A Critical Evaluation of Volatility in Indian Currency Market

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Abstract
The paper is aimed at examining the impact of introduction of currency derivatives on exchange rate volatility of Euro. The data used in this paper comprises of daily exchange rate of Euro in terms of Indian rupees for the sample period April 2005 to March 2015. To explore the time series properties Unit Root Test and ARCH LM test have been employed and to study the impact on underlying volatility GARCH (1, 1) model has been employed. The results indicate that the introduction of currency futures has not been successful in reducing the volatility of the foreign exchange market in India.
Keywords: Currency Futures, Exchange Rate, Forex Market, GARCH, Volatility**.**

Introduction

On August 15, 1971, the United States unilaterally ended convertibility of the dollar to gold. As a result, the Bretton Woods system officially ended and the dollar became fully fiat currency, which marked the beginning of a currency trading exchange 'CME' for Currency futures. The launch of currency future market has been a major milestone in the history of financial markets globally. The Chicago Mercantile Exchange (CME) became the first currency future exchange. But for India 2008 was the year which shall hold equal importance as National Stock Exchange was the first privileged exchange to flag off launch of Currency Derivatives segment on August 29, 2008, followed by Bombay Stock Exchange on October 1, 2008 and Multi Commodity Exchange's arm MCX-SX on October 7, 2008 finally United Stock Exchange on September 20, 2010. India has introduced Currency futures with partial convertibility of its currency in the capital account. Currency futures a crucial instrument for hedging, has made significant contribution in managing the currency risk exposure by eliminating credit risk, easing the accessibility to all market participants and introducing price transparency.

The derivatives market was launched primarily with the twin objectives to transfer risk and to boost liquidity, thereby ensuring better market efficiency. International experience of the rising markets with the introduction of currency futures is varied. In several cases, the volatility is found to be reduced following the introduction of 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 rising pressure on exchange rate volatility. Moreover, there is no clear evidence to prove that futures contracts traded on exchanges result in increased volatility in the prices for the underlying currency values. In the light of the above, it will be interesting to study and examine the effect of introduction of currency derivatives on spot market for exchange rate. This paper looks into this aspect and attempts to find out whether introduction of currency derivatives and currency future trading activity has decreased the volatility in Euro spot market or not.

Literature Review

Danthine (1978) found that the futures markets improved market depth and reduced volatility because the cost to informed traders of responding to mispricing is reduced.

Kumar and Seppi (1992) and Jarrow (1992) examined the impact of currency derivatives on spot market volatility and they found that speculative trading executed by big players in the derivatives market increases the volatility in the spot exchange rate. Hence, currency futures trading increases the spot market volatility.

Glen and Jorion (1993) examined the utility of currency futures/forwards and concluded that currency risk can be minimized through futures/forward hedging.

Chatrath, Ramchander and Song (1996) analyzed the impact of currency futures trading on spot exchange rate volatility by establishing relationship between level of currency futures trading and the volatility in the spot rates of the British pound, Japanese yen, Canadian dollar, Deutsche mark and Swiss franc. They concluded that there exists a causal relationship between currency futures trading volume and exchange rate volatility and also found that the trading activity in currency futures has a positive impact on conditional volatility in the exchange rate changes. Further, futures trading activity has declined on the day following increased volatility in spot exchange rates.

Shastri, Sultan and Tandon (1996) investigated the effect of the introduction of options on the volatility of currency markets and concluded that options contracts complete and stabilize the spot currency markets.

Jochum and Kodres (1998) examined the impact of the introduction of the futures market to the spot currency markets, and report varying results depending on the market they studied. For Mexico, they found that the introduction of currency futures help reduce the volatility of the spot currency market, while for Brazil and Hungary, they didn't find evident impacts.

Adrangi and Chatrath (1998) determined the impact of currency futures commitments and found that the volatility in exchange rate is not caused by overall growth in currency futures commitments. However, increase in the participation of large number of speculators and small traders do destabilize the markets.

Butterworth (2000) argued that introduction of the derivative trading leads to more complete market enhancing the information flow. Derivatives market allows for new positions and extended investment sets and enables to take position at lower cost. Derivatives trading bring more information to the market and allows for quicker disseminations of the information. The transfer of the speculative activity from spot to futures market decreases the spot market volatility.

Bologna and Cavallo (2002) found that the speculation in the derivatives market also leads to stabilization of the spot prices. Since derivatives are characterized by high degree informational efficiency, the effect of the stabilization permits to the spot market. The profitable speculation stabilizes the spot price because informed speculators tend to buy when the price is low pushing it up and sell when the price is high causing it to fall. These opposing forces constantly check the price swings and guide the price towards to the mean level. Uninformed speculators are not successful and are eliminated from the market. This profitable speculation in the derivatives market leads to a decrease in spot price volatility.

Bhargava and Malhotra (2007) analyzed futures trading on four currencies over the time period of 1982-2000 and found that the speculators and day traders destabilize the market for futures but it is not clear whether hedgers stabilize or destabilize the market. Exchange rate movements have an effect on expected future cash flow by changing the home currency value of foreign cash inflows and outflows and the terms of trade and competition. Consequently, the use of currency derivatives for hedging the unexpected movement of currency becomes more sensitive and essential.

Sharma (2011) investigated the impact of currency futures trading in India by establishing relation between volatility in the exchange rate in the spot market and trading activity in the currency futures. The results show that there is a bi-directional causality between the volatility in the spot exchange rate and the trading activity in the currency futures market.

Goyal and Mittal (2014) investigated currency futures impact on the volatility of exchange rate by using GARCH (1, 1) framework and found that currency futures trading have increased the volatility of the exchange rate of USD- INR.

Singh and Tripathi (2014) examined the impact of introduction of currency derivatives on exchange rate volatility of Pound and found that the introduction of currency futures trading has helped in reducing the exchange rate volatility of the foreign exchange market in India, the results also indicated that the importance of recent news on spot market volatility has decreased and the persistence effect of old news has declined with the introduction of currency futures trading.

Singh and Tripathi (2015) examined the impact of introduction of currency derivatives on exchange rate volatility of Euro and found presence of volatility in the Indian currency market, further they found that the introduction of currency futures trading has helped in reducing the exchange rate volatility of the foreign exchange market in India, the results also indicated that the importance of recent news on spot market volatility has decreased and the persistence effect of old news has declined with the introduction of currency futures trading.

The above mentioned fact has provided impetus to investigate the influence of currency derivatives in the perspective of emerging markets which in turn, necessitates further empirical investigation on the impact of currency futures trading on spot exchange rate volatility.

Objectives of the study:

The study has been made to fulfill the following objectives:

1. The estimate the level of volatility prevailing in the Indian currency market.
2. To examine whether volatility is stationary or it has changed over time.
3. To examine whether the introduction of derivatives been really successful in reducing the volatility in the currency market.

Hypotheses of the Study:

H_{01}: there is no volatility in the Indian Currency Market.

H_{02}: there is no significant change in level of currency market volatility after introduction of derivatives.

H_{03}: derivatives introduction has not been successful in reducing the volatility.

Data Collection

The historical currency values time series data have been collected from the official website of Reserve Bank of India i.e. www.rbi.org.in . Daily closing currency values will be used to find the impact of derivatives trading on currency market volatility.

The data set comprises of time series data on currency pair of EURINR. The data will be analyzed for a span of 10 years starting from1st April, 2005- 31st March, 2015. Ten years will be quite a good span of time to study the impact of any policy implication. Engle and Mezrich (1995) suggested that at least eight years of data should be used for proper GARCH estimation.

In order to study the impact of derivatives on currency market volatility, the whole study period has been bifurcated as follows:

Pre derivatives period: 1st April 2005 – 31st January 2010

Post Derivatives period: 1st February 2010 – 31st March 2015

Derivatives trading started in Indian markets on 28th August 2008 with the launch of futures contract of USDINR at NSE. The full set of currency derivatives products was only available after January 2010 i.e. for GBPINR, JPYINR and EURINR.

Thus **January 2010** has been used as cutoff date to study the impact of introduction of derivatives on volatility.

Daily rate of return is calculated by taking natural logarithm of the ratio of present day index level with the previous day index level. The return series over the period of study (Yt) constitutes the time series currency market data for the purpose of the study.

Normality Test

The Data distribution is said to be normal if its skewness is zero and kurtosis is three. The descriptive statistics like mean, standard deviation skewness and kurtosis of the return data over the period study for GBPINR. The normality test of the descriptive statistics is carried on by using an asymptotic Jarque-Bera (1981) test statistic. The formula of Jarque-Bera (JB) statistics is stated below:

$$JB\ Statistics = T\left(\frac{S^2}{6} + \frac{(K-3)^2}{24}\right)$$

T = No. of observations

S = Skewness coefficient

K = Kurtosis coefficient

JB test of normality is the test of the joint null hypothesis if S & K are 'O' and 3, respectively.

Stationarity Test on the Data

Before estimating the models, the unit root properties for the time series data have been tested individually for entire currency sets using Graphical method & ADF test statistic. Graphical method gives a visual estimate of the stationarity of the series which has been confirmed by ADF test statistic. Augmented Dickey fuller test is given by the following equation:

$$ADF = \alpha\Delta y_{t-1} + x'_t\delta + e_t$$

Where α & δ are parameters to be estimated & e_t is white noise error term

The ADF tests the following hypothesis:

H_0: α =0 (series has a unit root)

H_1: α <0 (series does not have a unit root) and is evaluated using t ratio.

Presence of Heteroscedasticity Test

This is a Lagrange multiplier (LM) test for autoregressive conditional heteroskedasticity (ARCH) in the residuals. It tests the null hypothesis that there is no ARCH effect up to order q in the residuals. After we run the usual ARMA model (mean equation), we obtain the residuals. To test for any ARCH effects the residuals are regressed upon their own values by using the following equation:

$$e_t^2 = \beta_0 + \left(\sum_{i=}^{q} \beta_i e_{t-1}^2\right) + v_t$$

Where, e = residual

ARCH LM test approximates chi square distribution with q degrees of freedom.

LM ~ χ_q (chi-square with d.f. q).

The null hypothesis of no ARCH effects is rejected if LM > critical values.

Development of Volatility Models for Estimation of Volatility

The GARCH model

GARCH models explain variance by two distributed lags, one on past squared residuals to capture high frequency effects or news about volatility from the previous period measured as the lag of the squared residual from mean equation, and second on lagged values of variance itself to capture long term influences. In the GARCH (1, 1) model, the variance expected at any given data is a combination of long run variance and the variance expected for the last period, adjusted to take into account the size of the last periods observed shock.

GARCH (1, 1) model is given as:

$$\sigma_t^2 = \alpha_0 + \sum_{i=1}^{q} \alpha_i \varepsilon_{t-1}^2 + \sum_{j=1}^{p} \beta_i \sigma_{t-1}^2$$

Parameter constraints:

$$\alpha_0 > 0$$
$$\alpha_1 > 0$$
$$\beta \geq 0$$

and $$\alpha_1 + \beta < 1$$

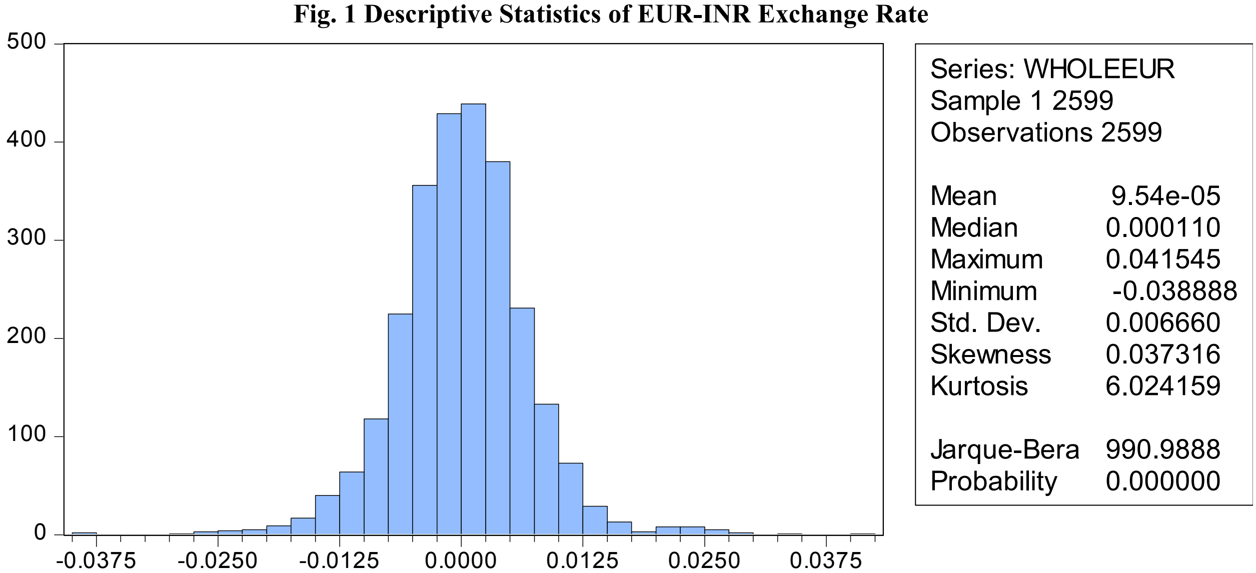
Where q represents the lags of the moving average terms and p representing the lags of the autoregressive terms. The above parameter constraints have been discussed for p=1.

GARCH Framework helps to detect variations in both level & structure of volatility where alpha (ARCH coefficient) shows the impact of current news on volatility; GARCH coefficient shows the impact of old news on volatility indicating the persistence of previous information. The sum of both ARCH & GARCH coefficient shows the persistence in volatility i.e. the speed at which old shocks to the return die out. A straightforward interpretation of the estimated coefficients of the GARCH equation is that the constant term α_0 is the long-term average volatility, i.e. conditional variance, whereas e_t and σ_t^2 represent how volatility is affected by current and past information, respectively.

Analysis of the Results

The descriptive statistics for EURINR have been reported in figure 1 below. The descriptive statistics report that EURINR series is not normally distributed as it has excess kurtosis (greater than 3). Further, the Jarque Bera test statistic which assumes normality rejects the null, for p value being low. The standard Deviation coefficient which is considered as a traditional measure of volatility has been reported as 0.006660 in fig 1.

Fig. 1 Descriptive Statistics of EUR-INR Exchange Rate



The daily closing price series has been converted into logarithmic returns by taking first differences. These closing prices have become stationary after they have been converted into log returns. The graph of the stationary Euro return series has been shown in fig. 2.

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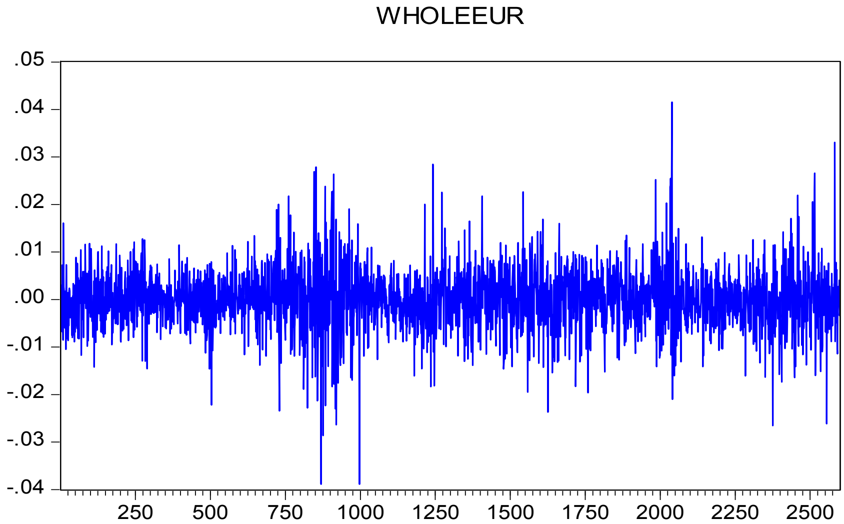

Fig. 2 Stationary EUR-INR Exchange Rate Series

A look at Fig 2 reveals some typical characteristics about the exchange rate series. The exchange rate series exhibit a changing variance, volatility clustering and mean reversion.

The stationarity of the series has also been confirmed using ADF test statistic and Phillips-Perron test statistics in table 1 and 2 testing the hypothesis of non stationarity. The low p value in both the tests rejects the null of non stationarity.

Table - 1

Null Hypothesis: WHOLEEUR has a unit root

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-49.20329	0.0001
Test critical values:	1% level	-3.432674	
	5% level	-2.862453	
	10% level	-2.567301	

*MacKinnon (1996) one-sided p-values.

Table - 2

Null Hypothesis: WHOLEEUR has a unit root

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-49.19353	0.0001
Test critical values:	1% level	-3.432674	
	5% level	-2.862453	
	10% level	-2.567301	

*MacKinnon (1996) one-sided p-values.

Standard Deviation as a measure of volatility has certain drawbacks. So we have employed the GARCH model to detect changes in the level of volatility (unconditional variance) of the error terms. As a prior step for estimating GARCH equation, a mean equation needs to be formulated. The mean equation for GARCH (1, 1) has been formulated as ARMA (2, 2) model using Box Jenkins methodology. The results for mean equation have been enumerated in the table below:

Table - 3

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	9.71E-05	0.000130	0.749248	0.4538
AR(2)	-0.671358	0.278909	-2.407085	0.0161
MA(2)	0.657347	0.283591	2.317938	0.0205

The coefficients of AR & MA terms are significant at 5% level. The constant term is however, insignificant at 5% level.

The squared residuals revealed significant correlation among the error terms with all Q statistics being significant as is evident from low p values reported in the last column of the table 4.

Table – 4

Correlogram of Residuals Squared

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
|* |	|* |	1	0.156	0.156	63.234	
|* |	|* |	2	0.097	0.074	87.694	
|* |	|* |	3	0.123	0.101	127.19	0.000
|* |	|* |	4	0.123	0.088	166.57	0.000
|* |	| |	5	0.076	0.033	181.63	0.000
|* |	|* |	6	0.164	0.130	251.46	0.000
|* |	| |	7	0.126	0.066	292.57	0.000
|* |	| |	8	0.108	0.053	323.16	0.000
| |	| |	9	0.071	0.009	336.25	0.000
| |	| |	10	0.035	-0.027	339.54	0.000
| |	| |	11	0.062	0.019	349.70	0.000
|* |	| |	12	0.104	0.054	378.07	0.000

These errors have been further tested using ARCH LM test at lag 1 reported in Table 5 below:

Table – 5

Heteroskedasticity Test: ARCH

F-statistic	64.66961	Prob. F(1,2594)	0.0000
Obs*R-squared	63.14523	Prob. Chi-Square(1)	0.0000

The ARCH LM Test has been used to check for heteroskedasticity testing the null hypothesis of no heteroskedasticity between the error terms. The results of ARCH LM Test have been found to be significant being p value for chi square distribution reported as zero. Thus, sufficient evidence for using GARCH model has been generated. Further to model the variance, GARCH (1, 1) equation has been estimated.

The result of the GARCH (1,1) model have been reported in table 6 below:

Table – 6

GARCH = C(4) + C(5)*RESID(-1)^2 + C(6)*GARCH(-1)

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	1.88E-05	0.000112	0.167063	0.8673
AR(2)	-0.717927	0.189729	-3.783954	0.0002
MA(2)	0.706200	0.193039	3.658338	0.0003
	Variance Equation			
C	4.50E-07	1.06E-07	4.249078	0.0000
RESID(-1)^2	0.047362	0.004457	10.62708	0.0000
GARCH(-1)	0.943226	0.004672	201.8715	0.0000

To examine the level of volatility prevailing in the Indian currency market, GARCH (1,1) equation has generated the values for different parameters. These parameter values have been found to be significant as p value is zero for the constant, the ARCH term & the GARCH term. The level of volatility in the Indian currency market has been examined using unconditional variance using the formula:

$$Var\ \varepsilon_t = \frac{\alpha_0}{1-(\alpha_1+\beta_1)}$$

Thus various values generated using GARCH (1,1) has been put into the above equation and the level of volatility has been estimated. The result derived for the whole period is 0.00004578. Level of volatility prevailing in the currency market has been found to be: 0.0000476 (approx 0) which is less than 0.05. So, we **reject the Hypothesis H_{01}** that there is no volatility in the Indian currency market.

The results of the diagnostic tests showed that the GARCH models were correctly specified. Ljung-Box test was used to check for any remaining autocorrelations in squared standardized residuals from the estimated variance equation of GARCH (1, 1) model. If the variance equation was specified correctly, statistics Q (12) should not be significant. The Q-statistics for the standardized residuals were insignificant as shown in the table 7, suggesting the GARCH models were successful at modeling the serial correlation structure in the conditional means and conditional variances.

Table – 7

Correlogram of Standardized Residuals Squared

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
| |	| |	1	0.019	0.019	0.9057	
| |	| |	2	-0.007	-0.007	1.0348	
| |	| |	3	0.003	0.003	1.0517	0.305
| |	| |	4	0.007	0.007	1.1878	0.552
| |	| |	5	-0.005	-0.005	1.2465	0.742
| |	| |	6	0.036	0.036	4.6271	0.328
| |	| |	7	0.009	0.008	4.8527	0.434
| |	| |	8	0.003	0.003	4.8725	0.560
| |	| |	9	-0.017	-0.017	5.6327	0.583
| |	| |	10	-0.024	-0.023	7.0756	0.529
| |	| |	11	-0.013	-0.012	7.5029	0.585
| |	| |	12	0.003	0.002	7.5210	0.676

The Lagrange Multiplier (ARCH-LM) test was used to test the presence of remaining ARCH effects in the standardized residuals. ARCH-LM test statistic for GARCH (1, 1) model did not exhibit additional ARCH effects remaining in the residuals of the models. The results of ARCH LM Test have been found to be insignificant being p value for chi square distribution reported as more than 5%. This showed that the variance equation was well specified.

Heteroskedasticity Test: ARCH

F-statistic	0.904090	Prob. F(1,2594)	0.3418
Obs*R-squared	0.904472	Prob. Chi-Square(1)	0.3416

After estimating the level of volatility in the Indian Currency market, an attempt has been made to find if volatility is static or changed with time. For this, unconditional variance has been estimated by using a dummy variable which the takes value of '0' & '1' in the pre & post derivatives period respectively. Any change in the unconditional variance of an asset price after derivatives has been detected by augmenting GARCH (1,1) equation to include a dummy variable.

$$\sigma_t^2 = \alpha_0 + \alpha_1\varepsilon_{t-1}^2 + \beta_1\sigma_{t-1}^2 + \delta D$$

Where, D is dummy variable.

The results for GARCH (1,1) model with a dummy variable has been given in Table 8:

Table – 8

GARCH = C(4) + C(5)*RESID(-1)^2 + C(6)*GARCH(-1) + C(7)*DUMMY

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	1.41E-05	0.000113	0.124182	0.9012
AR(2)	-0.711763	0.184707	-3.853472	0.0001
MA(2)	0.699783	0.187939	3.723452	0.0002
	Variance Equation			
C	4.34E-07	1.07E-07	4.049378	0.0001
RESID(-1)^2	0.047297	0.004729	10.00148	0.0000
GARCH(-1)	0.939764	0.005361	175.2958	0.0000
DUMMY	2.92E-07	1.01E-07	2.890320	0.0038

All the parameter values for GARCH (1,1) have been found to be significant for p values being low.

After the parameter values have been estimated using augmented GARCH (1,1) equation, the unconditional variance has been estimated.

The unconditional variance after event has been calculated as in equation

$$var\ \varepsilon_t = \frac{\alpha_0 + \delta}{1 - (\alpha_1 + \beta_1)}$$

Where $\boldsymbol{\delta}$ is coefficient of dummy variable

A significant positive (negative) coefficient of the dummy variable points to an increase (decrease) in the volatility as a result of futures trading (Samanta & Samanta 2007). The results from table 7 report a dummy variable coefficient to be 0.000000292 with a p-value of 0.0038. The value of the coefficient of dummy variable is significant & positive.

Hence we **Reject the Null Hypothesis** that there is no change in level of currency market volatility after introduction of derivatives. The significant & negative coefficient of dummy variable indicates that long term volatility has changed with time and has shown an incline. The level of volatility in the post derivatives period as estimated from the above equation comes out to be 0.0000560.

To examine if the introduction of derivatives has been successful in reducing the volatility, unconditional variance has been estimated. From table 8 it can be seen that the coefficient of dummy variable is positive & significant indicating an incline in volatility as a result of index futures trading but, the incline is only marginal. So it can be interpreted that futures trading has led to an incline in volatility. Hence we **cannot reject the hypothesis** that derivatives introduction has not been successful in reducing the volatility. The results are in consistent with the previous findings of Goyal and Mittal (2014).

Conclusion

The volatility in Indian currency market exhibits the characteristics with respect to the stylized features like volatility clustering, autocorrelation, asymmetry and persistence in its daily return. The impact of financial derivatives on the volatility of Euro returns is significant under GARCH (1, 1) model. It was found that after introduction of derivatives, the daily volatility during post derivative period has increased in comparison to pre-derivative, which suggests that that derivatives introduction has not been successful in reducing the volatility. The results of the diagnostic tests showed that the GARCH models were correctly specified as the values of Q-statistics for the standardized residuals were insignificant and the ARCH-LM test statistic did not exhibit additional ARCH effects remaining in the residuals of the models. The study also indicated that the Indian currency market is non-normal and stationary.

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