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Assessing the Effect of Commodity Price, USD Exchange Rate, Trade Balance on India's Economic Growth: An Empirical Analysis

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Abstract

This study investigates how external macroeconomic forces crude oil prices, gold prices, the USD/INR exchange rate, and the trade balance shape India's real GDP over 2000–2025 using annual data. India dependence on imported energy and its exposure to global price and currency shocks, the study evaluates whether these external variables exert persistent (long-run) effects on growth and how shocks transmit in the short run. The empirical strategy combines Johansen cointegration to assess long-run relationships, a Vector Error Correction Model (VECM) to capture short-run dynamics and adjustment toward equilibrium, and a Structural VAR (SVAR) to interpret the transmission of structural shocks across the system. The results indicate a stable long-run linkage between output and the external-sector variables, with short-run disturbances transmitted primarily through cost-push pressures and external balance constraints. Oil-price increases and rupee depreciation are associated with weaker growth dynamics, while gold exhibits a dual role providing hedging/wealth effects in risk-off periods but also intensifying external pressures through import demand. The findings highlight the need for an integrated resilience framework for India that prioritizes energy diversification and efficiency, credible exchange-rate and reserve management, stronger trade competitiveness, and structural measures to moderate import-intensive gold demand through monetization and attractive financial saving alternatives.

JEL Classification: F41, F31, F14, Q41, C32

Keywords: *Commodity prices, Cointegration, Economic growth, Exchange rate, Trade balance*

1. Introduction

India's economic growth trajectory over the last two decades has been increasingly shaped by external shocks transmitted through global commodity markets, exchange-rate movements, and trade dynamics (Mallick & Sousa, 2013; World Bank 2020). As a large net importer of crude oil and gold, India remains structurally exposed to changes in international prices that affect domestic inflation, production costs,

household balance sheets, and external-sector sustainability. Crude oil price movements directly influence transportation and industrial input costs and, consequently, inflation and output dynamics (Deheri, 2023; Economic Times, 2025). Gold, in contrast, occupies a distinctive position in India as both a culturally embedded store of value and an investment asset, influencing household savings and portfolio allocation decisions while also affecting the import bill (Khandelwal, 2025; Indian Express, 2025). These commodity-linked channels make macroeconomic stability and growth outcomes sensitive to global volatility and underscore the importance of understanding the combined macro-financial effects of key external variables.

In addition to commodity prices, the USD/INR exchange rate constitutes a central transmission mechanism through which external shocks influence India's domestic economy. Exchange-rate movements alter the local-currency cost of essential imports particularly energy and gold affect export competitiveness, and shape aggregate demand via trade and financial channels (Patra et al., 2017; Sahoo & Dash, 2018). Empirical evidence further indicates that exchange-rate volatility can influence growth performance by affecting investment, inflation expectations, and the external financing environment (Shaik & Rao, 2020; Kumar & Singh, 2023). Closely linked to these mechanisms is India's trade balance, which reflects the net effect of export earnings and import expenditures and often serves as a conduit through which global price shocks and currency movements translate into domestic macroeconomic outcomes (Kumar & Singh, 2023). With increased trade openness and evolving trade patterns, changes in export and import conditions can influence output, employment, and income, strengthening the relevance of the external sector for growth analysis (NITI Aayog, 2023; Kumar & Singh, 2023).

A growing literature has examined the macroeconomic implications of commodity price movements, exchange-rate fluctuations, and trade outcomes, including their roles in shaping growth and stability in emerging economies. Studies commonly report that oil price shocks can be contractionary for oil-importing countries due to higher costs and inflationary pressures, while exchange-rate depreciation may amplify the adverse effects by raising the domestic price of imports and tightening macroeconomic conditions (Patra et al., 2017; Deheri, 2023; Shaik & Rao, 2020). Parallel research emphasizes that trade dynamics and external imbalances may reinforce vulnerability by constraining external financing capacity and affecting domestic economic performance (Sahoo & Dash, 2018; Kumar & Singh, 2023). However, despite these insights, much of the empirical work assesses these drivers individually or in limited bilateral settings, which provides only partial evidence on the joint, system-wide influence of crude oil prices, gold prices, exchange rates, and the trade balance on India's growth performance.

This limitation is particularly important in the context of recent structural changes and global disruptions. Post-pandemic adjustments, supply-chain disruptions, changes in global monetary conditions, and heightened geopolitical tensions have altered global commodity-price dynamics,

exchange-rate conditions, and trade patterns potentially strengthening the interactions among these variables and their combined implications for growth. Policy-facing discussions similarly highlight the need to monitor external vulnerabilities and strengthen resilience through improved buffers and external-sector management (IMF, 2025; India Brand Equity Foundation, 2025). At the same time, recent scholarship has continued to develop empirical perspectives on commodity macro linkages and external shock transmission in emerging markets, reinforcing the relevance of updated multivariate evidence (Mukherjee & Naka, 2021). This study fills this gap by jointly examining how gold prices (GP), crude oil prices (OP), the USD/INR exchange rate (ER), and the trade balance (TB) influence India's real GDP growth (RGDP) over the period 2000–2025. The study focuses on both long-run and short-run relationships to understand whether these external factors move together with India's real economic activity over time and how shocks affect the economy in the short run.

Against this backdrop, the present study addresses the following research questions:

1. Do crude oil prices, gold prices, the USD/INR exchange rate, and the trade balance exhibit a stable long-run equilibrium relationship with India's economic growth?
2. How do shocks to these external variables affect growth dynamics in the short run, and how does the system adjust back to equilibrium after disturbances?
3. Which external factor(s) exert the strongest influence on India's growth trajectory over the sample period?

To answer these questions, this study examines annual data for India from 2000 to 2025 and applies a multivariate time-series framework designed to capture both long-run and short-run dynamics. Specifically, Johansen cointegration is used to test for long-run equilibrium relationships (Johansen, 1988), a Vector Error Correction Model (VECM) is employed to model short-run adjustments consistent with cointegration logic (Engle & Granger, 1987), and a Structural VAR (SVAR) framework is used to interpret structural shocks and dynamic responses (Sims, 1980; Lütkepohl, 2005).

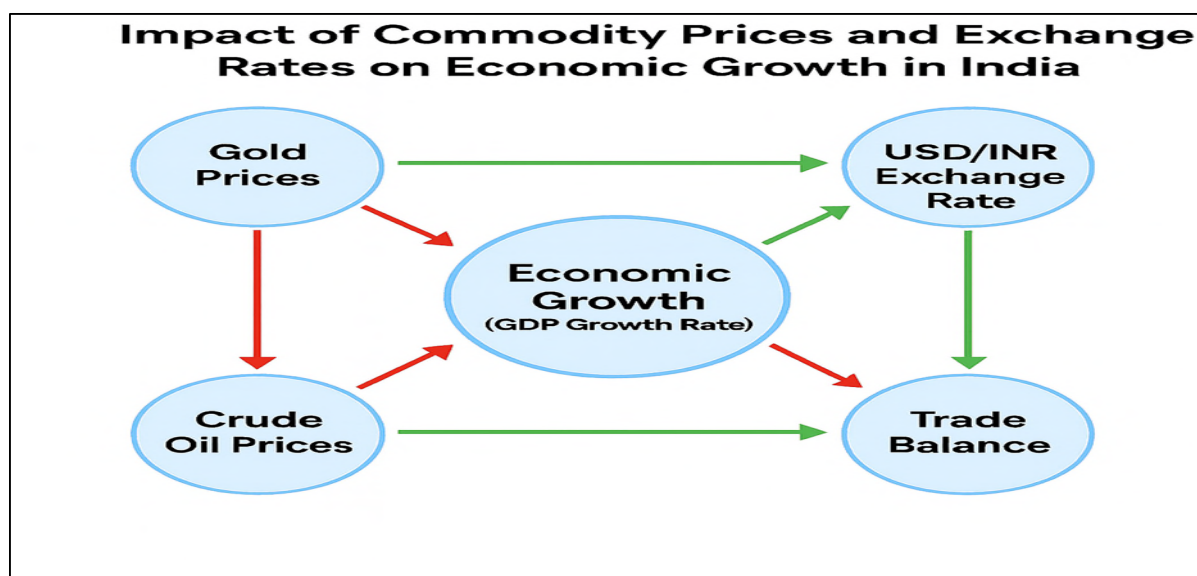


Fig:1 Shows gold, oil, USD/INR, trade balance shaping India's growth

This study contributes to the literature in three ways. First, it provides a unified empirical assessment of how crude oil prices, gold prices, the USD/INR exchange rate, and the trade balance jointly influence India's economic growth, addressing the limitation of studies that consider these channels in isolation. Second, by using a long sample period (2000–2025), it captures multiple global disruptions and policy shifts, offering updated evidence relevant to contemporary external vulnerability. Third, the findings generate policy-relevant insights for strengthening macroeconomic resilience through external-sector management, commodity-risk mitigation, and improved macro buffers (IMF, 2025; India Brand Equity Foundation, 2025). The novelty of this study lies in providing a single, system-wide and India-focused assessment of how gold prices (GP), crude oil prices (OP), the USD/INR exchange rate (ER), and the trade balance (TB) jointly shape India's real GDP (RGDP). Unlike much of the existing evidence that examines these external drivers one-by-one or in narrow bilateral settings, this study models them together in one multivariate framework, allowing their interactions and combined transmission to be captured more clearly (Patra et al., 2017; Sahoo & Dash, 2018; Shaik & Rao, 2020; Kumar & Singh, 2023). It is also novel in separating long-run equilibrium linkages from short-run adjustment dynamics using Johansen cointegration and a VECM framework (Johansen, 1988; Engle & Granger, 1987), and then applying a structural shock framework to interpret how unexpected movements in commodities, the exchange rate, and trade conditions propagate to output (Sims, 1980; Lütkepohl, 2005). By covering a long period that includes multiple major global disruptions and policy regimes, the study offers updated and more policy-relevant evidence on India's external vulnerability and macroeconomic resilience (IMF, 2025; India Brand Equity Foundation, 2025; Mukherjee & Naka, 2021). Finally, the analysis identifies which external factor is most influential for India's growth dynamics within the same consistent empirical setting, which is difficult to infer from fragmented single-variable studies (Patra et al., 2017; Sahoo & Dash, 2018; Shaik & Rao, 2020; Kumar & Singh, 2023).

2. Literature Review

India's economic growth has historically been shaped by global commodity markets, exchange-rate movements, and fluctuations in its trade position. As a major importer of crude oil price and gold price and a country with persistent trade deficits, external shocks in global markets significantly influence domestic macroeconomic conditions. The existing literature from 2018–2025 provides extensive insight of how crude oil prices, gold prices, USD exchange-rate volatility, and trade balance dynamics are interconnected and jointly shape economic performance in India and other emerging economies.

2.1 Commodity Prices and Macroeconomic Dynamics

2.1.1 Crude Oil Prices and Economic Activity

Crude oil is one of the most influential external variables for India due to its heavy dependence on imports. Studies has been done how oil price shocks affect output, inflation, exchange rates, and financial markets. Early studies suggests that crude oil tends to be pro-cyclical with India's economic growth, meaning rising oil prices reduce output and widen trade deficits (Sreenu, 2019). There are studies using VAR and GARCH frameworks confirm that oil price spikes increase production costs, intensify inflation, and depress industrial output in India (Sreenu, 2019; Sahadudheen & Kumar, 2023). Recent research also highlights the asymmetric nature of oil shocks. Chen et al., (2022), using a VAR-BEKK–GARCH model for BRICS, find that India experiences strong volatility spillovers from crude oil to currency and gold markets, particularly during periods of market stress. Similarly, Singh et al., (2025) observe that in India and China, oil price volatility acts as a significant transmitter of shocks to exchange rates and equity markets. These findings align with global evidence showing that oil markets transmit more risk during crises than during stable periods. Shokravi et al. (2025) show that political and economic risks significantly influence environmental performance in oil-exporting and importing countries, highlighting the vulnerability of nations like India and underscoring the need for sustainable energy and policy reforms. Saidu et al. (2021) show that oil price shocks have significant and asymmetric effects on exchange rates in major African oil-importing countries, highlighting how rising oil prices depreciate currencies evidence that supports oil-price exchange-rate sensitivity in import-dependent economies like India. Salem et al. (2025) show that oil price fluctuations during the Russia–Ukraine conflict significantly reduce stock market performance in both oil-importing and exporting countries, underscoring the strong impact of geopolitical oil shocks on global financial markets.

The influence of oil prices tends to intensify during global disruptions. For instance, during COVID-19 and the Russia–Ukraine conflict, the transmission of oil shocks to exchange rates and financial markets increased sharply (Kumeka et al., 2022). Patidar et al., (2024) studies show's that oil price movements during major geopolitical events such as wars, pandemics, and supply disruptions have historically reshaped global economic structures, with import dependent nations like India facing the highest vulnerability.

2.1.2 Gold Prices and Economic Stability

Gold plays a unique role in India as both a consumption commodity and a financial asset. Some studies indicate that gold markets interact strongly with oil and exchange-rate dynamics. In India, gold is often a recipient of volatility transmitted from oil and currency markets (Chen et al., 2022). Rastogi et al., (2022) find long-term conditional correlation between gold prices and interest rates, although they observe limited direct volatility spillover to interest rates. Gold also serves as a hedge during periods of global uncertainty. During COVID-19, gold prices showed strong hedging properties against stock market losses and acted as a stabilizing asset for portfolio investors (Li et al., 2023). Sahadudheen and Kumar (2023) conclude that gold and oil prices exhibit positive co-movement with the exchange rate, particularly during crisis periods, reinforcing gold's role as a safe-haven asset.

Beyond that financial stability, global evidence shows gold interacts with economic diversification processes. Bala (2025) finds that in GCC economies, gold prices positively influence the oil growth nexus and partly mediate the long-run relationship between oil prices and economic growth. This highlights the importance of gold not only as a financial instrument but also as a macroeconomic stabilizer.

2.2 Exchange Rate Volatility and Macroeconomic Performance

Exchange-rate movements significantly influence India's macroeconomic stability due to its import dependence. A growing body of research highlights strong bidirectional linkages between oil prices and exchange rates. Albulescu and Ajmi (2021) detect time-varying causality between international oil prices and the U.S. dollar real effective exchange rate, with causality strengthening during the Global Financial Crisis (GFC). These findings such as these align with evidence from BRICS markets, where exchange rates act as channels through which oil shocks affect domestic financial systems (Chen et al., 2022). India-specific research reinforces these results, Sahadudheen and Kumar (2023) report positive effect time-varying correlations between oil prices and the INR exchange rate, especially during crises. Melath and

Samsudheen (2025), using a TVP-VAR model, find that oil acts as a consistent net transmitter of shocks to major currencies such as USD and British Pound (GBP) during crises including the Global Financial Crisis (GFC), COVID-19, and the Russia–Ukraine war.

Exchange-rate volatility also affects trade flows. Arya et al., (2025) show that although exchange-rate fluctuations do not significantly alter India’s exports or imports directly, they create instability in short-term trade performance. Their findings indicate that Reserve Bank of India (RBI) interventions help stabilize currency volatility temporarily but do not address structural issues such as import dependence and limited export diversification. At a broader level, multiple studies insist that exchange-rate shocks intensify inflationary pressures in oil-importing countries. Bigerna (2023; 2024) concludes that energy-price shocks combined with exchange-rate depreciation contribute to inflation contagion, with asymmetric effects across countries.

In addition, recent exchange-rate–trade literature emphasizes that exchange-rate effects on trade balance can be nonlinear and asymmetric, and that the USD often acts as a “vehicle currency” even when trade does not involve the US directly. Using nonlinear ARDL (NARDL), Bao and Le (2021)^{a,b} show that exchange-rate movements can have asymmetric impacts on Vietnam’s bilateral trade with EU-27 countries and the UK, and they highlight that USD-based exchange rates provide stronger and more meaningful short-run and long-run effects than relying only on bilateral rates (Bao & Le, 2021)^{a,b}. Related evidence also supports a dynamic adjustment process consistent with the J-curve mechanism: Le et al. (2017/2018) find short-run negative effects of real exchange rate on trade balance but a positive long-run impact, confirming that the direction and magnitude of exchange-rate effects can differ across horizons (Le et al., 2017/2018). Together, these findings strengthen the motivation to consider asymmetry and short-run versus long-run separation when interpreting how exchange-rate shocks translate into external-sector outcomes.

2.3 Trade Balance, Openness, and Growth

India’s persistent trade deficit makes external shocks particularly relevant to its growth trajectory. Trade balance responds not only to oil import costs but also to exchange-rate dynamics and global demand. Studies examining trade openness and growth show mixed results across countries. Abdulkarim (2023), finds that oil exports and imports adversely affect long-term growth, suggesting resource dependence can hinder development. Although not directly focused on India, these findings have implications for economies with similar import

structures. For India, empirical research demonstrates that oil and gold imports widen the trade deficit and exert pressure on growth. Sreenu (2019) notes that rising oil import bills contribute significantly to inflation and current account imbalances. Some recent evidence from global trade network analysis shows India as a major importer with high instability, indicating that shocks in producer countries quickly transmit to India (Shahnazi et al., 2023).

Recent trade-balance studies further argue that exchange-rate impacts on trade balance may depend on invoicing and settlement practices, particularly the dominance of the USD as a vehicle currency. At an industry level, Bao and Le (2021)^{a,b} show that ASEAN's trade balance with the EU-28 is significantly influenced by the vehicle-currency USD exchange rate in the long run, and they report notable short-run and long-run asymmetries across industries, supporting the view that aggregation can hide important heterogeneous trade responses (Bao & Le, 2021)^{a,b}. Similarly, Bao et al. (2023) find that China's trade balances with the EU-28 respond nonlinearly to the USD vehicle-currency exchange rate at the industry level, and they argue that depreciation against the USD does not automatically improve trade balances, since responses depend on currency choice and sector structure (Bao et al., 2023). These insights are relevant for trade-deficit economies because they indicate that trade balance adjustment may not be explained fully by a simple bilateral exchange-rate channel, especially under high USD dominance in global trade.

Outside India, research from Türkiye reveals that monetary policy plays a stronger role in improving the trade balance than exchange-rate or price adjustments. Kocoglu and Kula (2025) find that contractionary monetary policy improves the trade balance primarily by reducing domestic demand, not through exchange-rate adjustments offering policy insights for emerging economies like India.

2.4 Integrated Spillover Effects Among Commodity, Currency, and Financial Markets

A consistent theme in the literature is that oil, gold, exchange rates, and financial markets exhibit strong interconnectedness. These interactions become especially pronounced during global crises. Multiple studies employing high-frequency econometric models such as VAR-BEKK, DCC-GARCH, and Vine-Copula show dynamic and asymmetric spillovers. Zeng et al. (2022) find substantial risk spillover from crude oil to China's stock market and exchange rate, with WTI crude generating the strongest systematic risk. Similar patterns are found in G20 economies, where oil is the most severely affected market during the COVID-19 period (Liu et al., 2024). Abid and Alotaibi (2020) show that crude oil prices strongly influence

macroeconomic activity by stimulating private investment in Saudi Arabia, while public investment crowds it out.

For India, evidence suggests that oil and gold are both sources and transmitters of volatility. Singh et al. (2025) show that gold and interest rates serve as primary volatility transmitters in India and China. Sahadudheen and Kumar (2023) find that volatility spillovers sharply increased during both the Global Financial Crisis and COVID-19, with COVID-19 generating the highest volatility. These interconnected findings highlight that India's external sector is vulnerable not simply to oil shocks, but to multi-market spillovers that propagate across commodity, currency, and financial markets simultaneously.

In line with this integrated view, the “vehicle currency” channel can also be interpreted as an additional global transmission mechanism, because USD movements may influence trade balances even between non-US partners (Bao & Le, 2021^{a,b}; Bao et al., 2023). This supports the broader argument that external shocks can transmit through multiple linked pathways commodity prices, exchange-rate dynamics, and trade balance adjustments rather than through a single isolated macroeconomic variable.

Research Gap

Overall, the literature confirms that crude oil prices, gold prices, and exchange-rate movements can influence macroeconomic performance, but the evidence is mostly examined in separate or partial frameworks (Sreenu, 2019; Sahadudheen & Kumar, 2023; Chen et al., 2022; Singh et al., 2025). At the same time, the post-2018 period is marked by major global shocks COVID-19, supply-chain disruptions, USD appreciation cycles, and geopolitical tensions which may have changed India's sensitivity to external factors, yet many empirical studies do not capture these recent dynamics (Kumeka et al., 2022; Patidar et al., 2024; Salem et al., 2025). Further, the trade balance is an important transmission channel for an import-dependent economy like India, but it is often not integrated into growth models, even though trade responses to exchange-rate changes can differ in the short run and long run (Shahnazi et al., 2023; Le et al., 2017/2018; Bao & Le, 2021; Bao et al., 2023). Therefore, the literature leaves limited India-focused evidence that jointly examines crude oil prices, gold prices, USD/INR exchange rate, and trade balance within one multivariate system to explain both long-run and short-run movements in economic growth. This study addresses this gap using Johansen cointegration and a VECM–SVAR framework.

Theoretical Perspective

The connection between commodity prices, exchange rates, trade balance, and economic growth is explained through several well-known economic theories. According to cost-push inflation theory, when crude oil prices rise, production becomes more expensive, inflation increases, and economic growth slows especially in countries like India that depend heavily on oil imports (Sreenu, 2019). Gold prices also matter because higher global gold prices increase India's import bill and put pressure on the external sector. Exchange rate behaviour is guided by Purchasing Power Parity and monetary theories, which state that currencies lose value when inflation rises and import costs increase. Studies show that when oil and gold prices go up, the Indian rupee often depreciates, raising import expenses further and affecting growth (Albulescu & Ajmi, 2021).

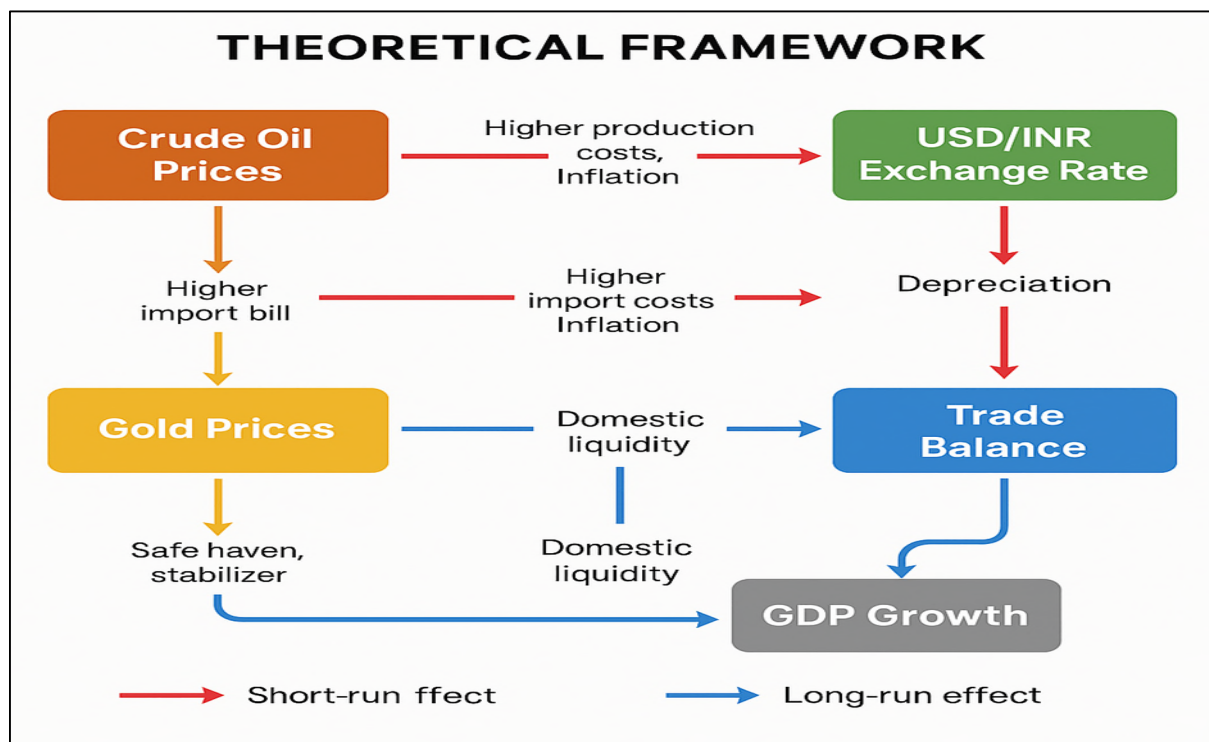


Figure: 2 Illustrates the conceptual linkages among gold prices, crude oil prices, the USD/INR exchange rate, and the trade balance, and explains how these factors are expected to jointly influence India's economic growth.

The effect of currency movements on trade is traditionally explained by the Marshall–Lerner condition and the J-curve, which suggest that depreciation can improve trade balance over time. In case of India, import demand for oil and gold is not very flexible, so depreciation does not reduce imports much meaning the trade deficit often remains high (Arya et al., 2025; Kocoglu

& Kula, 2025). Finally, the Mundell–Fleming model shows how commodity prices, exchange rates, capital flows, and trade balance interact in an open economy. Recent studies support the idea that shocks in oil, gold, and currency markets move together and affect overall economic performance (Chen et al., 2022; Sahadudheen & Kumar, 2023).

3. Material and Methods

This study employs a quantitative time-series econometric approach to analyse the impact of gold prices (*GP*), crude oil prices (*OP*), USD/INR exchange rate (*ER*), and trade balance (*TB*) on India's economic growth over the period 2000–2025 yearly data were taken for the analysis. Data for the variables including India's RGDP growth, gold prices, oil prices, exchange rate, and trade balance are sourced from reputable databases such as Macrotrends, RBI, BookMyForex, the World Bank, and the International Monetary Fund (IMF).

Stationarity Testing

To confirm suitability for cointegration analysis, stationarity of all series is assessed using Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests, specified as:

$$\Delta X_t = \alpha + \beta X_{t-1} + \sum_{i=1}^p \phi_i \Delta X_{t-i} + \varepsilon_t \dots \dots \dots I$$

Where ΔX_t is the first-differenced series. Results show all series are integrated of order one, $I(1)$.

Johansen Cointegration Test

The Johansen cointegration test is employed to determine the number of long-run equilibrium relationships among the $I(1)$ variables. The Johansen framework is based on the VECM representation:

$$\Delta Z_t = c + \sum_{i=1}^{p-1} \Gamma_i \Delta Z_{t-i} + \Pi Z_{t-1} + \varepsilon_t \dots \dots \dots \Pi$$

where:

- Z_t is the vector $(\ln(RGDP_t), \ln(GP_t), \ln(OP_t), \ln(ER_t), TB_t)'$,
- Γ_i capture short-run dynamics,

- Π is the long-run impact matrix, decomposed as:

$$\Pi = \alpha\beta'$$

where β represents the cointegrating vectors and α represents the adjustment speeds.

The test uses two statistics: the trace statistic and the maximum eigenvalue statistic. Based on these, the study finds two cointegrating vectors at the 5% significance level, indicating two statistically significant long-run relationships among the variables.

Lag Length Selection

Optimal lag length is determined using multiple criteria including the Likelihood Ratio (LR), Akaike Information Criterion (AIC), Schwarz Criterion (SC), and Final Prediction Error (FPE). All criteria consistently recommend a lag length of two, ensuring the model captures temporal dynamics without overfitting.

Structural Vector Autoregression (SVAR)

To reveal contemporaneous structural relations and the impulse responses, a 5-variable SVAR (2) model is estimated:

SVAR System

$$A_0 \begin{pmatrix} Y_t \\ GP_t \\ OP_t \\ EX_t \\ TB_t \end{pmatrix} = A_1 \begin{pmatrix} Y_{t-1} \\ GP_{t-1} \\ OP_{t-1} \\ EX_{t-1} \\ TB_{t-1} \end{pmatrix} + A_2 \begin{pmatrix} Y_{t-2} \\ GP_{t-2} \\ OP_{t-2} \\ EX_{t-2} \\ TB_{t-2} \end{pmatrix} + u_t \dots \dots \dots III$$

where:

- A_0 is the contemporaneous matrix,
- A_1, A_2 are lag coefficient matrices (5x5 each),
- u_t is the vector of orthogonalized structural shocks $(u_{Y_t}, u_{GP_t}, u_{OP_t}, u_{EX_t}, u_{TB_t})'$.

Vector Error Correction Model (VECM)

Using the cointegration results and lag length, the VECM is specified to quantify both short-run dynamics and the speed of adjustment to long-run equilibrium:

$$\Delta Y_t = \alpha + \sum_{i=1}^{p-1} \beta_i \Delta X_{t-i} + \lambda ECT_{t-1} + \varepsilon_t \dots \dots \dots IV$$

where ECT_{t-1} is the error correction term derived from the cointegrating relationship, and λ measures the speed of adjustment. A statistically significant and negative λ indicates convergence toward the long-run equilibrium.

Using the cointegration results and the selected lag structure, the VECM is estimated to quantify both short-run dynamics and the speed of adjustment to the long-run equilibrium. The error-correction term is defined as:

$$ECT_{t-1} = \beta' Z_{t-1} \dots \dots V$$

A compact VECM form can be written as:

$$\Delta Z_t = c + \sum_{i=1}^{p-1} \Gamma_i \Delta Z_{t-i} + \alpha ECT_{t-1} + \varepsilon_t \dots \dots \dots VI$$

Scalar form for each variable (equation-by-equation VECM)

For each equation $j \in \{1,2,3,4,5\}$, the scalar form is:

$$\Delta Z_{j,t} = c_j + \phi_j ECT_{t-1} + \sum_{i=1}^{p-1} \sum_{k=1}^5 \gamma_{jk,i} \Delta Z_{k,t-i} + \epsilon_{j,t} \dots \dots \dots VII$$

Given the selected lag length $p = 2$, the differenced dynamics include **one lag** ($p - 1 = 1$). Therefore, the system can be written explicitly as:

RGDP equation

$$\Delta \ln(RGDP_t) = c_1 + \phi_1 ECT_{t-1} + \sum_{k=1}^5 \gamma_{1k,1} \Delta Z_{k,t-1} + \epsilon_{1,t} \dots \dots \dots VIII$$

Gold price equation

$$\Delta \ln(GP_t) = c_2 + \phi_2 ECT_{t-1} + \sum_{k=1}^5 \gamma_{2k,1} \Delta Z_{k,t-1} + \epsilon_{2,t} \dots \dots \dots IX$$

Crude oil price equation

$$\Delta \ln(OP_t) = c_3 + \phi_3 ECT_{t-1} + \sum_{k=1}^5 \gamma_{3k,1} \Delta Z_{k,t-1} + \epsilon_{3,t} \dots \dots \dots X$$

Exchange rate equation

$$\Delta \ln(ER_t) = c_4 + \phi_4 ECT_{t-1} + \sum_{k=1}^5 \gamma_{4k,1} \Delta Z_{k,t-1} + \epsilon_{4,t} \dots \dots \dots XI$$

Trade balance equation

$$\Delta TB_t = c_5 + \phi_5 ECT_{t-1} + \sum_{k=1}^5 \gamma_{5k,1} \Delta Z_{k,t-1} + \epsilon_{5,t} \dots \dots \dots XII$$

where:

- ϕ_j is the adjustment speed (ECT coefficient) for variable j ,
- $\gamma_{jk,1}$ captures the short-run effect of the first lag of $\Delta Z_{k,t-1}$ on $\Delta Z_{j,t}$,
- a statistically significant and negative ϕ_j indicates convergence toward the long-run equilibrium.

Covariance Matrix of Structural Shocks

The reduced-form residuals are generally correlated; their covariance matrix can be written as:

$$S = \text{Var}(u_t) = \begin{bmatrix} \sigma_{11} & \sigma_{12} & \cdots & \sigma_{15} \\ \sigma_{12} & \sigma_{22} & \cdots & \sigma_{25} \\ \vdots & \vdots & \ddots & \vdots \\ \sigma_{15} & \sigma_{25} & \cdots & \sigma_{55} \end{bmatrix}$$

In the SVAR, structural shocks are orthogonal by construction; thus:

$$\Omega = \text{Var}(u_t) = \begin{pmatrix} \sigma_1^2 & 0 & 0 & 0 & 0 \\ 0 & \sigma_2^2 & 0 & 0 & 0 \\ 0 & 0 & \sigma_3^2 & 0 & 0 \\ 0 & 0 & 0 & \sigma_4^2 & 0 \\ 0 & 0 & 0 & 0 & \sigma_5^2 \end{pmatrix}$$

Methodological Improvements and Innovation

SVAR identification transparency (explicit A_0 restrictions)

To highlight the structural (not purely reduced form) contribution, the contemporaneous restriction structure is explicitly documented. A commonly used theory-consistent form is a restricted A_0 matrix such as:

$$A_0 = \begin{pmatrix} 1 & 0 & 0 & 0 & 0 \\ a_{21} & 1 & 0 & 0 & 0 \\ a_{31} & a_{32} & 1 & 0 & 0 \\ a_{41} & a_{42} & a_{43} & 1 & 0 \\ a_{51} & a_{52} & a_{53} & a_{54} & 1 \end{pmatrix}$$

This type of structure (i) treats commodity prices as primarily externally driven contemporaneously (restriction examples shown), and (ii) allows domestic variables (growth, exchange rate, trade balance) to respond within the period according to economic theory. An alternative identification (e.g., alternative restriction pattern/order) is used as a robustness check to show that impulse-response conclusions are not dependent on a single identification choice.

Structural-break robust stationarity check

Given the long period (2000–2025) that includes major disruptions, a break-robust unit-root specification is included as an additional check.

$$\Delta X_t = \mu + \beta t + \theta DU_t + \gamma DT_t + \alpha X_{t-1} + \sum_{i=1}^p c_i \Delta X_{t-i} + \varepsilon_t \dots \dots \dots XIII$$

where DU_t captures a level shift and DT_t captures a trend break at an endogenously determined break date. This strengthens the validity of the integration and cointegration decisions when structural changes are plausible.

Enhanced SVAR reporting

To make results more policy-informative, the SVAR analysis is complemented by variance decomposition and (where relevant) historical decomposition, in addition to impulse responses, to quantify the relative contribution of commodity, exchange-rate, and trade-balance shocks to fluctuations in growth.

Diagnostic Tests

Model assumptions and robustness are checked through several diagnostic tests:

- Breusch-Godfrey test for serial correlation in residuals to ensure independence.
- Jarque-Bera test for residual normality, where the test statistic is:

$$JB = \frac{n}{6} \left(S^2 + \frac{(K - 3)^2}{4} \right) \dots \dots \dots XIV$$

with n as sample size, S skewness, and K kurtosis.

- CUSUM and CUSUMSQ stability tests assess parameter stability and detect structural breaks by plotting cumulative sums of recursive residuals against confidence bounds.

All estimations and tests are performed using EViews 12 and Excel.

This comprehensive econometric framework consisting of stationarity checks, Johansen cointegration, VECM for short- and long-run dynamics, SVAR for structural analysis, accompanied by classical diagnostic tests provides robust inference on the joint influence of commodity prices, exchange rate movements, and trade balance on India's economic growth. The methodology ensures policy-relevant and statistically valid conclusions supported by the data spanning 2000 to 2025.

Ethical Considerations

This study was conducted using publicly available secondary data from recognized sources, ensuring strict observance to ethical standards in research. There were no human participants were involved, so risks of privacy or consent were avoided. All data sources are properly cited, and analyses are reported honestly and transparently. The research complies with institutional and journal guidelines regarding integrity, objectivity, and the responsible use of data, and aims to present unbiased results to support informed policy and academic discourse.

4. Result and Discussion

Analysis begins with descriptive statistics that explain the basic characteristics of the variables under study. The Johansen cointegration test identifies two significant long-run relationships among India's GDP growth, gold, oil prices, exchange rate, and trade balance, which are confirming the existence of long-term equilibrium linkages (Johansen, 1988). Subsequently, the Vector Error Correction Model (VECM) help to captures short-term dynamics and the speed with which deviations from long-run equilibrium are corrected (Engle & Granger, 1987). Structural Vector Autoregression (SVAR) is then utilized to uncover contemporaneous causal

interactions and structural shocks affecting economic growth (Sims, 1980). we finally, impulse response functions provide insights into the magnitude and persistence of these shocks over time (Lütkepohl, 2005).

Table:1 Summary Model of Descriptive Statistics, India's Economic Landscape

	<i>RGDP</i>	<i>CRUDE_OIL</i>	<i>EXCHANGE_RATE</i>	<i>GOLD_PRICE</i>	<i>TRADE_BALANCE</i>
<i>Mean</i>	1955.783	61.57500	59.44423	29556.31	-60.54538
<i>Median</i>	1842.180	60.99500	55.00500	27016.00	-61.46000
<i>Maximum</i>	4019.000	98.83000	88.72000	104263.0	-4.230000
<i>Minimum</i>	468.3900	19.96000	41.35000	4300.000	-142.9800
<i>Std. Dev.</i>	1104.578	23.08409	15.16913	24798.51	41.23802
<i>Skewness</i>	0.297084	0.045803	0.483995	1.329611	-0.179200
<i>Kurtosis</i>	1.988004	1.999379	1.805909	4.531722	2.069980
<i>Observations</i>	26	26	26	26	26

Source: Author Calculation

The data shows high volatility in India's macroeconomic variables, with pronounced commodity price swings, currency fluctuations, and persistent trade deficits reflecting structural external sector vulnerabilities and exposure to global shocks. These patterns justify the application of advanced econometric techniques to investigate the dynamic linkages between commodity prices, exchange rates, and economic growth. (See Table 1)

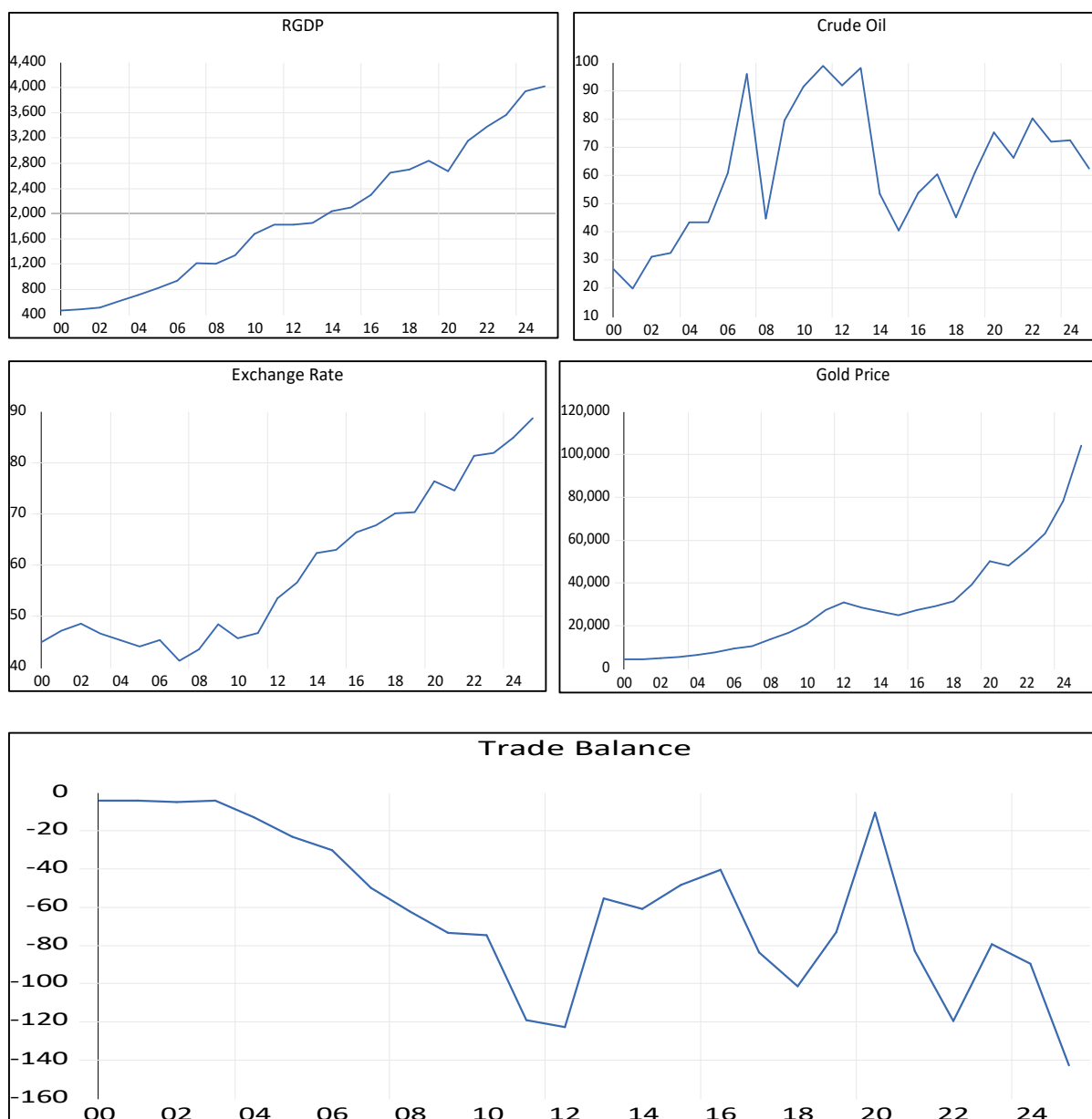


Figure: 3 Trends Analysis

Across all figures, gold prices in India have increased sharply over the years, while crude oil prices have been volatile with significant ups and downs. The trade balance mostly shows a growing deficit, meaning the country imports much more than it exports. The exchange rate has steadily weakened, it's showing that the rupee lost value against the US dollar, despite these challenges, real GDP has managed to grow consistently, reflecting continued economic growth but also exposure to global price swings and external pressures. (See Figure 3)

Table: 2 Summary of VAR Lag Order Selection Criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
-----	------	----	-----	-----	----	----

0	-728.3516	NA	2.39e+20	61.11263	61.35806	61.17775
1	-617.5528	166.1983	1.98e+17	53.96273	55.43530*	54.35340
2	-577.8982	42.95908*	8.00e+16*	52.74152*	55.44123	53.45775*

Source: Author Calculation

The lag order selection results confirm that lag 2 is the optimal specification for the VAR model fundamental subsequent VECM and SVAR analyses. Multiple criteria including the Likelihood Ratio (LR), Final Prediction Error (FPE), Akaike Information Criterion (AIC), and Hannan-Quinn (HQ) consistently identify lag 2 as the preferred choice. The selection of lag 2 ensures that the model adequately reflects the temporal interdependencies among GDP, commodity prices, exchange rates, and trade balance, providing an effective foundation for cointegration testing and structural impulse response analysis. (*See Table 2*)

Table: 3 Summary Model of Unit Root Test

	<i>ADF Statistics</i>	<i>Critical Value</i>	<i>Probability Value</i>	<i>Stationary Level</i>
<i>GDP</i>	-5.558397	-2.991878	0.0001	<i>1st Difference (I)</i>
<i>OP</i>	-6.513572	-2.991878	0.0000	<i>1st Difference (I)</i>
<i>ER</i>	-5.350905	-2.991878	0.0002	<i>1st Difference (I)</i>
<i>GP</i>	-4.709012	-2.998064	0.0011	<i>1st Difference (I)</i>
<i>TB</i>	-6.183374	-2.998064	0.0000	<i>1st Difference (I)</i>

Source: Author Calculation

The Augmented Dickey–Fuller (ADF) test shows that GDP, oil price (OP), exchange rate (ER), gold price (GP), and trade balance (TB) are all non-stationary in level but become stationary after taking the first difference. In simple terms, these variables follow long-term trends and only become stable once their changes are analysed rather than their raw levels. This is common in macroeconomic data, as many economic variables tend to move upward over time due to inflation, growth, and structural shifts (Hyndman & Athanasopoulos, 2018). Earlier studies also report that oil prices, exchange rates, and output series typically behave as I(1) processes in developing and emerging economies (Cheung & Lai, 1995; Chen et al., 2022; Sahadudheen & Kumar, 2023).

Confirming that all variables are I(1) is important because it allows us to use cointegration, VECM, and SVAR models. These models only work properly when the data have the same order of integration, ensuring that any long-run relationship we find is meaningful and not just a false statistical pattern. By showing the variables are I(1), the ADF results support the use of these advanced econometric methods and align with past research findings. (*See Table 3*)

Table 4: Summary Model of Johansen Cointegration Test for Long-Run Relationship among Macroeconomic Variables

<i>Hypothesized Cointegrating Relationship(s)</i>	<i>Eigenvalue</i>	<i>Trace Statistic</i>	<i>0.05 Critical Value</i>	<i>Max-Eigen Statistic</i>	<i>0.05 Critical Value</i>	<i>Sig. (5%)</i>	<i>Inference</i>
<i>None</i>	0.905806	104.1384**	69.8189	54.3352**	33.8769	Yes	<i>Cointegration exists</i>
<i>At most 1</i>	0.641939	49.8032**	47.8561	23.6222	27.5843	Partial	<i>Supported by Trace only</i>
<i>At most 2</i>	0.502737	26.1810	29.7971	16.0686	21.1316	No	<i>Not significant</i>
<i>At most 3</i>	0.279506	10.1123	15.4947	7.5398	14.2646	No	<i>Not significant</i>
<i>At most 4</i>	0.105819	2.5725	3.8415	2.5725	3.8415	No	<i>Not significant</i>

Source: Author Calculation

The Johansen cointegration test confirms the presence of stable long-run equilibrium relationships among India's GDP, gold price, crude oil price, exchange rate, and trade balance. Both Trace and Max-Eigen statistics reject the null hypothesis of no cointegration, indicating at least two cointegrating vectors at the 5% significance level. This indicate that global commodity price shocks, currency movements, and trade dynamics systematically influence India's economic growth over time, with the system adjusting back to equilibrium after deviations. These findings highlight the critical macroeconomic channels through which external factors oil prices affecting import costs and inflation, exchange rates shaping trade competitiveness, gold prices reflecting investment sentiment, and trade balance capturing external demand jointly determine growth outcomes. These results underscore the need for coordinated policy frameworks addressing energy security, exchange rate management, and export promotion to sustain growth stability while monitoring external shocks from commodity markets and currency fluctuations. (See Table 4)

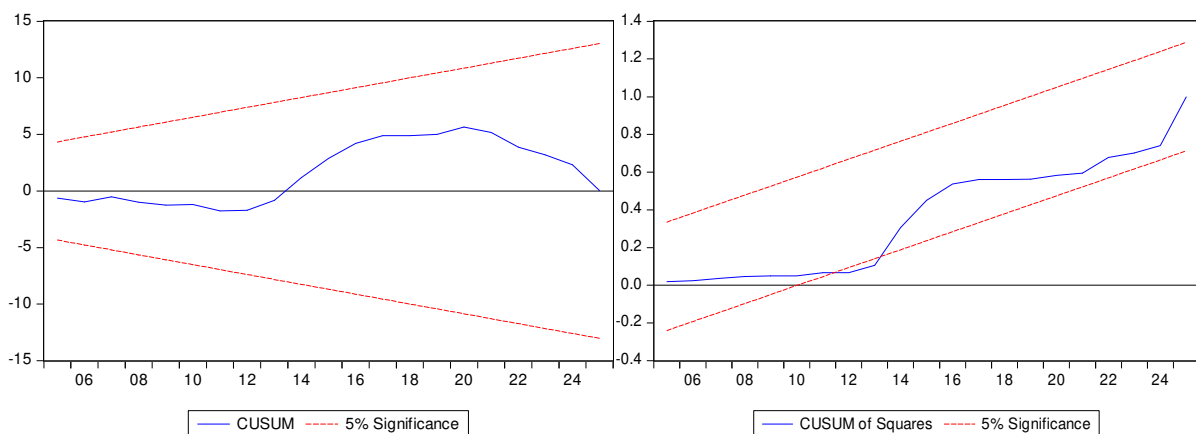


Fig: 4 Cusum and Cusum of Square Test

Both the CUSUM and CUSUMSQ plots confirm that your estimated model is stable over time, as the test lines remain within the 5% significance bounds during the sample period. This indicates there are no structural breaks or significant parameter instability in our time-series model, supporting the reliability of our results (Brown et al., 1975; Caporale & Pittis, 2004).(See Fig:4)

Table 5: VECM Residual Normality Test (Jarque–Bera)

<i>Component</i>	<i>Jarque–Bera Statistic</i>	<i>Degrees of Freedom</i>	<i>Probability</i>	<i>Normality Decision</i>
1	0.4611	2	0.7941	<i>Fail to Reject H_0</i>
2	1.6877	2	0.4300	<i>Fail to Reject H_0</i>
3	0.4712	2	0.7901	<i>Fail to Reject H_0</i>
4	2.8520	2	0.2403	<i>Fail to Reject H_0</i>
5	0.0669	2	0.9671	<i>Fail to Reject H_0</i>
<i>Joint Test</i>	5.5389	10	0.8524	<i>Residuals are jointly normal</i>

Source: Author Calculation

The Jarque–Bera test confirms that the residuals in all five equations of the model follow a normal distribution. The test shows high p-values (0.24–0.97), all well above the 0.05 threshold, meaning the null hypothesis of normality cannot be rejected for GDP, oil price, exchange rate, gold price, and trade balance. This indicates that residuals do not display problematic skewness or kurtosis. Such findings are consistent with the expectations outlined by Bera and Jarque (1981), who note that normally distributed residuals are essential for reliable statistical inference in regression and time-series models. Normality of residuals is an important diagnostic requirement in VECM and SVAR frameworks because it supports the validity of coefficient estimates, hypothesis testing, and confidence intervals. Prior studies in macro econometrics also emphasize that normally distributed residuals enhance the stability of structural impulse responses and reduce bias in variance decomposition (Newey & West, 1987; Chen et al., 2022). Therefore, the normality results strengthen the credibility of the subsequent long-run and short-run interpretations and provide confidence that the model satisfies a core econometric assumption. (See Table 5)

Table 6: Vector Error Correction Model (VECM) Estimates

Variable	D(GDP_B)	D(CRUDE_OIL)	D(EXCHANGE_RATE)	D(GOLD_PRICE)	D(TRADE_BALANCE)
Error Correction Term (CointEq1)	0.323 (0.141) [2.28]**	0.027 (0.018) [1.50]	-0.007 (0.002) [-2.99]***	0.454 (2.483) [0.18]	-0.077 (0.017) [-4.43]***
D(GDP_B(-1))	0.606 (0.567) [1.07]	-0.020 (0.071) [-0.29]	0.002 (0.010) [0.24]	31.160 (9.956) [3.13]***	-0.180 (0.070) [-2.59]***
D(GDP_B(-2))	1.070 (0.573) [1.87]*	-0.072 (0.072) [-1.00]	-0.006 (0.010) [-0.64]	1.362 (10.067) [0.14]	-0.303 (0.070) [-4.30]***
D(CRUDE_OIL(-1))	4.889 (2.532) [1.93]*	-0.451 (0.318) [-1.42]	-0.147 (0.043) [-3.44]***	-151.815 (44.487) [-3.41]***	-1.377 (0.311) [-4.43]***
D(CRUDE_OIL(-2))	0.321 (2.220) [0.14]	-0.180 (0.278) [-0.65]	-0.068 (0.037) [-1.82]*	-147.603 (39.007) [-3.78]***	-0.396 (0.273) [-1.45]
D(EXCHANGE_RATE(-1))	67.152 (26.657) [2.52]**	2.290 (3.343) [0.69]	-1.391 (0.450) [-3.09]***	-728.156 (468.415) [-1.55]	-10.789 (3.276) [-3.29]***
D(EXCHANGE_RATE(-2))	18.823 (25.064) [0.75]	1.672 (3.143) [0.53]	-0.846 (0.423) [-2.00]**	-185.149 (440.417) [-0.42]	-2.630 (3.080) [-0.85]
D(GOLD_PRICE(-1))	-0.025 (0.018) [-1.42]	0.003 (0.002) [1.14]	-0.0001 (0.0003) [-0.24]	1.037 (0.309) [3.35]***	0.005 (0.002) [2.12]**
D(GOLD_PRICE(-2))	0.037 (0.019) [2.02]**	0.001 (0.002) [0.29]	0.0001 (0.0003) [0.44]	0.323 (0.326) [0.99]	-0.008 (0.002) [-3.40]***
D(TRADE_BALANCE(-1))	1.847 (2.457) [0.75]	-0.438 (0.308) [-1.42]	0.054 (0.041) [1.31]	46.464 (43.182) [1.08]	-0.515 (0.302) [-1.71]*
D(TRADE_BALANCE(-2))	0.472 (1.599) [0.30]	-0.469 (0.200) [-2.34]**	0.012 (0.027) [0.46]	-49.436 (28.092) [-1.76]*	-0.781 (0.196) [-3.98]***
Constant (C)	-242.337 (164.472) [-1.47]	-3.928 (20.625) [-0.19]	6.465 (2.775) [2.33]**	-2568.598 (2890.08) [-0.89]	88.253 (20.210) [4.37]***
R-squared	0.49402	0.611739	0.687250	0.921334	0.861384

Variable	D(GDP_ B)	D(CRUDE_ OIL)	D(EXCHANGE_R ATE)	D(GOLD_PRI CE)	D(TRADE_BALA NCE)
Adj. R-squared	-0.0119	0.223477	0.374500	0.842668	0.722769
F-statistic	0.9763	1.575584	2.197444	11.71199	6.214195

Notes: Each cell reports Coefficient (Standard Error) [t-statistic] significance. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels respectively, based on standard two-tailed critical values $|t| \geq 2.576$, $|t| \geq 1.960$, and $|t| \geq 1.645$.

Source: Author Calculation.

Table 6 reports the VECM estimates capturing both short-run dynamics and long-run adjustment among India's real GDP, crude oil prices, the USD/INR exchange rate, gold prices, and the trade balance over 2000–2025. The results are discussed below equation by equation.

The error correction term (ECT) identifies which variables actively restore the long-run equilibrium after a shock. The exchange rate ($ECT = -0.007$, $t = -2.99^{***}$) and trade balance ($ECT = -0.077$, $t = -4.43^{***}$) are the two significant error-correcting variables, meaning that when the system is displaced, it is the rupee and the external balance not GDP that do the heavy lifting of adjustment. The trade balance corrects fastest, consistent with India's structurally import-heavy economy where external imbalances trigger automatic market and policy responses (Sahoo & Dash, 2018; Kumar & Singh, 2023). Crude oil and gold prices show insignificant ECTs, confirming they are globally determined and weakly exogenous to India's domestic conditions India is a price-taker in both markets (Chen et al., 2022; Deheri, 2023).

In the short run, a lagged rupee depreciation raises GDP (67.152, $t = 2.52^{**}$), reflecting export competitiveness gains with a one-year lag consistent with J-curve dynamics (Arya et al., 2025). Lagged gold prices also contribute positively (0.037, $t = 2.02^{**}$), capturing the wealth effect: as gold prices rise, Indian household balance sheets improve, supporting consumption (Khandelwal, 2025; Rastogi et al., 2022). The overall GDP equation fit is weak (Adj. $R^2 = -0.012$, $F = 0.976$), which is expected given only 26 annual observations relative to the number of regressors short-run GDP dynamics in this system are better read through the impulse responses than through the direct coefficients (Cheung & Lai, 1995).

Rising oil prices depreciate the rupee at both lag one (-0.147 , $t = -3.44^{***}$) and lag two (-0.068 , $t = -1.82^*$), confirming the classic oil-import cost channel: higher oil prices widen the current account deficit and push the rupee down (Sahadudheen & Kumar, 2023; Melath & Samsudheen, 2025). The exchange rate also mean-reverts large depreciations partially correct

in the next period (-1.391 , $t = -3.09^{***}$), likely reflecting RBI intervention and stabilising capital flows (Arya et al., 2025).

This is the best-fitting equation ($\text{Adj. } R^2 = 0.723$) and tells the clearest economic story. Higher lagged GDP worsens the trade deficit (-0.180 , $t = -2.59^{***}$; -0.303 , $t = -4.30^{***}$) growth in India pulls in more oil and gold imports faster than exports can respond, a structural import-led dynamic (Sreenu, 2019). Rising oil prices directly widen the deficit (-1.377 , $t = -4.43^{***}$), as India's oil import bill is the single largest driver of its trade gap. Rupee depreciation also worsens the trade balance in the short run (-10.789 , $t = -3.29^{***}$), reflecting inelastic import demand India cannot easily reduce oil and gold import volumes when prices rise, so a weaker rupee simply makes the deficit larger in rupee terms (Kocoglu & Kula, 2025). Finally, the trade balance self-corrects over two years (-0.781 , $t = -3.98^{***}$), consistent with cyclical import compression and export adjustment mechanisms.

Gold prices are the most predictable variable in the system ($R^2 = 0.921$). Stronger GDP raises gold demand (31.160 , $t = 3.13^{***}$), driven by India's income-linked household gold consumption. Higher oil prices, however, crowd out gold demand at both lags (-151.815 , $t = -3.41^{***}$; -147.603 , $t = -3.78^{***}$) rising energy costs compress disposable income, leaving less for gold purchases (Chen et al., 2022).

The VECM confirms a clear transmission chain in India's external economy: global oil price rises depreciate the rupee, the weaker rupee inflates import costs, and the trade deficit widens all of which cumulatively weaken growth conditions. Gold plays a dual role, supporting household wealth during uncertainty but adding to import pressure. The exchange rate and trade balance together act as the system's shock absorbers, restoring long-run equilibrium after disturbances. These findings align closely with the broader literature on oil-importing emerging economies and reinforce the case for integrated policy responses covering energy diversification, exchange rate management, and export promotion (IMF, 2025; Sahadudheen & Kumar, 2023; Singh et al., 2025).

Table: 7 Summary Model of Structural VAR Estimates

Coefficient	Estimate	Std. Error	z-Statistic	Prob.
C(1)	143.6731	20.7374	6.9282	0.0000***
C(2)	10.4651	3.3979	3.0799	0.0021***

C(3)	-1.6291	0.4482	-3.6351	0.0003***
C(4)	13.0035	453.2660	0.0287	0.9771
C(5)	-14.5911	4.0935	-3.5644	0.0004***
C(6)	14.9109	2.1522	6.9282	0.0000***
C(7)	-0.0728	0.3814	-0.1908	0.8487
C(8)	-823.7598	437.3893	-1.8834	0.0597*
C(9)	6.9593	3.3634	2.0691	0.0385**
C(10)	1.8676	0.2696	6.9282	0.0000***
C(11)	-963.9112	397.2600	-2.4264	0.0152**
C(12)	-3.6234	3.1670	-1.1441	0.2526
C(13)	1822.912	263.1148	6.9282	0.0000***
C(14)	2.4798	3.1030	0.7992	0.4242
C(15)	15.0999	2.1795	6.9282	0.0000***
Log likelihood	-614.6845			

Source: Author Calculation

Notes:

*, **, *** denote significance at 10%, 5%, and 1% levels respectively.

S-Matrix

$$S = \begin{pmatrix} S_{11} & 0 & 0 & 0 & 0 \\ S_{21} & S_{22} & 0 & 0 & 0 \\ S_{31} & S_{32} & S_{33} & 0 & 0 \\ S_{41} & S_{42} & S_{43} & S_{44} & 0 \\ S_{51} & S_{52} & S_{53} & S_{54} & S_{55} \end{pmatrix}$$

S-Matrix

$$S = \begin{pmatrix} 143.6731 & 0 & 0 & 0 & 0 \\ 10.4651 & 14.9109 & 0 & 0 & 0 \\ -1.6291 & -0.0728 & 1.8676 & 0 & 0 \\ 13.0035 & -823.7598 & -963.9112 & 1822.912 & 0 \\ -14.5911 & 6.9593 & -3.6234 & 2.4798 & 15.0999 \end{pmatrix}$$

S-Matrix

$$S = \begin{pmatrix} \text{GDP Shock} & 0 & 0 & 0 & 0 \\ \text{Impact of GDP Shock on OP} & \text{Crude Oil Shock} & \text{Exchange Rate Shock} & \text{Gold Price Shock} & \text{Trade Balance Shock} \\ \text{Impact of GDP Shock on ER} & \text{Impact of Crude Oil Shock on ER} & \text{Impact of Exchange Rate Shock on GP} & \text{Impact of Gold Price Shock on TB} & \text{Trade Balance Shock} \\ \text{Impact of GDP Shock on GP} & \text{Impact of Crude Oil Shock on GP} & \text{Impact of Exchange Rate Shock on TB} & \text{Impact of Gold Price Shock on TB} & \text{Trade Balance Shock} \\ \text{Impact of GDP Shock on TB} & \text{Impact of Crude Oil Shock on TB} & \text{Impact of Exchange Rate Shock on TB} & \text{Impact of Gold Price Shock on TB} & \text{Trade Balance Shock} \end{pmatrix}$$

The Structural VAR (SVAR) model results provide valuable insights into how India's economic growth interacts with crude oil prices, gold prices, exchange rates, and trade balance. The estimates capture both short-run and long-run relationships among these macroeconomic variables, reflecting the interconnected structure of India's economy within the global environment.

The Structural VAR results estimate indicate that several coefficients C(1), C(2), C(3), C(5), C(6), C(9), C(10), C(11), C(13), and C(15) are statistically significant at the 1% or 5% level. This results strongly suggests dynamic interactions between economic growth, oil prices, exchange rates, and trade balance. These significant parameters imply that shocks to GDP, currency movements, and energy prices create measurable ripple effects across the system, influencing both domestic and external sectors.

Conversely, coefficients C(4), C(7), C(12), and C(14) are found to be statistically insignificant, implying weaker or negligible short-term transmission effects for those specific linkages. Interestingly, the insignificance observed in some of these coefficients especially those associated with gold price fluctuations can be explained by recent global trends. Over the past few years, geopolitical tensions, inflation uncertainty, and the gradual move toward de-dollarization have encouraged central banks worldwide to accumulate gold reserves as a hedge against U.S. dollar dominance. Consequently, global gold prices have become increasingly policy-driven rather than market-driven. This shift has weakened the short-term linkage between gold price changes and key macroeconomic indicators like GDP and trade balance, resulting in statistically insignificant coefficients in the model. Similar observations were made by Mishra and Das (2024), who noted that gold prices in India often move independently of short-term macroeconomic shifts due to global reserve accumulation behaviour.

Among the significant coefficients, C(1) (143.67) confirms the positive and strong internal growth effect, meaning that India's GDP tends to build upon its own momentum. C(2) (10.46) shows that higher GDP increases demand for crude oil, emphasizing India's dependence on imported energy as economic activity rises. This relationship supports findings from

Choudhary and Das (2023), who highlighted that economic expansion in developing economies often raises energy consumption and import demand. On the other hand, $C(3)$ (-1.63) suggests that growth appreciation tends to strengthen the Indian rupee, reflecting investor confidence and capital inflows during periods of strong output performance.

The negative coefficient $C(5)$ (-14.59) indicates that GDP growth may worsen the trade balance, as rising income levels increase import demand for oil and gold. This mirrors Sahoo and Rath (2023), who found that India's import-led growth often expands the trade deficit during economic booms. Similarly, $C(6)$ (14.91) highlights that crude oil prices adjust strongly to their own market shocks, suggesting that oil price movements are largely influenced by global supply dynamics and geopolitical developments rather than domestic factors.

The exchange rate's significant coefficients $C(10)$ (1.87) and $C(11)$ (-963.91) confirm that the rupee experiences notable self-adjustment and inverse sensitivity to gold prices. When the rupee strengthens, imported gold becomes cheaper, reducing domestic gold prices. This aligns with India's position as one of the world's largest gold importers, where currency strength directly impacts the gold market.

The strong coefficient for $C(13)$ (1822.91) indicates that gold prices are highly volatile and self-driven. Gold acts as a safe-haven asset for Indian investors, responding quickly to uncertainty in oil or currency markets. Meanwhile, $C(15)$ (15.09) shows that trade balance adjustments are significant and self-correcting over time suggesting that India's external sector naturally stabilizes following shocks, supported by policy responses or cyclical corrections.

The S-Matrix further explains how shocks spread through the system. A shock to GDP impacts oil prices, exchange rates, and trade balance directly. Oil price shocks influence exchange rates and trade performance, while exchange rate movements affect gold prices and trade flows. Gold shocks mainly impact the trade balance, reflecting India's import-heavy gold market. These interactions reveal the complex web linking India's domestic economy with global commodity and financial markets.

Overall, the SVAR model captures the interconnected nature of global commodity prices, exchange rate fluctuations, and macroeconomic fundamentals. The results show that India's economic growth is positively influenced by oil price stability and currency appreciation, but negatively affected by trade imbalances and external commodity shocks. The presence of both significant and insignificant parameters reflects India's dual economic reality where some

channels like energy and trade remain deeply integrated, while others, like gold, have become decoupled due to changing global financial behaviour.

This model underscores that India's economic performance is shaped by both domestic fundamentals and global influences. Managing oil price volatility, ensuring exchange rate stability, and improving trade competitiveness will be crucial for sustaining long-term growth. As supported by Zhang and Kumar (2025), countries that maintain balanced trade and stable energy policies are better equipped to achieve resilient economic growth amid global uncertainty. (See Table 7)

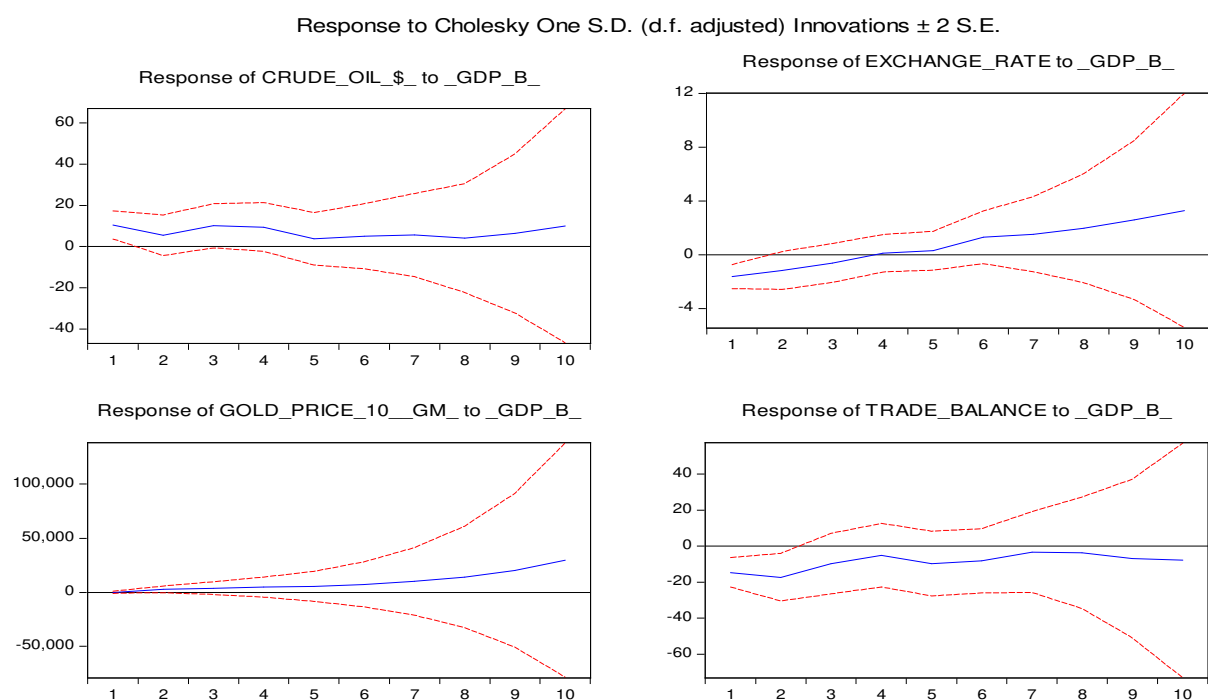


Figure: 5 Impulse Response to Cholesky

The impulse response results show that shocks to crude oil prices, exchange rates, gold prices, and the trade balance immediately influence India's GDP, but the effects gradually fade as the economy adjusts. A rise in crude oil prices reduces GDP in the short run due to higher import costs and inflation, consistent with findings from BRICS and Asian markets (Chen et al., 2022; Deheri & Ramachandran, 2023). Exchange rate shocks also lower GDP, as rupee depreciation increases the cost of oil and gold imports, matching evidence from India's oil-currency studies (Khraief et al., 2021; Albulescu & Ajmi, 2021). Gold price shocks generate quick GDP responses because gold acts as both a consumption and hedge asset in India, similar to patterns reported in volatility studies (Rastogi et al., 2022; Li et al., 2023). Trade balance shocks affect GDP immediately due to India's import dependence, consistent with global oil trade and

exchange-rate–trade balance research (Kumeka et al., 2022; Kocoglu & Kula, 2025). Overall, the results support the broader evidence that India is highly sensitive to short-run commodity and currency shocks but returns to equilibrium over time (Sahadudheen & Kumar, 2023; Singh et al., 2025) (See Figure 5).

5. Discussion

This study provides clear evidence of a strong long-run relationship between India's GDP and four major external variables crude oil prices, gold prices, the USD/INR exchange rate, and the trade balance. The Johansen cointegration results indicating multiple cointegrating vectors, and the VECM–SVAR estimates, show that these variables interact through both equilibrium-correction forces and structural short-run shocks. Similar long-run co-movement among oil, currency and financial variables has been documented in BRICS and Asian markets (Chen et al., 2022; Mishra & Dash, 2024). First, increases in crude oil prices exert a contractionary effect on GDP. The negative lagged coefficients in the VECM confirm that rising oil prices raise production and transport costs and intensify inflationary pressures, leading to lower economic activity. This aligns closely with earlier evidence showing that oil shocks transmit quickly to real output, inflation, and trade balances in oil-dependent economies like India (Deheri & Ramachandran, 2023; Sreenu, 2019; Kumeka et al., 2022). Second, rupee depreciation weakens short-run GDP growth. The negative and statistically significant exchange-rate terms indicate that currency weakness raises the domestic cost of crude oil, gold and intermediate imports, reducing consumption and investment. Comparable short-run depreciation effects have been reported in India–China oil–FX studies and global oil–currency causality work (Khraief et al., 2021; Albulescu & Ajmi, 2021; Singh et al., 2025). Third, gold shows a nuanced influence. While rising gold prices can widen the import bill, lagged gold-price increases also exhibit a stabilising effect, reflecting gold's role as both an imported commodity and a financial hedge. This echoes findings from India's gold–oil–interest-rate volatility studies and COVID-era hedging research where gold behaved as a safe-haven asset (Rastogi et al., 2022; Li et al., 2023).

Together, these results reinforce two main transmission mechanisms:

- Cost-push channel: - Oil and commodity shocks immediately increase input costs, raising inflation and compressing output, consistent with volatility-spillover evidence

for BRICS, MENA and Asian economies (Chen et al., 2022; Bigerna, 2024; Mishra & Dash, 2024).

- External-balance channel: - Exchange-rate movements and shifts in trade balance transmit shocks through foreign-exchange liquidity, import bills and financing conditions. Global evidence shows that oil-price shocks and currency swings significantly affect trade flows and foreign-reserve dynamics (Kumeka et al., 2022; Kocoglu & Kula, 2025).

The SVAR impulse responses from this study confirm the timing and magnitude of these spillovers: oil and currency shocks affect GDP immediately but gradually dissipate as long-run adjustment mechanisms restore equilibrium patterns also highlighted in dynamic connectedness studies across India and Asia (Sahadudheen & Kumar, 2023; Singh et al., 2025). Although the model diagnostics (normality and stability tests) indicate a well-behaved system, several limitations remain. Annual data restrict the ability to capture high-frequency volatility around events such as COVID-19, the Russia–Ukraine conflict, or rapid oil-price swings periods shown to cause abrupt spillovers in earlier research (Kumeka et al., 2022; Bigerna, 2024). Potential endogeneity between GDP and oil demand or between exchange rates and capital flows also persists, as noted in oil–FX literature (Albulescu & Ajmi, 2021; Khraief et al., 2021). In addition, nonlinear or asymmetric responses such as stronger reactions to oil-price spikes than declines are evident in many of the studies you provided but not fully tested here. Overall, the findings affirm that India’s economic growth is materially shaped by external commodity and currency shocks. Crude oil and exchange-rate fluctuations have the strongest contractionary effects, gold plays a dual stabilizing vulnerability role, and the trade balance amplifies the external shock transmission. These vulnerabilities are consistent with broader evidence from emerging markets and oil-importing economies (Chen et al., 2022; Mishra & Dash, 2024; Rastogi et al., 2022). To strengthen India’s growth resilience, policy measures should focus on reducing exposure to global oil volatility (strategic reserves, hedging, renewables), building stronger macro buffers (higher reserves, prudent fiscal space), and expanding savings instruments beyond gold to reduce import intensity. Future research should re-estimate the system with quarterly data, include global variables and test asymmetries to capture the richer shock dynamics documented in the international literature.

6. Conclusion and Policy Implications

This study investigates the joint influence of crude oil prices, gold prices, the USD/INR exchange rate, and the trade balance on India’s real GDP using Johansen cointegration, VECM,

and SVAR frameworks. The results indicate a meaningful long-run relationship among the variables and show that external shocks transmit to growth mainly through cost-push pressures, exchange-rate pass-through, and external-balance constraints. In practical terms, oil-price increases and episodes of currency weakness tend to tighten macroeconomic conditions by raising import costs, affecting inflation and financial conditions, and increasing external financing pressure, which can weaken growth momentum in the short run. Gold exhibits a mixed role in India's macroeconomic setting: it can serve as a hedge and support household balance sheets during uncertainty, but stronger gold demand can also add to import burdens and aggravate external imbalance. The error-correction dynamics suggest that the economy does move back toward its long-run equilibrium aftershocks, yet the adjustment is gradual enough that temporary global disturbances can still generate noticeable output costs before normalization occurs.

The findings imply that macroeconomic resilience in India requires an integrated external-vulnerability strategy rather than isolated responses. Reducing dependence on imported crude remains the most direct priority, which strengthens the case for accelerating renewable energy adoption, improving energy efficiency in oil-intensive sectors, supporting fuel-switching and logistics efficiency, and strengthening strategic petroleum reserves and risk-management practices to cushion global price spikes. Given the importance of exchange-rate transmission, exchange-rate management should focus on preventing disorderly movements through credible communication, adequate foreign-exchange buffers, and deeper hedging access particularly for import-dependent firms and MSMEs. so that external volatility does not cascade into investment and output weakness. Since the trade balance adjusts strongly when shocks occur, export competitiveness and stable trade performance become central to macro stability; policy efforts that improve logistics, productivity, and market access can reduce the economy's sensitivity to external price cycles. Gold-related policy should move beyond short-term tariff reliance toward structural measures that reduce external pressure while respecting household preferences, including expanding gold recycling and monetization, strengthening domestic value addition, and promoting attractive financial savings alternatives to moderate excess import demand.

These conclusions should be interpreted with caution because annual data may smooth intra-year transmission, macroeconomic variables can exhibit feedback effects, and some global drivers may not be fully captured in a parsimonious system. Future research can strengthen inference and improve policy quantification by using higher-frequency data, testing

asymmetric or nonlinear responses (for example, differing effects of oil-price increases versus decreases and depreciation versus appreciation), incorporating richer global controls such as global financial conditions and risk sentiment, and extending the analysis to sectoral output to identify which sectors transmit oil and exchange-rate shocks most strongly in the Indian context.

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