

# Dynamics of Currency Futures Trading and Underlying Exchange rate Volatility in India

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## Abstract

The paper is aimed at examining the impact of currency futures on exchange rate volatility of EURO after the introduction of currency futures trading in India. The data used in this paper comprises of daily exchange rate of EURO in terms of Indian rupees for the sample period January 02, 2008 to December 31, 2011. To explore the time series properties, Unit Root Test and ARCH LM test have been employed and to study the impact on underlying volatility, GJR GARCH (1, 1) model has been employed. The results indicate that the introduction of currency futures trading has had no impact on the spot exchange rate volatility of the foreign exchange market in India. Further, the results are also indicative of the fact that the importance of recent news on spot market volatility has increased and the persistence effect of old news has declined with the introduction of currency futures trading.

**Keywords:** Exchange Rate, Currency Futures, Forex Market Volatility, GARCH.

## 1. Introduction

Financial deleveraging and abrupt reversal of foreign capital flows due to the systemic risk emanating from manifold international occurrences has magnified the quantum of currency exposure in India and making the currency exposure to reach to an alarming state which need to be addressed meticulously in order to counter the evil effects of currency exposure on the economy. In consonance with the international practice of using currency derivatives, market regulators in India introduced derivatives trading and initiated the trading of currency futures in INR-EURO pair of currency in February, 2010 at National Stock Exchange. With the belief that currency derivatives would be able to provide a mechanism to alleviate currency exposure and strengthen the microstructure of Indian forex market, market participants started to apply currency futures in the process of risk management and the turnover in currency futures has magnified substantially.

However, the impact of derivatives trading on spot market is a polemic issue and the financial literature is evidencing varied and contradictory opinions both in theoretical and empirical orientations. In general, derivative markets have been criticized for bringing destabilizing force. It is argued that the inflow of and existence of speculators in derivatives market may produce destabilizing forces, which among other things create undesirable "bubbles". Further, transactions in derivative markets bring excess volatility into the underlying spot market due to the presence of uninformed noise and speculative trades induced by low transactions costs (Figlewski, 1981; Stein, 1987; Ross, 1989). On the contrary, it is argued that the introduction of derivatives trading leads to more complete market; enhances information flow and there by improves the investment choices facing investors. Market-wide information may be more efficiently impounded in the derivatives market with its low transaction costs which in turn leads to a reduced price disparity and low cash market volatility (Danthine, 1978; Butterworth 2000; Bologna and Cavallo, 2002). Moreover, derivatives markets play an important role within the price discovery process of underlying assets and currency futures have relatively lower transaction costs and capital requirement. Further, the arrival of external information is quickly incorporated into exchange rate as participant's expectations are updated and providing a phillip to market efficiency.

The issue of what impact derivatives trading would have on underlying cash market has been extensively explored in equity markets (e.g., Edwards, 1988; Harris, 1989; Bansal *et. al.*, 1989; Bessembinder and Seguin, 1992; Antoniou *et. al.*, 1998; Kyriacou and Sarno, 1999; Gulen and Mayhew, 2000; Bologna and Cavallo, 2002; Ryoo and Smith, 2003; Spyrou, 2005; Alexakis, 2007 among many others). However, the same issue has not been studied extensively in the context of currency markets. Some of the early studies pertaining to the introduction of currency futures in developed and emerging markets and their impact on spot exchange rate volatility are far from any consensus. Several studies evidenced a decline in spot exchange rate volatility with the introduction of currency derivatives whereas contradictory conclusions of magnification in exchange rate volatility were also noticed in the context of developed and emerging markets. The aforementioned fact has provided impetus to explore the influence of currency derivatives in Indian context. The present paper is aimed at analyzing the impact of the introduction of currency futures in INR-EURO pair on the spot exchange rate volatility. The rest of the paper is as follows: Section two discusses the existing literature; Section three specifies the data used; Section four deliberates on methodological issues; Section five analyses the data and interprets the result of analysis followed by Section six where conclusions and possible implications have been documented.

## 2. Review of Literature

### 2.1 Theoretical Literature

Figlewski (1981) argued that speculation in the derivatives market is transmitted to the underlying spot markets. The speculation produces a net loss with some speculators gaining (and others losing), thereby destabilize the market. Uninformed speculative traders increase price volatility by interjecting noise to a market with limited liquidity. The inflow and existence of the speculators in the derivatives market produces destabilization forces, which creates undesirable bubbles. Stein (1987) developed a model in which prices are determined by the interaction between hedgers and informed speculators. In this model, opening a futures market has two effects; (1) the futures market improves risk sharing and therefore reduces price volatility, and (2) if the speculators observe a noisy but informative signal, the hedgers react to the noise in the speculative trades, producing an increase in volatility. Ross (1989) assumed that there exist economies that are devoid of arbitrage and proceeds to provide a condition under which the no arbitrage situation will be sustained. It implies that the variance of the price change will be equal to the rate of information flow. The implication of this is that the volatility of the asset price will increase as the rate of information flow increases. Thus, if derivatives market increases the flow of information, the volatility of the spot price must change in the absence of arbitrage opportunity.

In contrast, the model developed by Danthine (1978) argued that the futures markets improve market depth and reduce volatility because the cost to informed traders of responding to mispricing is reduced. Butterworth (2000) also argued that introduction of the derivatives trading leads to more complete market enhancing the information flow. Derivatives market allows for new positions and expanded 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) argued 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.

### 2.2 Empirical Literature

Clifton (1985) found a strong positive correlation between futures trading and exchange rate volatility measured by the spread between the daily high and low exchange rates for Deutsche marks, Swiss franc, Canadian dollars, and Japanese yen. Grammatikos and Saunders (1986) investigated British pound, Canadian dollar, Japanese yen, Swiss franc and Deutsche mark foreign currency futures traded on the International Monetary Market over the period of 1978-1983 and found that there exists a bidirectional causal relationship between volume and price variability in futures market transactions.

Kumar and Seppi (1992) and Jarrow (1992) studied the impact of currency derivatives on spot market volatility and 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 usefulness 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, Canadian dollar, Japanese yen, Swiss franc and Deutsche mark. 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) investigate the effect of the introduction of options on the volatility of currency markets and conclude that options contracts complete and stabilize the spot currency markets. Jochum and Kodres (1998) examine 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 find that the introduction of currency futures help reduce the volatility of the spot currency market, while for Brazil and Hungary, they find no discernable impacts. Adrangi and Chatrath (1998) studied the impact of currency futures commitments and found that the overall growth in currency futures commitments has not caused exchange rates to be more volatile. However, increase in the participation of large speculators and small traders do destabilize the markets. They concluded that margin requirements that "penalize" speculators and small traders may serve to promote stability in the market. Chang and Wong (2003) examined the usefulness of currency futures/forwards and concluded that currency risk can be minimized through futures/forward hedging. Röthig (2004) reported a strong

causal relationship between the futures trading volume and GARCH-based exchange rate volatility for different currencies.

Bhargava and Malhotra (2007) analyzed futures trading on four currencies over the time period of 1982-2000 and found the evidence that day traders and speculators destabilize the market for futures but it is not clear whether hedgers stabilize or destabilize the market. Exchange rate movements affect 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 two-way causality between the volatility in the spot exchange rate and the trading activity in the currency futures market.

A synthesis of the empirical literature on the impact of currency futures trading on underlying market volatility purported that majority of studies are in the context of developed markets and in most of the cases, the exchange rates of currencies in US dollar have been used. The literature in the context of emerging markets is scanty except few studies and EURO has not been considered in any study since its introduction. Further, the outcomes of various studies asserted that the impact of introduction of currency futures trading has been different in different markets with respect to different span of time and it is difficult to arrive at a consensus with respect to the impact of currency futures introduction on the volatility of spot exchange rate. Again, looking at the typical characteristics of emerging economies emanating from structural and institutional changes, the exchange rate of domestic currency is witnessing unusual behavior in terms of volatility against other currencies. The aforementioned fact has provided impetus to explore the influence of currency derivatives in the context of emerging markets which in turn, necessitates further empirical investigation on the impact of currency futures trading on spot exchange rate volatility.

### 3. Data

The data used in this paper comprises of daily exchange rate of EURO in terms of Indian rupees for the sample period January 02, 2008 to December 31, 2011. The time series data have been collected from the data warehouse of Reserve Bank of India. In order to explore the impact of currency futures trading, the window period has been divided into pre introduction period (January 02, 2008 - January 31, 2010) and post introduction period (February 01, 2010- December 31, 2011). In addition, daily close prices of CNX Nifty Index have also been used. Daily close prices for the period have been collected from the NSE website.

### 4. Methodological Issues

The empirical literature documented two different methodologies to analyze the impact of derivatives trading on cash market volatility. One way to analyze the impact is by comparing the cash market volatility before and after the introduction of derivatives trading as adopted in studies (Edwards, 1988 and Bologna and Cavallo, 2002; for different equity markets; and Shastri, Sultan, and Tandon, 1996 and Jochum and Kodres, 1998; for different currency markets). The other way to study the impact of derivatives trading is by comparing the underlying market volatility and derivatives trading activity variables as adopted in studies (Bessembinder and Seguin, 1992; Gulen and Mayhew, 2000; for different equity markets, and Clifton, 1985; Chatrath, Ramchander, and Song, 1996; Rothig, 2004; Adrangi and Chatrath, 1998; and Bhargava and Malhotra, 2007; for different currency markets).

The present study is based on the first methodology of analyzing the impact of currency futures trading on underlying currency market volatility in India by comparing the underlying volatility before and after the introduction of currency futures in INR-EURO pair of currency. The data used in the study are essentially time series and it becomes necessary to unfold the statistical properties of the time series. Natural logarithm transformation is commonly used transformation techniques whereas ADF test is applied for observing the characteristics of the data series under study.

Under the study, the exchange rate series is transformed into its natural logarithm rate series. In view of the inherent heteroscedasticity of changes in exchange rates, it is considered advisable to transform it into log rate changes. Log transformation is likely to render the exchange rate changes to be homoscedastic and thereby make the series stationary. To smooth the changes in exchange rate, this transformation is done as it depicts the rate of change rather than actual change. The first difference of log exchange rates referred to as log returns have been used throughout the study. The logarithmic return has been applied in all the empirical tests in the study. Unless otherwise specified, the returns used from now are logarithmic returns.

In order to have a ready reference, descriptive statistics such as skewness, Kurtosis and Jarque-Bera have been calculated which provides basic albeit, elementary evidence about changes in the time series behavior and explains the fact that exchange rate distribution of currency for the pre-period, post-period & full period are not

normally distributed which is a well-documented fact in financial literature. Given the fact that, the presence of a stochastic trend or deterministic trend in a financial time series or its stationary/non-stationary in levels is a prerequisite for conducting any test, the study begins with the testing of exchange rate series for a unit root using Augmented Dickey Fuller (ADF) test. A stationary time series is one for which the mean and variance are constant over time; they depend only on the distance or lag between the two time periods and not on the actual time at which they are computed. The presence of a unit root indicates that the given series has become unstable or non-stationary; showing an uneven movement. The time series variables considered in this paper is daily exchange rate of INR-EURO and the ADF unit root test is performed by using the following equations:

$$\Delta Y_t = \alpha_1 Y_{t-1} + \sum_{j=1}^p \gamma_j \Delta Y_{t-j} + \varepsilon_t \quad \text{Eq.1}$$

$$\Delta Y_t = \alpha_0 + \alpha_1 Y_{t-1} + \sum_{j=1}^p \gamma_j \Delta Y_{t-j} + \varepsilon_t \quad \text{Eq.2}$$

$$\Delta Y_t = \alpha_0 + \alpha_1 Y_{t-1} + \alpha_2 t + \sum_{j=1}^p \gamma_j \Delta Y_{t-j} + \varepsilon_t \quad \text{Eq.3}$$

Another characteristic of time series that needs attention is the heteroscedasticity. The Lagrange Multiplier (LM) test is used to reject the null hypothesis of no ARCH effect, which is indicative of the fact that time series is heteroscedastic. Such heteroscedasticity causes the ordinary least square estimates to be inefficient as OLS regression assume constant error variance. Models that take into account the changing variance can make more efficient use of data. Property of heteroscedasticity in time series is well documented (Fama, 1965 & Bollerslev, 1986). The presence of heteroscedasticity in the time series calls for the use of ARCH family of models to study volatility.

The standard GARCH (p, q) model introduced by Bollerslev (1986) suggests that conditional variance of returns is a linear function of lagged conditional variance and past squared error terms. A model with errors that follow the standard GARCH (1, 1) model can be expressed as follows:

$$R_t = c + \varepsilon_t \text{ where } \varepsilon_t / \psi_{t-1} \sim N(0, h_t) \quad \text{Eq.4}$$

$$\text{and } h_t = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \alpha_2 h_{t-1} \quad \text{Eq.5}$$

The underlying issue being the exchange rate, the term  $R_t$  is replaced by  $R_{er,t}$  in the mean equation. Further, the impact of introduction of currency futures trading on foreign exchange market volatility can be isolated by removing from the time series, any predictability associated with other factors contributing to the volatility. CNX Nifty has been used as the independent variable in mean return equation to isolate market wide factors other than those which are associated with the introduction of currency futures trading. The mean equation to be estimated is as follows:

$$R_{er,t} = \gamma_0 + \gamma_1 R_{nifty,t} + \varepsilon_t \quad \text{Eq.6}$$

However, the standard GARCH models assume symmetry in the response of volatility to information. In other words, the models assume that the response of volatility, to 'bad' news as well as 'good' news, is similar. If the response is asymmetric, then the standard GARCH models will end up mis specifying the relationship and further, inferences based on this model may be misleading. However, the standard GARCH model can be easily extended to include asymmetric effects (Glosten, Jagannathan and Runkle, 1993). In the model, the asymmetric response of conditional volatility to information is captured by including, along with the standard GARCH variables, squared values of  $\varepsilon_{t-1}$  when  $\varepsilon_{t-1}$  is negative. In other words, the model allows for asymmetries by augmenting the standard GARCH model with a squared error term following 'bad' news. In doing so, it allows the negative return shocks to generate greater volatility than positive return shock. Hence, equation (5) is extended as follows:

$$h_t = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \alpha_2 h_{t-1} + \alpha_3 S_{t-1}^- \varepsilon_{t-1}^2 \quad \text{Eq.7}$$

$$\text{Where } S_{t-1}^- = 1 \text{ if } \varepsilon_{t-1} < 1$$

In studying the impact of currency derivatives, firstly, the existence of asymmetric response is tested for exchange rate for all the three periods. Test of asymmetry in the period pre and post introduction of derivatives, reveals the impact that introduction of derivatives trading has had on the response of volatility to new information generated. The test of asymmetric response for the full period helps in identifying the GARCH model to be specified while analyzing the impact of currency futures trading on spot market volatility. For this purpose, a dummy variable is added while specifying the volatility dynamics with the dummy taking a value of

zero before introduction of currency futures trading and one for the period after introduction. Capturing the asymmetric response for the full period of analysis, the GJR model along with a dummy is specified as follows:

$$h_t = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \alpha_2 h_{t-1} + \alpha_3 S_{t-1}^- \varepsilon_{t-1}^2 + \alpha_4 D_{er,t} \quad \text{Eq.8}$$

where,  $D_{er,t}$  is a dummy variable and  $\alpha_4$  is the coefficient of the dummy variable. If  $\alpha_4$  is statistically significant, it can be said that the existence of currency futures trading has had an impact on spot exchange rate volatility. Further, a significant positive value for  $\alpha_4$  would indicate that introduction of currency futures trading increases the volatility of the spot exchange rate.

## 5. Empirical Results

The descriptive statistics in Table 1 indicate that there is an increase in standard deviation of exchange rate return from 0.008244 to 0.016081 with the onset of currency futures trading. This may lead to the fact that there has been a marginal increase in volatility after the introduction of currency futures trading in the Indian foreign exchange market. However, at this stage, it is difficult to say that the increase in volatility after the introduction of currency futures trading is due to currency futures and not because of other factors that influence market wide movements. To make any significant inferences, one needs to further analyze the behavior of exchange rate returns and account for any predictability associated with other factors that may be having an impact on the volatility of the time series.

The Jarque-Bera test statistics of exchange rate returns as shown in Table 1 for the total period is 1513459 and statistically significant as well as the time series have excess kurtosis (197.5158). The computation of descriptive statistics such as skewness, Kurtosis and Jarque-Bera during the period under study provides elementary evidence about the fact that the distribution of exchange rates are not normally distributed which is in consonance with the documented financial literature.

Owing to the aforesaid fact, it is imperative to analyze whether there is the presence of unit root in the exchange rate series. The ADF test has been conducted at level and at first difference for different periods and the result is documented in Table 2. The ADF coefficients of exchange rate series at level for the total period, pre and post period are -2.413791, -2.64546 and -1.028839 respectively and statistically insignificant which indicates the presence of unit root and the exchange rate series is non-stationary. But, the ADF coefficients of exchange rate series at first difference for the total period, pre and post period are -28.40158, -22.57939 and -21.82535 respectively and statistically significant which indicates absence of unit root and the exchange rate series is stationary. The outputs of ADF test are in consonance with the already documented fact about time series that most of the time series data are non-stationary at level but stationary at first difference. Another characteristic of time series that needs attention is the heteroscedasticity. The Lagrange Multiplier (LM) test is used to reject the null hypothesis of no ARCH effect, which is indicative of the fact that time series is heteroscedastic. The Lagrange Multiplier (LM) test for no ARCH effect of exchange rate returns is having the *F-statistics* of 211.4946 and statistically significant with a zero probability, implying that there is a significant ARCH effect in exchange rate returns. All these results indicate that exchange rate returns series is heteroscedastic. The presence of heteroscedasticity in the exchange rate series calls for the use of ARCH family of models to study volatility. The ARCH family of models is exclusively designed to address the heteroscedastic behavior of financial time series data.

Before applying the ARCH model, it is essential to specify the model. The standard GARCH models assume symmetry in the response of volatility to information, which may not be the case always. Hence, the study first tests for existence of asymmetric response by specifying the GJR GARCH (1, 1) specification of volatility dynamics. The results of the asymmetric response analysis of exchange rate returns for the pre and post periods are reported in Table 3 and Table 4 respectively. The coefficients of asymmetric response for the pre period, post period and total period are -0.086927, 2.772952 and 1.600506 respectively and statistically significant which implies that the response of volatility to 'bad' news and 'good' news are different. The aforesaid issue has specified the use of GJR GARCH model to analyze the impact of currency futures on spot exchange rate volatility.

In the specified model,  $\alpha_1$  (ARCH 1) is the "news" coefficient; with a higher value implying that recent news has a greater impact on exchange rate changes. It relates to the impact of yesterday's news on today's exchange rate changes. In contrast,  $\alpha_2$  (GARCH 1) reflects the impact of "old news" on exchange rate changes. It indicates the level of persistence in information and its effect on volatility. After dividing the study period into before and after the introduction of currency futures trading, it is found that the  $\alpha_1 = 0.102167$  and  $\alpha_2 = 0.933412$  before the introduction of futures and  $\alpha_1 = 0.312947$  and  $\alpha_2 = -0.000309$  after the introduction of futures trading as presented in Table 3 and Table 4. The aforementioned changes in the coefficients of ARCH and GARCH are indicative of the fact that the importance of recent news on spot market volatility has increased and the persistence effect of old news has declined with the introduction of currency futures trading. This implies that after the

introduction of currency futures trading, the spot market has become more efficient owing to the diminishing importance of old news and faster incorporation of recent news in exchange rates.

In the model, the value of  $\alpha_1$  in the conditional variance equation is 0.338964 and more than the value of  $\alpha_2$  as shown in Table 5. This seems to suggest that past conditional variance has a lesser impact on volatility of exchange rate than recent news announcements. A high  $\alpha_2$  shows the persistence of volatility due to old news. The log likelihood value in respect of exchange rate series is high, which is an indication that GJR GARCH model is a good fit.

Finally, the impact of introduction of currency futures on the conditional volatility is analyzed by introducing a dummy in the variance equation. The dummy would take a value 'zero' in the pre introduction period and 'one' in the post introduction period. The results of the analysis have been documented in Table 5. The coefficient of the currency futures dummy  $\alpha_4$  is positive (4.63E-07) and there seems to have an increase in volatility but the coefficient is statistically insignificant. The result of the analysis implies that the spot exchange rate volatility is not influenced by the introduction of currency futures trading in INR-EURO pair of currency.

## 6. Conclusion

The magnification of cross-border transactions as a consequence to the structural and regulatory reforms has intensified the issue of currency exposure around the globe. Particularly, emerging economies being the favored destinations to undertake economic activities are experiencing substantial capital inflows through FDI and FII routes by relaxing regulatory norms and resultantly making their economies more vulnerable to international dynamism with respect to economic and financial issues. The growing currency exposure experienced by emerging economies at the back drop of financial deleveraging and abrupt reversal in foreign capital flows has instigated regulators and policy makers to introduce currency derivatives trading on currency through designated stock/currency exchanges to provide a mechanism to hedge currency exposure. However, such currency derivatives are capable of influencing the extent of volatility in the underlying spot exchange rate. Hence, it is imperative to explore the impact of currency futures trading on the volatility of spot exchange rate.

The objective of the present study is to examine the impact of currency futures trading on spot exchange rate volatility of the foreign exchange market in India. To explore the objective, daily exchange rate of EURO in terms of Indian rupees for the sample period January 02, 2008 to December 31, 2011 have been used. The time series data have been collected from the data warehouse of Reserve Bank of India. In order to explore the impact of currency futures trading, the window period has been divided into pre introduction period (January 02, 2008 - January 31, 2010) and post introduction period (February 01, 2010- December 31, 2011). In addition, daily close prices of CNX Nifty Index have also been used. Daily close prices for the period have been collected from the NSE website. To test the hypothesis, GJR GARCH model capable of capturing the asymmetric response has been employed.

The results indicate that the coefficient of the dummy variable is positive but statistically insignificant. Thus, it can be concluded that the introduction of currency futures trading has had no impact on the spot exchange rate volatility of the foreign exchange market in India. The implication of the result is that both hedging and speculative activities executed in currency futures market tend to offset the net effect of each other on the volatility of spot currency market. Further, the results of ARCH and GARCH coefficients before and after the onset of currency future trading are indicative of the fact that the importance of recent news on spot market volatility has increased and the persistence effect of old news has declined with the introduction of currency futures trading. This implies that after the introduction of currency futures trading, the spot market has become more efficient owing to the diminishing importance of old news and faster incorporation of recent news in exchange rates. However, the impact of currency futures trading on spot currency can be further refined with the availability of data pertaining to different groups of traders in the foreign exchange market.

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**Table 1: Descriptive Statistics of Daily Exchange Rate Return**

Descriptive Statistics of Exchange Rate Return			
	Pre Period	Post Period	Total Period
Mean	0.000234	0.00014	0.000189
Std. Dev.	0.008244	0.016081	0.012631
Skewness	-0.272203	-0.095024	-0.14007
Kurtosis	5.107721	156.1769	197.5158
Jarque-Bera	98.33142	451666.4	1513459
Probability	0	0	0

Source: Computed Output

**Table 2: Results of Unit Root Test**

Augmented Dickey-Fuller test Statistics				
Period	Exchange Rate at Levels		Exchange Rate at First Difference	
	t-Statistics	Probability	t-Statistics	Probability
Total Period	-2.413791	0.1381	-28.40158	0
Pre Period	-2.64546	0.0846	-22.57939	0
Post Period	-1.028839	0.7442	-21.82535	0

Source: Computed Output

**Table 3: Results of GJR GARCH and Asymmetric Response for the Pre Period**

Estimates of GJR GARCH Model for the Pre Period					
Variables	Description	Co-efficient	Standard Error	Z-Statistics	Probability
$\gamma_0$	Intercept	0.000243	0.000319	0.762637	0.4457
$\gamma_1$	Nifty (R)	-0.025474	0.009737	-2.61629	0.0089
$\alpha_0$	Constant	6.69E-07	3.76E-07	1.777529	0.0755
$\alpha_1$	ARCH	0.102167	0.029521	3.460864	0.0005
$\alpha_2$	GARCH	0.933412	0.020393	45.77121	0
$\alpha_3$	Asymmetric response	-0.086927	0.029181	-2.978858	0.0029

Source: Computed Output



**Table 4: Results of GJR GARCH and Asymmetric Response for the Post Period**

Estimates of GJR GARCH Model for the Post Period					
Variables	Description	Co-efficient	Standard Error	Z-Statistics	Probability
$\gamma_0$	Intercept	0.000672	0.000351	1.913114	0.0557
$\gamma_1$	Nifty (R)	0.082478	0.018709	4.408445	0
$\alpha_0$	Constant	3.99E-05	3.50E-06	11.39544	0
$\alpha_1$	ARCH	0.312947	0.135269	2.313524	0.0207
$\alpha_2$	GARCH	-0.000309	0.006029	-0.051277	0.9591
$\alpha_3$	Asymmetric response	2.772952	0.327482	8.46749	0

Source: Computed Output

**Table 5: Results of GJR GARCH Model for the Total Period**

Estimates of GJR GARCH Model for the Total Period					
Variables	Description	Co-efficient	Standard Error	Z-Statistics	Probability
$\gamma_0$	Intercept	0.000361	0.000237	1.522196	0.128
$\gamma_1$	Nifty (R)	-0.023285	0.008715	-2.67192	0.0075
$\alpha_0$	Constant	3.92E-05	3.53E-06	11.11867	0
$\alpha_1$	ARCH	0.338964	0.077423	4.378079	0
$\alpha_2$	GARCH	-0.000337	0.020367	-0.016546	0.9868
$\alpha_3$	Asymmetric response	1.600506	0.159639	10.02577	0
$\alpha_4$	DUMMY	4.63E-07	4.12E-06	0.11254	0.9104

Source: Computed Output

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