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Regime-Dependent Linkages Across South African Asset Markets and Commodities: Application of Markov-Switching Vector Autoregressive Model

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Abstract

Asset market comovements tend to increase during periods of market stress, reducing the effectiveness of traditional diversification strategies and challenging portfolio theory assumptions. The time-varying interdependence under different market conditions poses significant challenges for investors managing risk and policymakers formulating strategies. This study employs a Markov-Switching Vector Autoregressive (MSVAR) model to examine the regime-dependent linkages between asset markets and fills the gap in knowledge on comprehensive asset market linkages within South Africa. The results indicate that while shocks are transitory in bull markets, they persist for longer in bear markets. All asset markets respond significantly to shocks in the bear regime, suggesting a high level of contagion and reduced diversification opportunities. The foreign exchange market was identified as the main transmitter of risk to the other as-set markets in both regimes. In contrast, shocks emanating from the housing and commodity market were generally not significant. The findings confirm the flight-from-quality hypothesis, with investors preferring high-return assets, such as equities and oil, in bullish periods and safer assets during bearish periods. Bonds fail to act as a safe haven in crisis periods, while gold exhibited safe haven properties in the bear regime, consistent with the flight-to-quality phenomenon. These results have important implications for portfolio diversification and policy interventions. For investors, the ability to identify regime shifts allows for dynamic asset allocation strategies that adjust exposure depending on market conditions. Investors should shift their portfolios toward equities, housing and oil markets during bull periods to capture higher returns. For policymakers, understanding the nature and direction of shock transmission is critical for designing timely and targeted interventions to stabilize markets, such as implementing measures to contain disruptive fluctuations in the foreign exchange market, coordinating fiscal and monetary responses to preserve investor confidence, and developing macroprudential tools to mitigate risk spillover effects between asset markets during crisis periods.

Keywords: Asset market linkages, Bear regime, Bull regime, Flight-from-quality hypothesis

JEL classification: C32, G01, G10, G12, G15

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1. Introduction

With the advent of globalization, financial liberalization and cross-border capital flows, emerging markets have benefited from substantial portfolio inflows in recent years owing to international investors seeking higher yields (Koepke 2019). The globalization of financial markets has facilitated the entry of foreign investors into domes-tic markets, encouraging investment flows that support diversification opportunities (Chopra 2015). The comovement of asset markets is one of the most important inputs in investor's asset allocation decisions. Risk management, portfolio diversification and hedging strategies are considered to be more effective when investors account for the relationships between asset markets. However, the transmission of shocks and contagion across financial markets, which is driven by globalization, has intensified inter-dependence, integration and connectivity in the global economy (Yaya et al. 2024).

Traditionally, hedging assets such as bonds, commodities, and housing have historically been relied upon to offset stock market shocks (Wang 2023). Increasing evidence, however, shows that these markets tend to comove during crises, which undermines their effectiveness as safe havens (Kang et al. 2019). The flight-to-quality phenomenon, where investors shift capital from riskier to safer assets, often results in strong comovements and spillovers during crises (Papadamou et al. 2021). Non-conventional assets may provide alternative diversification benefits. Their limited depth and greater idiosyncratic risks raise concerns about long-term stability and the reliability of their hedging potential. Consequently, understanding the linkages and interdependence between asset markets has become crucial for investors and policy-makers.

Crises often amplify asset market linkages, challenging traditional diversification strategies. Portfolio theory underscores the importance of diversification in mitigating risk by combining assets with low correlations (Markowitz 1959). However, the dynamic nature of asset market linkages challenges this principle, as correlations are not static and may increase during times of economic distress (Markowitz 1959). Events such as the global financial crisis have highlighted the increased interdependence among asset markets during periods of economic turmoil, affecting diversification strategies and risk management (Bredin et al. 2015; Aït-Sahalia and Xiu 2016). The relevance of modeling asset market interdependence under varying market conditions has thus gained prominence. Finance literature provides evidence that traditional as-set markets are integrating with other markets particularly during stress periods. However, the literature focusing comprehensively on South African asset markets is relatively limited compared with abundant literature on international benchmarks. This gap is noteworthy given South Africa's importance as an emerging market with unique vulnerabilities.

Emerging markets present unique opportunities and challenges in understanding asset market linkages. While their partial integration with global markets offers diversification benefits, these markets often experience higher risk and risk during crises (Atenga and Mougoué 2021). In the South African context, asset market correlations have been observed to vary significantly across different market conditions (Papavassiliou 2014). The inclusion of diverse asset classes, such as commodities and real estate, in studies on emerging markets provide a more comprehensive understanding of interdependence and contagion effects (Chang and Cheng 2016).

The study makes the following contributions. This study employed a Markov-Switching Vector Autoregressive (MSVAR) model to capture the regime-dependent linkages between asset markets. As such, the study provides new evidence on how shocks transmit across multiple asset markets in South Africa under different market conditions. By investigating the dynamic relationships across bull and bear regimes, this research contributes to understanding the structural changes in asset market linkages and informs portfolio and risk management strategies. In this context, the South African financial markets deserve particular attention. South Africa plays a distinctive role among

emerging markets as a gateway into Africa and an economy integrated into global finance. The country attracts foreign portfolio flows, yet its markets are characterized by high risk, sovereign downgrades and reliance on external capital (Koepke 2019; Ngwakwe and Sebola 2019). Asset market linkages in South Africa therefore matter greatly for risk transfer, price discovery and portfolio management. The findings have significant implications for risk management and policy formulation. During periods of increased interdependence, traditional diversification strategies maybe less effective at mitigating risks, highlighting the need for alternative approaches, such as incorporating non-traditional asset classes or using hedging instruments (Guidolin et al. 2019). For policymakers, understanding the dynamics of asset market linkages is crucial for designing interventions that stabilize markets during crises and prevent systemic risks (Papadamou et al. 2021).

The remainder of the paper is arranged as follows. Section 2 summarizes a review of the literature. Section 3 describes the data and methodology employed by this study. Section 4 presents and discusses the results of the empirical analysis and Section 6 concludes. after).

2. Literature review

Existing literature often focuses on specific asset pairs or small subsets of assets rather than analyzing the joint behavior of equities, bonds, currencies, real estate and commodities within a unified framework. Within the stock–bond strand, recent evidence confirms state dependence and flight-to-quality dynamics. Sakemoto (2018) investigated the interlinkages between equity and bond markets in developed and emerging markets and found that equity market integration is a key driver of equity–bond comovement, with VIX identified as a key driver of asset market comovements. Soylu and Guloglu (2019) examined the flight-to-quality, flight-from-quality and contagion effects between eight emerging market stocks and US bonds and found evidence of flight-to-quality for five out of the eight markets examined. Lee (2021) investigated the comovement between stocks and treasury bonds in Europe and found evidence of flight-to-quality. Papadamou et al. (2021) examined the effects of the recent COVID-19 pandemic on the dynamic linkages between stock and bond returns for different countries in Europe, Asia, the US and the Australian regions for the January 2020 to April 2020 period and found evidence consistent with the flight-to-quality phenomenon. Methodologically, Das et al. (2018) and Liu et al. (2019) modeled time-varying and tail dependence in equity–bond linkages, while Guidolin et al. (2019) explored the effect of the US subprime crisis on ABS higher grade, treasury repos, treasury notes, corporate bonds and stock markets with a Bayesian estimation technique and identified flight-to-liquidity and correlated information channel. At a broader market level, Kang et al. (2019) examined connectedness, market integration and contagion between equity markets, bonds, commodities and VIX indices and showed that emerging economies are generally net receivers of shocks and developed markets are net transmitters.

Commodities are also considered a financial asset class, providing a hedge for equity price risk, particularly during periods of financial stress and stock market downturn (Chkili 2016). Following the advent of the crisis, the decline in the commodity markets with the simultaneous downturn in the equity markets created an increase in the correlation between both markets (Cheng et al. 2014; Adams and Glück 2015; Reboredo and Uddin 2016). Yıldırım et al. (2018) linked crisis-time oil price swings to financial market inefficiencies. Adewuyi et al. (2019) showed cross-market asymmetric shock spillover and low hedging effectiveness of gold in South Africa. Morema and Bonga-Bonga (2020) showed that the conditional correlation between gold and stock markets is negative during crisis periods, while the dynamic correlation between oil and stock markets is positive and increases during periods of market stress. Ayadi et al. (2021) reported significant

decoupling between equity and commodities during a crisis, except for the BREXIT period, where positive contagion was found. Mensi et al. (2021) showed that oil and gold futures provide significant hedge effectiveness for equity investors in the short term, with gold providing superior performance during periods of high stock market uncertainty. Dai et al. (2020) examined the dynamic dependence and risk contagion between oil, gold and US dollar foreign exchange markets. Sánchez García and Cruz Rambaud (2023) used a GARCH–VAR–Spillover Index approach and showed that risk spillovers between oil and stock markets are bi-directional, with US financial markets transmitting risk to oil during the global financial crisis, oil markets transmitting risk to stocks during COVID-19, and the DAX consistently acting as a net transmitter to Brent.

Empirical evidence on stock–exchange rate linkages is mixed. Exchange rate interactions are central in emerging markets where currency risk is transmitted quickly to domestic assets. Dong and Yoon (2018) documented positive stock–exchange rate relationships, while South African evidence pointed to equities as net transmitters and bonds as net receivers of risk that are amplified by currency channels. Dai et al. (2020) examined the dynamic dependence and risk contagion among oil, gold and US dollar foreign exchange markets for the data period from 1997 to 2018. In recent years, there has been growing literature conducted in African countries. In South Africa, studies found that stock markets respond to shocks emanating from exchange rates markets (Mlambo et al. 2013; Sikhosana and Aye 2018). Sikhosana and Aye (2018) showed precisely this pattern using spillover measures. These findings imply that regime identification should allow currency shocks to alter cross-asset dependence endogenously.

Real estate has become increasingly financialized, and its linkages with equities are regime variable. Two channels frame expectations. The wealth effect supports a positive relation with equities, while capital switching predicts rotation into property when equity risk is high. Using a Markov-switching VAR, Chiang et al. (2020) found that positive spillovers from housing to stocks are more likely in bear regimes, which suggests partial hedging potential that can nevertheless diminish when stress becomes systemic. Using a quantile-on-quantile approach, Caporin et al. (2021) showed that US REIT–equity contagion is regime specific and increased during the European debt crisis. In a broader multi-market setting, Liow and Ye (2018) found that stock and exchange rate returns significantly and positively affect securitized real estate in high-risk states, while bonds relate negatively, which underscores the need for regime-switching specifications.

Multi-asset studies and method papers converge on nonlinearity, asymmetry and state dependence, all of which motivate regime-switching frameworks. Guo et al. (2021) emphasized crisis-state contagion with impulse responses in an MSVAR setting. Skintzi (2019) argued that linear, constant-correlation models misrepresent dependence when tails and asymmetry matter. Faye et al. (2024) confirmed the presence of long-run relationships between gold, art, fine wine, residential real estate and US equities. However, the study found that convergence was nonlinear and time-varying, weakening during episodes of financial stress such as the global financial crisis and European sovereign debt crisis. Moutinho et al. (2025) demonstrated that risk transmission between oil and equities was consistently stronger than between gold and equities, with spillovers intensifying during crises. Gold was found to act as a safe-haven asset in certain markets, though this role was heterogeneous and became more pronounced in later crisis phases.

The literature on asset market linkages reveals a complex and dynamic relationship between different asset classes, influenced by factors such as market conditions and crises. The time-varying nature of these linkages challenges traditional theories and underscores the importance of employing advanced methodologies to capture their evolving patterns. Emerging markets, such as South Africa, provide valuable case studies for understanding these dynamics, particularly in the context of regime-dependent behavior.

3. Research methods and data

3.1. Data description

The data used in this study consisted of six core asset classes available in the South African market: stocks, bonds, foreign exchange, real estate, gold, and oil. These markets were selected owing to their prominence and diversity in representing the financial landscape. Monthly frequency data was employed to ensure consistency with the timeframes of asset market returns. The study period spanned 19 years, from February 2000 to December 2019. This timeframe captured significant financial market developments but intentionally excluded the COVID-19 period because of its unique effect on some resource markets, such as the oil market. Stock market data was obtained from the Johannesburg Stock Exchange (JSE) indices, while bond market data used returns from the All Bond Index (ALBI). The real effective exchange rate (REER) is used as a proxy for the foreign exchange market. The REER is USD-based, trade-weighted across South Africa's main partners, and deflated to remove inflation effects. The series are USD-based because the dollar remains the dominant reserve currency in global international finance, for advanced and emerging economies engaged in international trade and cross-border investment (Butt 2024). Housing performance was captured by the FNB House Price Index (FNB HPI). Commodity exposure used Bloomberg's generic front-month futures for gold (COMEX, GC1) and WTI crude oil (NYMEX, CL1). These rolled contracts keep short maturities, which improve price discovery when spot markets face supply–demand and inventory frictions (Cheng et al. 2014; Chantziara and Skiadopoulos 2008). The inclusion of diverse asset classes provided a comprehensive foundation for understanding the interlinkages within the South African financial markets.

The returns for the different asset markets were computed as the first difference of the natural logarithm of two successive monthly closing prices, computed as follows:

$$r_{it} = \log(p_{it}/p_{it-1}), \tag{1}$$

where r_{it} is the price return of the ith market, p_{it} is the monthly closing price of each asset market index, i = 1…6, at time t.

3.2. Methodology

To determine the dynamic nature of the relationship between the selected asset markets, this study employed the vector autoregressive (VAR) approach and the multivariate Markov-switching vector autoregressive (MSVAR) model (Krolzig 1997). The linear VAR was outlined as follows:

$$y_t = \Psi_0 + \sum_{j=1}^{p} \beta_j \, y_{t-j} + \mu_t \tag{2}$$

where Ψ_0 is the intercept term, β_j is the vector of autoregressive parameters and μ_t is the variance or heteroscedastic parameter. In empirical studies, scholars show that asset return series exhibit characteristics such as fat tail distribution, asymmetry and mean reversion (Kang et al. 2019). Hence, it was necessary to investigate the interdependence of asset markets using the MSVAR model that is able to capture the nonlinearity characteristics asset returns and better describe behavior of asset returns in different market conditions.

The multivariate Markov-switching vector autoregressive (MSVAR) model developed by Krolzig (1997) is an extension of the MS-AR model introduced by Hamilton (1989). The Markov-switching framework does not require a priori identification of crisis periods, the crisis periods are determined endogenously; thus, avoiding the problem of sub-period analysis or threshold dating. Moreover, the Markov-switching framework is able to model financial data series characteristics, such as risk persistence and clustering (Cont 2010). Compared to smooth transition VAR (STVAR) or time-varying VAR models which impose gradual or deterministic parameter changes, the MSVAR model allows for discrete shifts in the joint distribution of returns, consistent with the sudden onset of financial crises and sharp market reversals. A vector autoregressive (VAR) model with Markov-switching coefficients allows for the identification of bull and bear market states. Models are further distinguished depending on the number of VAR parameters that vary across regimes.

The models are further distinguished depending on the number of VAR parameters that vary across regimes. The VAR parameters include the intercept or mean, autoregressive coefficients and the variance-covariance matrix. Krolzig (1997) developed various models belonging to the MSVAR class. These models are classified into two categories; models with switching intercepts (MSI) and models with switching means (MSM). According to Krolzig (1997), the MSI(m)-VAR(p) model where only the intercept varies across regimes is defined as follows:

$$y_t = \chi_{s_t} + \sum_{j=1}^{p} \beta_j \, y_{t-j} + \mu_t, \tag{3}$$

where the residuals are assumed to be normally distributed, conditional on the regime, such that; $\mu_t \sim NID(0, \sum_{s_t})$. $y_t = (y_{1t}, \dots \dots, y_{Mt})$ and t = 1,… T is an M-dimensional time series vector, χ_{s_t} are the matrices of the regime-switching intercept term, β_j are the matrices of autoregressive parameters, p indicates the number of lags of the autoregressive term and $\sum_{s_t}$ is the variance-covariance matrix of a Gaussian zero-mean error process, μ_t. In equation 3, the autoregressive parameters and variance-covariance matrix are homogenous across the regimes and the intercept term is allowed to depend on an unobserved regime variable, s_t. The unobservable state-dependent parameter s_t is a random variable, which results in y_t changing from one regime to another. The intercept parameter, χ_{s_t}, regime-dependency is as follows:

$$\chi_{s_t} = \begin{cases} \chi_1 \; if \; s_t = 1 \\ \vdots \\ \chi_K \; if \; s_t = K \end{cases} \tag{4}$$

In general, s_t is assumed to follow an irreducible ergodic M-state Markov stochastic process with a transition matrix:

$$P = \begin{bmatrix} p_{1,1} & \cdots & p_{1m} \\ \vdots & \ddots & \vdots \\ p_{m1} & \cdots & p_{mm} \end{bmatrix} \tag{5}$$

where $p_{ij} = PR(S_t = j | S_{t-1} = i); \; i, j = 1, \dots \dots, m$ is a transition probability of switching from regime i in time t-1 to regime j in time t. This suggests that the current regime s_t depends on the previous period's regime, S_{t-1}.

The MSM(m)-VAR(p) model allows for regime-dependency in the mean. The equation is written as follows:

$$y_t - \mu_{s_t} = \sum_{j=1}^{p} \beta_j \left(y_{t-j} - \mu_{s_{t-j}}\right) + \mu_t, \mu_t \sim NID(0, \sum_{s_t}) \quad (6)$$

The MSM-VAR and MSI-VAR may also be specified to include regime-dependent autoregressive and error covariance parameters. The study also considered the Markov-switching model with regime-dependent intercepts and heteroscedasticity (MSIH), specified as follows:

$$y_t - \chi_{s_t} = \sum_{j=1}^{p} \beta_{j,s_t} y_{t-1} + \mu_t, \quad (7)$$

The general form of the MSIAH is represented as follows:

$$y_t = \chi_{s_t} + \sum_{j=1}^{p} \beta_{j,s_t} y_{t-1} + \mu_t, \quad (8)$$

where $y_t = (y_{1t}, \ldots . y_{nt})$ refers to an n-dimensional time series vector for the six asset returns examined in this study. χ_{s_t} is a vector of mean returns in a state s_t and β_{s_t} is a 6 x 6 matrix of autoregressive coefficients in the state s_t.

$$\mu st_{nt} \sim N(0, \sum_{s_t}), \quad (9)$$

where $\mu_t = (\mu_{1t}, \ldots, \mu_{nt})$ and $\sum_{s_t}$ is a n x n variance-covariance matrix conditional on S_t:

$$\sum_{s_t} = \begin{bmatrix} \sigma_{1,1,s_t} & \cdots & \sigma_{1,6,s_t} \\ \vdots & \ddots & \vdots \\ \sigma_{6,1,s_t} & \cdots & \sigma_{6,6,s_t} \end{bmatrix} \quad (10)$$

and

$$\rho_{v,w,s_t} = \frac{\sigma_{v,w,s_t,}}{\sigma_{v,s_t}\sigma_{w,s_t}} \quad (11)$$

is the contemporaneous correlation between the returns on assets in a state S_t.

The transition probabilities provide the expected duration that the system is expected to remain for a particular regime: $E(D_v) = \frac{1}{1-p_{v,v}}, v = 1,2, \ldots m$ where D_j denotes the duration of regime v.

The conditional distribution of y_t (conditional on the state s_t and on past information is:

$$f(y_t|y_{t-1}) = \sum_{i=1}^{M} f(y_t|S_t, y_{t-1}) \, Pr(S_t|y_1, \ldots, y_{t-1}) \quad (12)$$

where M represents the number of possible regimes. The log-likelihood function is then:

$$L = \sum_{t=1}^{T} ln[f(y_t|y_{t-1})], \quad (13)$$

where T is the number of observations in the data set. The expected maximization (EM) algorithm developed by Dempster et al. (1977) is used to maximize the log-likelihood value over the parameters μ_{s_t}, β_{s_t} and $\sum_{s_t}$ for s_t= 1,…., M and for the transition probabilities P. The EM starts with estimates of hidden data and iteratively produces a new joint distribution that increases the nonlinear probability of observed data.

One of the advantages of using a Markov-switching framework is the derivation of regime-dependent impulse response functions (IRFs), which can determine the state-dependent responses of variables to a shock in the economic system (Ehrmann et al. 2003). The IRFs allow for further investigation of the performance of different markets in the various regimes. The IRF can measure the magnitude of asymmetrical effects on market performance and the direction in which markets

respond to shocks in the VAR system (Shahrestani and Rafei 2020). The IRFs trace the effects of innovation in the economic system over time. The conventional method of conducting impulse response function analysis in the absence of structural shifts can result in misleading conclusions about the dynamic relationship between asset returns; thus, regime-dependent impulse response functions are used to describe the relationship between endogenous variables and fundamental disturbances within each Markov-switching regime. The IRFs were thus estimated according to the prevailing regime at the time the shock impacts on the system and throughout the duration of the response.

Assuming that the shock transmitted to the N_{th} endogenous variables in t_0, the contemporaneous response vector will determine the effect of the N_{th} random disturbance on the endogenous variables in t_0. The general form of the impulse response functions for a shock to the economic system, ε_t^0 is denoted as follows:

$$IRF(N) = E[Y_{t+N}|\varepsilon_t = \varepsilon_t^0, \Psi_{t-1}^0] - E[Y_{t+N}|\Psi_{t-1}^0] \quad (14)$$

where the history of the process up to period t-1 is known and denoted by the information set Ψ_{t-1}^0. The IRFs are estimated assuming that $\varepsilon_t \sim N(0, \sum)$, and $E(\varepsilon_t|\varepsilon_{wt} = \delta_w) = (\sigma_{1w}, \sigma_{2w}, \dots, \sigma_{mw})'\sigma_{ww}^{-1}\delta_w$, where $\delta_w = (\sigma_{ww})^{-1/2}$ denotes a one standard error shock. However, when considering a nonlinear context, the effects depend on shocks that occur between t and t+N, and on the history of past shocks, j_{t-1}. Guided by a similar approach used by Ehrmann et al. (2003), the regime-dependent generalized IRFs of a variable v for an arbitrary shock to variable w denoted by ε_wt=δ_w and historical shock j_{t-1} are denoted as follows:

$$GIRF(N, \delta_w, j_{t-1}) = E\left(Y_{i,t+N}\middle|\varepsilon_{wt} = \delta_w, j_{t-1}\right) - E\left(Y_{i,t+N}\middle|j_{t-1}\right) \quad (15)$$

The usefulness of regime-dependent IRF analysis depends on whether the regimes are highly persistent and also the time horizon of the regime (Shahrestani and Rafei 2020). One of the important features of the GIRF is that the generalized responses are not affected by the ordering of the variables in the system, which is an advantage compared to the orthogonality approaches. Because of this, the GIRF allows for a meaningful interpretation of the initial response of each variable to shocks emanating from other variables. To identify flight-to-quality episodes, an analysis of the IRFs is performed. The flight-to-quality phenomenon would take place when following a shock, investors sell a risky asset and buy a safer asset. Thus, evidence of the flight-to-quality effect is observed when the price of the risky asset falls and the price of the safer asset rises. The correlated information channel is identified through the nonlinear effect captured by the MSVAR (Guidolin et al. 2017), specifically, the effect generated by a shift to the bear regime.

4. Results and discussion

4.1. Descriptive statistics

Table 1 reports the descriptive statistics for the monthly returns of equity, bond, housing and foreign exchange markets and commodities markets (gold and oil). All series exhibit positive mean returns, indicating a generally bullish sample. The returns are generally low and there is a significant disparity between the maximum and minimum monthly returns for the sample period. The average monthly returns are 0.84 percent for equities, 0.84 percent for bonds and 1.02 percent for gold.

The oil market has the highest return and standard deviation over the sample period, while the housing market has the lowest return and standard deviation, consistent with oil's higher risk and real estate's smoother adjustment. In addition, consistent with the literature (Andersen et al. 2007; Morales et al. 2014), analysis of the return series indicates that stock returns display a high standard deviation in line with prior evidence of pronounced equity risk, and the foreign exchange market appears less risky than bonds over this sample. The risk-return tradeoff for the asset markets is consistent with portfolio theory.

Distributional features reinforce these risk patterns. Equities and oil are negatively skewed, implying greater downside tail risk and a higher probability of large losses, which is consistent with their higher volatility. In contrast, bonds, currency and housing displayed positive skewness, indicating smoother return distributions with occasional upside movements. Kurtosis values above three confirm that all return series are leptokurtic with fat tails. The Jarque–Bera test rejects normality at the 5 percent level for every asset, confirming that the returns are asymmetric and heavy tailed. This behavior is consistent with volatility clustering and regime shifts found in emerging financial markets (Chen et al. 2022). The non-normality is a common finding for financial time series data (Brooks 2019) and suggests that the return dynamics cannot be adequately captured by linear models that assume constant variance and symmetric shocks. Consequently, the MSVAR model was estimated using the Huber-White covariance method, which provides Quasi-Maximum Likelihood (QML) consistent standard errors that are robust to heteroscedasticity and non-normality.

The results of the unit root tests in Table 1 show that the ADF and PP tests produced strongly negative statistics for all variables, except housing, leading to a rejection of the null hypothesis of a unit root at conventional significance levels. This confirms that these series are stationary at levels (I(0)). The unit root test results for the housing series showed insignificant ADF and PP statistics, indicating a failure to reject the null hypothesis of a unit root. The first-differenced results, however, indicated strongly significant negative statistics, confirming that housing returns are integrated at order one, I(1). In addition, the KPSS statistics for all I(0) series were below their critical values, further confirming their stationarity. However, the values for bonds and forex were close to the margin, implying mild persistence or near-unit-root behavior, where shocks to these markets fade gradually and may lead to prolonged volatility periods. To account for potential structural breaks, the Zivot–Andrews test was applied, and the break-adjusted results further confirmed the stationarity for all return series at levels, indicated by the strongly negative and significant test statistics. Hence, all variables are I(0) or I(1), which supports MSVAR estimation.

The unconditional correlation among the asset markets is presented in Table 2. Overall, the significant correlations between the markets ranged between -0.41 and 0.34. Between the asset markets, a significant negative correlation was found between the oil and bond markets, indicating that bond prices tend to rise when oil markets weaken, reflecting a possible safe haven role of bonds during oil price downturns. The highest significant positive correlation was between the stock and oil futures markets, 0.34 significant at the 1 percent level, suggesting that oil price movements are closely related with stock market dynamics. Housing markets also showed a significant positive correlation with the stock market, 0.13, suggesting common drivers between financial and real asset markets. The exchange rate displayed a significant negative correlation with the bond market, suggesting that domestic currency depreciation is associated with declining bond values, while its significant positive correlation with gold supports the notion that gold serves as a hedge against currency weakness (Chen et al, 2022). Gold displayed a significant negative correlation with the bond market (-0.19) and a significant positive correlation with oil (0.29), highlighting its dual role as both a diversifier and a commodity-linked asset. Overall, these results show that while some asset pairs move independently, others exhibited significant comovements which has implications for portfolio diversification and safe haven strategies.

Table 1 - Descriptive statistics

Variable	STOCK	BOND	HOUSING	FOREX	GOLD	OIL
Mean	0.0084	0.0084	0.0068	0.0035	0.0102	0.00625
Median	0.0098	0.0076	0.0051	0.0009	0.0135	0.0081
Maximum	0.1313	0.0864	0.0302	0.1834	0.1859	0.2355
Minimum	-0.1503	-0.0563	-0.0139	-0.1021	-0.1504	-0.3080
Std. Dev.	0.0463	0.0208	0.0079	0.0377	0.0564	0.0947
Skewness	-0.2521	0.1999	0.6987	0.7401	0.0967	-0.4540
Kurtosis	3.6547	3.9874	4.1518	5.9528	3.7176	3.4316
J-B	6.7710***	11.2525***	32.5231***	108.1913***	5.4777*	10.0240***
PP	-15.9697***	-14.4259***	-3.2514*	-11.2505***	-17.2581***	-15.4672***
ADF	-15.9777***	-14.4515***	-2.8241	-11.3350***	-17.2741***	-15.3308***
KPSS	0.0527	0.0497	0.0422	0.0627	0.0526	0.0293
ZA	-16.3932***	-14.73941**	-5.2007***	-11.4991***	-17.5292**	-15.5740***
BDS test	0.0152***	0.0134***	0.1650***	0.0167***	0.0085*	0.015524***
Q(12)	6.5013	9.2520	78.004***	10.583	13.344	16.580
Q2(12)	77.261***	7.6919	38.521***	10.424	21.145**	23.117**
ARCH LM	8.3511***	3.2634*	319.3077***	0.1359	1.3766	8.8519***

Notes: (*) Significant at 10%; (**) Significant at 5%; (***) Significant at 1%. Unit root tests are performed for the intercept. Zivot and Andrews (ZA) (1992) were performed allowing for one structural break in the constant. BDS has two dimensions.

Table 2 - Unconditional correlation

Variable	Stock	Bond	Housing	Forex	Gold	Oil
Stock	1.0000					
Bond	0.0422	1.0000				
Housing	0.1330**	0.0661	1.0000			
Forex	-0.0939	-0.2733***	-0.0975	1.0000		
Gold	0.1186*	-0.1910***	-0.0089	0.3378***	1.0000	
Oil	0.3385***	-0.4073***	0.0081	0.1058	0.2931***	1.0000

Notes: (*) Significant at 10%; (**) Significant at 5%; (***) Significant at 1%

4.2. Regime-switching behavior of asset market returns: preliminary analysis and model selection

This section tested for nonlinearity and selected the appropriate VAR specification. First, following Reboredo (2010) and Chen et al. (2019), the Brock, Dechert and Scheinkman (BDS) test was applied to residuals. As shown in Table 1, most p values were below 5 percent, thus, the null of linear dependence was rejected. This result indicates that the dependence structure among asset returns is nonlinear and cannot be adequately examined by a linear VAR model. Despite generally moderate unconditional correlations, the BDS test indicates cross-market dependence varies across regimes, supporting the use of a nonlinear framework such as the MSVAR. Next, lag length was chosen using information criteria. The AIC and FPE favored two lags, while the SIC and HQC favored one lag. Given the sample size, SIC and HQC were preferred, therefore a one lag VAR was adopted. Model selection then compared five Markov-switching specifications, MSI, MSIH, MSM, MSIA and MSIAH, under two and three regimes. The AIC and HQC indicated that a two-

regime structure fit best, consistent with Chen et al. (2019), Chiang et al. (2020) and Shahrestani and Rafei (2020). Table 3 Panel A shows that the MSIAH(2)-VAR(1) achieved the lowest AIC and the highest log likelihood, which aligned with Roubaud and Arouri (2018) and Chiang et al. (2020). Finally, a likelihood ratio test, following Garcia and Perron (1996), with significance assessed using Davies' critical values, rejected the null of no regime changes. Panel B of Table 3 confirmed that MSVAR dominated the linear VAR in fit, which indicated regime-switching behavior in asset returns and justified the MSIAH(2)-VAR(1) as the preferred empirical specification. The selection of the MSIAH-VAR was motivated by the nonlinear dynamics inherent in financial returns. The periods of expansion and contraction are characterized by simultaneous regime shifts in the first and second moments. During bullish conditions, investor confidence and stable liquidity lead to higher returns and lower volatility. In bearish conditions, investors engage in flight-to-quality behavior, by shifting toward safer assets, causing the returns of risky assets to fall. These periods show increasing volatility and cross-market linkages. The MSIAH specification captures these dynamics by allowing for time variance in the intercept and variance-covariance matrix, which is important for modeling volatility clustering and contagion effects

Table 3 - Selection criteria and likelihood test

Panel A: Model Selection Criteria				
Model	LL	AIC	SIC	No. of coeff.
Linear VAR(1)	3268.377	-27.3422	-26.7257	42
MSM (2)-VAR(1)	3243.727	-26.7741	-25.7351	71
MSMH (2)-VAR(1)	3238.197	-26.6008	-25.3424	86
MSIH (2)-VAR(1)	3316.896	-27.2143	-25.8681	92
MSA (2)-VAR(1)	3295.213	-26.9554	-25.4774	101
MSIA (2)-VAR(1)	3345.666	-27.4463	-25.8759	107
MSIAH (2)-VAR(1)	3389.330	-27.6161	-25.7374	128
MSIAH (3)-VAR(1)	3481.256	-27.2546	-24.9876	195
Panel B: Likelihood test				
	VAR	MSIAH (2)-VAR(1)		LR test stat
Log-likelihood	3268.377	3389.330		241.906***

Figure 1 presents the monthly returns for the six asset markets. The plot shows that all markets exhibited high risk during the 2008 global financial crisis. Consistent with the unit root test results, all asset return series were stationary at their levels, with the exception of the housing market.

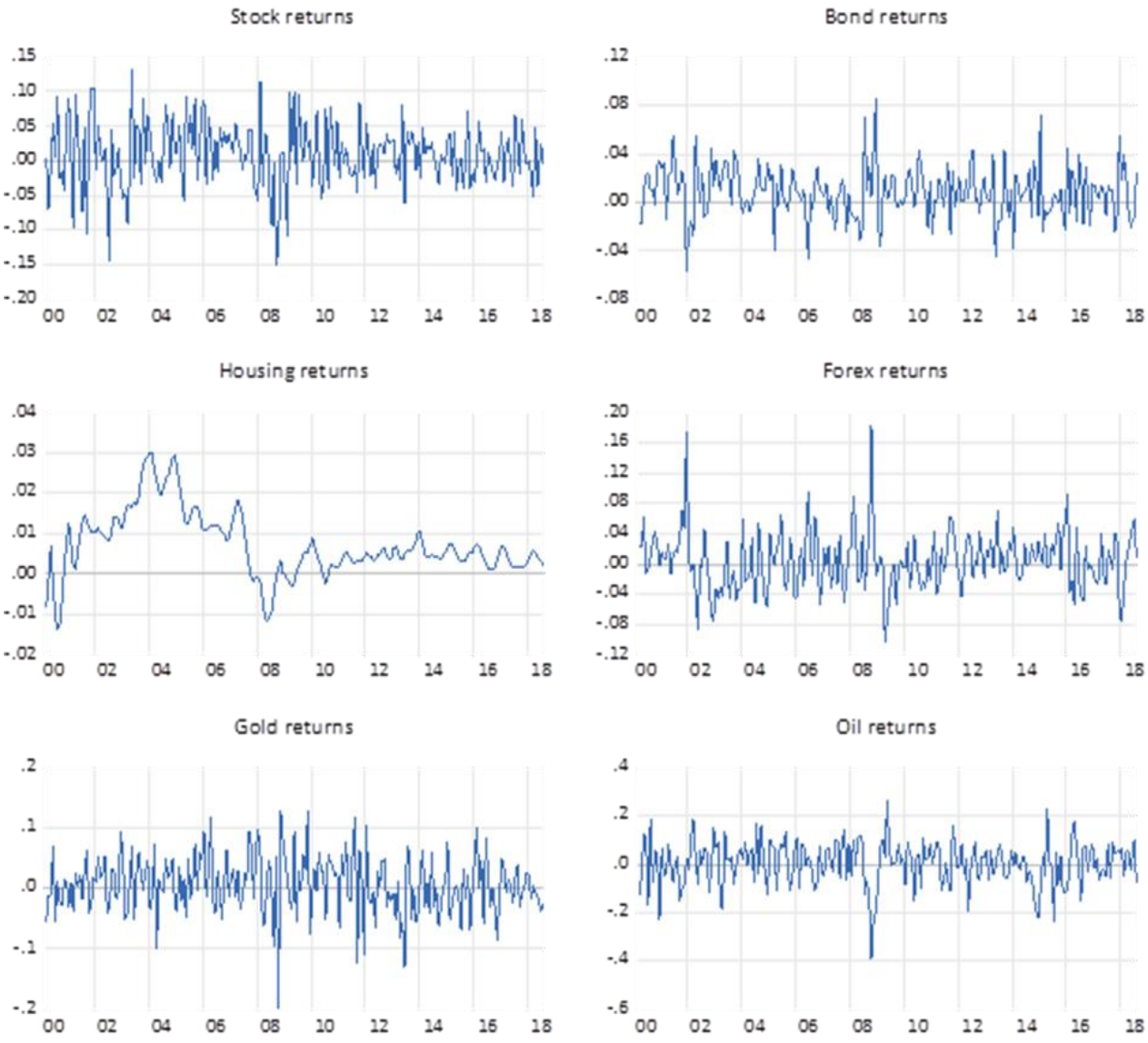


Figure 1 - Asset return series

4.3. MSVAR transition probabilities and expected regime properties

Table 4 reports the results for the autoregressive coefficients, regime transition probabilities, ρ_{11} and ρ_{22} and the expected durations for the MSIAH (2)-VAR (1) model. The model captures two latent regimes in the asset markets. The regimes are identified by observing the mean returns that differ across regimes, thus suggesting first moments distinguish the regimes. Regime 1 was identified as the bull market state (bull regime), with positive mean returns in the stock, housing and oil markets. This result is consistent with the flight-from-quality hypothesis, which suggests that during bullish periods, investors have a preference for high-return investment assets.

Table 4 - Selection criteria and likelihood test

Panel A: Estimated parameter values						
	Stock	Bond	Forex	Housing	Gold	Oil
χ_1	0.0092	-0.0073	-0.2352***	0.0023	-0.0848	0.3338
χ_2	-0.1099	-0.0412	0.1711	-0.0067	0.2119	-0.0613
$\beta_{1,stock}$	0.1504	-0.0140	-0.1854	0.0062	0.0910	-0.1804
$\beta_{2,stock}$	0.1785	0.0880	-0.5010***	-0.0158	-0.0162	-0.8684
$\beta_{1,bond}$	0.0150	-0.0410	0.0566	-0.0022	-0.0319	-0.0228
$\beta_{2,bond}$	0.4364***	0.0689	0.1924	-0.0093	0.2016	-0.9184***
$\beta_{1,forex}$	0.4454	0.4723	0.1025	0.6787***	-1.4923	-6.9487
$\beta_{2,forex}$	-5.2331	2.9129***	1.2814	0.3376	3.8262	0.6120
$\beta_{1,housing}$	-0.0750	0.0073	0.2431***	$-3.55e^{-5}$	-0.1235	-0.2068
$\beta_{2,housing}$	-0.0452	0.0499	0.1349	-0.0073	0.0365	-0.1840
$\beta_{1,gold}$	-0.0621	-0.0174	0.0317	0.0007	-0.0423	-0.0723
$\beta_{2,gold}$	-0.0075	-0.0272	-0.1353	-0.0033	-0.2667***	0.0714
$\beta_{1,oil}$	0.0133***	0.0075***	0.0013	-0.0001	0.0076	0.0036
$\beta_{2,oil}$	-0.0156	0.0105***	0.0193***	0.0005	0.0249	0.0411***
σ_1	0.0014***	0.0003***	0.0010***	$1.20e^{-6}$***	0.0023***	0.0086***
σ_2	0.0035***	0.0007***	0.0012***	$9.44e^{-6}$***	0.0049***	0.0065***
Panel B: Regime properties						
ϱ_{11}	0.9074					
ϱ_{22}	0.6576					
Dur_1	10.7970					
Dur_2	2.9204					

In contrast, Regime 2 showed positive mean returns only for forex and gold, with values of 0.47 and 0.67, respectively. These results provide evidence in support of the flight-to-quality phenomenon, which results in the price of currency and gold increasing when other markets are declining during an economic crisis (Baur et al. 2021). Regime 2 was thus classified as the bear market state (bear regime) with relatively lower returns and high risk in asset markets. The results imply that portfolio diversification strategies should increase exposure to equities, housing and oil markets in bullish periods, and reallocate toward gold and forex markets during crises to minimize losses. These findings are consistent with Chen et al. (2022) and Ryan et al. (2024), who also identify gold and currencies as safe havens in turbulent periods.

The probability of remaining in a bull regime, given that the current regime (p11) is bull, was 0.91 and the probability of transitioning from a bullish period to a bearish regime in the next period was 0.66 (p12). This means that once markets enter a bull period characterized by rising prices and strong investor sentiment, there is a higher probability that such optimism and growth will persist. However, the relatively high probability of switching from a bull to a bear regime suggests that despite this persistence, markets remain vulnerable to reversal when major shocks occur.

The duration of the regime indicates the persistence of one state compared to the second state. The duration of the bullish regime was five times longer than the bearish regime. The average duration of the bull market periods (Regime 1) was 10.80 and was higher than the duration of bear market periods (Regime 2), which was 2.92, indicating that the low risk regime is more persistent. These results are consistent with recent evidence by Moutinho et al. (2025), who report that co-risk persistence peaks during periods of financial turmoil but remains shorter in duration than tranquil regimes.

The results indicated that the autoregressive parameter estimates were mostly non-significant at all levels of significance in the bull regime compared to the bear regime. This suggests that during stable periods, asset prices are largely driven by their own fundamentals rather than by spillovers from other markets. Cross-market dependence is weakened by market efficiency and investor confidence in this regime. The results revealed a significant bidirectional relationship between the exchange rate and housing markets in the bull regime, suggesting that shocks in either market transmit to the other and create feedback effects. The dual causality suggests that currency appreciations may raise housing prices by reducing import input costs and reducing financing costs. Rising property prices may attract foreign investors, thus increasing capital inflows and further strengthen the domestic currency (Koepke 2019). This effect suggests close interdependence between housing market prices and currency movements during expansionary periods. In the bull regime, the oil and stock markets had positive average returns while the returns on bonds, currency and gold were negative; however, these values were insignificant. Contrastingly, in the bear regime, none of the average returns were significant, however, there were significant transmission channels linking stocks, bonds, forex, gold and oil. These results imply that while the linkages in the bull market are limited, in the bearish regime contagion channels magnify across asset market, thereby increasing systemic risk.

The turning point of the regimes was determined from the smoothed probabilities of the bull market regime displayed in Figure 2. The peaks in the smoothed regime probability graph coincided with economic, financial and socio-political factors globally and domestically in South Africa. For example, the markets reacted significantly during periods coinciding with the 2001–2002 Dotcom crisis, the 2007–2008 global financial crisis period and the 2010–2011 European debt crisis (Mensi et al. 2021; Umar et al. 2021). This coinciding process confirms the accuracy of the collected data and estimated results in reflecting the real-life events.

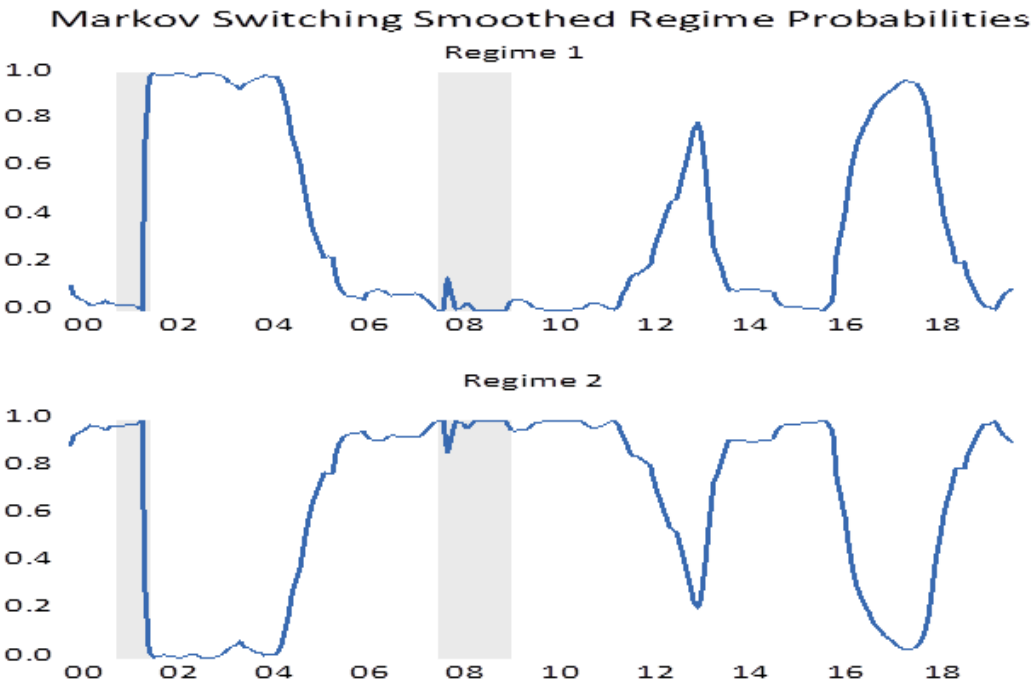


Figure 2 - Smooth regime probabilities

4.4. Results for the regime-dependent impulse response functions

Similar to Guidolin and Pedio (2017), this study explored financial contagion and transmission channels; flight-to-liquidity, flight-to-quality, and the risk premium channel. Figures 3 and 4 display the impulse response functions for the different asset market returns. The shocks to the system are equivalent to one standard deviation of the residuals derived from the MSVAR framework and the impulse responses are mapped out for a period of twelve months. Choleski-decomposition ordering is applied to ensure that the correlations in the innovations imposed on the variables in the MSVAR estimation are equivalent to zero (Liu et al. 2019). A limitation of Choleski-decomposition ordering is that the ordering of the variables in the MSVAR system influences the magnitude of the contemporaneous correlations of the innovations. Hence, for robustness, the MSVAR model was estimated with different orderings.

The IRFs indicate each asset market's response to its own shocks and from other markets under two regimes, thus providing further justification for estimating regime-dependent IRFs. Figures 3 and 4 present the impulse response functions (IRFs) for Regime 1 and Regime 2, respectively. Overall, the results from the impulse response analysis indicate that the asset returns have heterogeneous responses to shocks emanating from another market across the two different regimes, which suggests time-varying linkages between markets.

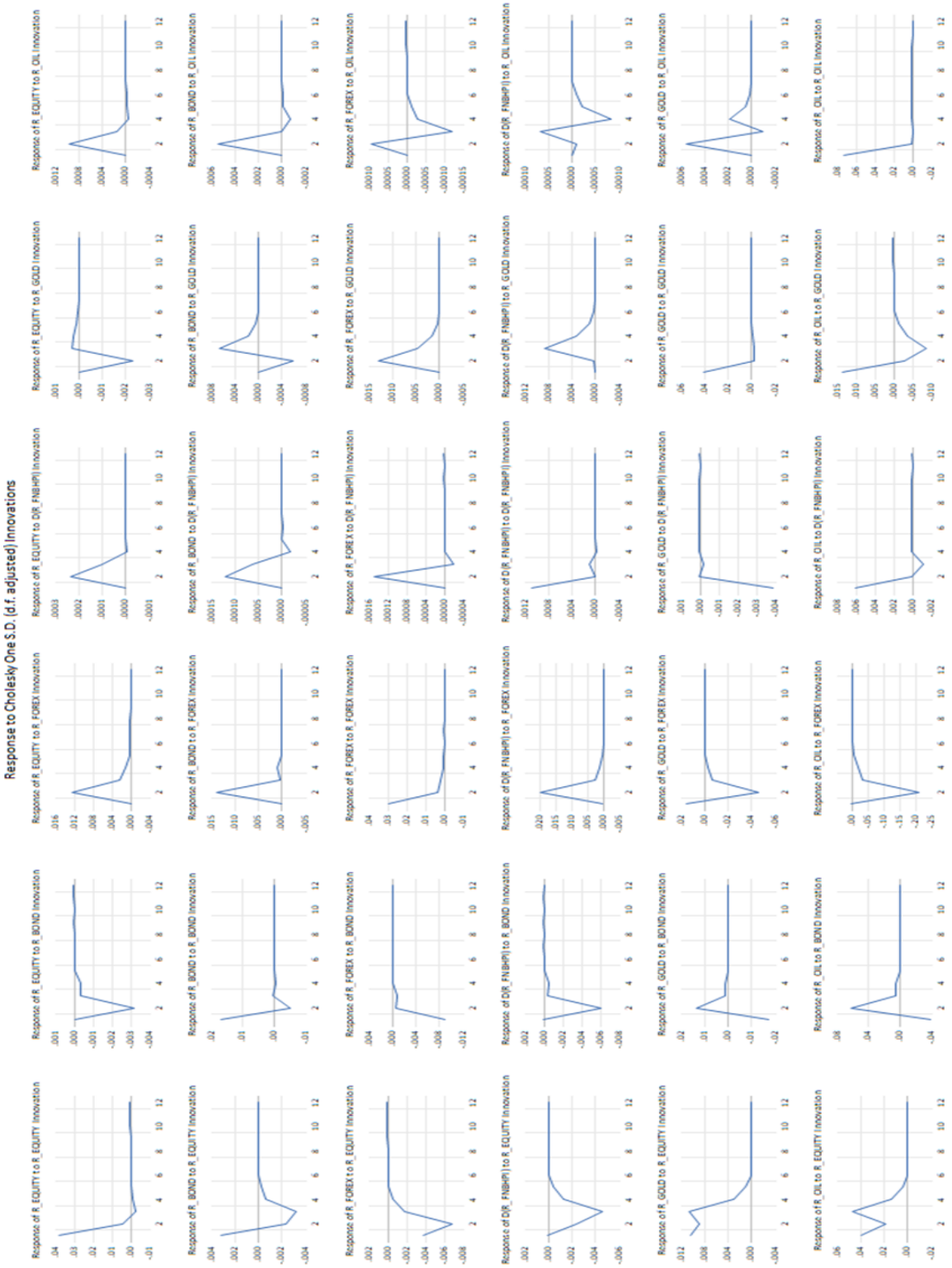
In the bull regime, the responses are concentrated in the short term, peaking within three months before reverting to equilibrium. In the early months following a shock, the immediate and short term responses reflect informational contagion, where investors revise valuations across assets in response to new information signals. These short-term adjustments are consistent with the correlated information effects that occur simultaneously across markets (Guidolin and Pedio 2017).

In the bear regime, the response of the asset market returns to a 100-basis point shock in other asset markets is higher in magnitude and the effects occur in the latter months (long-run) and are more persistent. These results are consistent with Ruzgar (2025), who found that BRICS stock markets become more volatile during crises, with greater market integration and reduced diversification opportunities. The persistence of these effects imply that markets move from an information-driven adjustment process to a structural contagion process, where risk aversion and capital outflows increase volatility. In contrast, the effects of innovations in the bull regime are short-lived and market reactions last less than six months before reverting to equilibrium. The reaction to a shock in the second regime is also higher compared to the first regime. This result is similar to Mokni and Youssef (2020) who found that the contagion effects between markets were more significant in the bear regime compared to the bull regime. The results further showed that asset returns were more responsive in the short term to innovations in the bull regime compared to the bear regime. In the short term, shocks transmit primarily through the flight-to-liquidity channel, owing to investors selling risky and less liquid assets to rebalance their portfolios. Over the long term, the risk premium and flight-to-quality channels dominate. These time-varying channels explain why diversification benefits deteriorate more sharply in the bear regime.

The effects of own shocks are more significant in the bull regime than in the bear regime, however, the effects are short term. This result suggests that the assumption of market efficiency does not hold, as past asset returns can predict current asset returns (Tudor and Anghel 2021). The feedback effects from the exchange market to the other asset markets are significant in both regimes. In particular, a one standard deviation shock in the exchange rate has a positive impact on stock, bond and housing returns in the bull regime. In contrast, the exchange rate impacts commodities, such as gold and oil. These findings suggest that forex markets are net transmitters of risk within the other asset markets. The impact of exchange rates on asset prices is explained through the flow-oriented model, which emphasizes that changes in exchange rates affect international

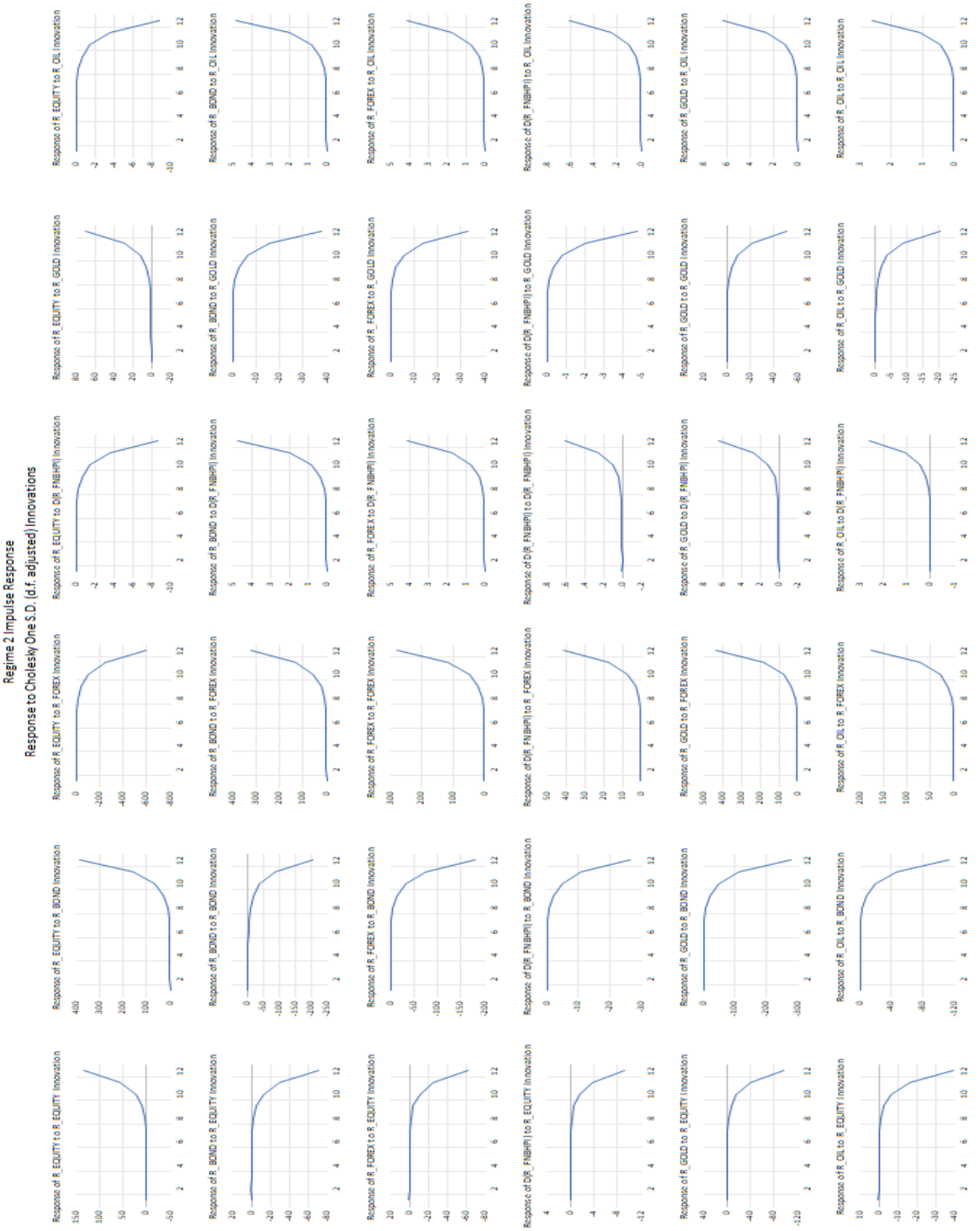
competitiveness, alter trade balances, influence national output, and ultimately shape stock prices (Sikhosana and Aye 2018; Dornbusch and Fischer 1980). Currency depreciation increases the demand for a nation's exports and results in an improvement in the trade balance. Thus, depreciation stimulates aggregate demand and increases the level of economic activity in a nation. Similarly, the stock-oriented model and the arbitrage pricing theory hypothesize a relation between exchange rate movements and stock returns (Gavin 1989; Mitra 2017).

In the bear regime, the effects of innovations have a long-run persistence. Bond and currency market innovations have opposite effects on asset markets. This result is consistent with Meyer and Hassan (2020) and Boakye et al. (2025), who showed that exchange rate volatility adversely affects African bond markets by raising yields and significant withdrawals of portfolio investments. The response of stock returns to bond market shocks is positive and peaks in the latter months. This result suggests contagion effects, which means that bonds cannot act as a hedge or diversifier for stock markets during periods of market turmoil. This result is similar to Flavin and Lagoa-Varela (2021) who found that bond market risk shocks have a positive impact on stock markets, therefore, resulting in an increase in comovements between stock and bond markets during periods of financial distress.



Source: Author's own depiction.

Figure 3 - Regime 1 impulse response functions



Source: Author's own depiction.

Figure 4 - Regime 2 impulse response functions

5. Conclusions

Allocating assets among different financial markets is important, particularly during periods of market downturns. The principle of portfolio diversification suggests that investing in assets that are weakly correlated can minimize losses that may occur as a result of a market crisis. It is therefore important to understand the extent of interlinkages between asset markets to maximize portfolio returns and minimize risk exposure. This study filled the gap in knowledge regarding the scarce literature on the comprehensive asset market linkages within South Africa using the MSVAR. The results indicate that the relationship between asset markets is distinguished by two regimes, namely, the bull regime which had a longer duration, and a shorter bear regime characterized by stronger and more persistent shocks.

We derived interesting conclusions. Firstly, the study concludes that South African asset markets experience persistent shocks in the bear regime compared to the bull regime. Secondly, there is a high level of contagion or reduced diversification opportunities across all the asset markets in the bear regime, evidenced by their significant response to shocks. Thirdly, the foreign exchange market is the main transmitter of risk to the other asset markets, regimes notwithstanding. Lastly, the study concludes that investors' preferences are regime-dependent, evidenced by flight-from-quality and flight-to-quality phenomena in bullish and bearish periods respectively. During bullish periods, investors channel capital toward high-return assets such as stock and oil, while in bearish periods, they reallocate to safer assets such as gold.

This study is important to investors because correctly identifying the market interdependence facilitates the implementation of better portfolio diversification strategies. It also helps policymakers because the efficacy of policy interventions depends on understanding the underlying shock transmission channels. Investors should adopt regime-dependent portfolio strategies. During bullish conditions, global investors should overweight their portfolios in equities, housing and oil markets to benefit from their high-risk premia. However, oil becomes pro-cyclical in bear markets, and commodity markets react positively to foreign exchange shocks. Therefore, investors should rebalance their portfolios by reducing unhedged oil and equity exposure to limit contagion. Institutional investors should stress-test their portfolios under both market conditions to understand the potential losses. From a policy perspective, strengthening the domestic financial markets is essential to reduce exposure to foreign exchange shocks and contagion across asset markets. This is achieved by improving central-bank liquidity support, managing exchange rate volatility and ensuring adequate hedging instruments in domestic markets. Macroprudential buffers should be adjusted according to the regime signals to prevent excessive leverage during expansion and cushion liquidity shortages in market downturns. Futhermore, policymakers can promote the development of alternative safe-haven assets, such as ESG-linked bonds, to further diversify domestic investors' risk exposure and enhance market resilience against systemic shocks. Future studies could extend this research to explore other transmission mechanisms such as the fundamental channel related to foreign direct investment and the financial channel which explains investor behavior. It is also important to acknowledge the evolution and development of advanced models. Incorporating wavelet analysis and network-based Markov Chain can provide valuable insights.

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Conflict of interest

No conflict of interest.

References

Adams, Z., Glück, T. (2015). Financialization in commodity markets: a passing trend or the new normal?. *Journal of banking & finance*, 60, 93-111.

Adewuyi, A. O., Awodumi, O. B., & Abodunde, T. T. (2019). Analysing the gold-stock nexus using VARMA-BEKK-AGARCH and Quantile regression models: New evidence from South Africa and Nigeria. *Resources Policy*, *61*, 348-362.

Aït-Sahalia, Y., & Xiu, D. (2016). Increased correlation among asset classes: Are volatility or jumps to blame, or both?. *Journal of Econometrics*, *194*(2), 205-219.

Andersen, T. G., Bollerslev, T., Diebold, F. X., & Vega, C. (2007). Real-time price discovery in global stock, bond and foreign exchange markets. *Journal of international Economics*, *73*(2), 251-277.

Atenga, E. M. E., Mougoué, M. (2021). Return and volatility spillovers to African equity markets and their determinants. *Empirical Economics*, *61*(2), 883-918.

Ayadi, A., Gana, M., Goutte, S., Guesmi, K. (2021). Equity-commodity contagion during four recent crises: Evidence from the USA, Europe and the BRICS. *International Review of Economics Finance*, *76*, 376-423.

Baur, D. G., Prange, P., Schweikert, K. (2021). Flight to quality–Gold mining shares versus gold bullion. *Journal of International Financial Markets, Institutions and Money*, *71*, 101296.

Boakye, R. O., Mensah, L., Kang, S., Osei, K. (2025). Connectedness across commodities, stocks, exchange rates and bonds markets in Africa: The Covid-19 pandemic case. *International Journal of Emerging Markets*, *20*(8), 3437-3464.

Bredin, D., Conlon, T., Potì, V. (2015). Does gold glitter in the long-run? Gold as a hedge and safe haven across time and investment horizon. *International Review of Financial Analysis*, *41*, 320-328.

Brooks, C. (2019). *Introductory econometrics for finance*. Cambridge university press.

Butt, U. (2024). *Challenges to the US dollar's dominance as the global reserve currency: Geopolitical, economic, and fiscal perspectives*. Economic, and Fiscal Perspectives (October 15, 2024).

Caporin, M., Gupta, R., Ravazzolo, F. (2021). Contagion between real estate and financial markets: A Bayesian quantile-on-quantile approach. *The North American Journal of Economics and Finance*, *55*, 101347.

Chang, G., Cheng, P. (2016). Evidence of cross-asset contagion in US markets. *Economic Modelling*, *58*, 219-226.

Chantziara, T., Skiadopoulos, G. (2008). Can the dynamics of the term structure of petroleum futures be forecasted? Evidence from major markets. *Energy Economics*, *30*(3), 962-985.

Chen, J., Zhu, X., Zhong, M. (2019). Nonlinear effects of financial factors on fluctuations in nonferrous metals prices: A Markov-switching VAR analysis. *Resources Policy*, *61*, 489-500.

Chen, Y., Xu, J., Hu, M. (2022). Asymmetric volatility spillovers and dynamic correlations between crude oil price, exchange rate and gold price in BRICS. *Resources Policy*, *78*, 102857.

Cheng, I., Xiong, W. (2014). Financialization of commodity markets. *Annu. Rev. Financ. Econ.*, *6*(1), 419-441.

Chiang, M. C., Sing, T. F., Wang, L. (2020). Interactions between housing market and stock market in the United States: A Markov switching approach. *Journal of Real Estate Research*, *42*(4), 552-571.

Chkili, W. (2016). Dynamic correlations and hedging effectiveness between gold and stock markets: Evidence for BRICS countries. *Research in International Business and Finance*, *38*, 22-34.

Chkili, W., Nguyen, D. K. (2014). Exchange rate movements and stock market returns in a regime-switching environment: Evidence for BRICS countries. *Research in International Business and Finance*, *31*, 46-56.

Chopra, P. K. (2015). Country risk: A theoretical and empirical analysis with special reference to northern African economies-Il rischio paese: un'analisi teorica e empirica con particolare riferimento ai paesi del Nord Africa. *Economia Internazionale/International Economics*, *68*(1), 81-137.

Cont, R. (2010). Stylized properties of asset returns. *Encyclopedia of quantitative finance*.

Dabrowski, M. (2020). *Can the Euro dethrone the US dollar as the dominant global currency? Not so soon, if ever*. Study for the Committee on Economic and Monetary Affairs, Policy Department for Economic, Scientific and Quality of Life Policies, European Parliament. Available at https://www. europarl. europa. eu/cmsdata/207504/CASE_FINAL 20

Dai, X., Wang, Q., Zha, D., Zhou, D. (2020). Multi-scale dependence structure and risk contagion between oil, gold, and US exchange rate: A wavelet-based vine-copula approach. *Energy Economics*, *88*, 104774.

Das, D., Kannadhasan, M., Tiwari, A. K., Al-Yahyaee, K. H. (2018). Has co-movement dynamics in emerging stock markets changed after global financial crisis? New evidence from wavelet analysis. *Applied Economics Letters*, *25*(20), 1447-1453.

Davies, R. B. (1987). Hypothesis testing when a nuisance parameter is present only under the alternative. *Biometrika*, *74*(1), 33-43.

Dempster, A. P., Laird, N. M., Rubin, D. B. (1977). Maximum likelihood from incomplete data via the EM algorithm. *Journal of the royal statistical society: series B (methodological)*, *39*(1), 1-22.

Dong, X., Yoon, S. M. (2018). Structural breaks, dynamic correlations, and hedge and safe havens for stock and foreign exchange markets in Greater China. *The World Economy*, *41*(10), 2783-2803.

Dornbusch, R., Fischer, S. (1980). Exchange rates and the current account. *The American Economic Review*, *70*(5), 960-971.

Ehrmann, M., Ellison, M., Valla, N. (2003). Regime-dependent impulse response functions in a Markov-switching vector autoregression model. *Economics Letters*, *78*(3), 295-299.

Fabozzi, F. J., Markowitz, H. M., Gupta, F. (2008). Portfolio selection. *Handbook of finance*, *2*, 3-13.

Faye, B., Le Fur, E., Prat, S. (2024). Exogeneous shocks, risk, and market convergence of real alternative and financial assets: evidence from nonlinear dynamics. *Annals of Operations Research*, *334*(1), 497-520.

Flavin, T. J., Lagoa-Varela, D. (2021). On the stability of stock-bond comovements across market conditions in the Eurozone periphery. *Global Finance Journal*, *49*, 100491.

Forbes, K. J., Rigobon, R. (2002). No contagion, only interdependence: Measuring stock market comovements. *The Journal of Finance*, *57*(5), 2223-2261.

Garcia, R., Perron, P. (1996). An analysis of the real interest rate under regime shifts. *The Review of Economics and Statistics*, 111-125.

García, J. S., Rambaud, S. C. (2023). Volatility spillovers between oil and financial markets during economic and financial crises: A dynamic approach. *Journal of Economics and Finance*, *47*(4), 1018-1040.

Gavin, M. (1989). The stock market and exchange rate dynamics. *Journal of International Money and Finance*, *8*(2), 181-200.

Gourène, G. A. Z., Mendy, P. (2018). Oil prices and African stock markets co-movement: A time and frequency analysis. *Journal of African Trade*, *5*(1), 55-67.

Guidolin, M., Pedio, M. (2017). Identifying and measuring the contagion channels at work in the European financial crises. *Journal of International Financial Markets, Institutions and Money*, *48*, 117-134.

Guidolin, M., Hansen, E., Pedio, M. (2019). Cross-asset contagion in the financial crisis: A Bayesian time-varying parameter approach. *Journal of Financial Markets*, *45*, 83-114.

Guo, F., Chen, C. R., Huang, Y. S. (2011). Markets contagion during financial crisis: A regime-switching approach. *International Review of Economics Finance*, *20*(1), 95-109.

Guo, Y., Li, P., Li, A. (2021). Tail risk contagion between international financial markets during COVID-19 pandemic. *International Review of Financial Analysis*, *73*, 101649.

Hamilton, J. D. (1989). A new approach to the economic analysis of nonstationary time series and the business cycle. *Econometrica: Journal of the Econometric Society*, 357-384.

Kang, S. H., Maitra, D., Dash, S. R., Brooks, R. (2019). Dynamic spillovers and connectedness between stock, commodities, bonds, and VIX markets. *Pacific-Basin Finance Journal*, *58*, 101221.

Koepke, R. (2019). What drives capital flows to emerging markets? A survey of the empirical literature. *Journal of Economic Surveys*, *33*(2), 516-540.

Krolzig, H. M. (1997). The markov-switching vector autoregressive model. In *Markov-switching vector autoregressions: Modelling, statistical inference, and application to business cycle analysis* (pp. 6-28). Springer Berlin Heidelberg.

Lee, H. (2021). Time-varying comovement of stock and treasury bond markets in Europe: A quantile regression approach. *International Review of Economics Finance*, *75*, 1-20.

Liow, K. H., Ye, Q. (2018). Regime-dependent linkages between securitized real estate market and major financial markets: some international evidence. *Pacific Rim Property Research Journal*, *24*(3), 225-247.

Liu, Z., Zhout, Y., Zhou, Z. (2019). International financial contagion during the subprime crisis: Evidence. *Behavioral finance: The coming of age*, 245.

Markowitz, H. M. (1959). *Portfolio selection: Efficient diversification of investments*. John Wiley Sons.

Mensi, W., Al Rababa'a, A. R., Vo, X. V., Kang, S. H. (2021). Asymmetric spillover and network connectedness between crude oil, gold, and Chinese sector stock markets. *Energy Economics*, *98*, 105262.

Mensi, W., Nekhili, R., Vo, X. V., Kang, S. H. (2021). Oil and precious metals: Volatility transmission, hedging, and safe haven analysis from the Asian crisis to the COVID-19 crisis. *Economic Analysis and Policy*, *71*, 73-96.

Meyer, D. F., Hassan, A. S. (2020). Analysis of the impact of exchange rate volatility on the South African government bond market. *International Journal of Economics and Finance*, *12*(2), 271-289.

Mlambo, C., Maredza, A., Sibanda, K. (2013). *Effects of exchange rate volatility on the stock market: A case study of South Africa.* (PhD diss.). University of Fort Hare.

Mitra, R. (2017). Stock market and foreign exchange market integration in South Africa. *World Development Perspectives*, *6*, 32-34.

Mokni, K., Youssef, M. (2020). Empirical analysis of the cross-interdependence between crude oil and agricultural commodity markets. *Review of Financial Economics*, *38*(4), 635-654.

Morales, M., Moreno, C., Vio, C. (2014). Foreign shocks on Chilean financial markets: spillovers and comovements between bond and equity markets. *Emerging Markets Finance and Trade*, *50*(sup5), 35-50.

Morema, K., Bonga-Bonga, L. (2020). The impact of oil and gold price fluctuations on the South African equity market: Volatility spillovers and financial policy implications. *Resources Policy*, *68*, 101740.

Moutinho, V., Almeida, L., Neves, M., Monteiro, J. (2025). Dynamic cross hedging, conditional co-movements in commodities and financial markets during subprime and sovereign debt crisis: Evidence from China and G7 countries. *Review of Financial Economics*.

Ngwakwe, C. C., Sebola, M. P. (2019). Differential effects of politically-driven policy uncertainty on exchange rate performance. *African Journal of Public Affairs*, *11*(1), 34-47.

Papadamou, S., Fassas, A. P., Kenourgios, D., Dimitriou, D. (2021). Flight-to-quality between global stock and bond markets in the COVID era. *Finance Research Letters*, *38*, 101852.

Papavassiliou, V. G. (2014). Cross-asset contagion in times of stress. *Journal of Economics and Business*, *76*, 133-139.

Reboredo, J. C. (2010). Nonlinear effects of oil shocks on stock returns: a Markov-switching approach. *Applied Economics*, *42*(29), 3735-3744.

Reboredo, J. C., Uddin, G. S. (2016). Do financial stress and policy uncertainty have an impact on the energy and metals markets? A quantile regression approach. *International Review of Economics Finance*, *43*, 284-298.

Roubaud, D., Arouri, M. (2018). Oil prices, exchange rates and stock markets under uncertainty and regime-switching. *Finance Research Letters*, *27*, 28-33.

Ruzgar, N. S. (2025). Impact of indices on stock price volatility of BRICS countries during crises: Comparative study. *International Journal of Financial Studies*, *13*(1), 8.

Ryan, M., Corbet, S., Oxley, L. (2024). Is gold always a safe haven?. *Finance Research Letters*, *64*, 105438.

Sakemoto, R. (2018). Co-movement between equity and bond markets. *International Review of Economics Finance*, *53*, 25-38.

Shahrestani, P., Rafei, M. (2020). The impact of oil price shocks on Tehran stock exchange returns: Application of the Markov switching vector autoregressive models. *Resources Policy*, *65*, 101574.

Sikhosana, A., Aye, G. C. (2018). Asymmetric volatility transmission between the real exchange rate and stock returns in South Africa. *Economic Analysis and Policy*, *60*, 1-8.

Skintzi, V. D. (2019). Determinants of stock-bond market comovement in the Eurozone under model uncertainty. *International Review of Financial Analysis*, *61*, 20-28.

Soylu, P. K., Güloğlu, B. (2019). Financial contagion and flight to quality between emerging markets and US bond market. *The North American Journal of Economics and Finance*, *50*, 100991.

Tudor, C., Anghel, A. (2021). The financialization of crude oil markets and its impact on market efficiency: Evidence from the predictive ability and performance of technical trading strategies. *Energies*, *14*(15), 4485.

Umar, Z., Jareño, F., Escribano, A. (2021). Agricultural commodity markets and oil prices: An analysis of the dynamic return and volatility connectedness. *Resources Policy*, *73*, 102147.

Wang, S. (2023). Tail dependence, dynamic linkages, and extreme spillover between the stock and China's commodity markets. *Journal of Commodity Markets*, *29*, 100312.

Wei, Y., Qin, S., Li, X., Zhu, S., Wei, G. (2019). Oil price fluctuation, stock market and macroeconomic fundamentals: Evidence from China before and after the financial crisis. *Finance Research Letters*, *30*, 23-29.

Yaya, O., Adenikinju, O., Olayinka, H. A. (2024). African stock markets' connectedness: Quantile VAR approach. *Modern Finance*, *2*(1), 51-68.

Yıldırım, D. Ç., Erdoğan, S., Çevik, E. İ. (2018). Regime-dependent effect of crude oil price on BRICS stock markets. *Emerging Markets Finance and Trade*, *54*(8), 1706-1719.