

Determination of Exchange Rates and A Forecasting Model for Indian Rupee

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Abstract

Post liberalization, the volume of foreign trade in India has grown consistently during the decade. The fluctuations in the foreign exchange rates could make the export or imports relatively much cheaper as well as much costlier. In this paper an attempt has been made to determine the factors affecting the exchange rate. For the analysis, quantitative variables such as the G-sec bond interest rates, the wholesale price index rates, the export import statistics and some qualitative data such as the political factor, the currency convertibility are taken into account. A multiple regression analysis was carried out to see the importance level of each factor taken into considerations and to understand the cause and effect on exchange rates.

Section 1: Variables Affecting Exchange Rates

There are number of factors affecting the exchange rate fluctuations in short run and in the long run. The objective of this section is to understand the determinants of exchange rate and look at each of the factors in isolation and try to determine the importance of the factors.

Quantitative Factors

- i. **Interest Rate (X_1):** Interest rate is one of the important factors on which the exchange rate fluctuations can be dependent. Looking at the relationship between the interest rates and the foreign exchange rates one can say that with the rise in the interest rates foreign money is pumped into the country as the increasing interest rates of the long term government bonds attracts foreign investors to invest in India as a result more and more transaction take place between countries leading to the fluctuations in the exchange rates.
- ii. **Inflation (X_2):** Wholesale price index measures the increase in the price levels of a country. This can also play an important role in price fluctuations as it could directly impact the exports

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and imports of a country. With the rise in inflation rate the price of the products increase as a result it could have a direct impact on the foreign trade.

- iii. **Balance of Payments:** Balance of payments (BOP) is basically the sum of the capital account balances and the current account balance, wherein capital account balance is the net difference between fixed capital expenditure done by the home country in the foreign country and current account balances refer to the net difference between the merchandise, services etc. of the home country to the foreign country.
 - a) **Capital Account balances (X_3):** As mentioned above, these balances refer to the net difference between the fixed capital movements from one country to the other country.
 - b) **Current account balances (X_4):** Current account balances means the net differences between the services and the trading done between the two countries. Now with the rise in the current balance in the positive direction the exports of services and trade become more than the imports and vice versa.
- iv. **Trade Balances (X_5):** The trade balances refers to the difference between the exports and the imports of a country. This can act as a significant factor that determines the foreign exchange rates fluctuation as because this is done on the daily basis and could directly link the exports-imports with the exchange rates.
- v. **Sensex (X_6):** BSE sensitive index (30 scripts) measures the mood of the corporate sector, which shows that financial wealth of the country in liquid terms. The price of scripts fluctuates, with the inflow and outflow of foreign investments. The index has become volatile with ups and downs frequently.

Qualitative Factors

- i. **Investors Psychology and Bandwagon Effects:** The bandwagon effect is the observation that people often do (or believe) things because many other people do (or believe) the same. The effect is often pejoratively referred to as herd instinct, particularly as applied to adolescents. Without examining the merits of the particular thing, people tend to "follow the crowd." The bandwagon effect is the reason for the bandwagon fallacy's success.
Literally, a bandwagon is a wagon that carries the band in a parade. Riding on the bandwagon is popular since one can enjoy the music, conveniently without walking. The phrase "jumping on the bandwagon" is therefore used in the sense of "joining an increasingly popular trend". Bandwagon effect is a technical term for an interaction of demand and preference. The bandwagon effect arises when people's preference for a commodity increases as the number of people buying it increases. This interaction potentially disturbs the normal results of the theory of supply and demand, which assumes that price and preference are independent.
Established theories like the Purchasing Power Parity (PPP) theory and the international Fisher Effect do not explain the short term movements in the exchange rates. One reason for this is the impact of the investor's psychology. Increasing evidence reveals that various psychological factors play an important role in determining the expectations of market traders as to likely future exchange rates. In turn, expectations have a tendency to become self fulfilling

prophecies.

- ii. Convertibility and Government Policy:** Due to government restrictions, a significant number of currencies are not freely convertible into other currencies. A country's currency is said to be freely convertible when the country's government allows both residents and non residents to purchase unlimited amounts of a foreign currency with it. A currency is said to be externally convertible when only nonresidents may convert it into a foreign currency without any limitations. A currency is nonconvertible when neither residents nor nonresidents are allowed to convert into a foreign currency.

Free convertibility is far from universal. Many countries place some restrictions on their resident's ability to convert the domestic currency into a foreign currency (a policy of external convertibility). Restrictions range from the relatively minor (such as restricting the amount of foreign currency they may take with them out of the country on trips) to the major (such as restricting domestic businesses' ability to take foreign currency out of the country). External convertibility restrictions can limit domestic companies' ability to invest abroad, but they present few problems for foreign companies wishing to do business in that country. For example, even if the Japanese government tightly controlled the ability of its residents to convert the yen into US dollars, all US businesses with its deposits in Japanese banks may at any time convert all their yen into dollars and take them out of the country. Thus, a US company with a subsidiary in Japan is assured that it will be able to convert the profits from its Japanese operation into dollars and take them out of the country.

Government limits convertibility to preserve their foreign exchange reserves. A country needs an adequate supply of these reserves to service its international debt commitments and to purchase imports. Governments typically impose convertibility restrictions on their currency when they fear that free convertibility will lead to a run on their foreign exchange reserves. This occurs when residents and nonresidents rush to convert their holdings of domestic currency into a foreign currency – a phenomenon generally referred to as capital flight. Capital flight is most likely to occur when the value of the domestic currency is depreciating rapidly because of hyperinflation, or when a country's economic prospects are shaky in other respects. Not only will a run on foreign exchange reserves limit the country's ability to service its international debt and pay for imports, but it will also lead to a precipitous depreciation in the exchange rate as residents and nonresidents unload their holdings of domestic currency on the foreign exchange markets.

- iii. Counter-trade:** Companies can deal with the non-convertibility problem by engaging in counter-trade. Counter-trade refers to a range of barter like agreements by which goods and services can be traded for other goods and services. Counter-trade can make sense when a country's currency is nonconvertible.

Section 2: Review of Literature

There are some studies that show evidence on the factors explaining foreign exchange forward premium such as money supply, interest rate, lagged forward premium (Baillie and Kilic). The result reported in this study for nine different currencies leads to the existence of an outer regime that is consistent with uncovered interest parity. Bansal and Dahlquist (2000) has found that although the variable affecting the exchange rate could remain same across the countries, there would be some factors peculiar to a country which might also work as a major determinant of exchange rate, in the case of emerging economies. Another paper using the time series data on various factors like central bank intervention on exchange rate fluctuation is a study by Baillie and Kilic in 2002. They investigated the relationship, role of authorities, and intervention effectiveness within the context of a GARCH time series model. Ito and Roley (1987) had found the relationship between the inflation, interest rate and exchange rates in the case of US Dollar/Yen interest rates in an early paper.

In his book International Business: Competing in the Global Marketplace, Charles Hill (2005) has observed that investor's psychology and Bandwagon effect play a major role in determining short run exchange rate movements. However these effects can be hard to predict. Investor psychology can be influenced by political factors and by microeconomic events, such as the investment decisions of individual firms, many of which are only loosely linked to macroeconomic fundamentals, such as relative inflation rates. Also, bandwagon effects can be both triggered and exacerbated by the idiosyncratic behavior of politics. Something like this seems to have occurred in South East Asia during 1997 when, one after another, the currencies of Thailand, Malaysia, South Korea, and Indonesia lost between 50 % and 70 % of their value against the US dollar in a few months.

Section 3: Research Methodology

In order to model the behavior of Exchange rate with the aforesaid quantitative variables (the rate of interest of the **10 years G-sec bonds**, the **wholesale price index**, the **capital account balances**, the **current account balances**, the **trade balances**, and the **BSE Sensex***), a regression model is developed. The data was collected for the period from 1999 to 2003 (Quarterly average data on exchange rates). The overall model is said to be significant if it has a high R2 value (~ 90 %). The significance of the individual variables is decided based on the statistical t-values, p values and the beta coefficients. If the p-value corresponding to any variable is less than 0.05 then the variable is said to be significant.

For forecasting the future exchange rates, the **time series modeling** has been used with data from the year 1994 to 2003, so as to have a deep insight of the **seasonality, trend, cyclicity, and irregularity** factors in the foreign exchange markets. Seasonal indices have been calculated with the help of 12-

*BSE SENSEX stands for Bombay Stock Exchange Sensitive index

month centered moving average. Once seasonal indices have been calculated, the de-seasonalized data ($T * C * I$) is obtained as:

$$T * C * I = (S * T * C * I) / S$$

Next a linear regression analysis is done on the de-seasonalized data to get the Trend. Once the Trend is removed from the de-seasonalized data, the remaining data is a combination of cyclicity and irregularity.

$$C * I = (T * C * I) / T$$

Irregularity in data is due to unpredictable events such as the WTC¹ blast, the Mumbai riots etc, which are very tough to measure and define. Therefore in the analysis irregularity component is assumed to be 100.

Source of data: Handbook of Statistics on Indian Economy, Reserve Bank of India, 2003. The data is month end exchange rates figures from January, 1994 to December, 2003 and is based on FEDAI (Foreign Exchange Dealers' Association of India).

Section 4: Analysis and Results

For the regression analysis Average Quarterly data of variables w.e.f January 1999 to December 2003 is taken and the relationship between various factors and the exchange rates has been found quiet significant, the reason being the R² value which in the model is coming out to be about 94.2%, 86.7%, and 95.4% for the dollar, pound and euro respectively. From this observation it can be concluded that these factors explain much variability of the exchange rate fluctuation. The regression equations from the model are:

$$\text{For dollar: } 58.28 - 0.44 * X_1 + 0.0024 * X_5 - 0.0017 * X_6 \quad \mathbf{R^2 = 94.2\%}$$

(t = 45.86) (t = - 3.75) (t = 3.09) (t = - 8.77)

$$\text{For pound: } 83.65 - 1.92 * X_1 \quad \mathbf{R^2 = 86.7\%}$$

(t = 16.29) (t = -4.02)

$$\text{For euro: } 56.11 - 2.21 * X_1 + 0.0013 * X_6 \quad \mathbf{R^2 = 95.4\%}$$

(t = 15.44) (t = -6.54) (t = 2.29)

(The **beta coefficients** has been take up-to two decimal places)

To further show the significance of the model the **Standard error** has been calculated, which in these cases are quite low i.e. 0.48, 1.94 and 1.37 for the dollar, pound and euro respectively which again shows that the error in the model is insignificant to reject the validation. Also the future exchange rates

¹ World Trade Centre

can be forecasted using the above mentioned equations, taking the variables as defined earlier and increasing the value of the variable the future can well be predicted. The t values reported are significant in the results. (Refer to Table 1, 2, 3 for the full model).

Effect of quantitative variables on Exchange Rate

- i. Interest rates:** A direct negative correlation between the interest rate and the foreign exchange rates is being observed i.e. with an increase of interest rate, the foreign exchange rates falls, this can be measured through the **Beta coefficients**. In the analysis the beta coefficients are **(-0.44), (-1.923) and (-2.21)** for dollar, pound, and euro respectively. Significant P-values also measures the strength and significance of this factor in the model. The **P-value** for all the exchange rates in this analysis are **less** than the minimum significance level of **0.05** which is commonly known as the **alpha** value, this give the indication that the dependence of this factor on the exchange rate is quiet high and plays a significant role in determining the exchange rates.
- ii. Inflation:** In the analysis inflation is not found significant except for Euro rates, as the **P-value** for all of them is very **high** from the minimum significance level of 0.05. For Euro it is very close to 0.05. From the correlation between the inflation rate and the exchange rate it is observed that there is low degree of correlation between them, which shows the less impact on the exchange rates. As a result one can say that although inflation seems to be an important factor but it is important for the internal reasons and has a slight impact on the foreign exchange markets.
- iii. Balance of Payments:** Capital account balances and the current account balances have been taken separately, the reason is to get a clearer idea of the relationship assumed.
 - a) Capital Account Balance:** Analyzing the statistical output, done through the regression analysis it has been observed that the P-value is very high as compared to the alpha value for all the three exchange rates. Thereby showing the insignificance of the capital account balances in determining the foreign exchange rate fluctuations and looking at the beta coefficient it can be said that the dependency of this factor on the exchange rates is very low for all the three exchange rates
 - b) Current Account Balance:** Regression analysis performed on this factor throws a high significant relationship of the current account balances with the foreign exchange rate. This can be supported with the lower p-value of the dollar analysis as compared to the alpha value, thereby emphasizing on the significance of the current account balances in determining the exchange rates.
- iv. Trade balances:** A **p-value of 0.012** is obtained in case of **dollar** analysis showing the relevance of the trade balances in determining the future exchange rates. This can further be used for the forecasting of the foreign exchange rates through the obtained regression equation and various **beta values**. This is a factor which is directly related to the exchange rate also i.e. there is a cross functionality between the two, the reason being that a slight change in the exchange rate could make a huge impact on the trade balance e.g. an appreciation in the domestic currency means that exports are costlier so it would hamper the exports whereas it

will boost the import part and instead of going to the positive direction it would move towards the negative part and harm the economy as a whole.

- v. **Sensex:** Again the p-value for this factor is very low as compared to the minimum value of alpha of 0.05, thereby emphasizing on the significance of the factor in the model and also from beta coefficients values one can derive that the impact that this factor has on the foreign exchange rates is quite significant to predict the future values. Also it can be drawn from the analysis that if a country is looking strong in economical terms the foreign exchange rates also shows a positive signs for the economy. This is similar to a practical situation. For example, when Indian economy is at boom, the exchange rate is also improving.

Section 5: Forecasting model for the Exchange rates – Time Series Analysis

With the gradual increase in the foreign trade of India, the fluctuation in the foreign exchange market has increased which can be see through the foreign exchange rates of rupee vis- vis various other currencies on a daily or on a weekly basis.

In this analysis the relationship between rupee and various other currencies such as dollar, pound and euro has been observed through time series modal and an attempt has been made to predict or forecast the future rates of these mentioned foreign currencies.

Rupee Vs Dollar, Pound, Euro

As stated earlier, the **time series modeling** with the data from the year 1994 to 2003 has been used. This is done in order to have a deep insight of the **seasonality, trend, cyclicity, and irregularity** factors in the foreign exchange markets. Under mentioned is the analysis of the various factors of tome series

- i. **Seasonality:** The seasonality factor of the dollar shows that for the first six months, the seasonal indices are below 100 whereas the next five months is showing a better seasonality index. Similarly for pound the first half is dominated by the figures below 100 and it is the other way round for the other half. From this an insight has been drawn that the first six months of the calendar year is not as significant as the other half of the year for the foreign exchange market trading is concerned. Now to forecast the future exchange rates seasonality factor has been obtained which is similar throughout different years.
- ii. **Trend:** To separate the trend part from the de-seasonalized data a regression analysis has been performed from which the **R² value** for the Dollar, Pound, and Euro rates has been obtained as approx 58%, 63% and 40%. The analysis seems to be fine enough to predict the trend for the future analysis for the dollar as well as for pound, but for euro it is not that good, the reason might be the change of **Deutche mark** to euro. Looking at the **P values**, which in this case is very low so it can be said that the model for determining the trend value is quiet good. A **regression equation** has been obtained which has an **intercept** (means the constant part), and the **“Beta”** co-efficient which measures the sensitivity of the change in the variable factor; in

this case it is the time or the year. Following are the regression equations:

X variable refers to time period in months.

- **Dollar** – 52 – 37.88 * X **R² = 58%**
(t = 54.1) (t = -12.6)
- **Pound** – 81.8 – 60.18 * X **R² = 63%**
(t = 59.9) (t = -14.2)
- **Euro** – 52.8 – 62.79 * X **R² = 40%**
(t = 23.1) (t = -8.9)

iii. Cyclicalilty: After the separation of the trend from the de-seasonalised data the model is left with the cyclicalilty and the irregularity factor. The analysis of the cyclicalilty through **regression** shows the absence of the cyclicalilty in the model. Also the **R² value** in all the three cases is very low i.e. around 20% and in some cases 6%, showing the insignificance of the factor. From various **residual plots** and other charts it's clearly visualize that **no cyclicalilty exists** for the given ten years of interval. So it can be concluded that the cyclicalilty factor is absent in forecasting the future exchange rates. As a result cyclicalilty factor cannot be included in the model to predict the future exchange rates.

iv. Irregularity: As stated earlier the Irregularity factor is assumed to be equal to 100.

Section 6: Conclusion

Factors Affecting the Exchange rate Fluctuation

The regression analysis performed has shown the relevance of the various factors that impact the exchange rate fluctuations, the most important of these are the interest rates, the Sensex, the trade balances i.e. the external trade done by the country and the current account balances, which again lays emphasis on the external trade of a country be it merchandising or be it the service sector balances. On the other hand the factors such as the capital account balances and the inflation rates are found to be insignificant as a factor affecting the exchange rates of the country. The analysis majorly focuses on the quantitative factors i.e. the factors that are quantifiable; however there are factors that are difficult to quantify are explained in section 2, and are called qualitative factors.

Time Series Analysis

Combining all the factors i.e. seasonality, trend, cyclicalilty and irregularity and using the **multiplicative** model i.e. **(S*T*C*I)²**, the forecasted values are obtained as shown in the exhibit 3. Now all the three cases assume that there is **no cyclicalilty exists** in the model therefore the cyclicalilty factor has been removed for predicting the future values, also the irregularity factor has been taken as 100, thereby the only two major factors left are trend and seasonality so as per the multiplicative model the forecast

² Seasonality*Trend*Cyclicalilty*Irregularity

equation becomes $(S \cdot T \cdot I) / 10000$. **Extrapolating** the value for the coming years i.e. the seasonal and the trend factor and thereby getting the forecasted values for the different exchange rates. Comparing the actual rates with the forecasted rates, significant amount of similarity has been observed between the predicted data and the actual ones. Further the significance of the model can be clarified using the de-seasonalized data and comparing it with the actual values. From the general overview of the forecasted values it can be said that there is a gradual increase in the exchange rates over the decided interval of ten years. And if the same trend continues then the rates are going to increase gradually over the time.

Section 7: Tables

Table 1: Regression analysis for Rupee/Dollar Exchange Rate

	<i>Coefficients</i>	<i>Standard Error</i>	<i>t Stat</i>	<i>P-value</i>
Intercept	58.28328763	1.270686965	45.86754193	5.56849E-12
X Variable 1	-0.443669986	0.118422689	-3.746494782	0.00457937
X Variable 2	0.074325532	0.090221712	0.823809818	0.431336305
X Variable 3	-0.000253207	8.71261E-05	-2.906208965	0.017418405
X Variable 4	1.254140980	5.05447E-05	0.24812539	0.809606081
X Variable 5	0.00244527	0.000790197	3.094506682	0.012835749
X Variable 6	-0.001726538	0.000196816	-8.772339346	1.05238E-05

<i>Regression Statistics</i>	
Multiple R	0.97057931
R Square	0.942024196
Adjusted R Square	0.90337366
Standard Error	0.481113077
Observations	16

Table 2: Regression analysis for Rupee/Euro Exchange Rate

	<i>Coefficients</i>	<i>Standard Error</i>	<i>t Stat</i>	<i>P-value</i>
Intercept	56.1101052	3.633125987	15.44402958	8.75393E-08
X Variable 1	-2.214004025	0.338592085	-6.538853458	0.000106537
X Variable 2	0.577540817	0.257960344	2.238874421	0.05193865
X Variable 3	0.000298646	0.000249109	1.198856445	0.261196015
X Variable 4	-0.000218739	0.000144516	-1.513593363	0.164425023
X Variable 5	-0.001723339	0.002259318	-0.762769733	0.465122386
X Variable 6	0.001288188	0.000562733	2.289162454	0.047840154

<i>Regression Statistics</i>	
Multiple R	0.977064663
R Square	0.954655355
Adjusted R Square	0.924425592
Standard Error	1.375590111
Observations	16

Table 3: Regression analysis for Rupee/Pound Exchange Rate

	<i>Coefficients</i>	<i>Standard Error</i>	<i>t Stat</i>	<i>P-value</i>
Intercept	83.65376303	5.135116428	16.29052899	5.49777E-08

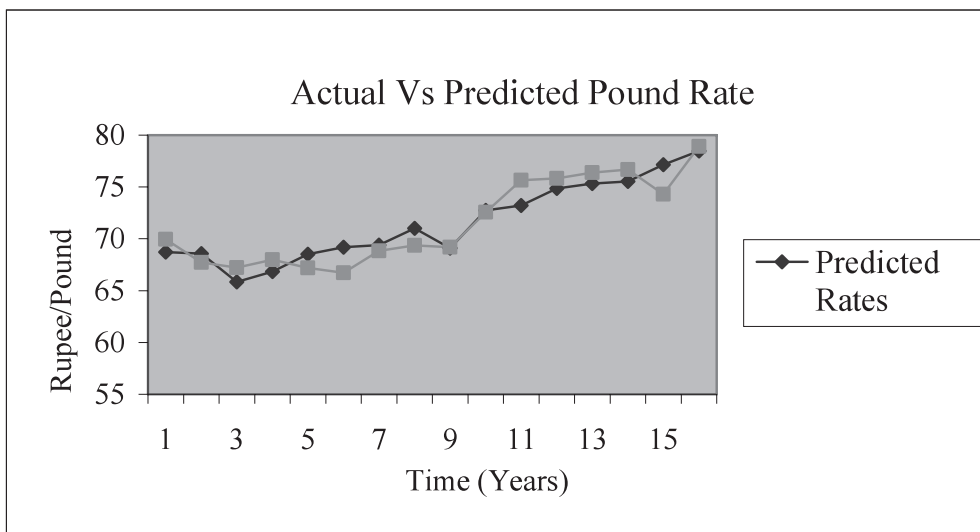
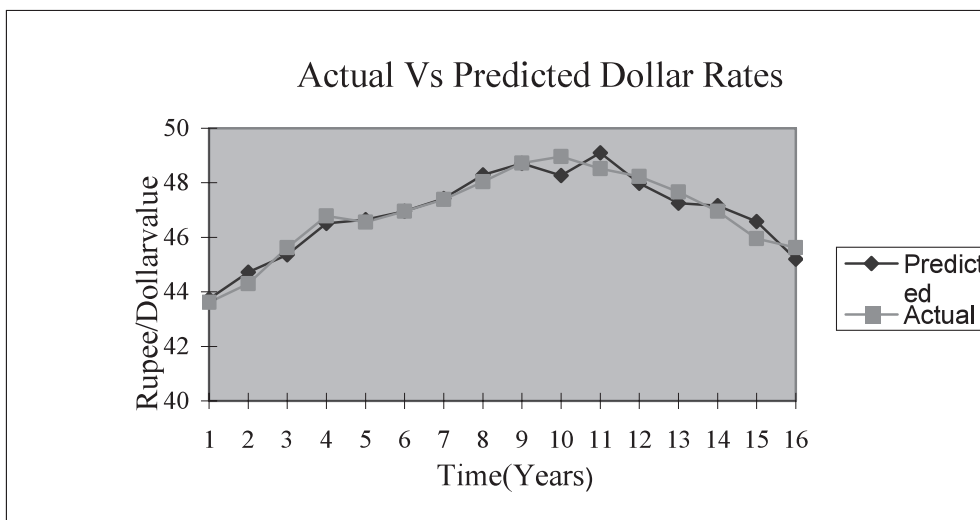
X Variable 1	-1.923792565	0.478571286	-4.019866255	0.003018669
X Variable 2	0.164993595	0.364605138	0.452526796	0.661600162
X Variable 3	6.66806E-05	0.000352095	0.189382342	0.853995295
X Variable 4	-0.00033264	0.000204262	-1.62849863	0.137860063
X Variable 5	-0.000150349	0.003193355	-0.047081977	0.963476092
X Variable 6	0.001091629	0.000795376	1.372469379	0.203147608

<i>Regression Statistics</i>	
Multiple R	0.931356545
R Square	0.867425013
Adjusted R Square	0.779041689
Standard Error	1.944280325
Observations	16

Section 8: Exhibits

Exhibit 1: Actual Vs Predicted exchange rates

Exhibit 2: Plot of Cyclic components



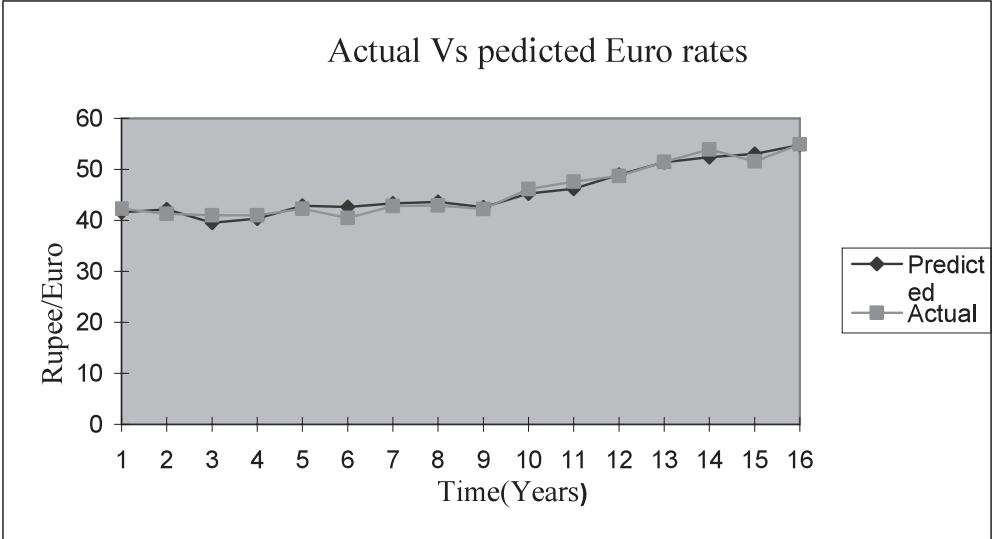
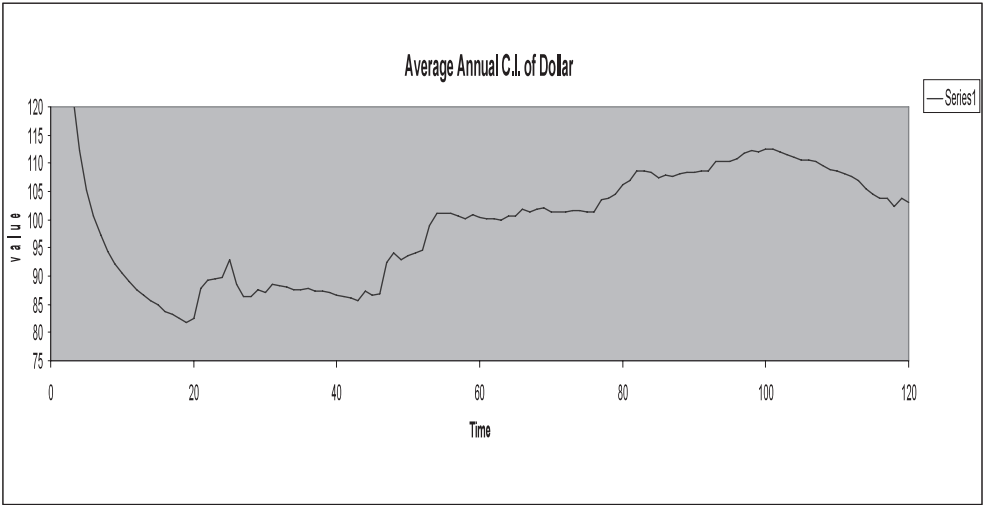
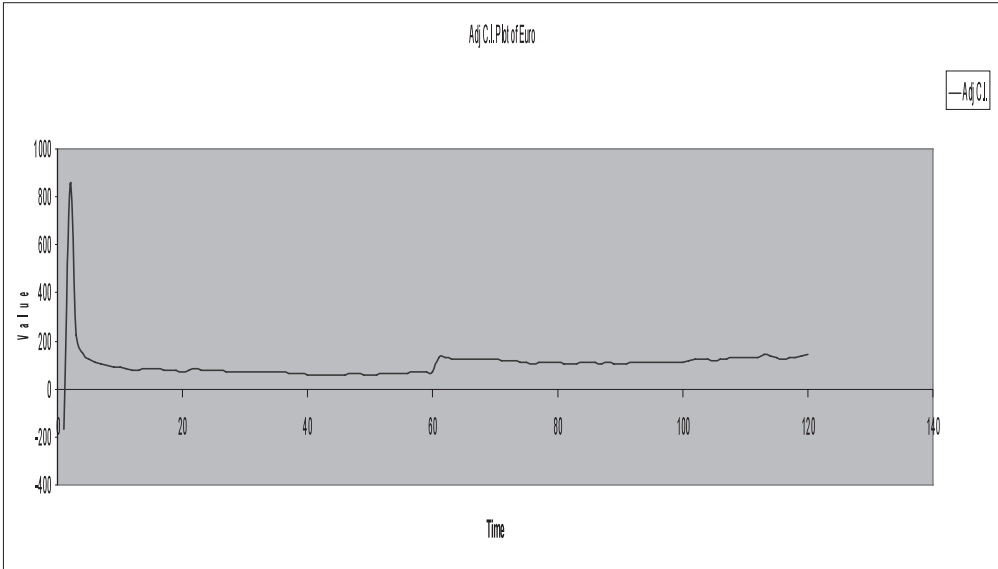
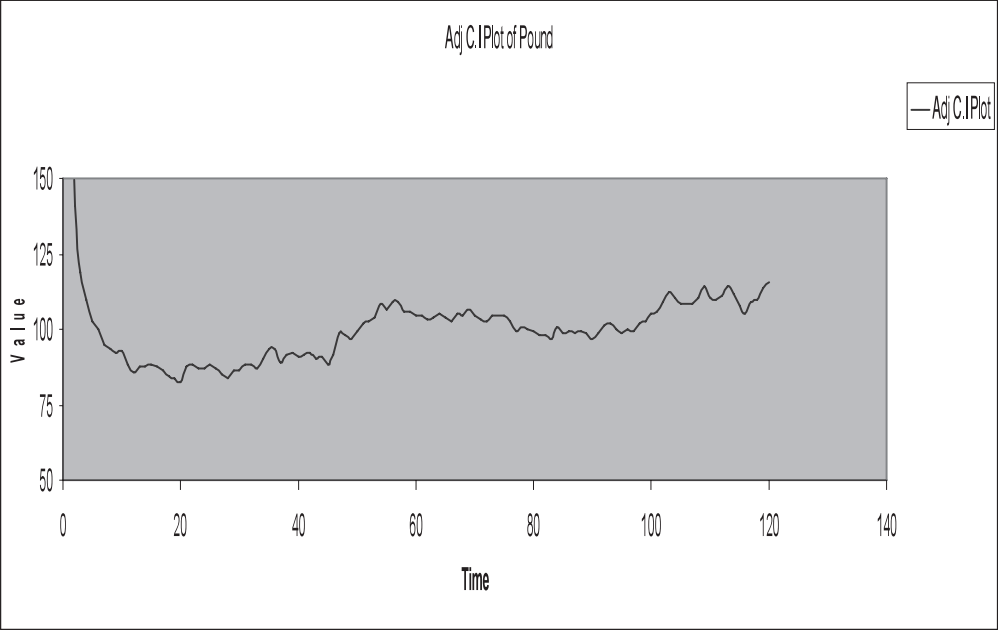
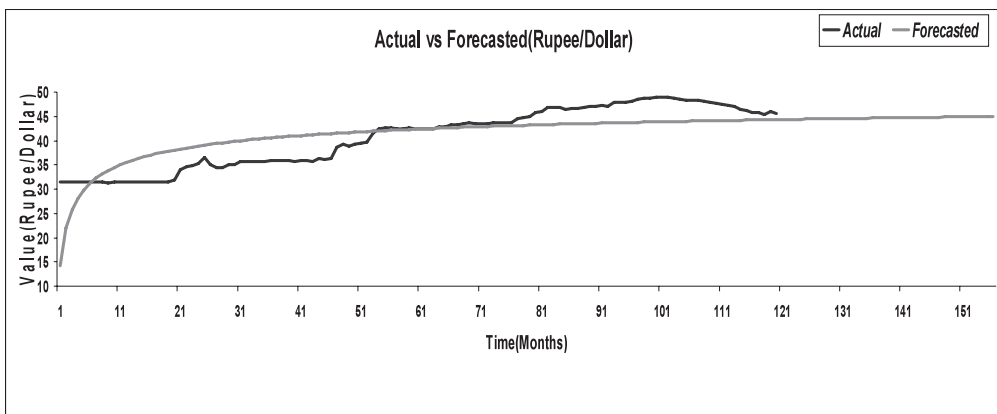
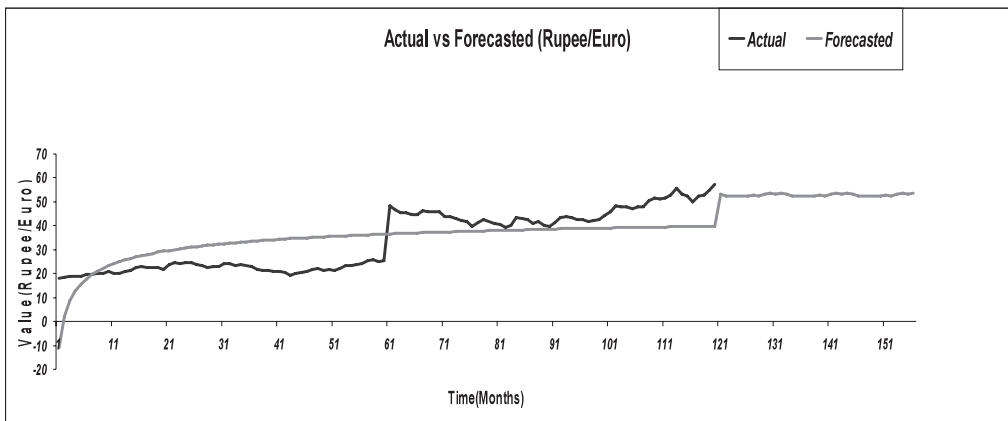
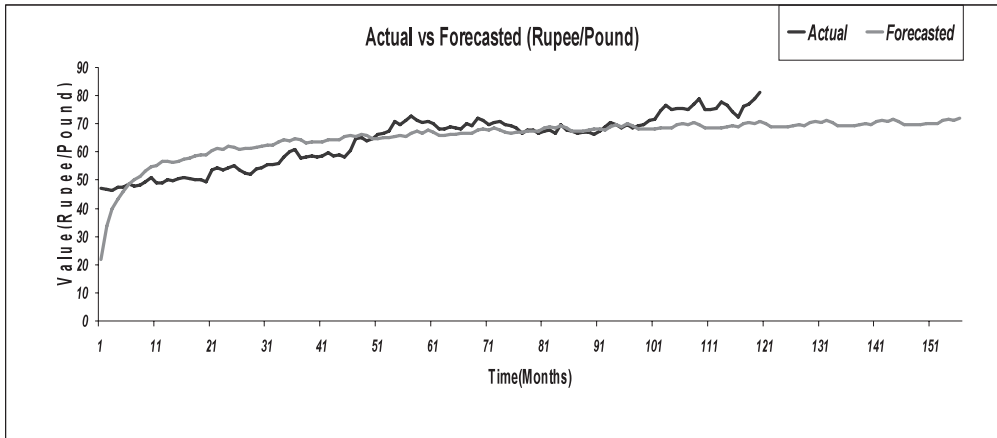


Exhibit 3: Forecasted Exchange Rate Values







Section 9: References

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