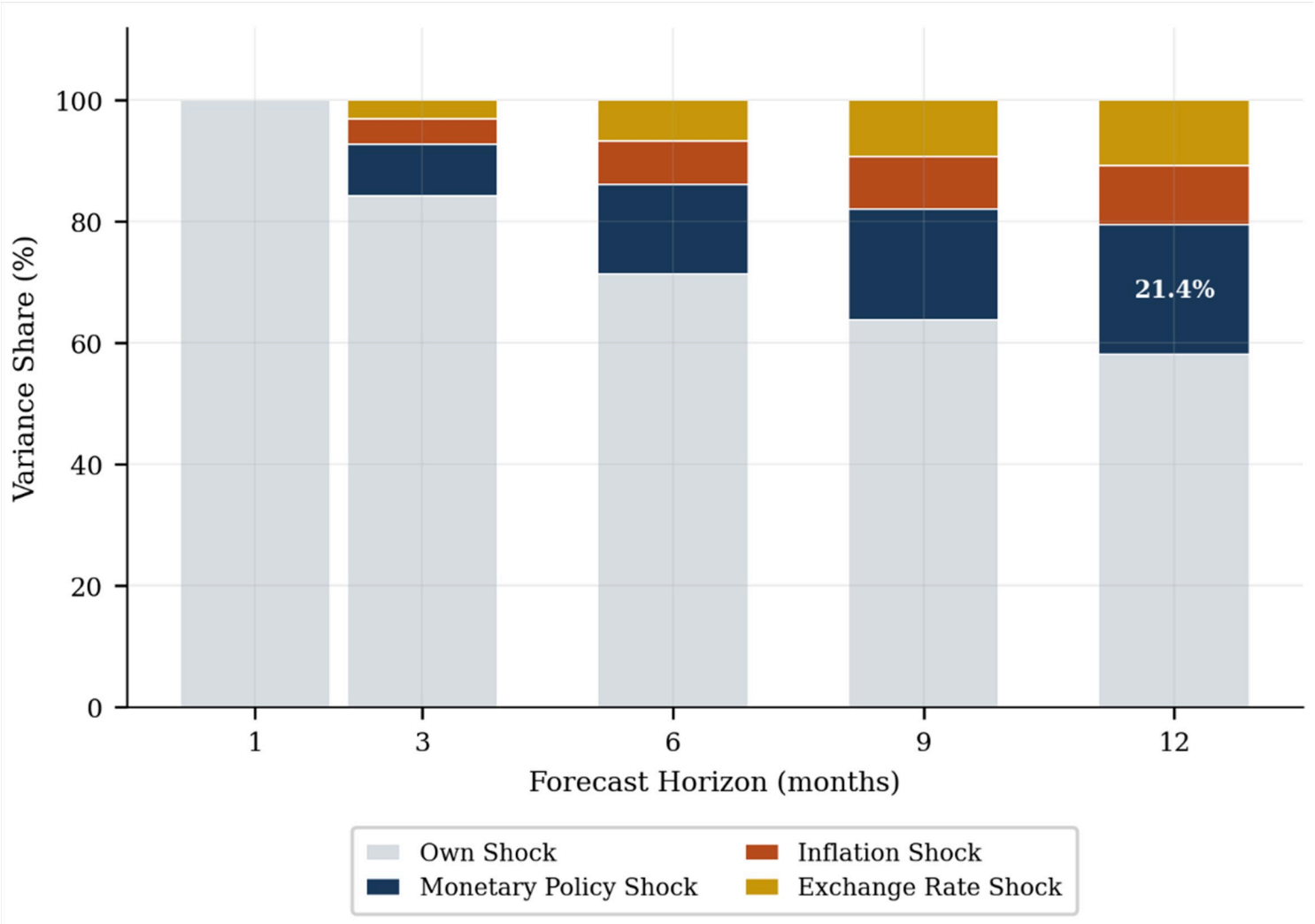


Figure 5

forecast error variance decomposition (FEVD) of GSE returns (%) (12-month horizon)

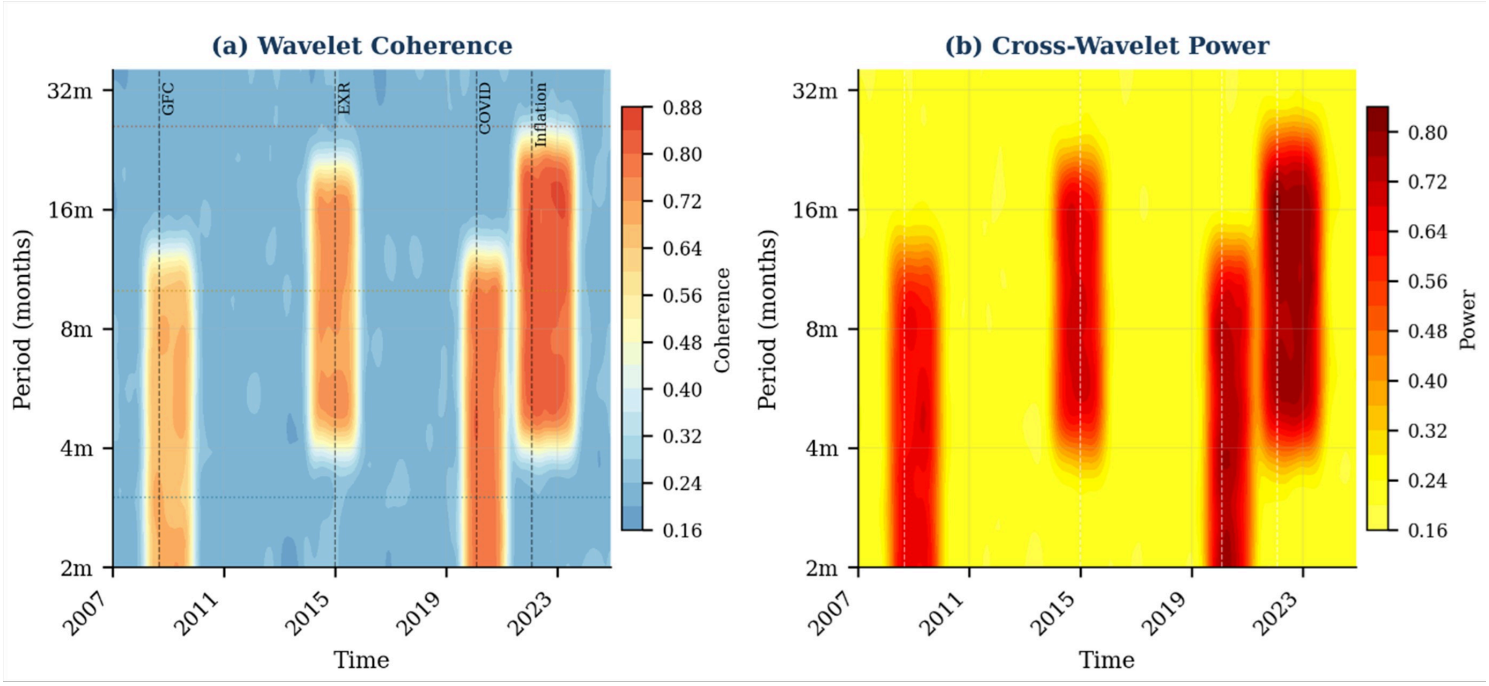


Figure 6

Wavelet coherence and cross-wavelet power — monetary policy shocks and GSE returns (January 2007 - December 2024)