ISSN (Print) : 0974-6846
Indian Journal of Science and Technology, *Vol 9(8), DOI: 10.17485/ijst/2016/v9i8/87904, February 2016* ISSN (Online) : 0974-5645

Foreign Exchange Rate Forecasting using Levenberg-Marquardt Learning Algorithm

S. Kumar Chandar[1*], M. Sumathi[2] and S. N. Sivanandam[3]

[1]Christ University, Bangalore - 560029, Karnataka, India; kcresearch2014@gmail.com
[2]Sri Meenakshi Government College for Arts for Women (Autonomous)
Madurai - 625002, Tamil Nadu, India; sumathivasagam@gmail.com
[3]Karpagam College of Engineering, Coimbatore - 641032, Tamil Nadu, India; sns12.kit@gmail.com

Abstract

Background/Objectives: Foreign currency Exchange (FOREX) plays a vital role for currency trading in the international market. Accurate prediction of foreign currency exchange rate is a challenging task. The paper investigates the FOREX prediction using feed forward neural network. **Methods/Statistical analysis:** This paper employs artificial neural network to forecast foreign currency exchange rate in India during 2010-2015.The exchange rates considered between Indian Rupee and four major currencies Euro, Japanese Yen, Pound Sterling and US Dollar. The network developed consists of an input layer, hidden layer and output layer. The neural network was trained with Levenberg-Marquardt (LM) learning algorithm. Root Mean Square Error (RMSE), Mean Absolute Error (MAE) and Forecasting Error (FE) are used as indicators for the performance of the networks. **Findings:** Simulation results are presented to show the performance of the proposed system. The paper also aims to suggest about network topology that must be chosen in order to fit time series kind of complicated data to a neural network model. The proposed technique gives the evidence that there is possibility of extracting information hidden in the foreign exchange rate and predicting into the future. **Applications/Improvements:** Finally, this paper presents the best network topology for FOREX prediction by comparing the effectiveness of various hidden layer performance algorithm using MATLAB neural network software as a tool.

Keywords: Exchange Rate, Forecasting Error, Mean Absolute Error, Network Topology and Levenberg - Marquardt Learning Algorithm

1. Introduction

The currency exchange market, also referred to as Foreign Exchange (FOREX) market was established in 1971, when floating exchange rate began to materialize. FOREX is the world's largest market with daily trading volume in excess of $3 trillion U.S Dollars[1]. Foreign currencies are special financial assets and exchange rates are vital financial indicators in the financial market. The problem of forecasting the movement of foreign exchange rates attracts increasing attentions. The forecasting of FOREX poses substantial theoretical and experimental challenges given the abandonment of the field exchange rates. Foreign exchange rates are influenced by several correlated economic, political and psychological factors. These factors are highly linked and interconnected with one another in very complex fashion. This complexity makes predicting FOREX changes extremely difficult. Accurate prediction of foreign currency exchange rate is a necessary factor for the success of many businesses. Researchers and practitioners have been attempting for an explanation of the movement of FOREX rates. Thus, diverse kinds of forecasting methods have been developed by many researchers and experts. These techniques are distinguishable from each other by what they hold to be constant into the future. Generally, there are two types of forecasting methodologies are available in the literature[3]. Fundamental and Technical analysis. These two methodologies are the basic forecasting methodologies which are in generally used in financial forecasting. Like

* *Author for correspondence*

other economic time series, foreign exchange market has its own trend, season and irregularity. Thus to identify model, generalize and recombine these patterns and to give foreign exchange market forecasting is the major challenge task.

In the recent years, there has been a growing interest in using the state-of-art computer techniques to forecast foreign exchange rate change. One stream of these advanced techniques was Artificial Neural Networks (ANNs). The reason why ANN gains popularity in foreign exchange rate prediction is because ANN can approximate any continuous measurable function with desired accuracy. Neural networks are more noise tolerant and having the ability to learn complex systems with incomplete or corrupted data. Furthermore, they are more flexible. Philip et al.[2] have designed a prediction model which is based on ANN. The proposed model used to predict the four major currencies. The model was tested using mean square error and standard deviation and network topology 1-3-1. Result show that the proposed artificial neural network foreign exchange rate forecasting model outperforms than Hidden Markov foreign exchange rate forecasting model. [3]have proposed an artificial neural network model to forecast the foreign exchange rate. The proposed model trained with different back propagation algorithm to predict foreign exchange rate between Australia dollar and Chinese yen. Simulation result shows that the LM based algorithm can predict accurately than other algorithms and also has smallest mean square error. Prediction of foreign exchange rate for US dollar, Pound, Euro and Japanese Yen against Indian rupee is introduced[4]. The authors have used daily and monthly data for forecasting. Results show that the hidden information in exchange rate could be extracted using ANN. Pacelli et al.[5] have developed neural network based technique to forecast exchange rate. The developed model can predict three days ahead of last data available. By the analysis of the data it is possible that the artificial neural network model developed can largely predict the trend of three days of exchange rate.

Artificial neural network is a powerful data modeling tool that is able to capture complex input/output relationships. This paper explains the application of neural networks in foreign exchange rates forecasting among major currencies European Currency (EURO), Japanese Currency (JYEN), Pound Sterling (PS) and US Dollar (USD) against Indian Rupee (INR). One of the significant contributions of this paper is our ability to propose an Artificial Neural Networks model to forecast FOREX rates. The proposed technique also has suggested that the optimal topology of ANN for accurate prediction. The five-year data set has been downloaded from bank's website[6]. Multiple experiments were conducted by taking various network topologies of the feed forward network along with Levenberg-Marquardt (LM) algorithms. Experimental results are presented to demonstrate the performance of the error back propagation method for FOREX rate prediction.

The rest of the paper is organized as follows: Section2 discusses the proposed method for forecasting foreign exchange rate. Empirical results of the proposed system have been discussed in section 3 and conclusion is presented in last section followed by relevant references.

2. Data and Model Building

Data of exchange rates of four currencies EURO, JYEN, PS and USD against INR from January 1, 2010toMay 31, 2015 were collected from Reserve Bank of India. Therefore, this series of exchange rates has1335 observations. The following graph (Figure 1) shows the exchange rates of four currencies for this period of time. The first 80% of data are used for training while the second 20% of data are used for testing the model.

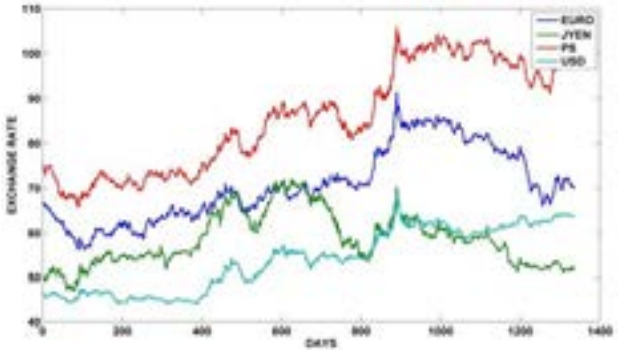

Figure 1. Exchange rates of EURO, JYEN, PS and USD against INR.

The neural networks built in this study were designed to produce the exchange rate. The input data is normalized before being input to the ANN. The input vectors of the training data are normalized with zero-mean and unit variance. The target values are also normalized between 0 and 1.The normalization for the input is done using Eq.(1)

$$Y_n = \frac{X - X_{\min}}{X_{\max} - X_{\min}}(h_i - l_i) \quad (1)$$

where, X denotes the original value that should be normalized, Y_n represents the normalized value of X,Xmin denotes minimum value of X,Xmax is maximum value of X,hi-Upper bound of the normalizing interval(in our case 1) and li-lower bound of the normalizing interval(in our case 0). After normalization the data will be in the range of [0, 1].

ANN is a promising computational technique that provides a new avenue for exploring dynamics of numerous economic and financial applications. It is an information process technique for modeling mathematical relationships between input variables and output variables. Neural networks are a class of generalized non-linear, on-parametric models inspired by studies of the brain and nerve system[7]. Based on the construction of the human brain, a set of processing elements or neurons are interconnected and organized in layers[8]. In the recent times, this technique is extensively used in financial markets, particularly to forecast stock price, interest rate, exchange rate, etc. The merit of ANN over more conventional econometric model is that they can model any complex pattern, possibly non-linear relationships without any assumptions about the underlying data generating process. ANN can be categorized into two types: (i) feed forward and (ii) feedback networks. Feed forward networks take inputs from the previous layer and send outputs to the next layer. The commonly used artificial neural network architecture is multilayer feed forward network. The present study uses back propagation (feed forward) neural technique for the forecasting exchange rate. In general, ANN can be thought of as a set of interconnected layers broadly divided into three layers. These three layers are input layer, hidden and output layer. Each layer has a certain number of processing elements named as neurons. Signals are passed between neurons over connection links. Each link has a weight and multiplied with the signal transmitted. Each neuron applies an activation function to its net input to determine its output signal. The neurons in the hidden layer are essentially hidden from view. Using additional number of neurons in hidden layer provides more flexibility and accurate processing. But, the flexibility comes at extra cost of complexity in the training algorithm. On the other hand, having less number of neurons in the hidden layer than required would cause reduced robustness of the system. Neural network performance is highly dependent on its structure. The interaction allowed between various nodes of the network is specified using the structure. The forecasting set up of ANN consists of followings steps: data preparation, network set up, evaluation and selection. An illustration of multilayer neural network is shown in Figure 2.

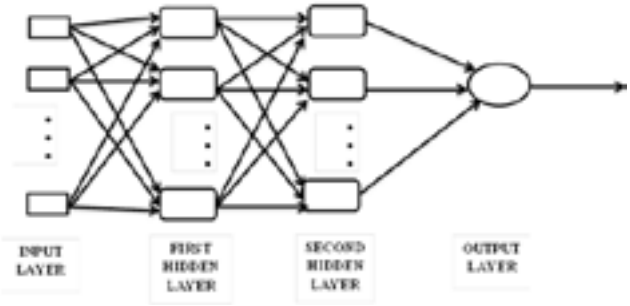

Figure 2. Multilayer neural network.

The multilayer neural network used in this study is trained with Levenberg-Marquardt to forecast the exchange rate. MATLAB software is used to train the net, test it and evaluate the performance. Table 1 shows the procedures have been used to do the same:

Table 1. Algorithm for forecasting FOREX

1. Initialize the weights to small random values
2. The minimum test error is initialized to the maximum real value
3. Introduce the training data set to the network more than once.
4. Perform back propagation using Mean Square Error (MSE) as the stopping criterion for learning, while exceeding the maximum number of epochs and time.
5. Test the net using testing data set and measure the performance of training and testing data set.
6. Evaluate testing set. In this study, the calculated values are saved in output file which contains the prediction value and error.
7. Compare the test error with minimum test error.
If the error < error
Save the weights
else
Train the net
End

3. Results and Discussion

In this study, Forecasting of foreign exchange rate in India is carried out based on ANN. In order to get best topology, multiple experiments were performed by taking different topologies of the feed forward network along with LM training algorithm. The ANN model is modeled for EURO, JYEN, PS and USD by using three inputs, one output and 2-5 hidden layers. In the algorithm, learning rates and momentum coefficients are set to 0.05 and 0.9 respectively. The summary of the results is presented in Table 2.

The forecasting performance of the proposed model is evaluated against widely used statistical metric namely, Root Mean Square Error (RMSE), Mean Absolute Error (MAE) and Forecasting error(FE). Suppose $(A_1,A_2,\ldots A_n)$ are actual values and $(P_1,P_2\ldots P_n)$ are predicted values then RMSE and MAE can be calculated by using the Eq. (2) and (3).

1. RMSE: It is root mean squared errors between actual and predicted values and can be written as

$$RMSE = \sqrt{\frac{1}{N}\sum_{k=1}^{N}\left(\left|A_k - P_k\right|\right)^2} \quad (2)$$

2. MAE: MAE gives the average absolute error between actual and predicted values,

$$MAE = \frac{1}{N}\sum_{k=1}^{N}\left|A_k - P_k\right| \quad (3)$$

Table 2 compares performance of the proposed model with different topology. In the table data in the first column 1-2-1, the first number 1 represents the number of input layer, second number 2 represents the varying values in the middle of the configuration are the number of hidden layers and 1 depicts the expected single output of the ANN[9,10]. From the table, it is observed that the results were not satisfactory for networks with just two, three and five hidden layer. The RMSE of neural network with 1-4-1(inputlayer-4 hidden layer-output layer) structure is very much low and varies from 0.2 to 0.4. This consistency proves their accurate prediction power and absolutely true for daily data. The results are also supported by MAE and mean FE. Experiments suggested that neural network with 1-4-1 is the most suitable structure method for FOREX prediction. Next, the performance of the proposed model for varying the number of layers in the hidden layer is illustrated in Figure 3 and Figure 4 respectively.

For the implementation of the proposed technique, we experimented with the following different neural network model configurations 1-2-1, 1-3-1, 1-4-1 and 1-5-1 using the Matlab Neural Network Tools Box and the results are presented in Table 3.

Table 2. Measurement of prediction performance

Network	Currency	Performance measures		
		RMSE	MAE	Mean FE
1- 2- 1	EURO	0.5924	0.0056	0.661
	JYEN	0.6398	0.0035	0.841
	PS	0.772	0.0205	0.686
	USD	0.3545	0.0056	0.478
1 -3- 1	EURO	0.4838	0.0069	0.517
	JYEN	0.4981	0.0063	0.628
	PS	0.5196	0.0039	0.456
	USD	0.7118	0.0061	0.845
1- 4- 1	EURO	0.3875	0.0005	0.389
	JYEN	0.3972	0.0038	0.499
	PS	0.4989	0.001	0.444
	USD	0.2873	0.0004	0.309
1 -5 -1	EURO	0.4855	0.0007	0.526
	JYEN	1.1547	0.0222	1.397
	PS	0.683	0.0002	0.562
	USD	0.2333	0.0054	0.387

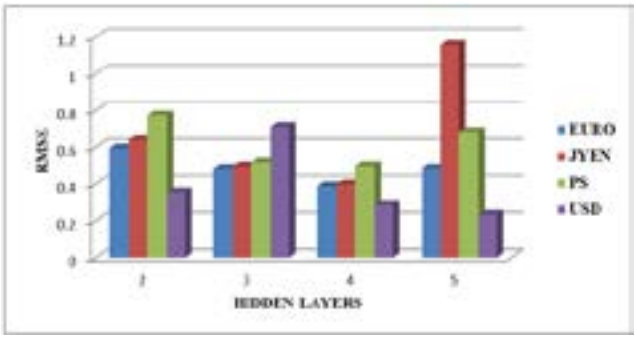

Figure 3. RMSE comparison for varying hidden layers.

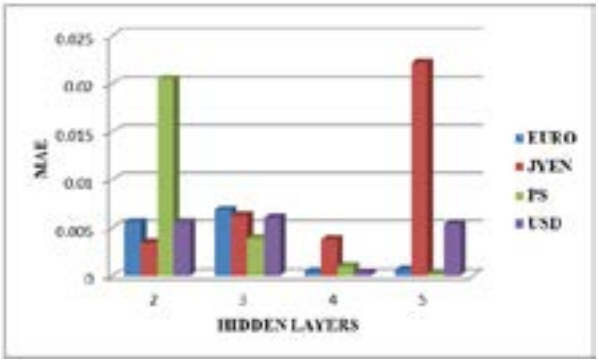

Figure 4. MAE comparison for varying hidden layers.

Table 3. Sample of empirical results of using proposed approach on different neural network topology

Currency name	Date	Actual value (in Rs.)	Predicted value with different network topology			
			2	3	4	5
EURO	6/6/2015	70.2924	70.74034	70.33849	70.21596	70.514
	7/6/2015	69.9659	70.55913	70.26449	70.0228	70.451
	8/6/2015	69.9323	70.34053	70.19478	69.91338	70.334
	9/6/2015	70.4986	70.07778	70.12916	70.15074	70.15
	10/6/2015	70.433€4	69.76304	70.06745	70.79099	69.891
JYEN	6/6/2015	51.89	52.16645	51.809	51.77454	52.29
	7/6/2015	51.67	52.16727	51.80336	51.8602	52.293
	8/6/2015	52.17	52.1681	51.78649	51.95502	52.294
	9/6/2015	52.3	52.16897	51.75756	52.05929	52.294
	10/6/2015	51.97	52.16986	51.71545	52.17349	52.293
PS	6/6/2015	99.1062	99.02451	99.14892	98.96609	98.328
	7/6/2015	98.8585	99.0214	99.23937	98.73928	98.321
	8/6/2015	98.2205	99.01615	99.32605	98.45374	98.354
	9/6/2015	97.8508	99.00873	99.40878	98.11597	98.441
	10/6/2015	97.6548	98.99912	99.48738	97.74202	98.597
USD	6/6/2015	63.5785	63.43807	63.7443	63.48405	63.459
	7/6/2015	63.3749	63.37025	63.7672	63.4354	63.466
	8/6/2015	63.569	63.29936	63.78754	63.38235	63.475
	9/6/2015	63.5065	63.2256	63.80566	63.32532	63.487
	10/6/2015	63.3793	63.14919	63.8225	63.26488	63.5

4. Conclusion and Future Enhancement

The paper investigates the FOREX prediction using feed forward neural network. To determine the performance of the proposed technique, empirical study was carried out with the published past data obtained from the Internet. Simulations were done by doing variations in the hidden layers to find the best topology for prediction. After several experiments with different network topology, the network predictive model that gave the most accurate prediction was 1-4-1 interms of RMSE and MAE. The empirical findings suggest that neural networks are an effective tool for FOREX prediction with proper architecture and can be used on real datasets. We would like to expand our by adding some more parameters for accurate prediction and minimize the processing time.

5. References

1. Fliess M, Join C. Time series technical analysis via new fast estimation methods: a preliminary study in mathematical finance. 23rd IAR Workshop on Advanced Control and Diagnosis; Coventry: United Kingdom; 2008.
2. Philip AA, Taofiki AA, Bidemi AA. Artificial Neural network model for forecasting foreign exchange rate. World of Computer Science and Information Technology Journal. 2011; 1(3):110–18.
3. Lavanya V, Parveentaj M, Foreign Currency Exchange Rate (FOREX) using neural network. International Journal of Science and Research. 2013; 2(10):174–77.
4. Pradhan RP, Kumar R. Forecasting exchange rate in india: an application of artificial neural network model. Journal of Mathematics Research. 2010; 2(4):111–17.
5. Pacelli V, Bevilacqua V, Azzollini M. An artificial neural network model to forecast exchange rates. Journal of Intelligent Learning Systems and Applications. 2011; 1(3):57–69.
6. RBI Data Repository [Internet]. [Cited 2015 Jun 15]. Available from: http://www.rbi.org.
7. Alon I, Min Q, Sadowski RJ. Forecasting aggregate retail sales: a comparison of artificial neural networks and traditional method. Journal of Retailing and Consumer Services. 2001. 8(3):147–56.
8. Malliaris M, Salchenberger L. Using neural networks to forecast the S & P 100 implied volatility. Neurocomputing. 1996; 10(2):183–95.
9. White H. Connectionist non-parametric regression: multilayer feed forward networks can learn arbitrary mappings. Neural Networks. 1990; 3(1):535–49.
10. Sefat MY, Borgaee AM, Beheshti B, Bakhoda H. Application of Artificial Neural Network (ANN) for modelling the economic efficiency of broiler production units. Indian Journal of Science and Technology. 2014 Nov; 7(11):1820–26. doi: 10.17485/ijst/2014/v7i11/43630.