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FORECASTING OF EXCHANGE RATE VOLATILITY BETWEEN USD/INR USING GARCH MODEL

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ABSTRACT

India moved away from a pegged exchange rate to the LERMS in 1992 and the currency market-determined exchange rate regime in 1993 which is considered an important structural change in the exchange rate market. With increased volatility in the exchange rate and to mitigate the risk arising out of excess volatility, currency futures were introduced in India in 2008 which is considered as the second important structural change. It is believed that currency futures will help in hedging the exposures of the exchange rate to favorable movements in the exchange rate. This research paper examines the volatility of the currency. The daily closing values of the Spot and Futures of USD/INR were gathered from 2017 to 2020 and represented by applying GARCH methods. The methods capture the volatility clustering and leverage effect during the study period. The test of unit root, volatility clustering, and ARCH effect is confirmed and established. The USD/INR spot and futures returns are further analyzed by GARCH (1, 1), EGARCH (1, 1), and TGARCH (1, 1) models. The results revealed that the coefficient has the possible indication in the EGARCH (negative and significant) as well as in the TARCH (positive and significant) models. Further, EGARCH (1, 1) model is proved to be the finest model to arrest the asymmetric volatility.

1. INTRODUCTION

Globalization and financial sector reforms in India lead to a tremendous change in the financial architecture of the economy. In the contemporaneous scenario, the activities in the financial markets and their relationships with the real sector have assumed notable importance. Since the inception of the financial sector reforms at the beginning of the 1990s and implementation execution of various reform measures have brought in a dramatic change in the functioning of the financial sector of the economy. The floating exchange rate that has been executed in India since 1991 facilitates a greater volume of trade and high volatility in equity as well as the Forex market, increasing its exposure to economic and financial risks. In recent years, because of increasing international diversification, cross-market return correlations, gradual abolishment of capital inflow barriers, and foreign exchange limitations or the adoption of more flexible exchange rate arrangements in emerging and transition countries, these two currencies have become significantly interdependent. These changes have increased the variety of investment opportunities as well as the volatility of exchange rates and risk of investment decisions and portfolio diversification process. At the time of the introduction of currency futures in India, it was thought that the currency futures market in India would make a notable contribution towards improving the menu of options available for currency risk management. International experience of the emerging markets with the introduction of currency futures is a mixed one. In several cases, the volatility is found to be reduced following the constitution of the currency futures market, though empirical evidence to the contrary also exists. The transaction volumes in currency futures in these countries have remained too small to put any significant upward pressure on exchange rate volatility. Also, there is no clear evidence to prove that futures contracts traded on exchanges result in increased volatility in the prices for the underlying commodity.

1.1 Objectives of the Study

- To estimate the existence of volatility in currency derivatives (USD/INR) by applying the GARCH family of models.
- To investigate the presence of volatility clustering and leverage effect by applying asymmetric models.

2. REVIEW OF LITERATURE

Dhananjay (2012) explored the effect of exchange-traded currency futures on exchange rate volatility in India. The study uses time-series techniques like unit root test, ARCH-LM test, and GARCH model. The daily Spot exchange rate of EURO/INR was collected from January 2nd, 2008 to 31st December 2011 and used in the analysis. The result reveals that the introduction of currency derivative trading has no impact on the volatility of spot exchange rate returns. Singh and Tripathi (2015) reports reveal in their studies that the volatility of spot exchange rate returns (EURO/ INR) has reduced after the introduction of currency derivative trading in August 2008 by the National Stock Exchange of India. They used the daily spot exchange rate of EURO/INR from April 2006 to December 2014 to explore the effect of the inception of currency derivative trading on exchange rate volatility in India. They conclude that futures trading enhanced the speed of recent news on volatility of the spot foreign exchange market and also improved market efficiency during the post currency derivatives period. Santosh et. al., (2011) also claim that currency futures trading has reduced the asymmetric volatility of the spot currency market in India. The GARCH, EGARCH, and TARCH techniques were used for analysis. The daily spot exchange rate of US Dollar/INR was used and the entire data divided into two periods; before the introduction of currency futures (from August 2000 to August 2008) and after the introduction of currency futures in NSE (from August 2008 to August 2010 to capture their effect on volatility in spot exchange rates. The result reveals that there was an altered significant structure of volatility in the foreign exchange market in India.

Arif (2011) verified the effect of the inception of currency futures on foreign exchange market volatility in Turkey. The daily spot exchange rate of Euro/US dollar was sourced from the Central Bank of Turkey for the period February 2002 to February 2008. The result suggests that the rate of information arrival into the market has increased and it incorporates current exchange rates more quickly than before the inception of futures trading. The result from the study shows that the volatility foreign exchange market in Turkey has reduced after the commencement of the currency futures period. Ashish (2015) used time series techniques such as unit root test, ARCH-LM test, and GARCH model and daily spot exchange rate of EURO/INR from 1st January 2006 up to 30th September 2014 to verify the effect of inception of currency futures on exchange rates volatility in India. The result shows that there has been a decline in the volatility of the spot foreign exchange market in India during the post currency futures period. Anuradha (2010) employed alternative time-series estimation techniques like VAR and reports that currency futures trading does not influence underlying spot exchange rate volatility in India. He obtained the daily closing exchange rates of US dollar/ INR from NSE from August 2008 to August 2009. The result shows that arrival news first aggregated into the currency futures market and then transmitted to the spot foreign exchange market.

Jochum and Kodres (1998) used the SEARCH model and found that inception currency futures trading has no significant impact on the volatility of spot exchange rate returns. Daily spot exchange rates of the Mexican peso and the Brazilian were collected from January 1st, 1995 to February 28th, 1997 for analysis. They concluded that the volatility of spot exchange rate returns is not influenced by the currency futures market. Adrangi and Chatrath (1998) reveal in their study that the inception of currency derivative trading destabilizes the spot foreign exchange market by increasing volatility. Drimbetas et. al., (2006) however argued that volatility of the spot market has declined during the post inception of currency futures period due to speculators actively trading in futures markets rather than spot markets. Daily data from ASE index 20 was collected from August 1997 to April 2005 to verify the effect of inception futures contracts on equity market volatility. The result suggests that the volatility of ASE index 20 has declined during the post inception futures period. The above empirical evidence has found mixed results both in India and outside of India. Therefore the present study re-investigates the effect of the inception of futures trading on spot currency market volatility in India.

3. DATA AND METHODOLOGY

The present study is directed towards analyzing the dynamics between Spot and Future prices of USD/INR Currencies. Near month expiry futures data from NSE is used in the analysis as the trading is more for near month expiry futures. A total of 571 observations of exchange rate were taken starting from 1st Jan 2017 to 31st Dec 2020. The results from daily data are more precise and are better able to capture the dynamics between Spot and Future prices of USD/INR Currencies. The data consists of – i) daily closing Spot prices of the USD/INR Currencies collected from Reserve Bank of India (RBI) reference rates and ii) the currency Future prices of USD/INR, Currencies was collected from National Stock Exchange (NSE).

Firstly, returns for currency were calculated as following:

$$Rt = 100 * \ln(St / St-1)$$

Where, St = Spot exchange rate at time‘t’

FOLLOWING ECONOMETRIC MODELS WERE USED FOR ANALYSIS

Augmented Dickey-Fuller (ADF) test, Philips-Perron (PP) test, Autoregressive Conditional Heteroscedasticity - Lagrange Multiplier (ARCH-LM) tests, and GARCH family of models were applied for the present research. The study has employed the E-views 11 package for investigation. Volatility is estimated on a daily spot and future returns of USD/INR.

UNIT ROOT TESTS

Augmented Dickey-Fuller (ADF) Test

The standard DF test is carried out by estimating the following Equation after subtracting yt-1 from both sides of the equation:

Dyt = ayt – 1 + xt ¢d + et,

Where a = r – 1. The null and alternative hypotheses may be written as,

H0: a = 0

H1: a < 0

The Phillips – Perron test

The Phillips – Perron test is carried out by estimating the following equation

$$\nabla y_t = \nabla y_{t-1} + u_t$$

Where yt is the time series data under consideration.

Null Hypothesis: H0: There is a unit root; the time series is non-stationary.

Alternate hypothesis: Ha: There is no unit root; the time series is stationary

Heteroscedasticity Test

It is extremely vital to first examine the residuals for the existence of heteroscedasticity before applying the GARCH model.

The presence of heteroscedasticity in residuals of the return is confirmed by applying the Lagrange Multiplier (LM) test.

Tools for measuring Volatility

In general, it is observed that escalating movement in the share market is followed by minor variances when compared to the downward movements with alike nature. This asymmetric moment is termed the leverage effect. Hence, the GeneralizedARCH (GARCH) methodology which is symmetrical will not be suitable to evaluate the unsteadiness in time series.

To capture the asymmetrical data, the Exponential GARCH (EGARCH) methodology advocated by Nelson (1991) and Threshold GARCH (TARCH) advocated by Glosten, Jaganathan, and Runkle (1993) and Zakonian (1994) are applied.

GARCH (1, 1)

The GARCH model in which the conditional variance rest on the former lags; specifies the conditional variance equation as:

mean equation : $r_t = \mu + \varepsilon_t$ and

variance equation: $\sigma^2_t = \omega + \alpha\varepsilon^2_{t-1} + \beta\sigma^2_{t-1}$,

Where r_t is the return of the asset at time t, μ is the average return and ε_t is the residual return and where ω>0, α ≥ 0, β ≥ 0. The degree of factors α and β denote the variability in time series. If (α + β) is close to unity, it states that distress at time t will carry on for future periods.

EGARCH (1, 1)

The volatility that happens to decline when returns rise and volatility happens to rise whenthe returns fall is often called the leverage effect (Enders 2004). EGARCH method captures the asymmetric reaction of the time changing variance where variance is constantly affirmative. It was developed by Nelson (1991) that υ is the asymmetric response parameter or leverage parameter. If it is below zero it specifies that unfavorable information boosts forthcoming fluctuation while favorable information mitigates the consequence on forthcoming doubts (Kalu 2010).

EGARCH (1, 1) is defined as,

$$\ln(\sigma_t^2) = \omega + \beta\ln(\sigma_{t-1}^2) + \gamma\frac{u_{t-1}}{\sqrt{\sigma_{t-1}^2}} + \alpha\left[\frac{|u_{t-1}|}{\sqrt{\sigma_{t-1}^2}} - \sqrt{\frac{2}{\pi}}\right]$$

TGARCH (1, 1)

The equation of the TGARCH for the conditional variance is:

$\sigma^2_t = \omega + \alpha\varepsilon^2_{t-1} + \gamma d_{t-1}\varepsilon^2_{t-1} + \beta\sigma^2_{t-1}$,

Where γ is termed as the asymmetry or leverage factor. Here, positive facts ($\varepsilon_{t-1} > 0$) and the adverse data ($\varepsilon_{t-1} < 0$) have variance outcomes. α_i connotes positive facts while $\alpha_i+\gamma_i$ connotes adverse information. Thus, in the position where γ is substantial and positive, negative information has more consequence on σ^2_t compared to the positive information.

4. EMPIRICAL RESULTS

4.1 Descriptive statistics results

Table 1 reveals that the mean value of the USD/INR currency pairs was 0.8684 high in the future market compared to the spot. It means investors were getting more returns in the future market as compared to the spot market. The three main indicators of distribution of a data series are Skewness, Kurtosis, and Jarque-Bera statistics. Descriptive statistics show that USD/INR spot and futures prices reported a positive skewness. It indicated the distribution has a long right tail. A positive skewness shows that the tail on the right side is longer than the left side and the bulk of the value lies to the left of the mean. Kurtosis of the data series registered a value more than 3 specifies excess peakedness than normal. The higher Jarque-Bera (JB) value in both spot and future returns is that the distribution is not normal. Thus the null hypothesis of normality is rejected as the probability value is less than 0.05 levels.

Table 1. Descriptive Statistics

Descriptive Statistics	USD/INR	
	Spot Prices	Future Prices
Mean	0.008684	0.008106
Median	0.001352	-0.014033
Std. Dev	0.625577	0.372427
SKewness	0.804935	0.509077
Kurtosis	168.2450	7.269077
Jarque-Bera	991071.4	699.0376
Probability	0.00000	0.00000
observations	871	871

Table 2. Augmented Dickey-Fuller Test (ADF) and Philip Perron Test (PP) of Spot and Futures Prices for USD/INR from January 2017 to December 2020

Currency Pair		Augmented Dickey-Fuller Test (ADF) Level with Intercept		Philip Perron Test (PP) Level with Intercept	
		T-Statistics	Prob. Value	T-Statistics	Prob. Value
USD/INR	Spot	-26.52246	0.0000	-42.38876	0.0001
	Future	-31.31099	0.0000	-31.25552	0.0000

Note: *ADF & PP Test critical values: 5% level-2.88,*
Data: Computed of Data

The test assumes the null hypothesis that the time series has a unit root (non-stationary). The ADF test statistic and Philip Perron Test (PP**)** statistics are -26.52246 and -31.31099 (p = 0.000) and -42.38876 and -31.25552 (p=0.0000) respectively for spot and futures return series indicate that the null hypothesis is rejected for all the considered USD-INR. The return series does not have a unit root. Thus, these spot and futures return series are stationary, and hence, we can proceed further to test its volatility using ARCH and GARCH models.

The estimated result of the ARCH-LM test is shown in Table 3. ARCH-LM test for heteroskedasticity is considered on residuals estimated by the GARCH model. ARCH-LM test outcome indicates that residuals derived from the regression estimation are free from heteroscedasticity ($p<0.05$) Therefore, ARCH-LM results hold further arch effect residual.

Table 3. Estimated Result of ARCH-LM Test

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	0.008915	0.009376	0.950827	0.3417
FUTURE	0.480663	0.021336	22.52792	0.0000
Variance Equation				
C	0.067770	0.003934	17.22678	0.0000
RESID(-1)^2	0.305960	0.063379	4.827484	0.0000
R-squared	0.081805	Mean dependent var		0.008684
Adjusted R-squared	0.080748	S.D. dependent var		0.625577
S.E. of regression	0.599788	Akaike info criterion		0.577266
Sum squared resid	312.6188	Schwarz criterion		0.599170
Log likelihood	-247.3994	Hannan-Quinn criter.		0.585647
Durbin-Watson stat	2.758638			

Table 4. GARCH (1, 1) Model for Exchange Rate Volatility

H0: No volatility impact		
GARCH = C(3) + C(4)*RESID(-1)^2 + C(5)*GARCH (-1) + C(6)*futures		
Variance Equation	Coefficient	Prob.
Constant C(3)	0.017555	0.0000
RESID (-1)^2 C(4)	0.102510	0.0000
GARCH(-1) C(5)	0.759096	0.0000
Futures C(6)	0.028189	0.0000
Durbin – Watson Statistics	2.225805	
Akaike Info Criterion	0.714036	
Schwarz criterion	0.746922	

Note:* significant at 5% level

The result states that the sum of ARCH and GARCH coefficients in the model is 0.861606 i.e. 86.16% which is positive and also statistically significant. The higher coefficient of ARCH and GARCH terms specify that the model selected is stable and good. RESID (-1)^2 is the ARCH term which is significant at 5% level. This specifies the recent past information is making a substantial positive impact on the volatility of spot exchange rate return. GARCH (-1) term is also having a significant positive impact on spot exchange rate volatility. The higher GARCH coefficient than the ARCH coefficient discloses that conditional variance is highly dependent on the previous period's forecast variance rather than information about prior period volatility. The futures coefficient is positive and significantly different from zero. This indicates the positive and significant consequence of futures trading activity on the volatility of spot exchange rate (i.e.) futures trading activity is positively related to spot exchange rate volatility in USD/INR. Thus, the result of this study supports the findings of Crain and Lee (1995) that the volatility is transmitted from the futures to the spot market.

Table 5. EGARCH (1, 1) Model for Exchange Rate Volatility

LOG(GARCH) = C(3) + C(4)*ABS(RESID(-1)/@SQRT(GARCH(-1))) + C(5)
*RESID(-1)/@SQRT(GARCH(-1)) + C(6)*LOG(GARCH(-1))

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	74.75955	0.015667	4771.700	0.0000
FUTURE	0.121020	0.018937	6.390538	0.0000
Variance Equation				
C(3)	-1.357431	0.164847	-8.234482	0.0000
C(4)	1.557808	0.214725	7.254913	0.0000
C(5)	-0.169428	0.102527	-1.652523	0.0984
C(6)	0.887427	0.032734	27.11054	0.0000

R-squared	-1.003287	Mean dependent var	70.41878
Adjusted R-squared	-1.005593	S.D. dependent var	4.336717
S.E. of regression	6.141613	Akaike info criterion	4.849078
Sum squared resid	32778.17	Schwarz criterion	4.881934
Log likelihood	-2105.773	Hannan-Quinn criter.	4.861649
Durbin-Watson stat	0.004827		

The volatility through EGARCH (1, 1) methodology is observed to consider the effect of positive or adverse statistical data. The outcome of the EGARCH (1, 1) model is shown in Table 5. The outcome reveals the occurrence of the leverage effect. C (5) is negative i.e. -0.169428 and statistically significant which specifies that any change in the spot price of USD/INR responds asymmetrically to the positive or adverse information in the currency market. Further, it can be concluded that affirmative news creates less variance or volatility than bad news. Hence, unfavorable information plays a very important part in volatility in comparison to affirmative news. The AIC and SC criteria of the model are 4.849078 and 4.881934 respectively.

Table 6. TGARCH (1, 1) Model for Exchange Rate Volatility

LOG(GARCH) = C(3) + C(4)*ABS(RESID(-1)/@SQRT(GARCH(-1))) + C(5)
*RESID(-1)/@SQRT(GARCH(-1)) + C(6)*LOG(GARCH(-1))

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	74.75955	0.015667	4771.700	0.0000
FUTURE	0.121020	0.018937	6.390538	0.0000
Variance Equation				
C(3)	-1.357431	0.164847	-8.234482	0.0000
C(4)	1.557808	0.214725	7.254913	0.0000
C(5)	-0.169428	0.102527	-1.652523	0.0984
C(6)	0.887427	0.032734	27.11054	0.0000

R-squared	-1.003287	Mean dependent var	70.41878
Adjusted R-squared	-1.005593	S.D. dependent var	4.336717
S.E. of regression	6.141613	Akaike info criterion	4.849078
Sum squared resid	32778.17	Schwarz criterion	4.881934
Log likelihood	-2105.773	Hannan-Quinn criter.	4.861649
Durbin-Watson stat	0.004827		

The leverage effect is measured through the TARCH (1, 1) model and the outcome of the model is shown in Table 5. The C (4)*(RESID (-1) ^2*(RESID (-1) <0) is negative i.e. -0.149452 and statistically not significant. This supports the statement that there is no leverage effect in the model and favorable information produces more volatility as compared to positive news or positive and adverse shocks have a diverse shock on the volatility of spot price of USD-INR return. The AIC and SC criteria of the model are 4.574352 and 4.607209 respectively.

5. CONCLUSION

The study used USD-INR currency rates as it is the pioneer in the Indian currency futures market. The daily closing values of the spot and futures of USD/INR were gathered from 2017 to 2020 and represented by applying GARCH methods. The methods capture the volatility clustering and leverage effect during the study period. The test of unit root, volatility clustering, and ARCH effect is confirmed and established. Though uncertain position in the global economy has a lot of influence on spot exchange rates, This study reveals ample evidence that the trading activities in currency futures affect both the return and volatility in spot exchange rate movements.

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