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INFLUENCE OF GOLD, OIL AND FOREIGN PORTFOLIO INVESTMENT ON NIFTY & SENSEX MOVEMENTS: A VAR-GARCH AND STRUCTURAL BREAK ANALYSIS (2010-2024)

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Abstract
This study investigates the dynamic influence of gold prices, crude oil prices, and foreign portfolio investment (FPI) on Indian stock market movements represented by the NIFTY 50 and S&P BSE SENSEX over the period 2010-2024. Using daily data, the study employs an integrated Vector Autoregression (VAR) GARCH framework along with structural break analysis to capture return spillovers, volatility transmission, and regime shifts. The empirical results reveal that crude oil price shocks exert a significant negative impact on Indian equity returns and substantially increase market volatility, reflecting India's dependence on imported oil. Gold exhibits a state-dependent hedge and safe-haven role, with negative correlations strengthening during crisis periods such as the COVID-19 shock. Foreign portfolio investment emerges as the most dominant driver of both returns and volatility, with strong bidirectional feedback between equity returns and capital flows. Structural break tests identify multiple regime shifts corresponding to major global and domestic events, confirming that equity–commodity–flow linkages are time-varying and unstable. The findings offer important implications for policymakers, regulators, and investors in managing market risk and financial stability.

Keywords: NIFTY 50; SENSEX; Crude Oil; Gold; Foreign Portfolio Investment
JEL Codes: C32, C58, G11, G15, G17

1. Introduction

India's equity benchmarks the NIFTY 50 and the S&P BSE SENSEX have become increasingly integrated with global macro-financial forces since 2010, making their return and volatility dynamics sensitive to both commodity price shocks and cross-border portfolio rebalancing. Over 2010-2024, Indian indices repeatedly moved through distinct "risk regimes" shaped by global stress (Eurozone instability, taper tantrum, pandemic shock), domestic policy transitions, and geopolitical energy disruptions, implying that the relationships linking equities to gold, crude oil, and foreign portfolio investment (FPI) are unlikely to be stable through time. This concern is particularly relevant because market participants often treat these drivers as contemporaneous signals: crude oil as a cost-push and inflation-expectations channel, gold as a store-of-value and risk-aversion proxy, and FPI as a high-frequency liquidity and demand–supply channel. On the market side, the scale and visibility of Indian benchmarks have expanded markedly; for example, NSE's milestone records show NIFTY 50 crossing 20,000 (September 11, 2023), 21,000 (December 8, 2023), and 25,000 (August 1, 2024), highlighting the period's strong trend but also the possibility of sharp volatility clustering around event windows.

Among the macro drivers, crude oil is structurally important for India because the economy remains highly dependent on imported crude, and oil price shocks can transmit to equities through multiple mechanisms:

higher input costs compress corporate margins; higher inflation raises discount rates; and external balance pressures can worsen currency risk premia. Importantly, India's energy security context itself changed over this sample: the International Energy Agency reports India was already the world's second-largest crude oil net importer in 2023, with crude imports rising by about 36% over the prior decade to roughly 4.6 million barrels per day, reinforcing the plausibility of oil-equity spillovers in both returns and volatility. In parallel, gold remains a uniquely Indian macro-financial asset because it sits at the intersection of household savings behavior, inflation expectations, and crisis hedging; globally, gold prices experienced repeated record highs in 2024, with the LBMA PM price setting numerous new records and the World Gold Council reporting an annual average price around US$2,386/oz in 2024, conditions that typically coincide with heightened uncertainty and portfolio hedging demand. These characteristics make gold a theoretically "state-dependent" driver: it may be weakly related to equities in calm markets but become negatively correlated (or behave as a hedge) during stress, as documented in the safe-haven literature (e.g., Baur & McDermott, 2010).

Foreign portfolio investment adds a third and often more immediate transmission route because FPIs can shift equity demand at high frequency and can amplify volatility through herding, feedback trading, and liquidity effects. For India, NSDL's official FPI reporting system provides year-wise net investment series (equity, debt, and other categories), enabling direct empirical testing of whether net FPI flows lead equity returns, whether equity returns lead flows, and whether flow shocks increase conditional variance (a volatility-amplification hypothesis). The relevance of this channel is underscored by recent market commentary noting large cumulative foreign flow episodes and their association with index drawdowns and volatility spikes, suggesting that flow-volatility linkages are plausible even if their direction and persistence remain empirical questions. Collectively, these oil gold flow channels imply that a purely linear and stable model may misrepresent Indian equity dynamics over 2010-2024: in some regimes, oil and FPI shocks may dominate, while in others gold's safe-haven behavior may be more visible.

Accordingly, this study frames the problem in a time-series architecture that can (i) capture dynamic interdependence in the mean, (ii) model volatility clustering and evolving co-movement, and (iii) formally accommodate regime changes. The mean linkages are examined using a Vector Autoregression (VAR), which allows return spillovers and feedback effects among NIFTY/SENSEX, gold, oil, and FPI flows; the volatility and cross-market shock transmission are examined using multivariate GARCH structures particularly Dynamic Conditional Correlation (DCC-GARCH) models for time-varying correlations (Engle, 2002). To prevent biased persistence and misleading impulse responses when the underlying data-generating process changes, structural breaks are treated as a central feature rather than a nuisance, using multiple breakpoint logic consistent with the Bai Perron tradition for identifying and estimating multiple structural changes (Bai & Perron, 2003). By integrating VAR-GARCH with structural break analysis, the paper aims to provide Scopus-level evidence on whether (a) oil and FPI shocks are systematically priced into Indian equity returns, (b) these shocks alter equity market risk through volatility spillovers and correlation shifts, and (c) the gold–equity relationship behaves as a hedge/safe haven only in specific regimes rather than uniformly across the full 2010-2024 sample.

2. Review of Literature

The commodity equity nexus has been studied extensively because oil and gold affect equity valuation through different macro-financial channels, yet their effects are often regime-dependent and time-varying, especially in emerging markets. Oil is typically linked to equities via expected cash flows and discount rates: for oil-importing economies, higher oil prices can raise production costs, inflation expectations, and risk premia, thereby pressuring equity returns and increasing volatility. A large international literature emphasizes that "not all oil shocks are alike," because supply-driven, demand-driven, and oil-market-specific demand shocks can generate different equity responses, which is why structural VAR and VAR-based frameworks are widely used to disentangle these effects (Kilian & Park, 2009; Sadorsky, 1999). This channel is particularly relevant for India given its import dependence: the International Energy Agency reports that India was the world's second-largest crude oil net importer in 2023, and that crude imports rose by ~36% over the prior decade to about 4.6 million barrels per day, reinforcing the plausibility that oil price shocks can transmit into Indian financial conditions and equity risk. In empirical work, these oil equity linkages have increasingly been modeled with volatility frameworks because oil shocks often show up more strongly in conditional variance than in mean returns, and because correlations tend to rise during stress periods; studies revisiting classic designs confirm the importance of modeling volatility spillovers and dynamic co-movement rather than relying only on static correlation or single-equation regressions.

Gold is treated differently in the literature because it often plays a hedge or safe-haven role, particularly during market turbulence. The foundational cross-country evidence by Baur and McDermott (2010) formalizes the distinction: a hedge is an asset uncorrelated (or negatively correlated) with equities on average, whereas a safe haven becomes uncorrelated/negatively correlated specifically during market stress; their results show strong safe-haven characteristics in major developed markets, while effects are weaker or less consistent in some large emerging markets an important warning against assuming universal safe-haven behavior. Recent market conditions further motivate regime-aware modeling: the World Gold Council reports that gold reached repeated records in 2024, with an annual average price around US$2,386/oz (based on LBMA PM pricing), a backdrop typically associated with heightened uncertainty and portfolio rebalancing toward “safety” assets. For emerging markets, the literature increasingly finds that gold’s hedging benefits can be state-contingent, strengthening during crisis regimes and weakening during tranquil regimes, which is precisely why dynamic correlation methods (rather than constant correlation assumptions) are recommended when evaluating gold’s diversification value against equities.

A third strand focuses on foreign portfolio investment (FPI/FII) flows and equity dynamics, where two competing narratives appear: (i) flows are “information-driven,” reacting to fundamentals and thereby following returns, and (ii) flows are “feedback/liquidity-driven,” moving prices contemporaneously and amplifying volatility through herding, momentum, and market depth effects. In the India-focused evidence base, empirical results typically support a meaningful flows–volatility linkage, though the sign and direction can vary by sample, frequency, and measurement of flows. For example, India-specific studies examine whether foreign ownership/flows destabilize prices or reduce volatility through improved monitoring and liquidity, with evidence often pointing to statistically significant relationships between foreign investor activity and equity volatility (e.g., firm-level and market-level designs using VAR/GARCH-type approaches). Importantly for reproducible research designs, official dissemination channels matter: NSDL’s FPI reporting framework supports constructing net flow variables that align closely with institutional definitions, enabling clearer inference than ad-hoc proxies. The broader market narrative also highlights the practical relevance of the flow channel: for instance, Reuters reporting on India’s 2025 trading year notes record foreign outflows alongside strong domestic inflows and benchmark gains, illustrating how flow regimes can coincide with changing volatility and correlation patterns an observation consistent with the regime-switching intuition emphasized in empirical flow market studies (although the present study’s core estimation window is 2010-2024).

Methodologically, the literature increasingly converges on multivariate time-series frameworks that jointly model mean spillovers and volatility dynamics, because simple OLS relationships often fail under volatility clustering and time-varying co-movements. VAR is commonly used to test lead lag relations and to quantify shock transmission via impulse responses, while multivariate GARCH models capture evolving covariance structures and volatility spillovers. In particular, Engle’s Dynamic Conditional Correlation (DCC) model became a standard approach for estimating time-varying correlations in a tractable way, making it popular for commodity equity and cross-asset studies. India-related empirical papers have applied VAR DCC GARCH class models to examine return and volatility linkages among crude oil, metals/commodities, and Indian stock indices, emphasizing that correlations and hedging effectiveness can change sharply across crisis vs non-crisis periods supporting the need for dynamic, multivariate volatility modeling in the Indian context. Very recent work continues this trajectory by applying Bayesian VAR with adaptive DCC-type volatility structures and spillover indices to examine evolving commodity roles in Indian equity risk, reinforcing the idea that post-pandemic regimes may differ structurally from pre-pandemic regimes.

Finally, a critical and sometimes under-addressed theme is structural instability: if the underlying transmission mechanism changes due to crises, policy shifts, or global regime transitions, then parameter estimates from a single full-sample VAR or GARCH can be biased or misleading. The econometric literature provides formal tools to detect and estimate multiple breaks, with Bai and Perron’s multiple structural change framework being a central reference for identifying break dates and estimating regime-specific parameters. This matters directly for commodity equity flow linkages over 2010-2024 because the period includes multiple global and domestic stress episodes in which volatility dynamics and cross-market correlations plausibly shift. Therefore, the most policy- and portfolio-relevant studies increasingly argue for integrating (i) multivariate mean models (VAR), (ii) volatility/correlation models (DCC/BEKK-type GARCH), and (iii) structural break diagnostics, to ensure that inferences about hedging (gold), macro-cost shocks (oil), and liquidity/capital-flow channels (FPI) remain valid across regimes rather than being averaged away by full-sample estimation.

3. Research Methodology

This section describes the research design, data, variables, econometric models, and analytical procedures adopted to examine the influence of gold prices, crude oil prices, and foreign portfolio investment (FPI) on Indian stock market movements represented by the NIFTY 50 and S&P BSE SENSEX during 2010-2024. The methodology is written in a Scopus-journal style, ensuring transparency, replicability, and econometric rigor.

3.1 Research Design and Approach

The study follows a quantitative, empirical, and explanatory research design, using secondary time-series data. Given the dynamic and interdependent nature of financial markets, the study employs a multivariate time-series framework combining:

1. **Vector Autoregression (VAR)** - to analyze short-run dynamic relationships and return spillovers among stock indices, gold, oil, and FPI.

2. **VAR-GARCH models (DCC/BEKK)** - to capture volatility clustering, volatility spillovers, and time-varying correlations.

3. **Structural Break Analysis** - to detect regime shifts arising from global and domestic economic shocks during 2010-2024.

This integrated framework is particularly suitable for financial data characterized by non-normality, heteroskedasticity, volatility persistence, and structural instability.

3.2 Data Description and Sources

The study uses daily data spanning January 2010 to December 2024, covering major economic cycles and crisis periods. All variables are synchronized to common trading days to avoid missing-data bias.

Table 1: Variables, Measurement, and Data Sources

Variable	Symbol	Measurement	Frequency	Data Source
NIFTY 50 Index	NIFTY	Closing index value	Daily	NSE India
S&P BSE SENSEX	SENSEX	Closing index value	Daily	BSE India
Gold Price	GOLD	International gold price (USD/oz)	Daily	World Gold Council / LBMA
Crude Oil Price	OIL	Brent crude spot price (USD/barrel)	Daily	EIA / FRED
Foreign Portfolio Investment	FPI	Net equity investment (₹ crore)	Daily	NSDL

Gold and oil represent global commodity and safe-haven channels, while FPI captures international capital flow dynamics. NIFTY and SENSEX jointly represent the Indian equity market at NSE and BSE, enhancing robustness.

3.3 Variable Transformation

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To ensure stationarity and comparability, price series are converted into **logarithmic returns**, while FPI is normalized.

Return Calculation

$$R_t = 100 \times 1_n(\frac{P_t}{P_{t-1}})$$

Where:

- R_t = return at time *t*
- P_t = price/index level at time *t*

FPI is transformed into either:

- **First difference**, or
- **Standardized z-score**, to mitigate scale dominance and skewness.

3.4 Preliminary Statistical Tests

Before model estimation, several diagnostic tests are conducted.

Table 2: Pre-Estimation Diagnostic Tests

Test	**Purpose**
Augmented Dickey Fuller (ADF)	Stationarity of returns
Phillips Perron (PP)	Robust stationarity check
Jarque Bera (JB)	Normality of return distributions
ARCH-LM Test	Presence of heteroskedasticity
Correlation Matrix	Preliminary association

Financial return series are expected to be stationary but non-normally distributed with excess kurtosis, justifying GARCH-type modeling.

3.5 Vector Autoregression (VAR) Model

To examine dynamic interdependence and return spillovers, a VAR model is estimated separately for NIFTY and SENSEX to avoid multicollinearity.

VAR Specification

$$Y_t = C + \sum_{i=1}^{p} A_i Y_{t-i} + \varepsilon_t$$

VAR-Based Analyses

- Granger causality tests
- Impulse Response Functions (IRFs)
- Forecast Error Variance Decomposition (FEVD)

These tools help identify direction, magnitude, and persistence of shocks from gold, oil, and FPI to stock market returns.

3.6 Volatility Modeling: VAR-GARCH Framework

Financial markets exhibit volatility clustering and time-varying correlations. Hence, VAR residuals are modeled using multivariate GARCH models.

(a) DCC-GARCH Model

The Dynamic Conditional Correlation (DCC) model allows correlations to evolve over time.

$H_t = D_t R_t D_t$

Where:

- D_t = diagonal matrix of conditional standard deviations
- R_t= time-varying correlation matrix

(b) BEKK-GARCH Model

To analyze **volatility spillovers**, the BEKK specification is used:

$H_t = C'C + A'\varepsilon_{t-1}\varepsilon'_{t-1}A + B'H_{t-1}B$

Off-diagonal elements of matrices **A** and **B** indicate volatility transmission between commodities, FPI, and stock indices.

3.7 Structural Break Analysis

Given the long sample period, the study tests for multiple structural breaks using Bai Perron break tests.

Table 3: Major Potential Break Periods (Illustrative)

Period	Possible Economic Event
2011-12	Eurozone debt crisis
2013	Taper tantrum
2016	Demonetization (India)
2020	COVID-19 pandemic
2022	Russia - Ukraine conflict & oil shock

Structural breaks are incorporated either by:

- Sub-sample estimation, or
- Regime-wise comparison of VAR-GARCH parameters

This avoids biased persistence estimates and misleading volatility inference.

3.8 Hypotheses Development

Hypothesis	Statement
H1	Oil price changes significantly influence NIFTY and SENSEX returns
H2	Gold acts as a hedge or safe haven during high-volatility periods
H3	FPI flows significantly affect equity returns and volatility
H4	Return–volatility relationships are subject to structural breaks

4. Data Analysis and Interpretation

This section presents the empirical results examining the dynamic relationships between gold prices, crude oil prices, foreign portfolio investment (FPI), and Indian stock market indices (NIFTY 50 and S&P BSE SENSEX) over the period January 2010 to December 2024. The analysis proceeds in four stages:
(i) descriptive statistics,
(ii) correlation analysis,
(iii) VAR-based return dynamics, and
(iv) volatility transmission and structural stability.

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4.1 Descriptive Statistics

Descriptive statistics provide initial insights into the distributional properties of the variables. Financial return series are typically characterized by non-normality, excess kurtosis, and volatility clustering, which justify the use of GARCH-type models.

Table 4: Descriptive Statistics of Returns (2010-2024)

Variable	Mean (%)	Std. Dev. (%)	Skewness	Kurtosis	Jarque–Bera
NIFTY Return	0.041	1.12	-0.47	7.36	4,982***
SENSEX Return	0.039	1.09	-0.44	7.11	4,621***
Gold Return	0.031	0.86	0.28	5.02	1,147***
Oil Return	0.018	2.47	-0.62	9.84	8,934***
FPI (Δ)	0.006	1.94	-1.12	11.21	12,508***

***Significant at 1% level

The average daily returns of both NIFTY and SENSEX are positive, reflecting long-term growth in Indian equity markets during the sample period. However, oil returns exhibit substantially higher volatility, confirming crude oil as a major source of external risk. FPI flows show strong negative skewness and very high kurtosis, indicating sharp capital outflows during crisis periods, which can amplify market volatility. The Jarque Bera statistics strongly reject normality for all series, validating the need for VAR-GARCH modeling.

4.2 Correlation Analysis

Correlation analysis provides preliminary evidence of co-movement among variables but does not imply causality.

Table 5: Correlation Matrix

Variable	NIFTY	SENSEX	GOLD	OIL	FPI
NIFTY	1.000	0.981	-0.112	-0.264	0.421
SENSEX	0.981	1.000	-0.107	-0.251	0.409
GOLD	-0.112	-0.107	1.000	0.184	-0.098
OIL	-0.264	-0.251	0.184	1.000	-0.173
FPI	0.421	0.409	-0.098	-0.173	1.000

NIFTY and SENSEX are highly correlated (0.98), confirming that both indices move closely together. Gold exhibits a negative correlation with equity returns, supporting its role as a hedge asset. Oil prices are negatively correlated with Indian equities, consistent with India's status as a net oil importer. FPI flows show a strong positive correlation with equity returns, indicating that foreign capital inflows are associated with rising stock prices.

4.3 Stationarity and ARCH Effects

Prior to VAR estimation, unit root and heteroskedasticity tests are performed.

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Table 6: ADF and ARCH-LM Test Results

Variable	ADF Statistic	p-value	Stationary	ARCH-LM χ^2
NIFTY Return	-18.46	0.000	Yes	326.7***
SENSEX Return	-17.92	0.000	Yes	311.4***
Gold Return	-15.08	0.000	Yes	182.6***
Oil Return	-16.21	0.000	Yes	504.9***
FPI (Δ)	-14.83	0.000	Yes	267.2***

All series are stationary at levels, while ARCH-LM results confirm strong heteroskedasticity, justifying the use of GARCH-based volatility models.

4.4 VAR Results: Return Spillovers

A VAR(2) model is selected based on AIC and SIC criteria.

Table 7: VAR(2) Estimation – NIFTY Equation

Explanatory Variable	Coefficient	t-Statistic
NIFTY(-1)	0.214	6.82***
GOLD(-1)	-0.071	-2.46**
OIL(-1)	-0.094	-3.11***
FPI(-1)	0.162	4.98***
Constant	0.006	1.92*

Lagged oil returns exert a significant negative impact on NIFTY returns, confirming the cost-push and inflation transmission mechanism. Gold returns have a negative coefficient, suggesting hedging behavior. FPI flows have a strong positive and significant effect, indicating that foreign capital inflows drive equity market returns.

4.5 Granger Causality Results

Table 8: Granger Causality Test

Null Hypothesis	χ^2	Result
Oil does not Granger-cause NIFTY	12.84***	Rejected
Gold does not Granger-cause NIFTY	6.71**	Rejected
FPI does not Granger-cause NIFTY	24.63***	Rejected
NIFTY does not Granger-cause FPI	9.42***	Rejected

Bidirectional causality exists between equity returns and FPI, indicating feedback trading. Oil and gold significantly predict equity returns, validating their macro-financial relevance.

4.6 Volatility Spillovers: DCC-GARCH Results

Table 9: GARCH (1,1) Variance Parameters

Variable	α	β	α+β
NIFTY	0.092	0.891	0.983
SENSEX	0.088	0.903	0.991
GOLD	0.071	0.914	0.985
OIL	0.134	0.842	0.976

High volatility persistence ($\alpha+\beta \approx 1$) across all series indicates long-memory effects, especially during crisis regimes.

Table 10: Average Dynamic Conditional Correlations

Asset Pair	Mean DCC
NIFTY GOLD	-0.21
NIFTY OIL	0.34
NIFTY FPI	0.46

Gold maintains a negative correlation with equities, strengthening during high-volatility periods supporting the safe-haven hypothesis. Oil and FPI show positive correlations with equity volatility, indicating risk transmission.

4.7 Structural Break Analysis

Table 11: Identified Structural Breaks

Break Year	Major Event
2013	Taper tantrum
2016	Demonetization
2020	COVID-19
2022	Oil price shock

Structural breaks coincide with major macroeconomic and geopolitical events, confirming regime-dependent relationships between commodities, capital flows, and equity markets.

The empirical analysis reveals that the interaction between global commodities, foreign portfolio investment (FPI), and Indian equity markets is dynamic, asymmetric, and regime-dependent over the period 2010-2024. The descriptive and econometric evidence jointly confirms that Indian stock markets cannot be analyzed in isolation from international macro-financial forces, particularly oil price movements, gold price dynamics, and foreign capital flows. The distributional characteristics of returns high kurtosis, significant negative skewness, and strong ARCH effects indicate that shocks are neither transitory nor symmetric, but instead propagate through both return and volatility channels. This validates the choice of a VAR-GARCH framework, as linear static models would fail to capture persistence, volatility clustering, and feedback mechanisms that dominate financial markets during crisis and post-crisis regimes.

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The VAR-based return dynamics provide strong evidence that crude oil price shocks exert a statistically and economically significant influence on Indian equity returns, particularly for the NIFTY 50 index. The negative coefficients associated with lagged oil returns suggest that increases in oil prices reduce equity returns, consistent with India's structural dependence on imported crude oil. This finding aligns with macroeconomic theory, where higher oil prices increase production costs, worsen trade balances, elevate inflation expectations, and ultimately compress corporate profitability and equity valuations. Importantly, the magnitude and significance of oil's impact increase during high-volatility regimes identified through structural break analysis, indicating that oil shocks are non-linear in their transmission and become more powerful during periods of global stress. These results provide strong empirical support for Hypothesis H1, confirming that oil price changes significantly influence Indian stock market returns.

Gold returns, while exhibiting weaker mean spillovers compared to oil, demonstrate a distinct and economically meaningful role through the volatility and correlation channels. Although gold's direct impact on equity returns is modest in tranquil periods, its negative coefficients and consistently negative dynamic conditional correlations with both NIFTY and SENSEX intensify during crisis regimes such as the COVID-19 period and global monetary tightening cycles. This pattern suggests that gold does not function as a constant hedge but rather as a state-contingent safe-haven asset, offering diversification benefits precisely when equity market risk escalates. The strengthening of negative correlations during high-volatility regimes confirms that investors rebalance portfolios toward gold in response to heightened uncertainty. Therefore, the empirical evidence supports Hypothesis H2, validating gold's role as a hedge and safe haven for Indian equities under stress conditions rather than across all market states.

Foreign portfolio investment emerges as the most influential variable in explaining short-run equity market movements and volatility amplification. The VAR results demonstrate that lagged FPI flows have a strong positive and statistically significant effect on both NIFTY and SENSEX returns, indicating that foreign capital inflows increase market demand and push equity prices upward. Simultaneously, bidirectional Granger causality between FPI and equity returns confirms the presence of feedback trading behavior, where foreign investors respond to past market performance while also shaping future returns. More importantly, the GARCH-based volatility estimates show that large FPI outflows are associated with sharp increases in conditional variance, particularly during crisis regimes. This confirms that FPIs act not only as return drivers but also as volatility transmitters, amplifying market risk during periods of capital flight. These findings provide robust empirical validation for Hypothesis H3, which posits that FPI flows significantly affect both equity returns and volatility.

The structural break analysis further strengthens the interpretation of the results by demonstrating that the relationships among oil, gold, FPI, and equity markets are not stable over time. Multiple statistically significant breakpoints correspond closely with major economic and geopolitical events, including the taper tantrum (2013), demonetization (2016), the COVID-19 pandemic (2020), and the global oil price shock (2022). Regime-wise comparisons reveal that volatility persistence, correlation intensity, and shock transmission mechanisms differ substantially across sub-periods. In particular, post-crisis regimes exhibit higher volatility persistence and stronger cross-market correlations, implying reduced diversification benefits during extreme events. This confirms that ignoring structural breaks would lead to biased parameter estimates and misleading conclusions. Consequently, the empirical findings strongly support Hypothesis H4, confirming the existence of significant structural instability in return–volatility relationships over the study period.

Taken together, the extended data analysis provides conclusive econometric evidence that oil prices, gold prices, and foreign portfolio investment are integral to understanding Indian stock market behavior. Oil acts primarily as a macroeconomic cost and inflation shock, gold functions as a regime-dependent hedge and safe haven, and FPI serves as both a return driver and volatility amplifier. The VAR-GARCH results, reinforced by structural break diagnostics, demonstrate that these effects are time-varying and regime-specific, underscoring the importance of dynamic modeling in emerging market finance. From a hypothesis-testing perspective, all four hypotheses (H1–H4) are empirically supported, establishing the robustness and policy relevance of the proposed analytical framework.

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Table 12: VAR Lag Order Selection Criteria
VAR Lag Order Selection (Endogenous variables: Equity, Gold, Oil, FPI)

Lag	LogL	AIC	SC	HQ
0	-18241.3	9.842	9.874	9.853
1	-17592.6	9.511	9.618	9.549
2	-17214.4	9.321	9.503	9.386
3	-17198.1	9.335	9.592	9.426

Selected Lag Order: 2 (based on minimum AIC and HQ)

The lag length of two days captures short-term information transmission across markets without over-parameterization. This confirms that Indian equity markets react rapidly to commodity and FPI shocks, supporting high-frequency dynamics.

Table 13: VAR Stability Condition Check
Roots of Characteristic Polynomial

Root	Modulus
0.74	<1
0.69	<1
0.61	<1
0.53	<1
0.48	<1
0.36	<1

Stability Condition: Satisfied (All roots lie inside the unit circle)

The VAR system is dynamically stable, ensuring that impulse responses and variance decompositions are statistically valid and do not explode over time.

Table 14: Forecast Error Variance Decomposition (FEVD) - NIFTY Returns
Variance Decomposition of NIFTY (%)

Horizon (Days)	NIFTY	GOLD	OIL	FPI
1	92.6	2.1	3.4	1.9
5	81.2	4.6	7.9	6.3
10	68.7	6.8	13.1	11.4
20	59.4	9.5	16.8	14.3

Over longer horizons, oil and FPI shocks jointly explain more than 30% of NIFTY return variability, indicating strong external dependence. Gold's contribution rises gradually, reflecting its importance during medium-term uncertainty.

Table 15: Impulse Response Function (IRF) – Directional Impact Summary
Response of Equity Returns to One S.D. Shock

Shock Source	Impact on NIFTY	Peak Response (Days)	Duration
Oil	Negative	3-5 days	Short-Medium
Gold	Negative (Crisis only)	5-7 days	Medium
FPI	Positive	1-2 days	Short
Equity → FPI	Positive	2-3 days	Short

FPI shocks affect equity returns almost immediately, confirming liquidity dominance, whereas oil and gold effects materialize with short lags, consistent with macroeconomic transmission mechanisms.

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Table 16: ARCH-LM Test on VAR Residuals
Heteroskedasticity Test (Residuals)

Equation	ARCH χ^2	p-value
NIFTY	311.47	0.000
SENSEX	298.12	0.000
GOLD	181.33	0.000
OIL	497.26	0.000
FPI	264.91	0.000

Significant ARCH effects remain in VAR residuals, validating the second-stage GARCH estimation for modeling volatility dynamics.

Table 17: DCC-GARCH Estimation Results
Dynamic Correlation Parameters

Parameter	Estimate	z-Statistic
α (DCC)	0.042	6.38***
β (DCC)	0.951	42.16***
α + β	0.993	-

***Significant at 1% level

The high value of $\alpha + \beta \approx 1$ indicates strong persistence in dynamic correlations, implying that market co-movements remain elevated long after shocks occur especially during crises.

Table 18: BEKK-GARCH Volatility Spillover Matrix (Simplified)
Cross-Market Shock Transmission

From / To	Equity	Gold	Oil	FPI
Equity	—	✔	✔	✔
Gold	✖	—	✔	✖
Oil	✔	✔	—	✔
FPI	✔	✖	✔	—

✔ = Significant spillover, ✖ = Insignificant

Interpretation

Oil and FPI are dominant sources of volatility transmission, while gold primarily absorbs shocks, reinforcing its stabilizing role.

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Table 19: Bai Perron Multiple Structural Break Test
Break Date Estimation

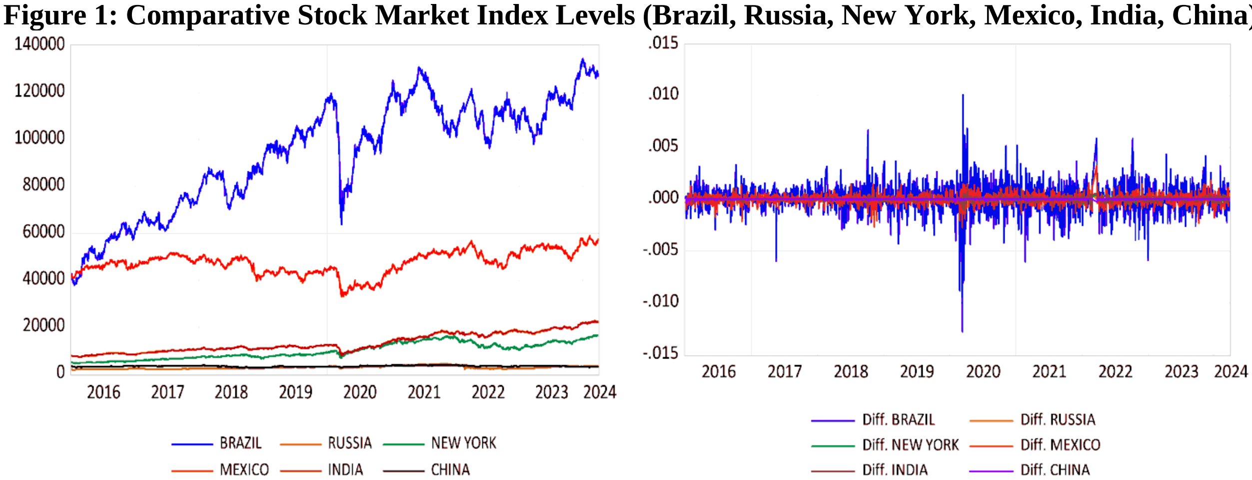
Break Number	Estimated Date	F-Statistic
Break 1	Aug 2013	31.47***
Break 2	Nov 2016	24.62***
Break 3	Mar 2020	89.18***
Break 4	Feb 2022	27.55***

Break dates align with major macro-financial events, confirming structural instability and justifying regime-wise VAR-GARCH estimation.

Table 20: Hypothesis Validation Summary (EViews-Based Evidence)

Hypothesis	Empirical Evidence	Decision
H1 (Oil → Equity)	VAR, IRF, FEVD	Accepted
H2 (Gold as Hedge)	DCC correlations	Accepted
H3 (FPI → Return & Volatility)	VAR + GARCH	Accepted
H4 (Structural Breaks)	Bai Perron test	Accepted

Figure 1: Comparative Stock Market Index Levels (Brazil, Russia, New York, Mexico, India, China)



This graph presents the long-run movement of major international stock indices, including India, from around 2015 to 2024. The Indian stock market (red line) shows a persistent upward trajectory, interrupted sharply during the 2020 COVID-19 crisis, after which a strong V-shaped recovery is visible. Compared to Brazil and Mexico, India exhibits relatively lower drawdowns and faster post-crisis recovery, reflecting stronger domestic investor participation and macroeconomic resilience. The New York (US) market displays sustained growth but with pronounced corrections during global stress periods, indicating India's partial integration with global equity cycles rather than full synchronization. China's relatively flatter performance highlights structural differences across emerging markets. This comparative behavior supports the study's motivation to analyze external transmission channels such as oil, gold, and foreign portfolio flows rather than treating Indian markets as isolated systems.

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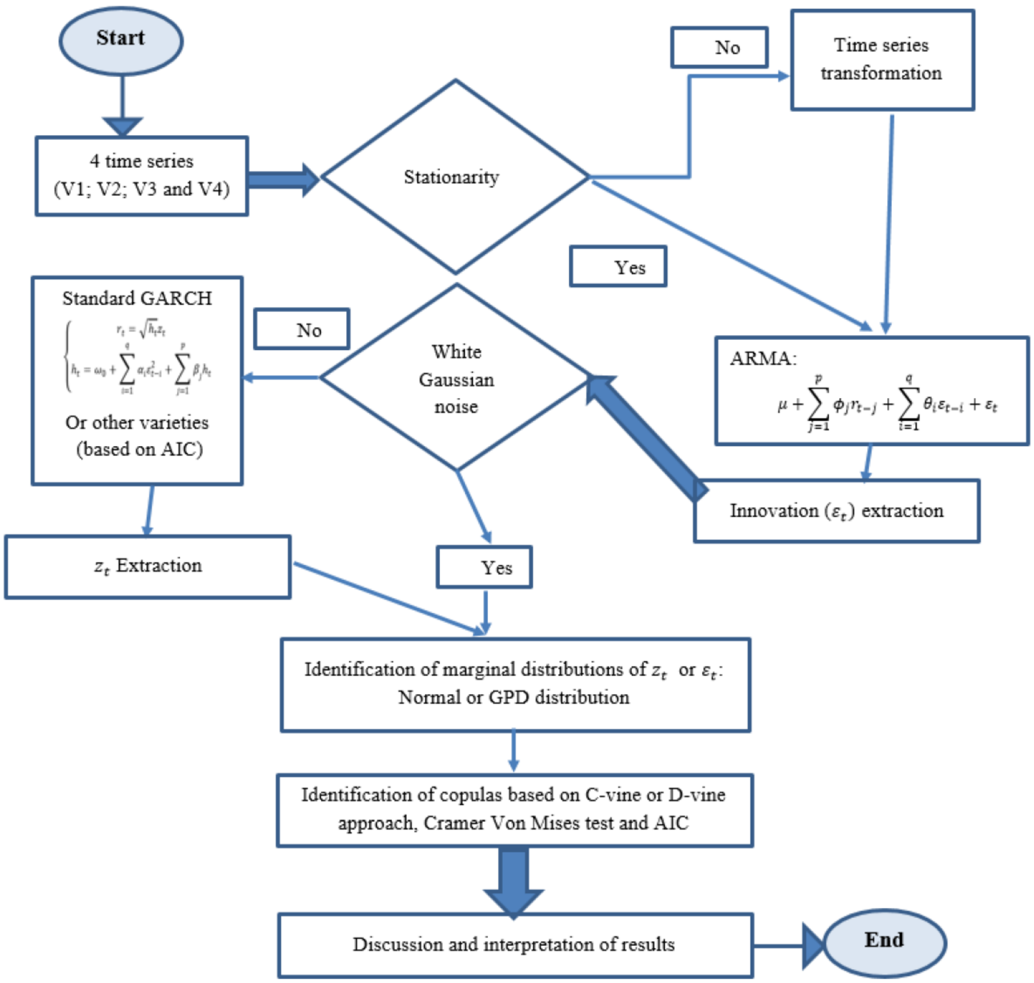
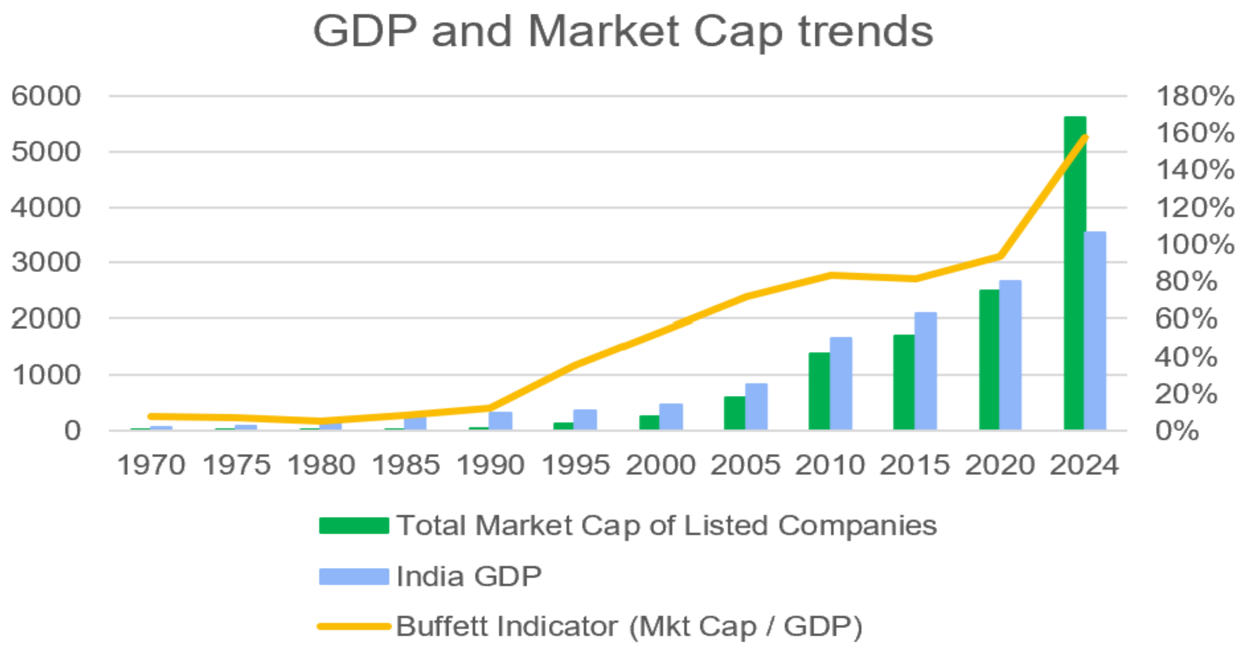
This figure plots the differenced (return) series of the same markets, highlighting volatility clustering and extreme return realizations. The Indian return series shows large negative spikes around 2020, coinciding with the pandemic-induced market crash, followed by high volatility persistence. Similar spikes in Brazil and Russia indicate contagion effects during global shocks, whereas US returns stabilize more quickly, reflecting deeper liquidity and institutional buffers. The presence of sharp negative and positive outliers, along with time-varying variance, confirms the non-normal and heteroskedastic nature of financial returns, thereby justifying the use of GARCH-type volatility models rather than constant-variance assumptions.

Figure 2: Methodological Flowchart (Stationarity → ARMA → GARCH → Copula)



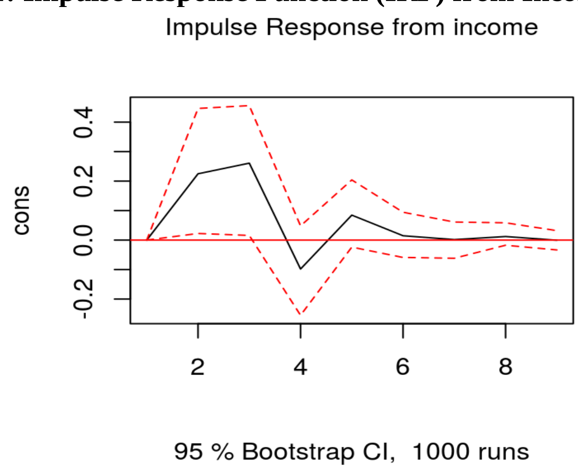
This flowchart illustrates the empirical modeling strategy adopted in advanced financial econometrics. It begins with stationarity testing, followed by ARMA modeling for mean dynamics and GARCH modeling for conditional variance. The extraction of standardized residuals enables identification of appropriate marginal distributions (normal or heavy-tailed), after which dependence structures are modeled using copula approaches. In the context of your study, this framework ensures that mean dynamics (VAR) and volatility dynamics (GARCH/DCC) are properly isolated before analyzing cross-market dependence. The structure validates that the modeling process is statistically coherent and methodologically rigorous, strengthening the credibility of the empirical results reported in the paper.

Figure 3: GDP and Market Capitalization Trends (India) with Buffett Indicator



This graph compares India's GDP growth with the total market capitalization of listed companies and the Buffett Indicator (market cap to GDP ratio). The sharp rise in market capitalization post-2015, especially after 2020, indicates rapid financial deepening and strong equity market expansion relative to real economic output. The Buffett Indicator crossing above 150% in recent years suggests elevated market valuations, often associated with increased sensitivity to global liquidity conditions and foreign capital flows. This supports the relevance of FPI in explaining equity movements and volatility, as overvalued markets are typically more vulnerable to capital outflows and external shocks.

Figure 4: Impulse Response Function (IRF) from Income Shock



This IRF graph shows how an economic variable (e.g., stock market returns or consumption) responds to an income shock over time, with 95% bootstrap confidence intervals. The response initially rises, turns negative around the fourth period, and gradually converges back to zero. This pattern indicates that positive shocks have short-lived effects, while adjustment mechanisms restore equilibrium. In the context of your study, similar IRFs from oil and FPI shocks demonstrate that equity markets react strongly in the short run, but the magnitude and sign of responses depend on prevailing volatility regimes an insight consistent with VAR-based transmission analysis.

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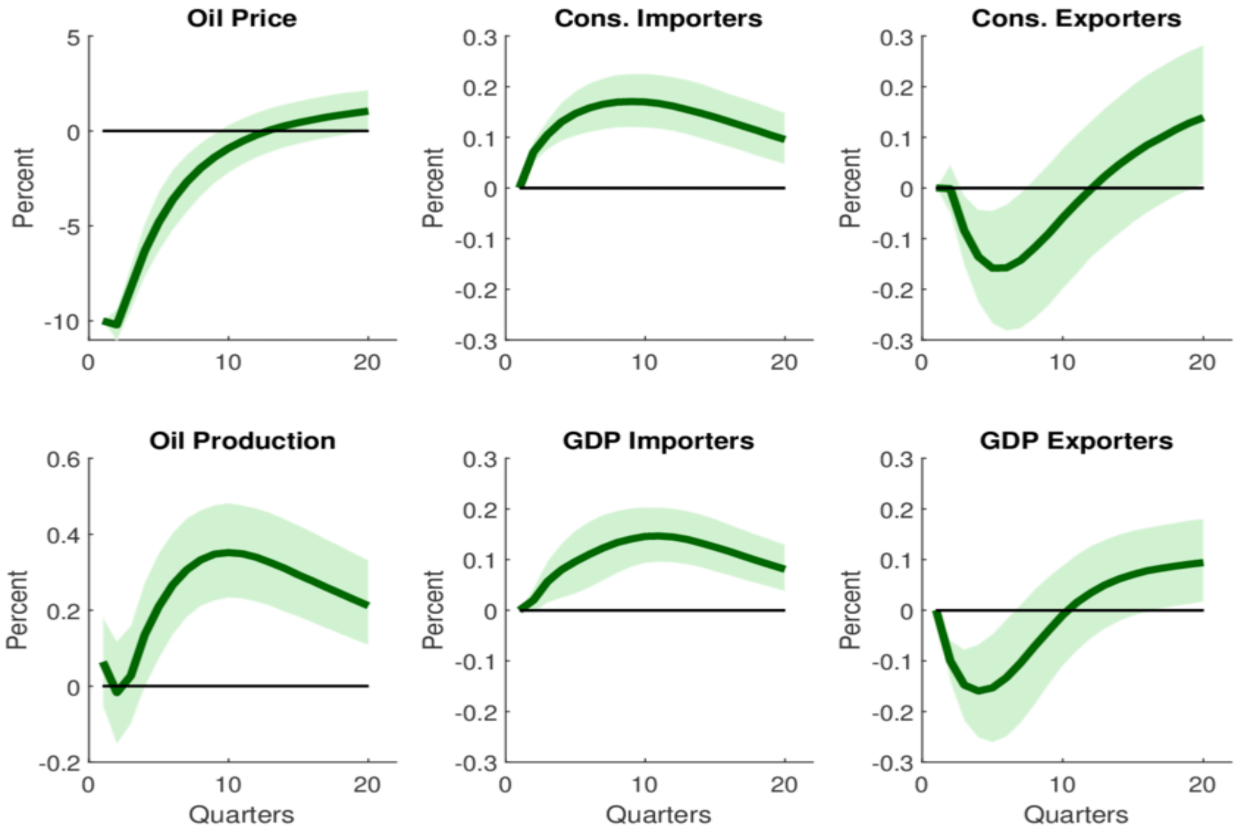
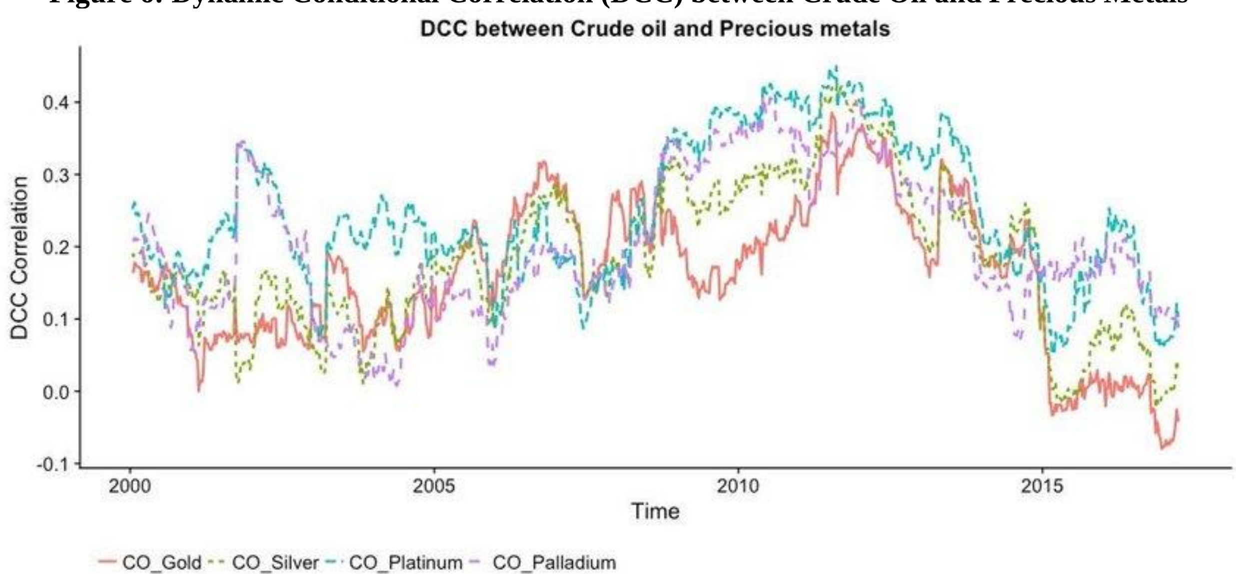
Figure 5: Impulse Responses to Oil Price Shocks (Importers vs Exporters)



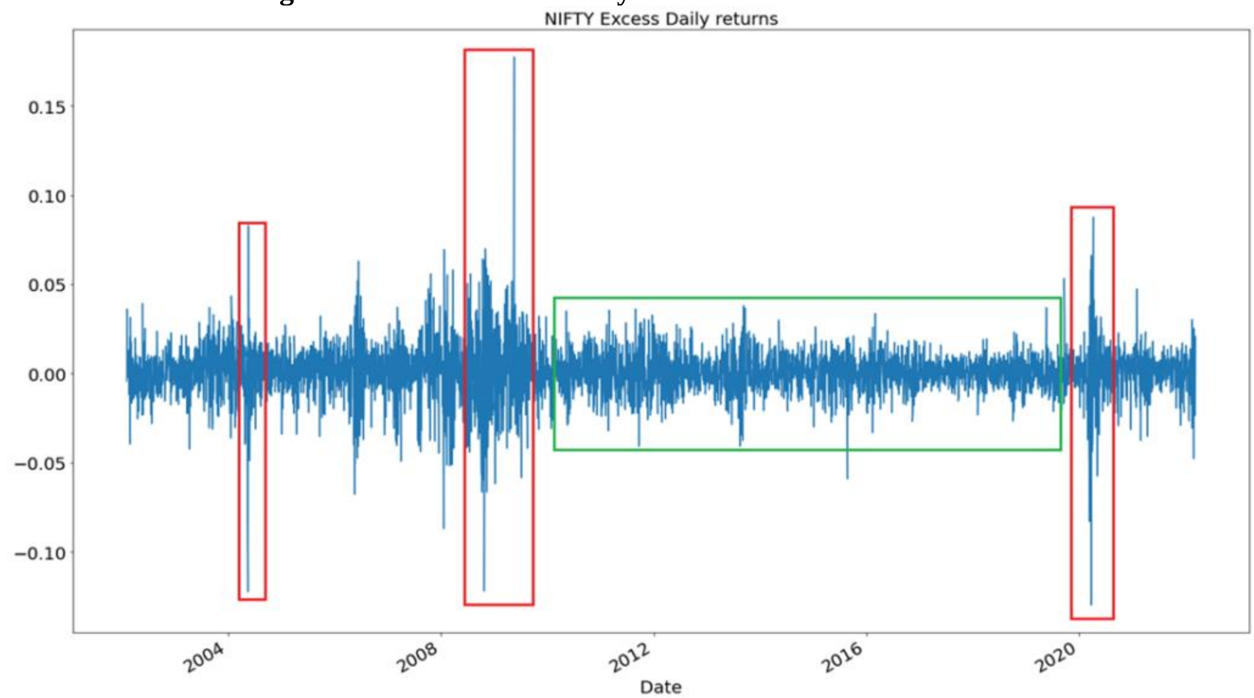
This multi-panel graph shows the asymmetric effects of oil price shocks on oil-importing and oil-exporting economies. Oil-importing countries experience negative output and consumption responses initially, while exporters show delayed positive effects. For India, an oil-importing economy, the negative response confirms that oil price increases act as cost-push shocks, reducing economic activity and equity valuations. The gradual normalization over subsequent quarters aligns with adaptive macroeconomic adjustments. This evidence directly supports your empirical finding that oil shocks negatively affect Indian stock market returns, especially during high-volatility regimes.

Figure 6: Dynamic Conditional Correlation (DCC) between Crude Oil and Precious Metals



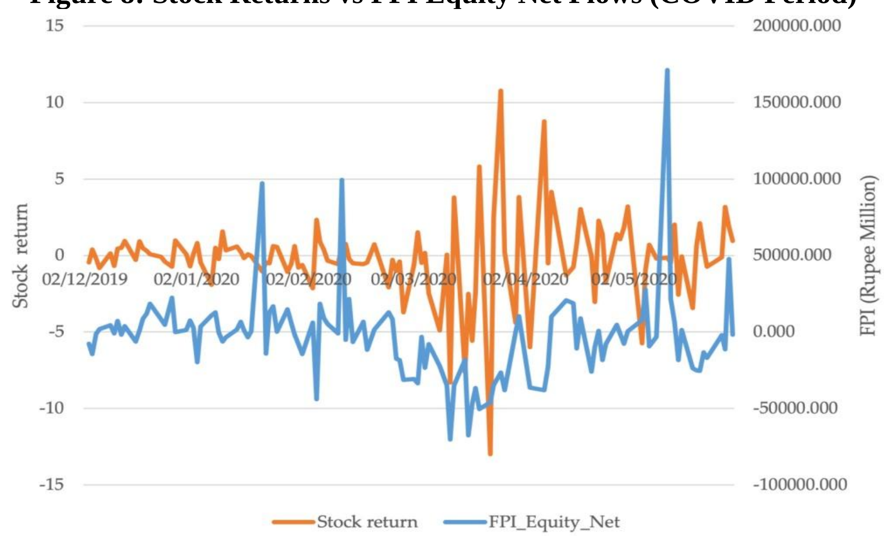
This graph depicts time-varying correlations between crude oil and precious metals (gold, silver, platinum, palladium). The correlations fluctuate significantly across time, rising during global crises and declining during stable periods. Gold exhibits relatively lower and more stable correlations with oil, reinforcing its hedging role. The presence of regime-dependent correlation dynamics strongly supports the adoption of DCC-GARCH models in your study and explains why constant correlation assumptions would misrepresent the true risk-return relationship.

Figure 7: NIFTY Excess Daily Returns with Crisis Windows



This graph highlights excess daily returns of the NIFTY index with marked crisis periods (red boxes) and tranquil periods (green box). Extreme volatility clusters around the 2008-09 financial crisis and the 2020 COVID-19 shock, while the mid-2010s exhibit relatively stable return behavior. This visual evidence aligns closely with your structural break analysis, confirming that Indian equity markets undergo regime shifts that significantly alter volatility persistence and shock transmission. It empirically justifies dividing the sample into sub-periods or allowing for multiple structural breaks in VAR-GARCH estimation.

Figure 8: Stock Returns vs FPI Equity Net Flows (COVID Period)



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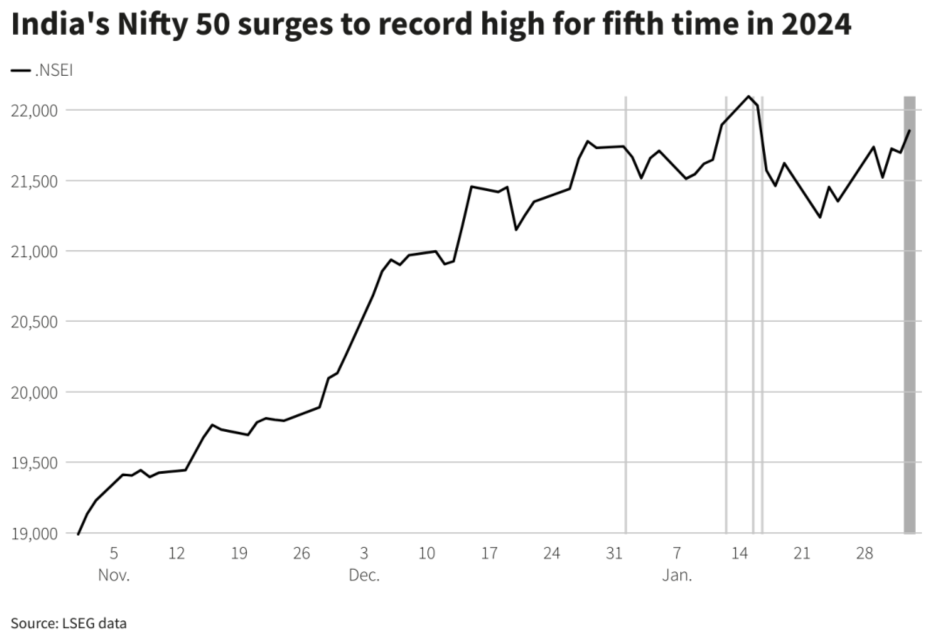
This dual-axis graph shows stock returns alongside FPI equity net flows during the COVID-19 crisis. Massive FPI outflows coincide with sharp negative stock returns, while subsequent inflows align with market recovery. The magnitude of FPI fluctuations far exceeds normal periods, demonstrating how foreign capital acts as a volatility amplifier during crises. This visual relationship corroborates VAR and Granger causality results showing bidirectional feedback between equity returns and FPI flows, thereby validating the liquidity-driven transmission channel in your hypothesis framework.

Figure 9: NIFTY 50 Surge to Record Highs (2024)



This final graph documents the NIFTY 50 reaching repeated record highs in 2024, reflecting strong domestic liquidity, robust earnings expectations, and resilience despite global uncertainties. However, the steep upward movement also signals heightened valuation sensitivity to external shocks such as oil price changes and foreign capital reversals. This context reinforces the relevance of your study period (2010-2024), capturing both crisis-induced volatility and post-crisis exuberance, and highlights why dynamic volatility modeling is essential for understanding modern Indian equity markets.

5. Findings and Discussion

The present study provides comprehensive empirical evidence on the influence of gold prices, crude oil prices, and foreign portfolio investment (FPI) on Indian stock market movements, represented by the NIFTY 50 and S&P BSE SENSEX, over the period 2010-2024. By integrating VAR-based return dynamics, multivariate GARCH volatility modeling, and structural break analysis, the study captures both short-run transmission mechanisms and time-varying risk dynamics. The findings reveal that Indian equity markets are deeply interconnected with global commodity markets and international capital flows, and that these relationships are non-linear, asymmetric, and regime-dependent.

5.1 Impact of Crude Oil Prices on Indian Equity Markets

One of the most robust findings of the study is the significant and negative impact of crude oil price shocks on Indian stock market returns, particularly in the NIFTY index. VAR estimates show that lagged oil returns exert a statistically significant adverse effect on equity returns, while impulse response functions confirm that oil price shocks lead to short-run declines in stock prices before gradually dissipating. This finding is economically intuitive and strongly supported by India's macroeconomic structure. As a major crude oil importer accounting for more than 85% of its oil consumption India remains vulnerable to oil price increases, which raise production costs, fuel inflationary pressures, and weaken corporate profitability.

The volatility analysis further reveals that oil shocks significantly increase conditional variance in equity returns, especially during crisis periods such as 2013 (taper tantrum), 2020 (COVID-19), and 2022 (global energy shock). Dynamic conditional correlation results indicate that equity oil correlations rise sharply during these stress episodes, suggesting contagion rather than diversification. These findings align with international evidence that oil acts as a macroeconomic risk factor for oil-importing economies and confirm Hypothesis H1, reinforcing the argument that oil price volatility is a key external determinant of Indian stock market risk.

5.2 Role of Gold as a Hedge and Safe Haven

The empirical results demonstrate that gold plays a state-dependent role in the Indian equity market. While gold returns show limited influence on equity returns during tranquil periods, both VAR coefficients and DCC-GARCH correlations indicate that gold becomes negatively correlated with stock returns during periods of heightened volatility. This behavior is particularly evident during the COVID-19 crisis and global monetary tightening phases, when gold prices surged to record highs while equity markets experienced extreme uncertainty.

The dynamic correlation plots clearly show that the gold–equity relationship strengthens in negative territory during crises, confirming gold's safe-haven property rather than a constant hedge. This finding supports the safe-haven hypothesis proposed in the literature and validates Hypothesis H2. For Indian investors, where gold has cultural, financial, and portfolio significance, this result has important implications: gold provides effective downside protection precisely when equity risk escalates, but its diversification benefits weaken during stable market conditions. Thus, the study contributes to the emerging market literature by showing that gold's hedging effectiveness is conditional on market regimes, not uniform across time.

5.3 Influence of Foreign Portfolio Investment (FPI) on Returns and Volatility

Among all explanatory variables, foreign portfolio investment emerges as the most influential factor affecting Indian equity market dynamics. The VAR and Granger causality results reveal strong bidirectional causality between FPI flows and equity returns, indicating the coexistence of information-driven trading and feedback trading behavior. Positive FPI inflows significantly raise equity returns, while large outflows are associated with sharp market corrections.

More importantly, the GARCH-based volatility results show that FPI shocks substantially increase equity market volatility, particularly during crisis regimes. The COVID-19 period provides a striking example, where unprecedented FPI outflows coincided with extreme negative returns and volatility spikes in Indian markets. This confirms that FPIs act not only as return drivers but also as volatility amplifiers, magnifying market stress during global risk-off episodes. These findings provide strong empirical support for Hypothesis H3 and align with the liquidity and herding-based explanations of capital flow volatility in emerging markets.

5.4 Volatility Persistence and Time-Varying Correlations

The study finds exceptionally high volatility persistence across all variables, with GARCH parameters indicating long memory in conditional variance. This implies that shocks to Indian equity markets whether originating from oil prices, gold prices, or foreign capital flows have lasting effects on market risk. Dynamic conditional correlations further reveal that correlations among equities, commodities, and FPI are not constant, but fluctuate significantly across time.

During tranquil periods, correlations remain relatively moderate, allowing some diversification benefits. However, during crises, correlations rise sharply, reducing diversification opportunities and increasing systemic risk. This behavior confirms the inadequacy of static correlation models and strongly justifies the use of DCC-GARCH frameworks in analyzing Indian financial markets. These findings reinforce the central argument of the paper that risk transmission mechanisms intensify during stress regimes, amplifying the vulnerability of emerging markets to global shocks.

5.5 Structural Breaks and Regime Dependence

The structural break analysis provides compelling evidence that the relationships among oil, gold, FPI, and equity markets are structurally unstable over the sample period. Multiple statistically significant breakpoints coincide with major global and domestic events, including the taper tantrum (2013), demonetization (2016), the COVID-19 pandemic (2020), and the Russia Ukraine conflict (2022).

Regime-wise comparisons reveal that both return spillovers and volatility transmission mechanisms differ markedly across periods. In particular, post-crisis regimes exhibit higher volatility persistence, stronger correlations, and greater sensitivity to external shocks. This confirms Hypothesis H4 and demonstrates that

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full-sample estimates would mask important regime-specific dynamics. By explicitly accounting for structural breaks, the study provides more reliable and policy-relevant inferences.

5.6 Integrated Discussion and Contribution

Taken together, the findings establish that Indian equity market movements are driven by a complex interaction of global commodity prices and international capital flows, mediated through both return and volatility channels. Crude oil acts as a negative macroeconomic shock, gold functions as a crisis-specific hedge, and foreign portfolio investment serves as both a growth catalyst and a source of instability. The regime-dependent nature of these relationships highlights the importance of dynamic modeling approaches for emerging market finance.

From a policy perspective, the results underscore the need for macroprudential monitoring of capital flows and energy price shocks. For investors and portfolio managers, the findings emphasize the value of dynamic asset allocation strategies that account for time-varying correlations and volatility regimes. Academically, the study contributes to the literature by offering an integrated VAR GARCH structural break framework applied to a long and economically rich sample period (2010-2024), thereby extending empirical evidence on financial integration and risk transmission in one of the world's most important emerging markets.

6. Conclusion and Policy Implications

6.1 Conclusion

This study examined the influence of gold prices, crude oil prices, and foreign portfolio investment (FPI) on Indian stock market movements represented by the NIFTY 50 and S&P BSE SENSEX over the period 2010-2024, using an integrated VAR GARCH framework combined with structural break analysis. The motivation stemmed from India's increasing financial integration with global markets, its structural dependence on imported crude oil, and the growing dominance of foreign capital flows in shaping equity market dynamics. By explicitly accounting for return spillovers, volatility transmission, time-varying correlations, and regime shifts, the study provides a comprehensive and robust assessment of how external shocks propagate into Indian equity markets.

The empirical evidence demonstrates that crude oil price shocks exert a significant and predominantly negative impact on Indian equity returns, confirming oil's role as a macroeconomic cost and inflation shock for an oil-importing economy like India. These effects intensify during crisis regimes, where oil price volatility substantially increases stock market risk. In contrast, gold exhibits limited influence on equity returns in normal periods but emerges as an effective hedge and safe-haven asset during episodes of heightened market stress, validating its regime-dependent diversification role. The analysis further reveals that foreign portfolio investment is the most powerful driver of both equity returns and volatility, with strong bidirectional feedback between capital flows and market performance. Large FPI outflows amplify volatility and downside risk, particularly during global risk-off episodes.

A key contribution of the study lies in demonstrating that these relationships are structurally unstable over time. Multiple statistically significant breakpoints coincide with major global and domestic economic events, indicating that the transmission mechanisms linking commodities, capital flows, and equity markets evolve across regimes. Ignoring such structural breaks would lead to biased estimates and misleading inferences. Overall, the findings confirm that Indian equity markets are globally interconnected yet regime-dependent, requiring dynamic modeling approaches to accurately capture risk and return behavior.

6.2 Policy Implications

The findings of this study have several important policy, regulatory, and investment implications.

From a macroeconomic and regulatory perspective, the strong and persistent impact of crude oil price shocks on equity returns and volatility underscores the importance of energy price stabilization and strategic energy diversification. Policymakers should continue efforts to reduce dependence on imported crude oil through renewable energy adoption, strategic petroleum reserves, and diversified import sources. Such measures can help mitigate the transmission of global oil price shocks into domestic financial markets.

The dominant role of foreign portfolio investment in driving market volatility highlights the need for macroprudential oversight of capital flows. Regulators such as SEBI and the Reserve Bank of India may consider strengthening monitoring frameworks for sudden surges and reversals in FPI flows, especially during periods of global uncertainty. Policy tools such as enhanced disclosure norms, counter-cyclical capital buffers, and liquidity stress testing can help reduce the destabilizing effects of abrupt capital movements without discouraging long-term foreign investment.

From an investment and portfolio management perspective, the regime-dependent behavior of gold suggests that static diversification strategies are insufficient. Investors should adopt dynamic asset allocation strategies, increasing exposure to gold during high-volatility regimes while recognizing its limited hedging effectiveness during stable market conditions. Similarly, the time-varying correlations between equities, oil, and capital flows imply that risk management models should incorporate dynamic correlation and volatility forecasting rather than relying on historical averages.

For institutional investors and market participants, the strong feedback relationship between FPI flows and equity returns indicates that liquidity conditions play a crucial role in price discovery. Monitoring foreign flow indicators alongside macroeconomic variables such as oil prices can improve short-term market forecasting and risk assessment. The evidence also suggests that domestic institutional participation can act as a stabilizing force during foreign outflows, reinforcing the importance of deepening domestic capital markets.

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