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Dynamic Relationship Between Rupee-Dollar Exchange Rate and Major Economic Indicators

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Abstract: It is very likely that dollar to rupee exchange rate has an influence on the major economic indicators of India like the GDP of India, the NIFTY 50 index, gold prices in India, import prices in India, and crude oil prices in India. The quarterly time series data of the seven variables have been used. The time considered for the study is 2016 Quarter 1 to 2022 Quarter 3 and dummy variables to adjust drastic changes during the Automobile industry crash in India and other global uncertainties (2018-Q3 to 2019-Q3) and covid (2019-Q4 to 2021-Q2) for all variables have been used. Unit Root test, Bound test, Johansen-Juselius multivariate cointegration test, and generalized forecast error variance decomposition have been used to analyze the data and it was found that there exists a relationship in the short run, although there does not seem to be a long-run equilibrium relationship between economic variables and changes in the exchange rates. This probably reflects the increasing disparity in economic, monetary, and hedging uses between these indicators and exchange rates. It may also imply that those economic indicators may not be sensitive to common macroeconomic factors in the long run. There is only rather weak evidence of a long-run relationship, investors may benefit from diversification into gold in the long run. Similarly, exporters may benefit from expanding their exports (if possible) if reserves are available, thereby diversifying the risk of price fluctuations in the long run. However, there is evidence that spot prices and exchange rates may be closely linked in the short-run aftershocks occur. Changes in the nominal price of oil have basically no information to provide to monetary authorities on changes in the exchange rate behavior and the opposite holds as well.

Keywords: Dollar to Rupee Exchange Rate, GDP of India, NIFTY 50 Index, Gold Prices in India, Import Prices in India, Crude Oil Prices in India, Relationships, Fluctuation

Introduction

Dynamic Relationship Between Dollar to Rupee Exchange Rate and Major Economic Indicators

The exchange rate between two currencies is an important economic indicator that reflects the relative strength of their respective economies. In the case of the United States Dollar (USD) dollar and the Indian rupee, the exchange rate between these two currencies has been the subject of much interest and analysis in recent years, given the significance of both economies in the global context. However, the exchange rate between these two currencies is not determined in isolation but rather influenced by a range of macroeconomic indicators such as crude oil, gold prices, Import prices, inflation, Nifty 50 Index prices, and GDP growth rates.

The dollar exchange rate is a measure of the value of the USD against a basket of currencies of different countries, most of whom are US trade partners. The weakening of the Indian rupee is directly proportional to the strengthening of the US dollar. The USD to rupee exchange rate is decided based on the demand and supply of both currencies. Climbing inflation had triggered negative sentiments in the minds of the investors, an increase in Fed Rate added to this skeptical behavior about the stock market, and hence demand for USD increased in international markets. According to Heaton and Lucas (1999) one of the key

economic indicators is the stock market. According to the ministry of commerce and industry, the All-India Wholesale Price Index (WPI) data indicates that the annual rate of inflation was 10.7% in September 2022 (over September 2021), compared to 12.41% in August 2022. The increase in prices of mineral oils, food items, crude oil, natural gas, chemicals and chemical products, basic metals, electricity, textiles, and other items as compared to the same month last year is the main cause of inflation in September 2022.

According to Ghosh (2014), the exchange rate is a significant financial factor that influences the choices made by governments, financial institutions, enterprises, and professional investors as well as foreign currency dealers. The relationship between domestic financial sector volatility and foreign exchange market volatility is particularly crucial because co-movements and spillovers between these markets show how easily a failure in one market can affect banks, lenders, and portfolio investors who invest in open economies According to Akbar *et al*. (2019) explanation, the interconnection of international markets and financial integration makes stock and foreign exchange markets more susceptible to changes in commodities prices. Investors are drawn to stock investing's risk because of its potential for unexpected volatility, which drives them to participate in the gold market. It's because gold is regarded as an alternative investment as well as a safe refuge during times of financial market volatility. The authors concluded that investors' expectations and portfolio managers in developing economies may greatly benefit from the interconnection of the gold market, stock market, and foreign exchange market.

This research aims to explore the dynamic relationship between the dollar-to-rupee exchange rate and the major economic indicators mentioned above to gain a better understanding of how changes in these variables and the exchange rate are related. By examining this relationship, the study aims to shed light on the factors that influence the exchange rate and how policymakers can use this knowledge to make informed decisions regarding trade, investment, and monetary policy.

The Objective of the Study

To understand the dynamic relationship between the USD to Rupee and various economic indicators namely the Gross Domestic Product (GDP) of India, National Stock Exchange Fifty (NIFTY) 50 Index, Gold prices in India, Import prices in India, Crude oil prices in India.

Rupee Depreciation

Existing literature on the concept of rupee depreciation has so far been ambiguous and controversial. Mishra (2017) Using daily data from the years 2003 to 2016, examined the volatility transmission between global crude oil prices and the exchange rate for Indian currency versus the USD. According to him, shocks to the currency rate in India have symmetric effects, meaning that both positive and negative effects have similar consequences in terms of magnitude. The study demonstrated the existence of a long-lasting impact of oil shocks on the volatility of the Indian rupee's exchange rate against the US dollar. Dai *et al*. (2020) make a systemic analysis of dependence and risk contagion among oil, gold, and the US dollar Foreign Exchange (US FX) markets. The results of the study confirmed that there is an existence of causality and volatility spillover from oil price return to exchange rate return and further showed that it holds for a specific quantile range of exchange rate return. Gold price return predicts exchange rate return at all points except at the lower and upper tail of its conditional distribution. Beckmann *et al*. (2016) examined the development of the correlation between the nominal oil price and dollar exchange rates of 12 economies. Even after the crises' peak, the overall association continued to get stronger over time. This growing tail reliance means that catastrophic occurrences are more likely to happen simultaneously for both series. There are repercussions from various angles due to the intensification of the relationship between the price of oil and exchange rates.

Stock Price Fluctuations and Inflation

Karim and Masih (2021) looked into how sensitive Islamic stock markets' returns were to fluctuations in oil prices at various investment horizons by analyzing their dynamics in the temporal and frequency domain, the conclusion implies that, as compared to realized volatility, the return on the Islamic stock markets is more sensitive to the indicated volatility of oil prices. Hussain *et al*. (2015) have investigated the factors that contributed to Pakistan's stock market's rapid expansion and rise in foreign portfolio investment. The findings go against past research from both developing and emerging countries, as they show that Pakistan's overall stock returns are not affected by changes in macroeconomic factors.

Sheikh *et al*. (2020) explained that there is a direct significant correlation between CPI and stock indexes over the long run and prior to the global economic recession. They discovered that after the global economic recession, investors only responded favorably to changes in the money supply and did not respond to changes in the interest rate or CPI. In the short run, they found that the interest rate has a significant negative impact on stock indexes, while the money supply has a positive impact.

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According to Sharma *et al*. (2018), inflation drives up manufacturing costs, which are then passed on to customers. The WPI increased to 10.49% in April 2017 from 7.39% in March 2017, indicating cost-push pressures. Cost-push pressures reduce purchasing power, which lowers living standards.

Relationship Between Dollar to Rupee Exchange Rate and Economic Indicators

According to Reboredo *et al*. (2016), Exchange rates and stock prices are two essential macroeconomic factors that are inextricably linked, Changes in exchange rates have an impact on stock prices because they can lower (raise) the international competitiveness of local enterprises and their cash flows, which in turn can lower (increase) domestic stock values. Exchange rates are affected by changes in stock prices. The co-movement of stock markets and exchange rate markets has been examined, with a focus on quantifying and assessing the effects of rate changes both up and down on upside and downside risk in stock markets and vice versa. Chinese stock exchange indexes and exchange rates for the renminbi were compared by Rutledge *et al*. (2014) through the examination of several time frames, the study increased our understanding of the link. The consequences of several key financial events, such as the loosening of exchange rate regulations and the global financial crisis, have also been examined. In an effort to assess the volatile spillovers and/or co-movements from other financial market segments to the forex market and analyze any potential changes in the relationship over the past ten years, (Ghosh, 2014) discovered that the capital inflows into the Indian stock market have had a significant impact on the USD-INR volatility in recent years. Following spillover from the stock market volatility are spillovers from the government securities market, the OIS market, the ted spread, and global crude prices. Using the NARDL model, (Asad *et al*., 2020) investigate the asymmetrical relationship between exchange rates, gold, oil, and stock prices. The study found that while there is a proven asymmetrical association between all macroeconomic fluctuation and stock prices, the relationship between exchange rate and stock prices is symmetrical in nature over the long run before and after the global financial crisis. Due to India's export-driven economy, the local currency devaluation (positive shocks to the USD vs INR) benefits the Bombay Stock Exchange stock index prices. According to Grewal (2013), a decline in currency value has an impact on many indices of economic growth. Reduced foreign investment, increased external debt pressure and rising oil and fertilizer subsidy costs are all effects of the rupee's depreciation. The improvement of the current account deficit as a result of export stimulation and import deterrence is the most advantageous result of the rupee's devaluation.

Abbas *et al*. (2018) looked at both domestic and foreign factors causing variances in stock returns in the global financial markets. They discovered that key factors influencing stock market volatility include the volatility of the money supply, inflation, exchange rate, and oil price. Using monthly data from India, Ajaz *et al*. (2017) investigated the dynamic relationship between stock prices, interest rates, and exchange rates. The findings showed that stock prices react asymmetrically to changes in interest rates and exchange rates; depreciation of the local currency increases the cost of imported inputs, which lowers profits and, as a result, lowers stock prices. Akbar *et al*. (2019) discovered a connection between the stock market, gold market, and foreign currency market. Stock prices and gold prices fall when exchange rates fluctuate negatively and the opposite is also true. The rise in the gold market results from a reduction in the value of the rupee, but the opposite is also true when the stock market falls. The stock market and the rupee's worth in terms of dollars both benefit from the drop in the price of gold. Delgado *et al*. (2018) examine the connections between the Mexican economy's exchange rates, stock market, consumer price index, and oil price variables. The results of the analysis of these variables show that the exchange rate has a statistically significant negative impact on the Mexican stock market index and a statistically significant positive impact on the Mexican consumer price index. An increase in the value of the Mexican peso has a positive impact on the stock market, while a decrease in the value of the Mexican peso raises the consumer price index.

The proof of factual effect as well as significant interactions among the prices of oil, gold, the US dollar, and stocks have been demonstrated by Arfaoui and Rejeb, (2017). They discovered that the stock markets, gold, and the USD have a big impact on oil prices. Oil futures prices and Chinese oil gross imports both have an impact on oil prices. Although the US imports of oil and the default premium have a small impact on the price of gold, movements in the oil, USD, and stock markets are of importance. Oil and stock market prices have a big impact on the USD exchange rate. By conducting an empirical assessment of potential non-linear asymmetries between the US-Canada exchange rate, (Jung *et al*., 2020) examined the factors influencing the relationship between oil prices and exchange rates and discovered that the real price of oil and the exchange rate has a bidirectional long-run relationship, with long-run asymmetries running from the exchange rate to the real price of oil. The mechanism governing the US dollar-Indian rupee exchange rate was investigated by Arora *et al*. (2015) They have discovered six variables that explain a significant portion of how exchange rates are set. They

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have also assessed how well the results accord with the prevailing theory and have drawn conclusions about how these variables are related to dollar-rupee exchange rates. The purchasing power parity theory is in agreement with the positive coefficient of Differential Inflation Rates (DIFR).

The above literature suggests that the dynamic relationship between the dollar-to-rupee exchange rate and major economic indicators is complex and multifaceted. While certain variables such as crude oil, gold prices, import prices, inflation, Nifty 50 Index prices, and GDP growth rates have been found to have a significant impact on the exchange rate, the precise nature of this relationship is likely to vary depending on the specific economic conditions prevailing at any given time.

Materials and Methods

The information and data are used from different websites like Investopedia, investing, money control and the reports of the governments like Exim, fuel prices etc.

The quarterly time series data of the seven variables namely the dollar rupee index, Nifty 50 index, Inflation rate, Import Price index, GDP of India, Gold prices in India, and Crude oil prices in India have been used. The time considered for the study is 2016 Quarter 1 to 2022 Quarter 3. We used dummy variables to adjust drastic changes during the Automobile industry crash in India and other global uncertainties (2018-Q3 to 2019-Q3), covid (2019-Q4-2021-Q2) for all variables (Fig. 1).

The descriptive statistics of all logged and raw data are reported in Tables 1-2, respectively. The volatility result showed that GDP had high volatility (S. D = 0.632) in the last 7 years and the rupee-dollar had very low volatility (0.032) comparing all other variables. All other variables showed low volatility in the past years (S.D between 0.1-0.4). The correlations between the variables have been reported in Table 3. Spearman's correlation showed that all variables have a positive correlation with each other except the Dollar Rupee exchange rate and Crude Oil (r = -0.065). Among positive correlations, the Inflation rate and gold price (r = 0.94), Nifty and Import Price Index (r = 0.86), Import Price and Inflation (r = 0.899), and, import price and Nifty (r = 0.774) showed very high positive correlations.

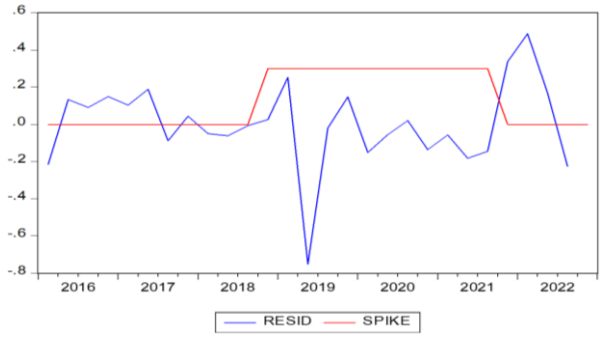

Fig. 1: Residual and dummy variable (spike)

Table 1: Descriptive statistics (log)

	lncrude	lngdp	lngold	lnimport	lninflation	lnnifty	lnrupedol
Mean	4.136644	1.765709	11.62112	6.333842	4.801266	9.462304	4.277489
Std. Dev.	0.342590	0.631862	0.213735	0.166465	0.101213	0.221275	0.031641
Skewness	-0.949212	1.087536	-0.138347	-0.082155	0.027280	0.274191	-0.801999
Kurtosis	5.308567	4.723115	1.266926	1.324064	1.698222	1.788488	4.375273
Jarque-Bera	10.050180	8.020899	3.465118	3.190228	1.909802	1.989544	5.022208
Probability	0.006571	0.018125	0.176831	0.202885	0.384850	0.369808	0.081179
Observations	27.000000	27.000000	27.000000	27.000000	27.000000	27.000000	27.000000

Note: All Variables are in logarithmic form

Table 2: Descriptive statistics (level)

	Crudeo IL	GDP	Gold	Import_price_index	Inflation	Nifty	Rupee dollar
Mean	65.907780	5.648148	113865.300000	570.821000	122.265900	13176.980000	72.093700
Std. Dev.	20.670570	10.476100	23721.430000	93.793320	12.375940	2983.705000	2.253978
Skewness	0.502277	-0.247237	-0.059409	-0.003205	0.132502	0.479986	-0.675654
Kurtosis	3.610129	10.647330	1.263267	1.333651	1.738583	1.779897	4.144160
Jarque-Bera	1.554061	66.066900	3.409154	3.123855	1.869076	2.711474	3.527030
Probability	0.459769	0.000000	0.181849	0.209731	0.392767	0.257757	0.171441
Observations	27.000000	27.000000	27.000000	27.000000	27.000000	27.000000	27.000000

Table 3: Correlation matrix

	Rupee-dollar	Import price index	Nifty	Inflation	Gold	Crude oil	GDP
Rupee-dollar	1.000000						
Import price index	0.080265	1.000000					
Nifty	0.162156	0.774659	1.000000				
Inflation	0.194512	0.899399	0.856357	1.000000			
Gold	0.148970	0.977310	0.779816	0.937552	1.000000		
Crude oil	-0.065040	0.208201	0.554014	0.407401	0.220183	1.000000	
GDP	0.102498	0.077254	0.206507	0.207518	0.089131	0.261424	1

Note: All Variables are in logarithmic form

Methodologically, we employ the generalized forecast error variance decompositions and the generalized impulse response functions of (Pesaran and Shin, 1998; Koop *et al*., 1996) to understand the impacts and responses to shocks. The generalized variance decomposition and generalized impulse response approaches have advantages over the orthogonalized approach of Sims (1980). The results of orthogonalized approach are sensitive to the order of variables in the VAR in contrast to the results generated from a generalized approach which do not vary according to the ordering. Forecast error Variance Decompositions (VDC) show how much of the variance of a variable can be explained by shocks to another variable in the same system of simultaneous equations known as the Vector Autoregressive model (VAR). Unexpected innovations to an individual variable can affect both "changes in itself" and the other variables. In a VAR system, the relative importance of these effects can be identified by the forecast error variance decompositions. For this reason, the variance decomposition method is an out-of-sample causality analysis. On the other hand, the impulse responses trace out the direction of the dynamic responses of a variable to innovations in other variables in the VAR. Both generalized impulse response functions and generalized forecast error variance decompositions are based on the estimation of the moving-average representation of the original VAR (Misra and Gupta, 2017).

Before running the generalized methods, it should be decided whether to use first-differenced data or levels. Engle and Granger (1987) emphasized the importance of this issue. If the variables are cointegrated and the corresponding cointegration vector is not used in the VAR system, the model with only first-differenced data will be mis specified. We use both the method developed by Johansen (1991; 1995); Johansen and Juselius (1990) (JJ, thereafter), and the bounds testing approach (Pesaran *et al*., 2001) to check for cointegration. The bounds' testing approach has several advantages over the JJ method. First, The JJ approach requires that all the series must be I (1), while the bound's testing approach does not require the same order of integration. Second, with the bounds testing approach, it is possible to determine the more efficient cointegrating relationships even if the sample size is very small (Ghatak and Siddiki, 2001) finally, the bounds testing approach overcomes the problems resulting from series with unit roots. The important advantage of the JJ over-bounds testing approach is that the JJ can be applied to I (2) or higher series if the series are having the same order of integration. To utilize the bounds testing approach, it is necessary to model the variable relationship using the Autoregressive Distributed Lag (ARDL) technique developed by Pesaran *et al*. (2001).

The bounds testing procedure requires the estimation of the following equations:

$$\begin{aligned}
\Delta LRUPEDOL_t &= a_{0w} + \sum_{i=1}^{k} b_{iw}\Delta LRUPEDOL_{t-1} + \\
&\sum_{i=1}^{k} c_{iw}\Delta LGDP_{t-i} + \sum_{i=1}^{k} d_{iw}\Delta LGOLD_{t-i} + \\
&\sum_{i=1}^{k} e_{iw}\Delta LINFLRATE_{t_i} + \sum_{i=1}^{k} f_{iw}\Delta LIMPORTIND_{t_i} \\
&+\sum_{i=1}^{k} g_{iw}\Delta LCRUDEOIL_{t-i} + \sum_{i=1}^{k} h_{iw}\Delta LNIFTY_{t-i} \\
&+\sum_{i=1}^{k} i_{iw}\Delta LER_{t-i} + \lambda_{1W} LRUPEDOL_{t-1} \\
&+\lambda_{2W} LGDP_{t-i} + \lambda_{3W} LGOLD_{t-i} + \\
&\lambda_{4W} LINFLRATE_{t-i}\ \lambda_{5W} LIMPORTIND_{t-i} + \\
&+\lambda_{6W} LCRUDEOIL_{t-i} + \lambda_{7W} LNIFTY_{t-i} + \varepsilon_{1\tau}
\end{aligned} \tag{1}$$

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$$\Delta LGDP_t = a_{0w} + \sum_{i=1}^{l} b_{iw}\Delta LGDP_{t-1} + \sum_{i=1}^{l} c_{iw}\Delta LRUPEEDOL_{t-i} + \sum_{i=1}^{l} d_{iw}\Delta LGOLD_{t-i} + \sum_{i=1}^{l} e_{iw}\Delta LINFLRATE_{t\_i} + \sum_{i=1}^{l} f_{iw}\Delta LIMPORTIND_{t\_i} + \sum_{i=1}^{l} g_{iw}\Delta LCRUDEOIL_{t-i} + \sum_{i=1}^{l} h_{iw}\Delta LNIFTY_{t-i} + \sum_{i=1}^{l} i_{iw}\Delta LER_{t-i} + \lambda_{1W} LGDP_{t-1} + \lambda_{2W} LRUPEDOL_{t-i} + \lambda_{3W} LGOLD_{t-i} + \lambda_{4W} LINFLRATE_{t-i}\ \lambda_{5W} LIMPORTIND_{t-i} + +\lambda_{6W} LCRUDEOIL_{t-i} + \lambda_{7W} LNIFTY_{t-i} + \varepsilon_{1\tau} \quad (2)$$

$$\Delta LGDP_t = a_{0w} + \sum_{i=1}^{m} b_{iw}\Delta LGOLD_{t-1} + \sum_{i=1}^{m} c_{iw}\Delta LRUPEEDOL_{t-i} + \sum_{i=1}^{m} d_{iw}\Delta LGDP_{t-i} + \sum_{i=1}^{m} e_{iw}\Delta LINFLRATE_{t-i} + \sum_{i=1}^{m} f_{iw}\Delta LIMPORTIND_{t\_i} + \sum_{i=1}^{m} g_{iw}\Delta LCRUDEOIL_{t-i} + \sum_{i=1}^{m} h_{iw}\Delta LNIFTY_{t-i} + \sum_{i=1}^{m} i_{iw}\Delta LER_{t-i} + \lambda_{1W} LGOLD_{t-1} + \lambda_{2W} LRUPEDOL_{t-i} + \lambda_{3W} LGDP_{t-i} + \lambda_{4W} LINFLRATE_{t-i}\ \lambda_{5W} LIMPORTIND_{t-i} + +\lambda_{6W} LCRUDEOIL_{t-i} + \lambda_{7W} LNIFTY_{t-i} + \varepsilon_{1\tau} \quad (3)$$

$$\Delta LINFLRATE_t = a_{0w} + \sum_{i=1}^{n} b_{iw}\Delta LINFLRATE_{t-1} + \sum_{i=1}^{n} c_{iw}\Delta LRUPEEDOL_{t-i} + \sum_{i=1}^{n} d_{iw}\Delta LGOLD_{t-i} + \sum_{i=1}^{n} e_{iw}\Delta LGDP_{t-i} + \sum_{i=1}^{n} f_{iw}\Delta LIMPORTIND_{t-i} + \sum_{i=1}^{n} g_{iw}\Delta LCRUDEOIL_{t-i} + \sum_{i=1}^{n} h_{iw}\Delta LNIFTY_{t-i} + \sum_{i=1}^{n} i_{iw}\Delta LER_{t-i} + \lambda_{1W} LGOLD_{t-1} + \lambda_{2W} LRUPEDOL_{t-i} + \lambda_{3W} LGOLD_{t-i} + \lambda_{4W} LGDP_{t-i}\ \lambda_{5W} LIMPORTIND_{t-i} + +\lambda_{6W} LCRUDEOIL_{t-i} + \lambda_{7W} LNIFTY_{t-i} + \varepsilon_{1\tau} \quad (4)$$

$$\Delta LIMPORTIND_t = a_{0w} + \sum_{i=1}^{q} b_{iw}\Delta LIMPORTIND_{t-i} + \sum_{i=1}^{q} c_{iw}\Delta LRUPEEDOL_{t-i} + \sum_{i=1}^{q} d_{iw}\Delta LGOLD_{t-i} + \sum_{i=1}^{q} e_{iw}\Delta LGDP_{t-i} + \sum_{i=1}^{q} f_{iw}\Delta LINFLRATE_{t-1} + \sum_{i=1}^{q} g_{iw}\Delta LCRUDEOIL_{t-i} + \sum_{i=1}^{q} h_{iw}\Delta LNIFTY_{t-i} + \sum_{i=1}^{q} i_{iw}\Delta LER_{t-i} + \lambda_{1W} LIMPORTIND_{t-i} + \lambda_{2W} LRUPEDOL_{t-i} + \lambda_{3W} LGOLD_{t-i} + \lambda_{4W} LGDP_{t-i}\ \lambda_{5W} LIMPORTIND_{t-1} + +\lambda_{6W} LCRUDEOIL_{t-i} + \lambda_{7W} LNIFTY_{t-i} + \varepsilon_{1\tau} \quad (5)$$

$$\Delta LCRUDEIL_t = a_{0w} + \sum_{i=1}^{s} b_{iw}\Delta LCRUDEIL_{t-i} + \sum_{i=1}^{s} c_{iw}\Delta LRUPEEDOL_{t-i} + \sum_{i=1}^{s} d_{iw}\Delta LGOLD_{t-i} + \sum_{i=1}^{s} e_{iw}\Delta LGDP_{t-i} + \sum_{i=1}^{s} f_{iw}\Delta LIMPORTIND_{t-i} + \sum_{i=1}^{s} g_{iw}\Delta LINFLRATE_{t-1} + \sum_{i=1}^{s} h_{iw}\Delta LNIFTY_{t-i} + \sum_{i=1}^{s} i_{iw}\Delta LER_{t-i} + \lambda_{1W} LCRUDEOIL_{t-i} + \lambda_{2W} LRUPEDOL_{t-i} + \lambda_{3W} LGOLD_{t-i} + \lambda_{4W} LGDP_{t-i}\ \lambda_{5W} LIMPORTIND_{t-i} + +\lambda_{6W} LINFLRATE_{t-1} + \lambda_{7W} LNIFTY_{t-i} + \varepsilon_{1\tau} \quad (6)$$

$$\Delta LNIFTY_t = a_{0w} + \sum_{i=1}^{u} b_{iw}\Delta LNIFTY_{t-i} + \sum_{i=1}^{u} c_{iw}\Delta LRUPEEDOL_{t-i} + \sum_{i=1}^{u} d_{iw}\Delta LGOLD_{t-i} + \sum_{i=1}^{u} e_{iw}\Delta LGDP_{t-i} + \sum_{i=1}^{u} f_{iw}\Delta LIMPORTIND_{t-i} + \sum_{i=1}^{u} g_{iw}\Delta LCRUDEOIL_{t-i} + \sum_{i=1}^{u} h_{iw}\Delta LINFLRATE_{t-1} + \sum_{i=1}^{u} i_{iw}\Delta LER_{t-i} + \lambda_{1W} LNIFTY_{t-i} + \lambda_{2W} LRUPEDOL_{t-i} + \lambda_{3W} LGOLD_{t-i} + \lambda_{4W} LGDP_{t-i}\ \lambda_{5W} LIMPORTIND_{t-i} + +\lambda_{6W} LCRUDEOIL_{t-i} + \lambda_{7W} LNIFTY_{t-i} + \varepsilon_{1\tau} \quad (7)$$

where, *k*, *l*, *m*, *n*, *o*, *q*, *s* and *u* are the lag lengths and determined by the Akaike Information Criterion (AIC). *b*, *c*, *d*, *e*, *f*, *g*, *h*, and *i* denote the short-run coefficients, while *λs* are the long-run coefficients.

Table 4 showed that using ADF, PP, and KPSS methods, data are stationary at first difference ($p<0.05$). The null hypothesis is that there is "no cointegration" in the long run in each equation, $\lambda1 = \lambda2 = \lambda3 = \lambda4 = \lambda5 = \lambda6 = 0$. The general F-statistics are calculated and compared with two different critical values obtained from Pesaran *et al*. (2001). Depending on the time series properties of the series, two sets of critical values are reported. One set is for the purely I (1) series and the other one is for the purely I (0) series. If all the series are either I (1) or I (0), we fail to reject the null hypothesis if the calculated F-statistic is lower than the critical values. On the other hand, if the series have different ordering, the test is inconclusive if the F-statistic is between both critical values. If the calculated statistic is greater than the critical value for the I (1) series, we conclude cointegration.

The following brief technical discussion for generalized variance decompositions and generalized impulse responses approach is rephrased from Cheung and Yuen (2002) and based on Koop *et al*. (1996); Pesaran and Shin (1998). Consider that H_t can be represented by the following VAR.

Table 4: Unit root test results

		Unit root test results table (ADF)						
At level		Crude oil	GDP	Gold	Import_price_index	Inflation	Nifty	Rupee dollar
With constant	t-Statistic	-1.4776	-6.381	-1.2729	-0.9162	1.0825	-0.5358	-3.4548
	Prob.	0.5288		0.6256	0.7666	0.9961	0.8685	0.018
		n0	***	n0	n0	n0	n0	**
With constant and trend	t-Statistic	-1.7408	-6.5671	-1.8777	-1.3558	-4.2754	-2.3088	-2.9856
	Prob.	0.7036	0.0001	0.6359	0.85	0.0124	0.415	0.1548
		n0	***	n0	n0	**	n0	n0
At First difference		d(Crudeoil)	d(GDP)	d(Gold)	d(Import_ price_index)	d(Inflation)	d(Nifty)	d(Rupee _dollar)
With constant	t-Statistic	-5.1809	-6.4933	-2.9857	-4.1724	-6.4865	-5.488	-4.6746
	Prob.	0.0003	0	0.0501	0.0035	0	0.0001	0.0011
		***	***	*	***	***	***	***
With constant and trend	t-Statistic	-5.1573	-6.3372	-2.9477	-4.1187	-6.6224	-5.4333	-4.8281
	Prob.	0.0018	0.0001	0.1656	0.0173	0.0001	0.0009	0.0037
		***	***	***	**	***	***	***
		Unit root test results table (PP)						
At level		Crudeoil	GDP	Gold	Import_price _index	Inflation	Nifty	Rupee_dollar
With constant	t-Statistic	-1.4776	-6.3818	-0.9755	-0.9537	2.3458	-0.2916	-3.4458
	Prob.	0.5288	0	0.7466	0.7541	0.9999	0.9135	0.0183
		n0	***	n0	n0	n0	n0	**
With constant and trend	t-Statistic	-1.74	-6.672	-1.5046	-1.5346	-6.4882	-2.3208	-3.1013
	Prob.	0.7039	0	0.8017	0.7907	0.0001	0.409	0.1268
		n0	***	n0	n0	***	n0	n0
At first difference		d(Crud eoil)	d(GDP)	d(Gold)	d (Import _price	d(Inflation)	d(Nifty)	d(Rupee _dollar) _index)
With constant	t-Statistic	-5.2023	-29.6626	-2.8393	-4.1724	-7.4078	-5.5796	-4.7132
	Prob.	0.0003	0.0001	0.0672	0.0035	0	0.0001	0.001
		***	***	*	***	***	***	***
With constant and trend	t-Statistic	-5.237	-28.64	-2.7849	-4.1187	-8.5927	-5.6103	-4.9573
	Prob.	0.0015	0	0.2151	0.0173	0	0.0006	0.0027
		***	***	n0	**	***	***	***
		Unit root test results table (KPSS)						
At level		Crudeoil	GDP	Gold	Import_pric price_index	Inflation	Nifty	Rupee_dollar
With constant	t-Statistic	0.2619	0.2142	0.7103	0.6673	0.7763	0.6544	0.184
	Prob.	n0	n0	**	**	***	**	n0
With constant and trend	t-Statistic	0.1678	0.0881	0.1003	0.103	0.1925	0.1411	0.1344
	Prob.	**	n0	n0	n0	**	*	*
At first difference		d(Crudeoil)	d(GDP)	d(Gold)	d(Import_price _index)	d(Inflation)	d(Nifty)	d(Rupee _dollar)
With constant	t-Statistic	0.1336	0.5	0.1788	0.1687	0.5	0.1854	0.3008
	Prob.	n0	**	n0	n0	**	n0	n0
With constant and trend	t-Statistic	0.1045	0.5	0.1462	0.1406	0.2802	0.0986	0.1172
	Prob.	n0	***	**	*	***	n0	n0

Notes: a: (*) Significant at the 10%; (**) Significant at the 5%; (***) Significant at the 1% and (no) Not Significant; b: Lag Length based on SIC; c: Probability based on one-sided p-values

$$H_t = \alpha + \sum_i^1 \phi H_{t-i} + \varepsilon_t \quad (8)$$

where, H_t is a $m \times 1$ vector of jointly determined endogenous variables, α is a vector of constant, $\phi 1$ through ϕp are m × m matrices of coefficients to be estimated and ε_t is an $m \times 1$ vector well-behaved disturbances with covariance $\Sigma = \sigma_{ij}$. The generalized impulse response of $H_t + n$ with respect to a unit standard deviation shock to j^{th} variable at time t is represented by $(M_n \Sigma e_j)(\sigma_{ij})^{-1}$, where $M_n = \phi 1 M_{n-1} + \phi 2 M_{n-2} + \ldots + \phi p M_{n-p}$, $n = 1, 2, \ldots$, $M_0 = I$, $M_n = 0$ for $nb0$ and e_j is $m \times 1$ selection vector with unity as its j^{th} element and zero elsewhere. Then, generalized forecast error variance decompositions can be computed by:

$$\frac{\sigma_{ij}^{-1} \sum_{i=0}^{n} \left(e_i' M_i \sum e_j\right)^2}{\sum_{i=0}^{n} \left(e_i' M_i \sum B M_i' e_i\right)^2} \quad (9)$$

We specifically employ generalized forecast error variance decompositions and generalized impulse responses to assess the relative strength of the GDP of India, the nifty 50 index, gold prices in India, import prices in India, wholesale price index, crude oil prices in India, the price and exchange rate equations and the transmission mechanisms between the variables under investigation.

Results

Before testing for the presence of cointegration, we must determine the time series properties of the variables. Dickey and Fuller (1979) (ADF), Phillips and Perron, (1988) (PP) tests are the most used methods to test for unit roots. However, it has been reported that both methods have weaknesses so new techniques have been developed. Thus, in addition to the ADF and PP, we have also utilized

Kwiatkowski *et al*. (1992) (KPSS) unit root tests. The results are reported in Table 4. The common suggestion of all the tests is that all variables are I (1) i.e., first difference, thus we can use both the bounds test and the JJ method to test for cointegration. The bounds test results are reported in Table 5. The results suggest that there is no cointegration between the economic variables and the exchange rate. That is, the GDP of India, the nifty 50 index, gold prices in India, import prices in India, the wholesale price index, and crude oil prices in India, are not the collective driving forces of each other in the long run, despite their strong correlations among themselves in the short run. The JJ results are reported in Table 6 and they also confirm that no evidence of cointegration is detected by the maximum eigenvalue test. However, the trace test (λtrace) suggested the presence of cointegration. The test results seem to be conflicting. Since scholars generally prefer the maximum eigenvalue test (λmax) over the trace test and considering the result of the bounds testing approach, we assume that the variables are not cointegrated. Thus, we have used the first differences of the data series in the VAR to estimate the generalized-forecast error variance decompositions and generalized impulse response functions.

Table 7 reports the results of the generalized forecast error variance decompositions for all the variables. The results clearly suggest that most of the variations in each of the economic indicators and the exchange rate are due to own innovation. While looking at individual variables for over five periods, it showed that in the initial period (1) The crude oil variation is fully explained by the shocks of crude oil itself (100%) but in the later stage small portion of variation, explained by Gold (2-3%), Nifty (4-12%) and import price index (3-9%), shows that the crude oil price is influenced by gold price, nifty and import price index in the mid and end of the period. likewise, the result of GDP showed that the majority of the variation (99.82%) in the initial period is explained by its own shock, and the remaining variation is caused by crude oil price (0.185%). But in the mid-period (3) only 51.90% of the variation is caused by its own shock and the remaining variations are explained majorly by the Import price index (28.47%), Inflation rate (8.68) and Crude oil price (4.14%).

Further, gold price variation in the initial period is caused by its own information (87.48%), and the remaining variation is caused by crude oil (8.55%) and GDP (3.98%). But at the end of the period (5), the price variation is caused by its own shock which amounts to only 22.95% and is majorly caused by crude oil price (24.96%) and Inflation rate (25.48%). The variation in the import price index during the initial period was explained (40.53%) by its own shock and the remaining variation has been majorly caused by the gold price (51.449%) and crude oil price (4.68%). But in later stages, all other variables have caused more than 80% of the variance in the import price index. The forecast error variance decomposition of the inflation rate showed that throughout the period from the initial to the end period, 80% of the variance in inflation was caused by its own shock. But the variation was explained by its own factor which drastically decreased in the case of nifty and it was highly influenced by import price index (22%), GDP (19%), and dollar to rupee exchange rate. finally, variance decomposition for the rupee-dollar exchange rate was calculated and the result showed that only 47.05% of the variance was explained by its own shock in the initial period, and the remaining variations were majorly explained by the import price index (37.94%). At the end period, major variation in the rupee-dollar was caused by the import price index (40%) and its own shock (30%).

Table 5: Bounds-testing cointegration procedure results

Cointegration hypotheses	F-statistics	Lags
F (LNCRUDE \LNIFTY LNGOLD LNIMPORT LNINFLAT LNRUPEE LNGDP)	2.571762	4,1
F (LNIFTY\LNGOLD LNIMPORT LNINFLAT LNRUPEE LNGDP LNCRUDE)	1.529296	4,1
F (LNGOLD\ LNIMPORT LNINFLAT LNRUPEE LNGDP LNCRUDE LNIFTY)	5.959426	4,1
F (LNIMPORT \LNINFLAT LNRUPEE LNGDP LNCRUDE LNIFTY LNGOLD)	1.230840	4,1
F (LNINFLAT\LNRUPEE LNGDP LNCRUDE LNIFTY LNGOLD LNIMPORT)	4.039721	4,1
F (LNRUPEE\LNGDP LNCRUDE LNIFTY LNGOLD LNIMPORT LNINFLAT)	1.857339	4,1
F (LNGDP\LNCRUDE LNIFTY LNGOLD LNIMPORT LNINFLAT LNRUPEE	2.386000	4,1

Notes: Critical values for the 1% significance level I (1) is 3.41 and I (0) is 4.68; for the 5% significance level I (1) is 2.62 and I (0) is 3.79; and for the 10% significance level I (1) is 2.26 and I (0) is 3.35. Critical values are from Pesaran *et al*. (2001)

Table 6: Johansen–Juselius multivariate cointegration test results

H0	λtrace	5% C.V.	Prob.**	λmax	5% C.V.	Prob.**
r = 0	408.810	139.275	0.000	193.479	49.586	0.000
r ≤1	215.331	107.347	0.000	126.457	43.420	0.000
r ≤2	88.874	79.341	0.008	42.905	37.164	0.010
r ≤3	45.969	55.246	0.253	23.232	30.815	0.315
r ≤4	22.737	35.011	0.526	12.486	24.252	0.723
r ≤5	10.251	18.398	0.457	9.932	17.148	0.404
r ≤6	0.319	3.841	0.572	0.319	3.841	0.572

Notes: C.V. denotes critical values. λtrace and λmax are the test statistics used to determine the existence of cointegration and, specifically, the number of cointegrating vectors

Table 7: Generalized forecast error variance decomposition

Dependent variable	Period	Crude oil	GDP	Gold	Import price index	Inflation	Nifty	Rupee dollar
Crude oil	1	100.000	0.000	0.000	0.000	0.000	0.000	0.000
	2	88.655	0.052	2.626	3.250	0.026	4.746	0.644
	3	72.208	6.734	2.413	5.343	1.960	8.714	2.629
	4	60.333	13.695	3.169	7.896	1.653	9.942	3.312
	5	57.156	14.992	2.963	8.585	1.569	11.580	3.154
GDP	1	0.185	99.815	0.000	0.000	0.000	0.000	0.000
	2	0.314	67.986	4.990	11.974	13.566	0.287	0.883
	3	4.141	51.905	3.503	28.473	8.688	2.656	0.634
	4	7.448	44.429	7.107	25.185	12.117	2.683	1.032
	5	8.570	40.112	9.080	27.187	10.950	3.067	1.034
Gold	1	8.547	3.977	87.476	0.000	0.000	0.000	0.000
	2	4.662	2.805	87.475	1.111	0.049	3.449	0.449
	3	15.184	1.853	51.817	7.842	18.477	3.677	1.150
	4	24.443	4.197	28.906	10.292	25.128	2.370	4.664
	5	24.958	8.187	22.951	10.387	25.483	2.155	5.879
Import_price index	1	4.670	3.351	51.449	40.530	0.000	0.000	0.000
	2	3.278	2.324	55.163	34.154	3.687	1.391	0.003
	3	15.469	1.710	49.054	26.402	5.590	1.293	0.482
	4	30.187	3.138	32.064	19.330	11.635	1.645	2.003
	5	30.380	4.795	22.646	19.916	16.446	2.250	3.568
Inflation	1	0.594	0.814	8.660	0.120	89.812	0.000	0.000
	2	0.354	6.445	9.776	0.680	80.882	0.594	1.269
	3	0.609	6.340	10.627	0.824	79.532	0.967	1.101
	4	0.485	6.121	9.268	1.539	80.871	0.820	0.897
	5	0.375	6.233	8.456	1.876	81.555	0.817	0.689
Nifty	1	2.628	12.410	3.573	2.777	0.008	78.604	0.000
	2	5.290	18.783	3.115	22.268	8.532	31.873	10.138
	3	8.746	21.812	2.978	22.538	8.905	24.341	10.680
	4	8.673	19.518	10.700	20.026	9.580	22.018	9.485
	5	8.147	18.167	14.319	22.061	8.869	19.916	8.520
Rupee_dollar	1	0.166	6.906	4.979	37.943	2.585	0.346	47.075
	2	2.232	6.619	5.653	33.472	14.760	0.187	37.078
	3	2.795	6.666	5.955	36.743	14.541	0.538	32.761
	4	2.697	6.349	5.431	41.402	13.534	0.485	30.102
	5	2.870	6.267	6.842	40.074	13.111	0.783	30.054

With the intention to know the impact of dollar rupee fluctuation on an economic variable, the impulse response function was determined and results are plotted in Fig. 2, which reveals that the initial impacts of Dollar to Rupee fluctuations on the GDP of India, Nifty 50 Index, Gold prices in India, import prices in India, inflation rate, crude oil prices in India assuming Dollar to Rupee rate is only exogenous variable. Figure 2 showed that crude oil price increased initially for the one standard deviation increase in the dollar to rupee rate but at the beginning of the third year, it started declining till the last period. The response of GDP to dollar to rupee showed that in the initial period, it decreased but after the third year it increased till the end of the 6th period. The response of gold to the dollar to rupee rate indicates that it initially declines rapidly but it recovers after the fourth period and later it becomes stable. But the response of the import price index to the dollar to rupee rate showed stability in the initial period but decline till the mid-period and again increase afterward till it became stable in the end period. Further, the response of the inflation rate for the one standard deviation changes in the dollar to rupee showed that it declined in the first two years but recovered in the third and fourth years, and afterward, it showed no response. Finally, the response of nifty to dollar to rupee rate exhibits an initial spike till the second period and a gradual decline in the later period.

Table 8 shows the trends in the varibles over 10 periods which is used to establish the relationship of each variables named crude oil, GDP, gold prices, imports,inflation, nifty fifty index with exchange rate which is expressed in the bellow charts.

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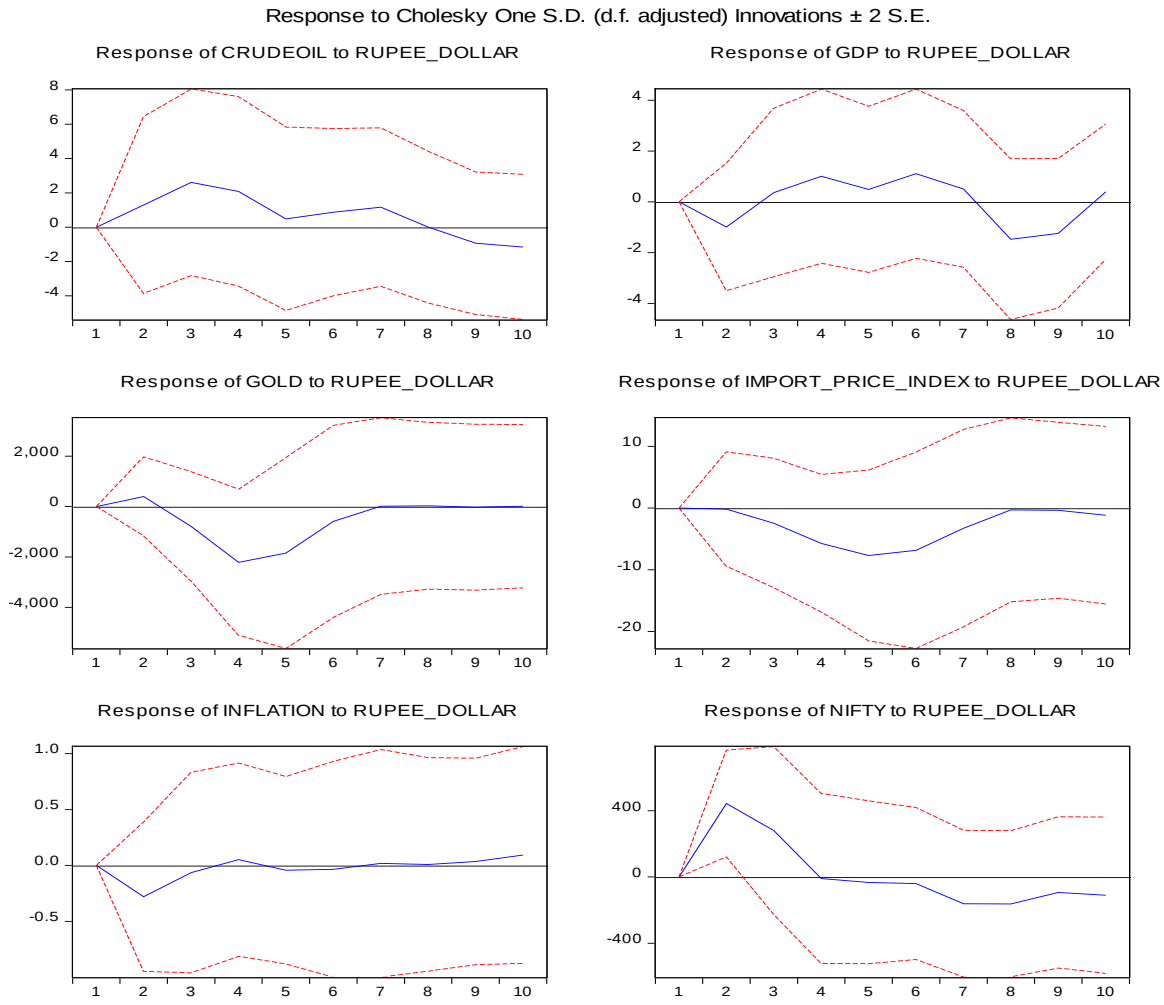

Fig. 2: Generalized impulse Response of Economic Indicators to Rupee-Dollar

Table 8: Response of rupee-dollar rate on various economic indicators (At level)

Period	GDP	Gold	Crude oil	Import_price_index	Inflation	Nifty
1	0.361967	-0.278605	0.131885	-0.843613	-0.220199	-0.080555
	(0.26908)	(0.26122)	(0.25755)	(0.22749)	(0.19118)	(0.18828)
2	0.344429	-0.431280	-0.180872	-0.767147	0.724476	0.027673
	(0.40362)	(0.45391)	(0.47668)	(0.44459)	(0.42607)	(0.24687)
3	0.204459	-0.278590	-0.130485	-0.606389	0.294477	0.131095
	(0.42437)	(0.56180)	(0.47312)	(0.52766)	(0.47053)	(0.25601)
4	-0.127168	0.084885	0.077948	-0.646324	-0.147332	0.001992
	(0.40701)	(0.51580)	(0.44089)	(0.53290)	(0.39641)	(0.22809)
5	0.086192	0.308607	0.019726	-0.043189	-0.034600	-0.127832
	(0.41235)	(0.40973)	(0.44371)	(0.51292)	(0.37070)	(0.21060)
6	0.098363	0.038973	-0.052140	0.276065	0.103604	-0.135218
	(0.34202)	(0.39678)	(0.45387)	(0.44919)	(0.36105)	(0.19669)
7	-0.034945	-0.184756	-0.190864	0.157039	0.010791	0.024837
	(0.28252)	(0.35806)	(0.43649)	(0.42487)	(0.34344)	(0.20338)
8	-0.093773	-0.198153	-0.152094	-0.044004	-0.192391	0.012460
	(0.28439)	(0.32885)	(0.39569)	(0.40558)	(0.30962)	(0.23676)
9	-0.003803	-0.034593	0.010920	-0.008937	-0.109160	-0.095259
	(0.28818)	(0.30890)	(0.35058)	(0.40134)	(0.27634)	(0.25776)
10	-0.040091	0.058669	0.089334	0.046646	0.001384	-0.106741
	(0.30075)	(0.25633)	(0.32177)	(0.37479)	(0.24747)	(0.23738)

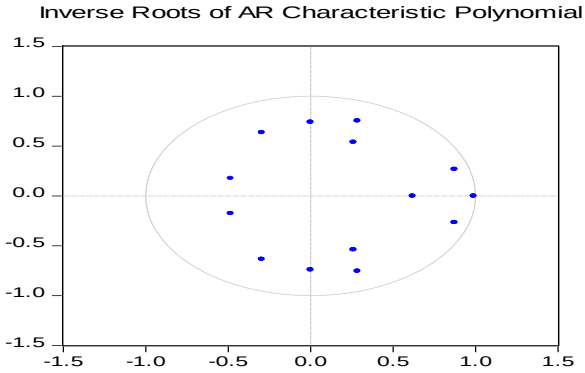

Fig. 3: Stability diagnostic result

As a final step, The VAR for generalized impulse responses and variance decompositions are checked for stability. The VAR system is stable in that all inverse roots of AR characteristics polynomials are within the unit circle (Fig. 3).

Limitations of the Study

There are several limitations to consider for a study investigating the dynamic relationship between the dollar-to-rupee exchange rate and major economic indicators. Some of these limitations include:

- Data availability and quality: The study's results may be limited by the availability and quality of the data used. If the data is incomplete, inaccurate, or outdated, the study's findings may not be representative of the actual relationship between the exchange rate and economic indicators
- Causality and correlation: The study may face difficulties in establishing causal relationships between the exchange rate and economic indicators. It may be challenging to determine whether changes in the exchange rate are causing changes in economic indicators or if the reverse is true
- Timeframe: The study's findings may only be relevant for a specific period and may not be generalizable to other time frames. Economic conditions and policies change over time and what may hold true in one period may not hold in another.
- External factors: The study may not be able to account for all external factors that may influence the exchange rate and economic indicators. These factors could include geopolitical events, natural disasters, and other unexpected events that may impact the study's findings
- Limited scope: The study may only consider a limited set of economic indicators and exchange rate movements. This limited scope may not fully capture the complex interactions between economic indicators and exchange rate movements

Conclusion

This study investigates the relationships between Dollar Rupee fluctuations and the GDP of India, the NIFTY 50 Index, Gold prices in India, import prices in India, the Inflation rate, and Crude oil prices in India, which are indicators of Indian economic growth. The latter is expected to be the link that relates to all these economic indicators. The Dollar to Rupee exchange rate is chosen because these two major currencies are interchangeably used in active portfolios in India. We find that there exists a relationship in the short run, although there does not seem to be a long-run equilibrium relationship between economic variables and changes in the exchange rates which confirms the previous literature. This probably reflects the increasing disparity in economic, monetary, and hedging uses between these indicators and exchange rates.

It may also imply that those economic indicators may not be sensitive to common macroeconomic factors in the long run. Oil is controlled by OPEC and the other oil-producing countries which have their own seasonality, inventories, and hedging strategies. Gold has almost limited supplies, is considered a haven asset, and responds strongly to inflationary expectations. Since there is only rather weak evidence of a long-run relationship, investors may benefit from diversification into gold in the long run. Similarly, exporters may benefit from expanding their exports (if possible) if reserves are available, thereby diversifying the risk of price fluctuations in the long run. However, there is evidence that spot prices and exchange rates may be closely linked in the short-run aftershocks occur. Changes in the nominal price of oil have basically no information to provide to monetary authorities on changes in the exchange rate behavior and the opposite holds as well.

The study has highlighted the need for policymakers to consider a range of economic indicators when formulating exchange rate policies. Furthermore, the research underscores the importance of robust data analysis techniques in understanding the complex interplay between the exchange rate and the broader economic landscape. Ultimately, a better understanding of the relationship between the dollar to rupee exchange rate and major economic indicators can aid in the development of effective economic policies, which can support growth and stability in both India and the global economy.

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Author's Contributions

Abhinandan Kulal: Date analysis and interpretation.
Deepak Kallige Vishwanath: Literature reviewed.
Sanath Kumar Kanthila: Results and discussion.

Ethics

The research paper shows the past performance and the relationship with different variables, where the relationship may change in the future.

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