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FORECASTING OF INR/USD EXCHANGE RATES

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ABSTRACT

This article investigates the out-of-sample forecast performance of auto regressive integrated moving average (ARIMA) and Feed forward neural networks models for forecasting of INR/USD exchange rates. Neural networks model is outperforming than the ARIMA model. The results show that the exchange rate is declining and the value of rupee is increasing in the near future.

Keywords: Box-Jenkins Methodology, Exchange Rate, Neural Networks.

INTRODUCTION

Foreign exchange market is a virtual place, where one currency gets exchanged with other currency. There is neither a particular place (physical market) nor there is an organized exchange as such where traders meet and exchange currencies (Annachhatre, 2010).The Foreign exchange market in India till late 1990’s remained highly regulated, i.e., restrictions on external transactions, barriers to entry, low liquidity and high transaction cost, etc. The exchange rate was managed mainly for facilitating India’s imports.During the early 1990s, India embarked on a series of structural reforms in the foreign exchange market. The movement away from pegged exchange rate regime to partially floated in 1992 and fully floated in 1993 was instrumental in developing a market-determined exchange rate of the rupee and was a significant step in the progress towards total current account convertibility. A well developed foreign exchange derivative market was started in 2008. The exchange rate policy does not aim at a fixed target or a pre-announced target or a band but is supported by the ability of Reserve Bank to intervene in the markets, if and when necessary, only to smoothen any undue volatilities or disorderly market behaviour, while allowing the underlying demand and supply conditions to determine the exchange rate movements over a period in an orderly manner (Sharma, 2011).

Exchange rate risk has risen far more than the amount of foreign trade and due to ever rising overseas investments; exchange rates have become increasingly volatile. Wild fluctuations in the rupee exchange rate within a short span of time are unsettling and leaving its imprint on the rest of the economy. The depreciating rupee will add further pressure on the overall domestic inflation and since India is structurally an import intensive country, as reflected in the high and persistent current account deficits month after month, the domestic costs will rise on account of rupee depreciation. The rupee depreciation will particularly hit the industrial sector and put higher pressure on their costs as items like oil, imported coal, metals and minerals, imported industrial intermediate products all are getting affected (ASSOCHAM, 2011).

Rupee-dollar rates were more or less stable till 1990. After 1991 it has started fluctuating widely, reason could be that the India adopted the US $ as a currency of intervention in 1992 and thereafter the rise in trade activities, increase in software exports, and mainly capital flows resulted in to these fluctuations. The volatile nature of the foreign exchange market is on rise due to increase in capital flows, the rising cross-border trade, and integration of the international financial market. It was observed that particularly after globalization the market has become extremely volatile thereby affecting the revenue and expenditure of the corporates. Unexpected changes in exchange rates can have important impacts on sales, prices and profits of both exporters and importers. And this situation has created a need for the forecasting. The time dependence of the exchange rates is usually complex in nature and hence, it is interesting to analyze using the newly developed statistical methods. Exchange rate forecasts are necessary to evaluate the foreign denominated cash flows involved in international transactions. Thus, exchange rate forecasting is very important to evaluate the benefits and risks attached to the international business environment. In this paper, we develop two forecasting models for the given data.

The foreign exchange market in India started in earnest less than three decades ago when in 1978 the government allowed banks to trade foreign exchange with one another. Today over 70% of the trading in foreign exchange continues to take place in the inter-bank market. Trading is regulated by the Foreign Exchange Dealers Association of India (FEDAI), a self regulatory association of dealers. Since 2001, clearing and settlement functions in the foreign exchange market are largely carried out by the Clearing Corporation of India Limited (CCIL) that handles transactions of approximately 3.5 billion US dollars a day, about 80% of the total transactions.As in any market essentially the demand and supply for a particular currency at any specific point in time determines its price (exchange rate) at that point. However, since the value of a country's currency has significant bearing on its economy, foreign exchange markets frequently witness government intervention in one form or another, to maintain the value of a currency at or near its "desired" level. Interventions can range from quantitative restrictions on trade and cross-border transfer of capital to periodic trades by the central bank of the country or its allies and agents so as to move the exchange rate in the desired direction. In recent years India has witnessed both kinds of intervention though liberalization has implied a long-term policy push to reduce and ultimately remove the former kind. It is safe to say that over the years since liberalization, India has allowed restricted capital mobility and followed a "managed float" type exchange rate policy (Chakrabarti, 2007).

METHODOLOGY

Data is collected from Reserve Bank of India, which contains the daily exchange rates from January 2, 2012 to August 21, 2013. We used to this data to model the exchange rates using two well-known methodologies namely Box-Jenkins Methodology and Neural Networks. The performance of the models tested on the data set consisting of daily exchange rates during 22.08.2013 to 19.09.2013 (validation set/out-of-sample) with the help of mean absolute error, root mean squared error and mean absolute percentage error.

Box-Jenkins methodology has a large class of models to choose from and a systematic approach for identifying the correct model form. Auto Regressive Integrated Moving Average (ARIMA) models are univariate time series forecasting models. A substantially improved procedure is now available for conducting Box-Jenkins ARIMA analysis which relieves the requirement for a seasoned perspective in evaluating the sometimes ambiguous autocorrelation and partial autocorrelation residual patterns to determine an appropriate Box-Jenkins model for use in developing a forecast model. For univariate model building, a class of autoregressive integrated moving average (ARIMA) models is postulated, of the form:

$$ARIMA(p,d,q) = \phi_p(B)\nabla^d \tilde{Z}_t = \theta_q(B)a_t$$

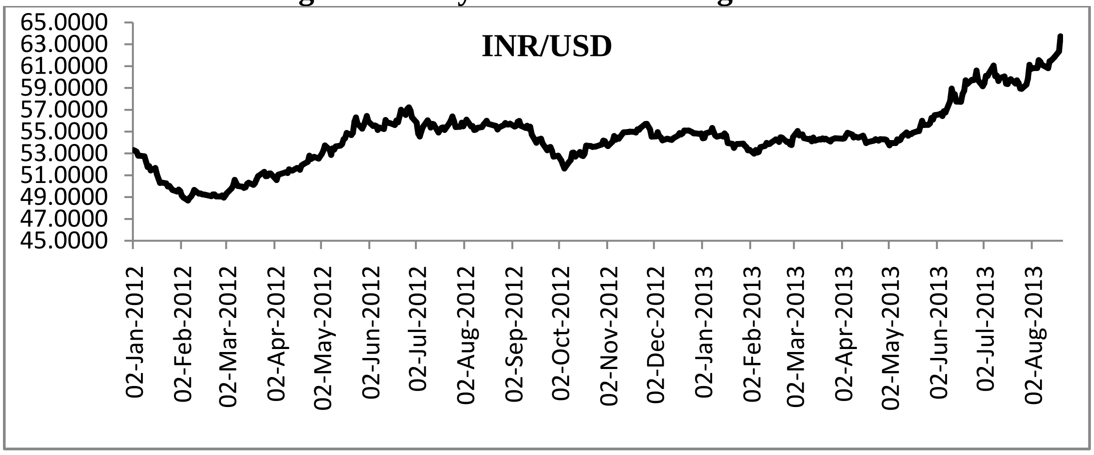
where: Z_t = observation at time t. $\bar{Z}$ = overall mean of the time series data. $\tilde{Z}_t = Z_t - \bar{Z}$. a_t = random shock, or white noise at time t and $a_t \sim NID(0,\sigma_a^2)$. B= a backward shift operator and $BZ_t = Z_{t-1}$. $\phi_p(B) = 1-\phi_1 B-\phi_2 B^2 - .... - \phi_p B^p$ is a polynomial in B of order p and is known as autoregressive operator. $\theta_q(B) = 1-\theta_1 B-\theta_2 B^2 - ......\theta_q B^q$ is a polynomial in B of order q and is known as moving average operator. $\nabla^d = (1-B)^d$ =difference operator. The Box-Jenkins methodology involves four steps (Box et.al., 1994): identification (2) estimation (3) diagnostic checking and (4) forecasting. First, the original series must be transformed to become stationary around its mean and its variance. Second, the appropriate order of p and q must be specified using autocorrelation and partial autocorrelation functions. Third, the value of the parameters must be estimated using some non-linear optimization procedure that minimizes the sum of squares of the errors or some other appropriate loss function. Diagnostic checking of the model adequacy is required in the fourth step. This procedure is continued until an adequate model is obtained. Finally, the future forecasts generated using minimum mean square error method (Box et. al. 1994). ARIMA models are used as benchmark models to compare the performance of the other models developed on the same data set.

Recently, ANN models have received increasing attention as decision making tools. Plentiful studies have shown that neural networks can be one of the very useful tools in time series forecasting. Neural networks have general nonlinear function mapping capability which can approximate any continuous function with arbitrarily desired accuracy (Zhang and Hu, 1998). Neural networks are data driven and data mining techniques provides a single platform for many of the statistical applications (Boiroju, 2012).Haykin (1999), Kastra and Boyd (1996) Zhang et.al. (1998), Reddy & Boiroju (2008) and Boiroju (2012) present the neural networks methodology and its application in time series forecasting. A typical neural networks model with one hidden layer with hyperbolic tangent activation function will be in the form of $Z_t = \mu + \sigma\left(\gamma + \delta Tanh\left(\alpha + \beta\left(Z_{t-1} - \mu\right)/\sigma\right)\right)$, in which μ and σ denote the mean and standard deviation of the time series and the hidden layer weights α, β and the output layer weights γ, δ are determined by using the supervised learning method. Feed forward neural networks (FFNN) is used with hyperbolic tangent function as an activation function under one hidden unit in a single hidden layer and the lagged observation taken as the input for the network to predict the future exchange rates. Neural networks are trained with the help of SPSS software.

RESULTS

The time plot of the daily exchange rates from 02 January, 2012 to 21 August, 2013 is given in the following figure

Figure 1. Daily INR/USD exchange rates



Source: Reserve Bank of India.

ARIMA model for the given data is developed using SPSS software and the adequate model from the different iterations is obtained as $\hat{Z}_t = Z_{t-1} + 0.111a_{t-9} + 0.154a_{t-12}$. This model more emphasises on the lagged observation with some significant previous errors. Similarly, the neural networks model for the given data is

$\hat{Z}_t = 54.59 + 2.84\left(0.396 - 5.755Tanh\left(0.071 - 0.179\left(Z_{t-1} - 54.59\right)/2.84\right)\right)$. The error measures in in-sample and out-of-sample data are presented in the Table 1 and the out-of-sample forecasts generated by the given two models are presented in the Table 2.Table 3 presents the next one week forecasts using the two models.

Table 1. Forecasting Errors of the Models

Measure of Error	Model	In-sample	Out-of-sample
MAE	ARIMA	0.267	1.820
	FFNN	0.267	0.972
RMSE	ARIMA	0.346	2.247
	FFNN	0.340	1.309
MAPE	ARIMA	0.485	2.758
	FFNN	0.485	1.478

The FFNN model has minimum error measures in both the stages of model building and forecasting. The two models presents almost the same errors at model building stage but the neural networks model performance in the out-of-sample set is significantly different from the ARIMA model.

Table 2. Out-of-Sample Forecasts of Daily Exchange Rates

Date	USD	ARIMA	FFNN
22-Aug-2013	65.42	63.47	63.11
23-Aug-2013	64.69	63.42	64.63
26-Aug-2013	64.23	63.50	64.08
27-Aug-2013	65.67	63.57	63.73
28-Aug-2013	68.36	63.51	64.80
29-Aug-2013	67.71	63.49	66.54
30-Aug-2013	66.57	63.64	66.15
02-Sep-2013	65.86	63.76	65.43
03-Sep-2013	66.89	63.77	64.94
04-Sep-2013	67.03	63.84	65.63
05-Sep-2013	66.04	64.02	65.73
06-Sep-2013	65.96	63.97	65.07
10-Sep-2013	64.22	63.97	65.01
11-Sep-2013	63.90	63.97	63.72
12-Sep-2013	63.67	63.97	63.47
13-Sep-2013	63.79	63.97	63.28
16-Sep-2013	62.48	63.97	63.38
17-Sep-2013	63.38	63.97	62.29
18-Sep-2013	63.14	63.97	63.05
19-Sep-2013	61.75	63.97	62.85

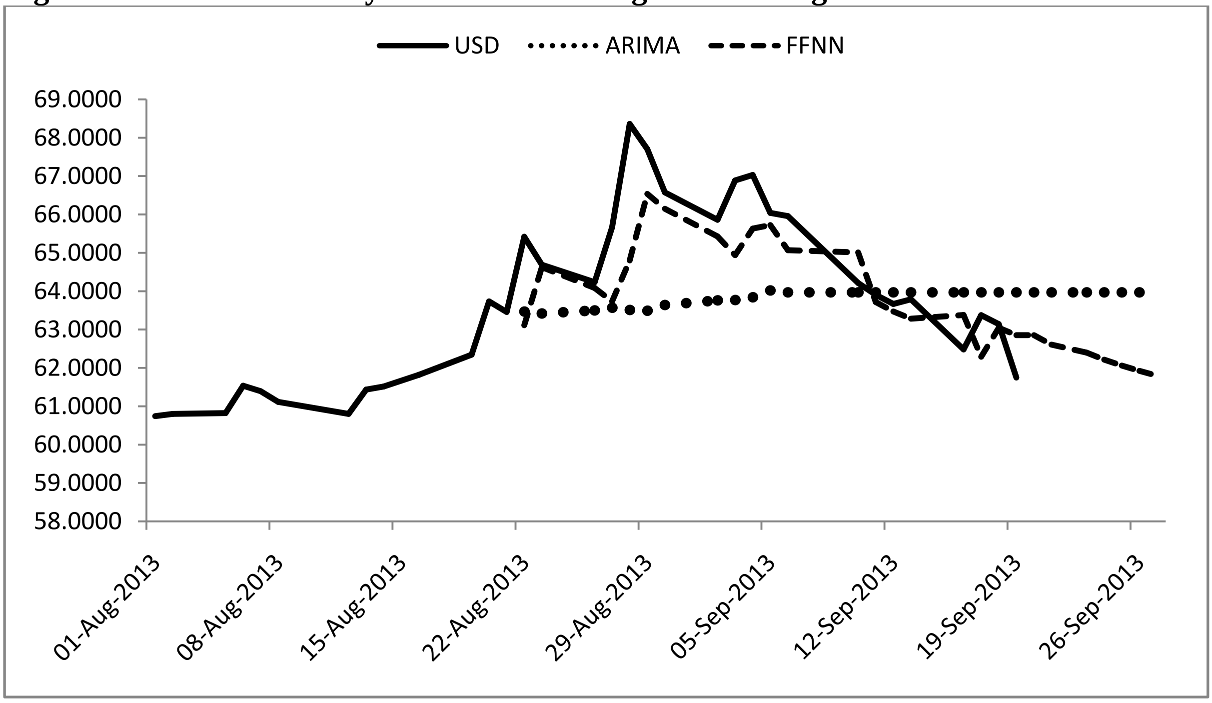
ARIMA model predicting the exchange rates linearly whereas the FFNN model presenting the fluctuating exchanges rates based on the input of the previous observation. These forecasts suggest that the FFNN model closely predicting the future exchange rates with minimum error as compared with the ARIMA model. The following Table presents the forecast for the next seven days using these two models.

Table 3. Forecasts of Exchange Rates for Next Seven Days

Date	ARIMA Forecasts	FFNN Forecasts
20-Sep-2013	63.97	62.85
21-Sep-2013	63.97	62.61
23-Sep-2013	63.97	62.40
24-Sep-2013	63.97	62.22
25-Sep-2013	63.97	62.06
26-Sep-2013	63.97	61.92
27-Sep-2013	63.97	61.80

From the above table, it is clear that the ARIMA model predicts a stationary value of Rs.63.97 per Dollar, whereas the FFNN model predicts that the exchange rates declining from Rs. 62.85 to 61.80 per dollar during 20-27 September, 2013. These forecasts are very useful for the future planning of tourism and EXIM policies. The following figure presents the forecasts of exchange rates in out-of-sample period to future seven days period.

Figure 2. Forecasts of Daily INR/USD Exchange Rates using ARIMA and FFNN Models



The figure 2, depicts that the forecasts of exchange rates are decreasing in the next seven days and stagnant trend observed from the forecasts of ARIMA model for the same period. The two forecasts suggest that there is a compound daily growth rate in exchange rate movement is varied from 0.00 per cent to -0.28 per cent.

CONCLUSION

This article analysed the out-of-sample forecasting performance of two competing models of exchange rate determination. In general, the results suggest that the behaviour of the exchange rate is decreasing and the value of the rupee is increasing in the near future.

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