ABSTRACT

Movement in Indian Rupee versus US Dollar exchange rate has significant impact on the decision making of exporters, importers, bankers, businesses, financial institutions, policymakers, investors, NRIs and tourists. The movement in exchange rate generates volatility which results in risk to the concerned entity. Several models given by researchers have tried to find the forecasting models which can help the entities to reduce the risk associated with currency movements after successfully forecasting the movement of currency rates. In this paper we have tried to review the books/literature on several foreign exchange forecasting models and more specifically models to forecast exchange rate of USD vs Indian Rupee. The reviewed papers have mentioned different methodology used by authors including Box-Jenkins Methodology of building ARIMA model, bi-variate analysis, fundamental analysis etc. The paper also mentions the need for the appropriate model for exchange rate forecasting for the use of customer as well as bankers and other market players of foreign exchange market. The paper also finds further scope for determining the appropriate model for the use of banks and customers. Forward premium data of last 15 years have been studied to find scope for a fresh model which can reasonably forecast the USD/INR rates in short term. The daily USD/INR data since 2001 have been used from the database of RBI towards achieving the findings and discussions of the paper in addition to average monthly/yearly data since 1947 for other purposes.

Keywords--- Exchange rate forecasting, univariate analysis, Bi-variate analysis ARIMA, Box-Jenkins methodology, out of sample approach, Naïve forecast, Forward Rates

I. INTRODUCTION

An exchange rate describes the price of one currency in terms of another. The arithmetical value of one currency keep changing in respect of another due to several economic factors. This gradual change creates uncertainty about the future value of the foreign exchange and therefore there is significant risk associated with movement of exchange rates due to its volatility. Forecasting exchange rate is quite important not only for the firms having their business spread over different countries but also for the firms confined their entire business in the domestic market only, because a change in foreign exchange rate can change the amount of revenue generated in domestic currency also. Thus we can easily say that exchange rate is a key financial variable which affects decisions made by all stake holder of foreign exchange viz. bankers, financial institutions, business entities, foreign exchange investors, exporters, importers and policymakers. Movements in exchange rates have important implications for the economy’s business cycle, trade and capital flows and are therefore crucial for understanding financial developments and changes in economic policy. There are several variables which have impact on exchange rate movement, like, interest rate differentials, purchasing power parity, forward premium, capital flows, economic strength, central bank interventions and trade deficit etc. Based on these variables/parameters, several researches have been carried out to find the model which can define or forecast the movement of currency rates over a period of time. Basic exchange rate forecasting approach are fundamental approach and technical approach. The models based on these approaches are as under:

Purchasing power parity model- where exchange rate between two currencies are decided based on the purchase price of a commodity in these two countries and on the basis of price changes occurring due to inflation.
Relative Economic strength model— Here the model is based upon the difference of economic strength between the two countries.

Econometric Model— Here factors like interest rate, economic growth, income parameters etc are considered to forecast the exchange rate.

Time series Model— It is based on technical analysis of past values of exchange rates, based on which future rates are predicted.

In addition to above, we have discussed in this paper, the scope of forecasting exchange rate based on the forward premium available in foreign exchange market in respect of USD/INR.

II. INDIAN PERSPECTIVE OF FOREIGN EXCHANGE POLICIES

In India, currency rates has remained mostly regulated since Independence till opening of Indian economy in 1991-1992 and the volatility of movement of USD/INR had therefore been different for period 1947 - 1974, 1975 – 1992 and from 1993 till date. Since Independence and till 1975 it was par value system. Subsequently after devaluation of Indian Rupee and after war with China and Pakistan, Indian Rupee was pegged with a basket of foreign currency and system was highly regularized and there were restriction on external transactions also. After paradigm shift in Indian Economic reforms, Liberalised Exchange Rate Management System came into existence after 1993. The movement of INR and foreign exchange policy since 1947 with respect to US Dollar is depicted in Chart 2.1 and table 2.1 respectively:

Till 2008, i.e till the time of world economic crisis, the volatility in USD/INR was subdued however the same have since increased significantly giving rise to higher amount of risk associated with exchange rate and requirement of forecasting was much more necessitated. In this paper, we have studied the volatility of USD/INR during these periods, which signifies the requirement of currency forecasting model for bankers and its customers, more specifically after 2001 when the exchange rates have become more volatile.

III. ECONOMIC THEORY AND REVIEW OF LITERATURE

In the international finance literature, various theoretical models are available to analyze exchange rate determination and behaviour. Most of the studies on
exchange rate models prior to the 1970s were based on the fixed price assumption studied by researchers like Marshall (1923), Lerner (1936), Nurkse (1944), Harberger (1950), Mundell (1961, 1962, 1963) and Fleming (1962). With the advent of the floating exchange rate regime amongst major industrialized countries in the early 1970s, an important advance was made with the development of the monetary approach to exchange rate determination. The dominant model was the flexible-price monetary model that has been analyzed in many early studies like Frenkel (1976), Mussa (1976, 1979), Frenkel and Johnson (1978), and by Vitek (2005), Nwafor (2006), Molodtsova and Papell, (2007). Following this, the sticky price or overshooting model by Dornbusch (1976, 1980) was evolved, which has been tested, amongst others, by Alquist and Chinn (2008) and Zita and Gupta (2007). The portfolio balance model developed by researchers like Dornbusch and Fischer (1980), Isard (1980), Branson (1983, 1984), which allowed for imperfect substitutability between domestic and foreign assets, and considered wealth effects of current account imbalances. With liberalization and development of foreign exchange and assets markets, variables such as capital flows, volatility in capital flows and forward premium have also become important in determining exchange rates. Furthermore, with the growing development of foreign exchange markets and rise in the trading volume in these markets, the micro level dynamics in foreign exchange markets increasingly became important in determining exchange rates. Market players in the foreign exchange market have access to private information about fundamentals or liquidity, which is reflected in the buying/selling transactions they undertake, that are termed as order flows (Medeiros, 2005; Bjonnes and Rime, 2003). Microstructure theory evolved in order to capture the micro level dynamics in the foreign exchange market (Evans and Lyons, 2001, 2005). Another variable that is important in determining exchange rates is central bank intervention in the foreign exchange market.

Non-linear models have also been considered in the research papers of Sarno (2003), Altaville and Grauwe (2006). Overall, forecasting the exchange rates has remained a challenge for both academicians as well as market participants. In fact, in the study of Meese and Rogoff’s seminal study (1983) on the forecasting performance of the monetary models demonstrated that these study failed to beat the random walk model. This has generated large number of studies that test the superiority of theoretical and empirical models of exchange rate determination vis-a-vis a random walk. In sum studies, several exchange rate models have been tested during the last three and a half decades. No particular model seems to work best at all times/horizons. Monetary models based on the idea of fundamentals’ driven exchange rate behaviour work best in the long-run, but lose their predictability in the short-run to naïve random walk forecasts. The volatility of exchange rates also substantially exceeds that of the volatility of macroeconomic fundamentals, thus providing further evidence of weakening fundamental-exchange rate link. A combination of the different monetary models, however, at times gives better results than the random walk. Order flows also play an important role in influencing the exchange rate.

IV. TIME SERIES MODEL

Most of the studies has used the Time series model to forecast the exchange rate. Time series models are based on the logic that data points taken over time may have an internal structure like autocorrelation, trend or seasonal variance. Paper uses univariate time series model called ARIMA (autoregressive integrated moving average) model, which says that the current value of a variable can be explained in terms of two factors: a combination of lagged values of the same variable and a combination of a constant term plus a moving average of past error terms. An autoregressive model is one where the current value of a variable can be explained in terms of values of the variable taken in the past plus an error term. An autoregressive model of order p, AR (p) is explained as: $y_t = \mu + \Phi_1 y_{t-1} + \Phi_2 y_{t-2} + \ldots + \Phi_p y_{t-p} + \epsilon_t$ (4.1)

Where $\epsilon_t$ is a white noise disturbance term. In the lag operator form equation (4.1) can be written as $\Phi (L) y_t = \mu + \epsilon_t$ Where $\Phi (L) = (1 - \Phi_1 L - \Phi_2 L^2 - \ldots - \Phi_p L^p)$

A moving average processes assumes that the current value of a variable can be explained in terms of sum of a constant term plus a moving average of current and past white noise disturbances terms. A moving average of order q, MA (q) is explained as: $y_t = \mu + \epsilon_t + \theta_1 \epsilon_{t-1} + \theta_2 \epsilon_{t-2} + \ldots + \theta_q \epsilon_{t-q}$ (4.2)

In the lag operator form equation (2) can be written as $\epsilon_t = \mu + \theta (L) \epsilon_t$ Where $\theta (L) = 1 + \theta_1 L + \theta_2 L^2 + \ldots + \theta_q L^q$ ARMA (p, q) process is a combination of AR (p) and MA (q) models. In the lag operator form this model is written as: $\Phi (L) y_t = \mu + \theta (L) \epsilon_t$ (4.3)

To build an ARIMA model one essentially use Box-Jenkins methodology (1976), which is an iterative process and involves four stages; Identification, Estimation, Diagnostic Checking and forecasting. The whole process starts with the checking of stationary and seasonality in the series. Further analysis of the series is performed on the basis of either a Unit-Root test or Correlogram5 technique.
**V. FORWARD RATES MODEL FOR USD/INR RATE**

It has been revealed from the studies (Sharma and Mitra, 2006) in context to India that forward premium on US Dollar (USD) is driven by the interest rate differential of the two countries combined with FII flow, current account balance. Further empirical analysis for the period Jan 1995 to Dec 2006 have shown that future rates prediction has improved with the use of forward rates and there is correlation between the forward rate and future rate (RCF, 2005-06). Forecasting of currency rate can be done on the basis of forward rates available in the market which has already discounted all the affecting factors. Using the forward rate quotes of different maturity (1-Month, 3-Month and 6-Month) the future rate of a currency pair may be obtained. In India, monthly, quarterly, half yearly and yearly forward premium are available in the foreign exchange market. We have found the future rates based on these forward premium and it has then been compared with actual rates. In our model, actual rate available 6 months ago, three months ago, one month ago and current rate along with forward rates for 1 month, 3 month and six month have been taken from RBI site and same has been taken to arrive future rate as under:

\[ R_{1f} = R_{c0} + P_{1m} \]

where, \( R_{1f} \) is future rate of currency after one month
\( R_{c0} \) is current exchange rate and
\( P_{1m} \) is premium / discount for one month

Similarly,

\[ R_{3f} = R_{c2} + P_{3m} \]

where, \( R_{3f} \) is future rate of currency after one month, based on two month previous rate
\( R_{c2} \) is exchange rate two month ago and
\( P_{3m} \) is premium / discount for 3 month, two month ago i.e during \( R_{c2} \)

and

\[ R_{6f} = R_{c5} + P_{6m} \]

where, \( R_{6f} \) is future rate of currency after one month, based on 5 month previous rate
\( R_{c5} \) is exchange rate five month ago and
\( P_{6m} \) is premium / discount for 6 month, five month ago i.e during \( R_{c5} \)

Thus predicted rate for one month future

\[ R_{f} = \text{average} \ (R_{1f} + R_{3f} + R_{6f}) + e \ (\text{error}) \]

**VI. FINDINGS**

Most papers has used Box-Jenkins methodology for building ARIMA model, exponential smoothing, naïve 1 and naïve 2 models. USD/INR rates of last 15 years shows that ARIMA models provides a better forecasting of exchange rates than exponential smoothing and Naïve models do. Comparison of the MAE (Mean absolute Error), MAPE (Mean absolute percentage Error), MSE (Mean Squared Error) and RMSE shows that the ARIMA model is the best among all these models. The main findings by Pammi dua and Rajiv Ranjan (RBI report 2012) are as follows:

(i) The monetary model generally outperforms the naïve model. This negates the findings of the seminal study by Meese and Rogoff (1983) that finds that models which are based on economic fundamentals cannot outperform a naïve random walk model.

(ii) The result that it is possible to beat the naïve model may be due to the fact that the intervention by the central bank may help to curb volatility arising due to demand-supply mismatch and stabilize the exchange rate. The exchange rate policy of the RBI is guided by the need to reduce excess volatility.

(iii) Forecast accuracy can be improved by extending the monetary model to include forward premium, volatility of capital inflows and order flow.

Thus, availability of information on certain key variables at regular intervals that affect the exchange rate can lead to a more informed view about the behavior of the future exchange rates by the market participants. Such key variables could include past data on exchange rates, forward premia, capital flows, turnover, and intervention by central banks etc.

Vincenzo Pacelli in “Forecasting Exchange Rates: a Comparative Analysis” has analyzed ANN (Artificial Neural Network), ARCH (Autoregressive Conditional Heteroskedasticity) and GARCH (Generalized Autoregressive Conditional Heteroskedasticity) models to forecast the daily exchange rates and arrived at the conclusion that these models provide better result than the other models and more specifically ARCH and GARCH are better than ANN models.

**Finding from Forward rate Model:**

The study was carried for the period 2001 to 2016 given in the table 6.1 from which it is clear that USD/INR has remained less volatile during 2001-06 where the standard deviation of USD/INR rate has remained below 1. However in 2007, 2008 and 2009 it’s value crossed 1 and the reason for high volatility was given to uncertainty due to global economic crisis of 2008. Thereafter, volatility of USD INR has increased till date.

**Table 6.1 (USD/INR rate movement since 2001 along with its volatility)**

<table>
<thead>
<tr>
<th>YEAR</th>
<th>AVERAGE USD/INR rate</th>
<th>LOW USD/INR rate</th>
<th>HIGH USD/INR rate</th>
<th>RANGE-USD/INR rate</th>
<th>STND. DEVIATION</th>
<th>VARIANCE</th>
</tr>
</thead>
</table>
For the period March 2011 till March 2016, the result of model given in equation (5.4) has been depicted through graph 6.1, which shows that except for the period Dec 2014 to March 2016, the model gives large amount of error and therefore we can conclude that forward rates do not give the true picture of exchange rate in future and therefore there are scope for additional research in this field.

We have studied the movement of USD/INR rate along with 1 month, 3 month and six month forward rate to arrive the average predicted rate since 2001 and the result has been depicted in the graph 5.1. The study shows that the model has worked for last two years very significantly. The studies carried during last five years has been depicted in the chart 5.1

VII. FUTURE SCOPE & CONCLUSION

Other models like Bayesian Vector Autoregression (BVAR), Bayesian Vector Error Correction Model (BVECM), exponential smooth transition autoregressive (ESTAR) model, Bootstrap technique, PCARIMA, ARCH models, a full family of GARCH models and various other non-linear models may be used for forecasting the USD/INR exchange rates.

Further use of forward premia of different maturities for forecasting of exchange rates can be studied
and appropriate error factor may be obtained so as to forecast exchange rate at higher confidence level.

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