International Research Journal of Multidisciplinary Scope (IRJMS), 2024; 5(3):955-968 IRJMS

Original Article | ISSN (O): 2582-631X DOI: 10.47857/irjms.2024.v05i03.0917

Forecasting the Volatility of Indian Forex Market: An Evidence from GARCH Model

Raja M[1], Muthu Gopalakrishnan M[2], Sathish Pachiyappan[2]*, Velmurugan[3]

[1]Bharathidasan University, Tiruchirappalli, Tamil Nadu, India, [2]CHRIST University, Bangalore, Karnataka, India, [3]Dr. Ambedkar Law University Chennai, Tamilnadu, India. *Corresponding Author's Email: sathish.p@christuniversity.in

Abstract

Forecasting the volatility of forex market will create more trading opportunities to investors, despite of ups and downs in the forex market. The present study attempted to examine how the volatility in the exchange rate between Indian rupee and selected four foreign currencies, such as US dollar, euro, Japanese yen and British pound, can influence the market return. The data, used in the present study, covered the daily price observation of four foreign currencies, for a period of 5 years, from 2019-2023. The GARCH (1, 1) (generalized autoregressive conditional hetero skedasticity) was used for develop the model for foreign exchange (FX) rates volatility. Mean equation model confirmed that the series had attained stationary and previous price did influence the current price. It was also supported by co-efficient values in the variance equation. The co-efficient value, in the variance equation, was around one, which showed that the forex market was efficient. Further, it was validated that the volatility shocks in forex market were quite persistent. The active investors in the market may use this opportunity immediately. The policy maker may correct this deviation through timely intervention in the currency market.

Keywords: Currency Market, Exchange Rate, Forecasting, Forex Market, Volatility.

Introduction

The price of a nation's currency, in terms of another currency, is known's as the exchange rate. World currencies are being traded everyday against one another to the tune of trillions of dollars per day. Exchange rate between currencies are important macroeconomic variables for investors, government, traders, bankers, policy makers, researchers, economists and industries engaged in international trade. According to efficient market hypothesis of Fama (1965), share price movements follow random walk and they are unpredictable. However, this hypothesis was not accepted by some economists (1, 2). Increase in the securities prices at stock market would appreciate the exchange rates, and decrease in securities prices would depreciate the exchange rates (3). Exports would increase, when there is depreciation in the local currencies, leading to more foreign currencies and revenue (4). The economists suggest that markets exhibit the same structure, with different scales, giving an opportunity to investigate the fractal and multiracial properties of economic and financial time series. Understanding the interrelationship between forex market volatility and stock market volatility creates ample trading opportunities. Stock markets returns are directly or indirectly affected by exchange rate fluctuations of currencies (5). Sudden shocks have caused structural changes in stock markets, leading to asymmetric effects on market efficiency, portfolio allocation, and volatile spillovers in forex market (6).

In the recent past, traders, mutual fund companies, investment companies, portfolio managers and firms, engaging in international trade, consider investment in foreign currencies, to be important. Hence these parties are keen on understanding the linkages between foreign exchange fluctuations and the impact on stock markets and economy. Theoretically, various external factors cause changes in exchange rates between currencies such as inflation rate, GDP growth, balance of payment, interest rate, and prices level. Understanding the exchange rate fluctuation and its consequences, would encourage the stock advisors and portfolio managers to offer valuable suggestions to address the volatility of forex

(Received 07th April 2024; Accepted 11th July 2024; Published 30th July 2024)

market related issues in India. Against this background, the present research paper attempted to forecast the volatility effect of four actively traded currencies, like Dollar (USD), Euro (EUR), Japanese Yen (JPY) and Great British Pound (GBP) on the Indian forex market.

There was no causal relationship between exchange rate volatility of Indian rupee and the US dollar, euro, Japanese yen. But, British Pound could influence the return and volatility of the Indian stock market. Volatility shock of Indian stock markets significantly influenced the Indian currency market. Spillovers in the return and volatility for banking, real estate and gold accounted for more than 25 percent of the forecast error variance in Indian forex market. Indian forex market absorbed the shocks from US economy. Events like general elections and demonetization affected the returns and volatility spillovers in the Indian forex market (7). NARDL model based time series analysis established dynamic link between real exchange rate and capital market in Nigeria. Further, this study also proved that there was bi-directional causality relationship between stock market volatility and exchange rate, but in recent times, there is unidirectional causality, from the stock market to exchange rate (8). Autoregressive distributed lag co integration technique proved that exchange rate volatility affected the depth and efficiency of Nigerian financial sector over the study period. Exchange rate volatility exerted negative effect on Nigerian financial market in the short run, but not in the long run. The long run exchange rate volatility reported adverse effect on Nigerian stock markets. Indonesian stock market reported causal relationship with foreign exchange market, as proved by stock price and exchange rate between the rupiah and U.S Dollar. Besides, there was short run and long run causality between stock price index and exchange rate. Increase in the stock price index triggers changes in the exchange rate of rupiah against US dollar (9).

Volatility spillover is transmitted by the Indian equity market, from Sensex to world economies, composite index. In the short run, Indian stock markets absorbed the spillover effect from global markets. But in the long run, Indian stock market did not absorb any volatility spillover or volatility transmission effect from Euro and NASDAQ (10). Exchange rate is one of the most important determinant factors for stock returns. Stock indices returns are significantly influenced by the foreign exchange rate fluctuations in India. The sensitivity of foreign exchange exposures is measured by the net inflows that are trade balance (11). The behavior of stock market and forex market are influenced by return and volatility spillover in the market. During the global financial crisis period and pre crisis period there was no return spillover from stock to forex markets and during the post crisis period, it was from forex to stock market (12). The central bank of a country changed its exchange rate, based on the co-movement of foreign exchange (Forex) in the matured global market such as US, British, Euro, China and Japan etc. To obtain appropriate profit at forex market, the investor should follow a portfolio investment strategy, with optimal portfolio weights and hedge ratios (13). Forecasting the foreign exchange rate is one of the important parameters to measure the foreign exchange rate risk of joint stock banks of Vietnam. Arima model is absolutely suitable for forecasting the foreign exchange rate of Vietnam (14).

The COVID-19 pandemic significantly influenced upward and downward movements of weak-form market efficiency of crypto currency and forex markets. Before and during Covid- 19 pandemics, there was a distinct shift in crypto currency and forex markets, efficiency (15). Exchange rate and monetary policy interventions on the forex market have significantly influenced the hospitality industry. Currency appreciations, during the pre covid-19 pandemic, benefitted all classes of hoteliers, but reduced the prices of luxury ones (16). Crude oil prices are significantly influenced by foreign exchange rates of global market. Russian–Ukrainian conflict and Covid-19 pandemic caused asymmetric effects on global crude oil price. Foreign exchange rates (FX) were interrelated with West Texas Intermediate (WTI) crude oil prices (17). The highly liquid global foreign exchange (Forex) market plays a crucial role in international trade and investment, especially in currency exchange. Convolution Neural Networks (CNNs) and Recurrent Neural Networks (RNNs), used for forecasting the foreign exchange (Forex) market, exhibit instability due to vulnerability of monolithic architecture (18). World's foreign exchange market is influenced by various technologies like block chain technology, crypto currencies, and electronic trading. Radical

changes took place in the foreign exchange markets, due to the induction of block chain technology (19). From the literature cited above, it is clear that majority of studies measured volatility of the forex market. It is evident that all the markets, reported volatility in the forex trading. Majority of studies were undertaken to measure the volatility of forex trading in the European and Middle East markets but only few studies were undertaken to measure the volatility of forex trading in Asian markets, especially in Indian markets Because of its distinct combination of economic background, market dynamics, and regulatory monitoring, the Indian foreign exchange market is remarkable. The behaviour of the market is influenced by the Reserve Bank of India's (RBI) active role in controlling and intervening to stabilise the rupee, in addition to several capital regulations. Its complexity is increased by the wide range of participants, which includes retail investors, commercial banks, and national and international players. Because of the managed float exchange rate framework under which the market functions, there is significant volatility that is impacted by national and international macroeconomic trends as well as political developments. The Indian forex market is further distinguished by the interaction between onshore and offshore markets, technological developments in trading, and the regulatory framework. For these reasons, study in this field is especially important. Hence the present study makes an attempt to measure the volatility of Indian forex market.

The study aims to find out the normal distribution of returns, earned by actively traded sample (American US Dollar, United Kingdom Great British Pound, European Union Euro and Japanese Yen) currencies in the Indian forex market, over the study period. The second objective of the study is to find out the hetero skedasticity of returns, earned by actively traded sample (American US Dollar, United Kingdom Great British Pound, European Union Euro and Japanese Yen) currencies in the Indian forex market, over the study period. Thirdly, to predict the volatility of actively traded sample (American US Dollar, United Kingdom Great British Pound, European Union Euro and Japanese Yen) currencies in the Indian forex market, over the study period.

Hypotheses of the study are,

H_1- There is no heteroskedasticity in the returns, earned by sample currencies, during the study period.

H_2- GARCH (1, 1) model does not predict the volatility in the floating exchange rate of sample currencies, traded in the Indian forex market during the study period.

Methodology

Period of study

For the purpose of forecasting the volatility of Indian forex market, four actively trading currencies, in the Indian forex market, were chosen i.e. American US Dollar, United Kingdom Great British Pound, European Union Euro and Japanese Yen. The present study attempted to forecast the volatility of above four currencies in Indian forex market, for the period of five years, from January1, 2019 to December 31, 2023.

Sample Design

In order to forecast the volatility of Indian forex market, the present study examined the movement of exchange rates and deviations for four sample currencies i.e. American US Dollar, United Kingdom Great British Pound, European Union Euro and Japanese Yen, for the period of five years, from January1, 2019 to December 31, 2023.

Sources of Data and Econometric Model

The daily return data of four sample currencies i.e. American US Dollar, United Kingdom Great British Pound, European Union Euro and Japanese Yen, were obtained from the Bombay Stock Exchange Official Directory, BSE website www.bseindia.com and Reserve Bank of India websites www.rbi.com. The information regarding Indian forex market was obtained from the RBI publications, Bombay Stock Exchange, National Stock Exchange official directory and BSE & NSE website www.bseindia.com, www.nseindia.com. The study used descriptive statistics to find out the normal distribution of returns earned by four sample currencies traded in the Indian forex market. Further, Unit Root Test is employed to find out the stationary of returns, earned by four sample currencies, traded in the Indian forex market. Finally, GARCH (1, 1) test used to forecast the volatility of four actively traded sample currencies in the Indian forex market i.e. American US Dollar, United Kingdom Great British Pound, European Union Euro and Japanese Yen. The GARCH model was used because it incorporates both prior

squared error factors and previous conditional variances, offering a more comprehensive account of volatility. Also, More suitable for capturing both short-term and long-term volatility patterns

Results and Discussion

This section describes forecasting the volatility of actively traded four (American US Dollar, United Kingdom Great British Pound, European Union Euro and Japanese Yen) sample currencies in the Indian forex market, by using the Descriptive Statistics, Unit Root Test and GARCH (1, 1) Model.

- Normality for the returns, earned by four (American US Dollar, United Kingdom Great British Pound, European Union Euro and Japanese Yen) actively traded sample currencies in the Indian forex market.
- Stationary for the returns, earned by four (American US Dollar, United Kingdom Great British Pound, European Union Euro and Japanese Yen) actively traded sample currencies in the Indian forex market.
- GARCH (1, 1) Model to forecast the volatility of actively traded four (American US Dollar, United Kingdom Great British Pound, European Union Euro and Japanese Yen) currencies in the Indian forex market.

Descriptive Statistics

Table 1 presents the deviations in the return by US Dollar, Pound Sterling, Euro and Japanese Yen, from 2019 to 2023. The maximum returns earned by the US Dollar, during the study period, ranged from 0.013524 to 0.033068, Pound Sterling ranged from 0.014947 to 0.036791, Euro ranged from 0.013526 to 0.041547 and Japanese Yen ranged from 0.024968 to 0.048119. The standard deviations, for the entire sample currencies, were less than one, indicating that all the sample currencies were riskless during the study period. The value of Kurtosis indicated the risk level of the sample currencies. The Kurtosis, for sample currencies, during the study period, ranged from 3.367750 to 8.679754 for US Dollar, ranged from 3.103608 to 13.00998 for Pound Sterling, ranged from 3.367752 to 8.679752 for Euro and ranged from 3.124847 to 5.164148 for Japanese Yen respectively. The Kurtosis values were greater than three, for all the sample currencies, it indicated that the distribution was leptokurtic and the deviations of return for all the samples currencies were low. The overall analysis of descriptive statistics showed that among the four sample currencies, the US Dollar earned low return, with low risk, during the study period.

Table 1: Descriptive Statistics to Check the Normality of Returns Earned by the Sample Currencies from 2019 to 2023

Name of the Countries	Year	Mean	Median	Maximum	Minimum	Standard Deviation	Skewness	Kurtosis
US Dollar	2019	0.000127	0.000390	0.013524	-0.019617	0.005657	-0.379718	3.367750
	2020	0.000852	-0.000851	0.014240	-0.026522	0.005945	-0.380626	4.102169
	2021	0.000446	-1.32e-07	0.033068	-0.026146	0.007670	0.508596	4.872575
	2022	-0.000338	-0.000422	0.030629	-0.017782	0.005149	0.626568	8.679754
	2023	-8.93e-07	-0.000195	0.010215	-0.010107	0.002635	0.208775	5.055359
Pound Sterling	2019	6.46e-08	0.000755	0.014947	-0.017026	0.005963	-0.363012	3.103608
	2020	0.000776	-0.000329	0.036791	-0.020469	0.007559	-0.713114	5.572174

	2021	0.000302	-0.000107	0.012478	-0.015798	0.005041	-0.243979	3.214871
	2022	0.000107	-2.21e-07	0.018685	-0.020912	0.005809	0.120600	3.592850
	2023	-0.000637	-0.000149	0.026852	-0.067761	0.008017	-2.311109	13.00998
	2019	0.000129	0.000392	0.013526	-0.019619	0.005659	-0.379720	3.367752
Euro	2020	0.000706	-0.000530	0.041547	-0.020980	0.007395	-0.959012	7.365181
	2021	0.000853	-0.000852	0.014240	-0.026522	0.005945	-0.380625	4.102169
	2022	0.000446	-1.32e-09	0.014240	-0.026146	0.007670	0.508595	4.872573
	2023	-0.000339	-0.000423	0.030630	-0.017783	0.005150	0.672566	8.679752
	2019	0.000267 4	0.000176	0.024968	-0.028636	0.008753	-0.069125	3.124847
Japanese Yen	2020	7.52e-05	-0.000257	0.048119	-0.027785	0.010189	-0.554009	5.034367
	2021	-0.000517	-0.000528	0.021496	-0.023219	0.006115	-0.098875	4.463183
	2022	0.000526	-0.000001	0.028003	-0.019369	0.006757	0.435916	5.164148
	2023	-7.80e-05	-0.000328	0.031704	-0.020557	0.008029	0.580258	4.571379

Table 2: Unit Root Test for Check the Stationary of Returns Earned by the Sample Currencies During 2019 to 2023

Year	Name of the Countries	t. Statistics	Critical Value			Durbin Watson Statistic	Status
			Median	Maximum	Minimum		
2019	US Dollar	-14.66675	-3.457526	-2.873490	-2.573170	1.991924	Stationary
	Pound Sterling	-14.37185	-3.456427	-2.872583	-2.572276	1.993208	Stationary
	Euro	-13.49452	-3.453436	-2.871592	-2.571461	1.970928	Stationary
	Japanese Yen	-15.58989	-3.453516	-2.873376	-2.570184	1.983628	Stationary
2020	US Dollar	-16.04652	-3.568487	-2.859210	-2.595280	2.248891	Stationary
	Pound Sterling	-14.95829	-3.659498	-2.985490	-2.796438	1.796329	Stationary

	Euro	-14.65464	-3.689495	-2.985462	-2.895392	1.978498	Stationary
	Japanese Yen	-15.97786	-3.879496	-2.956468	-2.986494	1.986459	Stationary
	US Dollar	-14.69748	-3.567215	-2.984759	-2.684389	2.119468	Stationary
2021	Pound Sterling	-15.4346	-3.569215	-2.984759	-2.684389	1.986823	Stationary
	Euro	-15.19885	-3.56895	-2.984687	-2.684381	1.989752	Stationary
	Japanese Yen	-15.61517	-3.568995	-2.984696	-2.684381	1.956956	Stationary
	US Dollar	-14.23238	-3.568858	-2.984582	-2.68426	2.684326	Stationary
2022	Pound Sterling	-15.21316	-3.568858	-2.984583	-2.684326	1.887649	Stationary
	Euro	-13.76896	-3.568741	-2.984556	-2.684298	1.887551	Stationary
	Japanese Yen	-14.94955	-3.568741	-2.984551	-2.684297	1.895786	Stationary
	US Dollar	-14.86936	-3.568741	-2.984550	-2.684297	1.886747	Stationary
2023	Pound Sterling	-14.56642	-3.568741	-2.984521	-2.684298	2.119952	Stationary
	Euro	-19.21725	-3.568626	-2.984481	-2.684271	2.118274	Stationary
	Japanese Yen	-15.53259	-3.568626	-2.984471	-2.684271	1.998295	Stationary

Unit Root Test

Table 2 reveals the results of Augmented Dickey Fuller (ADF) Test, for sample currencies, during the period 2019 to 2023. In the year 2019 the maximum value for sample currencies was at -2.873490 (US Dollar) and the minimum value was at -2.570184 (Japanese Yen). The median value was at -3.457526 for all sample currencies. The Durbin Watson Statistic values ranges from 1.970928 (Euro) to 1.993208 (Pound Sterling). In the year 2020, the maximum value was -2.859210 (U.S Dollar). The minimum value was -2.595280 (US Dollar). The median values ranged from -3.879496 (Japan Yen) to -3.568487 (US Dollar). The Durbin Watson Statistic values ranged from 1.796329 (US Dollar) to 1.986459 (Pound Sterling). The maximum value was -2.984759 (US Dollar) and the minimum value was -2.684389 (Pound Sterling), during 2021. The median value was at -3.567215 for all sample countries. The Durbin Watson Statistic values ranged from 2.119468 (US Dollar) to 1.956956 (Japan Yen). In year 2022, the maximum value was -2.984583 (Pound Sterling) and the minimum value was -2.684297 (Japanese Yen). The median value was -3.568858 for all sample countries. The Durbin Watson Statistic values ranged from 2.684326 (UD Dollar) to 1.895786 (Euro). The maximum value, for the year 2023, was at -2.984550 (U.S Dollar) and the minimum value was -2.684298 (Pound Sterling). The median value was at -3.568626 (Euro). The Durbin Watson Statistic values ranged from 1.886747 (US Dollar) to 2.119952 (Pound Sterling).

It is evident from the analysis that the test – statistics values of all sample currencies, namely, Us Dollar, Pound Sterling, Euro and Japanese Yen, were less than the critical values at 1 percent, 5 percent and 10 percent level during the study period. Hence the null hypothesis (NH01) - “There

is no heteroskedasticity in the returns earned by sample currencies during the study period" was rejected. In other words, there was no unit root and returns of all sample currencies were stationary.

Generalized Autoregressive Conditional Heteroscedasticity (GARCH (1, 1) Model)

The Table 3 presents the results of basic GARCH (1, 1) model. Three variables, C, RESID (-1) ^2, and the lag of the conditional variance for US Dollar and their co-efficient equations, during the period 2019 to 2023 are presented. The values of C ranged from 2.380016 (2019) to 6.13E-07(2023). The values of RESID (-1) ^2 ranged from 0.087226 (2019) to 0.258713 (2023). The R-squared values of US Dollar ranged from -0.002587 (2019) to 0.001246 (2023), showing the values to be less than 1. It implied that the series attained stationary. This result indicated that previous price exerted influence over the current price. The value of Akaike info criterion was less than Schwarz criterion value in the case of US dollar. It showed that the market was volatile. The GARCH (-1) was significant at 5% level. In other words, prediction of volatility in the floating exchange rate is possible. Hence the null hypothesis (H02) – "GARCH (1, 1) model does not predict the volatility in the floating exchange rate of sample currencies, traded in the Indian Forex market, during the study period" was rejected.

Table 3: GARCH (1, 1) Model for Forecast the Volatility of US Dollar during 2019 to 2023

Year	Variables	Co-efficient	Standard Error	Z- Statistic
2019	C	2.380016	2.391247	0.936417
	RESID (-1) ^2	0.087226	0.069708	1.458815
	GARCH (-1)	0.867541	0.125763	8.276321
	R-Squared	-0.002587	Mean dependent variable	0.000324
	Adjusted R-Squared	0.001763	S.D. dependent variable	0.006158
	Akaike info Criterion	-7.467683	Schwarz criterion	-7.436526
	Probability	0.000000	Hannan- Quinn criterian	-7.472428
2020	C	1.29E-05	9.73E-06	1.765813
	RESID (-1) ^2	0.128215	0.037356	3.749136
	GARCH (-1)	0.847341	0.047664	17.97860
	R-Squared	-0.002780	Mean dependent variable	0.000426
	Adjusted R-Squared	0.001356	S.D. dependent variable	0.007576
	Akaike info Criterion	-7.182735	Schwarz criterion	-7.156989
	Probability	0.000000	Hannan- Quinn criterian	-7.184547
2021	C	4.87E-05	3.45E-07	1.43559
	RESID (-1) ^2	0.121387	0.064058	1.655232
	GARCH (-1)	0.4832475	0.341223	1.420521
	R-Squared	-0.003678	Mean dependent variable	0.000234
	Adjusted R-Squared	0.000767	S.D. dependent variable	0.003528
	Akaike info Criterion	-8.527876	Schwarz criterion	-8.484947
	Probability	0.1526	Hannan- Quinn criterion	-8.512239
	C	8.75E-04	4.73E-06	1.715384
	RESID (-1) ^2	0.057442	0.032476	1.647382

2022	GARCH (-1)	0.847192	0.063413	13.45371
	R-Squared	-0.007425	Mean dependent variable	0.000283
	Adjusted R-Squared	-0.003231	S.D. dependent variable	0.003291
	Akaike info Criterion	-8.574319	Schwarz criterion	-8.528462
	Probability	0.00000	Hannan- Quinn criterion	-8.536735
2023	C	6.13E-07	1.40E-07	4.732106
	RESID (-1) ^2	0.258713	0.083726	3.12816
	GARCH (-1)	3.102816	0.145872	-0.913024
	R-Squared	-0.001246	Mean dependent variable	-8.82E-04
	Adjusted R-Squared	0.003127	S.D. dependent variable	0.002543
	Akaike info Criterion	-9.214872	Schwarz criterion	-9.170572
	Probability	0.3465	Hannan- Quinn criterion	-9.175362

Table 4: GARCH (1, 1) Model for Forecast the Volatility of Great British Pound during 2019-2023

Year	Variables	Co-efficient	Standard Error	Z- Statistic
2019	C	4.67E-05	3.13E-07	1.457932
	RESID (-1) ^2	0.066512	0.056243	1.375587
	GARCH (-1)	0.763871	0.145342	5.687381
	R-Squared	-0.000127	Mean dependent variable	6.47E-04
	Adjusted R-Squared	0.004231	S.D. dependent variable	0.006851
	Akaike info Criterion	-7.435724	Schwarz criterion	-7.285376
	Probability	0.0000	Hannan- Quinn criterion	-7.300161
2020	C	3.76E-17	2.01E-04	1.876457
	RESID (-1) ^2	0.147246	0.046238	3.478624
	GARCH (-1)	0.763145	0.061536	12.76867
	R-Squared	-0.012452	Mean dependent variable	0.000765
	Adjusted R-Squared	-0.006473	S.D. dependent variable	0.007436
	Akaike info Criterion	-7.086263	Schwarz criterion	-7.045138
	Probability	0.0000	Hannan- Quinn criterion	-7.087625
2021	C	2.26E-14	1.57E-07	1.354127
	RESID (-1) ^2	-0.042751	0.021087	-1.361721
	GARCH (-1)	0.932576	0.053816	17.73714
	R-Squared	-0.003637	Mean dependent variable	-0.000287
	Adjusted R-Squared	0.000735	S.D. dependent variable	0.005124
	Akaike info Criterion	-7.641053	Schwarz criterion	-7.675120

2022	Probability	0.0000	Hannan- Quinn criterion	-7.721321
	C	6.25E-04	4.21E-05	1.532274
	RESID (-1) ^2	0.138521	0.074675	1.963476
	GARCH (-1)	0.645312	0.161287	3.912425
	R-Squared	-0.000317	Mean dependent variable	0.000124
	Adjusted R-Squared	0.003746	S.D. dependent variable	0.005916
	Akaike info Criterion	-7.481723	Schwarz criterion	-7.348167
	Probability	0.0001	Hannan- Quinn criterian	-7.464238
2023	C	4.75E-06	2.72E-05	1.718619
	RESID (-1) ^2	0.165284	0.061428	2.865834
	GARCH (-1)	0.769742	0.085214	9.121457
	R-Squared	-0.006173	Mean dependent variable	-0.000621
	Adjusted R-Squared	-0.002168	S.D. dependent variable	0.008104
	Akaike info Criterion	-6.831028	Schwarz criterion	-6.786412
	Probability	0.0000	Hannan- Quinn criterian	-6.812587

GARCH (1, 1) Model to Forecast the Volatility of Pound Sterling in the Indian Forex Market during 2019 to 2023: The Table 4 presents the results of basic GARCH (1, 1) model. Three variables, C, RESID (-1) ^2, and the lag of the conditional variance for Pound Sterling and their co-efficient equations, during the period 2019 to 2023, are presented. The values of C ranged from 4.67E-05 (2019) to 4.75E-06 (2023). The values of RESID (-1) ^2 ranged from 0.066512 (2019) to 0.165284 (2023). The R-squared values of Pound Sterling ranged from -0.000127 (2019) to -0.006173 (2023), showing that these values were less than 1. It implied that the series attained stationarity. This result indicated that previous price exerted influence over the current price. The value Akaike info criterion was less than Schwarz criterion value in the case of Pound Sterling. It showed that the market was volatile. The GARCH (-1) was significant at 5% level. In other words, prediction volatility in the floating exchange rate is possible. Hence the null hypothesis (H02) – "GARCH (1, 1) model does not predict the volatility in the floating exchange rate of sample currencies traded in the Indian Forex market during the study period" was rejected.

GARCH (1, 1) Model for Forecast the Volatility of Euro in the Indian Forex Market during 2019 to 2023: The Table 5 presents the results of basic GARCH (1, 1) model. Three variables, C, RESID (-1) ^2, and the lag of the conditional variance for Euro and their co-efficient equations, during the period 2019 to 2023 are presented. The values of C ranged from 6.26E-05 (2019) to 7.32E-04 (2023). The values of RESID (-1) ^2 were ranged from 0.138521 (2019) to 0.361864 (2023). The R-squared values of Euro ranged from 0.000317 (2019) to -0.004178 (2023), showing that their values were less than 1. It implied that the series attained stationarity. This result indicated that previous price exerted influence over the current price. The value Akaike info criterion was less than Schwarz criterion value in the case of Euro. In other words, the market was volatile. The GARCH (-1) was significant at 5% level. The predication of volatility in the floating exchange rate is possible. Hence the null hypothesis (H02) – "GARCH (1, 1) model does not predict the volatility in the floating exchange rate of sample currencies, traded in the Indian Forex market, during the study period" was rejected.

Table 5: GARCH (1, 1) Model for Forecast the Volatility of Euro during 2019 to 2023

Year	Variables	Co-efficient	Standard Error	Z- Statistic
2019	C	6.26E-05	4.02E-15	1.533274
	RESID (-1) ^2	0.138521	0.064756	1.863476
	GARCH (-1)	0.654221	0.160283	3.812321
	R-Squared	0.000317	Mean dependent variable	0.000104
	Adjusted R-Squared	0.003746	S.D. dependent variable	0.005716
	Akaike info Criterion	-7381625	Schwarz criterion	-7.348167
	Probability	0.0001	Hannan- Quinn criterion	-7.364210
2020	C	4.47E-17	2.15E-07	2.178356
	RESID (-1) ^2	0.287576	0.071827	4.107154
	GARCH (-1)	0.618543	0.091821	6.815873
	R-Squared	-0.009214	Mean dependent variable	0.000713
	Adjusted R-Squared	-0.004861	S.D. dependent variable	0.007284
	Akaike info Criterion	-7.243604	Schwarz criterion	-7.216715
	Probability	0.0000	Hannan- Quinn criterion	-7.142616
2021	C	1.84E-08	1.93E-08	0.963192
	RESID (-1) ^2	-0.045667	0.015647	-3.316385
	GARCH (-1)	1.067253	0.018580	5.435421
	R-Squared	-0.021653	Mean dependent variable	-0.000841
	Adjusted R-Squared	-0.017346	S.D. dependent variable	0.005854
	Akaike info Criterion	-7.526791	Schwarz criterion	-7.484791
	Probability	0.0000	Hannan- Quinn criterion	-7.487976
2022	C	7.18E-04	1.64E-16	4.459532
	RESID (-1) ^2	0.158764	0.087381	1.861784
	GARCH (-1)	-0.364584	0.263614	-1.417287
	R-Squared	-0.003471	Mean dependent variable	0.000431
	Adjusted R-Squared	0.000827	S.D. dependent variable	0.007547
	Akaike info Criterion	-6.821962	Schwarz criterion	-6.976374
	Probability	0.1482	Hannan- Quinn criterion	-6.875431
2023	C	7.32E-04	2.62E-04	2.838513
	RESID (-1) ^2	0.361864	0.127360	3.437184
	GARCH (-1)	-0.416564	0.151423	2.817287
	R-Squared	-0.004178	Mean dependent variable	0.000434
	Adjusted R-Squared	0.000132	S.D. dependent variable	0.006213
	Akaike info Criterion	-7.821762	Schwarz criterion	-7.857352
	Probability	0.0038	Hannan- Quinn criterion	-7.874530

Table 6: GARCH (1, 1) Model for Forecast the Volatility of Japanese Yen during 2019 to 2023

Year	Variables	Co-efficient	Standard Error	Z- Statistic
2019	C	5.14E-06	3.75E-06	1.375346
	RESID (-1) ^2	-0.086417	0.051765	-1.736102
	GARCH (-1)	0.413279	0.471242	0.821574
	R-Squared	-0.000941	Mean dependent variable	-0.000278
	Adjusted R-Squared	0.003124	S.D. dependent variable	0.007857
	Akaike info Criterion	-6.538967	Schwarz criterion	-6.573486
	Probability	0.4061	Hannan- Quinn criterion	-6.621487
2020	C	5.11E-07	3.04E-07	1.681752
	RESID (-1) ^2	0.087845	0.028543	3.142820
	GARCH (-1)	0.867431	0.048320	1.754215
	R-Squared	-0.000054	Mean dependent variable	7.53E-04
	Adjusted R-Squared	0.004153	S.D. dependent variable	0.011293
	Akaike info Criterion	-6.527837	Schwarz criterion	-6.462837
	Probability	0.0000	Hannan- Quinn criterion	-6.387518
2021	C	8.12E-07	3.52E-05	2.271893
	RESID (-1) ^2	0.265761	0.127826	2.154328
	GARCH (-1)	0.521487	0.170728	2.836735
	R-Squared	-0.007167	Mean dependent variable	-0.000523
	Adjusted R-Squared	-0.002738	S.D. dependent variable	0.006187
	Akaike info Criterion	-7.427263	Schwarz criterion	-7.473163
	Probability	0.0047	Hannan- Quinn criterion	-7.579567
2022	C	2.57E-07	1.05E-07	2.483846
	RESID (-1) ^2	0.126281	0.031687	3.678764
	GARCH (-1)	3.758764	0.042853	1.883176
	R-Squared	-0.005875	Mean dependent variable	0.000534
	Adjusted R-Squared	-0.001713	S.D. dependent variable	0.006862
	Akaike info Criterion	-7.286185	Schwarz criterion	-7.262795
	Probability	0.0000	Hannan- Quinn criterion	-7.286754
2023	C	8.26E-17	1.06E-05	0.798371
	RESID (-1) ^2	0.035283	0.031098	1.138921
	GARCH (-1)	0.845328	0.182343	4.864132
	R-Squared	-0.000096	Mean dependent variable	-7.81E-04
	Adjusted R-Squared	0.004156	S.D. dependent variable	0.008135
	Akaike info Criterion	-6.712102	Schwarz criterion	-6.747832

Probability	0.0000	Hannan- Quinn criterion	-6.793735

GARCH (1, 1) Model for Forecast the Volatility of Japanese Yen in the Indian Forex Market during 2019 to 2023: The Table 6 presents the results of basic GARCH (1, 1) model. Three variables, C, RESID (-1) ^2, and the lag of the conditional variance for Japanese Yen and their co-efficient equations, during the period 2019 to 2023, are presented. The values of C ranged from 5.14E-06 (2019) to 8.26E-17 (2023). The values of RESID (-1) ^2 ranged from -0.086417 (2019) to 0.035283 (2023). The R-squared values of Japanese Yen ranged from -0.000941 (2019) to -0.000096 (2023), showing that their values were less than 1. It implied that the series attained stationarity. This result indicated that previous price exerted influence over the current price. The value Akaike info criterion was less than Schwarz criterion value in the case of Yen. It showed that the market was volatile. The GARCH (-1) was significant at 5% level. In other words, predictions of volatility in the floating exchange rate is possible. Hence the null hypothesis (H02) – "GARCH (1, 1) model does not predict the volatility in the floating exchange rate of sample currencies, traded in the Indian Forex market, during the study period" was rejected.

Theoretical Implications

The present study has many theoretical implications. First, the results of the present study would be useful to improve the growing body of the literature, relating to forecasting the volatility of forex market in India and abroad. Many earlier studies attempted to study the impact of currency rate fluctuations on Indian stock market and other countries' stock markets, but the present study is a new attempt to forecast the volatility in the Indian foreign exchange market. The results of the present study concurred with the findings of many previous studies. Though the results of some of the earlier studies have reported different causes for the forex market volatility, the present study attempted the new look to forecast the volatility of the Indian forex market during the period January1, 2017 to December 31, 2022.

Practical Implications

The findings of the present study have many implications for the investors of the forex market, especially those who are willing to make the investment, based on the interest rate fluctuation in the currency market. The results of the present study indicate that the future movement of the currency market can be predicted, based on the present data series. The fluctuations in the stock market were managed through using appropriate hedging strategy, by making rational investment in currency market. The model used in this study also confirms that the volatility impacts are persistent and the historical information will decay. The active investors in the market may use this arbitrage opportunity immediately. But the rational investors will take adequate time to react this situation. The policy maker may correct this deviation through timely interferences in the currency market.

Conclusion

The purpose of the study was to forecast the volatility of Indian Forex Market. Forex market could be influenced by various extraneous factors, such as exchange rate, interest rate and performance of the capital market, crude oil price and the price range of gold and other bullion etc. In the present study, the Researcher attempted to forecast the volatility of frequently traded four major currencies in Indian forex market, namely, American US Dollar, United Kingdom Great British Pound, European Union Euro and Japanese Yen. Normality test was used to find out whether all collected return data of exchange rate are log normally distributed or not. This study examined the critical factors, like stationary test and developing GARCH (1, 1) model to forecast the volatility of Indian forex market. The augmented Dickey–Fuller Test was used to test the stationary of the time series and the results of the stationary test indicated that the selected time series was stationary. The results of the augmented Dickey–Fuller Test revealed that the movement of the present data followed the past data series, indicating that the future movement can be predicted, based on the present data series. The mean equation in the GARCH (1, 1) model established that the exchange rate return obtained negative R squared value, with less than one. It implied that the series attained stationary and the previous price exerted influence over the current price. It was also supported by co-efficient values

in the variance equation. The co-efficient value in the variance equation was around one, which showed that the currency market was efficient. If the exchange rate in the forex market were to flourish, the investors could increase their investment in the currency market against the stock market. Further, rational investors invest more money in the stock market while it was dwindling in the currency market. The results and suggestions of the present study, based on the return data of four major currencies traded in the Indian forex market, indicated that it could be used as a platform for future research, by expanding different currencies, using different models. Similar type of studies may be conducted, using other currencies like Australian-Dollar, Canadian-Dollar, Bahraini – Bahraini Dinar, Brazil-Real, North Korea – Won, Kuwait- Kuwait Dinar, Malaysia-Ringgit and Singapore-Singapore Dollar, traded in the Indian currency market. This study was limited to four major currencies, which are traded in the Indian forex market. The period of the study was confined to only five years**.** All the limitations, associated with various statistical tools used in the study, may apply to this study also.

Abbreviations

Nil.

Acknowledgement

We express our gratitude to individuals and institutions whose support and guidance contributed significantly to this research. Special thanks to all the authors of this research for their invaluable assistance.

Author Contributions

Each author's contribution to the manuscript is as follows: Dr. Sathish Pachiyappan and Velmurugan has significantly contributed to the introduction and literature review for the research. Further, discussion and conclusion were done by Dr. M. Raja and Muthu Gopala Krishnan. All authors have read and approved the final version of the manuscript.

Conflict of Interest

The authors declare that there are no conflicts of interest regarding the publication of this manuscript.

We confirm that the research was conducted with utmost integrity and without any undue influence.

Ethics Approval

Not applicable.

Funding

This research was not financially supported by any funding agencies.

References

1. Yen G, Lee CF. Efficient market hypothesis (EMH): past, present and future. Review of Pacific Basin Financial Markets and Policies. 2008 Jun;11(02):305-29.
2. Lim KP, Brooks R. The evolution of stock market efficiency over time: A survey of the empirical literature. Journal of economic surveys. 2011 Feb;25(1):69-108.
3. Frenkel JA, Rodriguez CA. Portfolio Equilibrium and the Balance of Payments: A Monetary Approach. American Economic Review. 1975 Sep 1;65(4): 674-688.
4. Dornbusch R, Fischer S. Exchange rates and the current account. The American economic review. 1980 Dec 1;70(5):960-71.
5. Aravind M. FX volatility impact on Indian Stock Market: An empirical investigation. Vision. 2017 Sep;21(3):284-94.
6. Zitis PI, Kakinaka S, Umeno K, Stavrinides SG, Hanias MP, Potirakis SM. The Impact of COVID-19 on Weak-Form Efficiency in Cryptocurrency and Forex Markets. Entropy. 2023 Dec 5;25(12):1622.
7. Dey S, Sampath A. Returns, volatility and spillover–A paradigm shift in India?. The North American Journal of Economics and Finance. 2020 Apr 1;52:101110.
8. Omoregie OK. Foreign exchange and the capital market dynamics: New evidence from non-linear autoregressive distributed lag model. International Journal of Management, Economics and Social Sciences. 2020;9(1):1-23.
9. Kurniawan R. Dynamic Relationship between Stock Market and Foreign Exchange Market in Indonesia. Econ. Jounal FE-Unpad. 2005;20(1):112-37.
10. Nikhil Yadav, Anurag Bhadur Singh and Priyanka Tandon. "Volatility Spillover Effects between Indian Stock Market and Global Stock Markets: A DCC-GARCH Model", FIIB Business Review.2023;1(1):1–13.
11. Mahapatra S, Bhaduri SN. Dynamics of the impact of currency fluctuations on stock markets in India: Assessing the pricing of exchange rate risks. Borsa Istanbul Review. 2019 Mar 1;19(1):15-23.
12. Bijoy K. Stock and Currency Market Linkages: An Empirical Analysis from Emerging Economies. International Journal of Professional Business Review: Int. J. Prof. Bus. Rev.. 2023;8(8):1-35.
13. Ajao IO, Olugbode MA, Olayinka HA, Yaya OS, Shittu OI. Long memory cointegration and dynamic connectedness of volatility in US dollar exchange rates, with FOREX portfolio investment strategy. SSRN paper. 2022; 7(4): 646–664.
14. Ngan TM. Forecasting foreign exchange rate by using ARIMA model: A case of VND/USD exchange rate. Methodology. 2013;2014:2015.
15. Zitis PI, Kakinaka S, Umeno K, Stavrinides SG, Hanias MP, Potirakis SM. The Impact of COVID-19 on Weak-

Form Efficiency in Cryptocurrency and Forex Markets. Entropy. 2023 Dec 5;25(12):1622.
16. Blengini I, Heo CY. The role of exchange rate on hotelier's pricing decision and business performance: the case of Switzerland, a small open economy. Journal of Revenue and Pricing Management. 2024 Jun;23(3):206-216.
17. Shang J, Hamori S. Differential Tail Dependence between Crude Oil and Forex Markets in Oil-Importing and Oil-Exporting Countries during Recent Crisis Periods. Sustainability. 2023 Oct 3;15(19):14445.
18. Bormpotsis C, Sedky M, Patel A. Predicting Forex Currency Fluctuations Using a Novel Bio-Inspired Modular Neural Network. Big Data and Cognitive Computing. 2023 Sep 15;7(3):152.
19. Moşteanu NR, Flocea T. Revolutionizing Foreign Exchange Market: A Critical Analysis of Blockchain's Opportunities and Challenges. European Journal of Theoretical and Applied Sciences. 2023 Sep 1;1(5):33-44.