CHAPTER V

DATA ANALYSIS AND INTERPRETATION

This chapter presents the data analysis and interpretation of results. An attempt has been made to analyse the impact of exchange rates on Nifty Index. The secondary time series data have been collected for the period from January 2008- December 2017. Since the time series data have been used, the necessary data processing procedures have been followed. The data analysis and interpretation are presented in the following five sections.

5.1 MARKET BEHAVIOUR OF FOREIGN EXCHANGE MARKET AND STOCK MARKET

This objective studies the behaviour of foreign exchange and stock market by employing descriptive statistics over the study period of January 2008- December 2017.

5.2 IMPACT OF EXCHANGE RATES FLUCTUATIONS ON THE SHARE INDICES IN THE SHORT RUN

Analysis on short run relationship between exchange rate fluctuations and Nifty 50 has been done by employing Granger Causality test and Block Exogeneity test.

5.3 IMPACT OF EXCHANGE RATES FLUCTUATIONS ON THE SHARE INDICES IN THE LONG RUN

Analysis on long run relationship between exchange rate fluctuations and Nifty 50 has been done by employing Johansen Juselius Cointergration test and Vector Error Correction Model.

5.4 RELATIONSHIP BETWEEN EXCHANGE RATES AND SECTORAL INDICES LISTED IN NSE

An attempt has also been made to analyse the impact of sectoral indices listed in NSE with exchange rates by employing Granger Causality test and Johansen Juselius Cointergration test.

5.5 VOLATILITY SPILLOVER BETWEEN STOCK MARKET AND FOREIGN EXCHANGE MARKET

Volatility spillover between stock market and foreign exchange market has been studied by using GARCH and EGARCH model.

5.1 MARKET BEHAVIOUR OF FOREIGN EXCHANGE MARKET AND STOCK MARKET

Descriptive Statistics was used for preliminary analysis to study the nature of data. The statistical properties such as Mean, Standard deviation, Skewness, Kurtosis and Coefficient of Variation (CV) gives a brief background about the movement of stock market and foreign exchange market during the study period of January 2008 – December 2017. The Jarque-Bera test is used to analyse the normality of the data whether the variables are normally distributed. Further, the time series of weekly data of both the markets has been plotted to check whether there is a change in the behavior of any market. The data analysis and interpretation is divided into four sections which are as follows:

5.1.1 Descriptive Statistics of NIFTY and USD/INR

5.1.2 Descriptive Statistics of NIFTY and Euro/INR

5.1.3 Descriptive Statistics of NIFTY and GBP/INR

5.1.4 Descriptive Statistics of NIFTY and Yen/INR

5.1.1 Descriptive Statistics of Nifty and USD/INR

A summary of descriptive statistics of Nifty and USD/INR for the whole period of ten years from January 2007 to December 2017 is presented in table 5.1.

Table 5.1 Descriptive Statistics of Nifty and USD/INR

Statistics	NIFTY	USD/INR
Mean	6391.56	55.35
Median	5879.72	55.00
Maximum	10558.85	68.73
Minimum	2584.00	39.17
Std.Dev	1855.53	8.75
Skewness	0.27	-0.07
Kurtosis	2.29	1.53
CV	0.29	0.15
Jarque-Bera	17.52	47.28
Probability of Jarque-bera	0.0001	0.000
No of Observations	522	522

A detailed statistic given in the table 5.1 reports the following results. The average mean of nifty is 6391.56 ranging from 2584.00 to 10558.85 and USD/INR is 55.35 ranging from 39.17 to 68.73 respectively. The standard deviation of nifty is 1855.53 and USD/INR is 8.75 respectively. Thus, Nifty is highly volatile comparing to USD/INR as the standard deviation is low.

The co-efficient of variation (CV) is the ratio of standard deviation to the mean. Generally, high CV reflects inconsistency among the samples within the group. Thus, nifty (0.29) has shown greater consistency as compared to USD/INR (0.15).

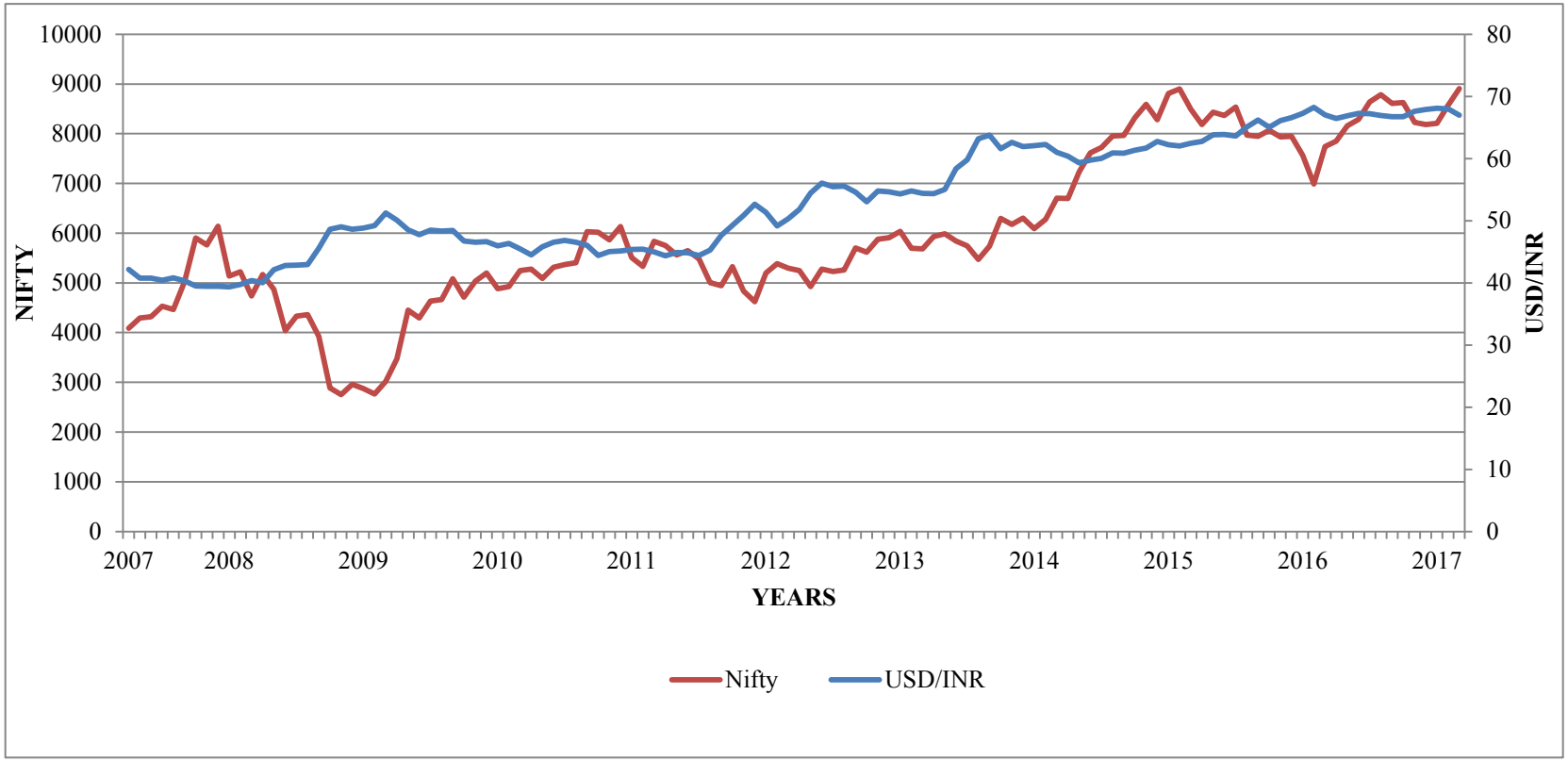
In a standard normal distribution skewness is Zero and Kurtosis is three. The distribution of the changes in both the market is not symmetric as the skewness is not zero in case of nifty and USD/INR. The skewness of Nifty are found to be positive which implies long right tails suggesting that the investors have a higher probability of earning positive returns in the market and the skewness of USD/INR are found to be negative which implies that the investors have a higher probability of earning negative returns in the market. Similarly, the coefficients of kurtosis were found to be positive for both the variables and are significantly lesser than 3 indicating platykurtosis (flatness of data).

The statistical results based on skewness and kurtosis, the normality test i.e. Jarque-Bera test shows that the distribution is not normal as the value of $P < 0.05$, so null hypothesis i.e. data series is normally distributed is rejected, signifying lack of symmetric nature in the returns. The results of descriptive statistics are also confirmed by Abburi and Stella(2017) and Gaurav Agarwal, Ankita Srivastava *et al.,*(2010)

The study is based on non-parametric test which does not require the assumption of normality regarding the sample data. So non-normality of the data is not an issue of concern in the present study.

Chart 5.1 Time Plot of Exchange Rate Series of USD/INR with NIFTY

(January 2007-December 2017)



5.1.2 Descriptive Statistics of Nifty and EURO/INR

A summary of descriptive statistics of Nifty and Euro/INR for the whole period of ten years from January 2007 to December 2017 is presented in Table 5.2

Table 5.2 Descriptive Statistics of Nifty and EURO/INR

Statistics	**NIFTY**	**Euro/INR**
Mean	6391.56	70.14
Median	5879.72	69.95
Maximum	10558.85	86.88
Minimum	2584.00	55.97
Std.Dev	1855.53	6.83
Skewness	0.27	0.31
Kurtosis	2.29	2.59
CV (%)	0.29	0.09
Jarque-Bera	17.52	12.03
Probability of Jarque-bera	0.0001	0.002
No of Observations	522	522

A detailed statistic given in the Table 5.2 reports the following results. The average mean of nifty is 6391.56 ranging from 2584.00 to 10558.85 and Euro/INR is 70.27 ranging from 55.97 to 86.88 respectively. The standard deviation of nifty is 1855.53 and Euro/INR is 6.83 respectively. Thus, Nifty is highly volatile comparing to Euro/INR as the standard deviation is low.

The co-efficient of variation (CV) is the ratio of standard deviation to the mean. Generally, high CV reflects inconsistency among the samples within the group. Thus, nifty (0.29) has shown greater consistency as compared to Euro/INR (0.09).

In a standard normal distribution skewness is Zero and Kurtosis is 3. The distribution of the changes in both the market is not symmetric as the skewness is not

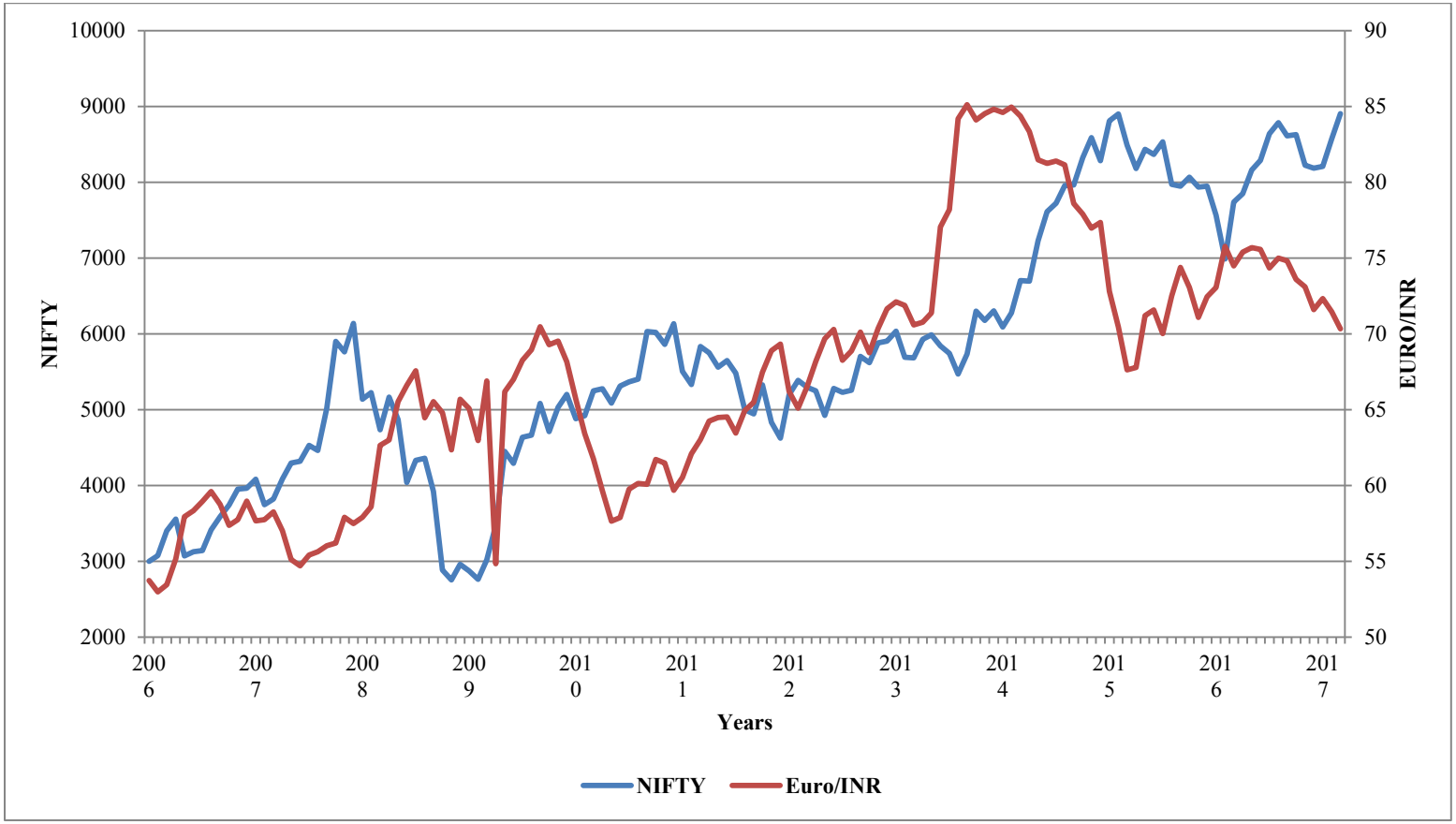
zero in case of nifty and Euro/INR. The skewness of nifty and Euro/INR are found to be positive which implies that both these variables have long right tails suggesting that the investors have a higher probability of earning positive returns in the market. Similarly, the coefficients of kurtosis were found to be positive for both the variables and are significantly lesser than 3 indicating platykurtosis (flatness of data).

The statistical results based on skewness and kurtosis, the normality test i.e. Jarque-Bera test shows that the distribution is not normal as the value of $P < 0.05$, so null hypothesis i.e. data series is normally distributed is rejected, signifying lack of symmetric nature in the returns. The results of descriptive statistics are also confirmed by Abburi and Stella(2017) and Gaurav Agarwal, Ankita Srivastava *et al.,*(2010)

The study is based on non-parametric test which does not require the assumption of normality regarding the sample data. So non-normality of the data is not an issue of concern in the present study.

Chart 5.2 Time Plot of Exchange Rate Series of Euro/INR with NIFTY

(January 2007-December 2017)



5.1.3 Descriptive Statistics of Nifty and GBP/INR

A summary of descriptive statistics of Nifty and GBP/INR for the whole period of ten years from January 2007 to December 2017 is presented in Table 5.3.

Table 5.3 Descriptive Statistics of Nifty and GBP/INR

Statistics	**NIFTY**	**GBP/INR**
Mean	6391.56	85.02
Median	5879.72	83.92
Maximum	10558.85	103.65
Minimum	2584.00	65.82
Std.Dev	1855.53	10.37
Skewness	0.27	0.20
Kurtosis	2.29	1.87
CV (%)	0.29	0.121
Jarque-Bera	17.52	31.409
Probability of Jarque-bera	0.0001	0.000
No of Observations	522	522

A detailed statistic given in the Table 5.3 reports the following results. The average mean of nifty is 6391.56 ranging from 2584.00 to 10558.85 and GBP/INR is 85.02 ranging from 65.82 to 103.65 respectively. The standard deviation of nifty is 1855.53 and GBP/INR is 10.37 respectively. Thus, Nifty is highly volatile comparing to GBP/INR as the standard deviation is low.

The co-efficient of variation (CV) is the ratio of standard deviation to the mean. Generally, high CV reflects inconsistency among the samples within the group. Thus, nifty (0.29) has shown greater consistency as compared to GBP/INR (0.121).

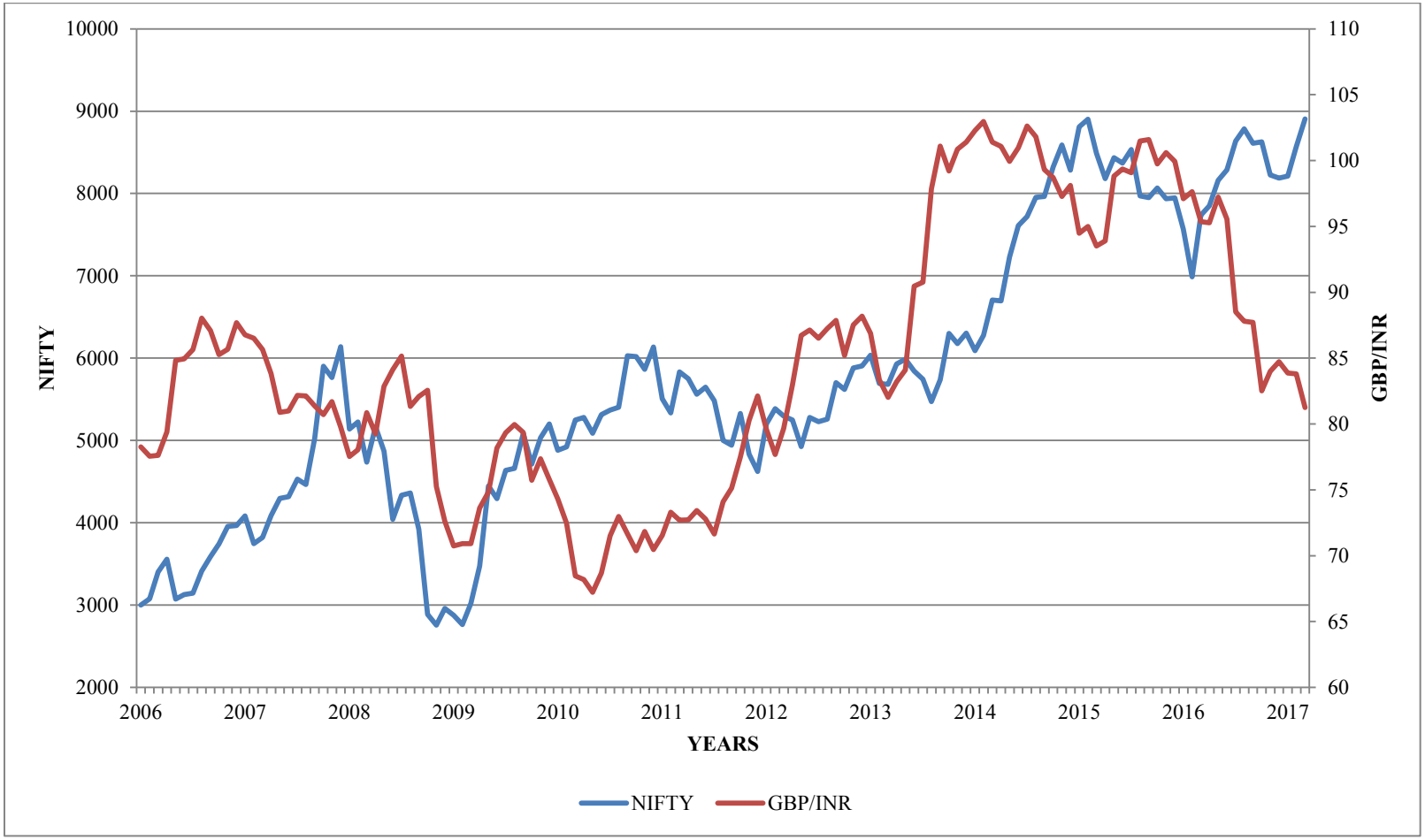
In a standard normal distribution skewness is Zero and Kurtosis is 3. The distribution of the changes in both the market is not symmetric as the skewness is not zero in case of nifty and GBP/INR. The skewness of nifty and GBP/INR are found to be positive which implies that both these variables have long right tails suggesting that the investors have a higher probability of earning positive returns in the market. Similarly, the coefficients of kurtosis were found to be positive for both the variables and are significantly lesser than 3 indicating platykurtosis (flatness of data).

The statistical results based on skewness and kurtosis, the normality test i.e. Jarque-Bera test shows that the distribution is not normal as the value of $P < 0.05$, so null hypothesis i.e. data series is normally distributed is rejected, signifying lack of symmetric nature in the returns. The results of descriptive statistics are also confirmed by Abburi and Stella(2017) and Gaurav Agarwal, Ankita Srivastava *et al.,*(2010)

The study is based on non-parametric test which does not require the assumption of normality regarding the sample data. So non-normality of the data is not an issue of concern in the present study.

Chart 5.3 Time Plot of Exchange Rate Series of GBP/INR with NIFTY

(January 2007-December 2017)



5.1.4 Descriptive Statistics of Nifty and YEN/INR

A summary of descriptive statistics of Nifty and Yen/INR for the whole period of ten years from January 2007 to December 2017 is presented in Table 5.4.

Table 5.4 Descriptive Statistics of Nifty and YEN/INR

Statistics	**NIFTY**	**Yen/INR**
Mean	6391.56	56.21
Median	5879.72	56.48
Maximum	10558.85	71.19
Minimum	2584.00	35.94
Std.Dev	1855.53	7.11
Skewness	0.27	-0.46
Kurtosis	2.29	3.53
CV (%)	0.29	0.12
Jarque-Bera	17.52	25.02
Probability of Jarque-bera	0.0001	0.000
No of Observations	522	522

A detailed statistic given in the Table 5.4 reports the following results. The average mean of nifty is 6391.56 ranging from 2584.00 to 10558.85 and Yen/INR is 56.21 ranging from 35.94 to 71.19 respectively. The standard deviation of nifty is 1855.53 and Yen/INR is 7.11 respectively. Thus, Nifty is highly volatile comparing to Yen/INR as the standard deviation is low.

The co-efficient of variation (CV) is the ratio of standard deviation to the mean. Generally, high CV reflects inconsistency among the samples within the group. Thus, nifty (0.29) has shown greater consistency as compared to Yen/INR (0.12).

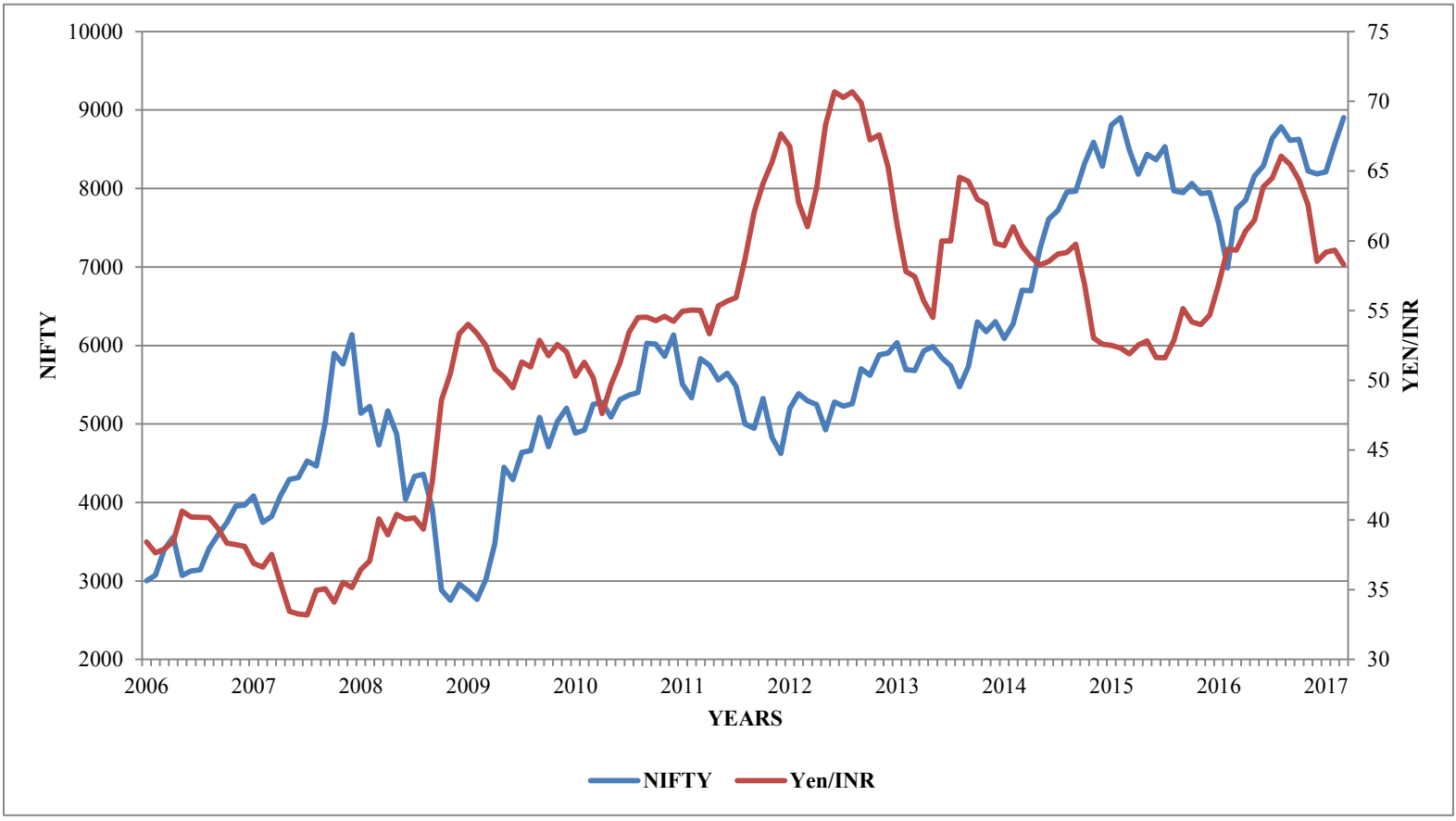
In a standard normal distribution skewness is Zero and Kurtosis is 3. The distribution of the changes in both the market is not symmetric as the skewness is not zero in case of nifty and Yen/INR. The skewness of Nifty are found to be positive which implies long right tails suggesting that the investors have a higher probability of earning positive returns in the market and the skewness of Yen/INR are found to be negative which implies that the investors have a higher probability of earning negative returns in the market. Similarly, the coefficients of kurtosis were found to be positive for both the variables and are significantly lesser than 3 for Nifty indicating platykurtosis (flatness of data) and greater than 3 for Yen/INR indicating leptokurtic distribution (peakedness of data)

The statistical results based on skewness and kurtosis, the normality test i.e. Jarque-Bera test shows that the distribution is not normal as the value of $P < 0.05$, so null hypothesis i.e. data series is normally distributed is rejected, signifying lack of symmetric nature in the returns. The results of descriptive statistics are also confirmed by Abburi and Stella(2017) and Gaurav Agarwal, Ankita Srivastava *et al.,*(2010)

The study is based on non-parametric test which does not require the assumption of normality regarding the sample data. So non-normality of the data is not an issue of concern in the present study.

Chart 5.4 Time Plot of Exchange Rate Series of Yen/INR with NIFTY

(January 2007-December 2017)



5.2 IMPACT OF EXCHANGE RATES FLUCTUATIONS ON THE SHARE INDICES IN THE SHORT RUN

The stock market plays a crucial role to bring a stable and efficient financial system of an economy. There are many number of factors directly or indirectly which have an impact on the stock market prices. The interrelationship between stock market and foreign exchange market returns have been documented in various theories. In order to examine the nature of the dynamic relationship of Nifty and exchange rates i.e. (USD/INR, EURO/INR, GBP/INR, and YEN/INR) in short run, Granger causality test and Block Exogeneity test have been performed. The data analysis and interpretation is divided in four sections which are as follows:

5.2.1 Short run relationship of NIFTY and USD/INR

5.2.2 Short run relationship of NIFTY and Euro/INR

5.2.3 Short run relationship of NIFTY and GBP/INR

5.2.4 Short run relationship of NIFTY and Yen/INR

5.2.1 Short run relationship of NIFTY and USD/INR

5.2.1.1 Unit Root Test:

The nature of data used in this study is the time series data. Before applying an econometric model using time series data it is a pre-condition that the series must be stationary. If the series has unit root or non-stationary, transformation of series from level data to differenced data is compulsory. In this study, exchange rate i.e., USD/INR along with Nifty are considered in logarithm to analyse the stationary of data using Augmented Dickey-Fuller (ADF) test and Phillip-Perron (PP) test.

Augmented Dickey-Fuller (ADF) test

ADF test is the most widely used test to examine the stationary of data .The ADF test for Nifty and USD/INR are presented in the table 5.5.

Hypothesis framework

H_0= Nifty and USD/INR has unit root or is a non-stationary

Table 5.5 ADF test for NIFTY and USD/INR

Variables	At Level		First Difference	
	With intercept	With trend & intercept	With intercept	With trend & intercept
NIFTY	-1.202 (0.671)	-2.506 (0.324)	-10.256 (0.0000)*	-10.218 (0.0000)*
USD/INR	-1.618 (0.472)	-1.935 (0.634)	-20.674 (0.0000)*	-20.698 (0.0000)*

Note: * indicates 1% level of significance

Table 5.5 shows the results of ADF test for nifty and USD/INR. The tests were conducted at level and first difference for the entire period of ten years from January 2007 to December 2017. Results indicated that, at level both the variables of p value were found more than 0.05 which confirmed that null hypothesis can‘t be rejected at level. It advocated that the nifty and USD/INR series were non stationary.

ADF statistics at first difference reported that nifty and USD/INR were found to be stationary as the p value is less than 0.05. Therefore, the null hypothesis of time series of non-stationary are rejected at 1% level of significance. The results of unit root test are consistent with the results of Pradip Kumar (2017) and Sahoo (2012).

Phillip-Perron (PP) test

The Phillip-Perron (PP) test is used to analyse unit root in time series analysis. The PP test for Nifty and USD/INR are presented in the Table 5.6.

Hypothesis Framework

H_0= Nifty and USD/INR has unit root or is a non-stationary

Table 5.6 PP test of NIFTY and USD/INR

Variables	At Level		First Difference	
	With intercept	With trend & intercept	With intercept	With trend & intercept
NIFTY	-1.398 (0.580)	-2.938 (0.154)	-10.296 (0.0000)*	-10.257 (0.0000)*

Table 5.6 (Continued)

Variables	At Level		First Difference	
	With intercept	With trend & intercept	With intercept	With trend & intercept
USD/INR	-1.611 (0.476)	-1.684 (0.756)	-20.691 (0.0000)*	-20.698 (0.0000)*

Note: * indicates 1% level of significance

Table 5.6 shows the results of PP test for nifty and USD/INR. The tests were conducted at level and first difference for the entire period of ten years from January 2007 to December 2017. Results indicated that at level both the variables of p value were found more than 0.05 which confirmed that null hypothesis cannot be rejected at level. It advocated that the nifty and USD/INR series were non stationary.

PP statistics at first difference reported that nifty and USD/INR were found to be stationary as the p value is less than 0.05. Therefore, the null hypothesis of time series of non-stationary are rejected at 1% level of significance. The results of unit root test are consistent with the results of Pradip Kumar (2017) and Sahoo (2012).

. Before doing Granger causality test, it is mandatory to find out the appropriate lag by using Lag order criterion. The Table 5.7 presents the VAR lag order selection criteria

Table 5.7 Lag Order Selection Result for Nifty and USD/INR

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-6174.08	NA	9370802	24.03	20.04	24.03
1	-3671.69	4975.55	5621.52	14.31	14.35*	14.32*
2	-3666.48	10.32*	5595.10*	14.30*	14.38	14.33
3	-3664.49	3.93	5638.91	14.31	14.42	14.35
4	-3662.90	3.12	5692.04	14.32	14.47	14.38
5	-3661.81	2.11	5757.07	14.33	14.51	14.40
6	-3660.26	3.02	5812.24	14.34	14.55	14.42
7	-3657.47	5.41	5839.74	14.34	14.59	14.44
8	-3654.31	6.12	5858.79	14.35	14.63	14.46

*indicates lag order selected by the criterion

The above Table 5.7 shows the different lag length suggested by criteria used for the Nifty and USD/INR. The Schwarz Information Criterion and Hann-Quinn information criterion suggest 1 lag length while sequential modified LR test statistic, Akaike Information Criteria and Final Prediction Error suggest 2 lag length. Since 3 out of 5 tests recommended in selecting lag length of 2, the lag number 2 is opted for the study to carry out Granger Causality test.

5.2.1.2 Granger Causality test

The dynamics of the short run relationship between the variables was studied by testing the causality between them. Granger Causality test was used for the same. Causality may be bi-directional, uni-directional and at some lags causality may be absent. For the series – Nifty and USD/INR was considered in logarithm and the results were as follows.

Hypothesis Framework

H_{0a}= Nifty does not granger cause USD/INR

H_{0b}= USD/INR does not granger cause Nifty

Table 5.8 Granger Causality test for Nifty and USD/INR

Null Hypothesis	F-statistics	Probability
Nifty does not Granger cause USD/INR	1.012	0.036**
USD/INR does not Granger cause Nifty	7.039	0.001*

Note: * denotes significance at 1% level

The F- values and the p- values in the test results suggest that the null hypotheses of *No Causality* are significant at 1% and therefore can be rejected. There is an evidence of Bi-directional causality between Nifty and USD/INR which means in the short run change in USD against INR cause a change in nifty and vice versa. Block Exogeneity test is performed to conform the above result.

Table 5.9 Block Exogeneity test for Nifty and USD/INR

Dependent variable: Nifty			
Excluded	Chi-sq	Df	Prob
USD/INR	14.079	2	0.0009*
All	14.079	2	0.0009*
Dependent variable: USD/INR			
Excluded	Chi-sq	df	Prob
Nifty	2.025	2	0.3632
All	2.025	2	0.3632

Note: * denotes significance at 1% level

The Block Exogeneity test results (shown in Table 5.9) also indicate that χ^2 values are statistically significant as the p value is less than 0.05. Thus both the Granger causality test and Block Exogeneity test results confirm that both the variables have a short term relationship.

5.2.2 Short run relationship of NIFTY and Euro/INR

5.2.2.1 Unit Root Test:

The nature of data used in this study is the time series data. Before applying an econometric model using time series data it is a pre-condition that the series must be stationary. If the series has unit root or non-stationary, transformation of series from level data to differenced data is compulsory. In this study, the exchange rate i.e., Euro/INR along with Nifty are considered in logarithm to analyse the stationary of data using Augmented Dickey-Fuller (ADF) test and Phillip-Perron (PP) test.

Augmented Dickey-Fuller (ADF) test

ADF test is the most widely used test to examine the stationary of data .The ADF test for Nifty and Euro/INR are presented in the table 5.10.

Hypothesis framework

H_0= Nifty and Euro/INR has unit root or is a non-stationary

Table 5.10 ADF test for NIFTY and Euro/INR

Variables	At Level		First Difference	
	With intercept	With trend & intercept	With intercept	With trend & intercept
NIFTY	-1.202 (0.671)	-2.506 (0.324)	-10.256 (0.0000)*	-10.218 (0.0000)*
EURO/INR	-2.090 (0.248)	-2.339 (0.411)	-22.842 (0.000)*	-22.832 (0.000)*

Note: * indicates 1% level of significance

Table 5.10 shows the results of ADF test for Nifty and Euro/INR. The tests were conducted at level and first difference for the entire period of ten years from January 2007 to December 2017. Results indicated that at level both the variables of p value were found more than 0.05 which confirmed that null hypothesis cannot be rejected at level. It advocated that the nifty and Euro/INR series were non stationary.

ADF statistics at first difference reported that nifty and Euro/INR were found to be stationary as the p value is less than 0.05. Therefore, the null hypothesis of time series of non-stationary are rejected at 1% level of significance. The results of unit root test are consistent with the results of Pradip Kumar (2017) and Sahoo (2012).

Phillip-Perron (PP) test

The Phillip-Perron (PP) test is used to analyse unit root in time series analysis. The PP test for Nifty and Euro/INR are presented in the table 5.11

Hypothesis Framework

H_0= Nifty and Euro/INR has unit root or is a non-stationary

Table 5.11 PP test of NIFTY and Euro/INR

Variables	At Level		First Difference	
	With intercept	With trend & intercept	With intercept	With trend & intercept
NIFTY	-1.398 (0.580)	-2.938 (0.154)	-10.296 (0.0000)*	-10.257 (0.0000)*
EURO/INR	-2.091 (0.248)	-2.339 (0.411)	-22.849 (0.000)*	-22.839 (0.000)*

Note: * indicates 1% level of significance

Table 5.11 shows the results of PP test for nifty and Euro/INR. The tests were conducted at level and first difference for the entire period of ten years from January 2007 to December 2017. Results indicated that at level both the variables of p value were found more than 0.05 which confirmed that null hypothesis cannot be rejected at level. It advocated that the nifty and Euro/INR series were non stationary.

PP statistics at first difference reported that nifty and Euro/INR were found to be stationary as the p value is less than 0.05. Therefore, the null hypothesis of time series of non-stationary are rejected at 1% level of significance. The results of unit root test are consistent with the results of Pradip Kumar (2017) and Sahoo (2012).

Before doing Granger causality test, it is mandatory to find out the appropriate lag by using Lag order criterion. The table 5.12 presents the VAR lag order selection criteria

Table 5.12 Lag Order Selection Result for Nifty and Euro/INR

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-6235.57	NA	1.19^{e+08}	24.27	24.28	24.27
1	-4037.38	4370.73	23324.13	15.773	15.78*	15.75*
2	-4036.96	0.81*	23652.18*	15.74*	15.82	15.77
3	-4032.93	7.96	23648.96	15.74	15.86	15.79
4	-4031.11	3.566	23850.97	15.775	15.90	15.81
5	-4028.04	6.01	23937.24	15.75	15.94	15.83
6	-4026.38	3.23	24156.41	15.76	15.98	15.85

Table 5.12 (Continued)

Lag	LogL	LR	FPE	AIC	SC	HQ
7	-4024.76	3.14	24381.52	15.77	16.02	15.87
8	-4022.10	5.14	24509.29	15.78	16.06	15.89

*indicates lag order selected by the criterion

The above table 5.12 shows the different lag length suggested by criteria used for the Nifty and Euro/INR. The Schwarz Information Criterioa and Hann-Quinn information criterion suggest 1 lag length whereas modified LR test statistic, Akaike Information Criteria and Final Prediction Error suggest 2 lag lengths. Since 3 out of 5 tests recommended in selecting lag length of 2, the lag number 2 is opted for the study to carry out Granger Causality test.

5.2.2.2 Granger Causality test

The dynamics of the short run relationship between the variables was studied by testing the causality between them. Granger Causality test was used for the same. Causality may be bi-directional, uni-directional and at some lags causality may be absent. For the series – Nifty and EURO/INR was considered in logarithm and the results were as follows.

Hypothesis Framework

H_{0a}= Nifty does not granger cause Euro/INR

H_{0b}= Euro/INR does not granger cause Nifty

Table 5.13 Granger Causality test for Nifty and Euro/INR

Null Hypothesis	F-statistics	Probability
Nifty does not Granger cause Euro/INR	0.294	0.745
Euro/INR does not Granger cause Nifty	3.593	0.028**

Note: ** denotes significance at 5% level

The F- values and the p- values in the test results suggest that the null hypotheses of *Euro/INR does not granger cause Nifty* are significant at 5% and therefore can be rejected but *Nifty does not granger cause Euro/INR* cannot be rejected . There is an evidence of uni-directional causality from Euro/INR to Nifty which means in the short run change in Euro

against INR cause a change in nifty. Block Exogeneity test is performed to conform the above result.

Table 5.14 Block Exogeneity test for Nifty and Euro/INR

Dependent variable: Nifty			
Excluded	Chi-sq	Df	Prob
Euro/INR	7.187	2	0.027**
All	7.187	2	0.027**
Dependent variable: EURO/INR			
Excluded	Chi-sq	Df	Prob
Nifty	0.588	2	0.745
All	0.588	2	0.745

Note: ** denotes significance at 5% level

The Block Exogeneity test results (shown in Table 5.14) also indicate that $\chi 2$ value for Euro/INR(dependent variable) are statistically significant at 5 per cent level as the p value is greater than 0.05. This implies that change in nifty cause the change in Euro/INR. Thus both the Granger causality test and Block Exogeneity test results confirm that have short term relationship.

5.3.1 Short run relationship of NIFTY and GBP/INR

5.3.1.1 Unit Root Test:

The nature of data used in this study is the time series data. Before applying an econometric model using time series data it is a pre-condition that the series must be stationary. If the series has unit root or non-stationary, transformation of series from level data to differenced data is compulsory. In this study, the exchange rate i.e., GBP/INR along with Nifty are considered in logarithm to analyse the stationary of data using Augmented Dickey-Fuller (ADF) test and Phillip-Perron (PP) test.

Augmented Dickey-Fuller (ADF) test

ADF test is the most widely used test to examine the stationary of data .The ADF test for Nifty and GBP/INR are presented in the table 5.15.

Hypothesis framework

H_0= GBP/INR has unit root or is a non-stationary

Table 5.15 ADF test for NIFTY and GBP/INR

Variables	At Level		First Difference	
	With intercept	With trend & intercept	With intercept	With trend & intercept
NIFTY	-1.202 (0.671)	-2.506 (0.324)	-10.256 (0.0000)*	-10.218 (0.0000)*
GBP/INR	-1.660 (0.451)	-1.948 (0.627)	-5.476 (0.0000)*	-5.476 (0.0000)*

Note: * indicates 1% level of significance

Table 5.15 shows the results of ADF test for Nifty and GBP/INR. The tests were conducted at level and first difference for the entire period of ten years from January 2007 to December 2017. Results indicated that at level both the variables of p value were found more than 0.05 which confirmed that null hypothesis cannot be rejected at level. It advocated that the nifty and GBP/INR series were non stationary.

ADF statistics at first difference reported that nifty and GBP/INR were found to be stationary as the p value is less than 0.05. Therefore, the null hypothesis of time series of non-stationary are rejected at 1% level of significance. The results of unit root test are consistent with the results of Pradip Kumar (2017) and Sahoo (2012).

Phillip-Perron (PP) test

The Phillip-Perron (PP) test is used to analyse unit root in time series analysis. The PP test for Nifty and GBP/INR are presented in the table 5.16.

Hypothesis Framework

H_0= Nifty and GBP/INR has unit root or is a non-stationary

Table 5.16 PP test of NIFTY and GBP/INR

Variables	At Level		First Difference	
	With intercept	With trend & intercept	With intercept	With trend & intercept
NIFTY	-1.398 (0.580)	-2.938 (0.154)	-10.296 (0.0000)*	-10.257 (0.0000)*
GBP/INR	-1.510 (0.527)	-1.582 (0.799)	-21.665 (0.000)*	-21.652 (0. 000)*

Note: * indicates 1% level of significance

Table 5.16 shows the results of PP test for nifty and GBP/INR. The tests were conducted at level and first difference for the entire period of ten years from January 2007 to December 2017. Results indicated that at level both the variables of p value were found more than 0.05 which confirmed that null hypothesis cannot be rejected at level. It advocated that the nifty and GBP/INR series were non stationary.

PP statistics at first difference reported that nifty and GBP/INR were found to be stationary as the p value is less than 0.05. Therefore, the null hypothesis of time series of non-stationary are rejected at 1% level of significance. The results of unit root test are consistent with the results of Pradip Kumar (2017) and Sahoo (2012).

Before doing Granger causality test, it is mandatory to find out the appropriate lag by using Lag order criterion. The table 5.17 presents the VAR lag order selection criteria

Table 5.17 Lag Order Selection Result for Nifty and GBP/INR

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-6452.32	NA	2.77^{e+08}	25.11	25.13	25.12
1	-4146.00	4585.70	35593.30	16.15	16.20	16.17
2	-4143.23	5.49	35763.52*	16.16*	16.24*	16.19

Table 5.17 (Continued)

Lag	LogL	LR	FPE	AIC	SC	HQ
3	-4141.05	4.30	3601.79	16.167	16.28	16.21*
4	-4139.60	2.84	36377.31	16.177	16.32	16.23
5	-4134.88	9.23	36276.31	16.174	16.35	16.24
6	-4130.59	8.37	36235.02	16.173	16.38	16.25
7	-4130.04	1.06	36725.29	16.186	16.43	16.28
8	-4123.91	11.86*	36422.25	16.178	16.45	16.28

*indicates lag order selected by the criterion

The above table 5.17 shows the different lag length suggested by criteria used for the Nifty and GBP/INR. The modified LR test statistic suggest 8 lag length, Hann-Quinn information criterion suggest 3 while Schwarz Information Criterion, Akaike Information Criteria and Final Prediction Error suggest 2 lag lengths. Since 3 out of 5 tests recommended in selecting lag length of 2, the lag number 2 is opted for the study to carry out Granger Causality test.

5.3.1.2 Granger Causality test

The dynamics of the short run relationship between the variables was studied by testing the causality between them. Granger Causality test was used for the same. Causality may be bi-directional, uni-directional and at some lags causality may be absent. For the series – Nifty and GBP/INR was considered in logarithm and the results were as follows.

Hypothesis Framework

H_{0a}= Nifty does not granger cause GBP/INR

H_{0b}= GBP/INR does not granger cause Nifty

Table 5.18 Granger Causality test for Nifty and GBP/INR

Null Hypothesis	**F-statistics**	**Probability**
Nifty does not Granger cause GBP/INR	0.448	0.638
GBP/INR does not Granger cause Nifty	2.390	0.092***

Note: *** indicates 10% level of significance

The results of Granger-causality test between Nifty and GBP/INR are shown in the table 5.18 The F- values and the p- values in the test results suggest that the null hypotheses of *GBP/INR does not granger cause Nifty* are significant at 10% and therefore can be rejected but *Nifty does not granger cause GBP/INR* cannot be rejected . There is an evidence of uni-directional causality from GBP/INR to Nifty which means in the short run change in GBP against INR cause a change in nifty. Block Exogeneity test is performed to conform the above result.

Table 5.19 Block Exogeneity test for Nifty and GBP/INR

Dependent variable: Nifty			
Excluded	Chi-sq	df	Prob
GBP/INR	4.780	2	0.091***
All	4.780	2	0.091***
Dependent variable: GBP/INR			
Excluded	Chi-sq	df	Prob
Nifty	0.897	2	0.6383
All	0.897	2	0.6383

Note: ***indicates 10% level of significance

The Block Exogeneity test results (shown in table 5.19) also indicate that $\chi 2$ values are statistically significant at 10 per cent level as the p value is greater than 0.10. Thus both the Granger causality test and Block Exogeneity test results confirm that both the variables do have short term relationship.

5.2.4 Short run relationship of NIFTY and Yen/INR

5.2.4.1 Unit Root Test:

The nature of data used in this study is the time series data. Before applying an econometric model using time series data it is a pre-condition that the series must be stationary. If the series has unit root or non-stationary, transformation of series from level data to differenced data is compulsory. In this study, the exchange rate i.e., Yen/INR along with Nifty are considered in logarithm to analyse the stationary of data using Augmented Dickey-Fuller (ADF) test and Phillip-Perron (PP) test.

Augmented Dickey-Fuller (ADF) test

ADF test is the most widely used test to examine the stationary of data .The ADF test for Nifty and Yen/INR are presented in the table 5.20.

Hypothesis framework

H_0= Yen/INR has unit root or is a non-stationary

Table 5.20 ADF test for NIFTY and YEN/INR

Variables	At Level		First Difference	
	With intercept	With trend & intercept	With intercept	With trend & intercept
NIFTY	-1.202 (0.671)	-2.506 (0.324)	-10.256 (0.0000)*	-10.218 (0.0000)*
YEN/INR	-2.789 (0.162)	-2.309 (0.425)	-8.307 (0.0000)*	-8.496 (0.0000)*

Note: * indicates 1% level of significance

Table 5.20 shows the results of ADF test for Nifty and Yen/INR. The tests were conducted at level and first difference for the entire period of ten years from January 2007 to December 2017. Results indicated that at level both the variables of p value were found more than 0.05 which confirmed that null hypothesis cannot be rejected at level. It advocated that the nifty and Yen/INR series were non stationary.

ADF statistics at first difference reported that nifty and Yen/INR were found to be stationary as the p value is less than 0.05. Therefore, the null hypothesis of time series of non-

stationary are rejected at 1% level of significance. The results of unit root test are consistent with the results of Pradip Kumar (2017) and Sahoo (2012).

Phillip-Perron (PP) test

The Phillip-Perron (PP) test is used to analyse unit root in time series analysis. The PP test for Nifty and Yen/INR are presented in the table 5.21.

Hypothesis Framework

H_0= Nifty and YEN/INR has unit root or is a non-stationary

Table 5.21 PP test of NIFTY and YEN/INR

Variables	At Level		First Difference	
	With intercept	With trend & intercept	With intercept	With trend & intercept
NIFTY	-1.398 (0.580)	-2.938 (0.154)	-10.296 (0.0000)*	-10.257 (0.0000)*
YEN/INR	-2.249 (0.190)	-1.584 (0.793)	-8.352 (0.0000)*	-8.503 (0.0000)*

Note: * indicates 1% level of significance

Table 5.16 shows the results of PP test for nifty and YEN/INR. The tests were conducted at level and first difference for the entire period of ten years from January 2007 to December 2017. Results indicated that at level both the variables of p value were found more than 0.05 which confirmed that null hypothesis cannot be rejected at level. It advocated that the nifty and YEN/INR series were non stationary.

PP statistics at first difference reported that nifty and Yen/INR were found to be stationary as the p value is less than 0.05. Therefore, the null hypothesis of time series of non-stationary are rejected at 1% level of significance. The results of unit root test are consistent with the results of Pradip Kumar (2017) and Sahoo (2012).

Before doing Granger causality test, it is mandatory to find out the appropriate lag by using Lag order criterion. The table 5.22 presents the VAR lag order selection criteria

Table 5.22 Lag Order Selection Result for Nifty and YEN/INR

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-3928.35	NA	15024.58	15.29	15.30	15.29
1	-1612.82	4604.03*	1.86	6.29	6.34	6.31
2	-1611.63	2.342	1.88	6.30	6.39	6.34*
3	-1608.60	5.985	1.89*	6.31*	6.42*	6.34
4	-1606.09	4.934	1.90	6.31	6.46	6.37
5	-1603.95	4.187	1.91	6.32	6.50	6.39
6	-1600.10	7.502	1.91	6.32	6.54	6.41
7	-1599.17	1.812	1.94	6.33	6.58	6.43
8	-1598.85	0.614	1.96	6.35	6.63	6.46

*indicates lag order selected by the criterion

The above table 5.22 shows the different lag length suggested by criteria used for the Nifty and Yen/INR. The modified LR test statistic suggests 1 lag length, Hann-Quinn information criterion suggest 2 lag length while Final Prediction Error, Schwarz Information Criterion and Akaike Information Criteria suggest lag length 3. Since 3 out of 5 tests recommended in selecting lag length of 3, the lag number 3 is opted for the study to carry out Granger Causality test.

5.2.4.2 Granger Causality test

The dynamics of the short run relationship between the variables was studied by testing the causality between them. Granger Causality test was used for the same. Causality may be bi-directional, uni-directional and at some lags causality may be absent. For the series – Nifty and Yen/INR was considered in logarithm and the results were as follows.

Hypothesis Framework

H_{0a}= Nifty does not granger cause Yen/INR

H_{0b}= Yen/INR does not granger cause Nifty

Table 5.23 Granger Causality test for Nifty and Yen/INR

Null Hypothesis	F-statistics	Probability
Nifty does not Granger cause Yen/INR	0.634	0.530
Yen/INR does not Granger cause Nifty	4.513	0.011**

Note: ** indicates 5% level of significance

The F- values and the p- values in the test results suggest that the null hypotheses of *Yen/INR does not granger cause Nifty* are significant at 5% and therefore can be rejected but *Nifty does not granger cause Yen/INR* cannot be rejected . There is an evidence of uni-directional causality from Yen/INR to Nifty which means in the short run change in Yen against INR cause a change in nifty. Block Exogeneity test is performed to conform the above result.

Table 5.24 Block Exogeneity test for NIFTY and YEN/INR

Dependent variable: Nifty			
Excluded	Chi-sq	df	Prob
LYEN/INR	9.026	3	0.011**
All	9.026	3	0.011**
Dependent variable: YEN/INR			
Excluded	Chi-sq	df	Prob
LNifty	1.268	3	0.530
All	1.268	3	0.530

Note: ** indicates 5% level of significance

The Block Exogeneity test results (shown in Table 5.24) also indicate that $\chi 2$ value for Yen/INR(dependent variable) are statistically significant at 5 per cent level as the p value is greater than 0.05. This implies that change in YEN/INR cause the change in nifty. Thus both the Granger causality test and Block Exogeneity test results confirm that have short term relationship.

5.3 IMPACT OF EXCHANGE RATES FLUCTUATIONS ON THE SHARE INDICES IN THE LONG RUN

This section includes the data analysis for examining the long run relationship between Nifty and four major currency pairs i.e. (USD/INR, EURO/INR, GBP/INR, and YEN/INR) traded in India. Studying about the long run relationship helps the investors to know about the dynamic relationship and their integration between both the markets. The data analysis was done by using Co-integration test and Vector Error Correction Model. The data analysis and interpretation is divided into four sections which are as follows:

5.3.1 Long run relationship of NIFTY and USD/INR

5.3.2 Long run relationship of NIFTY and Euro/INR

5.3.3 Long run relationship of NIFTY and GBP/INR

5.3.4 Long run relationship of NIFTY and Yen/INR

5.3.1 Long run relationship of NIFTY and USD/INR

The unit root test is checked while analyzing short run relationship between variables. The data was found to be stationary at first difference for both ADF and PP test. As the next step, Co-integration test was applied on the series to examine the long run equilibrium relationship between Nifty and USD/INR.

5.3.1.1 Co-integration test:

The co-integration test is used to analyze the existence of a stationary linear combination among the non-stationary variables of the same order. If such combination is found, an equilibrium relationship is said to exist among the variables. It is tested by using Johansen co-integration test. It is applied on the series to examine the long run equilibrium relationship between Nifty and USD/INR The result of the analysis is given in the table 5.25.

Hypothesis Framework

H_0= There is no co-integration between Nifty and USD/INR

Table 5.25 Johansen Co-integration Test for NIFTY and USD/INR

Unrestricted Cointegration Rank Test(Trace)				
Hypothesized No. of CE(s)	**Eigenvalue**	**Trace Statistic**	**0.05 Critical value**	**Prob.**
None*	0.156252	19.39036	15.49471	0.0123**
At most 1	0.000190	0.021630	3.841466	0.8830
Trace test indicates 1 co-integrating eqn at the 0.05 level *denotes rejection of the hypothesis at the 0.05 level **Mackinnon-Haug-Michelis (1999) p-values				
Unrestricted Cointegration Rank Test(Maximum Eigenvalue)				
Hypothesized No. of CE(s)	**Eigenvalue**	**Max-Eigen Statistic**	**0.05 Critical value**	**Prob.**
None*	0.156252	19.36873	14.26460	0.0071**
At most 1	0.000190	0.021630	3.841466	0.8830
Maximum Eigenvalue test indicates 1 cointegrating eqn at the 0.05 level *denotes rejection of the hypothesis at the 0.05 level **Mackinnon-Haug-Michelis (1999) p-values				
Unrestricted Co-integrating Coefficients(normalized by b*S11*b=1):				
NIFTY	**USD_INR**			
-0.001119	0.204265			
0.000436	0.045012			
Unrestricted Adjustment Coefficients(alpha):				
D(NIFTY)	129.7042	-0.063467		
D(USD_INR)	-0.151379	-0.011391		
1 Cointegrating Equation(s):		Log likelihood	-953.3666	
Normalized co-integrating coefficients (standard error in parentheses)				
NIFTY	**USD_INR**			
1.000000	-182.6153 (23.8983)			

Table 5.25(Continued)

Adjustment coefficients (standard error in parentheses)				
D(NIFTY)	-0.145081 (23.8983)			
D(USD_INR)	-0.000169 (0.00010)			

Note: ** indicates 5% level of significance

According to the results of the Johansen's Co-integration test as presented in Table 5.25, Maximal eigen statistic (λmax) of 19.36873 is greater than the 5 % critical value of 14.26460 and the trace test statistic (λtrace) of 19.39036 is greater than the critical value of 15.49471. If the nifty index increases by 1 time, USD/INR will decrease by 182.61 times. The null hypothesis of no co integration between Nifty and USD/INR is rejected at 5% level of significance.

These results prove that there is long run equilibrium relationship and their random walk moves together in the long run. In other words, in every period of short-term the USD/INR and Nifty tend to be mutually adjusted to achieve its long-term equilibrium. The above results are in consistent with D.K.Malhotra, 2007 and Pradip Kumar, 2017.

The next step is building the Vector Error Correction Model (VECM) where it can be used as an evidence to use as an additional support of the results produced by Johansen co-integration test and confirm the presence of a stable long run relationship between stock index and exchange rates.

Hypothesis Framework

H_0= There is no long run relationship between Nifty and USD/INR.

Table 5.26 Vector Error Correction Model for Nifty and USD/INR series

(January 2007 – December 2017)

Coefficients	Dependent Variable					
	D(NIFTY)			D(USD_INR)		
	Coefficient	Std. Error	t-Statistics	Coefficient	Std. Error	t-Statistics
ECT	-0.145081	0.03339	-4.34566*	-0.282196	0.10856	-2.59956*
D(NIFTY(-1))	-0.075348	0.09771	-0.77117	-0.000521	0.00029	-1.78775
D(NIFTY(-2))	-0.045207	0.10034	-0.45054	0.000534	0.00030	1.78605
D(USD_INR(-1))	-100.2366	36.4107	-2.75294	-0.001081	0.00030	-3.55412*
D(USD_INR(-2))	-7.207028	35.5651	-0.20264*	0.028175	0.10603	0.26571
C	69.61868	38.5536	1.80576	0.243380	0.11494	2.11737*

Note: * denotes significance level at the 0.05 level

* ECT stands for lagged error correction term

The above table 5.26 presents the results of VECM model for Nifty and USD/INR. The first coefficient is ECT stands for error correction term and it is the lagged estimated residual term from the co-integration equation. ECT shows the long run causality between dependent and independent variable. The ECT coefficient term was found negative and significant at 5 % level in both equations, with Nifty return as dependent variable (-0.145081) and with USD/INR as dependent variable (-0.282196). It indicated that there was long run causality running from Nifty to USD/INR and vice versa. The negative value of correction term specified that there was a downward adjustment in both nifty and USD/INR.

The speed of adjustment towards equilibrium was 14.5 % in the Nifty and 28.2% in USD/INR. The speed of adjustment was more in USD/INR. Therefore whenever there is disequilibrium in the USD/INR and Nifty, both the USD/INR as well as Nifty tried to adjust to maintain long term relationship. Thus, null hypothesis of no long run relationship between nifty and USD/INR is rejected at 5% level of significance.

5.3.2 Long run relationship of NIFTY and Euro/INR

The unit root test is checked while analyzing short run relationship between variables. The data was found to be stationary at first difference for both ADF and PP test. As the next step, Co-integration test was applied on the series to examine the long run equilibrium relationship, if any, between Nifty and Euro/INR.

5.3.2.1 Co-integration test:

Johansen co-integration test is applied on the series to examine the long run equilibrium relationship, if any, between Nifty and Euro/INR. The result of the analysis is given in the table 5.27

Hypothesis Framework

H_0= There is no co-integration between Nifty and EURO/INR

Table 5.27 Johansen Cointegration Test for NIFTY and EURO/INR

Unrestricted Cointegration Rank Test(Trace)				
Hypothesized No. of CE(s)	**Eigenvalue**	**Trace Statistic**	**0.05 Critical value**	**Prob.****
None	0.113	14.063	12.320	0.025**
At most 1	0.005	0.613	4.129	0.494
Trace test indicates 1 co-integrating eqn(s) at the 0.05 level *denotes rejection of the hypothesis at the 0.05 level **Mackinnon-Haug-Michelis (1999) p-values				
Unrestricted Cointegration Rank Test(Maximum Eigenvalue)				
Hypothesized No. of CE(s)	**Eigenvalue**	**Max-Eigen Statistic**	**0.05 Critical value**	**Prob.****
None	0.113	13.450	11.224	0.020**
At most 1	0.005	0.613	4.129	0.494
Maximum Eigenvalue test indicates 1 co-integrating eqn(s) at the 0.05 level *denotes rejection of the hypothesis at the 0.05 level **Mackinnon-Haug-Michelis (1999) p-values				

Table 5.27 (Continued)

Unrestricted Cointegrating Coefficients(normalized by b*S11*b=1):				
NIFTY	**EURO_INR**			
-4.776	9.848			
1.312	-2.450			
Unrestricted Adjustment Coefficients(alpha):				
D(NIFTY)	-0.020	0.001		
D(EURO_INR)	-0.003	0.002		
1 Cointegrating Equation(s):		Log likelihood	380.079	
Normalized cointegrating coefficients (standard error in parentheses)				
NIFTY	**EURO_INR**			
1.000000	-2.062 (0.014)			
Adjustment coefficients (standard error in parentheses)				
D(NIFTY)	-0.098 (0.028)			
D(EURO_INR)	0.014 (0.016)			

Note: ** indicates 5% level of significance

According to the results of the Johansen's Co-integration test as presented in Table 5.27, Maximal eigen statistic (λmax) of 13.450 is greater than the 5 % critical value of 11.224 and the trace test statistic (λtrace) of 14.063 is greater than the critical value of 12.320. If the nifty index increases by 1 time, Euro/INR will have a negative change of 2.062 times. The null hypothesis of no co-integration between Nifty and Euro/INR is rejected at 5% level of significance.

These results prove that there is long run equilibrium relationship and their random walk moves together in the long run. In other words, in every period of short-term the Euro/INR and Nifty tend to be mutually adjusted to achieve its long-term equilibrium. The above results are in consistent with Pradip Kumar, 2017 and Abburi & Stella (2017).

The next step is building the Vector Error Correction Model (VECM) where it can be used as an evidence to use as an additional support of the results produced by Johansen co-integration test and confirm the presence of a stable long run relationship between stock index and exchange rates.

Hypothesis Framework

H_0= There is no long run relationship between Nifty and Euro/INR.

Table 5.28 Vector Error Correction Model for Nifty and Euro/INR series

(January 2007 – December 2017)

Coefficients	Dependent Variable					
	D(NIFTY)			D(EURO_INR)		
	Coefficient	Std. Error	t-Statistics	Coefficient	Std. Error	t-Statistics
ECT	-0.075	0.023	-3.260*	-0.0234	0.012	1.957*
D(NIFTY(-1))	0.039	0.094	0.416	0.0112	0.052	0.213
D(NIFTY(-2))	-0.064	0.092	-0.702	0.020	0.051	0.404
D(EURO_INR(-1))	0.091	0.090	1.006	0.0009	0.050	0.019
D(EURO_INR(-2))	0.127	0.089	1.418	-0.065	0.049	-1.32
C	0.0079	0.0063	1.259	0.0012	0.003	0.359

Note: * denotes significance level at the 0.05 level

* ECT stands for lagged error correction term

The above table 5.28 shows the results of VECM model for Euro/INR and nifty. ECT shows the long run causality between dependent and independent variable. The ECT coefficient term was found negative and significant at 5 % level in both equations, with Nifty return as dependent variable (-0.075) and with EURO/INR as dependent variable (-0.0234). It indicated that there was long run causality running from Euro/INR to nifty and vice versa. The negative value of correction term specified that there was a downward adjustment in both markets.

The speed of adjustment towards equilibrium was 7.5 % in the Nifty and 2.3% in Euro/INR. The speed of adjustment was more in nifty. Therefore, whenever there is disequilibrium in the Nifty and Euro/INR, both these market tried to adjust to maintain long term

relationship. Thus, null hypothesis of no long run relationship between nifty and Euro/INR is rejected at 5% level of significance.

5.3.3 Long run relationship of NIFTY and GBP/INR

The unit root test is checked while analyzing short run relationship between variables. The data was found to be stationary at first difference for both ADF and PP test. As the next step, Co-integration test was applied on the series to examine the long run equilibrium relationship, if any, between Nifty and GBP/INR.

5.3.3.1 Co-integration test:

Johansen co-integration test is applied on the series to examine the long run equilibrium relationship, if any, between Nifty and GBP/INR. The result of the analysis is given in the table 5.29.

Hypothesis Framework

H_0= There is no co-integration between Nifty and GBP/INR

Table 5.29 Johansen Cointegration Test for Nifty and GBP/INR series

Unrestricted Cointegration Rank Test(Trace)				
Hypothesized No. of CE(s)	**Eigenvalue**	**Trace Statistic**	**0.05 Critical value**	**Prob.****
None	0.029	3.469	12.320	0.785
At most 1	0.000	0.020	4.129	0.906
Trace test indicates no co-integration at the 0.05 level *denotes rejection of the hypothesis at the 0.05 level **Mackinnon-Haug-Michelis (1999) p-values				
Unrestricted Cointegration Rank Test(Maximum Eigenvalue)				
Hypothesized No. of CE(s)	**Eigenvalue**	**Max-Eigen Statistic**	**0.05 Critical value**	**Prob.****
None	0.029	3.449	11.224	0.716
At most 1	0.000	0.020	4.129	0.906

Table 5.29 (Continued)

Maximum Eigenvalue test indicates no co-integration at the 0.05 level *denotes rejection of the hypothesis at the 0.05 level **Mackinnon-Haug-Michelis (1999) p-values				
Unrestricted Cointegrating Coefficients(normalized by b*S11*b=1):				
NIFTY	**GBP_INR**			
-4.057	8.040			
2.449	-4.588			
Unrestricted Adjustment Coefficients(alpha):				
D(NIFTY)	0.011	0.000		
D(GBP_INR)	-0.002	0.000		
1 Cointegrating Equation(s):		Log likelihood 414.476		
Normalized cointegrating coefficients (standard error in parentheses)				
NIFTY	**GBP_INR**			
1.00000	-1.981 (0.030)			
Adjustment coefficients (standard error in parentheses)				
D(NIFTY)	-0.044 (0.025)			
D(GBP_INR)	0.008 (0.009)			

Based on the above table 5.29 , it has been found that Nifty and GBP/INR do not have long run relationship at neither at five nor ten percent significance level. The null hypothesis of no co-integration between Nifty and GBP/INR is not rejected at 5% level of significance.

Thus, no long run co-integration exist between Nifty and GBP/INR, it is not necessary to do Vector Error Correction Model. The above results are in consistent with Gagan Deep Sharma & Namisha Mishra(2016).

5.3.4 Long run relationship of NIFTY and Yen/INR

The unit root test is checked while analyzing short run relationship between variables. The data was found to be stationary at first difference for both ADF and PP test. As the next step, Co-integration test was applied on the series to examine the long run equilibrium relationship, if any, between Nifty and Yen/INR.

5.3.4.1 Co-integration test:

Johansen co-integration test is applied on the series to examine the long run equilibrium relationship, if any, between Nifty and Euro/INR. The result of the analysis is given in the table 5.30.

Hypothesis Framework

H_0= There is no co-integration between Nifty and Yen/INR

Table 5.30 Johansen Cointegration Test for Nifty and YEN/INR series

Unrestricted Cointegration Rank Test(Trace)				
Hypothesized No. of CE(s)	**Eigenvalue**	**Trace Statistic**	**0.05 Critical value**	**Prob.****
None	0.081	13.109	12.320	0.036**
At most 1	0.029	3.455	4.129	0.174
Trace test indicates 1 co-integrating eqn(s) at the 0.05 level *denotes rejection of the hypothesis at the 0.05 level **Mackinnon-Haug-Michelis (1999) p-values				
Unrestricted Cointegration Rank Test(Maximum Eigenvalue)				
Hypothesized No. of CE(s)	**Eigenvalue**	**Max-Eigen Statistic**	**0.05 Critical value**	**Prob.****
None	0.081	13.109	11.224	0.046**
At most 1	0.029	3.455	4.129	0.174
Maximum Eigenvalue test indicates 1 co-integrating eqn(s) at the 0.05 level *denotes rejection of the hypothesis at the 0.05 level **Mackinnon-Haug-Michelis (1999) p-values				

Table 5.30 (Continued)

Unrestricted Cointegrating Coefficients(normalized by b*S11*b=1):				
NIFTY	**YEN_INR**			
-2.778	6.001			
-0.225	0.761			
Unrestricted Adjustment Coefficients(alpha):				
D(NIFTY)	0.017	0.004		
D(YEN_INR)	-0.005	0.003		
1 Cointegrating Equation(s):		Log likelihood	395.382	
Normalized cointegrating coefficients (standard error in parentheses)				
NIFTY	**YEN_INR**			
1.000000	-2.160 (0.032)			
Adjustment coefficients (standard error in parentheses)				
D(NIFTY)	-0.049 (0.017)			
D(YEN_INR)	0.016 (0.008)			

Based on the above table 5.30, the Maximal eigen statistic (λmax) of 13.109 is greater than the 5 % critical value of 11.224 and the trace test statistic (λtrace) of 13.109 is greater than the critical value of 12.320. If the nifty index increases by 1 time, Yen/INR will have a negative change of 2.16 times. The null hypothesis of no co-integration between Nifty and Yen/INR is strongly rejected at 1% level of significance.

These results prove that there is long run equilibrium relationship and their random walk moves together in the long run. In other words, in every period of short-term the Yen/INR and Nifty tend to be mutually adjusted to achieve its long-term equilibrium. The above results are in consistent with Abburi & Stella(2017) and Pradip Kuamr Mishra(2017).

The next step is building the Vector Error Correction Model (VECM) where it can be used as an evidence to use as an additional support of the results produced by Johansen co-integration test and confirm the presence of a stable long run relationship between stock index and exchange rates.

Hypothesis Framework

H_0= There is no long run relationship between Nifty and Yen/INR.

Table 5.31 Vector Error Correction Model for Nifty and YEN/INR series

(January 2007 – December 2017)

Coefficients	Dependent Variable					
	D(NIFTY)			D(YEN_INR)		
	Coefficient	Std. Error	t-Statistics	Coefficient	Std. Error	t-Statistics
ECT	-0.030	0.011	-2.638*	-0.012	0.005	-2.407*
D(NIFTY(-1))	0.035	0.100	0.355	-0.086	0.046	-1.857
D(NIFTY(-2))	-0.061	0.102	-0.600	0.034	0.047	0.739
D(NIFTY(-3))	0.064	0.101	0.636	0.032	0.046	0.693
D(NIFTY(-4))	0.232	0.101	2.292*	-0.117	0.047	-2.501*
D(YEN_INR(-1))	0.068	0.106	0.641	-0.029	0.049	-0.590
D(YEN_INR(-2))	-0.152	0.224	-0.680	0.188	0.104	1.811
D(YEN_INR(-3))	0.023	0.221	0.104	0.194	0.102	1.895
D(YEN_INR(-4))	-0.089	0.223	-0.398	-0.025	0.103	-0.247
C	0.002	0.006	0.393	0.005	0.003	1.567

Note: * denotes significance level at the 0.05 level

* ECT stands for lagged error correction term

The above table 5.31 shows the results of VECM model for YEN/INR and nifty. ECT shows the long run causality between dependent and independent variable. The ECT coefficient term was found negative and significant at 5 % level in both equations, with Nifty return as dependent variable (-0.030) and with YEN/INR as dependent variable (-0.012). It indicated that there was long run causality running from Nifty to YEN/INR and vice versa. The negative value of correction term specified that there was a downward adjustment in both markets.

The speed of adjustment towards equilibrium was 3% in the Nifty and 1.2% in GBP/INR. The speed of adjustment was more in nifty. Therefore, whenever there is disequilibrium in the Nifty and GBP/INR, both these market tried to adjust to maintain long term relationship. Thus, null hypothesis of no long run relationship between nifty and YEN/INR is rejected at 5% level of significance.

5.4 RELATIONSHIP BETWEEN EXCHANGE RATES AND SECTORAL INDICES LISTED IN NSE

The nature of the industry and the type of response they have on the fluctuations in exchange rate need not be uniform. An analysis of the response of share prices in each industry sector was mapped using Sectoral indices to represent the industry groups and were regressed on monthly exchange rates of Rupee against the Dollar, Euro, GBP and Yen. This analysis would certainly help the investors to identify the sectors that were affected by exchange rates. The data analysis was done by using Standard deviation, coefficient of variation, relative variance, co-integration and granger causality test.

The summary statistics and results of co-integration and causality test are presented as follows.

Table 5.32 Sectoral indices and USD/INR

	Exchange rate and INDEX	No. of observation	Summary Statistics		Relative variance	Co-integration	Evidence of Causality
			Std dev.	Coeff of variation			
1	USD/INR	522	8.75	6.32	3.43	Yes	USD/INR to Nifty auto
	NIFTY Auto	522	2961.00	1.84			
2	USD/INR	522	8.75	6.32	2.59	Yes	USD/INR to Nifty Bank
	NIFTY Bank	522	5306.36	2.44			
3	USD/INR	522	8.75	6.32	2.37	No	USD/INR to Nifty IT
	NIFTY IT	522	2892.87	2.66			
4	USD/INR	522	8.75	6.32	2.59	No	USD/INR to Nifty FS
	NIFTY FS	522	2168.36	2.44			
5	USD/INR	522	8.75	6.32	2.59	Yes	Bi-directional causality
	NIFTY FMCG	522	6546.37	2.44			
6	USD/INR	522	8.75	6.32	1.29	No	USD/INR to Nifty Metal
	NIFTY Metal	338	539.56	4.88			
7	USD/INR	522	8.75	6.32	2.13	Yes	Bi-directional causality
	NIFTY Media	522	635.80	2.96			
8	USD/INR	522	8.75	6.32	3.06	No	Bi-directional causality
	NIFTY Pharma	522	3358.33	2.06			
9	USD/INR	522	8.75	6.32	3.32	No	USD/INR to

	NIFTY Private	522	3379.72	1.90			Nifty Private
10	USD/INR	522	8.75	6.32	21.06	Yes	No evidence of causality
	NIFTY PSU	522	12249.61	0.30			
11	USD/INR	522	8.75	6.32	4.68	Yes	USD/INR to Nifty Realty
	NIFTY Realty	522	238.36	1.35			

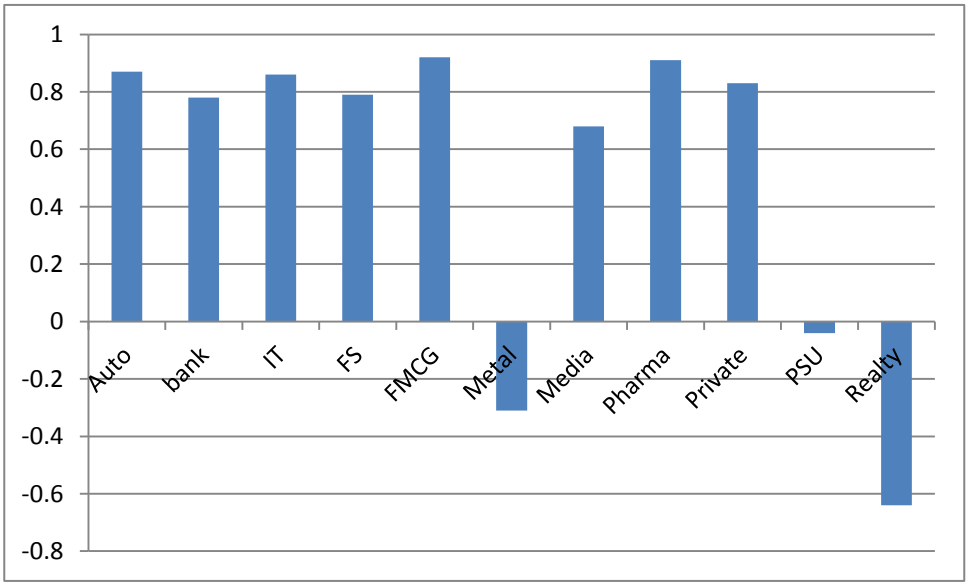
Note: Analysis of co-integration and Granger causality has been attached in the annexure

From the table 5.32, co-integration test reveals that out of 11 industry sectors identified only auto, bank, FMCG, Media, PSU and realty sectors were found to have long run relationship with exchange rate. Granger causality test reveals that sectors like Auto, Bank, Financial service, FMCG, Media, Private and realty sectors were found to have short run relationship with exchange rate.

The relative volatility is calculated by dividing coefficient of variation of sector index by that of the exchange rate. The share price for firms in PSU and Realty were mostly affected by exchange rate followed by sectors like Auto, financial services, bank and FMCG. The impact on metal and media sectors was among the least.

The Correlation between the exchange rate (USD/INR) and the various industry indices is depicted in the chart 5.5.

Chart 5.5 Correlation between Sectoral indices and USD/INR



From the chart 5.5, it is found that most of the sectoral indices are positively correlated with USD/INR (Nifty FMCG=0.92, Pharma =0.91, Auto=0.87, IT=0.86). Import intensive sectors like Metal (-0.31) PSU(-0.04) and Realty(-0.64) responded negatively to the weakening rupee.

Table 5.33 Sectoral indices and EURO/INR

	Exchange rate and INDEX	**No of observation**	**Summary Statistics**		**Relative variance**	**Co-integration**	**Evidence of Causality**
			Std dev.	**Coeff of variation**			
1	EURO/INR	522	6.83	10.29	5.59	No	Nifty Auto to EURO/INR
	NIFTY Auto	522	2961.00	1.84			
2	EURO /INR	522	6.83	10.29	4.21	No	EURO/INR to Nifty Bank
	NIFTY Bank	522	5306.36	2.44			
3	EURO /INR	522	6.83	10.29	3.86	No	EURO/INR to Nifty IT
	NIFTY IT	522	2892.87	2.66			
4	EURO /INR	522	6.83	10.29	4.21	No	Nifty FS to EURO/INR
	NIFTY FS	522	2168.36	2.44			
5	EURO/INR	522	6.83	10.29	4.21	No	No evidence of causality
	NIFTY FMCG	522	6546.37	2.44			
6	EURO/INR	522	6.83	10.29	2.10	No	EURO/INR to Nifty metal
	NIFTY Metal	338	539.56	4.88			
7	EURO/INR	522	6.83	10.29	3.47	No	EURO/INR to

	NIFTY Media	522	635.80	2.96			Nifty Media
8	EURO/INR	522	6.83	10.29	4.99	No	EURO/INR to Nifty Pharma
	NIFTY Pharma	522	3358.33	2.06			
9	EURO/INR	522	6.83	10.29	5.41	No	EURO/INR to Nifty Private Bank
	NIFTY Private Bank	522	3379.72	1.90			
10	EURO/INR	522	6.83	10.29	34.3	Yes	No evidence of causality
	NIFTY PSU	522	12249.61	0.30			
11	EURO/INR	522	6.83	10.29	7.79	Yes	No evidence of causality
	NIFTY Realty	522	238.36	1.35			

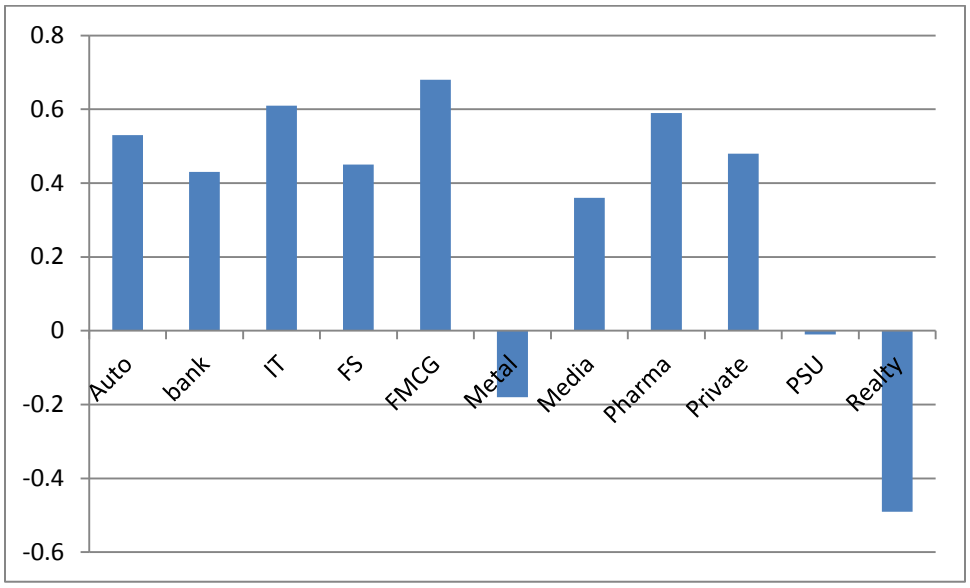
Note: Analysis of co-integration and Granger causality has been attached in the annexure

From the table 5.33, co-integration test reveals that out of 11 industry sectors identified only PSU and realty sectors were found to have long run relationship with exchange rate. Granger causality test reveals that sectors like Auto, Bank, IT, Financial service, Metal, Media, Private and Pharma sectors were found to have short run effect on exchange rate.

The relative volatility of each sector measured in terms of the coefficient of variation of sector index divided by that of the exchange rate. The share price for firms in PSU and Realty were mostly affected by exchange rate followed by sectors like Auto, financial services, bank and FMCG.

The Correlation between the Euro/INR and the various industry indices is depicted in the Chart 5.6.

Chart 5.6 Correlation between Euro/INR and Sectoral indices



From the chart 5.6, it is found that most of the sectoral indices are positively correlated with Euro/INR (Nifty FMCG=0.75, pharma =0.63, IT=0.61). Sectors like Metal (-0.18), PSU (-0.01) and Realty (-0.49) responded negatively to the weakening rupee.

Table 5.34 Sectoral indices and GBP/INR

	Exchange rate and INDEX	No of observation	Summary Statistics		Relative variance	Co-integration	Evidence of Causality
			Std dev.	Coeff of variation			
1	GBP/INR	522	10.37	8.20	4.45	No	No evidence of causality
	NIFTY Auto	522	2961.00	1.84			
2	GBP /INR	522	10.37	8.20	3.36	No	GBP/INR to Nifty Bank
	NIFTY Bank	522	5306.36	2.44			
3	GBP /INR	522	10.37	8.20	3.08	No	No evidence of causality
	NIFTY IT	522	2892.87	2.66			
4	GBP /INR	522	10.37	8.20	3.36	Yes	No evidence of causality
	NIFTY FS	522	2168.36	2.44			
5	GBP /INR	522	10.37	8.20	3.36	No	No evidence of causality
	NIFTY FMCG	522	6546.37	2.44			
6	GBP /INR	522	10.37	8.20	1.68	No	No evidence of causality
	NIFTY Metal	338	539.56	4.88			
7	GBP /INR	522	10.37	8.20	2.77	No	GBP/INR to Nifty Media
	NIFTY Media	522	635.80	2.96			
8	GBP /INR	522	10.37	8.20	3.98	No	GBP/INR to Nifty Pharma
	NIFTY Pharma	522	3358.33	2.06			
9	GBP /INR	522	10.37	8.20	4.31	No	GBP/INR to Nifty
	NIFTY	522	3379.72	1.90			

	Private						Private
10	GBP /INR	522	10.37	8.20	27.33	Yes	No evidence of causality
	NIFTY PSU	522	12249.61	0.30			
11	GBP /INR	522	10.37	8.20	6.07	Yes	GBP/INR to Nifty Realty
	NIFTY Realty	522	238.36	1.35			

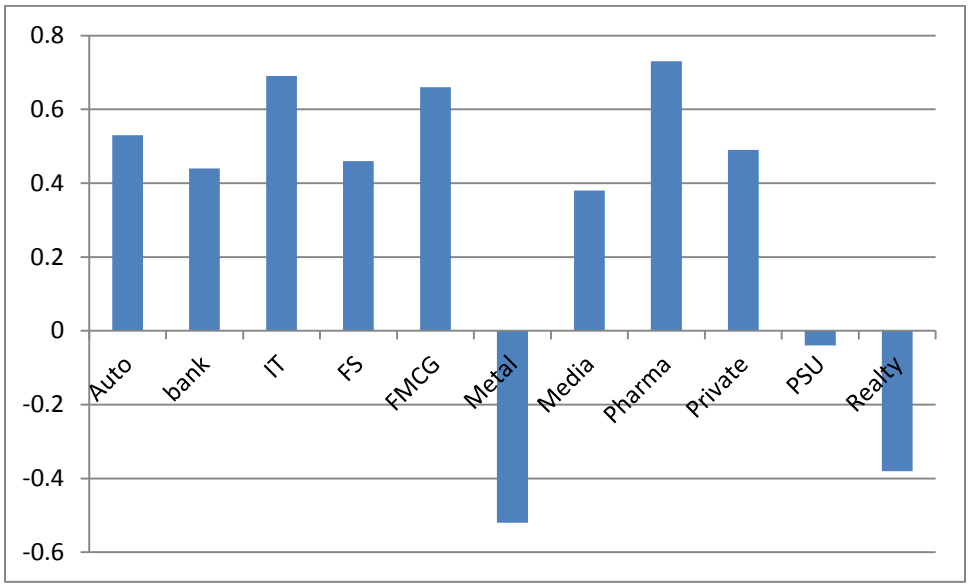
Note: Analysis of co-integration and Granger causality has been attached in the annexure

From the table 5.34, co-integration test reveals that out of 11 industry sectors identified, only Financial service, PSU, realty sectors were found to have long run relationship with exchange rate. Sectors like Bank, Media, Private, Pharma and Realty sectors were found to have short run effect on exchange rate.

The relative volatility is calculated by dividing coefficient of variation of sector index by that of the exchange rate. The share price for firms in PSU and Realty were mostly affected by exchange rate followed by sectors like Auto, financial services, bank and FMCG.

The Correlation between the GBP/INR and the various industry indices is depicted in the Chart 5.7.

Chart 5.7 Correlation between GBP/INR and Sectoral indices



From the chart 5.7, it is found that most of the sectoral indices are positively correlated with GBP/INR (Nifty Pharma=0.73, IT =0.69, FMCG=0.66). Sectors like Metal (-0.52), PSU (-0.04) and Realty(-0.38) responded negatively to the weakening rupee.

Table 5.35 Sectoral indices and YEN/INR

	Exchange rate and INDEX	No of observation	Summary Statistics		Relative variance	Co-integration	Evidence of Causality
			Std dev.	Coeff of variation			
1	Yen/INR	522	0.007	7.90	4.29	No	No evidence of causality
	NIFTY Auto	522	2961.00	1.84			
2	Yen /INR	522	0.007	7.90	3.23	No	YEN/INR to Nifty Bank
	NIFTY Bank	522	5306.36	2.44			
3	Yen /INR	522	0.007	7.90	2.96	No	No evidence of causality
	NIFTY IT	522	2892.87	2.66			
4	Yen /INR	522	0.007	7.90	3.23	No	YEN/INR to Nifty FS
	NIFTY FS	522	2168.36	2.44			
5	Yen /INR	522	0.007	7.90	3.23	Yes	YEN/INR to NIFTY FMCG
	NIFTY FMCG	522	6546.37	2.44			
6	Yen /INR	522	0.007	7.90	1.61	No	YEN/INR to Nifty Metal
	NIFTY Metal	338	539.56	4.88			
7	Yen /INR	522	0.007	7.90	2.66	No	YEN/INR to Nifty Media
	NIFTY Media	522	635.80	2.96			
8	Yen /INR	522	0.007	7.90	3.83	No	YEN/INR to Nifty Pharma
	NIFTY Pharma	522	3358.33	2.06			
9	Yen /INR	522	0.007	7.90	4.15	No	YEN/INR to NIFTY
	NIFTY	522	3379.72	1.90			

	Private						Private
10	Yen /INR	522	0.007	7.90	26.33	Yes	No evidence of causality
	NIFTY PSU	522	12249.61	0.30			
11	Yen /INR	522	0.007	7.90	5.85	Yes	YEN/INR to Nifty Realty
	NIFTY Realty	522	238.36	1.35			

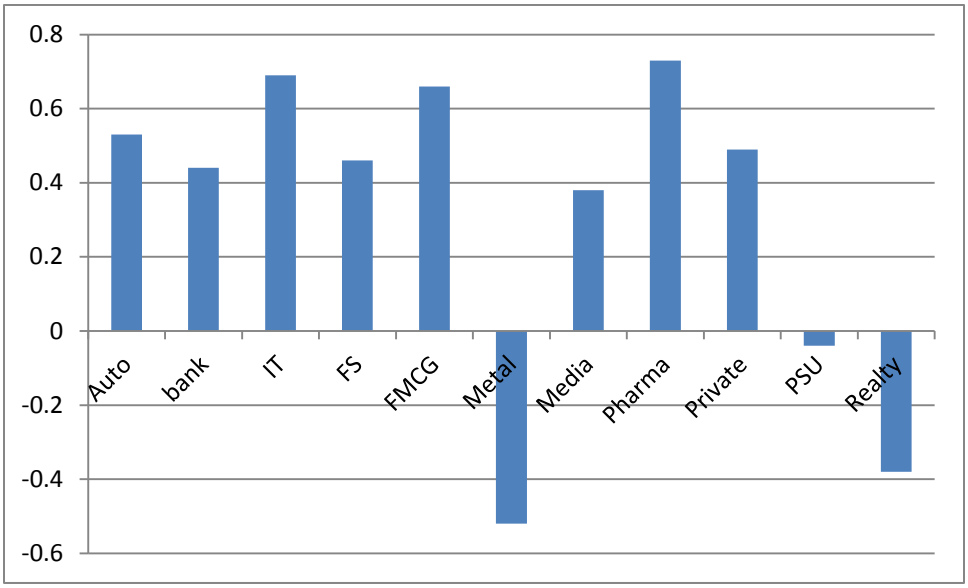
Note: Analysis of co-integration and Granger causality has been attached in the annexure

From the table 5.35, co-integration test reveals that out of 11 industry sectors identified only FMCG, PSU and Realty sectors were found to have long run relationship with exchange rate. Sectors like Bank, Financial services, FMCG, Metal, Media, Pharma, Private and Realty sectors seemed to cause short run effect on exchange rate.

The relative volatility is calculated by dividing coefficient of variation of sector index by that of the exchange rate. The share price for firms in PSU and Realty were mostly affected by exchange rate followed by sectors like Auto, financial services, bank and FMCG.

The Correlation between the Yen/INR and the various industry indices is depicted in the Chart 5.8.

Chart 5.8 Correlation between Yen/INR and Sectoral indices



From the above chart, it is found that most of the sectoral indices are positively correlated with Yen/INR (Nifty Pharma=0.73, IT=0.69, FMCG =0.66). Import intensive sectors like Metal (-0.52), PSU(-0.04) and Realty (-0.38) responded negatively to the weakening rupee.

5.5 VOLATILITY SPILLOVER BETWEEN STOCK MARKET AND FOREIGN EXCHANGE MARKET

This objective explores volatility spillovers between the Indian stock and Foreign exchange markets. The study of volatility spillovers provides useful information into how information is transmitted from foreign exchange market to stock market and vice versa. Also, it determines whether the volatility surprises in one market influences the volatility of return in the other market.

This section includes the data analysis for finding the Volatility spillover effect between Stock Market (Nifty) and Foreign exchange market (USD/INR, EURO/INR, GBP/INR, and YEN/INR) traded in India. The data analysis was done by using Unit root test (ADF & PP), Linear Regression, Autocorrelation, ARCH, GARCH (1,1) and E-GARCH (1,1).

To estimate the volatility of Stock market and Foreign exchange weekly stock market and exchange rate returns were used. The returns were calculated as follows.

$$RS_t = ln(S_t - S_{t-1})$$

$$RE_t = ln(E_t - E_{t-1})$$

Where,

RS_t and RE_t shows the stock price return and exchange rate return.

S_t and S_{t-1} are the stock prices of time period t and t-1.

E_t and E_{t-1} are the exchange rates of time period t and t-1 respectively

(D.K.Malhotra, 2007 Sahadudheen, 2015 and Pradip Kumar, 2017).

The data analysis and interpretation is divided in four sections which are as follows:

- Volatility Spillover of NIFTY and USD/INR
- Volatility Spillover of NIFTY and Euro/INR
- Volatility Spillover of NIFTY and GBP/INR
- Volatility Spillover of NIFTY and Yen/INR

5.5.1 Volatility Spillover of NIFTY and USD/INR

5.5.1.1 Unit root test:

The nature of data used in this study is in time series data. Before applying an econometric model using time series data it is a pre-condition that the series must be stationary. The common test to make time series data to stationary is done by Unit root test. In this study, Augmented Dickey-Fuller (ADF) test and Phillip-Perron (PP) test were used to investigate whether the time series data used in this study is stationary or not.

Hypothesis framework

H_0= Nifty and USD/INR has unit root or is a non-stationary

Table 5.36 Unit root test of NIFTY and USD/INR at level

Variables	Tests	Level	
		With intercept	With trend & intercept
NIFTY	ADF	-13.940 (0.0000)*	-13.961 (0.0000)*
	PP	-22.478 (0.0000)	-22.514 (0.0000)*
USD/INR	ADF	-20.729 (0.0000)*	-20.773 (0.0000)*
	PP	-20.723 (0.0000)*	-20.811 (0.0000)*

* MacKinnon critical values for rejection of hypothesis at 1%, 5% and 10% are -3.480818, -2.883579 and -2.578601 respectively.

From the table 5.36, both the ADF and PP test statistics showed that the null hypothesis of a unit root was rejected. Results indicated that T statistics for the exchange rate and nifty data were found higher than the critical value at 1%, 5% and 10% level of significance. Thus, the results of the exchange rate showed that the first difference series of USD/INR and nifty was stationary. The results of unit root test are consistent with the results of D.K.Malhotra (2007) and Abburi & Stella (2017).

5.5.1.2 Linear Regression Model

In order to find out the model that is best fit to explain the cause and effect relationship between the stock market returns and exchange rates returns, serial correlation test, jarque-bera normality test and ARCH LM test of heteroscedasticity have been applied on the residuals of the regression data. The Table 5.37 presents the regression analysis for nifty (dependent variable) and USD/INR(independent variable).

Table 5.37 Regression Analysis of Nifty as dependent variable

Variable	**Coefficient**	**Std.Error**	**Z-Statistics**	**Probability**
c	0.002	0.001	2.252	0.024**
USD/INR	-1.555	0.101	-15.269	0.000*
R-Squared	0.309	Akaike Information Criterion		-4.551
Adj R-Squared	0.308	Schwarz Criterion		-4.535
F-Statistic	233.152	Hannan-Quinn Criterion		2.115
Prob(F-Stat)	0.000*	**Durbin Watson Statistics**		**1.912**

The regression coefficient explains that the exchange rate (USD/INR) is found to be significant at 1% level of significance which is influencing the stock market returns. The Durbin Watson statistics 1.912 indicates that there is no serial or auto correlation in the time series data.

The table 5.38 presents the regression analysis for USD/INR(dependent variable) and nifty(independent variable).

Table 5.38 Regression Analysis between USD/INR as dependent variable

Variable	**Coefficient**	**Std.Error**	**Z-Statistics**	**Probability**
C	0.001	0.0003	2.893	0.004*
Nifty	-0.199	0.013	-15.269	0.000*
R-Squared	0.309	Akaike Information Criterion		-6.606
Adj R-Squared	0.308	Schwarz Criterion		-6.590
F-Statistic	233.152	Hannan-Quinn Criterion		-6.600
Prob(F-Stat)	0.000*	**Durbin Watson Statistics**		**1.988**

The regression coefficient shows that nifty is found to be significant at 1% level of significance which is influencing the USD/INR returns. The Durbin Watson statistics 1.988 indicates that there is no serial or auto correlation in the time series data.

Before modelling the volatility of time series data, the model should be diagnosed by various estimation diagnostics tests such as Ljung-Box Q2-statistic, Histogram and Jarque-Bera Statistics, Arch LM test of Heteroskedasticity. The above tests have been applied on the residuals taken from the Linear regression analysis.

5.5.1.3 Autocorrelation and Heteroscedasticity of Nifty and USD/INR

Ljung Box Q statistics is done to find out whether time series data are suffering from serial or auto correlation. The result of the analysis is shown in table 5.39.

Hypothesis Framework

H_0= The data are independently distributed or no serial correlation in the time series data

Table 5.39 Ljung-Box Q2-statistic for Nifty and USD/INR

Lags	Nifty and USDINR			USD/INR and Nifty		
	AC	PAC	Q-Stat	AC	PAC	Q-Stat
1	0.338	0.338	59.894*	0.136	0.136	9.714*
2	0.284	0.192	102.25*	0.124	0.107	17.739*
3	0.174	0.037	118.16*	0.061	0.033	19.717*
4	0.118	0.009	125.56*	0.081	0.059	23.215*
5	0.037	-0.046	126.27*	0.007	-0.020	23.241*
6	0.075	0.054	129.24*	0.111	0.100	29.802*
7	0.109	0.088	135.58*	0.021	-0.008	30.046*
8	0.108	0.045	141.76*	0.078	0.054	33.266*
9	0.110	0.032	148.19*	0.074	0.053	36.145*
10	0.122	0.043	156.18*	0.080	0.041	39.577*
11	0.134	0.058	165.76*	-0.053	-0.085	41.091*

Table 5.39 (Continued)

Lags	Nifty and USDINR			USD/INR and Nifty		
	AC	PAC	Q-Stat	AC	PAC	Q-Stat
12	0.102	0.016	171.36*	0.083	0.069	44.753*
13	0.163	0.097	185.36*	0.075	0.065	47.791*
14	0.073	-0.040	188.41*	0.009	-0.035	47.837*
15	0.107	0.037	194.62*	0.027	0.011	48.219*
16	0.153	0.103	207.30*	0.163	0.142	62.519*
17	0.132	0.029	216.67*	0.040	0.004	63.370*
18	0.116	0.016	224.02*	0.030	-0.029	63.858*
19	0.103	-0.001	229.76*	0.104	0.088	69.734*
20	0.113	0.031	236.68*	0.070	0.040	72.432*
21	0.142	0.083	247.60*	0.013	-0.030	72.523*
22	0.238	0.168	278.43*	0.006	-0.056	72.542*
23	0.144	-0.030	289.81*	0.028	0.035	72.959*
24	0.159	0.011	303.73*	-0.003	-0.016	72.964*

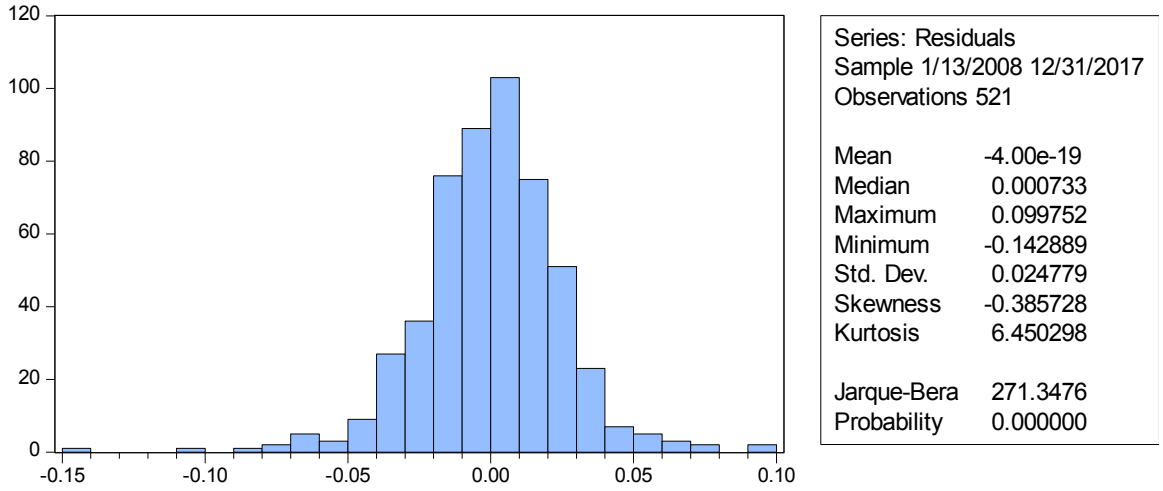
*indicates 1% level of significance

The table 5.39 shows the results of autocorrelation coefficients and Ljung- Box Q statistics for the squared standardized residuals of Nifty and USD/INR return series. The P-value of Q statistics was also found to be significant at 1% level of significance. Thus, both the returns series is auto correlated and exhibited dependencies on its past behavior. Therefore, null hypothesis of no serial correlation in the error terms is accepted.

5.5.1.4 Histogram and Jarque Bera statistics

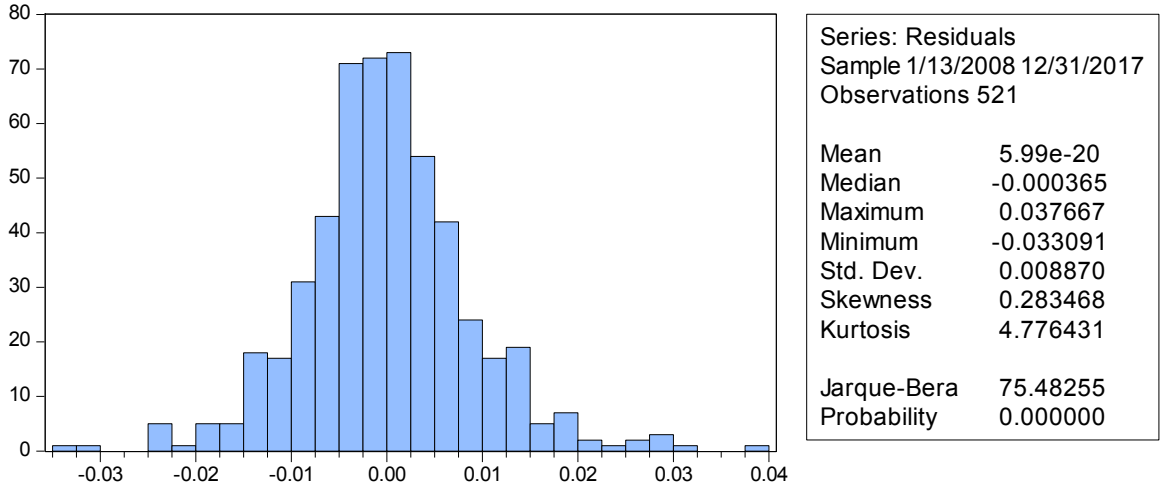
Jarque bera test is applied to find out whether the variables are normally distributed or not.

Chart 5.9 Histogram and Descriptive statistics between Nifty as dependent variable



From the chart 5.9, it is found that the Jarque bera value is 271.34 with the p-value is 0.000. Hence the p-value is less than 1% level of significance. It means that the residuals are not normally distributed. The results of jarque-bera test are consistent with the results of Pradip Kumar (2017) and Abburi & Stella (2017).

Chart 5.10 Histogram and Descriptive statistics between USD/INR as dependent variable



It is observed from the chart 5.10 the Jarque bera value is 75.48 with the p-value is 0.000. Hence the p-value is less than 5% level of significance. It means that the residuals are not normally distributed. The results of jarque-bera test are consistent with the results of Pradip Kumar (2017) and Abburi & Stella (2017).

5.5.1.5 ARCH-LM Test of Heteroscedasticity

The Autoregressive conditional heteroscedasticity Lagrange multiplier test were used to model the observed time series data. The results are presented in the table 5.40

Hypothesis Framework

H_0= There is no ARCH effect in Nifty and USD/INR time series data.

Table 5.40 ARCH-LM Test of Nifty and USD/INR

Dependent Variable: Nifty			
F-Statistic	69.953	Prob.F(1,117)	0.000*
Obs*R-Squared	61.868	Prob.Chi-Square(1)	0.000*
Dependent Variable: USD/INR			
F-Statistic	9.817	Prob.F(1,518)	0.001*
Obs*R-Squared	9.671	Prob.Chi-Square(1)	0.001*

* indicates 1% level of significance

The table 5.40 shows ARCH-LM (Lagrange Multiplier) test and it is found that the null hypothesis of 'No ARCH Effect' is strongly rejected at 5% level in case of all the concerned variables.

The presence of ARCH effects and serial correlation in the USD/INR return series contents the assumptions of ARCH family of models. So it will be appropriate to fit the GARCH models for the return series of USD/INR.

5.5.1.6 GARCH Models of Nifty and USD/INR

The Indian stock market and foreign exchange market volatility modeling or estimation is to be done by Autoregressive conditional Heteroscedasticity (ARCH), Generalized form of ARCH(GARCH) and its variant improved specification of GARCH models such as Exponential GARCH(EGARCH) model were used for analyzing the volatility behavior of both the markets.

The study use GARCH and EGARCH models of order (1, 1) because this order has been found to provide the most parsimonious representation of ARCH class of models.

Hypothesis Framework

H_0= There is no association between stock market return and foreign exchange market return.

Table 5.41 Analysis of GARCH (1,1) Model for Nifty and USD/INR Returns

Coefficients	GARCH(1,1)	
	Nifty → USD/INR	**USD/INR → Nifty**
Ω	$3.88e^{-05}$ (0.052)***	$1.30e^{-06}$ (0.154)
A	0.354 (0.000)*	0.083 (0.000)*
B	0.613 (0.006)*	0.876 (0.000)*
Ψ	0.369 (0.000)*	0.002 (0.004)*
Residual diagnostics		
Q^2(6) Stats p value	1.606 (0.205)	0.068 (0.934)
Jarque-Bera P value	1.122 (0.570)	3.076 (0.214)
LM P value	11.590 (0.128)	0.0287 (0.863)

Note: ω represents variance equation coefficients of constant; α represents ARCH coefficient; β represents GARCH coefficient; Ψ represent spillover effect.

Table 5.41 shows the estimation results of GARCH (1, 1) model for return series of Nifty and USD/INR. From the table 5.41, it is found that all four coefficients, ω(constant), α(ARCH), β(GARCH) and Ψ(spillover) in both the panel is found to be significant at 5%. The sum of coefficients of ARCH term and GARCH term i.e., α and → β (persistent coefficients) in GARCH model for Nifty USD/INR (0.967) and USD/INR → Nifty(0.959) is very close to 1, which indicates that the volatility shock of both the markets is quite persistent.

The volatility spillover parameter (Ψ) is significant for both the markets which conclude that there also exist bidirectional volatility spillovers between stock market and foreign exchange

market. Thus, both Nifty and USD/INR move in tandem with each other and there is a long run relationship between these two markets.

The robustness of GARCH(1,1) model was analyzed with three main diagnostics such as LB (Ljung-Box) Q statistics of the residuals, Jarque-Bera test for normality and ARCH-LM (Lagrange Multiplier) test. The p value of Q-stat for the squared standardized residuals is found to be greater than 0.05. It implies that GARCH models were successfully modeled. The results of ARCH-LM test stat accepted the null hypothesis i.e., there were no ARCH effects remaining in the residuals of the models as the p value is found to be greater than 0.05. It also implies that the models were fitted properly.

The above results are supported by D.K.Malhotra (2007) and Gagan Deep Sharma and Namish Mishra (2016).

5.5.1.7 Asymmetric GARCH model

The asymmetry effect also known as “Leverage effect” refers to the characteristics of time series that have many crucial impact on volatility when negative shocks happen than positive shocks. In order to overcome the limitation or weakness of GARCH model a number of extensions of the GARCH model have been developed to capture the asymmetric effects on time series data. Among the most popular asymmetric models, Exponential GARCH (EGARCH) model are used for this study.

Table 5.42 Analysis of EGARCH (1,1) Model for Nifty and USD/INR Returns

Coefficients	EGARCH(1,1)	
	Nifty → USD/INR	USD/INR→ Nifty
Ω	-0.286 (0.006)*	-0.268 (0.000)*
A	0.057 (0.011)*	0.067 (0.006)*
B	0.970 (0.000)*	0.977 (0.000)*
Φ	-0.081 (0.000)*	-0.080 (0.000)*
Ψ	8.838 (0.168)	4.678 (0.044)*
Residual diagnostics		
Q^2(6) Stats p value	0.0002 (0.988)	0.4786 (0.489)
Jarque-Bera P value	7.106 (0.286)	1.937 (0.379)
LM	1.083 (0.298)	0.001 (0.964)

Note: ω represents variance equation coefficients of constant; α represents ARCH coefficient; β represents GARCH coefficient; ϕ represent EGARCH coefficient; Ψ represent spillover effect.

The table 5.42 presents the estimated results of E GARCH(1,1) model to test the asymmetric behavior of Indian stock market and foreign exchange market. The significance of EGARCH term (ϕ) for both the panel shows the presence of asymmetric behavior of volatility.

The negative coefficient of EGARCH term(ϕ) for both the panel i.e.,(Nifty → USD/INR and USD/INR→ Nifty) which suggests that the negative shocks (bad news) create more effect on volatility than that of positive shocks (good news).

The robustness of EGARCH(1,1) model was analyzed with three main diagnostics such as LB (Ljung-Box) Q statistics of the residuals, Jarque-Bera test for normality and ARCH-LM (Lagrange Multiplier) test. The p value of Q-stat for the squared standardized residuals is found to be greater than 0.05. It implies that EGARCH models were successfully modeled. The results

of ARCH-LM test stat accepted the null hypothesis i.e., there were no ARCH effects remaining in the residuals of the models as the p value is found to be greater than 0.05. It also implies that the models were fitted properly.

Thus, these results of significant bidirectional volatility spillover reveals that there is an information flow between both Indian Stock Market and Foreign Exchange Market and both these markets are integrated with each other. These finding helps investors to predict the behavior of one market by using the information of other market.

The above results are supported by D.K.Malhotra (2007) and Gagan Deep Sharma and Namish Mishra (2016).

5.5.2 Volatility Spillover of NIFTY and EURO/INR

5.5.2.1 Unit root test:

The nature of data used in this study is in time series data. Before applying an econometric model using time series data it is a pre-condition that the series must be stationary. The common test to make time series data to stationary is done by Unit root test. In this study, Augmented Dickey-Fuller (ADF) test and Phillip-Perron (PP) test were used to investigate whether the time series data used in this study is stationary or not.

Hypothesis framework

H_0= Nifty and Euro/INR has unit root or is a non-stationary

Table 5.43 Unit root test of NIFTY and EURO/INR at level

Variables	Tests	Level	
		With intercept	With trend & intercept
NIFTY	ADF	-13.940 (0.0000)*	-13.961 (0.0000)*
	PP	-22.478 (0.0000)	-22.514 (0.0000)*

Table 5.43 (Continued)

Variables	Tests	Level	
		With intercept	With trend & intercept
EURO/INR	ADF	-23.103 (0.0000)*	-23.097 (0.0000)*
	PP	-23.106 (0.0000)*	-23.100 (0.0000)*

* MacKinnon critical values for rejection of hypothesis at 1%, 5% and 10% are -3.480818, -2.883579 and -2.578601 respectively.

From the table 5.43, both the ADF and PP test statistics showed that the null hypothesis of a unit root was rejected. Results indicated that T statistics for the exchange rate and nifty data were found higher than the critical value at 1%, 5% and 10% level of significance. Thus, the results of the exchange rate showed that the first difference series of EURO/INR and nifty was stationary. The results of unit root test are consistent with the results of Sahadudheen(2015).

5.5.2.2 Linear Regression Model

In order to find out the model that is best fit to explain the cause and effect relationship between the stock market returns and exchange rates returns, serial correlation test, jarque-bera normality test and ARCH LM test of heteroscedasticity have been applied on the residuals of the regression data. Table 5.44 shows the regression analysis for Nifty(dependent variable) and Euro/INR(independent variable).

Table 5.44 Regression Analysis between Nifty as dependent variable

Variable	**Coefficient**	**Std.Error**	**Z-Statistics**	**Probability**
C	0.0001	0.0001	0.902	0.367
EURO/INR	-0.191	0.043	-4.417	0.0000*
R-Squared	0.036	Akaike Information Criterion		-8.479
Adj R-Squared	0.034	Schwarz Criterion		-8.462
F-Statistic	19.509	Hannan-Quinn Criterion		-8.472
Prob(F-Stat)	0.0000*	**Durbin Watson Statistics**		**1.954**

The regression coefficient explains that the exchange rate (Euro/INR) is found to be significant at 1% level of significance which is influencing the stock market returns. The Durbin Watson statistics 1.954 indicates that there is no serial or auto correlation in the time series data.

Table 5.45 shows the regression analysis for Euro/INR (dependent variable) and nifty(independent variable).

Table 5.45 Regression Analysis between Euro/INR as dependent variable

Variable	**Coefficient**	**Std.Error**	**Z-Statistics**	**Probability**
C	0.0001	0.0001	0.971	0.318
EURO/INR	-0.189	0.0428	-4.417	0.0000*
R-Squared	0.036	Akaike Information Criterion		-8.490
Adj R-Squared	0.034	Schwarz Criterion		-8.476
F-Statistic	19.509	Hannan-Quinn Criterion		-8.485
Prob(F-Stat)	0.0000*	**Durbin Watson Statistics**		**1.943**

The regression coefficient indicates that the nifty is found to be significant at 1% level of significance which is influencing the Euro/INR returns. The Durbin Watson statistics 1.943 indicates that there is no serial or auto correlation in the time series data.

Before modelling the volatility of time series data, the model should be diagnosed by various estimation diagnostics tests such as Ljung-Box Q2-statistic, Histogram and Jarque-Bera Statistics, Arch LM test of Heteroskedasticity. The above tests have been applied on the residuals taken from the Linear regression analysis.

5.5.2.3 Autocorrelation and Heteroscedasticity of Nifty and EURO/INR

Ljung Box Q statistics is done to find out whether time series data are suffering from serial or auto correlation. The results of the analysis are reported in Table 5.46

Hypothesis Framework

H_0= The data are independently distributed or no serial correlation in the time series data

Table 5.46 Ljung-Box Q2-statistic for Nifty and Euro/INR

Lags	Nifty and EURO/INR			EURO/INR and Nifty		
	AC	PAC	Q-Stat	AC	PAC	Q-Stat
1	0.317	0.317	52.578*	0.161	0.161	13.667*
2	0.361	0.289	120.83*	0.099	0.075	13.839*
3	0.218	0.055	145.87*	0.144	0.121	29.708*
4	0.119	-0.053	153.38*	0.006	-0.042	29.725*
5	0.036	-0.073	154.06*	0.039	0.025	30.529*
6	0.077	0.063	157.15*	0.034	0.011	31.129*
7	0.182	0.208	174.74*	0.064	0.062	33.292*
8	0.159	0.082	188.17*	0.107	0.083	39.379*
9	0.154	-0.017	200.72*	0.072	0.035	42.140*
10	0.28	-0.035	209.44*	0.060	0.019	44.066*
11	0.140	0.058	219.84*	0.166	0.134	58.764*
12	0.060	0.008	221.79*	0.058	0.002	60.563*
13	0.161	0.133	235.68*	0.081	0.047	64.044*
14	0.083	-0.023	239.39*	0.064	0.003	66.218*
15	0.083	-0.059	243.07*	-0.018	-0.045	66.386*
16	0.120	0.051	250.77*	0.053	0.030	67.879*
17	0.129	0.087	259.72*	0.064	0.044	70.115*
18	0.040	-0.059	260.61*	0.066	0.038	72.447*
19	0.111	0.038	267.31*	0.032	-0.030	72.998*
20	0.090	0.006	271.71*	0.073	0.039	75.904*
21	0.123	0.067	279.89*	0.055	0.012	77.556*
22	0.150	0.101	292.17*	0.015	-0.026	77.675*
23	0.120	-0.013	300.03*	0.031	0.007	78.204*
24	0.107	-0.062	306.36*	0.044	0.013	79.256*

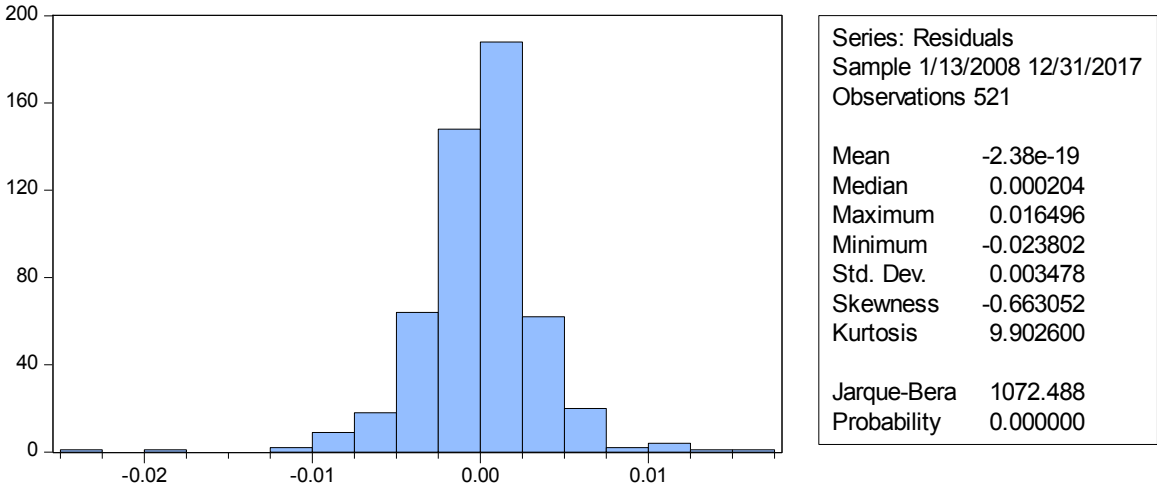
*indicates 1% level of significance

The table 5.46 shows the results of autocorrelation coefficients and Ljung- Box Q^2 statistics for the squared standardized residuals of Nifty and USD/INR return series. The P-value of Q statistics was also found to be significant at 1% level. Thus, both the returns series is auto correlated and exhibited dependencies on its past behavior. Therefore, null hypothesis of no serial correlation in the error terms is accepted.

5.5.2.4 Histogram and Jarque Bera statistics

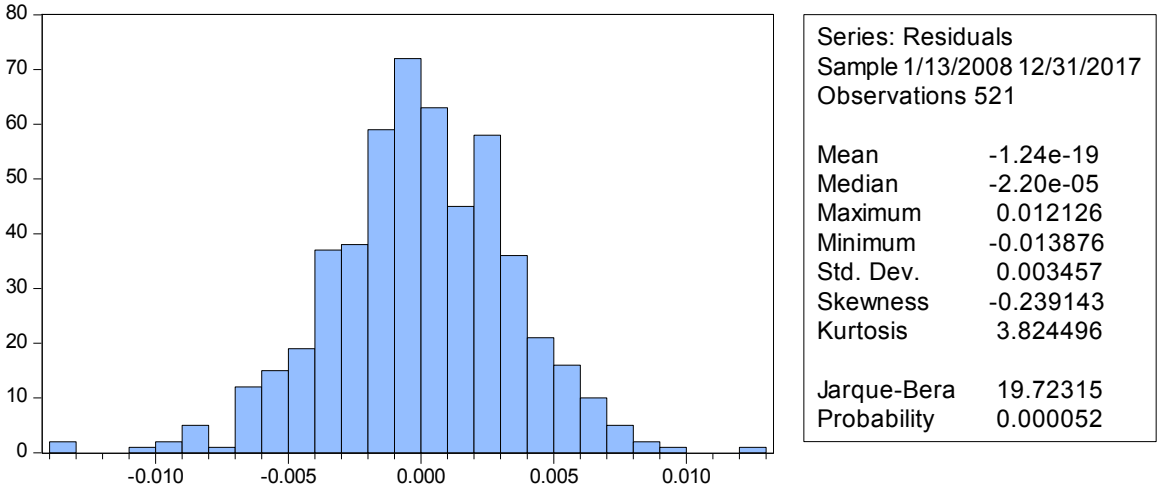
Jarque bera test is applied to find out whether the variables are normally distributed or not.

Chart 5.11 Histogram and Descriptive statistics between Nifty and Euro/INR



It is observed from the chart 5.11, that the Jarque bera value is 1072.48 with the p-value is 0.011. Hence the p-value is less than 5% level of significance. It means that the residuals are not normally distributed. The above results are in consistent with of Pradip Kumar (2017) and Abburi & Stella (2017).

Chart 5.12 Histogram and Descriptive statistics between Euro/INR and Nifty



From the chart 5.12, it is found that the Jarque bera value is 19.723 with the p-value is 0.000. Hence the p-value is less than 5% level of significance. It means that the residuals are not normally distributed. The above results are in consistent with of Pradip Kumar (2017) and Abburi & Stella (2017).

5.5.2.5 ARCH-LM Test of Heteroscedasticity

The Autoregressive conditional heteroscedasticity Lagrange multiplier test were used to model the observed time series data. The results are presented in the table 5.47.

Hypothesis Framework

H_0= There is no ARCH effect in the time series data.

Table 5.47 ARCH-LM Test of Nifty and EURO/INR

Dependent Variable: Nifty			
F-Statistic	58.598	Prob.F(1,117)	0.000*
Obs*R-Squared	52.846	Prob.Chi-Square(1)	0.000*
Dependent Variable: EURO/INR			
F-Statistic	13.883	Prob.F(1,117)	0.000*
Obs*R-Squared	13.573	Prob.Chi-Square(1)	0.000*

* indicates 1% level of significance

The table 5.47 shows ARCH-LM (Lagrange Multiplier) test and it is found that the null hypothesis of 'No ARCH Effect' is strongly rejected at 5% level in case of all the concerned variables.

The presence of ARCH effects and serial correlation in the Nifty and Euro/INR return series contents the assumptions of ARCH family of models. So it will be appropriate to fit the GARCH models for the return series of Euro/INR.

5.5.2.6 GARCH Models of Nifty and EURO/INR

The Indian stock market and foreign exchange market volatility modeling or estimation is to be done by Autoregressive conditional Heteroscedasticity (ARCH), Generalized form of ARCH(GARCH) and its variant improved specification of GARCH models such as Exponential GARCH(EGARCH) model were used for analyzing the volatility behavior of both the markets.

The study use GARCH and EGARCH models of order (1, 1) because this order has been found to provide the most parsimonious representation of ARCH class of models.

Hypothesis Framework

H_0= There is no association between stock market return and foreign exchange market return.

Table 5.48 Analysis of GARCH (1,1) Model for Nifty and EURO/INR Returns

Coefficients	GARCH(1,1)	
	Nifty → EURO/INR	**EURO/INR →Nifty**
ω	$-9.24e^{-08}$ (0.065)***	$4.58e^{-07}$ (0.123)
α	0.049 (0.000)*	0.094 (0.000)*
β	0.924 (0.000)*	0.874 (0.000)*
Ψ	0.012 (0.000)*	-0.003 (0.502)

Table 5.48(Continued)

Residual diagnostics		
Q^2(6) Stats	0.077 (0.780)	0.023 (0.878)
Jarque-Bera	5.916 (0.976)	1.082 (0.581)
LM	0.231 (0.630)	14.819 (0.881)

Note: ω represents variance equation coefficients of constant; α represents ARCH coefficient; β represents GARCH coefficient; Ψ represent spillover effect.

Table 5.48 shows the estimation results of GARCH (1, 1) model for return series of Nifty and EURO/INR. From the above table, it is found that ω (constant) for Euro/INR → NIFTY is significant. The α (ARCH effect) is found to be significant which indicated that both the market evidenced the presence of volatility clustering in GARCH (1,1) model. The sum of coefficients of ARCH term and GARCH term i.e., α and β (persistent coefficients) in GARCH model for Nifty → Euro/INR is 0.973 and Euro/INR → Nifty(0.968) is very close to 1, which indicates that the volatility shock of both the markets is quite persistent.

The volatility spillover parameter (Ψ) is found to be significant for Nifty → Euro/INR at 1% level of significance. This indicates that the volatility changes in Euro/INR exchange rate have spillover effects on the nifty returns. However, the spillover effects are not significant for Euro/INR →Nifty.

The robustness of GARCH(1,1) model was analyzed with three main diagnostics such as LB (Ljung-Box) Q statistics of the residuals, Jarque-Bera test for normality and ARCH-LM (Lagrange Multiplier) test. The p value of Q-stat for the squared standardized residuals is found to be greater than 0.05. It implies that GARCH models were successfully modeled. The results of ARCH-LM test stat accepted the null hypothesis i.e., there were no ARCH effects remaining in the residuals of the models as the p value is found to be greater than 0.05. It also implies that the models were fitted properly. The above results are supported by Sahadudheen(2015) and Gagan Deep Sharma & Namisha Mishra(2016).

5.5.2.7 Asymmetric GARCH model

The asymmetry effect also known as "Leverage effect" refers to the characteristics of time series that have many crucial impacts on volatility when negative shocks happen than positive shocks. In order to overcome the limitation or weakness of GARCH model a number of extensions of the GARCH model have been developed to capture the asymmetric effects on time series data. Among the most popular asymmetric models, Exponential GARCH (EGARCH) model are used for this study.

Table 5.49 Analysis of EGARCH (1,1) Model for Nifty and EURO/INR Returns

Coefficients	**EGARCH(1,1)**	
	Nifty → EURO/INR	**EURO/INR → Nifty**
ω	-0.267 (0.000)*	-5.964 (0.007)*
α	0.053 (0.040)**	0.351 (0.000)*
β	0.983 (0.000)*	0.502 (0.009)*
ϕ	-0.046 (0.018)**	0.032 (0.557)
Ψ	1151.06 (0.003)*	1658.74 (0.105)
Residual diagnostics		
Q^2(6) Stats p value	0.856 (0.784)	0.186 (0.666)
Jarque-Bera	0.948 (0.622)	0.900 (0.637)
LM	0.128 (0.719)	0.922 (0.337)

Note: ω represents variance equation coefficients of constant; α represents ARCH coefficient; β represents GARCH coefficient; ϕ represent EGARCH coefficient; Ψ represent spillover effect.

The table 5.49 presents the estimated results of E GARCH(1,1) model to test the asymmetric behavior of Indian stock market and foreign exchange market. All the coefficients

presented in the table are statistically significant as the p value is less than 0.05. The EGARCH term (ϕ) for Nifty→Euro/INR is significant at 5% level of significance which shows the presence of asymmetric behavior of volatility. The negative coefficient of Nifty →Euro/INR suggests that the negative shocks (bad news) create more effect on volatility than that of positive shocks (good news).

The robustness of EGARCH(1,1) model was analyzed with three main diagnostics such as LB (Ljung-Box) Q statistics of the residuals, Jarque-Bera test for normality and ARCH-LM (Lagrange Multiplier) test. The p value of Q-stat for the squared standardized residuals is found to be greater than 0.05. It implies that EGARCH models were successfully modeled. The results of ARCH-LM test stat accepted the null hypothesis i.e., there were no ARCH effects remaining in the residuals of the models as the p value is found to be greater than 0.05. It also implies that the models were fitted properly.

Thus, these results helps financial managers to obtain more insights in the management of their portfolio affected by these two markets(stock price and exchange rate). This should be particularly essential to domestic as well as international investors for hedging purpose and diversifying their portfolio.

The above results are supported by Sahadudheen(2015) and Gagan Deep Sharma & Namisha Mishra(2016).

5.5.3 Volatility Spillover of GBP/INR

5.5.3.1 Unit root test:

The nature of data used in this study is in time series data. Before applying an econometric model using time series data it is a pre-condition that the series must be stationary. The common test to make time series data to stationary is done by Unit root test. In this study, Augmented Dickey-Fuller (ADF) test and Phillip-Perron (PP) test were used to investigate whether the time series data used in this study is stationary or not.

Hypothesis framework

H_0= Nifty and GBP/INR has unit root or is a non-stationary

Table 5.50 Unit root test of NIFTY and GBP/INR at level

Variables	Tests	Level	
		With intercept	With trend & intercept
NIFTY	ADF	-13.940 (0.0000)*	-13.961 (0.0000)*
	PP	-22.478 (0.0000)	-22.514 (0.0000)*
GBP/INR	ADF	-22.339 (0.0000)*	-22.324 (0.0000)*
	PP	-22.334 (0.0000)*	-22.319 (0.0000)*

* MacKinnon critical values for rejection of hypothesis at 1%, 5% and 10% are -3.480818, -2.883579 and -2.578601 respectively.

From the table 5.50, both the ADF and PP test statistics showed that the null hypothesis of a unit root was rejected. Results indicated that T statistics for the exchange rate and nifty data were found higher than the critical value at 1%, 5% and 10% level of significance. Thus, the results of the exchange rate showed that the first difference series of GBP/INR and nifty was stationary. The results of unit root test are consistent with the results of D.K.Malhotra (2007) and Abburi & Stella (2017).

5.5.3.2 Linear Regression Model

In order to find out the model that is best fit to explain the cause and effect relationship between the stock market returns and exchange rates returns, serial correlation test, jarque-bera normality test and ARCH LM test of heteroscedasticity have been applied on the residuals of the regression data.

The table 5.51 shows the regression analysis for Nifty (dependent variable) and GBP/INR (independent variable).

Table 5.51 Regression Analysis between NIFTY as dependent variable

Variable	Coefficient	Std.Error	Z-Statistics	Probability
C	0.000	0.000	0.791	0.429*
GBP/INR	-0.158	0.045	-3.459	0.0006*
R-Squared	0.022	Akaike Information Criterion		-8.464
Adj R-Squared	0.020	Schwarz Criterion		-8.448
F-Statistic	11.967	Hannan-Quinn Criterion		-8.458
Prob(F-Stat)	0.0000*	**Durbin Watson Statistics**		**1.978**

The regression coefficient explain that the exchange rate (GBP/INR) is found to be significant at 1% level of significance which is influencing the stock market returns. The Durbin Watson statistics 1.978 indicates that there is no serial or auto correlation in the time series data.

The table 5.52 shows the regression analysis for GBP/INR (dependent variable) and nifty(independent variable).

Table 5.52 Regression Analysis between GBP/INR as dependent variable

Variable	Coefficient	Std.Error	Z-Statistics	Probability
C	$6.62e^{-05}$	0.0001	0.454	0.649
GBP/INR	-0.142	0.0411	-3.459	0.000*
R-Squared	0.022	Akaike Information Criterion		-8.569
Adj R-Squared	0.020	Schwarz Criterion		-8.553
F-Statistic	11.967	Hannan-Quinn Criterion		-8.563
Prob(F-Stat)	0.0005*	**Durbin Watson Statistics**		**1.994**

The regression coefficient indicates that the nifty is found to be significant at 1% level of significance which is influencing the stock market returns. The Durbin Watson statistics 1.994 indicates that there is no serial or auto correlation in the time series data.

Before modelling the volatility of time series data, the model should be diagnosed by various estimation diagnostics tests such as Ljung-Box Q2-statistic, Histogram and Jarque-Bera Statistics, Arch LM test of Heteroskedasticity. The above tests have been applied on the residuals taken from the Linear regression analysis.

5.5.3.3 Autocorrelation and Heteroscedasticity of Nifty and GBP/INR

Ljung Box Q statistics is done to find out whether time series data are suffering from serial or auto correlation. The results of the analysis are reported in table 5.53.

Hypothesis Framework

H_0= The data are independently distributed or no serial correlation in the time series data

Table 5.53 Ljung-Box Q2-statistic for Nifty and GBP/INR

Table

Lags	Nifty and GBP/INR			GBP/INR and Nifty		
	AC	PAC	Q-Stat	AC	PAC	Q-Stat
1	0.285	0.285	42.700*	0.202	0.202	21.455*
2	0.360	0.303	110.76*	0.304	0.275	70.096*
3	0.218	0.072	135.84*	0.266	0.187	107.38*
4	0.105	-0.070	141.68*	0.083	-0.065	111.01*
5	0.067	-0.037	144.04*	0.158	0.039	124.23*
6	0.065	0.040	146.29*	0.186	0.132	142.57*
7	0.159	0.167	150.71*	0.065	-0.019	144.82*
8	0.160	0.104	173.26*	0.170	0.063	160.23*
9	0.152	0.009	185.62*	0.091	0.005	164.62*
10	0.097	-0.066	190.68*	0.084	0.015	168.42*
11	0.108	0.018	196.88*	0.284	0.231	211.53*
12	0.061	0.026	198.88*	0.107	0.010	217.68*
13	0.172	0.173	214.74*	0.217	0.073	243.00*
14	0.117	0.037	222.07*	0.190	0.032	262.41*
15	0.086	-0.092	226.08*	0.023	-0.099	262.71*

5.53(Continued)

16	0.157	0.037	239.42*	0.077	-0.060	265.90*
17	0.126	0.081	248.04*	0.106	0.047	272.03*
18	0.048	-0.036	249.27*	0.057	0.050	273.79*
19	0.093	0.027	253.92*	0.082	-0.044	277.43*
20	0.086	0.017	257.99*	0.067	-0.002	279.88*
21	0.125	0.055	266.54*	-0.012	-0.061	279.97*
22	0.148	0.081	278.54*	-0.022	-0.128	280.24*
23	0.105	-0.015	284.54*	0.007	0.009	280.26*
24	0.129	-0.012	293.65*	-0.007	-0.031	280.29*

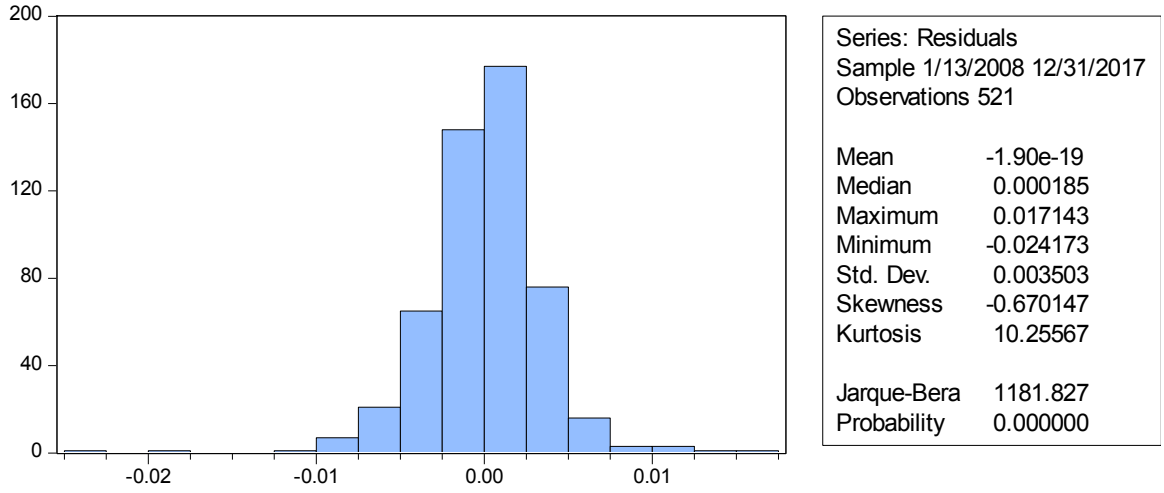
*indicates significance at 1% level

The table 5.53 shows the results of autocorrelation coefficients and Ljung- Box Q statistics for the squared standardized residuals of Nifty and GBP/INR return series. The Q^2 statistics of the squared residuals indicated that the independent and identically distributed hypothesis was rejected for exchange rate series. The P-value of Q statistics was also found to be significant at 1% level. Thus, both the returns series is auto correlated and exhibited dependencies on its past behavior.

5.5.3.4 Histogram and Jarque Bera statistics

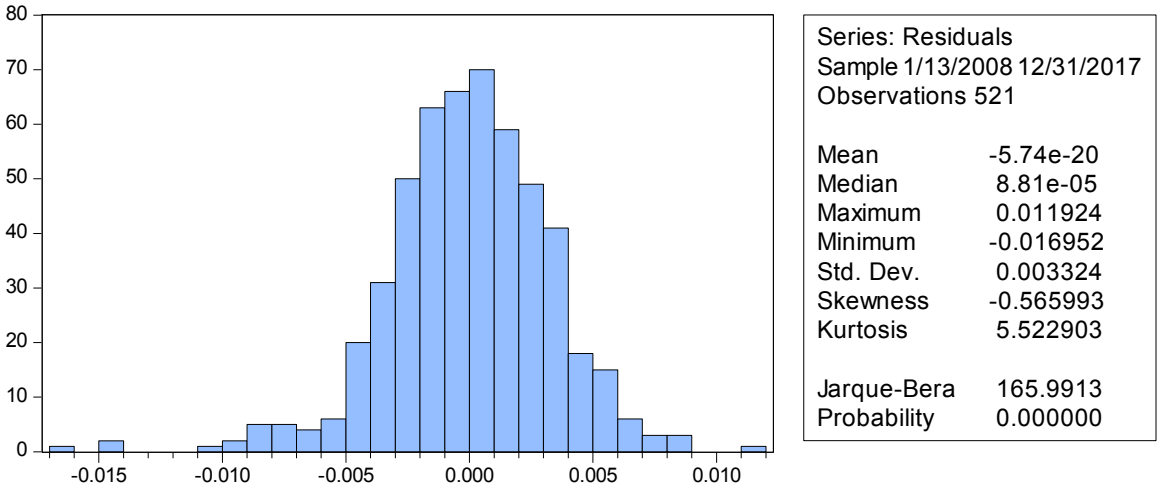
Jarque bera test is applied to find out whether the variables are normally distributed or not.

Chart 5.13 Histogram and Descriptive statistics between Nifty and GBP/INR



It is observed from the chart 5.13 that the Jarque bera value is 1181.82 with the p-value is 0.000. Hence the p-value is less than 5% level of significance. It means that the residuals are not normally distributed. The above results are in consistent with Pradip Kumar (2017) and Abburi & Stella (2017).

Chart 5.14 Histogram and Descriptive statistics between GBP/INR and Nifty



It is observed from the chart 5.14 that the Jarque bera value is 165.99 with the p-value is 0.000. Hence the p-value is less than 1% level of significance. It means that the residuals are not normally distributed. The above results are in consistent with Pradip Kumar (2017) and Abburi & Stella (2017).

5.5.3.5 ARCH-LM Test of Heteroscedasticity

The Autoregressive conditional heteroscedasticity Lagrange multiplier test were used to model the observed time series data. The results are presented in the table 5.54.

Hypothesis Framework

H_0= There is no ARCH effect in the time series data.

Table 5.54 ARCH-LM Test of NIFTY and GBP/INR

Dependent Variable: Nifty			
F-Statistic	46.436	Prob.F(1,117)	0.000*
Obs*R-Squared	42.780	Prob.Chi-Square(1)	0.000*
Dependent Variable: GBP/INR			
F-Statistic	22.129	Prob.F(1,117)	0.000*
Obs*R-Squared	21.304	Prob.Chi-Square(1)	0.000*

* indicates 1% level of significance

The table 5.54 shows ARCH-LM (Lagrange Multiplier) test and it is found that the null hypothesis of 'No ARCH Effect' is strongly rejected at 5% level in case of all the concerned variables.

The presence of ARCH effects and serial correlation in the Nifty and GBP/INR return series contents the assumptions of ARCH family of models. So it will be appropriate to fit the GARCH models for the return series of GBP/INR.

5.5.3.6 GARCH Models of Nifty and GBP/INR

The Indian stock market and foreign exchange market volatility modeling or estimation is to be done by Autoregressive conditional Heteroscedasticity (ARCH), Generalized form of ARCH(GARCH) and its variant improved specification of GARCH models such as Exponential GARCH(EGARCH) model were used for analyzing the volatility behavior of both the markets.

The study use GARCH and EGARCH models of order (1, 1) because this order has been found to provide the most parsimonious representation of ARCH class of models.

Hypothesis Framework

H_0= There is no association between stock market return and foreign exchange market return.

Table 5.55 Analysis of GARCH (1,1) Model for Nifty and GBP/INR Returns

Coefficients	GARCH(1,1)	
	Nifty → GBP/INR	GBP/INR →Nifty
ω	$6.98e^{-08}$ (0.428)	$2.12e^{-06}$ (0.018)
α	0.089 (0.0000)*	0.0865 (0.0416)**
β	0.897 (0.111)	0.831 (0.102)
Ψ	0.002 (0.601)	0.0416 (0.056)
Residual diagnostics		
Q^2(6) Stats p value	0.0239 (0.877)	0.601 (0.438)
Jarque-Bera	0.440 (0.802)	2.514 (0.284)
LM	0.041 (0.839)	0.224 (0.636)

Note: ω represents variance equation coefficients of constant; α represents ARCH coefficient; β represents GARCH coefficient; Ψ represent spillover effect.

Table 5.55 shows the estimation results of GARCH (1, 1) model for return series of Nifty and GBP/INR. The α (ARCH effect) is found to be significant for both the panel(Nifty → GBP/INR and GBP/INR →Nifty) which evidenced the presence of volatility clustering in the GARCH (1,1) model.

The sum of coefficients of ARCH term and GARCH term i.e., α and β (persistent coefficients) in GARCH model for Nifty → GBP/INR(0.986)and GBP/INR → Nifty(0.917) is very close to 1, which indicates that the volatility shock of both the markets is quite persistent. The volatility spillover parameter (Ψ) is found to be not significant

for both the markets which concludes that no causality between stock market and foreign exchange market. Volatility in Nifty does not affect the volatility in GBP/INR and vice versa. Thus, it is helpful for the investors as they can adopt portfolio investment as both the market function independently.

The robustness of GARCH(1,1) model was analyzed with three main diagnostics such as LB (Ljung-Box) Q statistics of the residuals, Jarque-Bera test for normality and ARCH-LM (Lagrange Multiplier) test. The p value of Q-stat for the squared standardized residuals is found to be greater than 0.05. It implies that GARCH models were successfully modeled. The results of ARCH-LM test stat accepted the null hypothesis i.e., there were no ARCH effects remaining in the residuals of the models as the p value is found to be greater than 0.05. It also implies that the models were fitted properly. The above results are supported by Gagan Deep Sharma & Namisha Mishra(2016).

5.5.3.7 Asymmetric GARCH model

The asymmetry effect also known as “Leverage effect” refers to the characteristics of time series that have many crucial impact on volatility when negative shocks happen than positive shocks. In order to overcome the limitation or weakness of GARCH model a number of extensions of the GARCH model have been developed to capture the asymmetric effects on time series data. Among the most popular asymmetric models, Exponential GARCH (EGARCH) model are used for this study.

Table 5.56 Analysis of EGARCH (1,1) Model for Nifty and GBP/INR Returns

Coefficients	EGARCH(1,1)	
	Nifty → GBP/INR	GBP/INR → Nifty
ω	-0.333 (0.004)*	-1.691 (0.017)**
α	0.0869 (0.004)*	0.0858 (0.001)*
β	0.978 (0.424)	0.861 (0.114)
ϕ	-0.086 (0.124)	0.017 (0.576)
Ψ	529.98 (0.122)	1492.30 (0.776)
Residual diagnostics		
Q^2(6) Stats p value	0.0308 (0.861)	0.132 (0.716)
Jarque-Bera	0.429 (0.526)	0.325 (0.158)
LM	0.990 (0.320)	1.523 (0.217)

Note: ω represents variance equation coefficients of constant; α represents ARCH coefficient; β represents GARCH coefficient; ϕ represent EGARCH coefficient; Ψ represent spillover effect.

The table 5.56 presents the estimated results of E GARCH(1,1) model to test the asymmetric behavior of Indian stock market and foreign exchange market. The leverage effect represented by the symbol ϕ is found to be negative for both the panel and not significant. The E-GRACH variance indicates that the stock market and foreign exchange market is symmetric in nature with insignificant leverage effects.

The robustness of EGARCH(1,1) model was analyzed with three main diagnostics such as LB (Ljung-Box) Q statistics of the residuals, Jarque-Bera test for normality and ARCH-LM (Lagrange Multiplier) test. The p value of Q-stat for the squared standardized residuals is found

to be greater than 0.05. It implies that EGARCH models were successfully modeled. The results of ARCH-LM test stat accepted the null hypothesis i.e., there were no ARCH effects remaining in the residuals of the models as the p value is found to be greater than 0.05. It also implies that the models were fitted properly. The above results are supported by Gagan Deep Sharma & Namisha Mishra(2016).

Thus, these results clearly indicate that both the markets function independently and investors can adopt portfolio diversification.

5.5.4 Volatility Spillover of Nifty and YEN/INR

5.5.4.1 Unit root test:

The nature of data used in this study is in time series data. Before applying an econometric model using time series data it is a pre-condition that the series must be stationary. The common test to make time series data to stationary is done by Unit root test. In this study, Augmented Dickey-Fuller (ADF) test and Phillip-Perron (PP) test were used to investigate whether the time series data used in this study is stationary or not.

Hypothesis framework

H_0= Nifty and YEN/INR has unit root or is a non-stationary

Table 5.57 Unit root test of NIFTY and YEN/INR at level

Variables	Tests	Level	
		With intercept	With trend & intercept
NIFTY	ADF	-13.940 (0.0000)*	-13.961 (0.0000)*
	PP	-22.478 (0.0000)	-22.514 (0.0000)*
YEN/INR	ADF	-23.449 (0.000)*	-23.572 (0.000)*
	PP	-23.440 (0.000)*	-23.571 (0.000)*

* MacKinnon critical values for rejection of hypothesis at 1%, 5% and 10% are -3.480818, -2.883579 and -2.578601 respectively.

From the table 5.57, both the ADF and PP test statistics showed that the null hypothesis of a unit root was rejected. Results indicated that T statistics for the exchange rate and nifty data were found higher than the critical value at 1%, 5% and 10% level of significance. Thus, the results of the exchange rate showed that the first difference series of YEN/INR and nifty was stationary. The results of unit root test are consistent with the results of Pradeep Kumar Mitra(2017) and Abburi & Stella (2017).

5.5.4.2 Linear Regression Model

In order to find out the model that is best fit to explain the cause and effect relationship between the stock market returns and exchange rates returns, serial correlation test, jarque-bera normality test and ARCH LM test of heteroscedasticity have been applied on the residuals of the regression data. The table 5.58 shows the regression analysis for Nifty (dependent variable) and YEN/INR (independent variable).

Table 5.58 Regression Analysis between Nifty as dependent variable

Variable	**Coefficient**	**Std.Error**	**Z-Statistics**	**Probability**
c	0.000	0.001	1.591	0.112
YEN/INR	-0.417	0.028	-14.895	0.0001*
R-Squared	0.299	Akaike Information Criterion		-8.798
Adj R-Squared	0.298	Schwarz Criterion		-8.781
F-Statistic	221.890	Hannan-Quinn Criterion		-8.791
Prob(F-Stat)	0.0000*	**Durbin Watson Statistics**		**1.931**

The regression coefficient explain that the exchange rate (YEN/INR) is found to be significant at 1% level of significance which is influencing the stock market returns. The Durbin Watson statistics 1.931 indicates that there is no serial or auto correlation in the time series data.

The table 5.59 shows the regression analysis for YEN/INR (dependent variable) and nifty(independent variable).

Table 5.59 Regression Analysis between YEN/INR as dependent variable

Variable	Coefficient	Std.Error	Z-Statistics	Probability
C	0.000	0.000	1.792	0.073
YEN/INR	-0.717	0.048	-14.895	0.000*
R-Squared	0.299	Akaike Information Criterion		-8.256
Adj R-Squared	0.298	Schwarz Criterion		-8.293
F-Statistic	221.890	Hannan-Quinn Criterion		-8.249
Prob(F-Stat)	0.0000*	**Durbin Watson Statistics**		**1.901**

The regression coefficient indicates that the nifty is found to be significant at 1% level of significance which is influencing the stock market returns. The Durbin Watson statistics 1.901 indicates that there is no serial or auto correlation in the time series data.

Before modelling the volatility of time series data, the model should be diagnosed by various estimation diagnostics tests such as Ljung-Box Q2-statistic, Histogram and Jarque-Bera Statistics, Arch LM test of Heteroskedasticity. The above tests have been applied on the residuals taken from the Linear regression analysis.

5.5.4.3 Autocorrelation test

Ljung Box Q statistics is done to find out whether time series data are suffering from serial or auto correlation. The results of the analysis are reported in table 5.60

Hypothesis Framework

H_0= The data are independently distributed or no serial correlation in the time series data

Table 5.60 Ljung-Box Q2-statistic for Nifty and YEN/INR

Table

Lags	Nifty and YEN/INR			YEN/INR and Nifty		
	AC	PAC	Q-Stat	AC	PAC	Q-Stat
1	0.394	0.394	81.450*	0.109	0.109	6.196*
2	0.308	0.181	131.41*	0.133	0.122	15.434*
3	0.213	0.051	155.20*	0.052	0.026	16.842*
4	0.195	0.071	175.31*	0.001	-0.023	16.842*

5.60(Continued)

Lags	Nifty and YEN/INR			YEN/INR and Nifty		
	AC		Q-Stat	PAC	PAC	Q-Stat
6	0.138	0.058	192.88*	0.070	0.049	29.154*
7	0.224	0.161	219..47*	0.037	-0.006	29.892*
8	0.358	0.255	287.57*	0.157	0.137	42.985*
9	0.267	0.029	325.59*	0.015	-0.014	43.098*
10	0.242	0.021	356.58*	0.084	0.037	46.892*
11	0.273	0.109	396.58*	0.071	0.045	49.602*
12	0.194	-0.008	416.82*	0.136	0.121	59.453*
13	0.214	0.096	441.32*	0.087	0.015	63.511*
14	0.143	-0.019	452.25*	0.016	-0.035	63.642*
15	0.170	0.003	467.90*	-0.010	-0.037	63.700*
16	0.212	0.054	492.18*	0.043	0.021	64.719*
17	0.188	0.008	511.34*	0.069	0.045	67.326*
18	0.099	-0.105	516.66*	0.050	-0.004	68.663*
19	0.215	0.095	541.77*	0.011	-0.024	68.731*
20	0.172	0.009	557.84*	-0.007	-0.043	68.761*
21	0.230	0.075	586.59*	0.088	0.084	73.003*
22	0.228	0.089	614.88*	0.057	0.029	74.789*
23	0.160	-0.073	628.88*	0.059	0.019	76.724*
24	0.148	-0.045	640.94*	0.106	0.067	82.834*

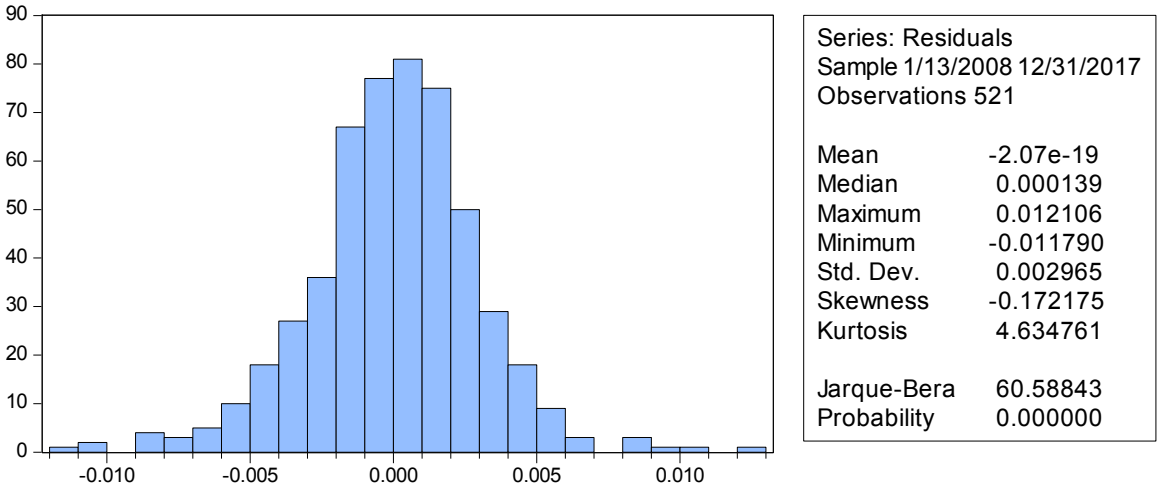
*indicates significance at 1% level

The table 5.60 shows the results of autocorrelation coefficients and Ljung- Box Q statistics for the squared standardized residuals of Nifty and YEN/INR return series. The Q^2 statistics of the squared residuals indicated that the independent and identically distributed hypothesis was rejected for exchange rate series. The P-value of Q statistics was also found to be significant at 1% level. Thus, both the returns series is auto correlated and exhibited dependencies on its past behavior.

5.5.4.4 Histogram and Jarque Bera statistics

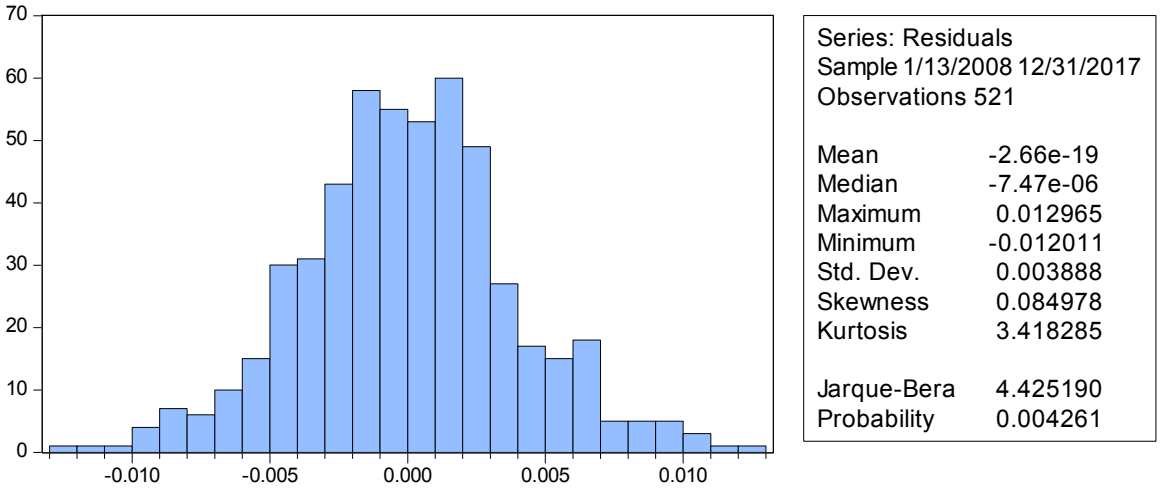
Jarque bera test is applied to find out whether the variables are normally distributed or not.

Chart 5.15 Histogram and Descriptive statistics between Nifty and YEN/INR



From the chart 5.15, it is found that the Jarque bera value is 60.588 with the p-value is 0.000. Hence the p-value is less than 5% level of significance. It means that the residuals are not normally distributed. The results are consistent with the results of Pradeep Kumar Mitra(2017) and Abburi & Stella (2017).

Chart 5.16 Histogram and Descriptive statistics between YEN/INR and Nifty



From the chart 5.16, it is found that the Jarque bera value is 4.425 with the p-value is 0.0042. Hence the p-value is less than 5% level of significance. It means that the residuals are not normally distributed. The results are consistent with the results of Pradeep Kumar Mitra(2017) and Abburi & Stella (2017).

5.5.4.5 ARCH-LM Test of Heteroscedasticity

The Autoregressive conditional heteroscedasticity Lagrange multiplier test were used to model the observed time series data. The results are presented in the table 5.61.

Hypothesis Framework

H_0= There is no ARCH effect in the time series data.

Table 5.61 ARCH-LM Test of NIFTY and YEN/INR

Dependent Variable: Nifty			
F-Statistic	96.895	Prob.F(1,117)	0.000*
Obs*R-Squared	81.942	Prob.Chi-Square(1)	0.000*
Dependent Variable: YEN/INR			
F-Statistic	6.203	Prob.F(1,117)	0.013*
Obs*R-Squared	6.153	Prob.Chi-Square(1)	0.013*

* indicates 1% level of significance

The table 5.61 shows ARCH-LM (Lagrange Multiplier) test and it is found that the null hypothesis of 'No ARCH Effect' is strongly rejected at 5% level in case of all the concerned variables.

The presence of ARCH effects and serial correlation in the Nifty and YEN/INR return series contents the assumptions of ARCH family of models. So it will be appropriate to fit the GARCH models for the return series of YEN/INR.

5.5.4.6 GARCH Models of Nifty and YEN/INR

The Indian stock market and foreign exchange market volatility modeling or estimation is to be done by Autoregressive conditional Heteroscedasticity (ARCH), Generalized form of

ARCH(GARCH) and its variant improved specification of GARCH models such as Exponential GARCH(EGARCH) model were used for analyzing the volatility behavior of both the markets.

The study use GARCH and EGARCH models of order (1, 1) because this order has been found to provide the most parsimonious representation of ARCH class of models.

Hypothesis Framework

H_0= There is no association between stock market return and foreign exchange market return.

Table 5.62 Analysis of GARCH (1,1) Model for Nifty and YEN/INR Returns

Coefficients	GARCH(1,1)	
	Nifty → YEN/INR	**YEN/INR→ Nifty**
Ω	$7.96e^{-08}$ (0.339)	$1.24e^{-06}$ (0.090)***
A	0.091 (0.000)*	0.124 (0.001)*
B	0.882 (0.0000)*	0.784 (0.000)*
Ψ	0.001 (0.497)	0.046 (0.061)***
Residual diagnostics		
Q^2(6) Stats	0.00098 (0.921)	0.0045 (0.947)
Jarque-Bera	0.098 (0.950)	1.930 (0.380)
LM	0.044 (0.832)	1.889 (0.168)

Note: ω represents variance equation coefficients of constant; α represents ARCH coefficient; β represents GARCH coefficient; Ψ represent spillover effect.

Table 5.62 shows the estimation results of GARCH (1, 1) model for return series of Nifty and YEN/INR. The α (ARCH effect) and β (GARCH effect) is found to be significant for Nifty → YEN/INR which evidenced the presence of volatility clustering in GARCH(1,1) model.

The sum of coefficients of ARCH term and GARCH term i.e., α and β (persistent coefficients) in GARCH model for Nifty → YEN/INR(0.973)and YEN/INR→ Nifty(0.908) is very close to 1, which indicates that the volatility shock of both the markets is quite persistent. The volatility spillover parameter (Ψ) is found to be significant for Yen/INR →Nifty at 5% level of significance. This indicates that the volatility changes in nifty returns have spillover effects on the Yen/INR. However, the spillover effects are not significant for Nifty →Yen/INR.

The robustness of GARCH(1,1) model was analyzed with three main diagnostics such as LB (Ljung-Box) Q statistics of the residuals, Jarque-Bera test for normality and ARCH-LM (Lagrange Multiplier) test. The p value of Q-stat for the squared standardized residuals is found to be greater than 0.05. It implies that GARCH models were successfully modeled. The results of ARCH-LM test stat accepted the null hypothesis i.e., there were no ARCH effects remaining in the residuals of the models as the p value is found to be greater than 0.05. It also implies that the models were fitted properly. The results are consistent with the results of Abburi & Stella(2017).

5.5.4.7 Asymmetric GARCH model

The asymmetry effect also known as "Leverage effect" refers to the characteristics of time series that have many crucial impacts on volatility when negative shocks happen than positive shocks. In order to overcome the limitation or weakness of GARCH model a number of extensions of the GARCH model have been developed to capture the asymmetric effects on time series data. Among the most popular asymmetric models, Exponential GARCH (EGARCH) model are used for this study.

Table 5.63 Analysis of EGARCH (1,1) Model for Nifty and YEN/INR Returns

Coefficients	EGARCH(1,1)	
	Nifty → YEN/INR	YEN/INR → Nifty
Ω	-0.259 (0.007)*	-0.655 (0.039)**
A	0.080 (0.004)*	0.0207 (0.000)*
B	0.984 (0.000)*	0.955 (0.000)*
Φ	-0.076 (0.000)*	0.018 (0.469)
Ψ	157.59 (0.356)	247.267 (0.594)
Residual diagnostics		
Q^2(6) Stats	0.051 (0.821)	0.9754 (0.323)
Jarque-Bera	0.492 (0.781)	2.353 (0.308)
LM	0.599 (0.439)	1.322 (0.250)

Note: ω represents variance equation coefficients of constant; α represents ARCH coefficient; β represents GARCH coefficient; ϕ represent EGARCH coefficient; Ψ represent spillover effect.

The table 5.63 presents the estimated results of E GARCH(1,1) model to test the asymmetric behavior of Indian stock market and foreign exchange market. All the coefficients presented in the table are statistically significant as the p value is less than 0.05. The EGARCH term (ϕ) for Nifty →Yen/INR is significant at 1% level of significance which shows the presence of asymmetric behavior of volatility. The negative coefficient of suggests Nifty →Yen/INR that the negative shocks (bad news) create more effect on volatility than that of positive shocks (good news).

The robustness of EGARCH(1,1) model was analyzed with three main diagnostics such as LB (Ljung-Box) Q statistics of the residuals, Jarque-Bera test for normality and ARCH-LM (Lagrange Multiplier) test. The p value of Q-stat for the squared standardized residuals is found

to be greater than 0.05. It implies that EGARCH models were successfully modeled. The results of ARCH-LM test stat accepted the null hypothesis i.e., there were no ARCH effects remaining in the residuals of the models as the p value is found to be greater than 0.05. It also implies that the models were fitted properly. The results are consistent with the results of Abburi & Stella(2017).

Thus, these results helps financial managers to obtain more insights in the management of their portfolio affected by these two markets(stock price and exchange rate). This should be particularly essential to domestic as well as international investors for hedging purpose and diversifying their portfolio.