“Dynamic relationship between equity, bond, commodity, forex and foreign institutional investments: Evidence from India”

Authors: Rajeev Matha, Geetha E., Satish Kumar, Raghavendra

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Abstract

The interrelationship between equity, bond, commodity and forex movements can provide investors with abundant trading opportunities regardless of whether one market is trending upward or downward. Hence, to understand the interlinkage between markets, this study examines the long-run and causal linkage between forex, G-sec bonds, oil prices, gold rates, foreign institutional investment (FII) flows, and equity market and sectoral index returns. Daily time-series data from August 2012 to August 2021 were considered for empirical analysis. Johansen's cointegration test revealed that foreign exchanges like USD, Euro, GBP and Yen, oil and gold rates, G-bond returns and FII flows were significantly cointegrated with the stock market and sectoral indices in the long run. Further, Granger causality found a uni-directional relationship between forex rates (i.e., USD, Euro, Yen) and the market, as well as sectoral indices, except Nifty 50 and Nifty IT indices. Oil price movements were found to effectively predict future price changes of Nifty consumer durables, auto, IT indices. Gold prices are useful to predict Nifty-Auto, Bank, Financial Services, Oil & Gas and PSU. The study also found a bi-directional relationship from FII inflows to the stock market and sectoral indices. The findings suggest that forex rates, oil prices and FII flows significantly affect India's stock market and sectoral performance. The study contributes to the existing literature by comprehensively examining the interlinkage between commodities such as oil and gold, foreign exchanges like USD, Euro, GBP and Yen, G-bond and FII flows and the stock market, and fourteen sectoral indices in the Indian context.

Keywords
stock, bond, commodity, forex, FII, Granger causality, financial instruments

JEL Classification
C53, E37 G17, G12, G15

INTRODUCTION

The sustained rise in the interdependence of commodity, bond, forex and equity markets accelerated the financialization process and witnessed increased volatility (Parab & Reddy, 2020). A volatile capital market has large implications for financial and economic stability. The interdependence between the market and economies plays a pivotal role in pricing securities in the market. The most traded commodities such as oil and gold, foreign exchanges like USD, euro, GBP and Yen, bond rates and foreign institutional inflows and outflows, and equity markets are intercorrelated. Therefore, price changes in one market can trigger price fluctuations in other markets. It is necessary to understand the long-run and causal relationship between the popular macro-economic indicators in the short run and long run, because economic indicators have been considered risk factors that significantly influence the financial market. The direction of causality between...
commodity, bond, forex and equity markets would provide insights to the investors, portfolio managers and policymakers for portfolio diversification and strategic decision-making (Arfaoui & Rejeb, 2017; Parsva & Tang, 2017).

The existing body of literature has evidenced uni-directional or bidirectional linkages either between forex and stock prices (Farooq & Keung, 2004; Akram, 2009; Ingahalli et al., 2016; Arvind, 2017; Parsva & Tang, 2017; Singh & Sharma, 2018) or oil and stock returns (Beckmann & Czudaj, 2013; Aydogan et al., 2017) or FII and stock returns (Chandra, 2012; Dhingra et al., 2016; Arora, 2016; Agarwal, 2016; Parab & Reddy, 2020). However, no studies comprehensively explore the interlinkage between forex, commodities, G-bonds, FIIs and equity markets. Additionally, the findings on the interlinkage between markets have been subject to intensive debate in the scientific community due to inconclusive results. For example, the study by Tudor and Dutaa (2012) found a uni-directional relationship, while studies by Akram (2009), Arvind (2017), and Parsva and Tang (2017) found bi-directional relationships and Farooq and Keung (2004) found no causal interlinkage between the variables. Furthermore, a considerable amount of literature has widely examined the interlinkage between the forex, commodities, G-bonds, FIIs and equity markets; however, limited attention has been paid to analyzing the correlation with equity markets sectoral indices such as Nifty-Auto, Nifty-Bank, Nifty – FMCG and macro-economic indicators from the Indian capital market context (Siddiqui & Azad, 2012; Parab & Reddy, 2020).

This paper attempts to address the following questions: Is there a long-run relationship between commodities such as oil and gold, foreign exchanges like USD, euro, GBP and Yen, G bond returns and foreign institutional inflows and outflows, and equity markets? Is there a casual and lead-lag relationship between commodities such as oil and gold, foreign exchanges like USD, euro, GBP and Yen, G bond returns and foreign institutional inflows and outflows, and the equity market? Considering the above questions, the prospective study is designed to investigate the long-term and causal relationship between forex, gold, oil, FII flows, Nifty 50, and other sectoral indices. In order to verify the stationarity of the data, the study employed the Augmented Dickey-Fuller Test (ADF), the Johansen cointegration test to examine the long-run relationship among variables, and the Granger causality test to examine the causal relationship between variables. This paper contributes to the body of literature by providing evidence on the causal and long-term relationship between forex, commodity, gold and equity markets in the Indian capital market, which will help investors in formulating investment strategies and policymakers in devising regulatory policies related to the market.

1. LITERATURE REVIEW

The studies on the degree of interdependency and co-movements between markets have captured the attention of researchers. The arbitrage pricing theory proposed by Ross (1976) argues that macroeconomic indicators significantly affect the performance of the stock market. Similarly, 'Portfolio balance approach' proposed by Frankel and Rodriguez (1975) established the interlinkage between the markets. The theory argues that a dynamic stock market attracts a large pool of foreign investment to the market and increases the demand for the domestic currency (Aravind, 2017, p. 2). Subsequently, market hypotheses such as Frenkel’s asset market hypothesis and ‘Goods and market approach’ (Dornbusch & Fischer, 1980) also explain the association between forex and stock markets. Furthermore, Friedman (1988) explained the relationship between stock market performance and money supply. Stable market conditions and the economy attract foreign investments to the market. Thus, foreign institutional investment (FII) is one of the key indicators for understanding equity return movements (Chandra, 2012). The most traded commodities, such as oil and gold, and government bonds can become good portfolio diversifiers by channelising funds during market crashes (Arfaoui & Rejeb, 2017).

In recent years, global markets have been vulnerable to unforeseen financial crises, including unexpected equity and foreign exchange price oscillations. The relationship between stock market return, price movements, and forex price variations

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has been widely explored (Patel, 2017). Aravind (2017) analyzed the effect of volatility in Forex rates of the Indian rupee with other major global currencies like US Dollar, Euro, Japanese Yen, and GBP on the stock price and return volatility in the Indian stock market using the granger causality test. The study exhibited a weak causal relationship between the exchange rate of USD, EUR and JPY to stock returns but a positive relationship with GBP. It concluded that an increase in the exchange rate of GBP causes an increase in the stock return; in contrast, any variations in other exchange rates of currencies will not influence stock returns significantly. Tudor and Dutta (2012) examined the causal relationship between equity returns and thirteen countries’ exchange rates. They found a significant bi-directional relationship only in South Korea and the uni-directional impact of the exchange rate on returns in other countries. Parsva and Tang (2017) examined the causal association between equity prices and forex rates of middle east economies. The study established the bi-directional causality between equity prices and exchange rates in middle east economies such as Iran, Oman, Saudi Arabia, and non-causality in Kuwait. At the same time, Farooq and Keung (2004) claimed the non-stationarity and non-cointegration among the exchange rate and stock prices, as contrary to other studies. It is also argued that uni-directional causality from stock price to exchange rates are possible only in the short run; it could not exist in the long term. Akram (2009) concluded that exchange rates and interest rates are negatively correlated with commodity prices; Commodity prices tend to increase when interest rates and foreign exchange rates are low (Mitra & Bhattacharjee, 2015; Bataineh, 2022). Adjasi et al. (2008) explored the effect of exchange rates and macroeconomic variables on the stock market using EGARCH models in the Gahan stock exchange. It is evident that the movement in the exchange rate influences volatility in the stock market (Saxena & Bhaduriya, 2012).

Further studies have extended the scope of research by exploring relative market indicators such as oil prices, gold rates and government securities to the existing causal relationship of forex and stock prices. Arfaoui and Rejeb (2017) explored the interlinkage between oil, gold, forex and stock market prices. The study found that oil and stock price are negatively correlated. Nevertheless, oil price positively influences gold prices and US exchange rates; USD is negatively correlated with oil, gold, and stock prices. Ingalphali et al. (2016) found the uni-directional relationship between oil, gold, forex, and security prices. Results exhibited that oil price effectively predicts exchange rates and gold prices. It implies that any fluctuations in oil prices cause variations in the stock prices. Exchange rates and oil prices have a substantial influence on each other. In support of this argument, the relationship between U.S. exchange rates and oil prices in major oil-importing and exporting countries through incorporating the MS-VECM model was analyzed; Results argued that the U.S. exchange rate movement has significantly influenced the oil prices (Beckmann & Czudaj, 2013; Kumar et al., 2021).

Additionally, Singh and Sharma (2018) explored the correlation between gold rates, oil prices, USD exchange rates, and Sensex in the pre-crisis and post-crisis periods using Johansen’s cointegration test to verify the long-run relationship. The study revealed a significant long-term relationship between gold, oil, USD, and Sensex. The studies by Arouri et al. (2012), Aydogan et al. (2017), Alqahtani et al. (2020), and Chien et al. (2021) found that the oil rate has a significant positive impact on the equity return. In contrast, Burian and Breck (2012) argued that the variation in oil prices has no impact on the stock market return.

Macroeconomic performance and its indicators are essential to predict the price movement in the market. The macro-economic indicators such as global crude oil rates, forex rates and gold prices are highly correlated and influence the stock, bond yields and other market-related indices. Singhal et al. (2019) explored the interrelationship between crude oil rates, gold prices, forex rates and equity returns in Mexico. International gold prices have a significant positive effect on stock prices, whereas it has no significant influence on forex rates. Oil prices were found to be more volatile than other variables and have a considerable negative impact on both equity and forex prices. This relationship exhibits an increase in oil prices, causing a decrease in both stock prices and forex rates. Diebold et al. (2009) examined the interdependency of return on stock, bonds, and gold. The relationship of variables and volatility of returns of developed compared with developing economies. The study
found that returns on bonds, stocks, and gold are not correlated and will not significantly influence each other; but have shown the patterns. Sumner et al. (2010) extended the study of Diebold et al. (2009) by incorporating the spill over-index. The study argued that gold prices might not be the best predictor for stock and bond returns. It also exerted a low spillover relationship from Gold to stock and bond. On the contrary, studies on the linkages between return on gold, stock, and U.S. bonds found a significant correlation between gold, stock and bond returns. And no correlation with other macro-economic variables (Lawrence, 2003). Studies also opined that gold investment is considered as the best portfolio diversifier and hedge option in extreme market conditions (Baur & Lucey, 2009; Yilanci et al., 2021).

Ratanapakorn and Sharma (2007) investigated the short-run and long-run relationship between equity prices and macroeconomic indicators. The research found a positive relationship between money supply, industrial production, forex, and short-term interest rates. Granger causality revealed that all the macro-economic variables cause the fluctuation in stock prices in the long run, not in the short run. Krchniva (2016) analyzed the causal relationship between economic activity and the stock market in seven countries and found a strong correlation. The study opined that the stock index could be a prominent predictor of economic activities. Diebold et al. (2009) found that returns on bonds, stocks, and gold are not correlated and will not significantly influence each other. Similarly, Sumner et al. (2010) found a weak correlation between the gold, equity and bond returns. On the contrary, studies on the linkages between return on gold, stock, and U.S. bonds found a significant correlation between gold, stock and bond returns. And no correlation with other macro-economic variables (Lawrence, 2003). Furthermore, Kolluri et al. (2015) explored cointegration between the Indian stock and bond market and other major foreign equity markets. Stock and bond market returns were cointegrated in the Indian and the other five foreign stock markets. In the Indian context, the association between bond and equity market is less explored along with other macro-economic variables. Therefore, the current study hypothesis as follows:

External factors like foreign institutional investments (FII) play a significant role in determining the stock prices and returns in the stock market. If the market condition is stable, it attracts a massive amount of funds in the form of foreign investments. Chandra (2012) explored the relationship between FII and stock returns. Granger causality test established a bi-directional relationship between foreign institutional investments and returns and observed variations in return on stocks, and foreign investments cause changes to each other. Dhingra et al. (2016) also found a significant positive correlation between the FII flow and equity returns. Arora (2016) studied the impact of equity flows of FII and Domestic institutional investment (DII) on future stock returns. DII substantially influences future stock returns, whereas FII negatively correlates with stock returns (Goyal 2013; Vohra, 2016). Agarwal (2016) investigated the influence of FII inflow in IPOs on financial market development. The study argued that FII has a significant positive impact on the growth of the stock market. Hence, any increase in the inflow of FII to the IPOs significantly increases the stock market return. Murthy and Singh (2013) attempted to determine the impact of FII and DII on stock returns. Researchers argued that DII flows significantly influence equity market return more than FII flows (Parab & Reddy, 2020).

H₁: Forex return does not Granger cause NIFTY 50 equity market and NIFTY Financial services, FMCG, Auto, Metal, Consumer durables, Oil and gas, IT, Media, Private Banks, PSU, Pharma, and Reality sectoral returns.

H₂: Oil rate does not Granger cause NIFTY 50 equity market and NIFTY Financial services, FMCG, Auto, Metal, Consumer durables, Oil and gas, IT, Media, Private Banks, PSU, Pharma, and Reality sectoral returns.

H₃: Gold rate does not Granger cause NIFTY 50 equity market and NIFTY – Financial services, FMCG, Auto, Metal, Consumer durables, Oil and gas, IT, Media, Private Banks, PSU, Pharma, and Reality sectoral returns.

H₄: Government bond rate does not Granger cause NIFTY 50 equity market and NIFTY – Financial services, FMCG, Auto, Metal,
Consumer durables, Oil and gas, IT, Media, Private Banks, PSU, Pharma, and Reality sectoral returns.

\[ H_2: \text{FII inflows and outflows do not Granger cause NIFTY 50 equity NIFTY – Financial services, FMCG, Auto, Metal, Consumer durables, Oil and gas, IT, Media, Private Banks, PSU, Pharma, and Reality sectoral returns.} \]

2. METHODS

This study examines the long-term and causal relationship between forex, gold, oil, FII flows, Nifty 50, and other sectoral indices. The study incorporated post positivism research philosophy and quantitative research technique. Daily time-series data from August 1, 2012 to August 31, 2021 have been considered for empirical analysis, which consists of 2,183 days. The analysis has included the four most traded foreign currencies, i.e., USD, Pound Sterling, euro, and Japanese Yen exchange rates. The data on forex rates and gold prices have been retrieved from the Reserve Bank of India (RBI) repository. The data on crude oil spot prices were obtained from www.eia.org. The data on foreign institutional investment, i.e., FII inflows and outflows, have been obtained from the National Securities Depository Limited (NSDL) database.

Moreover, the Nifty 50 return is considered a market indicator as it represents about 66.8% of the free float market capitalization of stocks listed on NSE and is a widely accepted benchmark by portfolio managers and researchers. National stock exchange (NSE) sectoral indices return such as Nifty Financial services, Nifty FMCG, Nifty Auto, Nifty Metal, Nifty Consumer durables, Nifty oil and gas, Nifty IT, Nifty Media, Nifty Private Banks, Nifty PSU, Nifty Pharma, and Nifty Reality have been considered to understand the sectoral impact. The market and sectoral indices data were retrieved from the NSE database. The data sets were cleaned by removing duplicate or irrelevant observations. Additionally, Using Microsoft excel software, data sets were formatted to ensure the consistency of the dates for all the time series by considering Nifty 50 data as a base.

EViews 10.0 software was used to analyze the data. Initially, a natural logarithm is used to decrease the skewness in the data; the returns are calculated using the following formula:

\[ R_t = \ln \left( \frac{P_t}{P_{t-1}} \right) \cdot 100, \]  

where \( \ln = \text{Natural log}; P_t \) is the price of the current period; and \( P_{t-1} \) is the price of the previous period.

Further, stationarity of the time series was verified using the Augmented Dickey-Fuller (ADF) test (Dickey & Fuller, 1979). The stationarity of the time series data implies that statistical properties will remain unchanged in the future. Unit root test is essential in econometrics forecasting and models. Granger-causality and Johansen cointegration tests assume the stationarity of time series data. The mathematical expression of ADF is as follows:

\[ \Delta y_t = a + \beta t + \gamma y_{t-1} + \delta \Delta y_{t-1} + \ldots + \delta_{p-1} \Delta y_{t-p+1} + \epsilon_t, \]  

where \( y_t \) denotes the time series to be tested; \( \beta = \) coefficient on a time trend; \( p = \) lag order of the autoregressive process; \( a = \) constant, \( \epsilon_t = \) error term.

Further, the Johansen cointegration test (Johansen, 1988) was applied to examine the cointegrating vectors in the data series. It evaluates the cointegrated vectors in two forms, i.e., Trace test and the Max-Eigen test. In time series results, trace tests determine the number of linear combinations, i.e., \( K \) is equal to the \( K_0 \) value, and the hypothesis that \( K \) is more significant than \( K_0 \). It is expressed as \( H_0: K = K_0, H_1: K > K_0 \). In addition, the Granger causality test was used to examine the short-run causal relationship between forex, gold, oil, equity flow of FII, Nifty 50 and other sectoral indices. The Granger causality test evaluates the ability to predict the variable’s potential to predict the future movements of the time series using prior actions of another time series data. The regression equation for the granger causality test is

\[ X_t = \alpha_1 + \sum_{k=1}^{m} \beta_{1k} X_{t-k} + \sum_{k=1}^{m} \gamma_{1k} Y_{t-k} + \epsilon_{1t}, \]  

\[ Y_t = \alpha_2 + \sum_{k=1}^{m} \beta_{2k} Y_{t-k} + \sum_{k=1}^{m} \gamma_{2k} X_{t-k} + \epsilon_{2t}, \]

where \( Y_t \) and \( X_t \) are variables to be tested; \( \epsilon_{1t} \) and \( \epsilon_{2t} \) are error terms, \( t \) is time period, \( k \) is no of lags.
3. RESULTS

3.1. Descriptive statistics

The summary of descriptive statistics is demonstrated in Table 1. The Nifty 50, Nifty CD, Nifty Auto, Nifty Bank, Nifty FS, Nifty FMCG, Nifty IT, Nifty O&G, Nifty PH, and Nifty P Bank sectors showed positive returns with the highest mean returns for Nifty CD and Nifty IT (0.05%). While Nifty Metal, Nifty PSU, and Nifty REA sectors exhibited negative returns, with the lowest mean returns for Nifty PSU (-0.05%). Further, positive mean returns were observed for US Dollar, Euro, Japanese Yen, GBP, Gold, and Government Bonds except for oil (-0.04%). Standard deviation explained the variation from the actual mean and showed the highest deviations for FII Purchase and FII Sales with 44.26% and 42.29%, respectively. This deviation is because of high fluctuations in foreign institutional investment inflow and outflows. The skewness of the data depicts positive skewness only for USD, Euro, Yen, and gold. The kurtosis measured the flatness of the data and found that the data was too peaked. Further, the Jarque-Bera test is applied to determine the data normality, and the null hypothesis is $H_0$: The data are normally distributed. The results showed that the p-value of the test statistics is insignificant at a 5% significance level and thus, data is not normally distributed ($H_1$).

3.2. Augmented Dickey-Fuller Test (ADF)

Table 2 describes the test results of the ADF proposed by Dickey and Fuller (1979), which tests the stationarity of the time-series data. Unit root test is essential in econometrics forecasting and models. The stationarity of the time series data implies that the statistical properties such as mean and variances should be constant over time. The Granger-causality test assumes the stationarity of time series data. The unit root test has been done using the ADF test to confirm the stationarity. This test postulates null hypothesis $H_0$: There is no stationarity in the data or a unit root in the data.

Table 1. Results of descriptive statistics

| Source: Authors' calculation. |
|---|
| **NIFTY_50** | **N_CD** | **N_AUTO** | **N_BANK** | **N_FS** | **N_FMCG** | **N_IT** | **N_MEDIA** | **N_METAL** | **N_O&G** | **N_PH** | **N_PSU** |
| Mean | 0.03 | 0.05 | 0.03 | 0.03 | 0.04 | 0.04 | 0.05 | 0.00 | -0.03 | 0.03 | 0.03 | -0.05 |
| Median | 0.05 | 0.07 | 0.07 | 0.05 | 0.06 | 0.09 | 0.05 | 0.03 | -0.01 | 0.06 | 0.05 | -0.05 |
| Minimum | -13.90 | -12.04 | -14.91 | -18.31 | -17.36 | -11.20 | -12.49 | -17.88 | -12.33 | -12.44 | -9.35 | -14.11 |
| Maximum | 10.23 | 7.41 | 9.90 | 10.00 | 8.03 | 7.99 | 8.92 | 8.04 | 9.39 | 8.68 | 9.87 | 25.95 |
| Std. Dev. | 1.14 | 1.29 | 1.40 | 1.57 | 1.49 | 1.13 | 1.34 | 1.60 | 1.78 | 1.36 | 1.23 | 2.16 |
| Skewness | -0.91 | -0.64 | -0.48 | -0.80 | -1.00 | -0.43 | -0.75 | -1.01 | -0.25 | -0.82 | -0.20 | 0.72 |
| Kurtosis | 21.86 | 10.19 | 13.82 | 15.72 | 15.63 | 12.72 | 14.07 | 13.33 | 6.14 | 13.31 | 8.88 | 14.83 |
| Jarque–bera | 32669 | 4849 | 10735 | 14951 | 14859 | 8664 | 11346 | 10078 | 919 | 9914 | 3163 | 12912 |
| P–value | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Observations | 2183 | 2183 | 2183 | 2183 | 2183 | 2183 | 2183 | 2183 | 2183 | 2183 | 2183 | 2183 |

| **N_P Bank** | **N_REALUS_DOLLAR** | **EURO** | **J_YEN** | **GBP** | **GOLD** | **OIL** | **G_Bonds** | **FII_IF** | **FII_OF** |
|---|
| Mean | 0.04 | -0.03 | 0.02 | 0.02 | 0.01 | 0.01 | 0.03 | -0.04 | 0.03 | 0.06 | 0.02 |
| Median | 0.05 | 0.09 | 0.02 | 0.01 | 0.00 | 0.02 | 0.00 | 0.00 | -0.23 | 0.00 | 0.00 |
| Minimum | -19.70 | -12.33 | -2.68 | -2.65 | -4.53 | -6.78 | -8.66 | -64.37 | -3.53 | -242.73 | -265.52 |
| Maximum | 10.49 | 8.09 | 4.02 | 4.15 | 4.81 | 3.68 | 12.85 | 49.37 | 2.66 | 238.10 | 219.80 |
| Std. Dev. | 1.58 | 2.11 | 0.47 | 0.59 | 0.74 | 0.63 | 0.90 | 3.15 | 0.31 | 44.26 | 42.29 |
| Skewness | -0.94 | -0.49 | 0.36 | 0.34 | 0.26 | -0.50 | 0.87 | -1.71 | -1.00 | -0.17 | -0.23 |
| Kurtosis | 18.83 | 5.76 | 9.13 | 6.11 | 5.92 | 10.69 | 29.87 | 149.97 | 20.05 | 6.65 | 7.91 |
| Jarque–bera | 23102 | 779 | 3468 | 920 | 801 | 5468 | 65954 | 1489571 | 26792 | 1221 | 2209 |
| P–value | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Observations | 2183 | 2183 | 2183 | 2183 | 2183 | 2183 | 2183 | 2183 | 2183 | 2183 | 2183 |

Note: **NIFTY_50** – Nifty 50 index, **N_CD** – Nifty consumer durable index, **N_AUTO** – Nifty auto index, **N_BANK** – Nifty bank index, **N_FS** – Nifty financial services index, **N_FMCG** – Nifty FMCG index, **N_IT** – Nifty I.T. index, **N_MEDIA** – Nifty Media index, **N_METAL** – Nifty metal index, **N_O&G** – Nifty oil & gas index, **N_PH** – Nifty Pharma index, **N_PSU** – Nifty PSU index, **N_PVT Bank** – Nifty Private Banks index, **N_REALITY** –Nifty Reality index, **G_Bonds** – Nifty composite G-sector bond index, **FII_IF** FII inflow and **FII_OF** FII outflow.
The null hypothesis is rejected if the ADF test values are less than the critical value at 5% (i.e., the p-value is less than 0.05). ADF-test results show that all the variables are stationary at levels. Therefore, the null hypothesis (H₀: There is no stationarity in the data) has been rejected. Hence, data is stationary for all the selected variables or does not have a unit root (H₁) by accepting the alternative hypothesis.

**Table 2. Augmented Dickey-Fuller test results**

| Variables          | t-statistic | p-value | *  |
|--------------------|-------------|---------|----|
| NIFTY_50           | –47.9411    | 0.0001* |    |
| N_CD               | –43.3128    | 0.0000* |    |
| N_Auto             | –45.2537    | 0.0001* |    |
| N_Bank             | –44.5496    | 0.0000* |    |
| N_FS               | –45.2947    | 0.0001* |    |
| N_FMCG             | –46.9470    | 0.0001* |    |
| N_IT               | –47.8779    | 0.0001* |    |
| N_Media            | –45.2732    | 0.0001* |    |
| N_Metal            | –46.8545    | 0.0001* |    |
| N_O&G              | –30.8682    | 0.0000* |    |
| N_Pha              | –43.1399    | 0.0001* |    |
| N_PSU              | –45.1130    | 0.0001* |    |
| N_PB               | –44.2425    | 0.0001* |    |
| N_Reality          | –43.0907    | 0.0000* |    |
| USD                | –46.7669    | 0.0001* |    |
| Euro               | –46.9642    | 0.0001* |    |
| YEN                | –46.6104    | 0.0001* |    |
| GBP                | –44.1241    | 0.0001* |    |
| Gold               | –45.0562    | 0.0001* |    |
| Oil                | –52.4445    | 0.0001* |    |
| G_Bonds            | –47.0592    | 0.0001* |    |
| FII Inflow         | –21.9471    | 0.0000* |    |
| FII Outflow        | –22.0827    | 0.0000* |    |

* denotes statistically significant at 5% (0.05).

3.3. Johansen cointegration analysis

Johansen’s cointegration test exhibits the long-run relationship between variables. This test is proposed by Johansen (1988); it examines the cointegrating vectors in the data series. Johansen cointegration test examines the cointegrated vectors in two forms, i.e., Trace test and the Max-Eigen test. In time series results, trace tests determine the number of linear combinations, i.e., K is equal to the K, value, and the hypothesis that K is more significant than K₀. It is expressed as H₀: K = K₀, H₁: K > K₀.

Table 3 shows the Trace and Max-Eigen values of all the dependent variables with the associated critical values. Forex rates, oil prices, gold rates, G-sec bond returns, FII purchases and sales are considered as independent variables in the test analysis. The null hypothesis (H₀: No cointegration between the variables) has been tested at the critical value of 5%. The long-run relationship among variables is proved only when the Trace and Max-Eigen values are higher than the respective critical values. The trace’s critical value at 5% is 239.2354, and Max-Eigen is 64.5047. Hence, Johansen cointegration test result values of Trace and Max-Eigen are consistently higher than their respective critical values. Therefore, the alternative hypothesis is accepted (H₁: There is cointegration between the variables.). At a 5% significance level, at least ten cointegrating pairs among the variables are visible in the Johansen cointegration test results. Two or more cointegrated pairs in the time series are verified and exhibit bi-directional or uni-directional relationships in the Granger causality test.

**Table 3. Results of Johansen’s cointegration test**

| Variables          | Trace*   | Max-Eigen** |
|--------------------|----------|-------------|
| NIFTY_50           | 2361.77  | 435.26      |
| N_CD               | 2376.74  | 434.20      |
| N_Auto             | 2369.57  | 443.92      |
| N_Bank             | 2382.38  | 436.22      |
| N_FS               | 2391.53  | 434.10      |
| N_FMCG             | 2391.31  | 434.10      |
| N_IT               | 2352.91  | 432.25      |
| N_Media            | 2338.77  | 435.55      |
| N_Metal            | 2341.01  | 433.91      |
| N_O&G              | 2351.75  | 433.28      |
| N_Pha              | 2370.36  | 443.47      |
| N_PSU              | 2359.14  | 429.32      |
| N_PB               | 2377.81  | 440.36      |
| N_Reality          | 2365.27  | 427.22      |

* Critical value at 5% is 239.2354 (Trace); ** critical value at 5% is 64.5047 (Max-Eigen).

3.4. Granger causality test

The Granger causality test evaluates the ability to predict the variable’s potential to predict the future movements of the time series using prior actions of another time series data. It is essential to understand the usefulness of the time-series data to predict another time series’ movement. The null hypothesis (H₀: There is no causality between variables) was tested to study the causal relationship of forex rates (H₁), oil (H₂), gold (H₃), G-sec bonds (H₄), FII inflows and FII outflows (H₅) with market performance indica-
tor Nifty 50 index returns as well as sectoral performance indicators such as Nifty Auto, Nifty Financial Services, Nifty FMCG, Nifty IT, Nifty Media, Nifty Metal, Nifty Consumer durables, Nifty Oil and gas, Nifty Pharma, Nifty Pvt. Banks, Nifty PSU, and Nifty Reality.

If the p-value of the Granger Causality Test is less than 5%, the null hypothesis is rejected. Alternatively, the paired granger causality test outcomes alternated between bi-directional, uni-directional and no causality. As a pre-requisite to the granger causality test, the stationarity of the variables was verified using the Augmented Dickey-Fuller (ADF). At a 5% significance level, the Johansen cointegration test results illustrate at least ten cointegrating pairs among the variables. These cointegrated pairs verify the fact that there must be either bi-directional or uni-directional Granger causality between them if two or more time series are cointegrated.

Table 4 shows the results of hypothesis testing. The p-value for the relationship between the forex rates such as USD ($H_{1a}$), Euro ($H_{1b}$), Yen ($H_{1c}$) and equity market as well as sectoral indices were less than 0.05 at a 5% level of significance. Hence, the null hypothesis is rejected. Alternatively, the granger causality test establishes a uni-directional relationship between forex rates (i.e., USD, Euro, Yen) and the market as well as sectoral indices except Nifty 50 and Nifty IT. Indices. Further, GBP ($H_{1d}$) has shown bi-directional, uni-directional and no causality. Firstly, the test results found a uni-directional relationship between GBP and NSE sectoral indices such as Nifty- Consumer durables, Pharma, PSU, and Pvt. Bank indices. Secondly, no causality with Nifty 50, Nifty-Auto, IT and Media. Lastly, a bi-directional relationship implies that future movements of GBP can be predicted by Nifty-Bank, FMCG, Financial services, Metal, Oil & Gas and Reality sectoral indices movements.

Furthermore, the p-value for the relationship between oil prices ($H_2$) and the equity market and sectoral indices was less than 0.05 at a 5% significance level. On the other hand, Granger causality test results found that oil price movements were found to be efficient in predicting the future price changes of Nifty- consumer durables, auto, and IT indices. In addition, the uni-directional relationship of oil with Nifty-50, Bank, Financial services, Metal, Oil & Gas, Pvt. Bank suggests that future prices can be forecasted by each other. The test results exhibited the bi-directional relationship between gold ($H_3$) and equity sectoral indices like Nifty-Auto, Bank, Financial services, Oil & Gas and PSU. Hence, gold prices are useful to predict Nifty-Auto, Bank, Financial Services, Oil & Gas and PSU. On the contrary, test results found no causal relationship with the Nifty 50 and the remaining sectoral indices. Similarly, G-sec bond index returns ($H_4$) are significant for forecasting the price movements of Nifty 50, Nifty-Auto, Bank, Financial services, FMCG, Pvt. banks and realty indices movements.

The test results exhibited a bi-directional relationship of FII inflows ($H_{5a}$) with all the markets and sectoral indices except Nifty – Media & Pharma. It implies that FII inflows significantly forecast the indices’ future price movements. On the other hand, Foreign institutional investment outflows ($H_{5b}$) are meaningful to forecast the movements of all the market and sectoral indices except Nifty- Bank, financial services and PSU.

The complete results of the Granger causality test are presented in Appendix A, Table A1.

### Table 4. Summary of hypothesis testing results

| Hypothesis 1a     | p-value | Decision   | Hypothesis 1b     | p-value | Decision   | Hypothesis 1c     | p-value | Decision   |
|-------------------|---------|------------|-------------------|---------|------------|-------------------|---------|------------|
| USD → N_50        | 0.287   | Not supported | Euro → N_50       | 0.346   | Not supported | Yen → N_50        | 0.725   | Not supported |
| USD → N_CD        | 0.000*  | Supported   | Euro → N_CD       | 0.000*  | Supported   | Yen → N_CD        | 0.000*  | Supported   |
| USD → N_Auto      | 0.000*  | Supported   | Euro → N_Auto     | 0.000*  | Supported   | Yen → N_Auto      | 0.000*  | Supported   |
| USD → N_BANK      | 0.000*  | Supported   | Euro → N_BANK     | 0.001*  | Supported   | Yen → N_BANK      | 0.000*  | Supported   |
| USD → N_FS        | 0.000*  | Supported   | Euro → N_FS       | 0.000*  | Supported   | Yen → N_FS        | 0.000*  | Supported   |
| USD → N_FMCG      | 0.000*  | Supported   | Euro → N_FMCG     | 0.001*  | Supported   | Yen → N_FMCG      | 0.000*  | Supported   |
| USD → N_IT        | 0.249   | Not supported | Euro → N_IT       | 0.531   | Not supported | Yen → N_IT        | 0.018*  | Supported   |
| USD → N_Media     | 0.000*  | Supported   | Euro → N_Media    | 0.020*  | Supported   | Yen → N_Media     | 0.000*  | Supported   |

Source: Authors’ calculation.
Table 4 (cont.). Summary of hypothesis testing results

| Hypothesis 1a | p-value | Decision | Hypothesis 1b | p-value | Decision | Hypothesis 1c | p-value | Decision |
|---------------|---------|----------|---------------|---------|----------|---------------|---------|----------|
| USD → N_Metal | 0.000*  | Supported| Euro → N_Metal | 0.003*  | Supported| Yen → N_Metal | 0.000*  | Supported|
| USD → N_O&G  | 0.000*  | Supported| Euro → N_O&G  | 0.000*  | Supported| Yen → N_O&G  | 0.000*  | Supported|
| USD → N_Pharma | 0.001* | Supported| Euro → N_Pharma | 0.007*  | Supported| Yen → N_Pharma | 0.000*  | Supported|
| USD → N_PSU  | 0.000*  | Supported| Euro → N_PSU  | 0.000*  | Supported| Yen → N_PSU  | 0.000*  | Supported|
| USD → N_Pvt. Bank | 0.000* | Supported| Euro → N_Pvt. Bank | 0.002* | Supported| Yen → N_Pvt. Bank | 0.000* | Supported|
| USD → N_Reality | 0.000* | Supported| Euro → N_Reality | 0.003* | Supported| Yen → N_Reality | 0.013* | Supported|

| Hypothesis 1d | p-value | Decision | Hypothesis 2 | p-value | Decision | Hypothesis 3 | p-value | Decision |
|---------------|---------|----------|---------------|---------|----------|---------------|---------|----------|
| GBP → N_S0   | 0.098   | Not supported | Oil → N_S0   | 0.002*  | Supported| Gold → N_S0   | 0.233   | Not supported|
| GBP → N_CD   | 0.037*  | Supported | Oil → N_CD   | 0.004*  | Supported| Gold → N_CD   | 0.499   | Not supported|
| GBP → N_Auto | 0.473   | Not supported | Oil → N_Auto | 0.000*  | Supported| Gold → N_Auto | 0.007*  | Supported|
| GBP → N_Bank | 0.126   | Supported | Oil → N_Bank | 0.002*  | Supported| Gold → N_Bank | 0.039*  | Supported|
| GBP → N_FS   | 0.074   | Not supported | Oil → N_FS   | 0.002*  | Supported| Gold → N_FS   | 0.018*  | Supported|
| GBP → N_FMCG | 0.146   | Not supported | Oil → N_FMCG | 0.365   | Not supported | Gold → N_FMCG | 0.273   | Not supported|
| GBP → N_IT   | 0.298   | Not supported | Oil → N_IT   | 0.000*  | Supported| Gold → N_IT   | 0.582   | Not supported|
| GBP → N_Media | 0.424   | Not supported | Oil → N_Media | 0.188   | Not supported | Gold → N_Media | 0.085   | Not supported|
| GBP → N_Metal | 0.64    | Not supported | Oil → N_Metal | 0.000*  | Supported| Gold → N_Metal | 0.546   | Not supported|
| GBP → N_O&G  | 0.105   | Not supported | Oil → N_O&G  | 0.017*  | Supported| Gold → N_O&G  | 0.034*  | Supported|
| GBP → N_Pharma | 0.027* | Supported | Oil → N_Pharma | 0.033*  | Supported| Gold → N_Pharma | 0.408   | Not supported|
| GBP → N_PSU  | 0.025*  | Supported | Oil → N_PSU  | 0.691   | Not supported | Gold → N_PSU  | 0.040*  | Supported|
| GBP → N_Pvt. Bank | 0.193   | Not supported | Oil → N_Pvt. Bank | 0.001* | Supported| Gold → N_Pvt. Bank | 0.052   | Not supported|
| GBP → N_Reality | 0.063   | Not supported | Oil → N_Reality | 0.056   | Not supported | Gold → N_Reality | 0.432   | Not supported|

| Hypothesis 4 | p-value | Decision | Hypothesis 5a | p-value | Decision | Hypothesis 5b | p-value | Decision |
|---------------|---------|----------|---------------|---------|----------|---------------|---------|----------|
| Gvt. Bond → N_S0 | 0.001* | Supported | FII_IF → N_S0 | 0.291    | Not supported | FII_OF → N_S0 | 0.225   | Not supported|
| Gvt. Bond → N_CD | 0.589   | Not supported | FII_IF → N_CD | 0.36     | Not supported | FII_OF → N_CD | 0.374   | Not supported|
| Gvt. Bond → N_Auto | 0.633   | Not supported | FII_IF → N_Auto | 0.23    | Not supported | FII_OF → N_Auto | 0.627   | Not supported|
| Gvt. Bond → N_Bank | 0.192   | Not supported | FII_IF → N_Bank | 0.387   | Not supported | FII_OF → N_Bank | 0.782   | Not supported|
| Gvt. Bond → N_FS  | 0.202   | Not supported | FII_IF → N_FS  | 0.29    | Not supported | FII_OF → N_FS  | 0.631   | Not supported|
| Gvt. Bond → N_FMCG | 0.087   | Not supported | FII_IF → N_FMCG | 0.217   | Not supported | FII_OF → N_FMCG | 0.047*  | Supported|
| Gvt. Bond → N_IT   | 0.019*  | Supported | FII_IF → N_IT   | 0.769   | Not supported | FII_OF → N_IT   | 0.643   | Not supported|
| Gvt. Bond → N_Media | 0.667   | Not supported | FII_IF → N_Media | 0.237   | Not supported | FII_OF → N_Media | 0.549   | Not supported|
| Gvt. Bond → N_Metal | 0.41    | Not supported | FII_IF → N_Metal | 0.487   | Not supported | FII_OF → N_Metal | 0.712   | Not supported|
| Gvt. Bond → N_O&G  | 0.114   | Not supported | FII_IF → N_O&G  | 0.929   | Not supported | FII_OF → N_O&G  | 0.898   | Not supported|
| Gvt. Bond → N_Pharma | 0.311   | Not supported | FII_IF → N_Pharma | 0.596   | Not supported | FII_OF → N_Pharma | 0.484   | Not supported|
| Gvt. Bond → N_PSU  | 0.156   | Not supported | FII_IF → N_PSU  | 0.784   | Not supported | FII_OF → N_PSU  | 0.953   | Not supported|
| Gvt. Bond → N_Pvt. Bank | 0.282   | Not supported | FII_IF → N_Pvt. Bank | 0.426   | Not supported | FII_OF → N_Pvt. Bank | 0.842   | Not supported|
| Gvt. Bond → N_Reality | 0.702   | Not supported | FII_IF → N_Reality | 0.238   | Not supported | FII_OF → N_Reality | 0.615   | Not supported|

Note: NIFTY_50 – Nifty 50 index, N_CD – Nifty consumer durable index, N_AUTO – Nifty auto index, N_BANK – Nifty bank index, N_FS – Nifty financial services index, N_FMCG – Nifty FMCG index, N_IT – Nifty I.T. index, N_MEDIA – Nifty Media index, N_METAL – Nifty metal index, N_O&G – Nifty oil & gas index, N_PH – Nifty Pharma index, N_PSU – Nifty PSU index, N_PVT Bank – Nifty Private Banks index, N_REALITY – Nifty Reality index, G_Bonds – Nifty composite G-sector bond index, FII_IF FII inflow and FII_OF FII outflow.

4. DISCUSSION

The study primarily examined the long-run relationship between forex, gold, oil, FII flows, G bond rates, Nifty 50 and other sectoral indices using the Johansen cointegration test. This test revealed that macro-economic indicators, commodities such as oil and gold, foreign exchanges like USD, euro, GBP and Yen, G bond index returns and FII inflows and outflows were significantly cointegrated with the stock market and sectoral indices in the long run. At a 5% significance level, at least ten cointegrating pairs among the variables are visible in the Johansen cointegration test results. Two or more cointegrated pairs in the time series are verified and exhibit bi-directional or uni-directional relationships in the Granger causality test. The findings contradict Alagidede et al. (2011), who argued that there is no long-run rela-
The relationship between exchange rates and stock returns in Australia, Canada, Japan, Switzerland, and the UK. The results of Ratanapakorn and Sharma (2007) argued that long-term cointegration exists between macro-economic variables and stock returns in the US market; the current study supports this argument in the Indian context. Therefore, the findings suggest that macro-economic indicators like forex, gold, Oil, FII flows, and G bond returns play a pivotal role in stock market performance in the long run.

Further, the study also examined the causal relationship between forex, gold, oil, FII flows, Nifty 50, and other sectoral indices using the Granger causality test. The study found a uni-directional relationship between forex rates (i.e., USD, Euro, Yen) and the market as well as sectoral indices except Nifty 50 and Nifty IT Indices. These findings are consistent with the works of Farooq and Keung (2004), Tudor and Dutta (2012), Saxena and Bhaduriya (2012), Lakshmanasamy (2021), who found a uni-directional relationship between exchange rates and stock returns. The study also found a bi-directional relationship between GBP and Nifty-Bank, FMCG, Financial services, Metal, Oil & Gas and Reality sectoral indices movements. These findings are partially consistent with the results of Adjasi et al. (2008) and Aravind (2017) in the bi-directional relationship between GBP and stock returns and contradict in the uni-directional relationship between USD, Euro, Yen and stock market performance in India (Aravind, 2017). In accordance with the present results of a bidirectional relationship between forex (GBP) and the equity market, previous studies have demonstrated bi-directional causality forex rates to stock price movements in South Korea (Tudor & Dutta, 2012), Iran, Oman, and Saudi Arabia (Parsva & Tang, 2017). Therefore, the significant relationship between forex and equity markets helps policymakers and investors to predict the market and sectoral performance based on forex rate movements.

Oil price movements were found to be efficient in predicting the future price changes of Nifty – consumer durables, auto, & IT indices. In addition, the uni-directional relationship of oil with Nifty-50, Bank, Financial services, Metal, Oil & Gas, Pvt. Bank suggests that future prices can be forecasted by each other. Uni-directional relationship between Nifty 50 returns and oil supported the results of (Arouri et al., 2012; Ingalhalli et al., 2016; Aydogan et al., 2017; Singh & Sharma, 2018). The bi-directional relationship has been noticed between Gold and other sectoral indices. Gold prices are useful to predict Nifty-Auto, Bank, Financial Services, Oil & Gas and PSU. The results are not supported by Diebold et al. (2009) and Sumner et al. (2010) and argued that gold prices might not be the best predictor for stock returns. G-sec bond index returns, and Nifty-IT index can be predicted by each other. It is also significant to forecast the price movements of Nifty 50, Nifty-Auto, Bank, Financial Services, FMCG, and Pvt. Banks and reality indices movements. Results of Lawrence (2002), Diebold et al. (2009), Sumner et al. (2010), and Kolluri et al. (2015) agreed that a bi-directional causality relationship was found between bond and stock returns.

Further, the study found a bi-directional relationship from FII inflows to the stock market and sectoral indices except for Nifty – Media & Pharma. On the other hand, FII outflows are meaningful to forecast the movements of all the market and sectoral indices except Nifty – Bank, financial services and PSU. These results align with those of previous studies by Chandra (2012), Murthy and Singh (2013), Goyal (2013), Vohra (2016), Dhingra et al. (2016), Arora (2016), Agarwal (2016), and Parab and Reddy (2020). Hence, financial indicators such as foreign institutional investment inflows and outflows are significant predictors for the equity market and sectoral indices price movement. This implies that FII inflows significantly forecast the indices’ future price movements.

**CONCLUSION**

This paper examined the long-run and causal relationship between commodities such as oil and gold, foreign exchanges like USD, euro, GBP and Yen, G bond returns and FII inflows and outflows, and the equity market sectoral indices. Johansen’s cointegration test revealed that macro-economic indicators commodities such as oil and gold, foreign exchanges like USD, euro, GBP and Yen, G bond index returns and FII inflows and outflows were significantly cointegrated with the stock market and sectoral
indices in the long run. Taken together, these results suggest that economic indicators such as oil and gold rates, forex rates, and financial indicators like G bond index returns and FII flow are intercorrelated and crucial in predicting the stock market and sectoral performance in the long term. The current findings highlight the importance of the long-run relationship between the variables. Hence, this study provides insights for regulatory bodies, policymakers and investors in long-term investment decisions.

Further, the Granger causality test establishes a uni-directional relationship between forex rates (i.e., USD, Euro, Yen) and the market as well as sectoral indices. Additionally, the study found a uni-directional relationship between GBP and NSE sectoral indices such as Nifty – Consumer durables, Pharma, PSU, Pvt. Bank indices, and a bi-directional relationship from GBP to Nifty-Bank, FMCG, Financial services, Metal, Oil & Gas and Reality sectoral indices movements. Taken together, these results suggest that forex rates significantly impact the stock market performance. Currency crises may adversely impact the stock market and sectoral prices. Therefore, regulatory bodies and policymakers could timely implement the policies as a preventive measure, emphasizing transparent pricing by preventing price volatility.

The current study revealed that commodities such as oil price movements were found to be efficient in predicting future price changes of stock markets and sectors, as oil is considered a key input material in industrial production. Regulatory bodies could moderate prices through fiscal and monetary policy amendments to prevent adverse price volatility. The study also found that FII inflow is meaningful in forecasting the movements of all the market and sectoral indices. Hence, FII inflows and outflows are significant predictors for the equity market and sectoral indices price movement, which is considered a significant financial indicator by institutional and retail investors for their investment decisions. Therefore, policymakers should regulate foreign capital flows and prevent imbalances through credible investment policies.

Investors may use the findings to forecast the expected returns from a given investment avenue explored in the study. The result of the study will be helpful for retail investors and financial institutions to understand the causal relationship between various macroeconomic variables, market indicators and sectoral performance indicators. This paper has contributed to the body of literature in terms of understanding the combined effect of variables on the stock market and is beneficial to analyze the inter-relation between forex, commodity, gold and capital markets. This study also provides insights on the influence of macro-economic variables such as forex rates, gold, oil, and foreign institutional investments on the Nifty 50 market indicator and other relative sectoral indices.

The current study analyzed the relationship between forex, oil prices, gold rates, G-sec bonds, FII purchases and FII sales on the market and sectoral indices. However, the Consumer Price Index (CPI), Wholesale price index (WPI), GDP and other macro-economic variables can be explored along with the existing independent variables. Future research can be expanded by considering the companies listed in the Nifty 50 or Sensex indices. In addition, cross-country comparative studies can be undertaken to enhance the generalizability of the results.

**AUTHOR CONTRIBUTIONS**

Conceptualization: Rajeev Matha, Geetha E., Satish Kumar, Raghavendra.
Data curation: Rajeev Matha, Raghavendra.
Formal analysis: Rajeev Matha, Geetha E., Satish Kumar, Raghavendra.
Funding acquisition: Rajeev Matha, Geetha E., Satish Kumar, Raghavendra.
Investigation: Rajeev Matha, Geetha E., Satish Kumar, Raghavendra.
Methodology: Rajeev Matha, Satish Kumar, Raghavendra.
Project administration: Geetha E., Satish Kumar, Raghavendra.
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## APPENDIX A

### Table A1. Granger causality test results of NIFTY-50, NIFTY – Consumer Durables, IT, Media indices

| NIFTY-50 | NIFTY – Consumer Durables | NIFTY – IT | NIFTY – Media |
|----------|--------------------------|------------|---------------|
| **Null Hypothesis** | **F-Statistics** | **p-value** | **Null Hypothesis** | **F-Statistics** | **p-value** | **Null Hypothesis** | **F-Statistics** | **p-value** |
| USD(X); N\_50(Y) | 1.242 | 0.287 | USD(X); N\_CD(Y) | 20.109 | 0.000* | USD(X); N\_IT(Y) | 1.39 | 0.249 | USD(X); N\_Media(Y) | 10.645 | 0.000* |
| N\_50(X); USD(Y) | 10.644 | 0.000* | N\_CD(X); USD(Y) | 8.24 | 0.000* | N\_IT(X); USD(Y) | 7.171 | 0.001* | N\_Media(X); USD(Y) | 13.206 | 0.000* |
| EURO(X); N\_50(Y) | 1.122 | 0.346 | EURO(X); N\_CD(Y) | 10.591 | 0.000* | EURO(X); N\_IT(Y) | 0.633 | 0.531 | EURO(X); N\_Media(Y) | 3.904 | 0.020* |
| N\_50(X); EURO(Y) | 8.349 | 0.000* | N\_CD(X); EURO(Y) | 10.1 | 0.000* | N\_IT(X); EURO(Y) | 4.813 | 0.008* | N\_Media(X); EURO(Y) | 13.462 | 0.000* |
| Yen(X); N\_50(Y) | 0.568 | 0.725 | GBP(X); N\_CD(Y) | 3.296 | 0.037* | GBP(X); N\_IT(Y) | 1.21 | 0.298 | GBP(X); N\_Media(Y) | 0.859 | 0.424 |
| N\_50(X); Yen(Y) | 9.215 | 0.000* | N\_CD(X); GBP(Y) | 5.189 | 0.006 | N\_IT(X); GBP(Y) | 2.228 | 0.108 | N\_Media(X); GBP(Y) | 2.51 | 0.082 |
| GBP(X); N\_50(Y) | 1.862 | 0.098 | Yen(X); N\_CD(Y) | 12.634 | 0.000* | Yen(X); N\_IT(Y) | 4.099 | 0.018* | Yen(X); N\_Media(Y) | 12.626 | 0.000* |
| N\_50(X); GBP(Y) | 0.899 | 0.481 | N\_CD(X); Yen(Y) | 12.55 | 0.000* | N\_IT(X); Yen(Y) | 13.033 | 0.000* | N\_Media(X); Yen(Y) | 16.655 | 0.000* |
| GOLD(X); N\_50(Y) | 1.369 | 0.233 | GOLD(X); N\_CD(Y) | 0.696 | 0.499 | GOLD(X); N\_IT(Y) | 0.541 | 0.582 | GOLD(X); N\_Media(Y) | 2.465 | 0.085 |
| N\_50(X); GOLD(Y) | 1.584 | 0.161 | N\_CD(X); GOLD(Y) | 0.858 | 0.424 | N\_IT(X); GOLD(Y) | 2.933 | 0.054 | N\_Media(X); GOLD(Y) | 0.104 | 0.901 |
| OIL(X); N\_50(Y) | 3.944 | 0.002* | OIL(X); N\_CD(Y) | 5.573 | 0.004* | OIL(X); N\_IT(Y) | 20.07 | 0.000* | OIL(X); N\_Media(Y) | 1.673 | 0.188 |
| N\_50(X); OIL(Y) | 9.368 | 0.000* | N\_CD(X); OIL(Y) | 0.024 | 0.976 | N\_IT(X); OIL(Y) | 1.708 | 0.181 | N\_Media(X); OIL(Y) | 1.03 | 0.357 |
| G\_Bonds(X); N\_50(Y) | 4.259 | 0.001* | G\_Bonds(X); N\_CD(Y) | 0.53 | 0.589 | G\_Bonds(X); N\_IT(Y) | 3.974 | 0.019* | G\_Bonds(X); N\_Media(Y) | 0.405 | 0.667 |
| N\_50(X); G\_Bonds(Y) | 1.53 | 0.177 | N\_CD(X); G\_Bonds(Y) | 2.987 | 0.051 | N\_IT(X); G\_Bonds(Y) | 3.075 | 0.046* | N\_Media(X); G\_Bonds(Y) | 1.178 | 0.308 |
| FII\_PU(X); N\_50(Y) | 1.232 | 0.291 | FII\_PU(X); N\_CD(Y) | 0.579 | 0.56 | FII\_PU(X); N\_IT(Y) | 0.263 | 0.769 | FII\_PU(X); N\_Media(Y) | 1.441 | 0.237 |
| N\_50(X); FII\_PU(Y) | 11.902 | 0.000* | N\_CD(X); FII\_PU(Y) | 3.426 | 0.033* | N\_IT(X); FII\_PU(Y) | 3.803 | 0.023* | N\_Media(X); FII\_PU(Y) | 2.152 | 0.117 |
| FII\_Sales(X); N\_50(Y) | 1.391 | 0.225 | FII\_Sales(X); N\_CD(Y) | 0.984 | 0.374 | FII\_Sales(X); N\_IT(Y) | 0.442 | 0.643 | FII\_Sales(X); N\_Media(Y) | 0.599 | 0.549 |
| N\_50(X); FII\_Sales(Y) | 2.318 | 0.041* | N\_CD(X); FII\_Sales(Y) | 7.35 | 0.001* | N\_IT(X); FII\_Sales(Y) | 3.53 | 0.030* | N\_Media(X); FII\_Sales(Y) | 6.259 | 0.002* |
Table A2. Granger causality test results of NIFTY – Auto, Bank, Metal, Oil and Gas indices

| NIFTY – Auto | NIFTY – Bank | NIFTY – Metal | NIFTY – Oil and Gas |
|--------------|--------------|---------------|---------------------|
| Null Hypothesis | F-Statistic | p-value | Null Hypothesis | F-Statistic | p-value | Null Hypothesis | F-Statistic | p-value |
| USD(X); N_Auto(Y) | 16.674 | 0.000* | USD(X); N_Bank(Y) | 17.582 | 0.000* | USD(X); N_Metal(Y) | 17.939 | 0.000* | USD(X); N_O&G(Y) | 20.419 | 0.000* |
| N_Auto(X); USD(Y) | 16.741 | 0.000* | N_Bank(X); USD(Y) | 23.236 | 0.000* | N_Metal(X); USD(Y) | 12.025 | 0.000* | N_O&G(X); USD(Y) | 21.924 | 0.000* |
| EURO(X); N_Auto(Y) | 5.954 | 0.003* | EURO(X); N_Bank(Y) | 7.443 | 0.001* | EURO(X); N_Metal(Y) | 6.025 | 0.003* | EURO(X); N_O&G(Y) | 12.304 | 0.000* |
| N_Auto(X); EURO(Y) | 10.139 | 0.000* | N_Bank(X); EURO(Y) | 14.064 | 0.000* | N_Metal(X); EURO(Y) | 12.693 | 0.000* | N_O&G(X); EURO(Y) | 11.883 | 0.000* |
| GBP(X); N_Auto(Y) | 0.749 | 0.473 | GBP(X); N_Bank(Y) | 2.075 | 0.126 | GBP(X); N_Metal(Y) | 0.64 | 0.527 | GBP(X); N_O&G(Y) | 2.257 | 0.105 |
| N_Auto(X); GBP(Y) | 5.293 | 0.005 | N_Bank(X); GBP(Y) | 7.739 | 0.000* | N_Metal(X); GBP(Y) | 5.682 | 0.004* | N_O&G(X); GBP(Y) | 10.854 | 0.000* |
| Yen(X); N_Auto(Y) | 17.015 | 0.000* | Yen(X); N_Bank(Y) | 14.068 | 0.000* | Yen(X); N_Metal(Y) | 13.914 | 0.000* | Yen(X); N_O&G(Y) | 16.963 | 0.000* |
| N_Auto(X); Yen(Y) | 19.796 | 0.000* | N_Bank(X); Yen(Y) | 26.42 | 0.000* | N_Metal(X); Yen(Y) | 21.402 | 0.000* | N_O&G(X); Yen(Y) | 24.286 | 0.000* |
| GOLD(X); N_Auto(Y) | 5.028 | 0.007* | GOLD(X); N_Bank(Y) | 3.253 | 0.039* | GOLD(X); N_Metal(Y) | 0.606 | 0.546 | GOLD(X); N_O&G(Y) | 3.401 | 0.034* |
| N_Auto(X); GOLD(Y) | 1.984 | 0.138 | N_Bank(X); GOLD(Y) | 0.097 | 0.908 | N_Metal(X); GOLD(Y) | 0.31 | 0.733 | N_O&G(X); GOLD(Y) | 2.588 | 0.075 |
| OIL(X); N_Auto(Y) | 12.693 | 0.000* | OIL(X); N_Bank(Y) | 6.525 | 0.002* | OIL(X); N_Metal(Y) | 12.682 | 0.000* | OIL(X); N_O&G(Y) | 4.077 | 0.017* |
| N_Auto(X); OIL(Y) | 1.574 | 0.208 | N_Bank(X); OIL(Y) | 4.632 | 0.010* | N_Metal(X); OIL(Y) | 4.201 | 0.015* | N_O&G(X); OIL(Y) | 3.445 | 0.032* |
| G_Bonds (X); N_Auto(Y) | 0.457 | 0.633 | G_Bonds(X); N_Bank(Y) | 1.652 | 0.192 | G_Bonds(X); N_Metal(Y) | 0.893 | 0.41 | G_Bonds(X); N_O&G(Y) | 2.171 | 0.114 |
| N_Auto(X); G_Bonds(Y) | 6.68 | 0.001* | N_Bank(X); G_Bonds(Y) | 7.04 | 0.001* | N_Metal(X); G_Bonds(Y) | 1.323 | 0.267 | N_O&G(X); G_Bonds(Y) | 4.777 | 0.009* |
| FIL_PU(X); N_Auto(Y) | 1.47 | 0.23 | FIL_PU(X); N_Bank(Y) | 0.949 | 0.387 | FIL_PU(X); N_Metal(Y) | 0.721 | 0.487 | FIL_PU(X); N_O&G(Y) | 0.074 | 0.929 |
| N_Auto(X); FIL_PU(Y) | 11.485 | 0.000* | N_Bank(X); FIL_PU(Y) | 22.943 | 0.000* | N_Metal(X); FIL_PU(Y) | 6.097 | 0.002* | N_O&G(X); FIL_PU(Y) | 8.739 | 0.000* |
| FIL_Sales(X); N_Auto(Y) | 0.466 | 0.627 | FIL_Sales(X); N_Bank(Y) | 0.245 | 0.782 | FIL_Sales(X); N_Metal(Y) | 0.34 | 0.712 | FIL_Sales(X); N_O&G(Y) | 0.108 | 0.898 |
| N_Auto(X); FIL_Sales(Y) | 4.388 | 0.013* | N_Bank(X); FIL_Sales(Y) | 1.289 | 0.276 | N_Metal(X); FIL_Sales(Y) | 4.326 | 0.013* | N_O&G(X); FIL_Sales(Y) | 4.29 | 0.014* |
### Table A3. Granger causality test results of NIFTY – Financial services, FMCG, Pharma, PSU indices

| NIFTY – Financial Services | NIFTY – FMCG | NIFTY – Pharma | NIFTY – PSU |
|----------------------------|--------------|----------------|-------------|
| Null Hypothesis | F-Statistics | p-value | Null Hypothesis | F-Statistics | p-value | Null Hypothesis | F-Statistics | p-value | Null Hypothesis | F-Statistics | p-value |
| USD (X); N_FS(Y) | 23.892 | 0.000* | USD(X); N_FMCG(Y) | 10.497 | 0.000* | USD(X); N_Pharma(Y) | 7.141 | 0.001* | USD(X); N_PSU(Y) | 12.205 | 0.000* |
| N_FS(X); USD(Y) | 23.864 | 0.000* | N_FMCG(X); USD(Y) | 8.023 | 0.000* | N_Pharma(X); USD(Y) | 6.867 | 0.001* | N_PSU(X); USD(Y) | 11.043 | 0.000* |
| EURO (X); N_FS(Y) | 10.289 | 0.000* | EURO(X); N_FMCG(Y) | 6.626 | 0.001* | EURO(X); N_Pharma(Y) | 4.995 | 0.007* | EURO(X); N_PSU(Y) | 9.163 | 0.000* |
| N_FS(X); EURO(Y) | 13.899 | 0.000* | N_FMCG(Y); EURO(Y) | 7.413 | 0.001* | N_Pharma(X); EURO(Y) | 7.038 | 0.001* | N_PSU(X); EURO(Y) | 14.901 | 0.000* |
| GBP (X); N_FS(Y) | 2.606 | 0.074 | GBP(X); N_FMCG(Y) | 1.926 | 0.146 | GBP(X); N_Pharma(Y) | 3.633 | 0.027* | GBP(X); N_PSU(Y) | 3.707 | 0.025* |
| N_FS(X); GBP(Y) | 7.816 | 0.000* | N_FMCG(X); GBP(Y) | 4.449 | 0.012* | N_Pharma(X); GBP(Y) | 3.258 | 0.039* | N_PSU(X); GBP(Y) | 5.957 | 0.003* |
| Yen (X); N_FS(Y) | 18.241 | 0.000* | Yen(X); N_FMCG(Y) | 7.917 | 0.000* | Yen(X); N_Pharma(Y) | 9.608 | 0.000* | Yen(X); N_PSU(Y) | 12.823 | 0.000* |
| N_FS(X); Yen(Y) | 25.952 | 0.000* | N_FMCG(X); Yen(Y) | 9.627 | 0.000* | N_Pharma(X); Yen(Y) | 8.112 | 0.000* | N_PSU(X); Yen(Y) | 15.975 | 0.000* |
| GOLD (X); N_FS(Y) | 4.008 | 0.018* | GOLD(X); N_FMCG(Y) | 1.298 | 0.273 | GOLD(X); N_Pharma(Y) | 0.896 | 0.408 | GOLD(X); N_PSU(Y) | 3.224 | 0.040* |
| N_FS(X); GOLD(Y) | 0.017 | 0.983 | N_FMCG(X); GOLD(Y) | 2.373 | 0.093 | N_Pharma(X); GOLD(Y) | 5.468 | 0.004* | N_PSU(X); GOLD(Y) | 1.258 | 0.285 |
| OIL (X); N_FS(Y) | 6.177 | 0.002* | OIL(X); N_FMCG(Y) | 1.008 | 0.365 | OIL(X); N_Pharma(Y) | 3.415 | 0.033* | OIL(X); N_PSU(Y) | 0.37 | 0.691 |
| N_FS(X); OIL(Y) | 4.351 | 0.013* | N_FMCG(X); OIL(Y) | 2.004 | 0.135 | N_Pharma(X); OIL(Y) | 1.227 | 0.293 | N_PSU(X); OIL(Y) | 1.239 | 0.29 |
| G_Bonds (X); N_FS(Y) | 1.601 | 0.202 | G_Bonds (X); N_FMCG(Y) | 2.448 | 0.087 | G_Bonds (X); N_Pharma(Y) | 1.167 | 0.311 | G_Bonds (X); N_PSU(Y) | 1.861 | 0.156 |
| N_FS(X); G_Bonds(Y) | 6.652 | 0.001* | N_FMCG(X); G_Bonds(Y) | 4.47 | 0.012* | N_Pharma(X); G_Bonds(Y) | 2.288 | 0.102 | N_PSU(X); G_Bonds(Y) | 0.758 | 0.469 |
| FII_PU (X); N_FS(Y) | 1.24 | 0.29 | FII_PU(X); N_FMCG(Y) | 1.53 | 0.217 | FII_PU(X); N_Pharma(Y) | 0.518 | 0.596 | FII_PU(X); N_PSU(Y) | 0.243 | 0.784 |
| N_FS(X); FII_PU(Y) | 23.579 | 0.000* | N_FMCG(X); FII_PU(Y) | 7.847 | 0.000* | N_Pharma(X); FII_PU(Y) | 0.757 | 0.469 | N_PSU(X); FII_PU(Y) | 8.486 | 0.000* |
| FII_Sales (X); N_FS(Y) | 0.46 | 0.631 | FII_Sales(X); N_FMCG(Y) | 3.073 | 0.047* | FII_Sales(X); N_Pharma(Y) | 0.726 | 0.484 | FII_Sales(X); N_PSU(Y) | 0.048 | 0.953 |
| N_FS(X); FII_Sales(Y) | 1.728 | 0.178 | N_FMCG(X); FII_Sales(Y) | 0.8 | 0.45 | N_Pharma(X); FII_Sales(Y) | 4.418 | 0.012* | N_PSU(X); FII_Sales(Y) | 1.11 | 0.33 |
Table A4. Granger causality test results of NIFTY – Private banks and Reality indices

| NIFTY – Private Bank | NIFTY – Reality |
|----------------------|-----------------|
| **Null Hypothesis**  | **F-Statistics** | **p-value**  | **Null Hypothesis** | **F-Statistics** | **p-value** |
| USD(X); N_PB(Y)      | 16.524          | 0.000*       | USD(X); N_Reality(Y) | 15.921          | 0.000*       |
| N_PB(X); USD(Y)      | 22.7            | 0.000*       | N_Reality(X); USD(Y) | 21.068          | 0.000*       |
| EURO(X); N_PB(Y)     | 6.319           | 0.002*       | EURO(X); N_Reality(Y) | 5.997           | 0.003*       |
| N_PB(X); EURO(Y)     | 12.518          | 0.000*       | N_Reality(X); EURO(Y) | 19.661          | 0.000*       |
| GBP(X); N_PB(Y)      | 1.645           | 0.193        | GBP(X); N_Reality(Y) | 2.773           | 0.063        |
| N_PB(X); GBP(Y)      | 7.44            | 0.001*       | N_Reality(X); GBP(Y) | 10.772          | 0.000*       |
| Yen(X); N_PB(Y)      | 12.793          | 0.000*       | Yen(X); N_Reality(Y) | 4.335           | 0.013*       |
| N_PB(X); Yen(Y)      | 23.691          | 0.000*       | N_Reality(X); Yen(Y) | 37.573          | 0.000*       |
| GOLD(X); N_PB(Y)     | 2.952           | 0.052        | GOLD(X); N_Reality(Y) | 0.84            | 0.432        |
| N_PB(X); GOLD(Y)     | 0.211           | 0.81         | N_Reality(X); GOLD(Y) | 3.152           | 0.043*       |
| OIL(X); N_PB(Y)      | 7.559           | 0.001*       | OIL(X); N_Reality(Y) | 2.894           | 0.056        |
| N_PB(X); OIL(Y)      | 5.746           | 0.003*       | N_Reality(X); OIL(Y) | 0.899           | 0.407        |
| G_Bonds (X); N_PB(Y) | 1.268           | 0.282        | G_Bonds (X); N_Reality(Y) | 0.355           | 0.702        |
| N_PB(X); G_Bonds(Y)  | 8.079           | 0.000*       | N_Reality(X); G_Bonds(Y) | 3.612           | 0.027*       |
| FII_PU(X); N_PB(Y)   | 0.854           | 0.426        | FII_PU(X); N_Reality(Y) | 0.289           | 0.749        |
| N_PB(X); FII_PU(Y)   | 22.573          | 0.000*       | N_Reality(X); FII_PU(Y) | 5.581           | 0.004*       |
| FII_Sales(X); N_PB(Y)| 0.172           | 0.842        | FII_Sales(X); N_Reality(Y) | 0.487           | 0.615        |
| N_PB(X); FII_Sales(Y)| 1.614           | 0.199        | N_Reality(X); FII_Sales(Y) | 4.462           | 0.012*       |

Note: Null hypothesis X ≠ Y (X does not Granger cause Y); * denotes statistically significant at 5% (0.05). NIFTY_50 – Nifty 50 index, N_CD – Nifty consumer durable index, N_AUTO – Nifty auto index, N_BANK – Nifty bank index, N_FS – Nifty financial services index, N_FMCG – Nifty FMCG index, N_IT – Nifty I.T. index, N.MEDIA – Nifty Media index, N_METAL – Nifty metal index, N_O&G – Nifty oil & gas index, N_PH – Nifty Pharma index, N_PSU – Nifty PSU index, N_PVT Bank – Nifty Private Banks index, Reality – Nifty Realty index, G_Bonds – Nifty composite G-sector bond index, FII_PU FII inflow and FII_SA FII outflow.