“Nexus between foreign exchange rate and stock market: evidence from India”

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NEXUS BETWEEN FOREIGN EXCHANGE RATE AND STOCK MARKET: EVIDENCE FROM INDIA

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Abstract

This study examines the impact of foreign exchange rate fluctuations on various NSE capitalized indices of India. Five exchange rates were chosen based on trading contracts in the currency derivative segment of NSE. These exchange rates are US Dollar-Indian Rupee (USD/INR), Euro-Indian Rupee (EUR/INR), Great Britain Pound-Indian Rupee (GBP/INR), Chinese Yuan-Indian Rupee (CNY/INR) and Japanese Yen-Indian Rupee (JPY/INR), which are used as a regressor in this study. The data of NSE Nifty large-cap 100, Nifty mid-cap 100 and Nifty small-cap from December 1, 2012 to December 1, 2022 was considered for the study. GARCH (1, 1) model was used to analyze the nexus between exchange rate fluctuations and capitalized indices, and it was further validated by DCC GARCH to evaluate the volatility spillover. The result shows that exchange rate fluctuations have a positive effect on stock market volatility along with a varying degree of incidence on small-cap, mid-cap, and large-cap. DCC α has been found to be significant in USD & GBP for small-cap, and GBP & CNY for mid-cap. On the other hand, USD, Euro, CNY and JPY have a significant impact on the large-cap index in the short-run. Further, it is found that there is long-run spillover effect (DCC β) of exchange rates on all capitalized indices of the Indian stock market, and it is highest in in the large-cap case.

Keywords exchange rate, stock market, volatility, spillover, India

JEL Classification F31, G10, G32, N20

INTRODUCTION

The global economy became interconnected due to trade openness and technological advancement. Because of the linkage of various economies and markets, it has been found that there is a large spillover from rich nations to poor nations. The dynamic links or spillover across various markets open up several possibilities to develop worldwide portfolios rather than being limited to specific sectors of a single country. Creating a global portfolio stimulates investors by allowing them to invest in a number of nations, which provides a buffer for their portfolio against country-specific risks and uncertainties. According to research conducted within the framework of international portfolio diversification, investment in emerging economies has increased during the last two decades. Therefore, investing in emerging economies is the most attractive opportunities for international portfolio investors. Moreover, the prominence of emerging nations in foreign investors' portfolios demonstrates the immense possibilities for studying and developing effective portfolio management solutions. Further, it is found that FIIs are taking more interest, particularly in emerging nations, due to their growth pattern in post-deregulation and trade openness. As a result, emerging economies offer a great deal of opportunities along with high risks.

Among the emerging and developing nations, India is unique in terms of its openness to globalization and institutional and regulatory frameworks. India adopted liberalization, privatization and globalization in 1991, opening up the economy for free movement of goods, services and capital, which in turn reinforced the financial sector in India. Indeed, the Indian stock market has grown exponentially over the last few decades. For example, the number of Demat accounts has significantly increased because of the rise in awareness and knowledge of the Indian stock market, and investors' confidence.

At the same time, it goes without saying that exchange rate fluctuations triggered by global and institutional factors affect India's economy. No wonder, the exchange rate fluctuations have played an important role in global capital movement and cross-country stock markets. Though countries are implementing policies for having more currency reserves but it is still becoming very difficult for developing countries to maintain the exchange rates with developed economies due to various macroeconomic disturbances (Fukuda & Kon, 2010). Currency values are affected by a wide range of external variables, such as economic growth, inflation expectations, interest rate differentials, capital movements, directions and compositions in foreign trade and so on. The over-all economic conditions and geo-political conditions are also playing a crucial role in determining the value of its currency. Stock market of a country is also affected by exchange rate fluctuations (Wong, 2022). In this context, the study is undertaken to analyze the effects of exchange rate fluctuations on Indian stock market.

Understanding the causes and effects of volatility is very important. Stock market volatility is a statistical measure of how frequently the price of an asset changes over time. Volatility measures how a security's price fluctuates over time, affecting the risk level which is associated with the price change. Traders and investors estimate an asset's volatility to examine past price swings and forecast future price changes. To determine the level of risk associated with an investment, one must examine the level of volatility (Singh et al., 2019, 2022). It has been observed that high volatility is associated with high risk, so investors want to invest in the stocks with the least volatility. Exchange rate fluctuations also have a bearing on the stock market volatility and risk. But, its net effects in terms of degree and direction depend on other macroeconomic variables and country-specific factors. Therefore, its net effects also vary from sector to sector, organization to organization, and country to country.

1. LITERATURE REVIEW AND HYPOTHESES FORMULATION

Expansion of global economic activities triggers faster economic growth. Both Blanchard et al. (2010) and Eaton et al. (2016) argued that cross-regional trade and financial movements are crucial in explaining why there is substantial linkage among global economies (Liao et al., 2019). Currency fluctuation is one of such economic activities, which considerably impacts any economy's growth (Aftab et al., 2021). Uncertain monetary policy and unstable future exchange rate ripen the jeopardy of exchange rate risk (Obstfeld & Rogoff, 1998). Extant literature clearly indicates the impact of exchange rate fluctuations on stock markets. However, there is considerable disagreement among the economists regarding the theoretical literature on the relationship between exchange rate fluctuations and economic development.

Foreign exchange rate fluctuation is always a matter of concern for developing countries. Exchange rate volatility affects not only exports-imports but also a country's GDP. While steps towards greater openness in the Indian forex market have been taken, they are inadequate because India relies on highly illiquid foreign capital inflows to meet its domestic consumption and investment demands (Jyoti, 2021). On the other hand, trade openness and free capital movement have considerable impact on exchange rates. Whilst financial liberalization has the potential to amplify real exchange rate volatility in developing nations, trade liberalization can help in mitigate it (Chen, 2022). Although numerous studies have been undertaken to find the impact of exchange rate fluctuations on different factors like trade value and oth-

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er policy-related factors. A study by Amado and Choon (2020) in Indonesia has proved that there is a significant impact of exchange rate fluctuation on Indonesia stock market. Indian stock market also has been significantly impacted by foreign exchange rate and FII flows. On the contrary, there is evidence that foreign exchange rates and Indian stock prices are not related and fluctuate in their own ways (Suriani et al., 2015).

The impact of exchange rate fluctuations on economic welfare depends on price mechanism and global instability. The changes in the overall state of the economy and the business climate, in general, can significantly affect exchange rate stability (Devereux & Engel, 2003). Theories useful to identify volatility are real option theory, interest rate parity, purchasing power parity, and classic flow theory (Anyanwu et al., 2017). According to the real option theory, the impact of macroeconomic uncertainty is inextricably linked to investment decisions (Dixit & Pindyck, 1994). Therefore, the unstable exchange rate can be used to understand investor behavior as a risk indicator. Moreover, the companies looking to increase their investment during stable exchange rate. Hence, it is evident that exchange rate fluctuations affect stock markets, which further depends on the macroeconomic conditions and degree of globalization (Mohanty et al., 2021; Oskooe, 2010).

Researchers discovered that the volatility of stock market returns is a critical factor in most investment and portfolio management decisions due to its close relationship to market uncertainty. Stock market volatility is one of the most important risk indicators, so it is very essential to forecast volatility to avert investment risk (Green & Figlewski, 1999; Pandey & Mohapatra, 2017). Volatility is said to be low when there is very low fluctuation in the market in short period and considered as low risk situation (Glosten et al., 1993). High volatility may lead to a bearish market whereas, when volatility is low, a bullish market is more likely to be happen (Ang & Liu, 2007).

The SD (standard deviation) is the most used measure of volatility; however, it has limitations due to its assumption of normality in return distributions (Chang et al., 2013; Mei et al., 2017). The tools used in the previous literature are numerous. Descriptive statistics is one such methodology that provides knowledge about skewness, kurtosis, etc. (Fletcher & Kihanda, 2005). Jarque-Bera test is used by the researchers to check the normality of the data (Thadewald & Büning, 2007). The study of financial asset returns is distinct from the analysis of other types of asset returns due to the leptokurtic dispersion of financial time series data, the volatility clustering of financial time series data, and the influence of leverage (Teplova & Shutova, 2011; Vikram et al., 2022). Models that measure volatility over time are of great value in times of turbulence. (Rastogi, 2014). Engle (1982) proposed an autoregressive conditional heteroscedasticity (ARCH) process to assess the dynamic nature of volatility over time. Bollerslev (1986) then developed generalized autoregressive conditional heteroscedasticity (GARCH) models to address the few limitations of ARCH models. Due to its high forecasting ability, the GARCH family models have replaced all other options for analyzing volatility in financial time series data (Brooks & Rew, 2002).

Further, it has been found that there is not much noticeable literature on the impact of exchange rate fluctuations on capitalized indices of NSE, India. So, based on the research gap, this study is conducted to assess the impact of exchange rate fluctuations on the stock market of India and to ascertain volatility spillover, especially NSE Nifty large-cap 100, Nifty mid-cap 100 and Nifty small-cap. Accordingly, the following hypotheses are formulated:

H01: *There is an impact of exchange rate fluctuations on the small-cap index of Nifty.*

H02: *There is an impact of exchange rate fluctuations on the mid-cap index of Nifty.*

H03: *There is an impact of exchange rate fluctuations on the large-cap index of Nifty.*

2. METHOD

The study is intended to examine the relationship between exchange rate fluctuations and capitalized indices of NSE, India. The study period was considered from December 1, 2012 to December

Table 1. Market capitalization

Source: ICICI Direct.

S. No.	Capitalization	Market-Cap in ₹ Crore (INR)	Number of Stocks
1	Nifty Large-Cap 100	19,218,632.96	100
2	Nifty Mid-Cap 100	3,314,566.98	100
3	Nifty Small-Cap	1,025,533.23	100

1, 2022. The data have been collected from three sources: NSE India, investing.com, and Yahoo finance. The data of market capitalization of NSE Nifty large-cap 100, Nifty mid-cap 100 and Nifty small-cap as of December 2022 are collected and recorded in Table 1. Number of observations varied from 2,470 to 2,490 while collecting the data for all the variables. Data have been cleaned in order to keep the observation equal for all selected variables. So, after the process of data sanitization and validation, total observations of 2,363 are considered for the study.

Five exchange rates have been chosen based on trading contracts in the currency derivative segment of NSE. These exchange rates are US Dollar-Indian Rupee (USD/INR), Euro-Indian Rupee (EUR/INR), Great Britain Pound-Indian Rupee (GBP/INR), Chinese Yuan-Indian Rupee (CNY/INR) and Japanese Yen-Indian Rupee (JPY/INR), which are used as a regressor in this study. The daily prices are converted into logarithmic return. The indices return is termed as LSMALL, LMID, and LLARGE; and the currencies' log returns are termed as LUSD, LEURO, LGBP, LCNY, and LJPY.

To find out the impact and effects, the study included multiple models and techniques. Descriptive statistics is used to provide the information and summarize the tendencies of the selected data. ADF test used to check unit root in the series. Models of the GARCH family like GARCH (1, 1) and DCC GARCH are used to check the volatility/effect of independent variables on dependent variables. The Augmented Dickey Fuller test (ADF) examines the return series' stationarity. Dickey and Fuller (1979, 1981) carried out the early and ground-breaking work on testing for a unit root in time series. In the univariate form of time series, ADF looks for a unit root. The presence of a constant factor in the regression is shown by a non-zero mean. The three fundamental regression models are listed herewith, followed by the ADF test:

No trend, no constant:

$$\Delta r_t = \gamma r_{t-1} + \sum \beta_i \cdot \Delta r_{t-1} + \varepsilon_t. \quad (1)$$

Constant, no trend:

$$\Delta r_t = \alpha + \gamma r_{t-1} + \sum \beta_i \cdot \Delta r_{t-1} + \varepsilon_t. \quad (2)$$

Constant and trend:

$$\Delta r_t = \alpha + \gamma r_{t-1} + \lambda_t + \sum \beta_i \cdot \Delta r_{t-1} + \varepsilon_t. \quad (3)$$

Akaike Information Criteria (AIC) is considered to run ADF for checking the stationarity of the series (Akaike, 1974) and to validate the lag length duration to avert serial correlation of the residuals. ARCH/GARCH tests are applied after stationarity of unit root tests. The autoregressive conditional heteroscedasticity-Lagrange multiplier test (ARCH-LM) is used to determine if there is heteroscedasticity in the residuals. As per the model, variance of error term is dependent on error term of previous days.

The ARCH equation is given below:

$$\varepsilon_t^2 = \omega + \alpha_1 \varepsilon_{t-1}^2 + \alpha_2 \varepsilon_{t-2}^2 + \ldots + \alpha_p \varepsilon_{t-p}^2 + v_t. \quad (4)$$

Where ε_t^2 = Squared residual; ω = Constant; α_1 = Coefficient.

GARCH model can be applied only if there is the ARCH effect in the series (Engle, 1982). The Lagrange Multiplier (LM) test for autoregressive conditional heteroscedasticity (ARCH) is used to check for heteroscedasticity in the return series. Contrary to models like ARMA, which employ a constant variance estimate, GARCH type models offer a variable estimate for the series' volatility for each prediction point. This means that any standardized residual resulting from the GARCH estimation will be less than the standardized residual resulting from the ARMA model. As a result, it would anticipate that the t-scores of the residuals would be less for the GARCH models than the ARMA model.

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Estimating models with many parameters, such as ARCH, can be challenging in empirical settings (q). Given that the variance in the next period in an ARCH (1) model depends only on the squared residual of the previous period. Generalized ARCH (p, q) models, or GARCH (p, q) models, are offered as a solution to this issue for modelling volatility (Bollerslev, 1986). Experts in financial modelling frequently choose GARCH (1, 1) over other forms when making predictions about the future values of financial instruments, since it better reflects the realities of the market. The simplest, but most widely accepted and adopted GARCH model is the GARCH (1, 1) model (Brooks & Rew, 2002). The specifications for the GARCH (1, 1) model are given along with the mean equation and variance equation:

Conditional mean equation:

$$y_t = \beta_0 + \varepsilon_t. \tag{5}$$

Conditional variance equation:

$$\sigma_t^2 = \alpha_0 + \sum_{i=1}^{p} \alpha_i \varepsilon_{t-i}^2 + \sum_{j=1}^{q} \beta_j h_{t-j}. \tag{6}$$

Where y_t = conditional mean; ε_r = error term; h_t = conditional variance; P and Q = lags of error term; σ_t^2 = conditional variance.

The predictable volatility model was created in order to determine a series' asymmetric behavior. Black (1976) first made this discovery and later confirmed by Schwert (1990). According to Enders (2004), the TGARCH conditional variance equation is as follows:

$$h_t = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \beta_1 h_{t-1} + \lambda \varepsilon_{t-1}^2 d_{t-1}. \tag{7}$$

Where d_{t-1} is termed as a dummy variable, where 1 can be used for the current period, and 0 for the previous period. Dummy denotes whether certain traits are present or absent. If the coefficient of the dummy variable is statistically significant, this indicates that the leverage effect is present.

Reviewing and analyzing the many connections that link multiple series together is the focus of a study on the transmission of volatility. Therefore, it is crucial for financial econometrics to comprehend and forecast an asset's temporal dependency in moments of the second order. It is now generally acknowledged that the markets and assets are affected by financial volatility throughout the time. Instead of using distinct univariate models, a multivariate modelling framework is opted that recognized this function produced more pertinent empirical models (Kebalo, 2016), through Dynamic Conditional Correlation GARCH (DCC GARCH) model (Engle, 2002).

$$Q_t = \left[1 - \sum_{i=1}^{P} \alpha_{DCC,i} - \sum_{j=1}^{Q} \beta_{DCC,j}\right] Q + \\ + \sum_{i=1}^{P} \alpha_{DCC,i} \left(\varepsilon_{t-j} \varepsilon_{t-1}^{'}\right) + \sum_{j=1}^{Q} \beta_{DCC,j} Q_{t-j}. \tag{8}$$

3. RESULTS

Descriptive statistics of the return series of all three capitalizations small-cap, mid-cap, and large-cap are depicted in Table 2. The highest mean return shown by mid-cap index followed by the large-cap, and small-cap has the lowest mean return. The large-cap has the highest kurtosis and small-cap has the lowest. All the series have kurtosis higher than 3. So, the series is heavy-tailed and found to be leptokurtic. However, all the series are negatively skewed, so the data are left-skewed.

Table 2. Descriptive statistics

Statistics	LSMALL	LMID	LLARGE
Mean	0.000380	0.000548	0.000469
Median	0.002117	0.001869	0.000785
Std. Dev.	0.013728	0.012116	0.010639
Skewness	–1.474892	–1.513949	–1.435572
Kurtosis	12.59867	15.06204	21.34997
Jarque-Bera	9923.913	15221.21	33950.31
Probability	0.000000	0.000000	0.000000
Sum	0.896778	1.295356	1.107321
Sum Sq. Dev.	0.444947	0.346586	0.267244

The ADF test is applied to the series to check the stationarity and the criteria taken for the test is AIC (Akaiki Information Criterion). It can be observed that all the series are showing significance at the 1% level (Table 3). In terms of volatility, the series of capitalized indices are mean reverting (Figure 1).

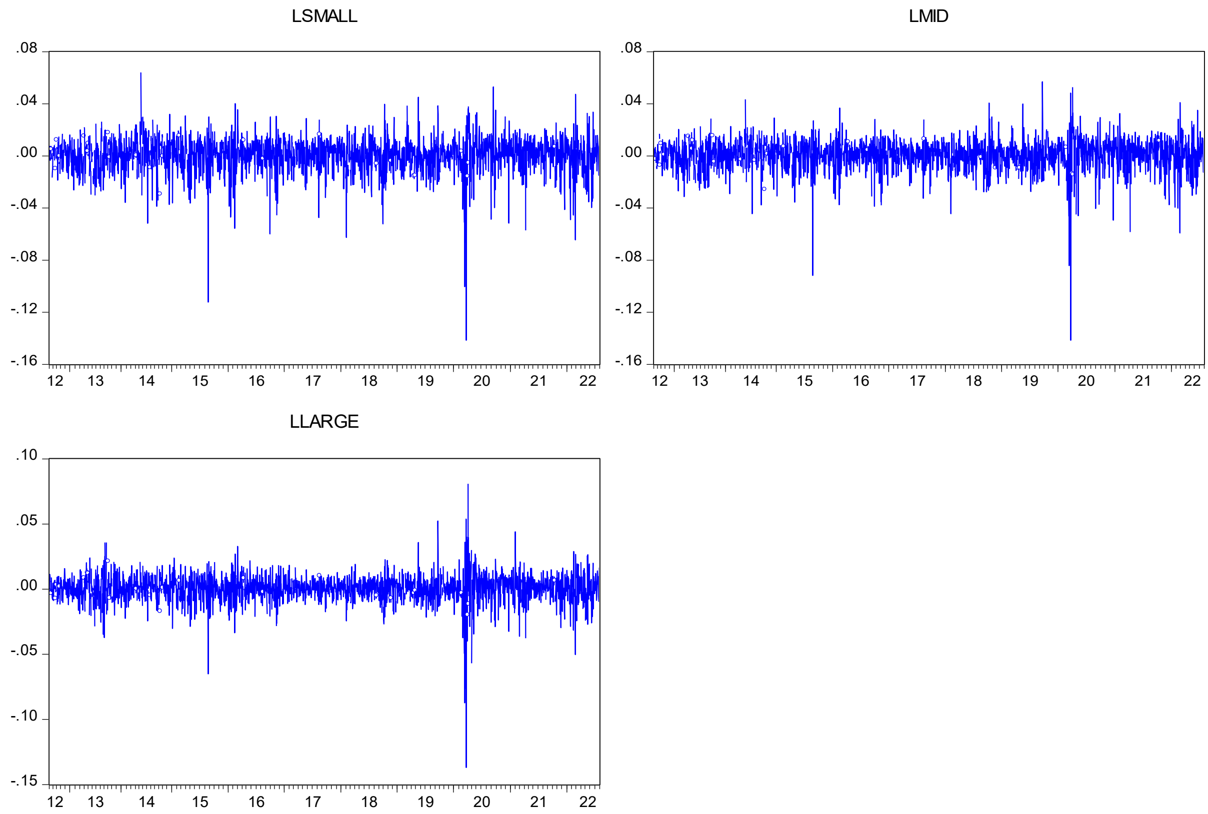

Figure 1. Time series plot of all the indices

Table 3. Unit root test results

Statistics	LSMALL	LMID	LLARGE
At Levels	0.0000	0.0001	0.0000

The ARCH L-M test is applied to check the heteroscedasticity of all the series. The basic criteria for applying any of the GARCH model is that there should be an ARCH effect. All the series in Table 4 show the probability 0.0000, hence, it is observed that there is heteroscedasticity in all the three return series.

Table 4. ARCH L-M test

Statistics	LSMALL	LMID	LLARGE
F-Statistics	19.61055	43.47160	59.24677
Probability	0.0000	0.0000	0.0000

GARCH (1, 1) is found to be the suitable model for volatility modelling. Table 5 shows GARCH (1, 1) model results. The reported items are α, β, probability of the variance equation and constant.

Table 5. GARCH test

Statistics	LSMALL	LMID	LLARGE
Constant	0.00000192	0.00000112	0.000000227
Probability	0.0000	0.0000	0.0000
α^*	0.174639	0.131507	0.097069
β^*	0.723669	0.792215	0.877425
$\alpha^* + \beta^*$	0.898308	0.923722	0.974494

The coefficients are found positive and statistically significant. The ARCH term value of small-cap is 0.174639, mid-cap is 0.131507, and large-cap is 0.097069. To report for the asymmetric aspect of stock market volatility, the GARCH model is adjusted. The threshold autoregressive conditional heteroscedasticity is a model of asymmetric GARCH (TGARCH). RESID (-1) ^2*(RESID(-1)<0) is the TGARCH term in the EViews software.

Table 6. TGARCH

Statistics	LSMALL	LMID	LLARGE
α^*	0.022190	-0.002928	−0.017665
β^*	0.712444	0.780617	0.877317
λ^*	0.253474	0.218841	0.196686
Probability	0.0000	0.0000	0.0000

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Table 7. GARCH model of small-cap and exchange rate as a regressor

Statistics	LUSD	LEURO	LGBP	LCNY	LJPY
Coefficient	0.002625	0.001895	0.000467	0.002368	0.002006
Probability	0.0000	0.0000	0.0092	0.0000	0.0000

The volatility relationship among all the exchange rates with the small-cap index is reported in Table 7.

It is observed that the probabilities of all the exchange rates are less than 0.05, which indicates the significance of the coefficients at the 5% level. US dollar is having the highest coefficient in the variance equation and GBP has the lowest. The GARCH term is highest in case where JPY is used as a regressor. The lowest beta is found in USD. The equations of the model are:

$$\begin{aligned} GARCH_{Small\ Cap} &= 2 \cdot 10^{-6} + \\ &+0.162600 \cdot RESID(-1)^{\wedge}2 + \\ &+0.723691 \cdot GARCH(-1) + \\ &+0.002625 \cdot LUSD. \end{aligned} \quad (9)$$

$$\begin{aligned} GARCH_{Small\ Cap} &= 19 \cdot 10^{-7} + \\ &+0.157250 \cdot RESID(-1)^{\wedge}2 + \\ &+0.735571 \cdot GARCH(-1) + \\ &+0.001895 \cdot LEURO. \end{aligned} \quad (10)$$

$$\begin{aligned} GARCH_{Small\ Cap} &= 18.8 \cdot 10^{-7} + \\ &+0.170686 \cdot RESID(-1)^{\wedge}2 + \\ &+0.728785 \cdot GARCH(-1) + \\ &+0.000467 \cdot LGBP. \end{aligned} \quad (11)$$

$$\begin{aligned} GARCH_{Small\ Cap} &= 19.2 \cdot 10^{-7} + \\ &+0.168036 \cdot RESID(-1)^{\wedge}2 + \\ &+0.726056 \cdot GARCH(-1) + \\ &+0.002368 \cdot LCNY. \end{aligned} \quad (12)$$

$$\begin{aligned} GARCH_{Small\ Cap} &= 19.2 \cdot 10^{-7} + \\ &+0.141437 \cdot RESID(-1)^{\wedge}2 + \\ &+0.748008 \cdot GARCH(-1) + \\ &+0.002006 \cdot LJPY. \end{aligned} \quad (13)$$

From the above equations, it can be concluded that all the dependent variables are able to explain the volatility of small cap index, as all the coefficients are found positive and significant.

The coefficients of exchange rates are 0.800538, 0.802801, 0.808973, 0.795909 and 0.799396 of USD, EURO, GBP, CNY, and JPY respectively. The ARCH and GARCH terms for the variables are reported in the equations. CNY has the highest ARCH term and GBP has the highest GARCH term. The lowest ARCH term is 0.109074 for JPY and the lowest GARCH is for CNY (0.795909). All the variables are found to have a positive effect on the volatility of the mid-cap index.

$$\begin{aligned} GARCH_{Mid\ Cap} &= 11.6 \cdot 10^{-7} + \\ &+0.112317 \cdot RESID(-1)^{\wedge}2 + \\ &+0.800538 \cdot GARCH(-1) + \\ &+0.001636 \cdot LUSD. \end{aligned} \quad (14)$$

$$\begin{aligned} GARCH_{Mid\ Cap} &= 10.9 \cdot 10^{-7} + \\ &+0.116259 \cdot RESID(-1)^{\wedge}2 + \\ &+0.802801 \cdot GARCH(-1) + \\ &+0.001533 \cdot LEURO. \end{aligned} \quad (15)$$

Table 8. GARCH model of mid cap and exchange rate as a regressor

Statistics	LUSD	LEURO	LGBP	LCNY	LJPY
Coefficient	0.001636	0.001533	0.000608	0.001410	0.001327
Probability	0.0000	0.0000	0.0000	0.0000	0.0000

$$GARCH_{Mid\ Cap} = 10.3 \cdot 10^{-7} + \\ +0.117246 \cdot RESID(-1)^{\wedge} 2 + \\ +0.808973 \cdot GARCH(-1) + \\ +0.000608 \cdot LGBP. \tag{16}$$

$$GARCH_{Mid\ Cap} = 11.4 \cdot 10^{-7} + \\ +0.120338 \cdot RESID(-1)^{\wedge} 2 + \\ +0.795909 \cdot GARCH(-1) + \\ +0.001410 \cdot LCNY. \tag{17}$$

$$GARCH_{Mid\ Cap} = 12.2 \cdot 10^{-7} + \\ +0.109074 \cdot RESID(-1)^{\wedge} 2 + \\ +0.799396 \cdot GARCH(-1) + \\ +0.001327 \cdot LJPY. \tag{18}$$

Error distribution taken in the specification of the model is normal Gaussian. All the variables are found significant at the 1% level. CNY contributes highest to the volatility of the large-cap index, and GBP has the lowest impact in this case. The beta term is found the highest in GBP.

$$GARCH_{Large\ Cap} = 33.7 \cdot 10^{-8} + \\ +0.084905 \cdot RESID(-1)^{\wedge} 2 + \\ +0.878052 \cdot GARCH(-1) + \\ +0.000727 \cdot LUSD. \tag{19}$$

$$GARCH_{Large\ Cap} = 29.1 \cdot 10^{-8} + \\ +0.087918 \cdot RESID(-1)^{\wedge} 2 + \\ +0.882071 \cdot GARCH(-1) + \\ +0.000721 \cdot LEURO. \tag{20}$$

$$GARCH_{Large\ Cap} = 27.4 \cdot 10^{-8} + \\ +0.089025 \cdot RESID(-1)^{\wedge} 2 + \\ +0.884106 \cdot GARCH(-1) + \\ +0.000370 \cdot LGBP. \tag{21}$$

$$GARCH_{Large\ Cap} = 31.6 \cdot 10^{-8} + \\ +0.088861 \cdot RESID(-1)^{\wedge} 2 + \\ +0.877746 \cdot GARCH(-1) + \\ +0.000735 \cdot LCNY. \tag{22}$$

$$GARCH_{Large\ Cap} = 36.7 \cdot 10^{-8} + \\ +0.082975 \cdot RESID(-1)^{\wedge} 2 + \\ +0.877661 \cdot GARCH(-1) + \\ +0.000704 \cdot LJPY. \tag{23}$$

The probability of F-statistics and Chi-square of all indices was found to be insignificant (Table 10). The probabilities of F-statistics and Chi-square of small-cap are 0.7601 and 0.7600, respectively. The probabilities of mid-cap are 0.6832 and 0.6831. The large-cap has probabilities of 0.6195 and 0.6193. Finally, it can be concluded that all the indices' models are free from the heteroscedasticity issue and the models are fit and robust.

Table 10. ARCH L-M diagnostic test

Statistics	Small-Cap	Mid-Cap	Large-Cap
Prob. F	0.7601	0.6832	0.6195
Prob. Chi-Square	0.7600	0.6831	0.6193

DCC-GARCH analyses the spillover effect of one variable to another. The spillover of exchange rates to capitalized indices is analyzed. DCC α and DCC β for all the variables are shown in Table 11. The estimates, standard error, t-value and significance are presented in the table. DCC α shows short-run spillover and DCC β shows long-run spillover.

Table 9. GARCH model of large cap and exchange rate as a regressor

Statistics	LUSD	LEURO	LGBP	LCNY	LJPY
Coefficient	0.000727	0.000721	0.000370	0.000735	0.000704
Probability	0.0000	0.0000	0.0000	0.0000	0.0000

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Table 11. Dynamic conditional correlation parameters

Variables	Coefficients	LSMALL		LMID		LLARGE	
		DCC *α*	DCC *β*	DCC *α*	DCC *β*	DCC *α*	DCC *β*
USD	Estimates	0.034059	0.779568	0.034623	0.775001	0.051645	0.804255
	Std. Error	0.016385	0.137130	0.018901	0.195495	0.019967	0.100886
	t-value	2.07862	5.68489	1.83176	3.96429	2.58650	7.97196
	Sig. Value	0.037652	0.000000	0.066987	0.000074	0.009696	0.000000
EURO	Estimates	0.008480	0.984984	0.008422	0.986162	0.018827	0.957486
	Std. Error	0.006524	0.012978	0.015823	0.034244	0.008024	0.023163
	t-value	1.299886	75.898082	0.532251	28.798015	2.346246	41.336915
	Sig. Value	0.193640	0.000000	0.594552	0.000000	0.018964	0.000000
GBP	Estimates	0.004660	0.994285	0.005621	0.993060	0.018883	0.965010
	Std. Error	0.001686	0.002372	0.002218	0.003319	0.020095	0.052815
	t-value	2.76403	419.13952	2.53384	299.17329	0.93966	18.27160
	Sig. Value	0.005709	0.000000	0.011282	0.000000	0.347391	0.000000
CNY	Estimates	0.017809	0.942758	0.021717	0.945580	0.037021	0.895405
	Std. Error	0.010840	0.053732	0.010354	0.035668	0.016095	0.062818
	t-value	1.64297	17.54550	2.09740	26.51082	2.30021	14.25389
	Sig. Value	0.100390	0.000000	0.035958	0.000000	0.021436	0.000000
JPY	Estimates	0.017257	0.966212	0.010496	0.982350	0.015938	0.968175
	Std. Error	0.013601	0.036515	0.010847	0.023115	0.006355	0.015773
	t-value	1.26886	26.46058	0.96761	42.49813	2.50781	61.38215
	Sig. Value	0.204492	0.000000	0.333241	0.000000	0.012148	0.000000

The result shows that exchange rate fluctuations have spillover effect on stock market volatility along with a varying degree of incidence on small-cap, mid-cap, and large-cap. Hence, all the hypotheses (H01, H02 and H03) are accepted. DCC α has been found to be significant in USD & GBP for small-cap, and GBP & CNY for mid-cap. On the other hand, USD, Euro, CNY and JPY have a significant impact on the large-cap index in the short-run. Further, it is found that there is long-run spillover effect (DCC β) of exchange rates on all capitalized indices of the Indian stock market, and it is highest in in the large-cap case.

4. DISCUSSION

The impact of exchange rate fluctuations on the stock market of India, especially NSE Nifty large-cap 100, Nifty mid-cap 100 and Nifty small-cap, is studied based on five selected exchange rates. In terms of standard deviation, small-cap stock is found to be riskier (0.013728) than the other two. Large-cap has the lowest standard deviation (0.010639), indicates the least volatile and uncertainty. All the series are found to be stationary at levels, confirmed by the ADF test. Applied ARCH model revealed that there is a heteroscedasticity in the series. The small-cap has the highest alpha and large-cap has the lowest. The observed GARCH value is 0.723669 for small-cap, 0.792215 mid-cap, and 0.877425 for the large-cap index. All the three capitalizations have values of $\alpha^* + \beta^* < 1$, which means the covariance of the models are stationary. It can also be concluded that the series have time-varying volatility.

The value of the small-cap returns of TGARCH term (λ) is positive (0.253474) and statistically significant. The TGARCH term for the mid-cap index is also positive and it is 0.218841, and large-cap index is found to be positive (0.196686). Hence modelling of information, news or events has found to be very significant in determining asset volatility, and it has also been found that leverage effect exists in all the series. In addition, the result shows that bad news has a greater impact on all the variables than good news. DCC GARCH result reveals that there is a long-run information transmission from exchange rates to capitalized indices. Therefore, it can be observed that in the long term, there is a significant impact of the exchange rate on capitalized indices of the Indian stock market. There have been so many evidences that economic variables affect stock market significantly. Asian stock market and exchange rate have a unidirectional relationship (Tran &

Nguyen, 2022). This study is also supported by the previous literatures where the asymmetry in exchange rate is transmitted to the stock market (Wong, 2022; Mohapatra & Bhaduri, 2019). Contrary to this, some study corroborated that exchange rate hardly affects the movement of stocks (Gokmenoglu et al., 2021; Zhou et al., 2014).

CONCLUSION

The study is undertaken to assess the impact of exchange rate fluctuations on India's stock market. To find the effect of exchange rate fluctuation and its spillover effect, ARCH, GARCH, TGARCH and DCC GARCH tests are used. All the exchange rates and capitalized indices are found volatile, as confirmed by the ARCH L-M test. In the GARCH (1, 1) model, the sum of ($\alpha+\beta$) is found to be close to unity. As a result, volatility shocks are observed to last very long across all capitalizations. Presence of leverage effect is also confirmed by TGARCH. Besides, DCC α of USD with small-cap (0.037652) and large-cap (0.009696) is found to be significant, but insignificant in the case of the mid-cap index. So, it can be concluded that there is a short-run spillover of USD to small-cap and large-cap indices. However, the DCC β is found to be significant in all the three caps. That indicates a long-run spillover from USD to all the indices. While estimating the spillover of Euro to capitalized indices, only large-cap exhibits a short-run spillover, and other two are found insignificant at the 5% significance level. But there is a long-run spillover from Euro to all the capitalizations. GBP has shown a short-run spillover effect on small-cap and mid-cap, but the large-cap is found to be insignificant. At the same time, p-value of all the beta for GBP are found to be significant. So, there is a long-run volatility spillover from GBP to all the capitalized indices. There is a short-run volatility spillover from CNY to small-cap and mid-cap, whereas long-run spillover can be seen in all the caps. There is a short-run spillover from JPY to large-cap and long-run spillover to all the capitalizations. The asymmetry in exchange rate is found to influence stock return in the long-run, but only few exchange rates affect India's stock market in the short-run.

This study's findings can help policymakers to develop sound regulations that benefit investors and keep the stock market running smoothly. The study discovered a significant long-run relationship between exchange rates and indices. As a result, investors who intend to invest in indices or stocks for a longer period must also consider currency volatility. Furthermore, long-term investors will face difficulties due to long-run spillover if they want to hedge their portfolio by taking positions in the currency. However, with indices, currencies with no short-run spillover can be considered for the same. This study can also be helpful to prospective stakeholders to make trustworthy and informed investment choices and decisions.

AUTHOR CONTRIBUTIONS

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