

How to Cite:

Singh, A., & Patra, G. (2022). Impact of currency futures on spot rate volatility in Indian foreign exchange market. *International Journal of Health Sciences*, 6(S6), 7431–7448. <https://doi.org/10.53730/ijhs.v6nS6.11944>

Impact of currency futures on spot rate volatility in Indian foreign exchange market

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Abstract--The work aimed going to ascertain the efficacy of the currency futures on cash-market or Spot exchange rates volatility with respect of USD/INR, EURO/INR, GBP/INR & JPY/INR. The daily closing of have been taken from RBI website. Also, the time series data is checked for stationarity using ADF test. Existence of ARCH effect examined in spot rate residual of the return series data and checked with Autoregressive conditional heteroskedasticity L.M. test by using GARCH (1,1) model. Findings of GARCH model shows that large volatility is persistent pre-introduction of currency futures and finding shows presence of time-varying conditional volatility of returns of currencies spot prices at pre-post and total period of currency futures introduction in currency exchange market. The variances in volatility of the exchange rate returns of pre and post introduction of currency futures time periods being analyzed by using statistical tools. Findings shows to be importantly varied and volatility has been came down in the post futures era also series were found more stable in terms of volatility.

Keywords--exchange-rate, ADF, ARCH, GARCH, currency-futures, volatility, heteroskedasticity.

Introduction

Structural reforms begin during year 1991 in India. Keeping in view the significance of derivatives in substantial financial system, index futures in equity

market has been started with year 2000 later it continued with starting of futures and options. Currency Derivatives started with currency futures in 2008 as futures for USD followed by in currencies pound, euro and yen too. With introduction of currencies futures made currency derivative market as a useful tool risk management and cost effectiveness in currencies management or import & export business. But the literature reviews shows that there can be seen a visible impact of currencies futures on their underlying markets in different periods. A school of scholars emphasized that post introduction of currency futures brought an instability in spot exchange rate volatility, second school of scholars says currency futures has improved the overall capital and equity markets. Therefore is it necessary to conduct an assessment of to observe the pre and post effect on underlying currencies of futures to check the volatility effect.

Literature Review

Clarida, R. & Gali, J. (1994) stipulated an ascertainment the root cause of real exchange-rate volatility right after downfall of Bretton Woods 1971, through surveys. Study investigates money can impact the real exchange rates during short run only. Also VAR applied for forecasting the real-exchange rates with inflation lags differential and changes in lags in case of U.S. output compared to the world output. The study is a contrast of Yen, DM in comparison of U.S. Dollar. Study source reported a relativeness of Dollar-DM and Dollar-Yen using VAR after collapse of Bretton Wood 1971 and found unconditional variance in comparison. Hossain, A., (1997) demonstrates developed a model of macroeconomic in tradable and non-tradable commodities during the time period of 1973-1996 in Bangladesh with 4.5 GDP as per historical data.

4.5% GDP resulted because of foreign aid and increase in demand of nontradable goods too. Appreciation in demand of nontradable goods results in increase in output and employment of nontradable goods. Study indicates real exchange rate doesn't influence the demand of nontradable goods and sector, these goods appears price inelastic. Demand for tradable goods declined from 59% during 1973-1975 to 44% during 1995-1996. Share of employment respectively declined from 68% to 58%. But this declined was associated with per-capita income increase from 65% to 68%. Adverse effects on tradable goods demand resulted positive effects on per-capita income, real exchange rate and trade balance. This appreciation in entire economic boom in Bangladesh economy was a result in structural adjustment programs IMF-World Bank. It might encouraged investors to invest directly some key areas or export oriented manufacturing like gas and oil because of this Bangladesh Economy experienced foreign capita-induced and boom in economy. Study reports cause and effect relationship between tradable-nontradable goods and exchange rates.

Hossain, A., (1997) demonstrated responses of exchange-rate to the inflation in Bangladesh starting since 1972-1999 annually and monthly both date investigated. Study reported consumer price inflation led to devaluation. Inflation impact on depreciation in currency has become sluggish after reforms undertaken. General perception is devaluation in currency value lead to increase in inflation in developing countries. Study stipulated possibility of causal linkage between devaluation and inflation. Study reported effects of nontradable goods,

inflation influences the exchange rate and contrast of inflation and Exchange rate. Study is an extended version of the previous study conducted and lead to same results, still there can be a lot more macroeconomic variable can put in consideration. Study focuses on only structural adjustment made by IMF-World Bank and ripple effect of those structural adjustments.

Mussa, M., (1997) demonstrated extension of fundamental principles in monetary approach to BOP in floating exchange rate regime with intervention of authorities and controlled rate movements. Study indicates four points first relativeness of exchange rate with price of each national currency, not country's outputs and can be find by supply of monies & demand. Frankel, J. A., (1999) always demonstrated an essay form on Not a one Currency Regime found fit for all nations, Currencies/time. This study stipulated that it's a choice of an individual country to imply the exchange rate regime from country's own choice depending and evaluating the current economic and global scenario. This study supports no single exchange rate regime for all times. Referred to East Asian Crises author indicates that the during East Asian Crises the major problem was nations did not have pegged to the dollar rather countries those pegged to the dollar like Mexico, Thailand, Russia, Brazil they sailed well during the time of crises or in general also. Further study indicates points for complete floating exchange rate suggestion and a complete flexible rate regime suggestion, Blancing Fixed vs. Flexible Exchange Rates, The Optimum Currency Area, Cornet Solution are right for some Countries and dollarization proposal. A rigid peg or free float has yet to be rationalized theoretically. This study reported a complicated intermediate regime which are 22 insufficient to verify, transparent operations are also not possible to satisfy the trade partners and global investors.

Basurto, G., & Ghosh, A., (2000) demonstrated stabilization programs i.e. strict monetary policy in Asian Crisis Countries (Indonesia, Korea and Thailand) was designed to defend the crisis of Exchange rate but results confirms that with the huge depreciation in exchange rate and tightening of monetary policy has raised fear of raise interest rate that resulted in widespread bankruptcies and a large risk. To establish the relationship with tighter monetary policy, increase in nominal interest rates and Exchange rate volatility VAR is being used to get correlation values. Basurto, G., & Ghosh, A., stipulated bigger rates of interest are not correlated to exchange rate increased during the Est Asian Crisis. The study contributes towards examining if high rates of interest results in exchange-rate despeciation being other thing remain the same and found the higher real rate of interest are correlated to exchange rate but no impact of money supply in economy on rate of interest & exchange rate depreciation. Also the study contributes that the efficacy of News and adverse political conditions could create interest and exchange rate risk. The study reported examination of a East Asian Countries Cries situation and the remedial action taken or suggests an alternative approach to deal with crises but the research could lead to more clear view point if the variables study conducted pre and post crises conditions and compared.

Tanner, E., (2000) demonstrated (EMP) i.e. Exchange market pressure its product of total of Exchange- Rate Depreciation and reserve outflows , conclude the excess supply in manged Ex regime. Hua, H., (2002) demonstrated relativeness of trade weighted real exchange rate of USD/DM reference to degree of the openness in

economy to the trade with support of the theory intertemporal monetary model of a small open 23 economy with nominal rigidities. Economies produces shocks with when they are more open to foreign trade. Sources reported forty eight countries confirms relationship. Karfakis, C., (2003) stipulated exchange determination monetarist model of the time of hyperinflation in Romania to test the data of Lei/dollar exchange rate. Study indicates a swift enhance of money supply and inflation led to depreciation of Lei on the other hand enhance the Romanian real income became the root of appreciation of Lei. Study reported policy implication expansion with an aim to manage inflation can produce economic growth and can boost the value of Lei.

Macdonald, R., & Ricci, A. L., (2004) recorded as sharp depreciation in South African Rand of 25 percent in year 2002 than value of Rand in YoY period and 45% average depreciation than the average of year 1995. Research question is to find the equilibrium level of currency depreciation and macroeconomic variables because macroeconomic variables continuously effects the exchange rate. Egert, B., (2009) A high frequency study of South African Rand and U.S. Dollar in time period of Jan. 2001 to July 2007. The study examines importance of fundamentals of economic in describing the increase and decrease of exchange price in time duration of the study, ponder on whether monetary fundamentals has role in nominal exchange rate determination in S.A. or the political risk have an impact of rand exchange rate, whether the export of goods changes the view point of the investors FDI/FIIs towards south African economy, whether the emerging economies have an impact of rand exchange rate and whether the interest policy of central bank influences the exchange rates.

Hsieh, W., (2009) demonstrated four major models of IND/USD exchange rates and PPP Model, presented the interest Parity Model, Monetary Model. Study Indicates PPP model an indicator of the coefficient has expected positive sign and significant at the 1% level. Liew, K. V., Baharumshah, Z. A., & Puah, H. C., (2009) demonstrated long run relationship among exchange rate and determinants. Approach of multivariate cointegration is used. Study indicates small openness is good for emerging economies like Thailand. Mirchandani, A., (2013) demonstrated FX of India experienced a substantial change in 1991 to 2010. Study has developed relationship between inflation data, Exchange rate data, Interest Rate data and Foreign Exchange market, Current Account & International Trade. Research tool used is correlation. Venkatesan, T., & Ponnammam, S. M., (2017) demonstrated rupee is setting its mark in international markets, its seen through Nepal and Bhutan started pegging of Indian rupee, high GDP of India enable India to stand out of the league of emerging economies. Study indicates increase in GDP enable to become strong exchange rate along with factors gross domestic savings, forex reserve and inflation. Study reported relativeness of Exchange rate INR/USD and Macroeconomic variables using research tools of econometric modelling, ADF test, Vector Auto Regressive Model and ARDL and found FDI has long-term relationship in efficacy of Ex and significance of macroeconomic variables in exchange rate.

Mishra, S., & Debasish, S.S.,(2019) demonstrated an analysis of volatility spillover amount exchange rate and crude oil price in India from June-2003 to March-2016. Study analyse efficacy of crude oil price on exchange-rate of

INR/USD with research tool (GARCH) and (EGARCH). This work contributes up in prices of crude oil redirect to decrease in INR/USD exchange rate. Sharma, C., (2019) demonstrated relationship among export at commodity level in context of India and exchange rate risk. Panel data on monthly basis used to analyse covering hundred products during the time 2012-2017. To quantify volatility of exchange rate both real and nominal are considered and prediction has been done using autoregressive conditional heteroscedastic method (ARCH). Vinish, K., & Sabat, J., (2020) demonstrated relationship among oil prices and Ex in India. GARCH & EGARCH models employed in this work to check efficacy of oil stock prices on nominal exchange rate in last decade. Study reported, All period have varying volatility.

Data

The exchange-rate data of USD/INR, EUR/INR, GBP/INR & JPY/INR of the study period February, 2004 to August-2020 is collected through the website of RBI. Currency futures in USD/INR listed in year 29th August, 2008 and in year 2010 October currency futures of EUR/INR, GBP/INR & JPY/INR introduced. The prime objective of the study presented is divided into two parts i.e. stated as pre-introduction period i.e. from 3rd February, 2004 to 31st December 2007 of USD/INR and for currencies EUR/INR, GBP/INR, JPY/INR is from 1st January, 2006 to 31st January, 2010. Post Introduction period data is from 1st February, 2010 to 30th September 2014 of Currencies EUR/INR, GBP/INR & JPY/INR and for USD/INR from 01st September, 2008 to 30th August 2013.

Research Methodology

Influence of currency futures on underlying Cash market volatility comprehension is divided into two methods. First, match the cash market volatility pre introduction currency futures & post introduction period of currency futures. (Bologna & Cavallo, 2002, Edwards, 1988, Jochum & Kodre, 1998). Second, impact of future trading on volumes of trading of spot exchange market. This study worked on first approach for investigating the effect on spot exchange volatility of currency futures in all four currencies pre and post introduction of currency futures in India. Time series of exchange rates is been converted in natural logarithms. Later, the return is calculated through considering first difference of the log values. To know the more deepness of the time series data descriptive statistics, mean, median, mode, skewness, kurtosis, Jarque and Bera is being applied in all three periods of time series return data. It is known that the stationarity at level is an imperative for the time series data analysis in advance statistical techniques. Augmented Dicky-Fuller (ADF) has been applied to unit-root testing to estimate stationarity in return series at level. A time series is called stationary if time series has zero mean and constant variance. Non-stationary time series has unit-root and depict not even patterns. Findings entail that applying advanced statistical test on time series can't be considered, that's why stationarity of times series on first level is needed. The times series variables opted in the study is everyday exchange rate of USD_INR, ERO_INR, GBP_INR & JPY_INR and the ADF test applied on the these series by using equation given below:-

$$\Delta Y_t = a_1 Y_{t-1} + \sum_{j=1}^p \beta_j \Delta Y_{t-j} + \varepsilon_t \dots \dots \dots (1)$$

$$\Delta Y_t = \alpha_0 + a_1 Y_{t-1} + \sum_{j=1}^p \beta_j \Delta_{t-j} \varepsilon_t \dots \dots \dots (2)$$

$$\Delta Y_t = \alpha_0 + \alpha_1 Y_{t-1} + a_2 t + \sum_{j=1}^p \beta_j \Delta Y_{t-j} + \varepsilon_t \dots \dots \dots (3)$$

Data under study is a time series data that has been further examined for the existence of the heteroskedasticity by using the Lagrange Multiplier (LM) method. The Lagrange Multiplier (LM) got existed null-hypothesis of without ARCH impact. A time series said to be heteroskedastic if the null-hypothesis is no accepted. The heteroskedasticity in a time series makes the estimates of ordinary least square (OLS) regression inefficient as OLS assumes constant error variance. To capture the heteroskedasticity of time series the ARCH model can applied. Bollerslve in 1986 introduced the standard GARCH (p,q) which suggests that conditional variance of returns is a linear function of lagged conditional variance and past squared error term. The equation of standard GARCH is:

$$Rt = c + \beta 1 Rt - 1 + \varepsilon t \dots \dots \dots (4)$$

$$ht = \omega + \alpha_{t-1}^2 + \beta 1 ht_{-1} \dots \dots \dots (5)$$

Empirical Results

In Table 1 results of Descriptive Statistics are shown that shows the standard deviation of the post introduction period has increased. So, it can be said that the growth in volatility by the introduction of the currency-futures in all four currencies. But at this point it is unable to identify the reasons behind this growth. To make imperative assumption, there must be more analysis done to understand the reaction of exchange rate returns and prediction of forthcoming exchange rates other factors can be influential to impact a time series data's volatility. The value of mean is also increased in all four currencies substantially. In Table-1, it can be seen that exchange rates are skewed negatively in pre introduction period and positively in post introduction time. Jarque-Bera statistics of exchange rate returns in all the periods found statistically significant. Value of indicators of sknewnes, kurtosis and Jarque-Bera shows exchange rate distribution value not normally distributed that has been conformed with same studies carried out in some previous studies.

To get more deep insight into our examination, it is imperative to get stationarity in exchange rate return series. For stationarity ADF test in all three currencies pairs at level pre/post and all period, with intercept and with trend and intercept and without trend and intercept. After ensuring stationarity, the return series of exchange rate examined for existence of ARCH effect. Further deepness into analysis lead, towards to check the stationarity of the data i.e. exchange rate time series data is stationary or not. For this objective ADF test of unit root has been applied at level for different periods and the findings are displayed in Table2: To estimate the mean equation ARIMA (p,d,q) model applied and selected order of "p" and "q" for looking at the correlogram. i.e. p is autoregressive component and q is moving averages component and the applied ARIMA AR (1) and MA (1) term found

AR(1) component is statistically significant and MA(1) ie. Moving averages is also statistically significant.

After checking AR(1) & MA (1) existence of ARCH effect is checked by conducting Heteroskedasticity Test to check H_0 No existence of ARCH effect to the specified Lag or H_1 there are ARCH effect to the specified lag. As we found p is <0.05 that confirms existence of ARCH effect.at one lag and 5% significant and one ARCH is enough. To remove the negative lags later we applied Simplified GARCH model with an object: to Forecast the volatility of returns in all four currencies spot rates. Though series visualization volatility clustering is visible in currencies pre-post and in total period data. Through Histogram and stats clearly Leptokurtic Has fat tails can be seen in all four currencies pre-post and total series data which exhibits a high frequency series a fat tail.

As ARCH effect exists when we apply GARCH (1,1) results shows where dependent variable are returns of spot currencies series data of pre-post and of total period. In Pre introduction of Currency futures Convergence Achieved after 12 integrations in USDINR Pre, 13 in EUROINR, 13 in GBPINR and 19 in JPYINR pre introduction of currency futures in respective currencies as Table 10 shows. Coefficients of the constant's variance term, ARCH & GARCH parameters are positive and statistically significant at the 1% Level in pre-introduction period of currencies futures in Indian Exchange Market. Also, in all four currencies data pre introduction of currency futures in currency exchange market shows that coefficients of conditional variance specification join the stability conditions of $0 < b_1 < 1, 0 < \theta_1 < \text{and } b_1 + \theta_1 < 1$. But in EUROINR & GBPINR exchange rate $b_1 + \theta_1 > 1$ shows that the large volatility in pre-introduction of currency futures era. Findings states the existence of time-varying conditional volatility of returns of currencies spot prices at pre-post and total period of currency futures introduction in currency exchange market. Results after the conversion of exchange rate returns into stationary data of all four currency at without intercept and trend to apply LM test to check the effect of ARCH.The LM test with null hypothesis of no presence of ARCH effect applied on each time series to check the ARCH effect and found presence of ARCH effect after applying ARMA test. Since Presences of ARCH effect is there the application of GARCH (1,1) Model can be used.

Table 1
Descriptive Statistics and Normality of USDINR, EuroINR, GBPINR & JPYINR

Date: 11/10/21 Time: 22:11												
Sample: 2/03/2004 8/31/2020 USD_INR SP				Sample: 2/03/2004 8/31/2020 EURO_INR SP			Sample: 2/03/2004 8/31/2020 GBP_INR SP			Sample: 2/03/2004 8/31/2020 JPY_INR SP		
	PRE	POST	TOTAL	PRE	POST	TOTAL	PRE	POST	TOTAL	PRE	POST	TOTAL
Mean	43.98837	58.59184	55.10754	59.46405	74.90991	68.60603	79.35125	92.41289	85.50595	42.86896	60.83877	53.50031
Median	44.32000	61.51850	53.08550	58.12000	75.27615	69.12430	79.96530	92.30055	84.72400	40.75500	60.71000	55.07000
Maximum	46.95000	76.80840	76.80840	71.06000	91.46820	91.46820	89.42080	106.0281	106.0281	55.96000	72.12000	72.12000
Minimum	39.27000	39.27000	39.27000	51.84000	58.63000	51.84000	65.64710	79.85630	65.64710	32.69000	50.98000	32.69000
Std. Dev.	2.011328	10.07268	10.81490	4.873470	6.510339	9.613328	5.387385	6.294579	8.748130	6.332025	5.197431	10.50637
Skewness	-0.961839	-0.204370	0.251860	0.658612	-0.199065	0.049060	-0.351488	-0.010423	0.157066	0.548903	0.143267	-0.309121
Kurtosis	2.966299	1.729923	1.574535	2.326527	2.390808	1.843972	2.190421	1.888051	2.342050	1.992954	2.209663	1.919998
Jarque-Bera	147.6041	226.5261	381.9949	149.2839	52.38856	224.9551	101.5953	97.40307	88.83984	151.4686	69.87823	258.8144
Probability	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Sum	42096.87	178939.5	221036.3	97342.65	177836.1	275178.8	168304.0	174660.4	342964.4	70219.36	144370.4	214589.7
Sum Sq. Dev.	3867.441	309754.2	469017.9	38856.16	100578.4	370588.4	61530.71	74845.44	306884.4	65634.75	64075.52	442639.1

Observations	957	3054	4011	1637	2374	4011	2121	1890	4011	1638	2373	4011
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Table 2
Unit-Root Test

ADF Statistics								
Exchange-Rate Data (Spot Rate)								
	USDINR SP		EUROINR SP		GBPINR SP		JPYINR SP	
	With Intercept		With Intercept		With Intercept		With Intercept	
Period	t -statistics	Prob.	t -statistics	Prob.	t -statistics	Prob.	t -statistics	Prob.
Pre-Period	0.145373	0.9689	-1.689731	0.4363	-1.689731	0.4363	-0.625785	0.8624
Post-Period	-1.227825	0.6646	-1.709673	0.4262	-1.709673	0.4262	-1.934582	0.3165
Total-Period	-0.040844	0.9537	-1.001176	0.7550	-1.001176	0.7550	-1.072998	0.7285

ADF Test Statistics								
Exchange-Rate Data (Spot Rate)								
	USDINR SP		EUROINR SP		GBPINR SP		JPYINR SP	
	With Trend and Intercept		With Trend and Intercept		With Trend and Intercept		With Trend and Intercept	
Period	t -statistics	Prob.	t -statistics	Prob.	t -statistics	Prob.	t -statistics	Prob.
Pre-Period	-0.867898	0.9576	-2.245877	0.4631	-2.245877	0.4631	-1.806514	0.7014
Post-Period	-2.641545	0.2617	-2.216990	0.4793	-2.216990	0.4793	-2.099057	0.5455
Total-Period	-2.553242	0.3022	-2.976899	0.1388	-2.976899	0.1388	-2.433620	0.3618

ADF Test Statistics								
Exchange-Rate Data (Spot Rate)								
	USDINR SP		EUROINR SP		GBPINR SP		JPYINR SP	
	Without intercept and trend		Without intercept and trend		Without intercept and trend		Without intercept and trend	
Period	t -statistics	Prob.	t -statistics	Prob.	t -statistics	Prob.	t -statistics	Prob.
Pre-Period	-1.425411	0.1438	0.175462	0.7371	0.175462	0.7371	0.626790	0.8516
Post-Period	1.952827	0.9883	1.033451	0.9214	1.033451	0.9214	0.484381	0.8197
Total-Period	1.714167	0.9795	0.998064	0.9166	0.998064	0.9166	0.733874	0.8731

Table 3
ADF Test on Return Series obtained Stationarity in Time Series

ADF Statistics								
Exchange Rate Return Data (Spot Rate)								
	USDINR SP		EUROINR SP		GBPINR SP		JPYINR SP	
	Without intercept and trend		Without intercept and trend		Without intercept and trend		Without intercept and trend	
Periods	t -statistics	Prob.	t -statistics	Prob.	t -statistics	Prob.	t -statistics	Prob.
Pre-Period	-- 30.41035	0.0000	-40.88307	0.0000	-34.74697	0.0000	-42.74499	0.0001
Post-Period	-55.06619	0.0001	-46.12490	0.0001	-41.33486	0.0000	-48.84284	0.0001

Total-Period	-29.69763	0.0000	-61.76807	0.0001	-61.19628	0.0001	-64.25992	0.0001
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Table 4
ARMA Results of Pre-Introduction of Currency Futures of USDINR_SP,
EUROINR_SP, GBPINR_SP & JPYINR_SP

USDINR SP					EUROINR SP					GBPINR SP					JPYINR SP				
Dependent Variable: PRE-USDINR_SP RETURN					Dependent Variable: PRE-EUROINR_SP RETURN					Dependent Variable: PRE-GBPINR_SP RETURN					Method: ARMA Maximum Likelihood (BFGS)				
Date: 12/02/21 Time: 19:01					Date: 12/02/21 Time: 19:04										Date: 12/02/21 Time: 19:09				
Sample: 2/04/2004 10/28/2010					Sample: 2/04/2004 10/29/2012										Sample: 2/04/2004 10/29/2010				
Included observations: 956					Included observations: 1636					Included observations: 2120					Included observations: 1637				
Convergence achieved after 21 iterations					Convergence achieved after 29 iterations					Convergence achieved after 18 iterations					Convergence achieved after 17 iterations				
Variable	Coefficient	Std. Error	t-Statistic	Prob.	Coefficient	Std. Error	t-Statistic	Prob.		Coefficient	Std. Error	t-Statistic	Prob.		Coefficient	Std. Error	t-Statistic	Prob.	
C	0.000146	9.99E-05	1.458206	0.1451	5.26E-05	0.000157	0.335588	0.7372		2.22E-05	0.000156	0.142084	0.8870		0.000153	0.000203	0.753574	0.4512	
AR(1)	0.461769	3.494591	0.132138	0.8949	0.508930	0.535227	0.950868	0.3418		0.460269	0.264632	1.739278	0.0821		0.543517	0.144592	3.758962	0.0002	
MA(1)	0.466726	3.493886	0.133584	0.8938	0.529183	0.529411	0.999570	0.3177		0.499887	0.258528	1.933591	0.0533		0.606900	0.137015	-4.429453	0.0000	
SIGMASQ	9.28E-06	2.51E-07	36.96799	0.0000	4.30E-05	9.26E-07	46.38959	0.0000		4.53E-05	7.53E-07	60.18362	0.0000		8.27E-05	1.72E-06	48.15086	0.0000	

Table 5
ARCH effect Results of Pre-Introduction of Currency Futures of USDINR_SP,
EUROINR_SP, GBPINR_SP & JPYINR_SP

USDINR SP					EUROINR SP					GBPINR SP					JPYINR SP				
Dependent Variable: RESID^2					Dependent Variable: RESID^2					Dependent Variable: RESID^2					Dependent Variable: RESID^2				
Date: 12/02/21 Time: 18:56					Date: 12/02/21 Time: 19:02					Date: 12/02/21 Time: 19:05					Date: 12/02/21 Time: 19:10				
Sample (adjusted): 3 957					Sample (adjusted): 2/05/2004 10/28/2010					Sample (adjusted): 2/05/2004 10/29/2012					Sample (adjusted): 2/05/2004 10/29/2010				
Included observations: 955 after adjustments					Included observations: 1635 after adjustments					Included observations: 2119 after adjustments					Included observations: 1636 after adjustments				
Variable	Coefficient	Std. Error	t-Statistic	Prob.	Coefficient	Std. Error	t-Statistic	Prob.		Coefficient	Std. Error	t-Statistic	Prob.		Coefficient	Std. Error	t-Statistic	Prob.	
C	5.81E-06	7.39E-07	7.855949	0.0000	3.74E-05	2.65E-06	14.09823	0.0000		4.04E-05	2.88E-06	14.03404	0.0000		5.51E-05	5.05E-06	10.91665	0.0000	
RESID^2(-1)	0.374698	0.030033	12.47606	0.0000	0.129788	0.024538	5.289244	0.0000		0.109027	0.021604	5.046515	0.0000		0.334884	0.023309	14.36711	0.0000	

Table 6
ARMA Results of Post-Introduction of Currency Futures of USDINR_SP,
EUROINR_SP, GBPINR_SP & JPYINR_SP

USDINR SP					EUROINR SP					GBPINR SP					JPYINR SP				
Dependent Variable: RETURN					Dependent Variable: RETURN					Dependent Variable: RETURN					Dependent Variable: RETURN				
Date: 12/02/21 Time: 19:56					Date: 12/02/21 Time: 20:02					Date: 12/02/21 Time: 20:07					Date: 12/02/21 Time: 20:12				
Sample: 1/02/2008 8/31/2020					Sample: 11/01/2010 8/31/2020					Sample: 10/31/2012 8/31/2020					Sample: 11/02/2010 8/31/2020				
Included observations: 3053					Included observations: 2373					Included observations: 1889					Included observations: 2372				
Convergence achieved after 27 iterations					Convergence achieved after 20 iterations					Convergence achieved after 16 iterations					Convergence achieved after 29 iterations				
Variable	Coefficient	Std. Error	t-Statistic	Prob.	Coefficient	Std. Error	t-Statistic	Prob.		Coefficient	Std. Error	t-Statistic	Prob.		Coefficient	Std. Error	t-Statistic	Prob.	
C	0.000204	9.14E-05	2.237238	0.0253	0.000147	0.000130	1.129299	0.2589		6.51E-05	0.000163	0.398948	0.6900		9.79E-05	0.000151	0.647676	0.5173	
AR(1)	0.320573	1.815869	0.176540	0.8599	0.092677	0.298661	0.310308	0.7564		0.444682	0.254175	1.749511	0.0804		0.830506	0.237672	3.494336	0.0005	
MA(1)	0.325956	1.812239	0.179864	0.8573	0.147242	0.297412	0.495078	0.6206		0.395188	0.260850	1.515009	0.1299		0.818596	0.245185	3.338682	0.0009	
SIGMASQ	2.48E-05	3.51E-07	70.60441	0.0000	3.54E-05	6.80E-07	52.09623	0.0000		4.04E-05	5.96E-07	67.80326	0.0000		5.42E-05	1.00E-06	53.97440	0.0000	

Table 7
ARCH effect Results of Post-Introduction of Currency Futures of USDINR_SP,
EUROINR_SP, GBPINR_SP & JPYINR_SP

USDINR SP					EUROINR SP				GBPINR SP				JPYINR SP			
Dependent Variable: RESID^2					Dependent Variable: RESID^2				Dependent Variable: RESID^2				Dependent Variable: RESID^2			
Date: 12/02/21 Time: 19:56					Date: 12/02/21 Time: 20:02				Date: 12/02/21 Time: 20:07				Date: 12/02/21 Time: 20:12			
Sample (adjusted): 1/03/2008 8/31/2020					Sample (adjusted): 11/02/2010 8/31/2020				Sample (adjusted): 11/01/2012 8/31/2020				Sample (adjusted): 11/03/2010 8/31/2020			
Included observations: 3052 after adjustments					Included observations: 2372 after adjustments				Included observations: 1888 after adjustments				Included observations: 2371 after adjustments			
Variable	Coefficient	Std. Error	t-Statistic	Prob.	Coefficient	Std. Error	t-Statistic	Prob.	Coefficient	Std. Error	t-Statistic	Prob.	Coefficient	Std. Error	t-Statistic	Prob.
C	1.94E-05	1.23E-06	15.79228	0.0000	2.82E-05	1.71E-06	16.56198	0.0000	3.67E-05	3.16E-06	11.63105	0.0000	4.31E-05	2.68E-06	16.07163	0.0000
RESID^2(-1)	0.215111	0.017683	12.16488	0.0000	0.202552	0.020115	10.06948	0.0000	0.091942	0.022929	4.009815	0.0001	0.204674	0.020110	10.17774	0.0000

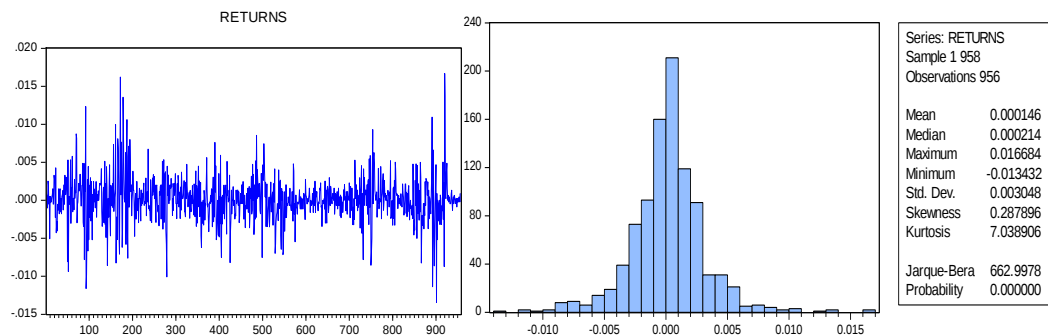
Table 8
ARMA Results of Total Period USDINR_SP, EUROINR_SP, GBPINR_SP & JPYINR_SP

USDINR SP					EUROINR SP				GBPINR SP				JPYINR SP			
Dependent Variable: RETURN					Dependent Variable: RETURN				Dependent Variable: RETURN				Dependent Variable: RETURN			
Date: 12/02/21 Time: 20:23					Date: 12/02/21 Time: 20:32				Date: 12/02/21 Time: 20:37				Date: 12/02/21 Time: 20:42			
Sample: 2 4011					Sample: 2/04/2004 8/31/2020				Sample: 2/04/2004 8/31/2020				Sample: 2/04/2004 8/31/2020			
Included observations: 4010					Included observations: 4010				Included observations: 4010				Included observations: 4010			
Convergence achieved after 27 iterations					Convergence achieved after 21 iterations				Convergence achieved after 17 iterations				Convergence achieved after 21 iterations			
Variable	Coefficient	Std. Error	t-Statistic	Prob.	Coefficient	Std. Error	t-Statistic	Prob.	Coefficient	Std. Error	t-Statistic	Prob.	Coefficient	Std. Error	t-Statistic	Prob.
C	0.000121	7.23E-05	1.674742	0.0941	0.000110	0.000101	1.085222	0.2779	4.32E-05	0.000109	0.394641	0.6931	0.000121	0.000124	0.975458	0.3294
AR(1)	0.332509	2.228110	0.149234	0.8814	0.253752	0.419073	0.605506	0.5449	0.185376	0.294422	0.629625	0.5290	0.505893	0.206122	2.454341	0.0142
MA(1)	0.336181	2.226608	0.150983	0.8800	0.280515	0.417380	0.672085	0.5016	0.221825	0.292447	0.758514	0.4482	0.538915	0.201256	2.677754	0.0074
SIGMASQ	2.11E-05	2.45E-07	86.09669	0.0000	3.85E-05	5.39E-07	71.50776	0.0000	4.31E-05	4.67E-07	92.15968	0.0000	6.60E-05	8.65E-07	76.24278	0.0000

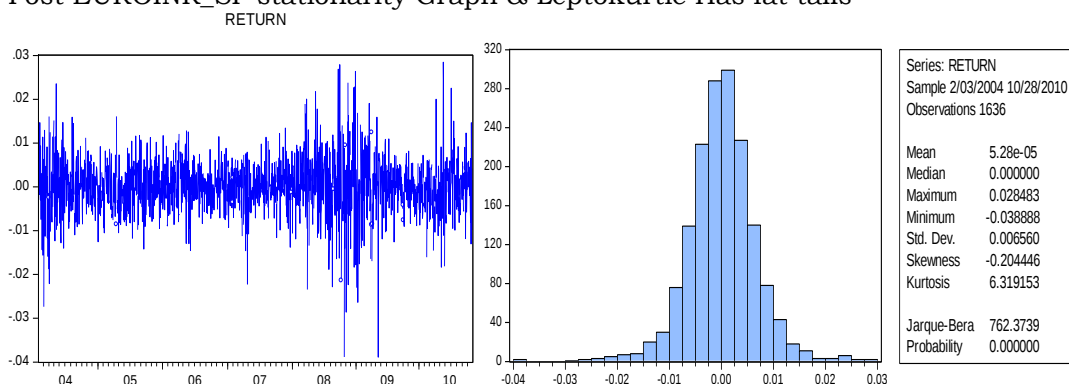
Table 9
ARCH effect Results of Total Period USDINR_SP, EUROINR_SP, GBPINR_SP & JPYINR_SP

USDINR SP					EUROINR SP					GBPINR SP					JPYINR SP				
Dependent Variable: RESID^2					Dependent Variable: RESID^2					Dependent Variable: RESID^2					Dependent Variable: RESID^2				
Date: 12/02/21 Time: 20:28					Date: 12/02/21 Time: 20:33					Date: 12/02/21 Time: 20:37					Date: 12/02/21 Time: 20:42				
Sample (adjusted): 3 4011					Sample (adjusted): 2/05/2004 8/31/2020					Sample (adjusted): 2/05/2004 8/31/2020					Sample (adjusted): 2/05/2004 8/31/2020				
Included observations: 4009 after adjustments					Included observations: 4009 after adjustments					Included observations: 4009 after adjustments					Included observations: 4009 after adjustments				
Variable	Coefficient	Std. Error	t-Statistic	Prob.	Coefficient	Std. Error	t-Statistic	Prob.	Coefficient	Std. Error	t-Statistic	Prob.	Coefficient	Std. Error	t-Statistic	Prob.			
C	1.62E-05	9.50E-07	17.00033	0.0000	3.23E-05	1.49E-06	21.70934	0.0000	3.86E-05	2.13E-06	18.15081	0.0000	4.67E-05	2.62E-06	17.85136	0.0000			
RESID^2(-1)	0.233756	0.015360	15.21842	0.0000	0.163054	0.015586	10.46143	0.0000	0.102697	0.015714	6.535338	0.0000	0.291745	0.015110	19.30807	0.0000			

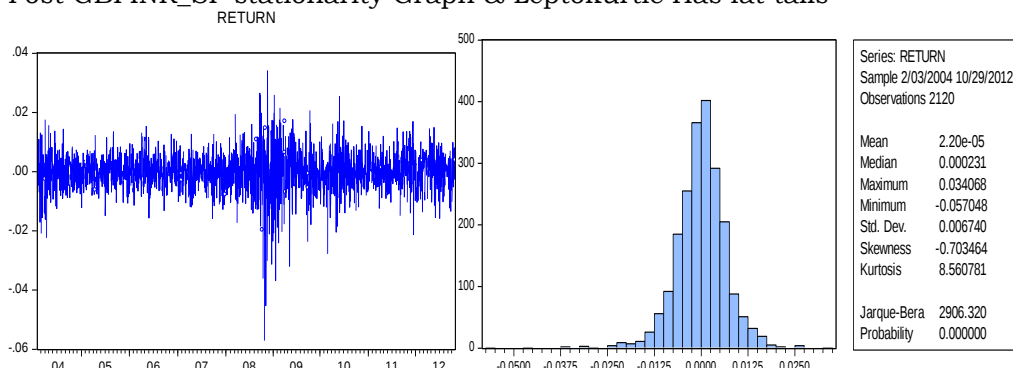
Pre-USDINR_SP stationarity Graph & Leptokurtic Has fat tails



Post EUROINR_SP stationarity Graph & Leptokurtic Has fat tails



Post GBPINR_SP stationarity Graph & Leptokurtic Has fat tails



Post JPYINR_SP stationarity Graph & Leptokurtic Has fat tails

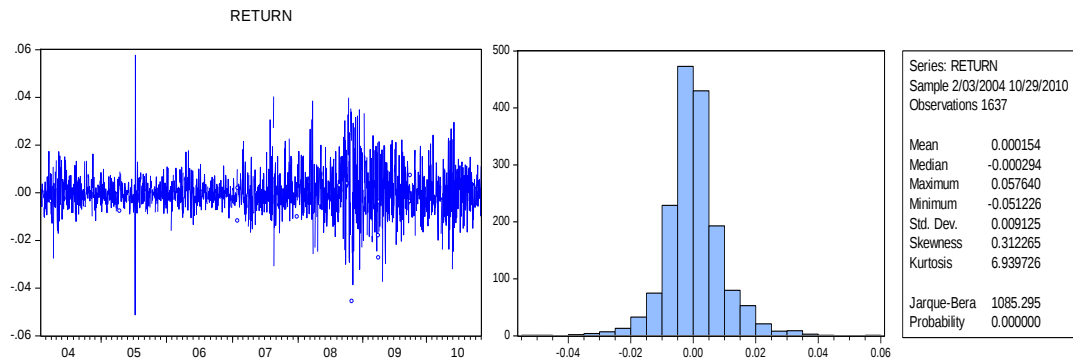
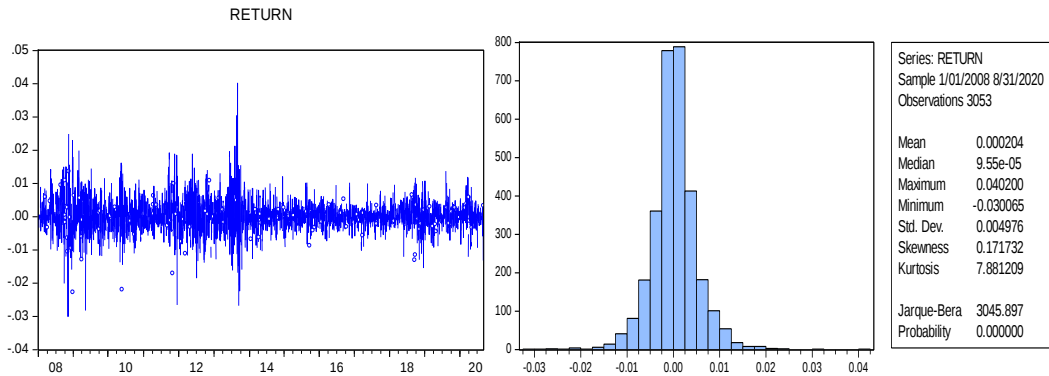


Table 10

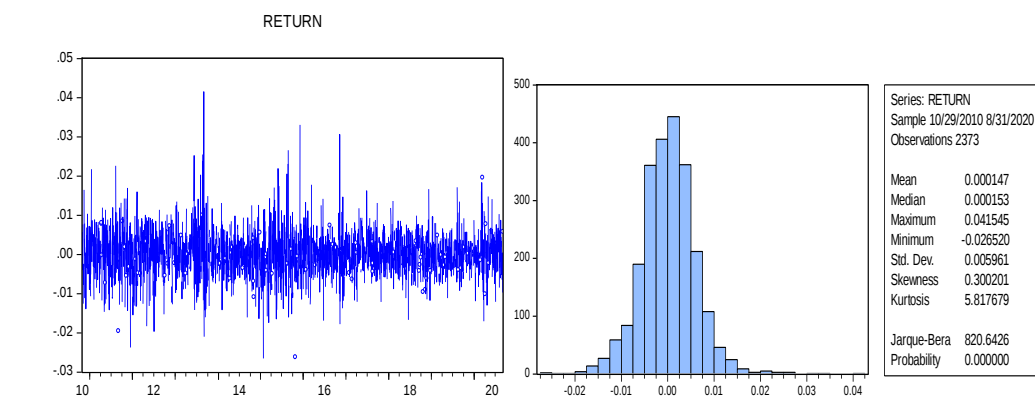
GARCH (1,1) Results of Pre USDINR_SP, EUROINR_SP, GBPINR_SP & JPYINR_SP

USD INR SP					EURO INR SP					GBP INR SP					JPY INR SP				
RETURN					RETURN					RETURN					RETURN				
Date: 12/05/21 Time: 20:54					Date: 12/06/21 Time: 19:50					Date: 12/06/21 Time: 20:08					Date: 12/06/21 Time: 20:21				
Sample (adjusted): 3 957					Sample (adjusted): 2/05/2004 10/28/2010					Sample (adjusted): 2/05/2004 10/29/2012					Sample (adjusted): 2/05/2004 10/29/2010				
Included observations: 955 after adjustments					Included observations: 1635 after adjustments					Included observations: 2119 after adjustments					Included observations: 1636 after adjustments				
Convergence achieved after 12 iterations GARCH = C(3) + C(4)*RESID(-1)^2 + C(5)*GARCH(-1)					Convergence achieved after 13 iterations GARCH = C(3) + C(4)*RESID(-1)^2 + C(5)*GARCH(-1)					Convergence achieved after 13 iterations GARCH = C(3) + C(4)*RESID(-1)^2 + C(5)*GARCH(-1)					Convergence achieved after 19 iterations GARCH = C(3) + C(4)*RESID(-1)^2 + C(5)*GARCH(-1)				
Variable	Coefficient	Std. Error	z-Statistic	Prob.	Variable	Coefficient	Std. Error	z-Statistic	Prob.	Variable	Coefficient	Std. Error	z-Statistic	Prob.	Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	5.14E-05	6.17E-05	0.832371	0.4052	C	4.34E-06	0.000133	0.032562	0.9740	C	1.79E-05	0.000123	0.145688	0.8842	C	-6.07E-05	0.000183	-0.331596	0.7402
RESID^2(-1)	-0.000744	0.035767	-0.020787	0.9834	RESID^2(-1)	0.003432	0.026148	0.131245	0.8956	RESID^2(-1)	0.038359	0.023154	1.656642	0.0976	RESID^2(-1)	-0.028202	0.026279	-1.073176	0.2832
Variance Equation					Variance Equation					Variance Equation					Variance Equation				
C	5.11E-07	1.03E-07	4.942818	0.0000	C	3.34E-07	1.04E-07	3.209376	0.0013	C	4.85E-07	1.24E-07	3.906051	0.0001	C	1.95E-06	2.64E-07	7.384252	0.0000
RESID(-1)^2	0.332739	0.036976	8.998808	0.0000	RESID(-1)^2	0.047477	0.006463	7.346421	0.0000	RESID(-1)^2	0.048852	0.006098	8.010884	0.0000	RESID(-1)^2	0.111911	0.013145	8.513403	0.0000
GARCH(-1)	0.653216	0.029783	21.93236	0.0000	GARCH(-1)	0.944569	0.006753	139.8668	0.0000	GARCH(-1)	0.938788	0.007593	123.6416	0.0000	GARCH(-1)	0.865457	0.014233	60.80570	0.0000

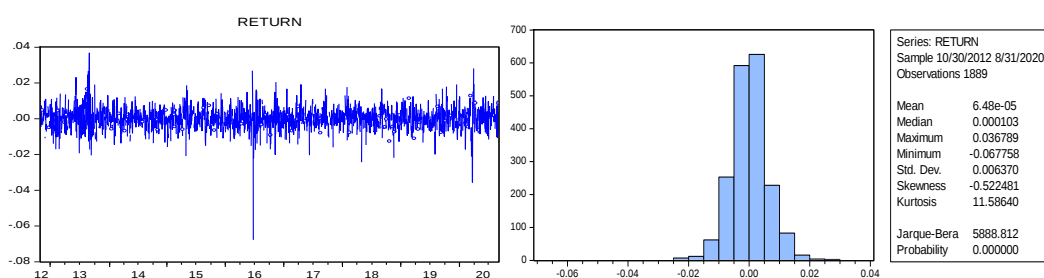
Post-USDINR_SP stationarity Graph & Leptokurtic Has fat tails



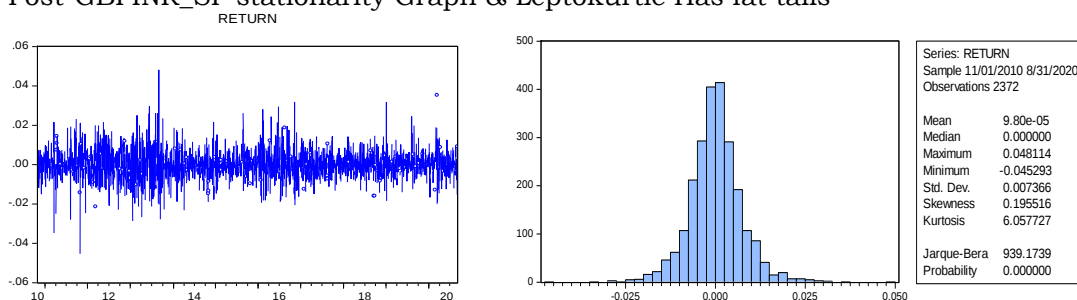
Post-EROINR_SP stationarity Graph & Leptokurtic Has fat tails



Post-GBPINR_SP stationarity Graph & Leptokurtic Has fat tails



Post-GBPINR_SP stationarity Graph & Leptokurtic Has fat tails

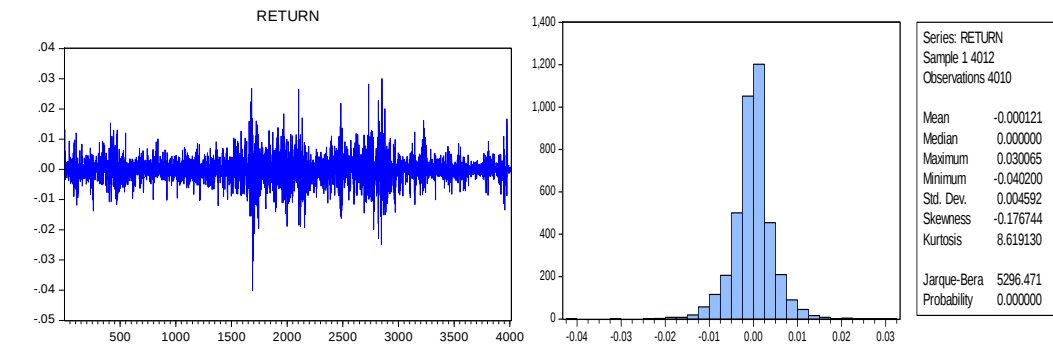


In Post-introduction of Currency futures Convergence Achieved after 13 integrations in USDINR Post, 15 in EUROINR, 27 in GBPINR and 11 in JPYINR Post introduction of currency futures in respective currencies as Table 11 shows. Coefficients constant's variance term, the ARCH and GARCH parameters are positive and statistically significant at the 1% Level in Post-introduction period of currencies futures in Indian Exchange Market. Also, in all four currencies data Post introduction of currency futures in currency exchange market shows that all coefficients of the conditional variance specification meet the stability conditions of $0 < b_1 < 1$, $0 < \theta_1 < 1$ and $b_1 + \theta_1 < 1$. But in EUROINR exchange rate $b_1 + \theta_1 > 1$ shows that the large volatility in Post-introduction of currency futures era. These findings clearly establish the Presence of time-varying conditional volatility of returns of currencies spot prices at Post-post and total period of currency futures introduction in currency exchange market.

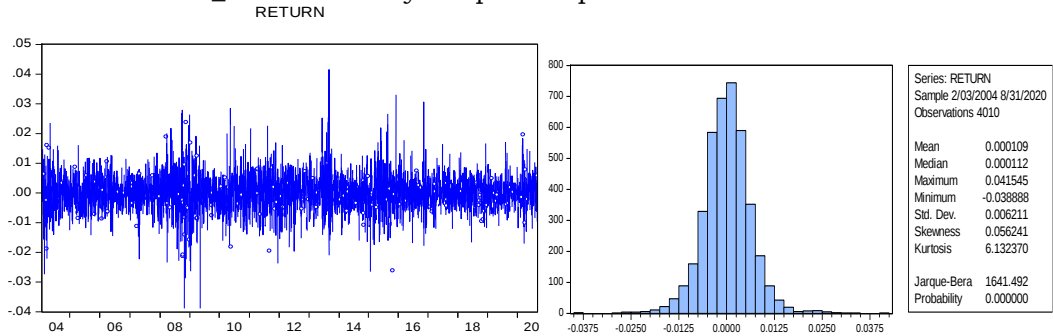
Table 11
GARCH (1,1) Results of Post USDINR_SP, EUROINR_SP, GBPINR_SP &
JPYINR_SP

USD_INR_SP					EURO_INR_SP				GBP_INR_SP				JPY_INR_SP			
Date: 12/06/21 Time: 21:10					Date: 12/06/21 Time: 21:18				Date: 12/06/21 Time: 21:24				Date: 12/06/21 Time: 21:31			
Sample (adjusted): 1/03/2008 8/31/2020					Sample (adjusted): 11/02/2010 8/31/2020				Sample (adjusted): 11/01/2012 8/31/2020				Sample (adjusted): 11/03/2010 8/31/2020			
Included observations: 3052 after adjustments					Included observations: 2372 after adjustments				Included observations: 1888 after adjustments				Included observations: 2371 after adjustments			
Convergence achieved after 13 iterations					Convergence achieved after 15 iterations				Convergence achieved after 27 iterations				Convergence achieved after 11 iterations			
GARCH = C(3) + C(4)*RESID(-1)^2 + C(5)*GARCH(-1)					GARCH = C(3) + C(4)*RESID(-1)^2 + C(5)*GARCH(-1)				GARCH = C(3) + C(4)*RESID(-1)^2 + C(5)*GARCH(-1)				GARCH = C(3) + C(4)*RESID(-1)^2 + C(5)*GARCH(-1)			
Variable	Coefficient	Std. Error	z-Statistic	Prob.	Coefficient	Std. Error	z-Statistic	Prob.	Coefficient	Std. Error	z-Statistic	Prob.	Coefficient	Std. Error	z-Statistic	Prob.
C	5.80E-05	7.04E-05	0.823940	0.4100	0.00011	0.00010	1.006898	0.3140	-3.37E-05	0.000133	0.252305	0.8008	-1.56E-05	0.000130	0.119985	0.9045
RESID^2(-1)	0.015553	0.018941	0.821109	0.4116	0.043631	0.020001	2.181441	0.0292	0.007424	0.025830	0.287409	0.7738	0.003977	0.021754	0.182840	0.8549
Variance					Variance				Variance				Variance			
C	6.08E-07	7.28E-08	8.348266	0.0000	8.37E-07	1.38E-07	6.082738	0.0000	4.17E-06	8.94E-07	4.662642	0.0000	2.42E-06	3.40E-07	7.122090	0.0000
RESID(-1)^2	0.137718	0.011214	12.28093	0.0000	0.054992	0.005213	10.54944	0.0000	0.108194	0.015965	6.776877	0.0000	0.103272	0.009068	11.38847	0.0000
GARCH(-1)	0.839903	0.011252	74.64395	0.0000	0.921464	0.006181	149.0816	0.0000	0.787633	0.035297	22.31453	0.0000	0.854163	0.012798	66.73946	0.0000

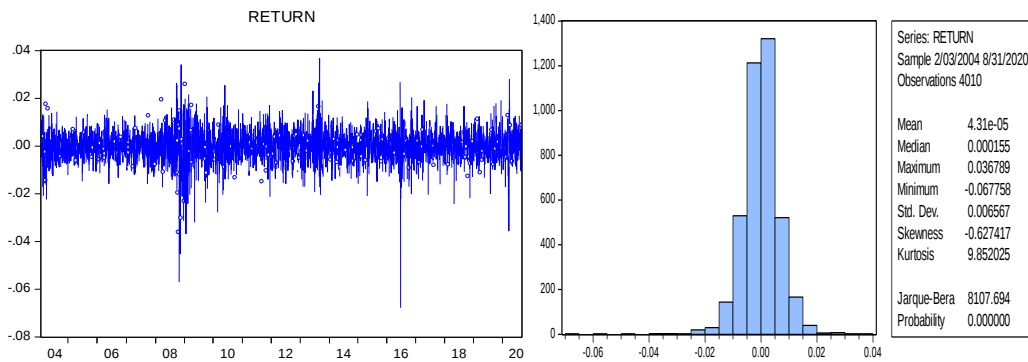
Total-USDINR_SP stationarity Graph & Leptokurtic Has fat tails



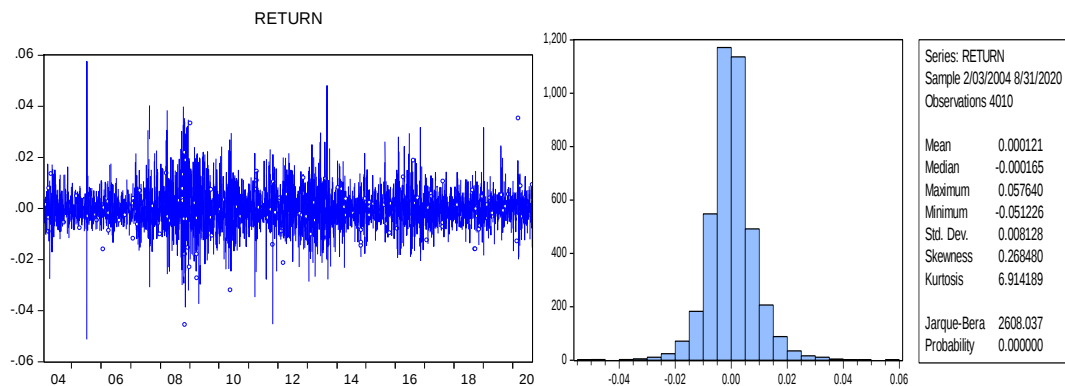
Total-EUROINR_SP stationarity Graph & Leptokurtic Has fat tails



Total-GBPINR_SP stationarity Graph & Leptokurtic Has fat tails



Total-JPYINR_SP stationarity Graph & Leptokurtic Has fat tails



In Total-introduction of Currency futures Convergence Achieved after 13 integrations in USDINR Total, 15 in EUROINR, 27 in GBPINR and 11 in JPYINR Total introduction of currency futures in respective currencies as Table 11 shows. Coefficients constant's variance term, the ARCH and GARCH parameters are positive and statistically significant at the 1% Level in Total-introduction period of currencies futures in Indian Exchange Market. Also, in all four currencies data Total introduction of currency futures in currency exchange market shows that all coefficients of the conditional variance specification meet the stability conditions of $0 < b_1 < 1, 0 < \theta_1 < 1$ and $b_1 + \theta_1 < 1$. These findings clearly establish the Presence of time-varying conditional volatility of returns of currencies spot prices at Total-Total and total period of currency futures introduction in currency exchange market.

Table 12
GARCH (1,1) Results of Total USDINR_SP, EUROINR_SP, GBPINR_SP &
JPYINR_SP

USD_INR_SP					EURO_INR_SP				GBP_INR_SP				JPY_INR_SP			
Date: 12/06/21 Time: 21:45					Date: 12/06/21 Time: 21:51				Date: 12/06/21 Time: 21:56				Date: 12/06/21 Time: 22:02			
Sample (adjusted): 3 4011					Sample (adjusted): 2/04/2004 8/31/2020				Sample (adjusted): 2/05/2004 8/31/2020				Sample (adjusted): 2/05/2004 8/31/2020			
Included observations: 4009 after adjustments					Included observations: 4010 after adjustments				Included observations: 4009 after adjustments				Included observations: 4009 after adjustments			
Convergence achieved after 13 iterations					Convergence achieved after 7 iterations				Convergence achieved after 19 iterations				Convergence achieved after 15 iterations			
GARCH = C(3) + C(4)*RESID(-1)^2 + C(5)*GARCH(-1)					GARCH = C(3) + C(4)*RESID(-1)^2 + C(5)*GARCH(-1)				GARCH = C(3) + C(4)*RESID(-1)^2 + C(5)*GARCH(-1)				GARCH = C(3) + C(4)*RESID(-1)^2 + C(5)*GARCH(-1)			
Variable	Coefficient	Std. Error	z-Statistic	Prob.	Coefficient	Std. Error	z-Statistic	Prob.	Coefficient	Std. Error	z-Statistic	Prob.	Coefficient	Std. Error	z-Statistic	Prob.
C	1.70E-05	4.51E-05	0.376691	0.7064	-2.74E-20	8.39E-10	-3.26E-11	1.0000	1.44E-06	9.07E-05	0.015852	0.9874	-3.25E-05	0.000104	0.311826	0.7552
RESID^2(-1)	0.009818	0.016896	0.581072	0.5612	1.000000	4.724677	0.211655	0.8324	0.023592	0.016954	1.391529	0.1641	0.013716	0.016665	0.823032	0.4105
Variance Equation					Variance Equation				Variance Equation				Variance Equation			
C	3.70E-07	5.08E-08	7.282071	0.0000	4.44E-37	3.69E-38	12.02613	0.0000	1.43E-06	2.09E-07	6.857482	0.0000	2.10E-06	1.91E-07	11.02055	0.0000
RESID(-1)^2	0.188997	0.012422	15.21478	0.0000	0.150000	0.013127	11.42645	0.0000	0.075791	0.005509	13.75786	0.0000	0.106507	0.007382	14.42846	0.0000
GARCH(-1)	0.807842	0.010176	79.38748	0.0000	0.600000	0.026946	22.26638	0.0000	0.889298	0.009477	93.83617	0.0000	0.862067	0.008939	96.43402	0.0000

Conclusion

The currency futures introduction in currency exchange market can be summed as growth in capital inflow in India. Derivates are handful tool for hedging and foreign exchange or risk management. Currency Derivatives strengthens government to regularizing transaction are being carried out in exchange market. This research work has been conducted to analyze influence of launch of currency futures in the underlying market for all four currencies ie. USDINR, EUROINR, JPYINR and GBPINR. Daily closing prices has been taken from RBI website data and divided as pre-post and total periods currency pairwise as per the demand of the research work. Applied ARCH & GARCH (1,1) and seen the volatility-clustering. Test results show volatility in pre & post and total periods is significantly different & high volatility in pre-futures period and found more stable trend in the entire period.

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