Chapter VI

Macroeconomic Determinants Affecting Exchange Rate

CHAPTER VI

MACROECONOMIC DETERMINANTS AFFECTING EXCHANGE RATE

6.1 INTRODUCTION

The integrated economic growth of the country eventually depends on the macroeconomic determinants. In general, the macroeconomic variables are interconnected and inconsistent in nature. Any fluctuations in one variable, subsequently causes the trend of other economic variable. It affects the nation's economic development. Currency value is one of the determining aspects for the economic growth. Exchange rate fluctuations of Indian rupee against other currencies may have a positive or negative impact on the economy. Thus, it is necessary to investigate the macroeconomic determinants that influences or affects the fluctuations in exchange rate. In India, currency depreciation is one of the major issues for the investors, policy makers, etc., and there by affects the international operational activities. This chapter analyses the macroeconomic determinants affecting the exchange rate of Indian rupee against the currencies. The four major currencies, namely, exchange rate of Indian rupee against US dollar, Pound sterling, Yen and Euro were taken as dependent variables. The selective variables that affect the movements of exchange rate are taken for the study. The Macroeconomic variables, such as, Foreign Exchange Reserves, FDI, Interest rate, Inflation rate, IIP, Money supply, Gold prices and Crude oil prices have been taken and analysed by applying unit root test, Vector Autoregression, Autoregressive Distribution Lag Model.

Descriptive statistics of exchange rate

The descriptive statistics of monthly data of exchange rate of Indian rupee against major currencies namely USD, GBP, EURO and YEN for the period 2007-08 to 2016-17 are given below

Table 6.1

Descriptive statistics of Exchange rate

	USD	GBP	EURO	YEN
Mean	53.573	84.942	54.533	68.992
Median	52.240	82.860	54.815	68.885
Maximum	68.230	102.970	70.680	85.110
Minimum	39.370	67.220	33.200	54.710
Std.Dev.	9.181	10.418	9.157	7.643
Skewness	0.127	0.263	-0.677	0.265
Kurtosis	1.613	1.838	3.053	2.581
Jarque-Bera	9.937	8.129	9.183	2.283
Probability	0.000	0.017	0.010	0.319
Observations	120	120	120	120

Source: Computed

Table 6.1 depicts the descriptive statistics of the exchange rate of Indian rupee. The summary statistics has shown that the mean exchange rate of an Indian rupee against Pound Sterling stood at Rs.84.94, it is found to be the highest among other currencies, followed by the currencies, namely, Yen Rs.68.99, Euro Rs.54.53 and USD Rs.53.57. The Standard deviation of USD, GBP, EURO and YEN are 9.18, 10.42, 7.64 and 9.12 respectively. It is also evidenced that exchange rate of GBP has shown a large extent variation during the study period. The value of exchange rate of GBP has ranged from Rs.67.22 – Rs.102.97. The Skewness value for the exchange rate of USD (0.127), GBP (0.263) and YEN (0.265) are positively skewed and while exchange rate of EURO is negatively skewed with the value of - 0.677. The value of kurtosis of all the currencies have resulted a playkurtic of normal distribution. The normality test of Jarque – Bera test of the exchange rate indicate that the p-values are significant at 1 per cent and also found that the currencies are not normally distributed.

Descriptive statistics of the Macroeconomic Determinants

The descriptive statistics of eight Macroeconomic determinants, such as, Foreign Exchange Reserves, Foreign direct Investment, Inflation rate, Interest rate, Crude oil prices, Gold prices, Index of Industrial Production and Money Supply for the period of ten years from 2007-08 to 2016-17 are given in table 6.2

Table 6.2

Descriptive statistics of the Macroeconomic Determinants

	Foreign exchange reserves	FDI	Interest rate	Inflation rate	Crude oil prices	Gold prices	IIP	Money supply
Mean	16460.06	2584.330	8.299	8.275	82.023	22655.94	166.021	1160.405
Median	15589.55	2244.284	8.680	8.350	82.595	26206.83	166.850	1283.635
Maximum	24725.10	6177.070	12.210	16.200	132.471	31672.83	205.300	1919.945
Minimum	8440.010	705.000	4.420	1.900	28.078	8707.420	128.202	477.405
Std.Dev.	4491.830	1248.055	1.712	2.883	26.728	7301.208	16.352	397.224
Skewness	0.465	0.965	-0.559	0.233	-0.205	-0.533	-0.185	-0.261
Kurtosis	2.126	3.173	2.956	2.925	1.758	1.776	2.428	1.698
Jarque-Bera	8.159	18.765	6.277	1.116	8.546	13.171	2.321	9.832
Probability	0.016	0.000	0.043	0.572	0.014	0.001	0.313	0.007
Observations	120	120	120	120	120	120	120	120

Source : Computed.

Table 6.2 describes the summary statistics of the Macroeconomic determinants for the study period from 2007-08 to 2016-17. The mean value of Gold prices (Rs.22655.94) are found to be higher followed by Foreign Exchange Reserves (16460.06), FDI (Rs.2584.33), Money supply (Rs.1160.40), IIP (Rs.166.02), Crude oil prices (Rs.82.02), Interest rate were at (8.299 per cent) and the least mean value is found for inflation rate (8.275 per cent). The standard deviation of all the macroeconomic variables have shown large extent of variation. It is found that among the macroeconomic

determinants, gold prices have shown a large extent variation during the study period and the value of Gold Prices has ranged from Rs.8,707.42 – Rs.31,672.83 respectively. Among the macroeconomic determinants, the values of Foreign exchange reserves, FDI and Inflation rate are positively skewed, while the other variables, such as, Interest rate, Gold prices, Crude oil prices, Money Supply, IIP are found to be negatively skewed. The kurtosis values of all the macroeconomic determinants have shown a positive values resulting a playkurtic of normal distribution. The test of normality, namely, Jarque – Bera test has shown higher values for all the currencies which indicates that the data is not normally distributed.

Before proceeding, the analysis of the macroeconomic determinants affecting the exchange rate fluctuations, it is essential to check the stationarity for the variables taken for the study. In General, there will be a presence of non stationarity in the variables of time series data. If the non stationary data variables are used in the study then the result will be spurious. The assumption of stationarity has to be proven for the exchange rate and macroeconomic determinants taken for the study by applying unit root test.

6.2 MACROECONOMIC DETERMINANTS AFFECTING EXCHANGE RATE

Unit root test

Unit root test is a test of stationarity of the variables used in the study. The most common test, namely, unit root test – Augmented dickey fuller test (ADF) is used to confirm the property of stationarity in the data. If the "t" statistic value has the more negative values then the null hypothesis is rejected and have unit root at some level of confidence.

The table 6.3 and 6.4 depicts the unit root test for the exchange rate and Macroeconomic determinants.

Unit-root tests for Foreign Currency Exchange rates

Augmented Dickey Fuller test (ADF) has been done to test the stationarity for the currency exchange rates (US dollar, Pound, Euro and Yen). The null hypotheses have been framed to prove the assumption. The test results are given in table 6.3

H_0 : Foreign currency exchange rate has unit root test.

H_1 : Foreign currency exchange rate does not have a unit root test.

Table 6.3

Unit-root tests for Foreign Currency Exchange rates

Currency	Variable Name	State	ADF test (t-value)	Prob.	Sig.
USD	X1	Level	-0.976677	0.7599	Ns
	D(X1)	1st difference	-8.328800	0.000	**
GBP	X2	Level	-1.141323	0.6977	Ns
	D(X2)	1st difference	-9.175229	0.0000	**
YEN	X3	Level	-2.478957	0.1232	Ns
	D(X3)	1st difference	-8.003065	0.0000	**
EURO	X4	Level	1.726470	0.4154	Ns
	D(X4)	1st difference	-9.328793	0.0000	**

Ns – Not Significant, ** - Significant at 1 per cent level.

Table 6.3 reveals the ADF test results of the currency exchange rates, which has shown that all the currency exchange rates are non-stationary at levels. To make it stationary the first difference has been done. The results of first difference shows that all the currencies exchange rate are stationary and significant at 1 per cent level. Hence, the null hypothesis is rejected and the alternative hypothesis is accepted.

Unit -root tests for Macroeconomic determinants

The unit root test - Augmented Dickey Fuller test (ADF) has been done to test the stationarity for the macroeconomic determinants – foreign exchange reserves, FDI, interest rate, inflation rate, crude oil prices, IIP, gold prices and money supply. The null hypotheses have been framed to prove the assumption. Table 6.4 presents the unit root test results of macroeconomic determinants.

H_0 : Macroeconomic determinants has a unit root test

H_1 : Macroeconomic determinants does not have a unit root test

Table 6.4

Unit-root tests for Macroeconomic determinants

	Variable Name	Level of difference	ADF test (t-value)	Prob.	Sig.
Foreign Exchange Reserves	X5	Level	-0.669379	0.8493	Ns
	D(X5)	1st difference	-10.66078	0.0000	**
FDI	X6	Level	-4.561719	0.0003	**
	D(X6)	1st difference	-17.97512	0.0000	**
Interest Rate	X7	Level	-2.505173	0.1168	Ns
	D(X7)	1st difference	-7.868738	0.0000	**
Inflation Rate	X8	Level	-1.785247	0.3862	Ns
	D(X8)	1st difference	-9.056249	0.0000	**
Crude oil prices	X9	Level	-2.245166	0.1917	Ns
	D(X9)	1st difference	-6.327603	0.0000	**
Gold Price	X10	Level	-1.710149	0.4236	Ns
	D(X10)	1st difference	-9.806477	0.0000	**
IIP	X11	Level	-1.184543	0.6791	Ns
	D(X11)	1st difference	-4.65848	0.0002	**
Money Supply	X15	Level	2.045312	0.9999	Ns
	D(X15)	1st difference	-8.579221	0.0000	**

Ns- Not significant ** - Significant at 1 per cent level.

It is inferred from the table 6.4 that all the Macroeconomic indicators are non-stationary at levels, except the variable FDI (X6) which shows stationarity at level itself and other variables have shown Stationarity at first differences. Thus the stationarity variables are significant at 1 per cent level. Hence, the null hypothesis is rejected and the alternative hypothesis is accepted.

The variables at different lags and differences are given as follows,

D(X1) is First Difference of X1

D(X1(-1)) is lag one of D(X1)

D(X1,2) is Second Difference of X1

D(X1(-1),2) is lag one of D(X1,2)

VECTOR AUTOREGRESSION

Vector Autoregression is an econometric tool used to find the relationship between linear interdependencies of the variables over a period of time. It is a generalization of univariate Autoregression (AR explained as, the variable X at time t is decided by the previous values of x say at t-1, t-2 etc.) where more than one endogenous variable is involved. Each dependent variable is explained as function of its own lagged values plus the lagged values of other variables. Each equation in the VAR can be estimated as OLS regression equation. However, all the assumptions of OLS must be satisfied in this VAR model. Lag denotes the time period of the variable. The residual diagnostic test, namely, heteroscedasticity test, Serial correlation test and normality test of error variances are applied. The VAR modeling for Foreign exchange rate was conducted separately for each currency with the macroeconomic determinants. The macroeconomic indicators considered for the study are given below:

- Foreign exchange reserves (X5)
- FDI (X6)
- Interest rate (X7)
- Inflation rate (X8)
- Crude oil prices (X9)
- Gold price (X10)
- IIP (Index of Industrial Production) (X11)
- Money supply (X12).

- D(X1) is First Difference of X1
- D(X1(-1)) is lag one of D(X1).
- D(X1,2) is Second Difference of X1
- D(X1(-1),2) is lag one of D(X1,2) and so on.

The results of VAR are given below. Each column in the table corresponds to an equation in the AR. For each right-hand side variable, the estimated coefficient, its standard error, and the *t*-statistic are given. For example, the coefficient for D(X1(-1)) in the DX1 equation is 0.081017.

The first part of the additional output presents the standard OLS regression statistics for each equation. The results are computed separately for each equation using the appropriate residuals and are displayed in the corresponding column. The numbers at the very bottom of the table are the summary statistics for the VAR system as a whole. The estimated VAR model given below can be used for forecasting purposes also.

6.3 MACROECONOMIC DETERMINANTS AFFECTING EXCHANGE RATE OF INR/USD

To identify the macroeconomic determinants influencing the movement of exchange rate of Indian rupee against USD – Vector Autoregression and ARDL model have been analysed.

Vector Autoregression Estimates for Exchange Rate of an Indian rupee against USD

Vector Autoregression have been applied for exchange rate of Indian rupee against USD and presented in table 6.5 and the null hypothesis have been framed to identify which macroeconomic determinants that affect the exchange rate of Indian rupee against USD

H_0: The variables, namely, Foreign exchange reserves, FDI, Interest rate, Inflation rate Gold price, Crude oil prices, Money supply and Index of Industrial Production do not significantly affect the exchange rate of INR/USD

Table 6.5

Vector Autoregression Estimates for Exchange rate of an Indian rupee against US dollar

		D(X1)	D(X5)	X6	D(X7)	D(X8)	D(X9)	D(X10)	D(X11)	D(X12)
D(X1(-1))	Co.effi	0.081017	-81.43012	16.93636	0.008208	-0.035429	-0.615477	-29.04597	0.332904	-170.6568
	Std.err	0.10513	40.2964	130.683	0.05784	0.10658	0.66272	93.0936	0.93078	95.4975
	t-stat	0.77066	-2.02078*	0.12960	0.14190	-0.33241	-0.92871	-0.31201	0.35766	-1.78703
D(X5(-1))	Co.effi	0.001207	0.132119	0.512564	9.28E-05	-0.000296	0.000470	0.212824	-0.000175	-0.111476
	Std.err	0.00027	0.10337	0.33523	0.00015	0.00027	0.00170	0.23881	0.00239	0.24497
	t-stat	4.47441**	1.27813	1.52899	0.62558	-1.08269	0.27673	0.89120	-0.07335	-0.45506
X6(-1)	Co.effi	5.60E-05	0.029409	0.405906	1.54E-05	1.19E-06	0.000180	-0.060223	-0.000565	-0.063174
	Std.err	7.0E-05	0.02696	0.08743	3.9E-05	7.1E-05	0.00044	0.06228	0.00062	0.06389
	t-stat	0.79673	1.09088	4.64262**	0.39713	0.01665	0.40623	-0.96694	-0.90712	-0.98880
D(X7(-1))	Co.effi	0.155487	-84.19131	34.34279	0.360055	0.014886	-1.709487	-117.4198	0.699997	167.5133
	Std.err	0.17759	68.0734	220.766	0.09772	0.18005	1.11955	157.265	1.57239	161.325
	t-stat	0.87552	-1.23677	0.15556	3.68469**	0.08267	-1.52695	-0.74664	0.44518	1.03836
D(X8(-1))	Co.effi	0.167637	48.74398	-27.19088	0.005677	0.185076	-0.736958	-51.34469	-0.636066	23.70335
	Std.err	0.09434	36.1617	117.274	0.05191	0.09565	0.59472	83.5414	0.83528	85.6986
	t-stat	1.77694	1.34795	-0.23186	0.10936	1.93499	-1.23917	-0.61460	-0.76150	0.27659
D(X9(-1))	Co.effi	-0.022902	-0.313164	5.669783	0.010324	0.008664	0.443825	4.683761	-0.029762	-9.575182
	Std.err	0.01447	5.54488	17.9823	0.00796	0.01467	0.09119	12.8099	0.12808	13.1407
	t-stat	-1.58322	-0.05648	0.31530	1.29702	0.59078	4.86694**	0.36564	-0.23237	-0.72867

		D(X1)	D(X5)	X6	D(X7)	D(X8)	D(X9)	D(X10)	D(X11)	D(X12)
D(X10 (-1))	Co.effi	-0.000298	-0.075130	-0.129982	-3.31E-05	2.87E-05	0.001163	0.118721	0.000976	0.124573
	Std.err	0.00012	0.04485	0.14545	6.4E-05	0.00012	0.00074	0.10362	0.00104	0.10629
	t-stat	-2.54834*	-1.67511	-0.89364	-0.51390	0.24195	1.57672	1.14579	0.94194	1.17200
D(X11 (-1))	Co.effi	-0.015059	1.467802	-4.246579	-0.012495	-0.007201	0.062435	-0.302899	-0.563110	3.711678
	Std.err	0.00940	3.60307	11.6850	0.00517	0.00953	0.05926	8.32390	0.08323	8.53884
	t-stat	-1.60207	0.40737	-0.36342	-2.41586*	-0.75556	1.05364	-0.03639	-6.76609**	0.43468
D(X12 (-1))	Co.effi	-7.38E-05	-0.013812	-0.001615	-6.64E-05	-0.000162	0.000197	-0.128271	-0.002874	0.062816
	Std.err	0.00012	0.04610	0.14950	6.6E-05	0.00012	0.00076	0.10650	0.00106	0.10925
	t-stat	-0.61375	-0.29960	-0.01080	-1.00313	-1.32684	0.25935	-1.20441	-2.69903**	0.57497
C	Co.effi	0.010832	75.90916	1498.720	-0.011331	0.139274	-0.940666	373.8500	4.270347	952.5879
	Std.err	0.22267	85.3514	276.799	0.12252	0.22575	1.40370	197.181	1.97148	202.272
	t-stat	0.04865	0.88937	5.41447	-0.09249	0.61693	-0.67013	1.89598	2.16606	4.70944
R^2		0.276400	0.136430	0.189476	0.170873	0.073431	0.285129	0.046038	0.348419	0.066609
Adj.R^2		0.216100	0.064466	0.121932	0.101780	-0.003783	0.225556	-0.033459	0.294121	-0.011173
F-statistic		4.583747**	1.895807	2.805238**	2.473061*	0.951007	4.786242**	0.579119	6.416754**	0.856352
Log likelihood		-155.6507	-857.6147	-996.4435	-85.15451	-157.2741	-372.9104	-956.4213	-412.9918	-959.4295
AIC		2.807640	14.70533	17.05836	1.612788	2.835154	6.490007	16.38002	7.169353	16.43101
SC		3.042443	14.94014	17.29317	1.847592	3.069958	6.724811	16.61483	7.404157	16.66581
Mean dep		0.212627	131.4184	2596.242	-0.032881	-0.033898	-0.120558	168.4750	0.580011	802.5431
S.D.dep		1.068386	374.8697	1254.874	0.549172	0.957224	6.776095	823.9810	9.968446	854.5211

Source: Computed, **Significant at the 0.01 level.* Significant at the 0.05 level.

The table 6.5 reveals that exchange rate (D(X1)) is taken as a dependent variable, and the independent variables, namely, Foreign exchange reserves (D(X5)) and Gold prices (D(X10)) at lag1 have a significant effect at 1 per cent level and 5 per cent level. Foreign exchange reserves D(X5) is taken as a dependent variable, it is found that the variable USD (D(X1)) at lag 1 is significant at 5 per cent level. With respect to Foreign Direct Investment (X6) as a dependent variable, it is found to be significant at its own lag 1 at 1 per cent level. Interest rate (D(X7)) is taken as a dependent variable, it is found to be significant at its own lag 1 itself at 1 per cent level and also with the variable Index of Industrial Production (D(X11)) at lag 1 is significant at 5 per cent level respectively. Crude oil price (D(X9)) is taken as a dependent variable, it is significant with its own lag 1 at 1 per cent level. Index of Industrial Production (D(X11)) is taken as a dependent variable, and it is found that it is significant at its own lag 1 and also with the variable Money supply (D(X12)) at 1 per cent level.

Among the variables taken, the value of F-statistic for the variables D(X1) (4.583747), X6 (2.805238), D(X9) (4.786242) and D(X11) (6.416754) are found to be statistically significant at 1 per cent level. The variable D(X7) stood with F value of 2.473061 is significant at 5 per cent level. The value of R^2 is the measure of goodness of fit in the model. Here, between the variables taken, the R^2 value of the variable D(X11) is found to be higher with 0.348419 denotes 34 per cent of the variance in dependent variable Y has been explained by movements of independent variables X, it denotes that the model is average fit. The null hypothesis is rejected where the exchange rate of INR/USD are affected by the macroeconomic determinants Foreign Exchange Reserves, Gold prices, Crude oil price and Index of Industrial production.

AUTOREGRESSIVE DISTRIBUTED LAG (ARDL) MODEL

Autoregression Distributed Lag (ARDL) model is a restricted case of VAR, which is essential to analyse an economic situation. The ARDL is highly used for forecasting purposes, since the changes in a particular variable in current period may have impact on the changes in the future periods of other economic variables or indicators. The estimates of VAR model are used further to construct ARDL test. The ARDL model for USD is given below.

ARDL model for the exchange rate of INR/USD

The Autoregression Distribution Lag model has been applied for the exchange rate of Indian rupee against US dollar for the study period and given in table 6.6.

Table 6.6

ARDL Model for the exchange rate INR/USD

Dependent Variable: D(X1) USD				
Variable	**Coefficient**	**Std.Error**	**t-Statistic**	**Prob.**
D(X1(-1))	0.081017	0.105127	0.770657	0.4426
D(X5(-1))	0.001207	0.000270	4.474411	0.0000**
X6(-1)	5.60E-05	7.03E-05	0.796732	0.4274
D(X7(-1))	0.155487	0.177593	0.875522	0.03832*
D(X8(-1))	0.167637	0.094340	1.776940	0.0784
D(X9(-1))	-0.022902	0.014466	-1.583217	0.1163
D(X10(-1))	-0.000298	0.000117	-2.548344	0.0122**
D(X11(-1))	-0.015059	0.009400	-1.602070	0.1121
D(X12(-1))	-7.38E-05	0.000120	-0.613751	0.5407
C	0.010832	0.222669	0.048648	0.9613
R-squared	0.276400	Mean dependent var.		0.212627
Adjusted R-squared	0.216100	S.D. dependent var.		1.068386
S.E. of regression	0.945929	Akaike info criterion		2.807640
Sum squared resid	96.63641	Schwarz criterion		3.042443
Log likelihood	-155.6507	Hannan-Quinn criter.		2.902977
F-statistic	4.583747	Durbin-Watson stat		1.950798
Prob (F-statistic)	0.000039			

Source: Computed, **Significant at the 0.01 level (2-tailed).*Significant at the 0.05 level (2-tailed).

The table 6.6 shows the results of ARDL model for the exchange rate USD. It is noted that the variables, namely, Foreign Exchange Reserves (X5), Interest Rate (X7) and Gold Price (X10) are the significant predictors of USD, which is significant at 1 per cent and 5 per cent level. X5 is found to be more significant (P value less than 0.001) in contributing to the changes in USD compared to the other significant predictors.

Residuals Diagnostic tests

The commonly used three diagnostic test, namely, Heteroscedasticity test, Serial correlation and Normality test have been applied for the residuals of the exchange rate.

Heteroscedasticity Test

Further whether the model exhibits any heteroscedasticity (absence of constant variance) has been tested by using Breusch-Pagan-Godfrey Heteroscedasticity test.

Heteroscedasticity Test: Breusch-Pagan-Godfrey for INR/USD

The Heteroscedasticity test have been applied for the exchange rate of Indian rupee against USD with the following null hypothesis. The Heteroscedasticity test for INR/USD are given in table 6.7

H_0: There is no presence of Heteroscedasticity in the residuals

Table 6.7

Heteroscedasticity Test: Breusch-Pagan-Godfrey for INR/USD

F-statistic	0.930488	Prob.F(9,108)	0.5019
Obs*R-squared	8.491373	Prob.Chi-Square(9)	0.4855
Scaled explained SS	9.734013	Prob.Chi-Square(9)	0.3724

Source: Computed

The table 6.7 shows the heteroscedasticity test of USD. It is inferred that the Obs*R-squared (8.491373) and the associated probability value which reveals that presence of heteroscedasticity is very less. Hence the null hypothesis is accepted.

Breusch-Godfrey Serial Correlation LM Test

Further, Breusch-godfrey serial correlation LM test has been conducted to test the serial correlation (error terms at near or far off of time periods being correlated). A model without serial correlation is considered to be good.

Breusch-Godfrey Serial Correlation LM Test for INR/USD

The Serial correlation test have been done for the exchange rate of Indian rupee against USD. The null hypothesis have been framed to test the presence of serial correlation in the exchange rate of INR/USD. The Serial Correlation test for INR/USD are given in table 6.8

H_0: There is no presence of serial correlation in the residuals

Table 6.8

Breusch-Godfrey Serial Correlation LM Test for INR/USD

F-statistic	0.478926	Prob.F(2,106)	0.6208
Obs*R-squared	1.056739	Prob.Chi-Square(2)	0.5896

Source: Computed

The table 6.8 shows the results of serial correlation LM test for USD. It shows that the Obs*R-squared is (1.056739) with corresponding probability value (P=0.5896 is above 0.05) indicates that there is an absence of serial correlation in the exchange rate USD. Hence, the null hypothesis is accepted.

Test of Normality

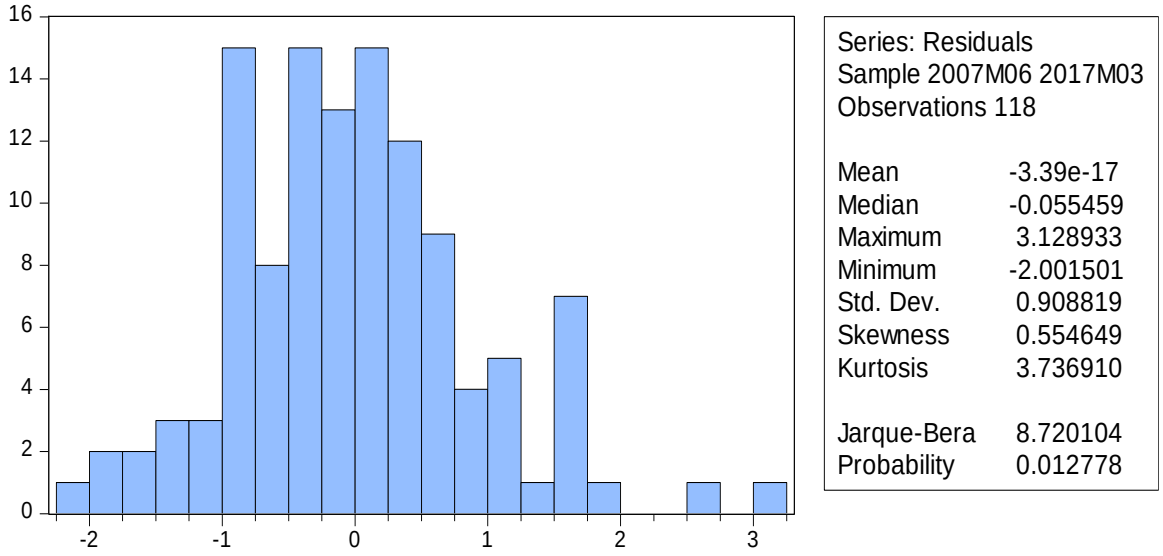
From the ARDL test estimates, the residual term is found out and the normality of residual term has been conducted using Jarque-Bera Test.

Normality Test of INR/USD

The normality test for the exchange rate for USD have been given in 6.1

Graph 6.1

Normality Test of INR/USD



Graph 6.1 portrays the normality test for the exchange rate of INR/USD. It is found that the Jarque bera test value stood at 8.720 and the associated significance level is below 0.05 which shows that the residual of the exchange rate are not normally distributed.

CUSUM test of stability

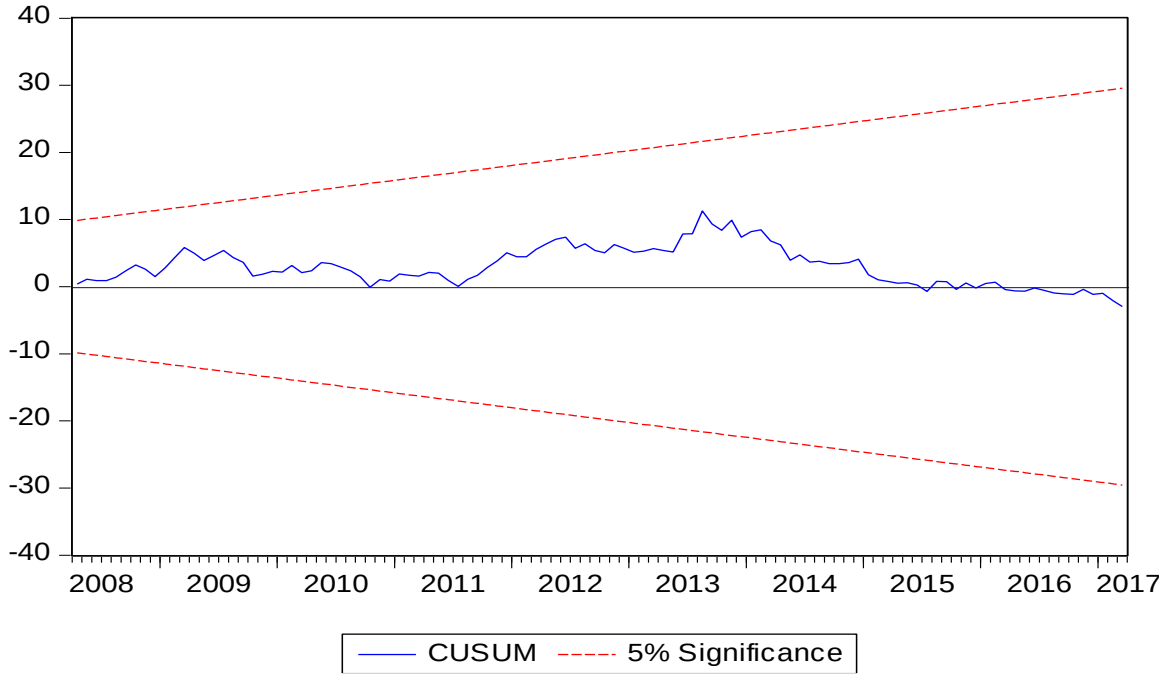
The CUSUM test (Brown, Durbin, & Evans, 1975) is based on the cumulative sum of the recursive residuals (Recursive residuals are defined as the difference between the observed Y and estimated Y, but calculated without using all the observations.). The calculate recursive residuals are calculated by using the first t − 1 observations for the ARDL model discussed above. If this sum goes outside a critical bound (i.e., 95 per cent confidence interval). It is concluded, that there is a structural break at the point at which the sum began its movement toward the bound.

CUSUM test of stability of INR/ USD

The CUMSUM test of stability for the exchange rate of USD have been presented in Graph 6.2

Graph 6.2

CUSUM test of stability of INR/USD



The graph 6.2 shows the CUMSUM test for the exchange rate INR/USD, it is observed from the graph that the blue line signifies the data (i.e, CUSUM residuals), which is significant at 5 per cent level. It is inferred that the data used in the model using ARDL is stable.

VAR Granger Causality/Block Exogeneity Wald Tests

The Granger causality test is used to determine whether one time series is useful in forecasting another. Granger causality is a statistical concept of causality which is based on prediction. According to Granger causality, if a variable A "Granger-causes" (or "G-causes") the variable B, then past values of A should contain information that helps to predict B above and beyond the information contained in the past values of B alone.

For each equation in the VAR estimates given above, the table displays chi-squared (Wald) statistics for each and the joint significance of each of the other lagged endogenous variables in the equation. The statistic in the last row (All) is the chi-squared statistic for joint significance of all other lagged endogenous variables in the equation. The test results are given below.

VAR Granger Causality/Block Exogeneity Wald Tests

Table 6.9 shows the VAR Granger Causality/Block Exogeneity Wald Tests for the exchange rate for INR/USD.

Table 6.9

VAR Granger Causality/Block Exogeneity Wald Tests for INR/USD

Dependent variable: D(X1) USD			
Excluded	**Chi-sq**	**df**	**Prob.**
D(X5)	20.02036	1	0.0000**
X6	0.634781	1	0.4256
D(X7)	0.766539	1	0.3813
D(X8)	3.157516	1	0.0756
D(X9)	2.506576	1	0.1134
D(X10)	6.494058	1	0.0108*
D(X11)	2.566628	1	0.1091
D(X15)	0.376691	1	0.5394
All	31.62873	8	0.0001**

Source: Computed, ** Significant at the 0.01 level.* Significant at the 0.05 level

The table 6.9 shows that the chi-square values for the two variables, namely, Gold price (D(X10)) and foreign exchange reserves (D(X5)) are significant at 5 per cent level and at 1 per cent level. The overall chi-square value (31.62873), and the probability value (P<0.0001) shows that all the lagged endogenous variables in the equation jointly G-causes the dependent variable D(X1), i.e., USD.

6.4 MACROECONOMIC DETERMINANTS AFFECTING EXCHANGE RATE OF INR/GBP

To identify the macroeconomic determinants influencing the movement of exchange rate of Indian rupee against GBP – Vector Autoregression and ARDL model have been analysed.

Vector Autoregression Estimates for Exchange Rate of Indian rupee against Pounds Sterling

Vector Autoregression have been applied for exchange rate of Indian rupee against GBP is presented in table 6.10 and following the null hypothesis have been framed to identify which macroeconomic determinants that affect the exchange rate of Indian rupee against GBP

H_0: The variables, namely, foreign exchange reserves, FDI, Interest rate, Inflation rate Gold price, Crude oil prices, Money supply and Index of Industrial Production do not significantly affect the exchange rate of INR/GBP

Table 6.10

Vector Autoregression Estimates for Exchange rate of Indian rupee against Pounds sterling

		D(X2)	D(X5)	X6	D(X7)	D(X8)	D(X9)	D(X10)	D(X11)	D(X12)
D(X2(-1))	Co.effi	-0.005540	-32.18523	-73.62878	0.000220	0.064039	-0.292228	-74.93337	0.442767	-31.79707
	Std.err	0.09663	17.2991	55.4999	0.02477	0.04523	0.28345	39.2142	0.39642	41.3698
	t-stat	-0.05733	-1.86052	-1.32665	0.00890	1.41571	-1.03096	-1.91087	1.11690	-0.76861
D(X5(-1))	Co.effi	0.002543	0.112840	0.679230	0.000101	-0.000462	0.000424	0.334442	-0.000726	-0.224083
	Std.err	0.00056	0.10107	0.32426	0.00014	0.00026	0.00166	0.22911	0.00232	0.24171
	t-stat	4.50434**	1.11643	2.09468*	0.69728	-1.74979	0.25595	1.45972	-0.31365	-0.92708
X6(-1	Co.effi	4.61E-05	0.029333	0.398374	1.51E-05	8.49E-06	0.000175	-0.066212	-0.000535	-0.059984
	Std.err	0.00015	0.02704	0.08676	3.9E-05	7.1E-05	0.00044	0.06130	0.00062	0.06467
	t-stat	0.30544	1.08466	4.59152**	0.38982	0.12001	0.39479	-1.08006	-0.86381	-0.92749
D(X7(-1	Co.effi	-0.154799	-103.8918	91.63805	0.364043	-0.045373	-1.825963	-82.42201	0.574438	102.6118
	Std.err	0.36956	66.1576	212.251	0.09471	0.17299	1.08402	149.969	1.51606	158.212
	t-stat	-0.41887	-1.57037	0.43174	3.84372**	-0.26228	-1.68444	-0.54960	0.37890	0.64857
D(X8(-1)	Co.effi	0.091253	51.48006	-40.39867	0.004925	0.198546	-0.723981	-60.35299	-0.598286	35.04775
	Std.err	0.20198	36.1578	116.004	0.05176	0.09455	0.59246	81.9639	0.82859	86.4694
	t-stat	0.45179	1.42376	-0.34825	0.09515	2.09998*	-1.22199	-0.73634	-0.72205	0.40532
D(X9(-1)	Co.effi	0.073180	6.381754	8.693403	0.009815	0.007287	0.497120	10.56041	-0.074241	2.495383
	Std.err	0.02840	5.08408	16.3110	0.00728	0.01329	0.08330	11.5248	0.11651	12.1583
	t-stat	2.57673*	1.25524	0.53298	1.34851	0.54811	5.96750**	0.91632	-0.63722	0.20524
D(X10(-1)	Co.effi	-0.000455	-0.079541	-0.095919	-3.14E-05	-5.42E-06	0.001150	0.143332	0.000865	0.100615
	Std.err	0.00025	0.04468	0.14336	6.4E-05	0.00012	0.00073	0.10129	0.00102	0.10686
	t-stat	-1.82101	-1.78006	-0.66908	-0.49075	-0.04640	1.57052	1.41504	0.84518	0.94156

		D(X2)	D(X5)	X6	D(X7)	D(X8)	D(X9)	D(X10)	D(X11)	D(X12)
D(X11(-1)	Co.effi	-0.014372	1.019119	-6.317414	-0.012531	-0.005293	0.057725	-2.172568	-0.552891	3.732012
	Std.err	0.02032	3.63713	11.6688	0.00521	0.00951	0.05960	8.24478	0.08335	8.69799
	t-stat	-0.70739	0.28020	-0.54139	-2.40665*	-0.55655	0.96860	-0.26351	-6.63352*	0.42907
D(X12(-1)	Co.effi	-0.000146	-0.003925	-0.015255	-6.78E-05	-0.000146	0.000264	-0.133895	-0.002870	0.088678
	Std.err	0.00026	0.04573	0.14672	6.5E-05	0.00012	0.00075	0.10366	0.00105	0.10936
	t-stat	-0.57268	-0.08582	-0.10398	-1.03583	-1.22288	0.35271	-1.29162	-2.73823**	0.81086
C	Co.effi	-0.259586	54.94357	1506.766	-0.009079	0.126572	-1.096885	369.2828	4.341782	907.0136
	Std.err	0.47407	84.8653	272.270	0.12149	0.22191	1.39055	192.376	1.94477	202.951
	t-stat	-0.54757	0.64742	5.53409	-0.07473	0.57038	-0.78881	1.91959	2.23255	4.46913
R^2		0.237904	0.131611	0.202349	0.170719	0.089382	0.286442	0.076405	0.355097	0.044238
Adj.R^2		0.174396	0.059245	0.135878	0.101613	0.013497	0.226979	-0.000562	0.301355	-0.035409
Sum sq.resids		445.5335	14277787	1.47E+08	29.26201	97.62224	3833.310	73367211	7497.827	81654734
S.E.equation		2.031086	363.5956	1166.508	0.520523	0.950742	5.957652	824.2124	8.332126	869.5185
F-statistic		3.746049**	1.818691	3.044168**	2.470374*	1.177866	4.817139**	0.992703	6.607440**	0.555422
Log likelihood		-245.8214	-857.9431	-995.4989	-85.16547	-156.2496	-372.8019	-954.5126	-412.3841	-960.8270
AIC		4.335956	14.71090	17.04235	1.612974	2.817789	6.488168	16.34767	7.159052	16.45469
SC		4.570760	14.94570	17.27716	1.847778	3.052593	6.722972	16.58248	7.393856	16.68950
Mean dep		0.002966	131.4184	2596.242	-0.032881	-0.033898	-0.120558	168.4750	0.580011	802.5431
S.D.dep		2.235334	374.8697	1254.874	0.549172	0.957224	6.776095	823.9810	9.968446	854.5211

Source: Computed, **Significant at the 0.01 level.* Significant at the 0.05 level

The table 6.10 shows that Pound sterling (D(X2)) is taken as a dependent variable, and the independent variables, namely, Foreign exchange reserves (D(X5)) and Crude oil prices (D(X9)) at lag 1 are significant at 1 per cent and 5 per cent level of significance. Foreign direct investment (D(X6)) is taken as a dependent variable, and it is found that it is significant with the two variables, namely, Foreign exchange reserve (D(X5)) and foreign direct investment (D(X6) at lag 1 at 5 per cent level and at 1 per cent level. With respect to crude oil price (X7) as a dependent variable, it is found to be significant at its own lag 1 itself at 1 per cent level and also with the variable Index of Industrial Production (D(X11)) at lag 1 at 5 per cent level. As, Inflation rate (D(X8)) is taken as a dependent variable, it is found to be significant at its own lag 1 itself at 5 per cent level respectively. Crude oil price (D(X9) is taken as a dependent variable, and it is found that it is significant at its own variable at lag 1 at 1 per cent level. The variable Index of Industrial Production (D(X11) is taken as a dependent variable, and it is found that it is significant at its own variable at lag 1 and also with the variable money supply D(X12) at lag 1 at 1 per cent level.

Among the variables taken, the value of F-statistic for the variables, X6 (3.044168) and D(X9) (4.917139) are found to be statistically significant at 1 per cent level. The variables D(X2) (3.74609), D(X7) (2.470374) and DX11 (6.607440) are significant at 5 per cent level. The value of R is the measure of goodness of fit of the model. Here, between the variables taken for the study, it is found that the R^2 value of the variable D(X11) (0.355097) is found to be higher which denotes 35 per cent of the variance in dependent variable Y can be explained by movements of independent variables X, it also indicates that the model is average fit. Hence, the null hypothesis is rejected where the macroeconomic determinants, such as, foreign exchange reserves, foreign direct investment, Crude oil prices and Index of Industrial Production influences the exchange rate of INR/GBP.

ARDL model for the exchange rate of INR/GBP

The Autoregressive Distribution Lag model has been applied for the exchange rate of Indian rupee against Pound sterling were given in table 6.11.

Table 6.11

ARDL Model for the exchange rate of INR/GBP

Dependent Variable: D(X2) GBP				
Variable	**Coefficient**	**Std.Error**	**t-Statistic**	**Prob.**
D(X2(-1)	-0.005540	0.096635	-0.057332	0.9544
D(X5(-1)	0.002543	0.000565	4.504338	0.0000**
X6(-1)	4.61E-05	0.000151	0.305443	0.7606
D(X7(-1)	-0.154799	0.369564	-0.418868	0.6761
D(X8(-1)	0.091253	0.201982	0.451789	0.6523
D(X9(-1)	0.073180	0.028400	2.576730	0.0113*
D(X10(-1)	-0.000455	0.000250	-1.821012	0.0714
D(X11(-1)	-0.014372	0.020317	-0.707386	0.4808
D(X12(-1)	-0.000146	0.000255	-0.572676	0.5681
C	-0.259586	0.474067	-0.547573	0.5851
R-squared	0.237904	Mean dependent var		0.002966
Adjusted R-squared	0.174396	S.D.dependent var		2.235334
S.E.of regression	2.031086	Akaike info criterion		4.335956
Sum squared resid	445.5335	Schwarz criterion		4.570760
Log likelihood	-245.8214	Hannan-Quinn criter.		4.431294
F-statistic	3.746049	Durbin-Watson stat		1.981941
Prob(F-statistic	0.000396			

Source: Computed, **Significant at the 0.01 level.*Significant at the 0.05 level

The table 6.11 depicts the ARDL model of Pound sterling. It is observed that the two variables, namely, Foreign Exchange Reserves (X5) and Crude Oil Price (X9) are the significant predictors of GBP. X5 is found to be more significant (P value less than 0.001) in contributing to the changes in GBP.

Residuals diagnostic tests

The commonly used three diagnostic test, namely, Heteroscedasticity test, Serial correlation and normality test have been applied for the residuals of the exchange rate.

Heteroscedasticity Test: Breusch-Pagan-Godfrey for INR/GBP

The Heteroscedasticity test for the exchange rate of Indian rupee against GBP are given in table 6.12. The null hypothesis have been framed to test the presence of heteroscedasticity in the exchange rate of INR/GBP.

H_0: There is no presence of Heteroscedasticity in the residuals

Table 6.12

Heteroscedasticity Test: Breusch-Pagan-Godfrey for INR/GBP

F-statistic	0.355241	Prob.F(9,108	0.9535
Obs*R-squared	3.392769	Prob.Chi-Square(9	0.9467
Scaled explained SS	5.943788	Prob.Chi-Square(9	0.7455

Source: Computed

The table 6.12 portrays the Heteroscedasticity Test for pound sterling. The Obs*R-squared (3.392769) and the associated probability value (P=0.9467 is greater than 0.05) has shown that there is no presence of heteroscedasticity. Hence, the null hypothesis is accepted.

Breusch-Godfrey Serial Correlation LM Test for GBP

The Serial correlation test have for the exchange rate of Indian rupee against GBP are shown in table 6.13.The null hypothesis have been framed to prove the assumption.

H_0: There is no presence of serial correlation in the residuals

Table 6.13

Breusch-Godfrey Serial Correlation LM Test for INR/GBP

F-statistic	2.432320	Prob.F (2,106)	0.0927
Obs*R-squared	5.177733	Prob.Chi-Square (2)	0.0751

Source: Computed

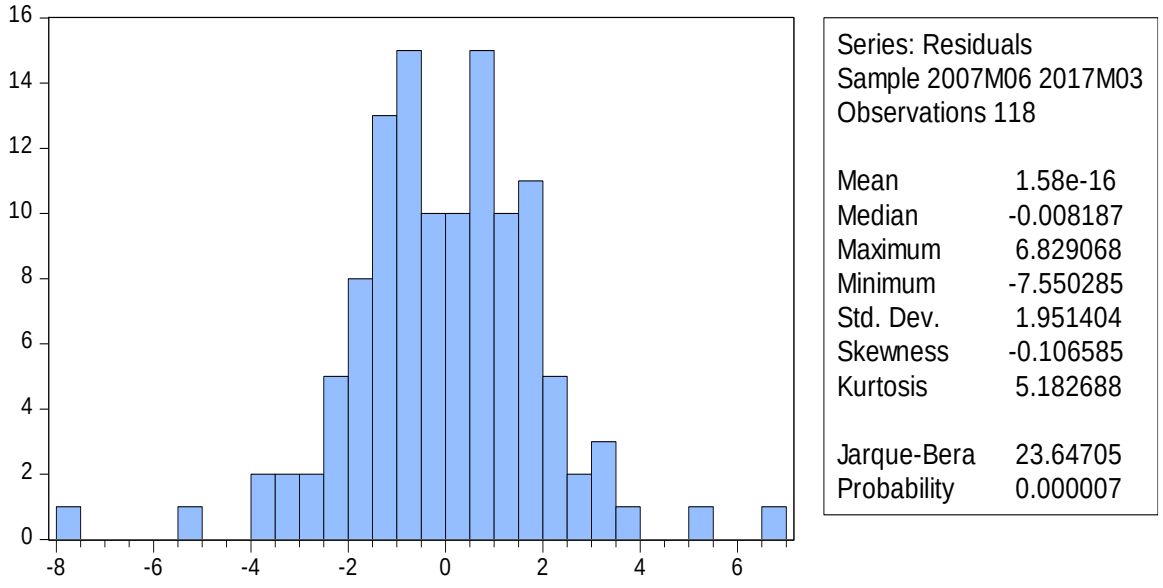
The table 6.13 shows the serial correlation LM test for GBP. It is found that the Obs*R-squared (5.177733) with corresponding probability value (0.0751) is above 0.05, has depicted that the evidence of serial correlation is absent in this data. Hence, the null hypothesis is accepted.

Normality Test of INR/GBP

The normality test for the exchange rate for GBP have been given in Graph 6.3

Graph 6.3

Normality Test of INR/GBP



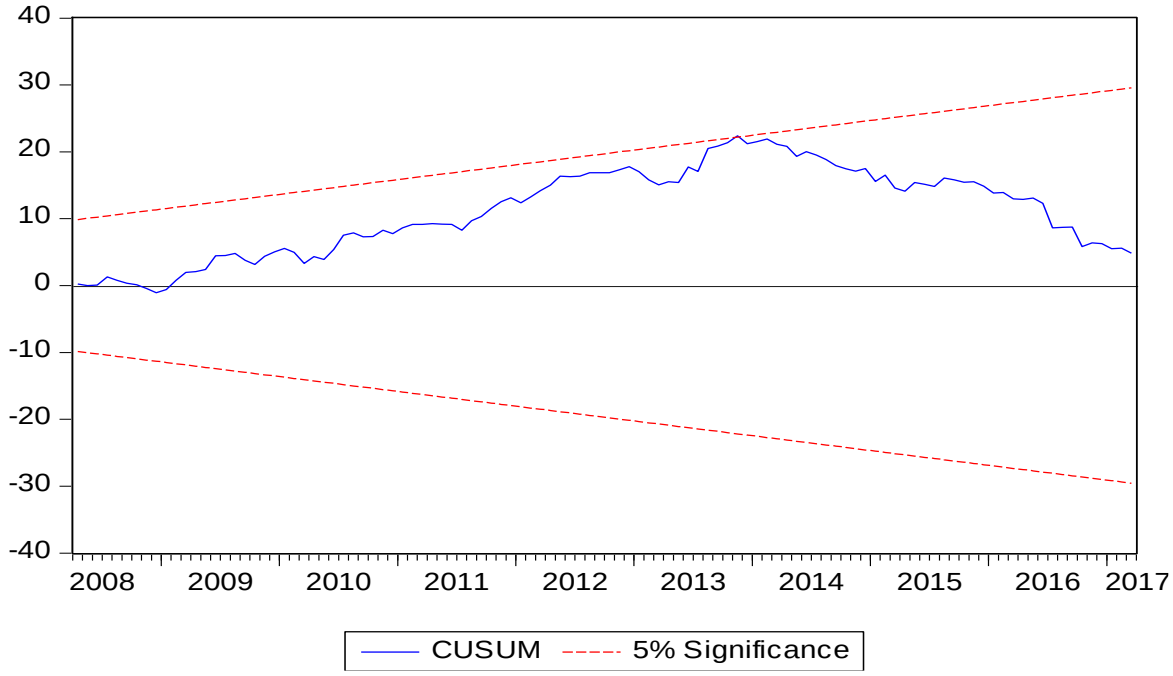
The graph 6.3 shows the normality test of pounds sterling. It is found that the jarque bera test value stood at 23.64705 and the associated significance level below 0.05 (P>0.05) shows that the error term is not normally distributed.

CUSUM test of stability of INR/GBP

The CUMSUM test of stability for the exchange rate of GBP have been presented in Graph 6.4

Graph 6.4

CUSUM test of stability for INR/GBP



From the above graph 6.4, the blue line signifies the data (i.e, CUSUM residuals, which was within the 5 per cent significance level. This impliess that the data used in the ARDL model was stable.

VAR Granger Causality/Block Exogeneity Wald Tests

Table 6.14 shows the VAR Granger Causality/Block Exogeneity Wald Tests for the exchange rate of INR/GBP.

Table 6.14

VAR Granger Causality / Block Exogeneity Wald Tests for INR/GBP

Dependent variable: D(X2) GBP			
Excluded	**Chi-sq**	**df**	**Prob.**
D(X5)	20.28906	1	0.0000**
X6	0.093295	1	0.7600
D(X7)	0.175451	1	0.6753
D(X8)	0.204114	1	0.6514
D(X9)	6.639538	1	0.0100*
D(X10)	3.316086	1	0.0686
D(X11)	0.500396	1	0.4793
D(X15)	0.327958	1	0.5669
All	30.04329	8	0.0002**

Source: Computed, ** Significant at the 0.01 level.* significant at the 0.05 level

Table 6.14 reveals the results VAR Granger Causality / Block Exogeneity Wald Tests for GBP. It indicates that the chi-square values for the variables, namely, foreign exchange reserves (D(X5) and Crude oil price (D(X9) are found to be significant at 1 per cent level and 5 per cent level. The chi-square value (30.04329) (P<0.001) shows that all the lagged endogenous variables in the equation jointly G-causes the dependent variable, GBP (D(X2).

6.5 MACROECONOMIC DETERMINANTS AFFECTING EXCHANGE RATE OF INR/YEN

To identify the macroeconomic determinants influencing the movement of exchange rate of Indian rupee against YEN – Vector Autoregression and ARDL model have been analysed.

Vector Autoregression Estimates for Exchange Rate of Indian Rupee against YEN

Vector Autoregression have been applied for exchange rate of Indian rupee against YEN and presented in table 6.15 and the null hypothesis have been framed and to identify which macroeconomic determinants that affect the exchange rate of Indian rupee against YEN.

H_0: The variables, namely, foreign exchange reserves, FDI, Interest rate, Inflation rate Gold price, Crude oil prices, Money supply and Index of Industrial Production do not significantly affect the exchange rate of INR/YEN

Table 6.15

Vector Autoregression Estimates for Exchange rate of Indian rupee against YEN

		D(X3)	D(X5)	X6	D(X7)	D(X8)	D(X9)	D(X10)	D(X11)	D(X12)
D(X3(-1))	Co.effi	0.265841	-21.29404	33.56642	-0.017537	-0.030783	0.353874	74.10520	-0.625291	-52.36967
	Std.err	0.11545	24.7140	78.8853	0.03491	0.06435	0.40050	55.8091	0.55939	58.3190
	t-stat	2.30270*	-0.86162	0.42551	-0.50242	-0.47836	0.88359	1.32783	-1.11781	-0.89799
D(X5(-1))	Co.effi	0.001295	0.063579	0.505042	0.000114	-0.000310	-0.000432	0.127313	0.000637	-0.249332
	Std.err	0.00046	0.09775	0.31200	0.00014	0.00025	0.00158	0.22073	0.00221	0.23066
	t-stat	2.83668**	0.65045	1.61874	0.82899	-1.21705	-0.27297	0.57678	0.28814	-1.08097
X6(-1)	Co.effi	5.99E-06	0.030360	0.408441	1.34E-05	-4.18E-07	0.000236	-0.052220	-0.000636	-0.061908
	Std.err	0.00013	0.02743	0.08755	3.9E-05	7.1E-05	0.00044	0.06194	0.00062	0.06472
	t-stat	0.04678	1.10688	4.66527**	0.34659	-0.00585	0.53003	-0.84310	-1.02378	-0.95650
D(X7(-1))	Co.effi	0.139554	-119.7298	34.23813	0.368701	0.004959	-2.110546	-151.1153	1.028550	95.02571
	Std.err	0.30958	66.2733	211.539	0.09360	0.17257	1.07398	149.658	1.50006	156.389
	t-stat	0.45078	-1.80661	0.16185	3.93898**	0.02874	-1.96517	-1.00974	0.68567	0.60763
D(X8(-1))	Co.effi	0.224021	52.93966	-23.13104	0.001922	0.183259	-0.618095	-36.01758	-0.773806	31.18571
	Std.err	0.17163	36.7422	117.278	0.05189	0.09567	0.59542	82.9710	0.83164	86.7025
	t-stat	1.30522	1.44084	-0.19723	0.03703	1.91551	-1.03809	-0.43410	-0.93046	0.35969
D(X9(-1))	Co.effi	-0.028991	2.591476	7.830756	0.008163	0.007886	0.514635	13.47309	-0.109237	-4.222573
	Std.err	0.02604	5.57382	17.7912	0.00787	0.01451	0.09033	12.5868	0.12616	13.1528
	t-stat	-1.11343	0.46494	0.44015	1.03690	0.54337	5.69758**	1.07042	-0.86585	-0.32104

		D(X3)	D(X5)	X6	D(X7)	D(X8)	D(X9)	D(X10)	D(X11)	D(X12)
D(X10(-1))	Co.effi	-0.000376	-0.068552	-0.164561	-1.13E-05	5.61E-05	0.000626	0.027946	0.001761	0.147184
	Std.err	0.00025	0.05280	0.16853	7.5E-05	0.00014	0.00086	0.11923	0.00120	0.12460
	t-stat	-1.52409	-1.29832	-0.97643	-0.15171	0.40798	0.73156	0.23438	1.47339	1.18130
D(X11(-1))	Co.effi	-0.011504	1.615932	-3.907443	-0.012760	-0.007409	0.070091	0.787253	-0.572760	3.923814
	Std.err	0.01712	3.66542	11.6997	0.00518	0.00954	0.05940	8.27723	0.08296	8.64948
	t-stat	-0.67186	0.44086	-0.33398	-2.46473*	-0.77631	1.18000	0.09511	-6.90366**	0.45365
D(X12(-1))	Co.effi	-0.000146	0.002423	-0.007326	-6.64E-05	-0.000153	0.000278	-0.129026	-0.002883	0.097460
	Std.err	0.00022	0.04627	0.14770	6.5E-05	0.00012	0.00075	0.10449	0.00105	0.10919
	t-stat	-0.67625	0.05236	-0.04960	-1.01662	-1.26984	0.37085	-1.23479	-2.75296*	0.89256
C	Co.effi	0.154249	55.42238	1500.305	-0.007459	0.132337	-1.142788	359.0398	4.419516	910.3639
	Std.err	0.40148	85.9460	274.333	0.12139	0.22379	1.39278	194.083	1.94534	202.811
	t-stat	0.38420	0.64485	5.46892	-0.06144	0.59135	-0.82051	1.84993	2.27185	4.48872
R^2		0.185414	0.109897	0.190707	0.172653	0.074444	0.284591	0.060516	0.355109	0.046132
Adj.R^2		0.117531	0.035721	0.123266	0.103707	-0.002685	0.224974	-0.017775	0.301368	-0.033357
Sum sq.res		319.3509	14634808	1.49E+08	29.19380	99.22366	3843.253	74629373	7497.687	81492918
S.E.equ		1.719579	368.1134	1174.990	0.519916	0.958508	5.965373	831.2717	8.332048	868.6565
F-statistic		2.731401**	1.481580	2.827753**	2.504184*	0.965183	4.773631**	0.772965	6.607786**	0.580353
Log likelihood		-226.1755	-859.4002	-996.3538	-85.02778	-157.2096	-372.9547	-955.5190	-412.3830	-960.7099
AIC		4.002974	14.73560	17.05684	1.610640	2.834060	6.490758	16.36473	7.159034	16.45271
SC		4.237778	14.97040	17.29165	1.845444	3.068864	6.725562	16.59953	7.393838	16.68751
Mean dep		0.207797	131.4184	2596.242	-0.032881	-0.033898	-0.120558	168.4750	0.580011	802.5431
S.D.dep		1.830512	374.8697	1254.874	0.549172	0.957224	6.776095	823.9810	9.968446	854.5211

Source: Computed, **Significant at the 0.01 level.* Significant at the 0.05 level

The table 6.15 shows that value Yen (D(X3)) is taken as a dependent variable, it is found to be significant at its own lag 1 itself and also with the variable foreign exchange reserves (DX5)) at lag1 at 1 per cent level and 5 per cent level. Similarly, Foreign direct investment X6 is taken as a dependent variable, it is found to be significant at 1 per cent level at its own lag 1 itself. With respect to Interest rate D(X7) taken as a dependent variable, it was found to be significant at its own lag 1 itself and also with the independent variable Index of Industrial Production (DX11)) at lag 1 have significant effect at 1 per cent and 5 per cent level. Crude oil price (DX9)) is taken as a dependent variable, it is found to be have significant at its own lag 1 at 1 per cent level respectively. Index of Industrial Production (DX11)) is taken as a dependent variable, it was found that it was significant with its own variable (DX11)) at lag 1 and also with the variable Money supply (DX12)) at lag 1 at 1 per cent and 5 per cent level of significance.

Among the variables taken, the value of F-statistic for the variable D(X7) (2.504184) were significant at 5 per cent level and the variables DX3 (2.731401), X6 (2.827753), DX9 (4.773631) and DX11 (6.607786) are found to be statistically significant at 1 per cent level. The value of R^2 is the measure of goodness of fit of the model. Here, between the variables taken the R^2 value of the variable DX11 found to be higher with (0.355109) denotes 35 per cent of the variance in dependent variable Y can be explained by movements of independent variables X which denotes that the model is average fit. Hence the null hypothesis is rejected. The movement of exchange rate of rupee against Yen was influenced by the macroeconomic determinants foreign exchange reserves, interest rate, money supply, Index of Industrial Production and Crude oil prices.

ARDL model for the exchange rate of INR/YEN

Table 6.16 depicts the Autoregressive Distribution Lag model for the exchange rate of Indian rupee against YEN.

Table 6.16

ARDL Model for the exchange rate INR/YEN

Dependent Variable: D(X3) YEN				
Variable	**Coefficient**	**Std.Error**	**t-Statistic**	**Prob.**
D(X3(-1))	0.265841	0.115447	2.302704	0.2320
D(X5(-1))	0.001295	0.000457	2.836683	0.0054**
X6(-1)	5.99E-06	0.000128	0.046783	0.9628
D(X7(-1))	0.139554	0.309584	0.450779	0.6531
D(X8(-1))	0.224021	0.171635	1.305218	0.0196*
D(X9(-1))	-0.028991	0.026037	-1.113434	0.0268*
D(X10-1))	-0.000376	0.000247	-1.524090	0.1304
D(X11(-1))	-0.011504	0.017122	-0.671865	0.5031
D(X12-1))	-0.000146	0.000216	-0.676255	0.5003
C	0.154249	0.401482	0.384199	0.7016
R-squared	0.185414	Mean dependent var.		0.207797
Adjusted R-squared	0.117531	S.D. dependent var.		1.830512
S.E. of regression	1.719579	Akaike info criterion		4.002974
Sum squared resid	319.3509	Schwarz criterion		4.237778
Log likelihood	-226.1755	Hannan-Quinn criter.		4.098312
F-statistic	2.731401	Durbin-Watson stat		2.137802
Prob F-statistic	0.006548			

Source: Computed, **Significant at the 0.01 level.* Significant at the 0.05 level

Table 6.16 states the ARDL model for the exchange rate YEN. It is observed that Foreign Exchange Reserves (X5) is significant at 1 per cent level, and the variables Gold price (X8) and Crude Oil Price (X9) are the significant predictors of YEN at 5 per cent level.

Residuals diagnostic tests

The commonly used three diagnostic test, namely, Heteroscedasticity test, Serial correlation and normality test have been applied for the residuals of the exchange rate.

Heteroscedasticity Test: Breusch-Pagan-Godfrey for INR/YEN

Table 6.17 presents the Heteroscedasticity test for the exchange rate of Indian rupee against YEN. The null hypothesis have been framed to test the presence of heteroscedasticity in the exchange rate of INR/YEN.

H_0: There is no presence of Heteroscedasticity in the residuals

Table 6.17

Heteroscedasticity Test: Breusch-Pagan-Godfrey for INR/YEN

F-statistic	1.357354	Prob.F9,108	0.2166
Obs*R-squared	11.99098	Prob.Chi-Square9	0.2138
Scaled explained SS	13.53476	Prob.Chi-Square9	0.1399

Source: Computed

The table 6.17 narrates the heteroscedasticity test for YEN. The Obs*R-squared (11.99098) and the associated probability (P=0.2138 is greater than 0.05), shows that there is no presence of heteroscedasticity. Hence, the null hypothesis is accepted.

Breusch-Godfrey Serial Correlation LM Test

The Serial correlation test have been done for the exchange rate of Indian rupee against YEN are shown in table 6.18. The null hypothesis have been framed to test the presence of serial correlation in the exchange rate of INR/YEN.

H_0: There is no presence of serial correlation in the residuals

Table 6.18

Breusch-Godfrey Serial Correlation LM Test for INR/YEN

F-statistic	2.639428	Prob.F2,106	0.0761
Obs*R-squared	5.597693	Prob.Chi-Square2	0.0609

Source: Computed

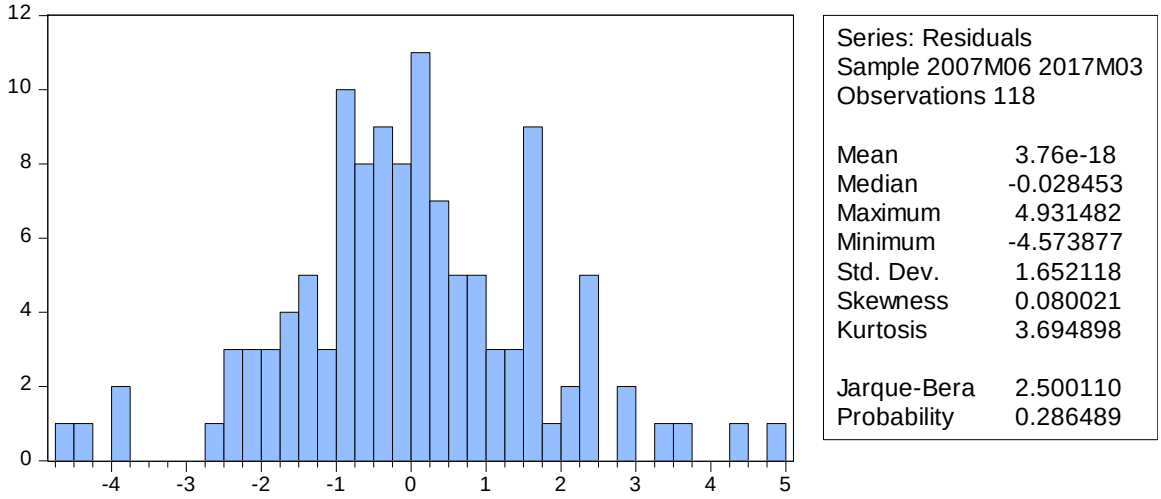
The table 6.18 shows the serial correlation LM test of YEN. The Obs*R-squared is (5.597693) with corresponding probability value (0.0.0609 which is above 0.05) reveals the evidence of serial correlation is absent in this data. Hence the null hypothesis is accepted

Normality Test of INR/YEN

The normality test for the exchange rate for YEN have been given in Graph 6.5

Graph 6.5

Normality Test for INR/YEN



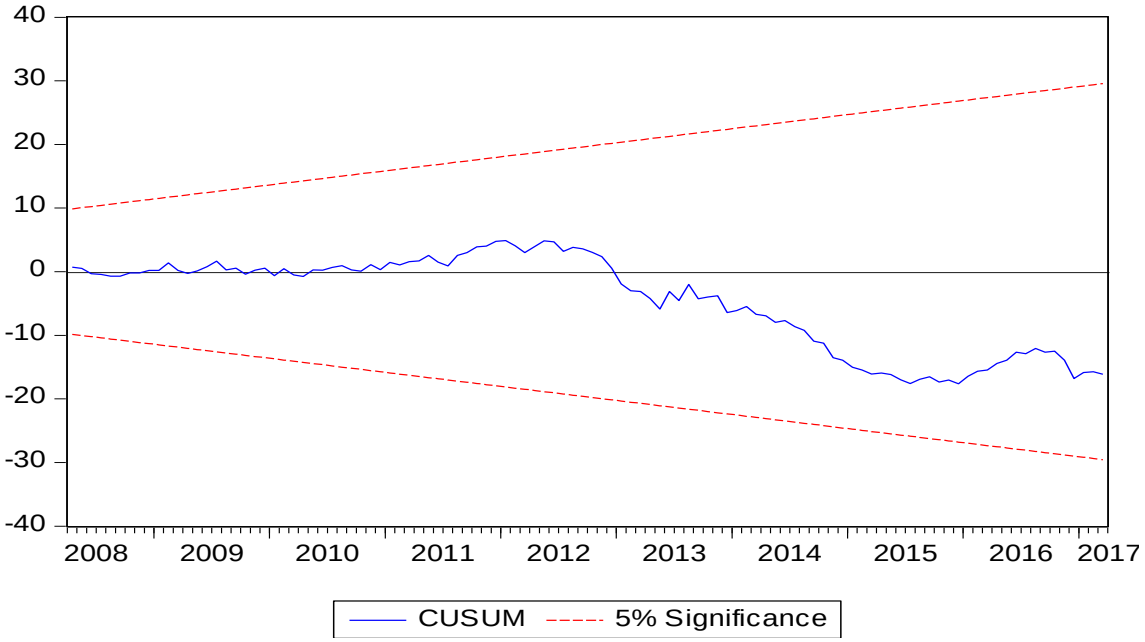
Graph 6.5 portrays the normality test of Yen, the value is (2.500110) and the associated significance level is above 0.05 (P>0.05) which shows that the error term is normally distributed.

CUSUM test of stability of INR/YEN

The CUMSUM test of stability for the exchange rate of YEN have been presented in Graph 6.6

Graph 6.6

CUSUM test of stability for INR/YEN



From the above graph 6.6, the blue line signifies the data i.e, CUSUM residuals, which was within the 5 per cent significance level. This infers that the data used in the model using ARDL was stable.

VAR Granger Causality/Block Exogeneity Wald Tests

Table 6.19 shows the VAR Granger Causality/Block Exogeneity Wald Tests for the exchange rate of INR/YEN.

Table 6.19

VAR Granger Causality/Block Exogeneity Wald Tests for INR/ YEN

Dependent variable: D(X3) YEN			
Excluded	**Chi-sq**	**df**	**Prob.**
D(X5)	8.046773	1	0.0046**
X6	0.002189	1	0.9627
D(X7)	0.203201	1	0.6521
D(X8)	1.703594	1	0.0191*
D(X9)	1.239735	1	0.2655
D(X10)	2.322851	1	0.1275
D(X11)	0.451402	1	0.5017
D(X12)	0.457321	1	0.4989
All	13.28948	8	0.01023*

Source: Computed,**Significant at the 0.01 level.* Significant at the 0.05 level

Table 6.19 depicts the results of VAR Granger Causality / Block Exogeneity Wald Tests for YEN. It indicates that the chi-square values for the variables, namely, Foreign exchange reserves (D(X5) and Inflation rate (D(X8) are found to be significant at 1 per cent level and 5 per cent level. The chi-square value (13.28948) ($P<0.001$) shows that all the lagged endogenous variables in the equation jointly G-causes the dependent variable, YEN (D(X3).

6.6 MACROECONOMIC DETERMINANTS AFFECTING EXCHANGE RATE OF INR/EURO

To identify the macroeconomic determinants influencing the movement of exchange rate of Indian rupee against EURO – Vector Auto Regression and ARDL model have been analysed.

Vector Autoregression Estimates for Exchange Rate of Indian rupee against Euro

Vector Autoregression have been applied for exchange rate of Indian rupee against Euro and presented in table 6.20 and the null hypothesis have been framed and to identify which macroeconomic determinants that affect the exchange rate of Indian rupee against Euro

H_0: The variables, namely, foreign exchange reserves, FDI, Interest rate, Inflation rate Gold price, Crude oil prices, Money supply and Index of Industrial Production do not significantly affect the exchange rate of INR/Euro

Table 6.20

Vector Autoregression Estimates for Exchange rate of Indian rupee against Euro

		D(X4)	D(X5)	X6	D(X7)	D(X8)	D(X9)	D(X10)	D(X11)	D(X12)
D(X4(-1))	Co.effi	0.077918	-44.12440	-4.411968	-0.011701	0.104851	-0.173561	-9.800844	0.146648	-68.69937
	Std.err	0.10490	23.2140	75.1306	0.03324	0.06047	0.38213	53.5326	0.53521	55.3107
	t-stat	0.74276	-1.90077	-0.05872	-0.35205	1.73402	-0.45419	-0.18308	0.27400	-1.24206
D(X5(-1))	Co.effi	0.001426	0.110858	0.536448	0.000118	-0.000483	8.07E-05	0.196735	-3.99E-05	-0.190084
	Std.err	0.00045	0.10041	0.32496	0.00014	0.00026	0.00165	0.23154	0.00231	0.23923
	t-stat	3.14316**	1.10409	1.65082	0.82150	-1.84651	0.04881	0.84967	-0.01723	-0.79455
X6(-1)	Co.effi	-5.12E-05	0.031578	0.405215	1.49E-05	4.32E-06	0.000199	-0.059344	-0.000574	-0.058209
	Std.err	0.00012	0.02698	0.08732	3.9E-05	7.0E-05	0.00044	0.06222	0.00062	0.06428
	t-stat	-0.42019	1.17045	4.64069**	0.38482	0.06148	0.44883	-0.95384	-0.92334	-0.90551
D(X7(-1))	Co.effi	0.072359	-122.5962	43.13488	0.364882	-0.009167	-2.009232	-131.4702	0.859002	85.61923
	Std.err	0.29431	65.1283	210.783	0.09325	0.16964	1.07209	150.189	1.50157	155.178
	t-stat	0.24586	-1.88238	0.20464	3.91305**	-0.05404	-1.87412	-0.87537	0.57207	0.55175
D(X8(-1))	Co.effi	0.034818	49.83388	-29.48424	0.003111	0.204416	-0.704395	-50.05283	-0.645653	29.60309
	Std.err	0.16360	36.2033	117.170	0.05183	0.09430	0.59595	83.4865	0.83469	86.2597
	t-stat	0.21282	1.37650	-0.25164	0.06002	2.16769*	-1.18196	-0.59953	-0.77353	0.34319
D(X9(-1))	Co.effi	0.031130	6.298615	4.813985	0.010274	0.006800	0.487687	6.815219	-0.055502	3.372806
	Std.err	0.02291	5.06918	16.4061	0.00726	0.01320	0.08345	11.6898	0.11687	12.0781
	t-stat	1.35892	1.24253	0.29343	1.41562	0.51500	5.84440**	0.58301	-0.47490	0.27925

		D(X4)	D(X5)	X6	D(X7)	D(X8)	D(X9)	D(X10)	D(X11)	D(X12)
D(X10(-1))	Co.effi	-0.000374	-0.062414	-0.123262	-2.32E-05	-5.13E-05	0.001149	0.119164	0.000947	0.134838
	Std.err	0.00021	0.04689	0.15177	6.7E-05	0.00012	0.00077	0.10814	0.00108	0.11173
	t-stat	-1.76362	-1.33096	-0.81217	-0.34612	-0.41961	1.48835	1.10195	0.87600	1.20681
D(X11(-1))	Co.effi	-0.014071	2.342470	-4.288006	-0.012416	-0.008102	0.067392	-0.052299	-0.566337	5.298972
	Std.err	0.01633	3.61267	11.6922	0.00517	0.00941	0.05947	8.33100	0.08329	8.60773
	t-stat	-0.86190	0.64840	-0.36674	-2.40044*	-0.86103	1.13323	-0.00628	-6.79941	0.61561
D(X12(-1))	Co.effi	-0.000187	0.002381	-0.004470	-6.74E-05	-0.000159	0.000313	-0.122719	-0.002939	0.095855
	Std.err	0.00021	0.04564	0.14771	6.5E-05	0.00012	0.00075	0.10525	0.00105	0.10874
	t-stat	-0.90507	0.05217	-0.03026	-1.03151	-1.34099	0.41659	-1.16600	-2.79299**	0.88147
C	Co.effi	0.278352	45.79285	1502.621	-0.011104	0.147746	-1.140477	364.1404	4.387601	893.6066
	Std.err	0.38366	84.9001	274.774	0.12156	0.22114	1.39756	195.784	1.95742	202.287
	t-stat	0.72551	0.53937	5.46857	-0.09135	0.66810	-0.81605	1.85991	2.24153	4.41752
R^2		0.147655	0.132789	0.189376	0.171669	0.097607	0.280794	0.045475	0.348101	0.052544
Adj.R^2		0.076627	0.060521	0.121824	0.102642	0.022407	0.220860	-0.034069	0.293776	-0.026411
Sum sq.resi		291.1750	14258421	1.49E+08	29.22849	96.74053	3863.656	75824194	7579.163	80945128
S.E.equ		1.641970	363.3489	1175.955	0.520225	0.946438	5.981186	837.8997	8.377197	865.7320
F-statistic		2.078812**	1.837460	2.803409	2.486970**	1.297972	4.685056*	0.571692	6.407753*	0.665490
Log likelihood		-220.7259	-857.8630	-996.4508	-85.09784	-155.7143	-373.2671	-956.4561	-413.0207	-960.3120
AIC		3.910609	14.70954	17.05849	1.611828	2.808716	6.496053	16.38061	7.169842	16.44597
SC		4.145412	14.94435	17.29329	1.846632	3.043520	6.730857	16.61542	7.404646	16.68077
Mean dep		0.129068	131.4184	2596.242	-0.032881	-0.033898	-0.120558	168.4750	0.580011	802.5431
S.D.dep		1.708742	374.8697	1254.874	0.549172	0.957224	6.776095	823.9810	9.968446	854.5211

Source: Computed, **Significant at the 0.01 level.* Significant at the 0.05 level.

The table 6.20 predicts that exchange rate of Euro (DX4) is taken as a dependent variable, which is found to be significant with the variable foreign exchange reserves (DX5) at lag1 at 1 per cent level. Foreign direct investment X6 is taken as a dependent variable, and it is found to be significant with the variable X6 at its own lag 1 itself at 1 per cent level. With respect to Interest rate (DX7) has been taken as a dependent variable, it is found to be have a significant effect at its own lag 1 itself an also with IIP at 1 per cent level and 5 per cent level of significance. As Crude oil price (DX9) is taken as a dependent variable, it is found to be have significant effect with its own lag 1 at 1 per cent level of significance respectively. Index of Industrial Production (DX11) is taken as a dependent variable, it is found to be significant with its own variable at its own lag 1 at 1 per cent and 5 per cent level of significance.

Among the variables taken, the value of F-statistic for the variable DX4 (2.078812) DX7 (2.48690) is significant at 1 per cent level and the variables DX9 (4.685056) and DX11 (6.407753) are found to be statistically significant at 5 per cent level. The value of R^2 is the measure of goodness of fit of the model. Here, between the variables taken the R^2 value of the variable DX11 found to be higher (0.348101), which denotes 34 per cent of the variance in dependent variable Y can be explained by movements of independent variables X which denotes the model is average fit. Hence the null hypothesis is rejected. The macroeconomic determinants Index of industrial production, crude oil price, Interest rate and foreign exchange reserves influences the exchange rate of INR/EURO.

ARDL model for the exchange rate of INR/Euro

The Autoregressive Distribution Lag model has been applied for the exchange rate of Indian rupee against Euro for the study period.

Table 6.21

ARDL Model for the exchange rate INR/EURO

Dependent Variable: D(X4) Euro				
Variable	**Coefficient**	**Std.Error**	**t-Statistic**	**Prob.**
D(X4(-1))	0.077918	0.104904	0.742758	0.4592
D(X5(-1)	0.001426	0.000454	3.143159	0.0022**
X6-1	-5.12E-05	0.000122	-0.420194	0.6752
D(X7(-1))	0.072359	0.294314	0.245857	0.8063
D(X8(-1))	0.034818	0.163602	0.212822	0.8319
D(X9(-1))	0.031130	0.022908	1.358924	0.1770
D(X10(-1))	-0.000374	0.000212	-1.763625	0.0806
D(X11(-1))	-0.014071	0.016326	-0.861899	0.03907*
D(X12-1))	-0.000187	0.000206	-0.905075	0.3674
C	0.278352	0.383663	0.725511	0.4697
R-squared	0.147655	Mean dependent var.		0.129068
Adjusted R-squared	0.076627	S.D. dependent var.		1.708742
S.E.of regression	1.641970	Akaike info criterion		3.910609
Sum squared resid	291.1750	Schwarz criterion		4.145412
Log likelihood	-220.7259	Hannan-Quinn criter.		4.005946
F-statistic	2.078812	Durbin-Watson stat		2.038448
Prob F-statistic	0.037545			

Source: Computed, **Significant at the 0.01 level.* Significant at the 0.05 level

Table 6.21 reveals the ARDL model of euro. It is noted that the two variables, Foreign Exchange Reserves (X5) and Crude Oil Price (X11) are the significant predictors of Euro, which is significant at 0.01 per cent and 0.05 per cent level.

Heteroscedasticity Test: Breusch-Pagan-Godfrey for INR/EURO

Table 6.22 shows the Heteroscedasticity test for the exchange rate of Indian rupee against Euro. The null hypothesis have been framed to test the presence of heteroscedasticity in the exchange rate of INR/EURO.

H_0: There is no presence of Heteroscedasticity in the residuals

Table6.22

Heteroscedasticity Test: Breusch-Pagan-Godfrey for INR/ EURO

F-statistic	0.920138	Prob.F9,108	0.5108
Obs*R-squared	8.403645	Prob.Chi-Square(9)	0.4940
Scaled explained SS	13.51190	Prob.Chi-Square(9)	0.1408

Source: Computed

The table 6.22 states that, the Obs*R-squared (8.403645) and the associated probability (P=0.4940 which is greater than 0.05) shows that there is no presence of heteroscedasticity. Hence, the null hypothesis is accepted.

Breusch-Godfrey Serial Correlation LM Test

The Serial correlation test have been done for the exchange rate of Indian rupee against Euro are presented in table 6.23.The null hypothesis have been framed to prove the assumption.

H_0: There is no presence of serial correlation in the residuals

Table 6.23

Breusch-Godfrey Serial Correlation LM Test of INR/EURO

F-statistic	1.558985	Prob.F2,106	0.2151
Obs*R-square	3.371768	Prob.Chi-Square2	0.1853

Source: Computed

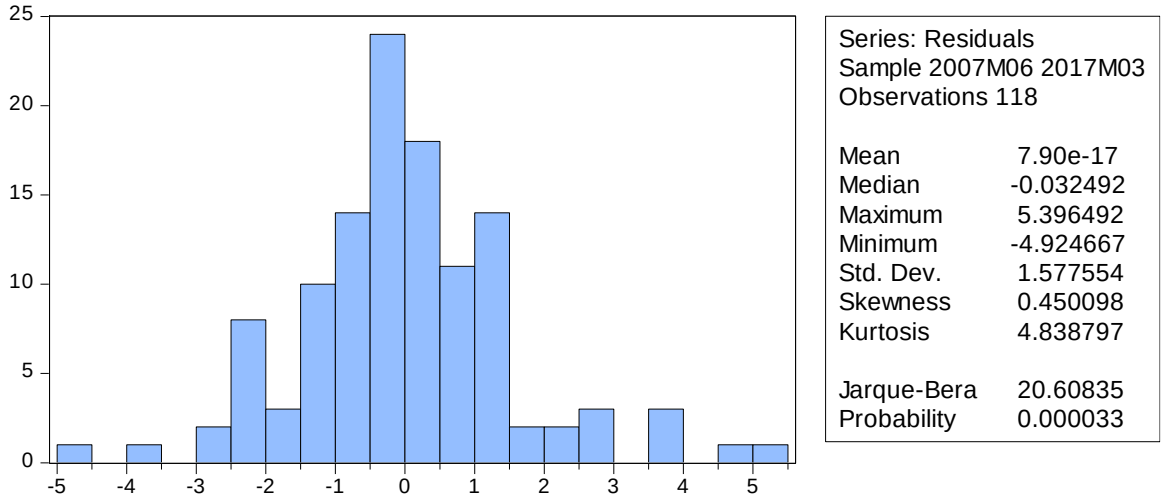
The table 6.23 shows the LM test results of euro. It is noted that the Obs*R-square is (3.371768) with corresponding probability value (0.1853is above 0.05) and it is found that the evidence of serial correlation is absent in this data. Hence, the null hypothesis is accepted.

Normality Test of INR/Euro

The normality test for the exchange rate for Euro have been given in Graph 6.7

Graph 6.7

Normality Test of INR/EURO



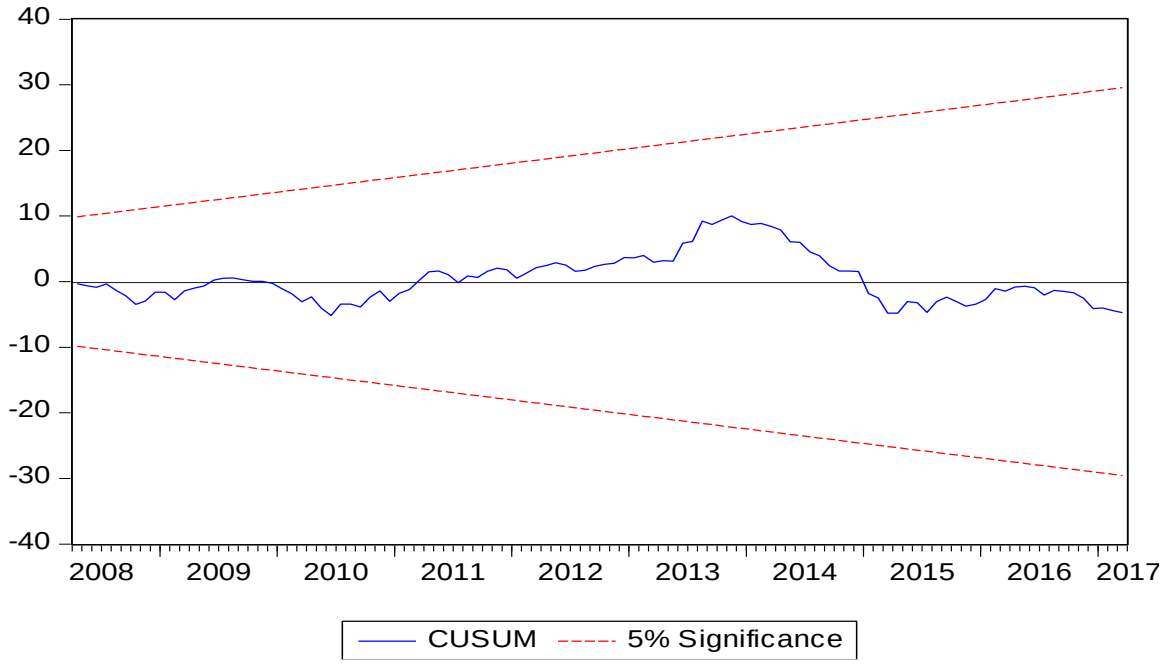
The Graph 6.7 shows the normality test of euro. It is found from the test that the value stood at (20.060835) and the associated significance level below (P< 0.05) shows that the error term is not normally distributed.

CUSUM test of stability of INR/Euro

The CUMSUM test of stability for the exchange rate of Euro have been presented in Graph 6.8

Graph 6.8

CUSUM test of stability of INR/EURO



The above graph 6.8 indicates that, the blue line signifies the data i.e, CUSUM residuals, is significant at 5 per cent level. It is also noted that the data used in the ARDL model was stable.

VAR Granger Causality/Block Exogeneity Wald Tests

Table 6.24 shows the VAR Granger Causality/Block Exogeneity Wald Tests for the exchange rate of INR/Euro.

Table 6.24

VAR Granger Causality/Block Exogeneity Wald Tests for INR/EURO

Dependent variable: D(X4) EURO			
Excluded	**Chi-sq**	**df**	**Prob.**
D(X5(-1))	9.879451	1	0.0017
X6	0.176563	1	0.6743
D(X7(-1))	0.060446	1	0.8058
D(X8(-1))	0.045293	1	0.8315
D(X9(-1))	1.846675	1	0.0018**
D(X10(-1))	3.110373	1	0.0778
D(X11(-1))	0.742869	1	0.03887*
D(X12(-1))	0.819160	1	0.3654
All	15.97207	8	0.0428

Source: Computed, ** Significant at the 0.01 level.* Significant at the 0.05 level

Table 6.24 depicts that the chi-square values for the variables Crude oil prices (DX9) and Index of Industrial Production (DX11) are significant at 1 per cent level and 5 per cent level. The chi-square value (15.97207) ($P<0.005$) which shows that all the lagged endogenous variables in the equation jointly G-causes the dependent variable Euro (DX4).

6.7 CONCLUSION

In this chapter, Vector Autoregression (VAR) and Autoregressive Distribution Lag model (ARDL) have been employed to analyse the macroeconomic determinants affecting the exchange rate of Indian rupee against select foreign currencies in the long run. The results of VAR analysis and ARDL have shown that the variables, namely, Foreign exchange reserves, Crude oil prices, Gold prices, Index of Industrial Production, Interest rate and money supply are the major predictors of exchange rate. Hence, it can be

concluded that overall exchange rate is influenced by some macroeconomic variables which are proved to be significant and thereby influences the exchange rate volatility against select foreign currencies. There is no presence of heteroscedasticity and serial correlation in the macroeconomic determinants. India being a developing economy observes the exchange rate its being affected by macroeconomic indicators of the economy. The obtained results would assist the economists and policy makers to frame the macroeconomic policies.