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Alareeni Bahaaeddin
Allam Hamdan *Editors*

Technovate: The Art of Business Transformation through Technology

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Analysing the Interplay Between Forex Rates and Financial Assets in India: Insights from ARIMA and VAR Models

Jahnavi M, Purushottam Bung, and N. Nagasubba Reddy

1 Introduction

Understanding the association between foreign exchange rates (FOREX) and financial assets is important, especially in emerging markets like India. The Indian economy is rapidly growing and is significantly influenced by global economic trends and fluctuations in forex markets. Asset prices influence the value of the Indian rupee against the top major currencies in various financial sectors and investor sentiment. The financial assets considered in the study include a selection of investment categories from the wide range of financial assets available in India. They are the stock market index, which reflects investor confidence and economic progress, gold which is considered as a safe investment asset during economic downtrends, and REITs, which offer new investment opportunities with high liquidity and high dividend benefits, the investor who is no appetite prefers investments into government bonds and in Treasury bills. It is crucial to analyse these assets because they all are highly sensitive to foreign exchange rates and economic conditions.

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This study adopts a quantitative approach, analyzing historical data using statistical methods and econometric instruments. The research aims to identify patterns of dependency and transmission mechanisms between Forex rates and financial assets by examining correlations, volatility consequences, and possible cointegrating linkages. Such insights are crucial for investors looking to optimize asset allocation strategies, politicians developing effective monetary and fiscal policies, and academics contributing to the academic debate on financial markets in emerging economies like India.

2 Literature Review

Dr. Gulab, Phalahari. [1], this literature examines the impact of exchange rates on various economic variables and offers recommendations for exchange rate policy. Findings indicate that exchange rates influence productivity and the tourism sector. The study also explores the effects of exchange rates on productivity, consumption, and exports, suggesting that fluctuations can significantly impact these economic factors. Recommendations for exchange rate policy are provided based on these effects.

Shivani, Koradia, Abhir, Mehra, Devansh, and Agrawal. [2] assessed the impact of foreign exchange fluctuations on the Indian stock market and related investment opportunities, providing recommendations for investors based on currency movements in Nifty50 sectors. Findings reveal a negative correlation between the Nifty50 and the USD, significantly impacting the stock market. The power, oil, and gas sectors negatively correlate with the USD. The study concludes that the Nifty50 and USD exhibit a negative correlation, with the USD being the most influential, and highlights the notable negative correlation of the power, oil, and gas sectors with the USD.

Rajeev, Matha, Geetha E., Satish Kumar, and Raghavendra. [3] analyzed the dynamic association between equity, bond, commodity, foreign institutional investments, and Forex rates. This literature explores the long-run and causal linkages between forex rates, bonds, commodities, FII flows, and the equity market in India. From the analysis, it is evident that FII, oil prices, and foreign exchange rates have a significant impact on Indian stock markets, where gold prices do not have a major impact. It is observed that gold prices are useful in forecasting sectoral index directions. Granger causality tests indicate a uni-directional relationship between forex rates and the stock market. These findings underscore the significant influence of economic factors on the Indian stock market and the predictive power of gold prices for sectorial indices.

Mariia, Bondarenko, and Karel, Brůna. [4]. The study is based on measuring the Impact of exchange rate exposure on the company stock returns. This literature examines how FX exposure affects the stock returns of European companies from 2012 to 2018, finding that medium-size and service-sector firms are more significantly impacted by FX risk. The results show a statistically significant link between

exchange rates and stock returns, with medium-size and service-sector firms being more vulnerable to FX fluctuations. The conclusion emphasizes the higher exposure of these firms to FX risk and the substantial effect on their stock returns.

A. Kotishwar. [1]. This literature investigates the impact of currency fluctuations on equity and debt markets from 2008 to 2019, finding that the rupee versus the dollar significantly affects equity investments, while the euro has an insignificant impact on debt investments. The results highlight the substantial influence of the rupee-dollar exchange rate on equity fund flows into India, whereas the euro's effect on debt investments is minimal. The conclusion underscores the significant role of the rupee-dollar exchange rate in equity investments and the moderate influence of the euro on debt investments.

Yuxin, Zhao. [5]. This literature analyses the influence and effects of exchange rates, offering suggestions for exchange rate policies. Findings indicate that exchange rates positively affect productivity and the tourism market, while a fixed exchange rate benefits import-export economies by reducing risks. The results highlight the extensive influence of exchange rates on various factors and provide recommendations for policy adjustments. The conclusion underscores the significant impact of exchange rates and suggests four core exchange rate policies.

Lukas, Menkhoff, Malte, Rieth, and Tobias, Stoehr. [6]. This literature examines the prolonged impact of FX interventions on exchange rates, highlighting that these effects can last for months. The signaling channel dominates over the portfolio channel in FX interventions. Key findings show that FX interventions significantly impact exchange rates for an extended period, leading to falling interest rates and rising stock prices, particularly for large firms. These results underscore FX interventions' substantial influence on exchange rates and broader financial markets.

Arya, Kumar, Saroj, Kanta, Biswal, Prafulla, and Kumar, Swain. [7]. This literature indicates that variations influence the Sensex in gold, oil, and Forex, while these factors do not influence each other. Granger causality tests confirm that gold, oil, and Forex significantly impact the Sensex, but these factors have no mutual influence. These findings highlight that the volatility of the Indian financial market is driven by specific economic factors, with practical implications for investment professionals and policymakers in understanding market dynamics.

M. Aravind. [8]. This literature investigates the impact of FX volatility on Indian stock market returns, examining the relationship between currency market and stock market volatility. The findings indicate that FX volatility significantly affects the NSE stock market, influencing investors' decisions to shift investments based on market performance. No ARCH effect was found in the volatility of USD, EUR, and JPY, and a GARCH (1, 1) model was employed for detailed scenario modeling. The study concludes that FX rate volatility impacts the Indian stock market, though no Autoregressive Conditional Heteroskedasticity effect was detected in FX volatility to NSE returns.

Golaka, C., Nath, G., and P. Samanta. [9], this study examines the integration between Forex and stock markets in India using Granger's causality test and Geweke's feedback measures. The findings reveal that while the VAR framework shows a weak causal link between these markets, Geweke's feedback measures

detect a strong causal relationship. This suggests that traditional VAR models may not capture the full magnitude of the interactions between forex and stock markets, emphasizing the significance of using more comprehensive measures like Geweke's to understand market dynamics.

Research Gap

Despite extensive research on forex rates and financial assets, there is limited comprehensive analysis of multiple asset classes, including stock market indices, REITs, 10-year bond yields, T-bill rates, and gold prices in India. Most studies focus on individual assets or macroeconomic effects without exploring their interconnectedness and sensitivity to forex fluctuations. Additionally, applying ARIMA models to forecast future trends of these assets is under-explored. This study's objective is to bridge the above-said gaps by computing a comparative analysis and forecasting future trends using ARIMA in the Indian financial market. This study contributes to the academic literature on the relationships between forex rates and financial assets in emerging market contexts.

Objectives of the Study

- To measure the impact of forex rates on the volatility and the performance of financial assets in India.
- To forecast future trends of Forex, stock market indices, REITs, bond yields, T-bill rates, and gold prices using ARIMA models.
- To provide strategic insights for optimizing portfolio diversification and enhancing risk management strategies in response to forex fluctuations.

3 Research Methodology

The methodology used for the study is an analytical approach wherein the ARIMA model is employed first to forecast the future trends of the study variables, which are forex rates, stock market index, REIT rates, 10-year bond yields, T-bill interest rates, and gold prices based on the historical data for 10 years, for the analysis monthly historical data is considered and is collected from RBI website and BSE website. Further analysis is carried out using correlation, regression, VAR, IRF, causality tests, and cointegration tests to examine the relationships, interconnectedness, and long-term and short-term impacts of forex rates and financial assets; such insights are crucial for decision-making. The analysis is carried out using R studio.

4 Data Analysis & Methods

The future positions of financial instruments for the next year are forecasted using the ARIMA model in R programming. This model was chosen for its handling of time series data and its ability to capture trends, seasonality, and other patterns in the historical data. The ARIMA model was applied to monthly average data to predict future values and provide a comprehensive outlook, as shown in Table 1.

Table 1 shows the forecasted values for the Indian Rupee (INR) against the US Dollar (USD) for 2024; the forecast indicates an upward trend. At a 95% confidence level, the USD's value is expected to fluctuate between ₹79.31 and ₹91.75 throughout 2024. The forecast indicates a stable trend in the 10-year bond yield, with a point estimate remaining constant at 7.21% throughout 2024. At a 95% confidence level, the yield is expected to range between approximately 5.96% and 8.46%. The forecast indicates a gradual upward trend in gold prices per troy ounce, with point forecasts showing a steady increase throughout 2024. At a 95% confidence level, the cost of gold is expected to range between approximately ₹150,864.1 and ₹206,089.0 by December 2024. The forecast indicates a steady upward trend in the yields of 91-day T-bills, with point forecasts showing a gradual increase throughout 2024. At a 95% confidence level, the yields are expected to range between approximately 4.615872% and 10.405417% by December 2024. The forecast indicates a stable trend in REIT values throughout 2024, with the point forecast remaining constant at 2310.625. However, the wide confidence intervals indicate uncertainty and potential volatility in REIT values.

Table 1 Forecasted values of forex rates and the financial assets using ARIMA

Forecasted period	Forex rate	10-year bond yield rate	Gold price per 10 g	T-bill rate	REIT bonds
Jan-24	83.59	7.21	169,925.30	6.98	2310.63
Feb-24	83.77	7.21	170,702.70	7.04	2310.63
Mar-24	83.95	7.21	171,480.10	7.09	2310.63
Apr-24	84.13	7.21	172,257.40	7.13	2310.63
May-24	84.30	7.21	173,034.80	7.18	2310.63
Jun-24	84.48	7.21	173,812.20	7.23	2310.63
Jul-24	84.65	7.21	174,589.60	7.27	2310.63
Aug-24	84.83	7.21	175,367.00	7.32	2310.63
Sep-24	85.00	7.21	176,144.40	7.37	2310.63
Oct-24	85.18	7.21	176,921.80	7.42	2310.63
Nov-24	85.36	7.21	177,699.20	7.46	2310.63
Dec-24	85.53	7.21	178,476.60	7.51	2310.63

Source: Data Analysis

Analysing the Relationship Between Forex and Financial Assets Using Correlation and Linear Regression Analysis

Forex and Gold Price

The result shows a correlation coefficient of 0.9282, indicating a very strong positive association between the two variables. The p-value is less than 2.2e-16, less than the alpha level 0.05, suggesting that the observed correlation is statistically significant.

The linear regression model between Gold Price and Forex shows a strong relationship. The coefficient for Forex (4282) suggests that for every unit increase in Forex, we expect the Gold Price to increase by 4282 units. Both coefficients are statistically significant ($p < 0.001$), indicating a meaningful relationship. The linear equation is:

$$\textbf{Gold price} = -196,673 + (4282)\,\textbf{Forex}$$

The model's goodness of fit is high, with an R-squared of 0.8615. The adjusted R-squared (0.8603) confirms the model's reliability after accounting for the number of predictors. The F-statistic (734.1) is highly significant ($p < 0.001$), suggesting that the model is significant in explaining Gold Price variability based on Forex.

Forex and 91-day T-Bill Rates

The result shows a correlation coefficient of -0.4929, indicating a moderate negative linear relationship between Forex rates and 91-day average T-bill rates. The p-value is 1.07e-08, significantly lower than the alpha level 0.05, suggesting that the observed correlation is statistically significant.

The linear regression model between the 91-day T-bill rate and Forex shows a statistically significant relationship. The coefficient for Forex (-0.12282) suggests that for every unit increase in Forex, we expect the 91-day T-bill rate to decrease by 0.12282%. Both coefficients are highly significant ($p < 0.001$), indicating a significant relationship between Forex and the 91-day T-bill rate. The linear equation is:

$$\textbf{Average 91 - day T - bill rate} = 14.7689 + (-0.12282)\,\textbf{Forex}$$

The model's goodness of fit is moderate, with an R-squared of 0.243, and the adjusted R-squared (0.2366) confirms the model's reliability after adjusting for the number of predictors. The F-statistic (37.87) is significant ($p < 0.001$), indicating that the model is significant in explaining 91-day T-bill rate variability based on Forex.

Forex and 10-Year Bond Yield

The result shows a correlation coefficient of −0.4423, indicating a moderate negative linear relationship between Forex rates and 10-year bond yields. The p-value is 4.255e-07, significantly lower than the alpha level of 0.05, suggesting that the observed correlation is statistically significant.

The linear regression model between the 10-year bond yield and Forex indicates a statistically significant relationship. The coefficient for Forex (−0.0512) indicates that for every unit increase in Forex, we expect the 10-year bond yield to decrease by 0.0512%. Both coefficients are highly significant ($p < 0.001$), indicating a negative relationship between Forex and the 10-year bond yield. The linear equation is:

$$\mathbf{10-year\ bond\ yield} = \mathbf{10.7893} + \left(\mathbf{-0.0512}\right)\mathbf{Forex}$$

The model's goodness of fit is modest, with an R-squared of 0.1956 and the adjusted R-squared (0.1888) adjusts for the number of predictors and confirms the model's reliability. The F-statistic (28.69) is significant ($p < 0.001$), indicating that the model is significant in explaining 10-year bond yield variability based on Forex.

Forex and REIT

The result shows a correlation coefficient of −0.5942, indicating a moderate negative linear relationship between Forex rates and REIT values. The p-value is 8.443e-13, significantly lower than the alpha level 0.05, suggesting that the observed correlation is statistically significant.

The regression model between the REIT rate and Forex shows a statistically significant relationship. The coefficient for Forex (−31.571) indicates that for every unit increase in Forex, we expect the REIT rate to decrease by 31.571 units. Both coefficients are highly significant ($p < 0.001$), indicating a strong negative relationship between Forex and the REIT rate. The linear equation is:

$$\mathbf{REIT} = \mathbf{5102.364} + \left(\mathbf{-31.571}\right)\mathbf{Forex}$$

The model's goodness of fit is moderate, with an R-squared of 0.353 and the adjusted R-squared (0.3476) confirms the model's reliability after adjusting for the number of predictors. The F-statistic (64.39) is significant ($p < 0.001$), indicating that the model is significant in explaining REIT rate variability based on Forex.

Forex and Stock Market

The result shows a correlation coefficient of 0.8761, indicating a powerful positive linear relationship between Forex rates and the stock market index. The p-value is less than 2.2e-16, significantly lower than the alpha level of 0.05, suggesting that the observed correlation is statistically significant.

The linear regression model between the Stock Market Index and Forex indicates a significant relationship. The coefficient for Forex (742.3) indicates that for every unit increase in Forex, we expect the Stock Market Index to increase by 742.3 units. Both coefficients are highly significant ($p < 0.001$), indicating a strong relationship between Forex and the Stock Market Index. The linear equation is:

$$\textbf{Stock market index} = -\mathbf{36,725.8} + \left(\mathbf{742.3}\right)\textbf{Forex}$$

The model's goodness of fit is substantial, with an R-squared of 0.7676 and the adjusted R-squared (0.7656) confirms the model's reliability after adjusting for the number of predictors. The F-statistic (389.8) is highly significant ($p < 0.001$), indicating that the model is significant in explaining Stock Market Index variability based on Forex.

The Granger Causality Test examines whether past values of one time series can predict future values of another time series. By constructing lagged values of the variables in a vector autoregressive (VAR) model, the test statistically evaluates whether including these past values significantly improves the prediction accuracy. This helps identify directional causal relationships, which is crucial for understanding the influence of different financial assets on each other in both short-term and long-term contexts. For analysis purposes, all the variables in the data have been rationalized.

Vector Autoregressive (VAR) models were constructed with different lag values with a maximum lag length of 12, as shown in the output of VAR. The best var. model is selected based on minimum Information criteria. In the current analysis, the best lag length in the VAR model is 'p = 1'.

```
> VARselect(newdatats,lag.max = 10,type='const')
$selection
AIC(n)  HQ(n)  SC(n) FPE(n)
     1      1      1      1

$criteria
                  1            2            3
4            5
AIC(n) 3.030344e+01 3.047334e+01 3.073384e+01 3.095908e+01
3.076558e+01
HQ(n)  3.072399e+01 3.125437e+01 3.187534e+01 3.246106e+01
3.262804e+01
SC(n)  3.134047e+01 3.239926e+01 3.354864e+01 3.466277e+01
3.535816e+01
FPE(n) 1.449028e+13 1.727337e+13 2.274615e+13 2.930929e+13
2.531305e+13
                  6            7            8
9       10
```

```
AIC(n) 3.104512e+01 3.094161e+01 3.114078e+01 3.115333e+01
3.116852e+01
HQ(n)  3.326805e+01 3.352502e+01 3.408466e+01 3.445769e+01
3.483336e+01
SC(n)  3.652658e+01 3.731195e+01 3.840001e+01 3.930145e+01
4.020553e+01
FPE(n) 3.595787e+13 3.594522e+13 5.064120e+13 6.233707e+13
8.222751e+13
```

The estimation equation for each of the financial assets is as follows:

```
Estimation results for equation gp:
===================================
gp = ex.l1 + gp.l1 + st.l1 + tb.l1 + bond.l1 + reit.l1 + const
          Estimate Std. Error t value Pr(>|t|)
ex.l1   -4.277e+02  4.133e+02  -1.035   0.3030
gp.l1    1.878e-01  9.244e-02   2.032   0.0445 *
st.l1   -9.966e-01  5.913e-01  -1.686   0.0947 .
tb.l1    1.445e+03  1.667e+03   0.867   0.3880
bond.l1 -2.605e+03  2.277e+03  -1.144   0.2552
reit.l1 -4.707e+00  2.704e+00  -1.741   0.0845 .
const    8.188e+02  3.387e+02   2.417   0.0173 *
Estimation results for equation st:
===================================
st = ex.l1 + gp.l1 + st.l1 + tb.l1 + bond.l1 + reit.l1 + const
          Estimate Std. Error t value Pr(>|t|)
ex.l1    120.41214   83.76682   1.437   0.1534
gp.l1     -0.00410    0.01874  -0.219   0.8272
st.l1      0.29583    0.11984   2.468   0.0151 *
tb.l1   -332.26892  337.89163  -0.983   0.3276
bond.l1 -166.56966  461.62029  -0.361   0.7189
reit.l1    0.37721    0.54800   0.688   0.4927
const    114.16494   68.65264   1.663   0.0991 .
Estimation results for equation tb:
===================================
tb = ex.l1 + gp.l1 + st.l1 + tb.l1 + bond.l1 + reit.l1 + const
          Estimate Std. Error t value Pr(>|t|)
ex.l1   -4.812e-03  2.073e-02  -0.232  0.81683
gp.l1   -2.776e-06  4.636e-06  -0.599  0.55051
st.l1    9.409e-05  2.965e-05   3.173  0.00195 **
tb.l1    4.116e-01  8.361e-02   4.923 2.99e-06 ***
bond.l1  2.396e-01  1.142e-01   2.097  0.03822 *
reit.l1  6.262e-05  1.356e-04   0.462  0.64510
const   -2.157e-02  1.699e-02  -1.270  0.20688
Estimation results for the equation bond:
=========================================
```

```
bond = ex.l1 + gp.l1 + st.l1 + tb.l1 + bond.l1 + reit.l1 + const
          Estimate Std. Error t value Pr(>|t|)
ex.l1    -1.712e-02  1.708e-02  -1.002    0.318
gp.l1     2.630e-06  3.819e-06   0.689    0.492
st.l1     3.651e-05  2.443e-05   1.494    0.138
tb.l1     2.874e-02  6.888e-02   0.417    0.677
bond.l1   3.974e-01  9.410e-02   4.223 4.96e-05 ***
reit.l1  -9.095e-05  1.117e-04  -0.814    0.417
const    -1.367e-02  1.399e-02  -0.977    0.331

Estimation results for equation reit:
=====================================
reit = ex.l1 + gp.l1 + st.l1 + tb.l1 + bond.l1 + reit.l1 + const
          Estimate Std. Error t value Pr(>|t|)
ex.l1     4.991e+00  1.621e+01   0.308  0.75877
gp.l1     1.595e-03  3.626e-03   0.440  0.66091
st.l1    -2.561e-02  2.319e-02  -1.104  0.27185
tb.l1    -1.893e+02  6.539e+01  -2.895  0.00457 **
bond.l1   1.153e+02  8.934e+01   1.291  0.19934
reit.l1   2.022e-01  1.061e-01   1.906  0.05918 .
const    -1.859e+00  1.329e+01  -0.140  0.88900
```

Source: Data Analysis

From the output of the VAR analysis, it is evident that the forex rates do not have a significant direct impact on the financial assets shown for the study in its short run. Most of the financial assets have exhibited a strong significant autocorrelation.

The Granger causality and Instantaneous causality tests were conducted to analyze whether the past value of one variable helps in predicting the future values of another variable (granger causality) and, at the same time, whether this variable has an immediate effect on other variables (instantaneous causality test).

From the Granger causality test, as shown in Table 2, it is evident that historical values of foreign exchange rates failed to predict the future values of the financial assets chosen for the study, but they have a significant immediate effect on them. When it comes to interconnectedness among the study variables, it is clear that none of the variables except the stock price, which is significant in both Granger causality and in the instantaneous causality test, which indicates that its past values help in predicting the future values of other financial variables and at the same time this variable stock market have an immediate effect on all of the variables under the study.

Table 2 Granger causality and instantaneous effects

		Granger causality tests			Instantaneous causality tests		
Cause	Effect	F-test	P value	Significance @ 5%	Chi-squared	P value	Significance @ 5%
ex	gp, st, tb, bond, reit	0.8204	0.5353	Not Significant	25.642	0.000105	Significant
gp	ex, st, tb, bond, reit	0.89523	0.4837	Not Significant	4.5985	0.4668	Not Significant
st	ex, gp, tb, bond, reit	3.6959	0.002628	Significant	34.182	2.19E-06	Significant
tb	ex, gp, st, bond, reit	2.0315	0.07235	Not Significant	14.771	0.01139	Significant
bond	ex, gp, st, tb, reit	1.8357	0.1038	Not Significant	12.003	0.03475	Significant
reit	ex, gp, st, tb, bond	1.6288	0.1501	Not Significant	29.208	2.11E-05	Significant

Source: Data Analysis

Based on the instantaneous causality test results as shown in Table 2, forex rates, T-bill rates, bond yields, and REIT rates have an immediate impact on the other financial assets chosen for the study, wherein gold prices represents concurrent relationship with these variable which moves simultaneously, but the gold prices does not exhibits the simultaneous effect on the other financial assets which suggests that they fail to influence these variables instantly. The stock market index exhibits both simultaneous and instantaneous effects, highlighting its interconnectedness on financial assets. This analysis underscores the importance of considering immediate reactions in financial markets, particularly regarding forex rates, T-bill rates, bond yields, and REITs.

Impulse Response Function

The impulse response function is used to understand how changes in forex rates (shocks in forex rates) can influence different financial assets under the study. From the above plots as shown in Fig. 1, it is evident that the forex rate shock significantly impacts gold prices(gp) and the stock market(st), with both showing a strong initial response that stabilizes over time. However, for REITs, the impact is minimal and significant. T-bill rates and bonds show no significant response to forex rate shocks for the other two financial assets, indicating no impact.

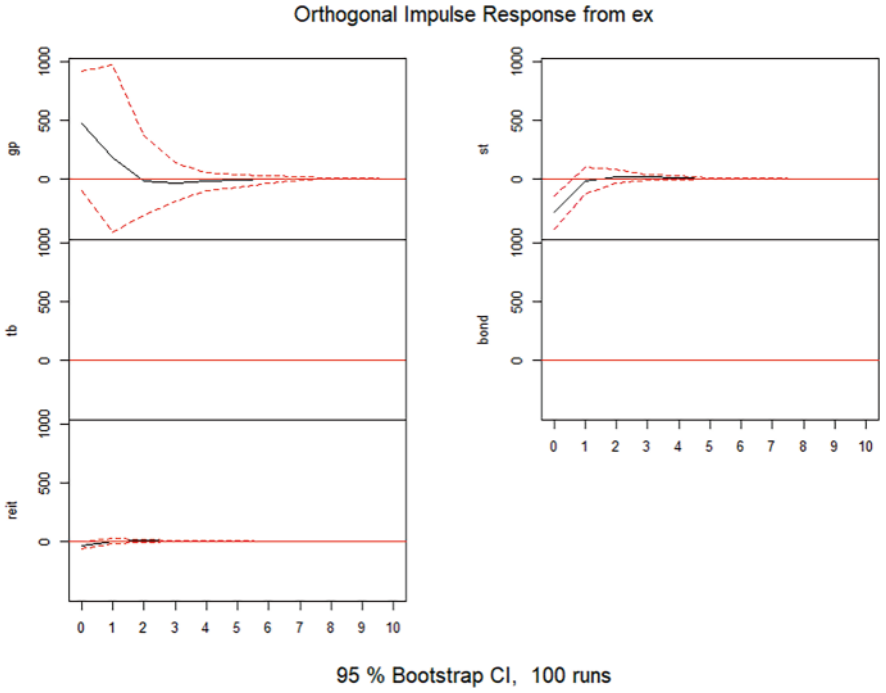

Fig. 1 Impulse response of forex rates on chosen financial assets

Cointegration Test

```
johansen_test <- ca. jo(newdata[, c("ex," "gp," "st," "tb,"
"bond," "reit")], type = "trace," K = 2, edit = "const")
> summary(johansen_test)
Test type: trace statistic, without linear trend and constant in
cointegration
Eigenvalues (lambda):
[1] 4.613544e-01 3.902904e-01 3.553508e-01 3.214335e-01
[5] 2.626543e-01 1.821603e-01 6.106227e-16
Values of test statistic and critical values of test:
           test 10pct   5pct   1pct
r <= 5 |  23.53  7.52   9.24  12.97
r <= 4 |  59.18 17.85  19.96  24.60
r <= 3 | 104.55 32.00  34.91  41.07
r <= 2 | 155.92 49.65  53.12  60.16
r <= 1 | 213.80 71.86  76.07  84.45
r = 0  | 286.19 97.18 102.14 111.01
vecm <- cajorls(johansen_test, r = 5)
> summary(vecm$rlm)
```

```
Call:
lm(formula = ex.d ~ ect1 + ect2 + ect3 + ect4 + ect5 + ex.dl1 +
    gp.dl1 + st.dl1 + tb.dl1 + bond.dl1 + reit.dl1 - 1, data =
data.mat)
Residuals:
     Min       1Q   Median       3Q      Max
-2.41637 -0.54822  0.01869  0.52571  2.05621
Coefficients:
           Estimate Std. Error t value Pr(>|t|)
ect1     -9.061e-01  1.330e-01  -6.810 6.07e-10 ***
ect2     -5.079e-05  2.995e-05  -1.696   0.0928 .
ect3      2.322e-05  1.755e-04   0.132   0.8950
ect4      3.167e-01  4.251e-01   0.745   0.4579
ect5     -4.314e-01  7.028e-01  -0.614   0.5406
ex.dl1   -8.596e-01  1.108e-01  -7.762 5.54e-12 ***
gp.dl1   -2.261e-05  2.342e-05  -0.965   0.3367
st.dl1   -2.150e-04  1.501e-04  -1.433   0.1548
tb.dl1    3.373e-01  4.893e-01   0.689   0.4922
bond.dl1 -5.410e-02  6.014e-01  -0.090   0.9285
reit.dl1 -1.017e-03  7.269e-04  -1.400   0.1645
Call:
lm(formula = gp.d ~ ect1 + ect2 + ect3 + ect4 + ect5 + ex.dl1 +
    gp.dl1 + st.dl1 + tb.dl1 + bond.dl1 + reit.dl1 - 1, data =
data.mat)
Residuals:
   Min     1Q Median     3Q    Max
 -7932  -1944   -164   1614  10845
Coefficients:
           Estimate Std. Error t value Pr(>|t|)
ect1     -4.197e+02  5.335e+02  -0.787   0.4333
ect2     -8.750e-01  1.201e-01  -7.287 5.92e-11 ***
ect3     -1.716e+00  7.039e-01  -2.438   0.0164 *
ect4     -3.888e+03  1.704e+03  -2.281   0.0245 *
ect5     -2.610e+03  2.818e+03  -0.926   0.3565
ex.dl1   -7.348e+02  4.441e+02  -1.655   0.1010
gp.dl1   -7.057e-01  9.393e-02  -7.513 1.92e-11 ***
st.dl1   -1.548e+00  6.018e-01  -2.572   0.0115 *
tb.dl1    2.499e+03  1.962e+03   1.273   0.2056
bond.dl1 -2.102e+03  2.412e+03  -0.872   0.3854
reit.dl1 -5.895e+00  2.915e+00  -2.022   0.0457 *
Call:
lm(formula = st.d ~ ect1 + ect2 + ect3 + ect4 + ect5 + ex.dl1 +
    gp.dl1 + st.dl1 + tb.dl1 + bond.dl1 + reit.dl1 - 1, data =
data.mat)
Residuals:
```

```
     Min       1Q   Median       3Q      Max
-2679.74  -359.70    83.84   412.96  1653.74
Coefficients:
           Estimate Std. Error t value Pr(>|t|)
ect1      123.97690  113.45502   1.093 0.276985
ect2       -0.03848    0.02554  -1.507 0.134825
ect3       -0.58096    0.14968  -3.881 0.000181 ***
ect4      279.55677  362.45542   0.771 0.442253
ect5      522.76318  599.27485   0.872 0.385002
ex.dl1    145.60076   94.44228   1.542 0.126129
gp.dl1     -0.01858    0.01997  -0.930 0.354279
st.dl1     -0.53772    0.12797  -4.202 5.54e-05 ***
tb.dl1    -78.99973  417.23473  -0.189 0.850187
bond.dl1 -319.74887  512.83000  -0.623 0.534296
reit.dl1    0.20339    0.61985   0.328 0.743458
Call:
lm(formula = tb.d ~ ect1 + ect2 + ect3 + ect4 + ect5 + ex.dl1 +
    gp.dl1 + st.dl1 + tb.dl1 + bond.dl1 + reit.dl1 - 1, data =
data.mat)
Residuals:
     Min       1Q   Median       3Q      Max
-0.34341 -0.09786 -0.00959  0.08032  0.49207
Coefficients:
           Estimate Std. Error t value Pr(>|t|)
ect1      3.630e-02  2.830e-02   1.283 0.202409
ect2     -7.160e-06  6.370e-06  -1.124 0.263534
ect3      1.511e-04  3.734e-05   4.048 9.85e-05 ***
ect4     -4.350e-01  9.041e-02  -4.811 4.99e-06 ***
ect5      2.873e-01  1.495e-01   1.922 0.057266 .
ex.dl1   -4.573e-03  2.356e-02  -0.194 0.846454
gp.dl1   -4.803e-06  4.983e-06  -0.964 0.337289
st.dl1    1.089e-04  3.192e-05   3.411 0.000917 ***
tb.dl1   -5.119e-01  1.041e-01  -4.918 3.21e-06 ***
bond.dl1  2.600e-01  1.279e-01   2.032 0.044630 *
reit.dl1  8.726e-05  1.546e-04   0.564 0.573700
Call:
lm(formula = bond.d ~ ect1 + ect2 + ect3 + ect4 + ect5 + ex.dl1 +
    gp.dl1 + st.dl1 + tb.dl1 + bond.dl1 + reit.dl1 - 1, data =
data.mat)
Residuals:
     Min       1Q   Median       3Q      Max
-0.33409 -0.09214  0.01048  0.08895  0.34224
Coefficients:
           Estimate Std. Error t value Pr(>|t|)
ect1      5.598e-03  2.259e-02   0.248   0.8047
```

```
ect2       4.521e-09  5.084e-06   0.001   0.9993
ect3       5.592e-05  2.980e-05   1.877   0.0633 .
ect4       1.620e-01  7.216e-02   2.244   0.0269 *
ect5      -6.955e-01  1.193e-01  -5.829 6.07e-08 ***
ex.dl1    -4.030e-03  1.880e-02  -0.214   0.8307
gp.dl1     2.018e-06  3.977e-06   0.507   0.6129
st.dl1     5.465e-05  2.548e-05   2.145   0.0342 *
tb.dl1     7.610e-02  8.307e-02   0.916   0.3617
bond.dl1  -5.285e-01  1.021e-01  -5.177 1.08e-06 ***
reit.dl1  -1.029e-04  1.234e-04  -0.834   0.4061
Call:
lm(formula = reit.d ~ ect1 + ect2 + ect3 + ect4 + ect5 + ex.dl1 +
    gp.dl1 + st.dl1 + tb.dl1 + bond.dl1 + reit.dl1 - 1, data =
data.mat)
Residuals:
    Min      1Q  Median      3Q     Max
-528.03  -54.35   -0.69   73.91  262.93
Coefficients:
           Estimate Std. Error t value Pr(>|t|)
ect1       7.323e+00  2.135e+01   0.343   0.7323
ect2      -4.050e-03  4.805e-03  -0.843   0.4012
ect3       2.126e-02  2.817e-02   0.755   0.4520
ect4      -1.642e+02  6.820e+01  -2.407   0.0178 *
ect5       1.438e+02  1.128e+02   1.275   0.2052
ex.dl1     8.647e+00  1.777e+01   0.487   0.6276
gp.dl1     1.103e-03  3.759e-03   0.293   0.7698
st.dl1    -2.673e-02  2.408e-02  -1.110   0.2695
tb.dl1    -1.964e+02  7.851e+01  -2.501   0.0139 *
bond.dl1   1.058e+02  9.650e+01   1.096   0.2755
reit.dl1  -7.380e-01  1.166e-01  -6.328 6.08e-09 ***
```

From the output analysis of the co-integration test, it is evident that the forex rates are significantly influenced by its past values, whose coefficient is negative, which indicates that there is a tendency to revert towards its previous levels as shown in ex.dl1 with a negative coefficient. The deviations from the equilibrium lead to swift market adjustments as reflected in ect1. When it comes to gold prices, it follows an autoregressive pattern and indicates that the current prices are highly dependent on its past values. The coefficient of ect2 emphasizes gold as an asset regarded as a safe asset against long-term fluctuations due to uncertainties in economic downtrends or due to inflation. The st.dl1 is negative for the stock market index, indicating adjustments over time, and the coefficient of ect3 indicates that the price of the index reacts against long-term economic factors to maintain equilibrium. The ect4 of the Treasury bill rate indicates a self-correcting mechanism to ensure stability in its value, and it is also influenced by its past values tb.dl1. The ect4 of REIT bond price indicates that the current price of REIT depends on its past

values, and it gets adjusted with investor sentiment and real estate market conditions to attain equilibrium.

Using VECM analysis, we assess the long-term impacts on financial indicators. The significant error correction terms, particularly 'ect3', 'ect4', and 'ect5', indicate that deviations from long-term equilibrium have notable long-term consequences. These factors demonstrated significant effects on different indicators like reit, bond, tb (treasury bill), st (stock market)., Specifically, 'ect4' substantially negatively impacts 'reit.d', suggesting that long-term deviations related to this term lead to sustained declines in real estate investment trust values. Similarly, 'ect5' significantly affects 'bond.d', highlighting its role in driving long-term changes in bond market dynamics. Lagged variables also exhibit considerable significant influence,

- St.di1 significantly affects st.d
- For example, dl1 significantly affects ex.d
- gp.dl1,st.dl1,reit.dl1 significantly affects gp.d
- tb.dl1,st.dl1,bond.dl1 significantly affects tb.d
- st.dl1,bond.dl1 significantly affects bond.d
- tb.dl1,reit.dl1 significantly affects reit.d

Other variables, ect1 and ect2, show limited significance across most models, indicating their minimal role in short-term predictions. The findings underscore that short-term lagged variables influence immediate adjustments. The long-term impacts are definite through specific error correction terms, which correct deviations from equilibrium over time. This indicates that deviations captured by these terms are crucial in understanding the enduring effects on financial indicators.

5 Conclusion

The results of the ARIMA model proved helpful to give an idea about future trends of selected financial instruments. The research showed an increasing trend for the forex rate (USD vs. INR), 10-year bond rates, and a steep increase in gold. The research also indicates an anticipated hike in 91-day T-bill rates, which is an indicator of market expectations and economic conditions.

Inferred from the correlation and regression, there exists a strong association between forex rates and financial assets that have been chosen. Between gold prices and stock indices, a high positive association existed with forex rates, while 91-day T-bill yields, 10-year bond yields, and reits showed a moderate negative association. Policy-makers and investors are greatly guided by these results in their perception of interlinkages and the response of financial assets to forex volatility.

From VAR analysis, forex rates (ex) do not play a direct statistically significant role in the short term on any of the selected financial assets for study. The analysis further showed that the majority of the financial assets have a high degree of autocorrelation, which means their past values are strongly correlated with their current values. Among the selected financial assets, the stock market index showed a

significant predictive and contemporaneous impact on the other variables, whereas forex rates, t-bill rates, bond yields, and REITs had a strong contemporaneous relationship with these assets. The stock market index influences T-bill rates, T-bill rates influence REITs, and bond yields significantly influence T-bill rates. From the impulse response function, forex rate shockwaves have a considerable impact on the gold prices and stock markets, although their effect becomes stable over time, whereas there is no notable response of T-bill rates and bond yields to forex rate shocks. From the Johansen cointegration test, it can be observed that the long-run relationships exist between these variables, and notable determinants are found using VECM analysis, i.e., lag values and error correction terms.

VEC analysis indicates the existence of long-run equilibrium relationships between the assets; even in the short run, these variables are linked in the long run. The significance of the error correction terms points to the self-adjusting nature of the system, which means the deviations from equilibrium are corrected in the long run. The stock market index determines short-run dynamics and long-run stability to a greater extent compared to forex rates. On the other hand, the rates of forex have a more restricted direct effect, although they also influence the overall financial scene through their interplay with other variables. It can be seen from the feedback loops that there is a web of financial assets, showing how a change in one asset will affect others.

The analysis also emphasizes fluctuating rates among the chosen assets, reflecting differing market efficiencies. These observations indicate that policymakers and investors need to factor these intricate interactions and adjustment mechanisms into their strategy-making and decision-making. Overall, the analysis results stressed complex dynamic inter-linkages and causality between selected financial assets based on the need for the index of the stock market to influence other financial assets in forecasting the others and with the immediate influence exerted over other variables and with forex exchange rates and the rest of assets acting contemporarily in contrast to through long-term causal interrelations.

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