Volatility and Spill Over: Empirical research on USD-INR Exchange Rate and Sensex

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Abstract

The present research is based on measuring volatility between dollar rupee exchange rate and BSE Sensex. The data collection is carried out during April 2001 to March 2022 and exploratory design of research is applied for the study. Descriptive statistical analysis is applied to process gathered data including GARCH (1,1) correlation and regression analysis. We found the presence of return and volatility spillover effects between INR-USD exchange rate and the BSE Sensex. The results of this study imply that the INR-USD exchange rate and the BSE Sensex are interdependent, and changes in one can have an impact on the other.

Keywords: GARCH, Spillovers, Volatility, Exploratory Design, Sensex

Introduction

Liberalisation, globalisation and recent economic reforms has led to a significant transformation in global investment and trading patterns in the recent years. Today's global financial markets are marked by interdependence of economies and have changed the whole lot of global financial landscape. As a result study of relationships between major macroeconomic indicators and key asset classes has

564

garnered attention of several researchers. Understanding the intricacies and co-integrating relationships between major stock market indices and exchange rates can be of paramount importance for investors and policy makers. India being one of the fastest growing economies and US being the epicentre for trade and one of the most developed economies, there has been a surge in bilateral trade and investments between the two countries. Indo-US ties, trade treaties and cross country portfolio investments have yielded considerable relevance to INR-USD exchange rates. Bombay stock exchange is one of the oldest stock exchanges in India and SENSEX is its leading indicator and serves as a benchmark indicator of overall health and performance of Indian stock market.The link between the USD-INR exchange rate and the Sensex, India's benchmark stock market index, is a crucial part of India's financial environment. This link is complicated and can be impacted by a variety of economic, geopolitical, and market factors. The movements of the USD-INR exchange rate and the Sensex have far-reaching implications for investors, policymakers, and the wider economy. Understanding these linkages is critical for making educated investment decisions, developing successful economic policies, and sustaining financial stability in the face of a global financial system that is becoming increasingly linked.

The purpose of this research study is to look at the complex link between the INR-USD exchange rate and the BSE Sensex, focusing on the spillover effects of returns and volatility between these two important financial variables i.e. understanding how changes in the exchange rate (e.g., USD-INR) can influence the returns and volatilities of the stock market index (e.g., BSE Sensex), and vice versa. The influence of changes in the exchange rate on the returns of the stock market index, or vice versa, is referred to as return spillover. Positive return spillover means that a rise in the exchange rate leads to better stock market index returns, whereas negative return spillover shows that an increase in the exchange rate leads to lower stock market index returns. The influence of changes in the exchange rate on the volatility of the stock market index, on the other hand, is referred to as volatility spillover. Positive volatility spillover means that a rise in the exchange rate causes increased volatility in the stock market index, whereas negative volatility spillover says that an increase in the exchange rate causes decreased volatility in the stock market index. Currency volatility caused by geopolitical events or economic uncertainties can cause higher market volatility, influencing the BSE Sensex. A stable and predictable exchange rate, on the other hand, may result in lesser stock market volatility. This information is required for making sound investment decisions, managing risk, and developing sound economic policies.

The motivation for investigating return and volatility spillovers stems from the possible ramifications for investors and policymakers. Market players can better grasp the impact of macroeconomic events and design more educated investment strategies by comprehending the interconnectivity between the currency exchange rate and the stock market. Furthermore, policymakers can acquire insights into the pathways via which financial disruptions spread across markets and create effective financial stability interventions.

To achieve the research objectives, the researchers have employed ADF, PP test to check stationarity of data and then ARCH/ GARCH Model (Generalized Autoregressive Conditional Heteroskedasticity) have been applied using Eviews. These models allow for the estimation of relationships between INR-USD exchange rate and the BSE Sensex, as well as the identification of spillover effects over time.

The research paper is organised into 4 sections. The first section covers an extensive review of the existing literature on currency-market interactions and spillover effects. The second Section covers the sources of data and the methodology employed for analyzing return and volatility spillovers. The third

section throws light on interpretation of the results. The fourth section summarises the conclusion and theoretical and practical implications of the research.

Literature Review:

A growing body of research studies the return and volatility spillover between the foreign exchange rate and stock market. However most of the studies have focused on developed countries rather than developing countries. (Mishra 2004). A review of the literature revealed various viewpoints from analysts on the issue of whether exchange rate swings impact the stock market. Exchange rate volatility has implications for a country's financial system, particularly the stock market (Kanas 2000). The USD/INR exchange rate and the volatility of the BSE Sensex are significantly positively correlated. Investors should consider exchange rate shifts while making investing choices because the USD/INR exchange rate has a substantial impact on the BSE Sensex.(Ahluwalia et al 2018). Although there is a sizable amount of volatility spillover between exchange rates and stock returns, this spillover could be overstated if volatility changes are not taken into consideration.(Malik 2021).

Mishra et al (2007) finds that there is a strong spillover impact between the stock and foreign exchange markets in India based on the evidence of a bidirectional relationship between the two markets. Vincent (2020) also concludes that there is bidirectional volatility spillover between the foreign exchange market and major stock market sectors in the long run, even though they are very small in magnitude. The foreign exchange market is negatively impacted by the stock market's volatility spillover, whereas the stock market is positively impacted by the foreign exchange market's volatility spillover. (Zhang et al 2021). There is a long term relationship between foreign exchange markets and stock markets and there is an information flow between these markets. Both the markets move in coordination with each other(Mitra 2017).

Indian stock market return is co-integrated with market returns of US, UK and Japanese stock markets.The US stock market transmits inbound volatility to the Indian stock market.India experiences rapid volatility spillover from international markets, with the effect lasting just up to three days (Bahadur et al 2017). Conditional volatility of currency rates has a notable leveraging effect on the Indian Rupee. As a result, the volatility of the Indian Rupee is significantly influenced by asymmetries in innovation (Panda et al 2019). There is a two-way causal relationship between the Indian stock market and foreign exchange market. This implies that changes made in one market may result in changes made in the other, and vice versa.(Mishra 2004)

Several Methodologies have been used by various authors to understand the return and volatility spillover effects between exchange rates and stock markets. (Kutlu 2020 et al) used the GARCH model for volatility analysis and AS model for return and spillover analysis. (Bhowmik et al 2020) conducted a systematic literature review of previous studies featuring GARCH family-based model stock market return and volatility.It suggests that GARCH models are effective for analyzing stock market return and volatility. Zhu et al (2019) utilized two models to test the volatility spillover effect among the foreign exchange market, stock market, and bond market in China. VS-MSV model l is used to test the volatility spillover effect between the stock and foreign exchange market in China whereas CoVaR model is used to measure the volatility spillover effect in China's foreign exchange bond market.The volatility spillover between the Indian stock and foreign exchange markets is examined using the diagonal BEKK-GARCH model by Vincent (2020). The study uses the daily data of BSE sector indices and the everyday rupee exchange rate against the US dollar.

566

Changes in exchange rates can have an impact on a nation's balance of payments. Exchange-rate earnings have an impact on firm yield levels and the trade balance of an economy. Price changes in the stock markets can have indirect effects on the exchange rate, wealth, and liquidity that affect aggregate demand.(Subair et al 2004). Financial investigators, specialists, and controllers all view a divergent movement in stock prices as a measure of risk. Excessive stock return volatility " undermines the value of stock prices as a "pointer" of the true major economic indicators of a company (Karolyi, 2001).

The link between the stock market and foreign exchange can be attributed to a number of factors.The spillover effects are heavily influenced by macroeconomic factors such as GDP, inflation, interest rates, and currency rates.(Taly 2015) (Abbas 2019). Additionally, when the rate declines, investors take a selling stance, which results in a drop in indices, and vice versa (Ahluwalia et al 2018). The existence of the portfolio-balance technique in the Indian context, also causes a unidirectional spillover from the stock market to the foreign exchange market (Majumder 2015)

Methodology:

The relationship between the variables-BSE SENSEX indices and the INR/USD exchange rate will form the basis for the analysis in this study.The data collection is carried out during April 2001 to March 2022.and exploratory design of research is applied for the study.Data from secondary sources are also used for this study which is acquired from the online platforms like websites of BSE.Descriptive statistical analysis is applied to process and gather the data which includes GARCH (1,1)correlation and regression analysis.The closing price details of the last trading day of INR/USD,exchange rates and BSE SENSEX can be clearly seen and are well explained in the end part of the study.BSE was found as a strong core element of the stock market sector from January 1,1986.During this years 1978-79 is considered as base year and SENSEX considered the base value as hundred from the beginning of financial year,ie April 1,2023.

Objectives of the study:

The researchers have framed the following objectives for the study:

- To examine the linkages between the INR-USD exchange rate and the BSE Sensex.
- To investigate the presence of return and volatility spillover effects between INR-USD exchange rate and the BSE Sensex

Research Hypothesis:

For the above stated objectives the researchers framed the following hypotheses to analyse the interconnections between the INR-USD exchange rate and the BSE Sensex

- There is a significant return spillover effect between the INR-USD exchange rate and the BSE Sensex.
- There is a significant volatility spillover effect between the INR-USD exchange rate and the BSE Sensex.

Data

To evaluate the presence and magnitude of return and volatility spillover effects between the INR-USD exchange rate and the BSE Sensex, the researchers selected monthly data from April 2001 to March

2022. The SENSEX closing prices have been collected from yahoofinance.com while data on Exchange rates have been collected from Bloomberg Terminal.

Logarithmic returns were then calculated using the formula:

R = ln P(t) – ln P(t-1)

Where, R is the daily return

P(t) is the closing Price of the day

P(t-1) is the closing price of previous day

Research Techniques:

The researchers used ADF and the PP test to determine data stationarity before using the ARCH/ GARCH Model (Generalised Autoregressive Conditional Heteroskedasticity) with Eviews. These models may estimate the links between the INR-USD exchange rate and the BSE Sensex, as well as identify spillover effects over time.

Data Analysis and Interpretation:

Descriptive Statistics:

A Preliminary analysis was done to analyse the basic behaviour of the data. The results of descriptive statistics for SENSEX returns and INR-USD exchange rate returns are tabulated and shown in table 1:

	RBSE	REXCH
Mean	0.011203	0.001923
Median	0.011157	-0.000434
Maximum	0.248851	0.076851
Minimum	-0.272992	-0.068299
Std. Dev.	0.064113	0.020657
Skewness	-0.704675	0.341551
Kurtosis	6.003332	5.242451
Jarque-Bera	115.1073	57.47081
Probability	0.000000	0.000000
Sum	2.811975	0.482692
Sum Sq. Dev.	1.027632	0.106680
Observations	251	251

Table No. 1: Descriptive statistics of Sensex and exchange rate returns

Figure 1. Alt Text: Statistical analysis of standard deviation,data distribution using skewness and kurtosis analysis,jarque-bera test to understand the normal distribution of the data along with probability distribution data

It was observed that the mean return of SENSEX and USD-INR are 0.011 and 0.001923 respectively. The maximum and minimum values of Sensex returns were observed to be 0.248851 and -0.272992

respectively. Similarly the maximum and minimum values of Exchange rate returns were observed to be 0.076851 and -0.068299 respectively. The Sensex return series exhibited negative skewness and are leptokurtic. While exchange rate returns exhibited positive skeweness. The Jarque Bera test indicates that the p values of both Sensex and Exchange rate return are less than 0.05 which indicates that none of these return series are normally distributed.

Unit Root Stationarity test:

For the purpose of testing unit root Augmented Dickey Fuller test and Phillip Pheron Test is applied on Sensex and exchange rate values. The results of ADF and PP tests are tabulated and presented in table no 2.

| Indices | AUGMENTED DICKEY FULLER TEST | | | | PHILLIPS PERRON TEST | | | | |
| | level form | | At first difference | | level form | | At first difference | | |
	TEST STATISTICS	P VALUE LEVEL	TEST STATISTICS	P VALUE	TEST STATISTICS	P VALUE LEVEL	TEST STATISTICS	P VALUE	Decision
BSE	-1.27326	0.8919	-16.008	0.0000	-1.30641	0.884	-16.008	0.0000	I(1)
INR_USD ER	-2.20627	0.4836	-15.1677	0.0000	-2.20174	0.4861	-15.1549	0.0000	I(1)

Table No 2: ADF and PP test

Table No.2 Alt text :The data derived from Augmented Dickey Fuller test and Phillip Pheron Test on sensex and exchange rate values are explained above.

The results indicate Sensex and Exchange rate values are non-stationary at level since p values are greater than 0.05 and are stationary at first difference since p values are less than 0.05. Thus all series are I (1). The unit root null hypothesis has been rejected in favour of the stationary alternative in both the cases at first difference.

ARCH effect:

The values of Sensex and exchange rates were then examined for the ARCH effect to check the presence of heteroskedasticity in the data. In order to test ARCH effect the series were first differenced and then ARCH test was applied. The results are indicated in table No 3.

Heteroskedasticity Test: ARCH

F-statistic	5.852085	Prob. F(1,247)	0.0163
Obs*R-squared	5.762931	Prob. Chi-Square(1)	0.0164

Test Equation:

Dependent Variable: RESID^2

Method: Least Squares

Date: 07/29/23   Time: 14:21

Sample (adjusted): 2001M07 2022M03

Included observations: 249 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.003472	0.000616	5.638757	0.0000
RESID^2(-1)	0.152169	0.062903	2.419108	0.0163

R-squared	0.023144	Mean dependent var		0.004097
Adjusted R-squared	0.019189	S.D. dependent var		0.008904
S.E. of regression	0.008819	Akaike info criterion		-6.615906
Sum squared resid	0.019209	Schwarz criterion		-6.587653
Log likelihood	825.6803	Hannan-Quinn criter.		-6.604534
F-statistic	5.852085	Durbin-Watson stat		1.998210
Prob(F-statistic)	0.016282			

Table No 3: Heteroscedasticity Test: ARCH

Table No.3.Alt Text :To analyse the time series in the context of linear regression to find out errors which are not homogeneous,this test is used.

The results indicate that the probability is less than 5% which means heteroscedasticity is present thus ARCH effect was present in both the variables. Hence, we can apply the GARCH (1, 1) model.

GARCH (1,1) Model for examining volatility spillover:

The researchers applied the GARCH (1, 1) model to assess volatility spillover between Sensex and INR-USE exchange rates. The results of the GARCH Model have been reported in table 4.

Table 4:Alt text:Garch model is used to study the relationship between sensex and INR-USE rates on volatility spillover.The variance spillover errors which are autocorrelated are studied and observed in this analysis which are listed above.

$$GARCH = C(6) + C(7)*RESID(-1)^2 + C(8)*GARCH(-1) + C(9)*UTV$$

Variable	Coefficient	Std. Error	z-Statistic	Prob.
@SQRT(GARCH)	0.574322	1.676660	0.342539	0.7319
C	-0.024428	0.146860	-0.166335	0.8679
RBSE(-1)	0.370626	1.641988	0.225718	0.8214
EBSE(-1)	-0.301349	1.675173	-0.179891	0.8572
UTM	-0.033409	0.007277	-4.590952	0.0000

Variance Equation				
C	0.002988	0.004439	0.673238	0.5008
RESID(-1)^2	0.150000	0.239693	0.625801	0.5314
GARCH(-1)	0.600000	0.553970	1.083091	0.2788
UTV	0.000000	3.55E-05	0.000000	1.0000
R-squared	0.153925	Mean dependent var		0.011365
Adjusted R-squared	0.140055	S.D. dependent var		0.064243
S.E. of regression	0.059575	Akaike info criterion		-2.453033
Sum squared resid	0.865989	Schwarz criterion		-2.325896
Log likelihood	314.4026	Hannan-Quinn criter.		-2.401858
Durbin-Watson stat	1.759017			

Table No 4: GARCH (1, 1) model

The mean equation reveals that there is a significant return spillover effect between the INR-USD exchange rate and the BSE Sensex. Changes in the exchange rate lead to notable effects on the returns of BSE Sensex. Also, the variance equation results indicate that the volatility spillover effect between the INR-USD exchange rate and BSE Sensex is insignificant i.e. Changes in the exchange rate do not influence the volatility of BSE Sensex.

CONCLUSION AND RECOMMENDATIONS:

The results of this study imply that the INR-USD exchange rate and the BSE Sensex are interdependent, and changes in one can have an impact on the other. The selection of exchange rates as independent variable and sensex as dependent variable highlights this fact more prominently.The observational analysis based on empirical evidence on sensex and exchange rates relationship had opened up the possibility of future research both at micro and macro level for contributing to the financial progress of the nation.

Further, the results highlight the underlying interconnection of financial markets and currency rates, emphasising the significance of taking both domestic and international factors into account when analysing the behaviour of these variables.This study also brings understanding on the significance of macroeconomic variables on exchange rate volatility opening up the possibilities for qualitative future research in this field.The analysis of GARC test clearly portrays the volatility of sensex is completely dependent on the exchange rates which in turn strengthen the objectives of the study.

For investors and policymakers, this has significant implications because they must take exchange rate volatility and stock market returns into account as their priority.Future researchers can study the relationship between other currencies like Euro and SENSEX or NIFTY. Future studies might also pay attention to how information flow influences the relationships between foreign currencies and stock market indices.A comparison of developed countries and developing countries and their currencies are also advisable as a suggestion in this study.The diplomatic ties and relationships of countries can also be strengthened by such studies.

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