F inancial
Internet Quarterly

MODELING THE RELATIONSHIPS AMONG THE STOCK MARKET, GOLD PRICE, OIL PRICE AND EXCHANGE RATE: A VECM AND VDA APPROACH

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Abstract

Globalization and liberalization have heightened the volatility and complexity of financial markets, prompting investors to diversify their portfolios across different asset classes. This study investigates the dynamic interrelationships among the Indian stock market benchmark index (Nifty 50), gold prices, oil prices (Brent and WTI), and the USD/INR exchange rate, using high-frequency daily data from January 2009 to March 2023. By employing a Vector Error Correction Model (VECM) and Variance Decomposition Analysis (VDA), the study explores both the short-term and long-term dynamics between these asset classes. The results reveal that a long-term equilibrium exists among the variables, with significant cointegration, indicating that investors may not benefit from diversifying their portfolios across these assets. The VECM analysis further shows that the stock market is influenced by changes in gold prices, exchange rates, and oil prices, with long-run causality running from these variables to the Nifty 50. Variance decomposition highlights the growing impact of gold, exchange rates, and oil prices on stock market fluctuations over time. These findings provide crucial insights for investors, portfolio managers, and policymakers, suggesting that external shocks in commodity prices and exchange rates can significantly affect stock market performance. The study concludes that understanding these dynamic linkages is essential for managing investment risks and formulating effective monetary and fiscal policies.

Cite this:

Agrawal, P.K. & Kumar, M. (2024). Modeling the relationship among the stock market, gold price, oil price and exchange rate: a VECM and VDA approach. Financial Internet Quarterly 21(1), pp. 1-14.

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Introduction

Due to globalization and liberalization in the overall global economy, volatility, complexity and uncertainty in the financial environment across the globe has increased. Therefore, there has been urgent need of diversification in different asset classes for the investors seeking optimum portfolio performance. As the market is highly dynamic in nature and it changes its integration behavior, there is a need to re-examine its linkages with other investment options like the price of Gold, Exchange Rate, or Crude Oil prices (Brent & WTI) as time progresses. It is important to explore dynamic linkages of the Indian stock markets with the Gold Price, Exchange Rate (USD INR), or Crude Oil prices (Brent & WTI) by extending time periods covered in the previous studies. A number of portfolio managers include equity, oil and gold in their portfolios to leverage their risk-adjusted returns (Jain & Biswal, 2016 as cited by Akkoc & Civcir, 2019). Economists and financial practitioners have shifted their focus to studying the interconnections between the stock market with different asset classes as a result of the Israel-Lebanon war, Israel - Hamas war, Russia - Ukraine Crisis, COVID-19 epidemic, the stock market crash of October 1987, the Asian financial crisis of 1997, and the subprime mortgage crisis of 2007. These incidences make it clear that a deep understanding of cointegration of Indian stock markets with other investment asset class is crucial for investors. Hence, this demands the application of a cointegration test to assess spurious relations among these markets. Analysis showed that these assets have given a good positive return, which proves the strong economic growth of countries. India is a major importer of gold and oil. After China, India is the world's biggest consumer and importer of gold and in oil, Indian stands ranked third after China and the USA, respectively. At least 25,000 tons of gold have been physically accumulated and stockpiled by Indian households, according to estimates (THE WEC, 2023). Gold has a long and significant cultural history with the Indian people as it is an integral part of weddings, festivals and daily life. Investment in gold has also served as a hedge against inflation, political unrest and war. According to The Hindu (November 20, 2023), in October 2023, India's gold imports amounted to 123 metric tons, which is an increase from 77 tons in the previous year. The value of these imports nearly doubled, reaching $7.23 billion compared to $3.7 billion in the previous year. "Switzerland, the UAE, South Africa, Guinea, and Peru are the main suppliers of gold to India. In contrast to earlier research, this one looks at the time after the global financial crisis and pandemic, which were a fascinating one for India's stock markets, for crude oil and gold. This study seeks to establish and validate the dynamic relation between the prices of commodities, specifically gold and crude oil, with the USD/INR exchange rate and the Indian stock index Nifty 50. This research paper utilizes high frequency daily data to investigate the effects of swings and interrelationships among the prices of crude oil, stock market returns proxied by Nifty 50, and gold. Empirical research has investigated the connection between variables that determine the fluctuation of oil and gold prices and their relationship with economic activity. However, there is a scarcity of studies that examine the dynamic relation between oil, gold, exchange rate, and stock market return in the Indian context. This research seeks to systematically illustrate the dynamic interlinkages among the price of gold, the price of oil, the exchange rate, and stock market returns using the VECM and VDA method. Very few researchers have employed VECM and VDA analysis in their research and validated the model. It is also crucial to validate the relationship on a regular basis because all of these variables have changed significantly throughout the years. India is a strong resilient economy and its growth is outpacing other major economies of the world which can be seen in robust macroeconomic indicators. The rise in government spending on infrastructure, downward trend of inflation, declining external debt to GDP Ratio, rise in foreign exchange reserve (approx. $700 bn), remarkable growth in manufacturing sector due to Atmanirbhar Bharat and the increasing number of unicorns indicates that India is on the right trajectory to move ahead on its path to becoming a USD 5 trillion economy. India surpassed the UK as the fifth largest economy and it's on track to overtake Japan and Germany and will be the third largest economy by 2029.

The remaining content of the paper is outlined as follows. Section 2 focuses on the relevant literature review. Section 3 outlines the material and methods, Section 4 deals with the result and discussion, Section 5 completes the paper and finally section 6 deals with the managerial implications.

Literature review

Ndlovu and Ndlovu (2024) assessed the dynamic linkages among gold prices, stock prices, the exchange rate and interest rate in South Africa by applying Vector Autoregression and a Bayesian Vector Autoregression Model. Monthly data was collected from June 1995 to December 2022. A positive relationship exists in stock prices, exchange rates, gold prices, and interest rates. However, a hike in interest rate induces negative relations with gold and stock prices. Moreover, a positive shock in gold prices lead to negative consequences in both interest rates and stock prices. Mishra and Dash (2024) investigated volatility of Asian stock exchanges with crude oil and found no short-run volatility spillover

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from crude oil to the Malaysian, Pakistani and South Korean and Turkish stock markets, whereas Chinese, Indian, Japanese, Singapore stock exchanges show the short-run volatility spillover from crude oil in the short run. Pata et al. (2024) assessed the causality among stock returns, crude oil and gold prices in Turkey and found time-varying causality running from crude oil price and gold price to Turkish stock market returns and crude oil. Gold prices have a greater impact on stock market volatility. Cui (2023) investigated the dynamic relationship amongst gold, crude oil, exchange rate and Chinese stock market indexes by DCC GARCH method for the period from March 1, 2000, to August 3, 2022. The findings reveal that gold and crude oil are positively correlated with the Shanghai Stock Exchange and the China Industrial Index, while negative correlations were found between the USD/CNY exchange rate and the two Chinese stock indices. Jia et al. (2023) discussed the causal relationship between crude oil, gold, and dollar price in the USA and negative causality was found between gold and the US dollar index. Olajide et al. (2023) identified the impact of crude oil and stock prices on exchange rates in Indonesia and concluded that lower oil price returns lead the Indonesian currency per US dollar to depreciate and stock returns have a negative and significant relationship with exchange rates. Valarmathi et al. (2023) analyzed the relationship between gold prices and stock market prices in India and observed no relationship between gold prices and BSE sectoral indices. Arisandhi and Robiyanto (2022) studied the correlation among exchange rates, gold, and stock prices in ASEAN-5 during the pandemic and found a weak correlation between exchange rates and gold prices on the stock market. A negative correlation was seen during the pandemic which infers that the exchange rate was a better alternative asset than gold, which was positively correlated with stock prices. Jindal (2023) investigated the relationship amongst oil prices, gold and exchange rates for the period from January 1, 2017, to December 31, 2021, and found a significant relationship between exchange rates and crude oil with the stock market, while other variables like gold have an insignificant relationship with the stock market in the long run. Singh and Sharma (2018) examined the dynamic interlinkages relationship among gold, crude oil, dollar exchange rate, and the stock market benchmark indices Sensex (referred to as GODS) during the pre, post and crisis periods. An equilibrium relationship was found among the variables during the pre-crisis and crisis eras, but not during the post-crisis period. The VECM analysis indicates that none of the four variable models exhibit long-term causality during the pre-crisis period. Mhlongo and Olaomi (2021) examined the dynamic relationship between oil, gold, exchange rates, and stock markets in Africa. They utilized the DCC

GARCH Method and analyzed monthly data from January 2000 to December 2019. The results indicate the presence of time-varying co-movement in all African marketplaces. While analyzing interdependencies between assets such as gold, stocks, interest rates and exchanges, Akbar et al. (2019) examined the interconnections between gold price, stock prices, exchange rate, and interest rate in the Pakistan economy. They analyzed monthly data from 2001 to 2014 and found that there is no enduring association between these variables in the long term. Singhal et al. (2022) assessed the dynamic connections between crude oil, exchange rates, and the Norwegian stock market. They utilized the ARDL bound technique and discovered the presence of a long-term equilibrium relationship among oil prices, exchange rates, and the Norwegian stock market. Samour et al. (2022) investigated the influence of oil price and gold price on the equities market of South Africa (JSE) using the bootstrap (B-ARDL) method. Tests have revealed that the price of gold has a reverse impact on the equities market in South Africa. Conversely, oil prices have a beneficial impact on the South African share market. They also infer that gold is a reliable investment asset that should be utilized to safeguard against risks. Jain and Ghosh (2013) investigated whether there is any long-term association and causality in relation to global oil prices, metal prices and exchange rate. It was found that there is an intangible relationship in the long-term between gold prices and exchange rates. Bhunia (2013) examined the cointegration among crude oil, gold price and exchange rate for the period 1991 to 2012 and proves the existence of a long-run relationship among the variables. Sujit and Kumar (2011) studied dynamic interlinkages among gold prices, stock returns (S&P 500), exchange rate and oil prices for the period 1998-2011 and found out that prices of gold, stock market indices and oil are all directly influenced by exchange rates. Thakolsri (2021) analyzed a monthly dataset from 2000-2018 and established a strong long-run relationship between the price dynamics of asset classes such as gold, oil, foreign exchange and the Thai stock market index. He found a long run equilibrium relationship among the variables in Thailand. This also implied that each of the asset classes serves as a safeguard against the others. While the literature review comprehensively covers previous research on the interlinkages between stock markets, gold, oil prices, and exchange rates, this study extends the understanding by focusing on India-specific dynamics during a particularly volatile period (2009-2023). This period includes the aftermath of the global financial crisis, the COVID-19 pandemic, and recent geopolitical tensions. Unlike prior studies, which often focus on short-term fluctuations or limited data, our work contributes by offering a long-term per-

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spective on the cointegration of these assets, providing unique insights into how these variables interact over extended time horizons. The use of high-frequency daily data further strengthens the study by revealing short-term and long-term dynamics in greater detail than earlier research. Previous studies largely neglect India's unique position as both a major consumer of gold and oil, and as a fast-growing economy. This study's focus on these interrelations within the Indian context, along with the employment of VECM and VDA models, provides insights that are particularly relevant to both investors and policymakers.

MATERIAL AND METHOD

In order to discover the long-term equilibrium relationship benchmark indices of India Nifty 50, Gold Price, USD/INR Exchange Rate, Oil Price Brent and West Texas Intermediate (WTI) Crude Oil referred as WTI hereafter were selected for analysis. These are the major investment asset classes across the globe hence there is a need to assess whether constructing a portfolio with Nifty 50, Gold Price, Exchange Rate, Oil Price (Brent and WTI) would benefit investors.

Every type of relevant information, whether it is related with the domestic or global economy is quickly incorporated or discounted in the benchmark index (Kumar & Dhankar, 2009). All the data on a daily basis in USD was collected for the timeframe 1st January 2009 to 31stMarch 2023 constituting 3340 observations from the Bloomberg Terminal in USD terms to maintain the consistency in the analysis. The entire dataset was noted in dollar terms to ensure consistency across the figures and also adjusted to eliminate discrepancies in the dataset. As all the information is quickly incorporated into prices, high frequency data is more noticeable and significant as comparison to low frequency data. The daily continuously compounded returns of Nifty 50, Gold Price, USD/INR Exchange Rate, Oil Price (Brent & WTI) have been calculated using the log of series.

$$R = (LogP_t - LogP_{t-1}) * 100$$

Where:
R = Quarterly Return
P_t = Closing price of current Quarter
P_{t-1} = Previous Quarter closing price

The Augmented Dickey Fuller (ADF) Test, formulated by Dickey and Fuller (1979), is used to assess the stationarity of data. This test was conducted by adding lagged values of dependent variable ΔY_t in the preceding three equations. Y_t is a random walk:

$$\Delta Y_t = \delta Y_{t-1} + \sum_{i=1}^{m} \alpha_i \Delta Y_{t-1} + \varepsilon_t$$

Y_t is a random walk with Intercept:

$$\Delta Y_t = \beta_1 + \delta Y_{t-1} + \sum_{i=1}^{m} \alpha_i \Delta Y_{t-1} + \varepsilon_t$$

Y_t is a random walk with Intercept around a deterministic trend:

$$\Delta Y_t = \beta_1 + \beta_2 t + \delta Y_{t-1} + \sum_{i=1}^{m} \alpha_i \Delta Y_{t-1}$$

ΔY_{tv} is the first difference of the:

$$Y_t (\Delta Y_t = Y_t - Y_{t-1})$$

The term β_1 is intercept term; t is linear time or trend variable and represents the white noise error term.

Schwarz-Bayes Information Criterion (SIC) has been suggested by Schwarz, used to select an optimal lag length (m). Hypothesis of this test is:
H_0: = 0 Non-stationary
H_1: < 0 Stationary

Null hypothesis contains unit root (non-stationary). To test the presence of unit root, t-statistic needs to be calculated

$$\tau = \frac{\delta}{\sqrt{var(\delta)}}$$

and compared with the critical value at different significance levels. If null hypothesis is rejected, data do not contain unit root at all three possibilities.

Johansen Cointegration test is employed to determine any stochastic trend among the Nifty 50, BRENT, USD/INR EXCHANGE RATE, GOLD and WTI. When there exists any long run equilibrium relationship or stochastic trend, investors will not benefit by diversifying their portfolios across these markets, as the markets move in the same direction in the long run. The Vector Error Correction Model (VECM) was chosen due to its ability to capture both short-term and long-term equilibrium relationships among the variables, ensuring that dynamic adjustments are accounted for.

RESEARCH OBJECTIVE

A well devised research objective could facilitate appropriate adoption of methodology for research and reaching the conclusion. Herein, the objective of the study is as follows:
1. To investigate dynamic interrelationships among the Indian stock market benchmark index (Nifty 50), gold prices, oil prices (Brent and WTI), and the USD/INR exchange rate.
2. To capture the speed of adjustment of the Indian stock market to gold prices, oil prices (Brent and WTI), and the USD/INR exchange rate.

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3. To detemine the impact of gold prices, oil prices (Brent and WTI), and the USD/INR exchange rate on the Indian stock market by applying the variance decomposition method.

Results and discussions

The movement of the USD/INR Exchange rate, Gold Price, Brent, WTI and Nifty 50 from the period January 01, 2023 to March 31, 2023 are shown below. It is shown that during this period the Pandemic Nifty 50, WTI and Brent were significantly decreased, while at the same time investment in gold increased because it is considered a safe investment option. The closure of production activity had a significant negative impact on the Indian economy, resulting in a substantial depreciation of the rupee as exports were decreased during that time due to migration of industrial workers.

Figure 1: Movement of USD/INR Exchange Rate (2009-2023)

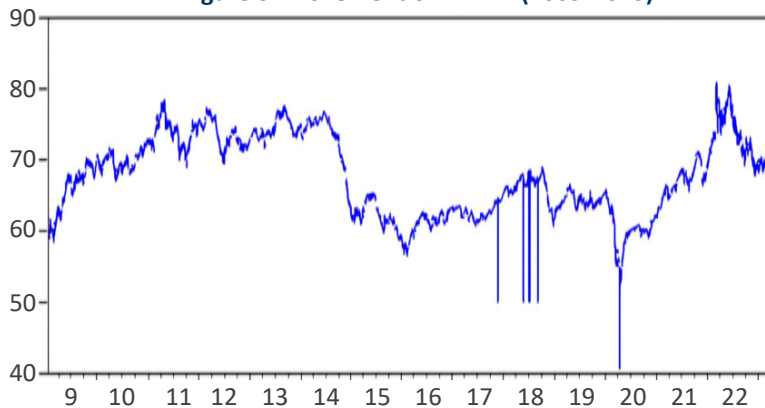*Source: Author's own work using EViews software.*

Figure 2: Movement of Gold (2009-2023)

Source: Author's own work using EViews software.



Figure 3: Movement of BRENT (2009-2023)

Source: Author's own work using EViews software.

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Figure 4: Movement of WTI (2009-2023)

Source: Author's own work using EViews software.

Figure 5: Movement of Nifty 50 (in $) (2009-2023)
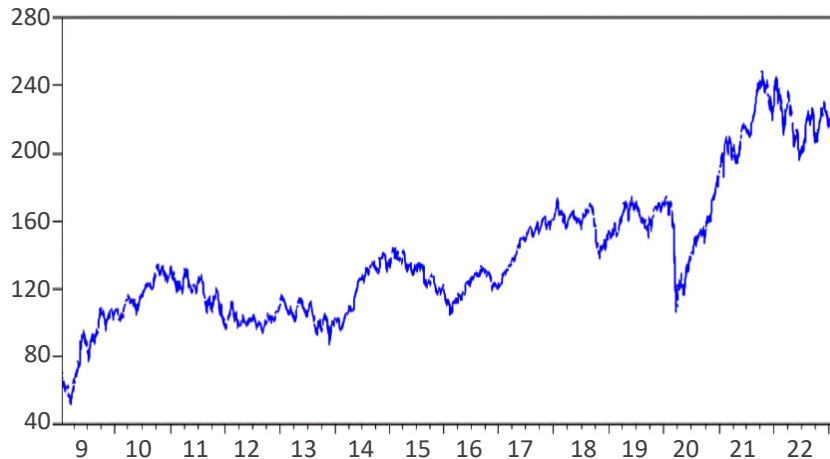
Source: Author's own work using EViews software.

To begin, we have made an effort to comprehend the return series' features and properties, as well as its visual representation. The return series' measures of central tendency such as Median, Mean, Kurtosis, Skewness and Standard Deviation, generally known as Descriptive Statistics and more are shown in Table 1 below.

Table 1: Descriptive statistics

	LR USD/INR exchange rate	LR gold price	LR Nifty 50	LR BRENT	LR WTI
Mean	0.018852	0.024274	0.033246	0.033290	0.015634
Median	0.000000	0.049922	0.056913	0.098152	0.000000
Maximum	3.932821	4.966568	16.365080	32.482540	3.932821
Minimum	-3.322810	-9.512069	-13.747380	-28.220610	-3.322810
Std. Dev.	0.473622	1.043275	1.329890	2.829678	0.454343
Skewness	0.271329	-0.428182	0.040247	0.344508	0.274310
Kurtosis	9.286561	7.563163	17.201680	27.206900	9.783292
Jarque-Bera	5540.967000	2999.851000	27749.850000	81369.790000	6445.370000
Probability	0.000000	0.000000	0.000000	0.000000	0.000000

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	LR USD/INR exchange rate	LR gold price	LR Nifrty 50	LR BRENT	LR WTI
Sum	62.965100	81.074230	111.042800	110.855300	52.218590
Sum Sq. Dev.	748.990000	3634.246000	5835.418000	26655.560000	689.262600
Total Observations	3340.000000	3340.000000	3340.000000	3340.000000	3340.000000

Source: Author's own work.

It is clear from Table 1 that Nifty 50, Exchange rate, Gold Price, Brent and WTI had positive returns. Indian Stock Market benchmark indices Nifty 50 and BRENT had the maximum and approximate equal return followed by Gold, Exchange Rate and WTI. BRENT is highly risky because its standard deviation is high compared to the others, Nifty 50, Gold, Exchange Rate and WTI.

Kurtosis and Skewness figures show that returns do not follow a normal distribution. Only Gold Price displays a negatively skewed distribution and rest indicator follow the positive skewed distributions. Jarque Bera test also supported the fact that all market returns do not follow a normal distribution, similar to the results as indicated by kurtosis and skewness.

Table 2: Correlation among the stock market returns

	Nifty 50	Gold Price	USD/INR Exchange Rate	BRENT	WTI
NIFTY50	1.000000	0.590446	0.763893	-0.044452	0.751104
GOLD PRICE	0.590446	1.000000	0.426716	0.248173	0.436309
USD/INR Exchange Rate	0.763893	0.426716	1.000000	-0.362915	0.985296
BRENT	-0.044452	0.248173	-0.362915	1.000000	-0.352537
WTI	0.751104	0.436309	0.985296	-0.352537	1.000000

Source: Author's own work.

As we see from Table 2, positive correlation exists among Nifty 50 – Gold Price, USD/INR Exchange rate - Nifty 50, and Gold Price with Exchange Rate. Hence, this demands the application of a cointegration test to assess the same. The next issue is to examine whether there exists a long-run or short-run aspect of this implication

The results presented above are in agreement with those of Singhal et al. (2019), who discovered that oil prices influence exchange rates and stock prices in a negative way. Further, prices in gold exhibit strong correlation with prices in stocks. This also implies that gold prices, currency rate, as well as stock prices move in the same direction.

There was a high positive correlation among exchange rate and WTI. This is because changes in the price of energy items, like oil, have a major impact on

important macroeconomic variables as evident in a study by Delgado et al. (2018).

Most oil transactions internationally are conducted in USD, and a depreciation in local currency occurs due to increased oil demand. This highlights that oil prices tend to indicate global exchange rates as found by a study conducted by Amano and van Norden (1998).

The Augmented Dickey Fuller test highlights that daily prices of Gold, Exchange Rate, WTI, Brent and Nifty 50 are non-stationary when level. However, Gold Price, Exchange Rate, WTI, Brent and Nifty 50 are stationary (with intercept and trend) at first difference meaning all the stock markets indices are first order integrated, or I(1). The next step is to evaluate whether they are cointegrated too (see: Table 3).

Table 3: Augmented Dickey Fuller Test

Indices	Level Form (with intercept and trend)	At First Difference (with intercept and trend)	Decision
Gold Price ($)	-1.634368	-57.59278	I(1)
USD/INR Exchange Rate	-0.663214	-23.40599	I(1)
Oil Price Index (WTI)	-2.436625	-39.39255	I(1)
Oil Price Index (BRENT)	-2.436625	-39.39255	I(1)
NIFTY 50 ($)	-0.243602	-43.47221	I(1)

Source: Author's own work.

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Johansen maximum likelihood estimators are used to check for the presence/absence of cointegrating vectors. Johansen technique supersedes the Engle-Granger approach while analyzing cointegration. It has been found from previous studies that when compared to alternative multivariate approaches and single equation methods, the Johansen procedure performs better. The multivariate Johansen Cointegration test is a good indicator to use if foreign investors want to diversify their money in different asset classes.

Table 4: Multivariate Cointegration of Nifty 50 with select Asian stock markets

Pairs of stock Prices Indices	No. of CE(s)	Trace Statistic	Critical Value (0.05)	P Value	Cointegration (Present/Not Present
Nifty 50	None*	121.67820	69.81889	0.0000	
BRENT	At most 1	34.03524	47.85613	0.4999	
USD/INR Exchange rate	At most 2	15.46916	29.79707	0.7490	Present
Gold	At most 3	5.66438	15.49471	0.7348	
WTI	At most 4	0.01209	3.84147	0.9123	

Note: CE denotes Cointegrating Equation(s), trace test indicates 1 cointegrating equation(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level

Source: Author's own work.

Table 4 shows the long-run association relationship among Nifty 50, Brent, Exchange Rate, Gold and WTI when all are taken together, cointegration exists, implying thereby that in the long-run, they move together. This highlights that these markets are informationally efficient and a long-run equilibrium relationship indicates that investors will not benefit by portfolio diversification in Nifty 50, Brent, Exchange Rate, Gold and WTI when all are taken together in the long-run. If the trace statistic is less than the critical value (5%), then the hypothesized number of cointegrating equations (CE) are accepted.

Vector Error Correction Model (VECM)

Cointegration does not inculcate any information about the speed with which variables adjust to deviations from their common stochastic trend in the short-run. An error correction mechanism is used to capture the speed of adjustment towards equilibrium between two non-stationary variables. When the variables are cointegrated and the number of cointegrating vectors is determined, the next test is to apply the VECM. Cointegration indicates that the series has an error correction term and ECM implies that the series are cointegrated (Engle & Granger, 1991). VECM includes the error correction term or speed of adjustment in the model. VECM also shows from where the information is flowing into the market.

After running VECM, Equation 1.4 yields the model for D (Nifty 50) as dependent variable and Brent, WTI, Gold and Exchange rate as independent variables. Table 4 describes the independent variable with respective coefficients of Equation 1.4.

Table 5 describes the independent variable with respective coefficients of model.

$$D(NIFTY\_IN\_USD) = C(1)*(NIFTY\_IN\_USD(-1))$$
$$-0.108861052517*GOLD(-1) - 213.354923268$$
$$*WTI(-1) + 0.500720264548*BRENT(-1) - 206.302531121)$$
$$+C(2)*D(NIFTY\_IN\_USD(-1)) + C(3)*D(NIFTY\_IN\_USD(-2))$$
$$+C(4)*D(NIFTY\_IN\_USD(-3)) + C(5)*D(GOLD(-1))$$
$$+C(6)*D(GOLD(-2)) + C(7)*D(GOLD(-3)) + C(8)$$
$$*(EXCHANGE\_RATE(-1)) + C(9)*D(EXCHANGE\_RATE(-2))$$
$$+C(10)*D(EXCHANGE\_RATE(-3)) + C(11)*D(WTI(-1)) + C(12)$$
$$*D(WTI(-2)) + C(13)*D(WTI(-3)) + C(14)*D(BRENT(-1))$$
$$+C(15)*D(BRENT(-2)) + C(16)*D(BRENT(-3)) + C(17)$$

Table 5 has been generated by running VECM considering Dependent Variable as D (Nifty 50) and Brent, WTI, Gold and Exchange rate as independent variables. Three lag is considered as suggested by SIC. Long-run causality or speed of adjustment towards long-run equilibrium is indicated by C(1) and it must be significant and negative.

Since coefficient C(1) is negative and significant, long-run causality is found to run from Brent, WTI, Gold and Exchange rate to Nifty 50. The observed value of C(1) of about -0.000259 suggests that only about 0.02% of the discrepancy which is seen between long-term and short-term Nifty 50 is corrected within a day. Thereby 1% unit change in

$$NIFTY\_IN\_USD(-1) - 0.108861052517$$
$$*GOLD(-1) - 213.354923268*EXCHANGE\_RATE(-1)$$
$$+215.080743579*WTI(-1) + 0.500720264548$$
$$*BRENT(-1) - 206.302531121$$

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will affect D (Nifty 50) by -0.000259. This suggests a slow rate of adjustment to equilibrium. Coefficients C (5) and C(14) are also significant which indicate that

they are also affecting the D (Nifty 50). The lag value of Brent and Gold is also affecting the Nifty 50.

Table 5: Model Specifications and Regression Analysis

Coefficient	Independent Variables	Coefficient	T Statistic	P-value
C(1)=Error Correction term*	NIFTY_IN_USD(-1) - 0.108861052517 × GOLD(-1) - 213.354923268 × EXCHANGE_RATE(-1) + 215.080743579 × WTI(-1) + 0.500720264548 × BRENT	-0.000259	-3.290260	0.0010
C(2)	D(NIFTY_IN_USD(-1))	-0.003717	-0.182652	0.8551
C(3)	D(NIFTY_IN_USD(-2))	-0.010945	-0.538131	0.5905
C(4)	D(NIFTY_IN_USD(-3))	0.005013	0.246751	0.8051
C(5)*	D(GOLD(-1))*	0.006886	3.499349	0.0005
C(6)	D(GOLD(-2))	0.000945	0.476667	0.6336
C(7)	D(GOLD(-3))	0.001610	0.813644	0.4159
C(8)	D(EXCHANGE_RATE(-1))*	-0.033087	-0.290270	0.7716
C(9)	D(EXCHANGE_RATE(-2))	0.153425	1.347088	0.1780
C(10)	D(EXCHANGE_RATE(-3))*	0.011500	0.100929	0.9196
C(11)	D(WTI(-1))	-0.067806	-0.551219	0.5815
C(12)	D(WTI(-2))	-0.011043	-0.090161	0.9282
C(13)	D(WTI(-3))	0.017244	0.141237	0.8877
C(14)**	D(BRENT(-1))	0.016119	1.872940	0.0612
C(15)	D(BRENT(-2))	0.013983	1.480342	0.1389
C(16)	D(BRENT(-3))	0.001980	0.230002	0.8181
C(17)		0.040576	1.347722	0.1778

Dependent Variable: D(Nifty 50), * indicates significant at 5%, ** indicates significant at 10%
Source: Author's own work.

Breush Godfrey Serial Correlation LM Test

The Breusch–Godfrey test is used for autocorrelation in the errors in a significant regression model. The null hypothesis was framed as there is no serial correla-

tion of lag 3 existing. Since the p value is less than 0.05 hence, we accept our null hypothesis that no serial correlation exists in the model.
H_0: There is no serial correlation.
H_1: Serial Correlation Exists.

Table 6: Breush Godfrey Serial Correlation LM Test

Test Statistics	Value	Probability	Value
F Statistic	1.352426	Prob. (3, 3317)	0.2555
Obs*R-squared	4.076755	Prob. Chi-Square (3)	0.2533

Source: Author's own work.

One of the mandatory requirements of the VECM approach is that C(1) values must be negative and significant and there is no serial correlation. Hence, this model fit well.

Variance Decomposition Analysis (VDA)

Variance Decomposition Analysis (VDA) is a technique employed to quantify the dynamics of a VAR system. The Variance Decomposition Analysis (VDA) quantifies the extent to which movements in the dependent variables can be attributed to their own shocks, as op-

posed to shocks originating from other variables (Brooks, 2008). It indicates the amount of information contributed by each variable to other variables in a Vector Autoregression (VAR) model.

Variance Decomposition Analysis (VDA) of Nifty 50 with Gold, Exchange Rate, Brent and WTI

VDA of Nifty 50 with Gold, Exchange Rate, Brent and WTI has been described in this section, for the quarterly data ranging from January 01, 2009 to March

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31, 2023. It is visible that in the current date 100% of variation of Nifty 50 is due to its own shock or innovation. However, with the passage of time, Nifty 50 is less affected by its own shock or innovation. Variation of Gold to Indian markets starts at 0% in the current date, and increases approximately to 18.94% in first quarter of 2023. In the second quarter of the year 2009, 96.69% of total variation in Nifty 50 is due to its own shock and the remaining 3.31% is explained by Gold, Exchange Rate, Brent and WTI. On the other hand, in the last quarter of 2023, 63.21% of variation is due to its own shock and 36.79% is explained by the Gold (18.94%), Exchange Rate (1.72%), Brent (5.50%) and WTI (10.59%). As the Indian economy has become more globalized, liberalized and interlinked, Gold, Exchange Rate, Brent and WTI have begun to have a dominant impact in Indian stock markets. Finally, for the Indian market, its own innovation or domestic factors could have played a dominant role.

Table 7: Variance Decomposition Analysis of Nifty 50 with Gold, Exchange Rate, Brent and WTI

Period	S.E.	NIFTY_IN_USD	GOLD	USD/INR Exchange_Rate	BRENT	WTI
1	14.96086	100.00000	0.000000	0.000000	0.000000	0.000000
2	19.70046	96.69197	2.708753	0.013718	0.217151	0.368409
3	23.30450	95.98343	2.202087	1.281009	0.214865	0.318606
4	24.51344	93.91466	3.497167	1.200830	0.943967	0.443372
5	24.87416	92.66301	3.989724	1.235866	1.205528	0.905867
6	25.21543	90.81831	5.589060	1.207568	1.442642	0.942417
7	25.42216	89.41425	6.534279	1.188013	1.903755	0.959704
8	25.75520	87.21574	7.738430	1.157497	2.794478	1.093852
9	26.14987	84.76705	9.093654	1.140287	3.862987	1.136019
10	26.40171	83.17165	9.559318	1.118644	4.884790	1.265602
11	26.56228	82.17207	9.857246	1.114110	5.455406	1.401171
12	26.63248	81.80070	9.903430	1.114584	5.602477	1.578813
13	26.71887	81.60884	9.895695	1.127757	5.665374	1.702336
14	26.82749	81.55353	9.816258	1.133867	5.648265	1.848082
15	26.95921	81.48022	9.724297	1.156799	5.593846	2.044840
16	27.07746	81.34908	9.642711	1.180797	5.550048	2.277363
17	27.18036	81.19644	9.569973	1.201766	5.510256	2.521566
18	27.25759	80.98529	9.526067	1.230081	5.479088	2.779471
19	27.32735	80.69021	9.512864	1.262753	5.453753	3.080424
20	27.39953	80.31821	9.566771	1.305578	5.438477	3.370959
21	27.47901	79.88697	9.685289	1.343937	5.438731	3.645071
22	27.57117	79.38752	9.872875	1.382388	5.451969	3.905246
23	27.67440	78.85116	10.102920	1.419774	5.464368	4.161784
24	27.79097	78.30360	10.365710	1.453966	5.472103	4.404622
25	27.92129	77.77749	10.645170	1.481013	5.470224	4.626099
26	28.06846	77.28431	10.928440	1.500978	5.454580	4.831690
27	28.23415	76.81678	11.217630	1.515618	5.426282	5.023695
28	28.41718	76.36947	11.511180	1.524852	5.390277	5.204220
29	28.61297	75.92679	11.816740	1.529957	5.352360	5.374149
30	28.81611	75.47399	12.138380	1.531724	5.317131	5.538775
31	29.02366	74.99677	12.482190	1.531731	5.289621	5.699683
32	29.23300	74.49257	12.844200	1.530647	5.274155	5.858430
33	29.44264	73.96494	13.217030	1.529163	5.272447	6.016419
34	29.65146	73.42264	13.591890	1.527803	5.283023	6.174649
35	29.85931	72.87724	13.959060	1.526807	5.303278	6.333617
36	30.06602	72.34049	14.309240	1.526464	5.329952	6.493850
37	30.27124	71.82276	14.634310	1.527004	5.358944	6.656979
38	30.47486	71.32956	14.931210	1.528658	5.386616	6.823960
39	30.67699	70.86246	15.200000	1.531445	5.410786	6.995302

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Period	S.E.	NIFTY_IN_USD	GOLD	USD/INR Exchange_Rate	BRENT	WTI
40	30.87784	70.41899	15.443370	1.535442	5.430720	7.171482
41	31.07754	69.99412	15.665370	1.540760	5.446436	7.353310
42	31.27638	69.58153	15.871280	1.547492	5.458555	7.541141
43	31.47470	69.17499	16.066590	1.555627	5.468090	7.734705
44	31.67302	68.76924	16.256100	1.565091	5.476052	7.933518
45	31.87204	68.36037	16.443680	1.575817	5.483170	8.136962
46	32.07260	67.94624	16.632050	1.587669	5.489850	8.344188
47	32.27563	67.52623	16.823060	1.600443	5.496221	8.554042
48	32.48203	67.10093	17.017690	1.613883	5.502142	8.765354
49	32.69270	66.67154	17.216360	1.627736	5.507317	8.977042
50	32.90842	66.23959	17.419100	1.641754	5.511434	9.188125
51	33.12987	65.80651	17.625790	1.655700	5.514265	9.397734
52	33.35755	65.37344	17.836320	1.669363	5.515712	9.605164
53	33.59180	64.94101	18.050680	1.682576	5.515841	9.809889
54	33.83282	64.50943	18.268910	1.695221	5.514895	10.011540
55	34.08069	64.07857	18.491040	1.707224	5.513238	10.209920
56	34.33535	63.64822	18.717010	1.718553	5.511286	10.404930
57	34.59666	63.21814	18.946610	1.729210	5.509452	10.596590

Source: Author's own work.

Impulse Response Function

The below figure highlights the impulse reaction behavior in Gold, WTI, Exchange Rate and Brent to Nifty 50. Impulse responses are generated for 10 periods on the basis of Monte Carlo Response standard error methods. Dotted lines represent 95% confidence intervals and the blue line indicates response behavior. One period equals one quarter.

The figure shows that upon introducing 1 unit of positive shock, impulse or innovation in Gold, the Nifty 50 initially decreased and after a lapse of 2 period gradually attained an upward movement till the fourth period and consolidated across latter periods.

Moreover, the figure shows that upon introducing 1 unit of positive shock in Exchange Rate, the Nifty 50 continued its downward movement till the second period and began its upward movement and consolidated slowly across latter periods. This is one of the significant studies as it corroborates the initiatives taken by the government to neutralize the adverse impact of exchange rate fluctuations. So, one can safely say that in spite of remarkable shifts in exchange rates, its impact tends to get nullified over a period of time due to economic interventions by monetary and fiscal policy making authorities.

Contrary to the above patterns, we also find that upon introducing 1 unit of positive shock in BRENT, the Nifty 50 initially declined for 2 periods and then went upward till the fourth period and finally followed a downward movement across latter periods. This is attributed to the fact that India imports about 85% of its crude oil demand (mostly BRENT) and only 15% is met through indigenous sources. (Source: Policy on Import of Crude Oil, 2023). Therefore, as the BRENT prices increase, the corresponding inflation also increases considerably resulting in negative impact on the Indian economy which is reflected in Nifty 50 and vice versa.
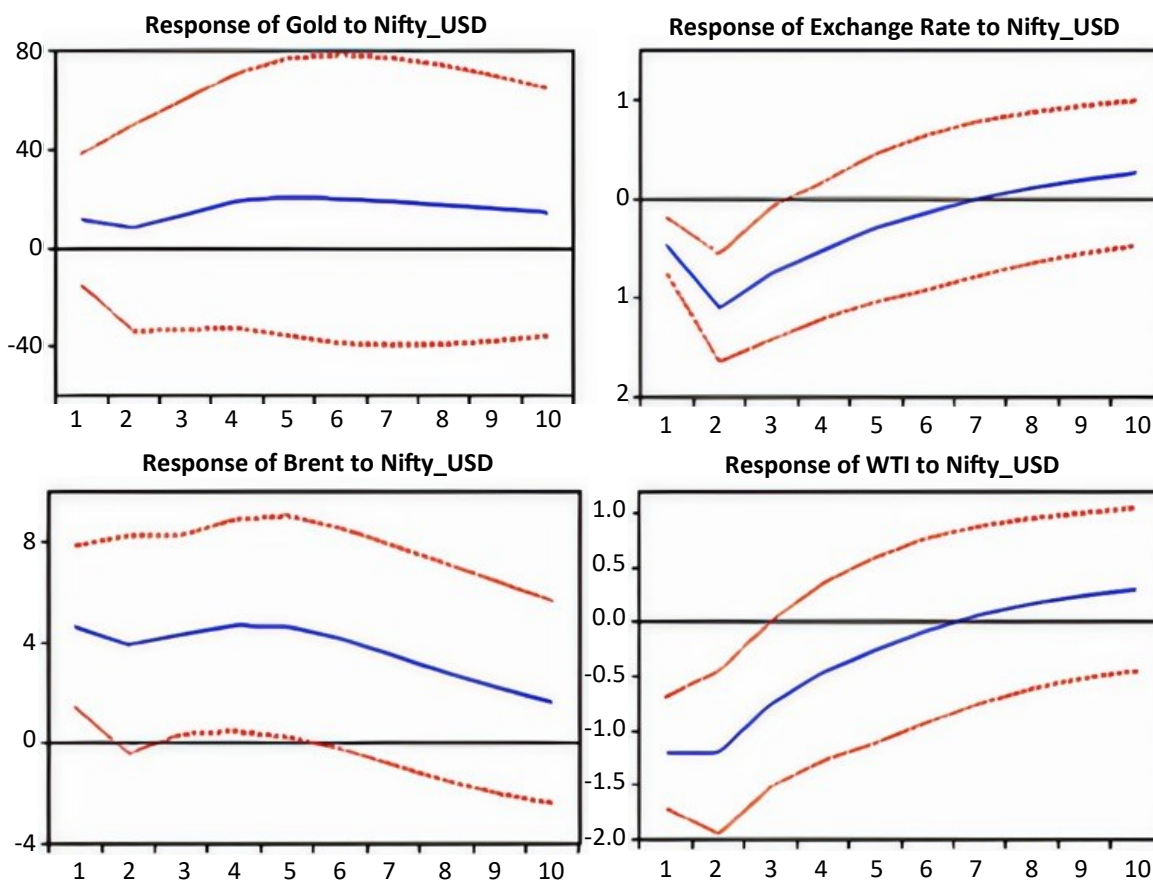
Conclusion

This paper investigates the dynamic relationships among Nifty 50, gold, exchange rate and crude oil (Brent and WTI) during a 2009-2023 timeframe by adopting the Unit Root Test technique, Johansen Juselius Cointegration test, VECM and VDA Analysis. The result indicates that the long-run causality relationship runs from oil prices, gold prices and exchange rate to the benchmark indices Nifty 50.

There is a strong positive relationship between the Nifty 50 and the price of gold, the Nifty 50 and the exchange rate, the gold price and the exchange rate, and the BRENT price to gold. In addition, there is a strong correlation between stock prices and gold prices, and a negative correlation between oil prices and stock prices and exchange rate movement. So, it's not uncommon for the value of a currency, the price of gold, and the price of stocks to all trend in the same way.

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Figure 6: Impulse Response Function

Source: Author's own work.

The results of Cointegration suggest international investors will not be benefitted by portfolio diversification upon making investments in Nifty 50, Gold, Brent, WTI and Exchange Rate as multivariate cointegration or a long-run equilibrium relationship exists among the variables. One of the significant findings of this study is that a long-run causality relationship also runs from Gold, Brent, WTI and Exchange Rate to Nifty 50. Results of variance decomposition analysis concluded that in the year 2023, 63.21% of variation in Nifty 50 is due to its own shock and 36.79% is explained by Gold (18.94%), Exchange Rate (1.72%), Brent (5.50%) and WTI (10.59%). Beyond financial and investment choices, the result of dynamic linkages can also direct monetary and fiscal policymaking authorities. This study makes a significant contribution to the understanding of long-term asset integration in India's financial markets. It uniquely shows that portfolio diversification across stocks, gold, and oil may not offer significant risk reduction, as these assets are cointegrated in the long-run. This insight is critical for portfolio managers who might otherwise rely on these asset classes for diversification.

Furthermore, future research could investigate the effects of other asset classes like bitcoins or bonds in

a similar VECM framework, particularly as these assets gain relevance in financial markets. Additionally, exploring the impact of government policy role in stabilizing markets can provide deeper managerial insights. Moreover, there is potential to assess the impact of policy interventions, such as changes in import duties on gold or government initiatives to stabilize the currency, on these interrelationships. This would help policymakers develop strategies that respond more effectively to financial market shocks.

Managerial implication

The effectiveness of diversification methods may be limited by the existence of long-run equilibrium linkages among Nifty 50, gold, oil prices, and exchange rates. Investors must thoroughly evaluate the possible advantages of diversifying their investments among these assets. Gaining a comprehensive understanding of the interconnected relationships found in the study can assist in more effectively mitigating investment risks. An illustration of this would be the identification of the inverse relationship between oil prices and stock prices, which can provide valuable insights for developing methods to reduce risk. Managers must remain watchful of external shocks or swings in oil prices, gold

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prices, and exchange rates, as these factors might have a substantial impact on the performance of Nifty 50. Investors should take into account the interaction between Nifty 50, gold prices, oil prices, and exchange rates while making investing decisions. Modifications in any of these variables can result in a series of interconnected consequences on the remaining variables. Policymakers can utilize the findings from the study to develop efficacious monetary and fiscal policies. Gaining insight into the causal connections among the Nifty 50, gold prices, oil prices, and currency rates can assist in formulating strategies targeted at achieving stability in financial markets and fostering economic expansion. Central banks have the flexibility to modify their mone-tary policies in order to respond to fluctuations in these important factors, with the goal of preserving stable prices and promoting economic growth. Exporters and importers might utilize derivative instruments to mitigate the risks associated with unfavorable fluctuations in exchange rates and commodity prices. To successfully reduce the impact of variations in Nifty 50, gold prices, oil prices, and exchange rates, hedging methods should consider the observed correlations and causative linkages. Managers and policymakers must adjust their strategies to consider these dynamic connections and guarantee resilience in response to shifting market conditions.

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