Neural Network Based Forecasting of Foreign Currency Exchange Rates

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***ABSTRACT*-The foreign currency exchange market is the highest and most liquid of the financial markets, with an estimated $1 trillion traded every day. Foreign exchange rates are the most important economic indices in the international financial markets. The prediction of them poses many theoretical and experimental challenges. This paper reports empirical proof that a neural network model is applicable to the prediction of foreign exchange rates. The exchange rates between Indian Rupee and four other major currencies, Pound Sterling, US Dollar, Euro and Japanese Yen are forecast by the trained neural networks. The neural network was trained by three different learning algorithms using historical data to find the suitable algorithm for prediction. The forecasting performance of the proposed system is evaluated using three statistical metrics and compared. The results presented here demonstrate that significantly close prediction can be made without extensive knowledge of market data.**

Keywords- Artificial Neural Network, Back Propagation Algorithm, Forecasting, Foreign Exchange Rate and Training Function.

I. INTRODUCTION

Forecasting of Foreign Exchange Rate (FOREX) is one the challenging applications in modern time series forecasting. The rates are naturally noisy, disordered and non-stationary. These characteristics suggest that there is no absolute information that could be obtained from the past performance of such as markets to fully capture the dependency between the future exchange rates and that of the past. One assumption is made in such cases is that the historical data integrate all those behavior. As a result, the historical data plays a vital role in the process.

The currency exchange rates play a significant role in compulsive the dynamics of the currency market. Proper prediction of currency exchange rate is a crucial factor for the success of many business and investment firm. Although the market is well known for its unpredictability, fickleness and volatility, there are number of groups like Banks, Agency and other for predicting exchange rates using numerous techniques. There are many types of theoretical models including both time series and econometric approaches have been widely used to model and forecast exchange rates such as Autoregressive Conditional Heteroskedasticity (ARCH), General Autoregressive Conditional Heteroskedasticity (GARCH) and chaotic dynamics applied to financial forecasting. While these models may be better for a particular situation and they perform poorly in other applications. Artificial Neural Networks (ANNs) have received more attention as decision-making tools.

The Artificial Neural Networks are the well-known function approximates in prediction and system modeling, has recently shown its great applicability in time series analysis and forecasting. Artificial Neural Network is more effective in describing the dynamics of non-stationary time series due to its unique non-parametric, noise-tolerant and adaptive properties. ANNs are universal function approximates that can map any nonlinear function without a prior assumptions about the data.

The main purpose of this paper is to investigate the use of Artificial Neural network based methods for prediction of foreign exchange rates with accurate. We apply Back Propagation Neural Network (BPNN) for predicting currency exchange rates of Indian Rupee (INR) against four other currencies such as Pound Sterling (PS), US Dollar (USD), EURO, and Japanese Yen (JYEN). BPNN is trained with three different existing learning algorithms. Total of 80% historical exchange rates data for each of four currency rates, were collected and used as an inputs to build the prediction system in our study and then additional 20% exchange rates data were used to evaluate the model. The prediction results of all these models were compared based on three statistics metrics. From the results, it is observed that the Resilient Back propagation (RB) forecast more accurately than other two algorithms.

The rest of the paper is organized as follows: Section 2 will describe the related works. Section 3 discusses the proposed method for forecasting foreign exchange rate .Experimental results and performance of the system has been discussed in section 4 and conclusion is presented in last section.

II. RESEARCH BACKGROUND

Many studies have demonstrated the forecast ability of the traditional neural network models. In this section, we will briefly review some of the previous work in this area.

Dunis et al [1].examines the use of Neural Network Regression (NNR) models in forecasting and trading the US Dollar against Euro exchange rate. The authors demonstrated that NNR model gives better forecasting and trading results than ARMA models. Kaashoek et al [2] have introduced a new technique for prediction. The authors also reduce the size of neural networks by using multiple correlation coefficients, principal component analysis and graphical analysis techniques. The experimental results show that pruned neural networks give best forecasting results and the long-term dynamic properties of the resulting neural network models compare favorably with ARIMA models. Kamruzzaman et al [3].have developed neural network based model to forecast the exchange rate and uses three learning algorithms, i.e. Standard Backpropagation (SBP), Scaled Conjugate Gradient (SCG) and Backpropagation with Baysian Regularization (BPR), to forecast the exchange rates of six foreign currencies against Australian dollar. The results show that all the NN-based models outperform traditional ARIMA model and SCG based model performs best. Kin Keung Lai et al[4].proposes a multistage neural network meta-learning method for forecasting US Dollar against Euro exchange rate. The experimental results show that the proposed system outperforms the individual ARIMA, BPNN, SVM systems and some hybrid models. Nag et al [5]. Presents a forecasting model based on neural network and genetic algorithm. The results of the comparative experiments show that the new model provides best performance than traditional neural network and statistical time series modeling approaches. Tenti [6] compares the forecasting ability of three different recurrent neural network architectures and then devises a trading strategy based on the forecasting results to optimize the profitability of the system. The author suggests that the recurrent neural networks are particularly suitable for forecasting foreign exchange rates. Wu[7] applies multilayer feed forward neural networks to forecast Taiwan Dollar against US Dollar exchange rate .The author have shown that the results are better than ARIMA models and neural network approach is a competitive and robust method for the forecasting. Yuehui Chen et al [8].have developed a Flexible Neural Tree (FNT) model is used for forecasting three major international currency exchange rates, namely US Dollar against Euro, British Pound and Japanese Yen. The authors demonstrated that the proposed model provides better forecasts than multilayer feed forward neural network model and adaptive smoothing neural network model. Zhang [9] presents a hybrid forecasting model that combines both ARIMA and neural network approaches. The empirical results suggest that the hybrid model outperforms each of the two individual models.

III. METHODOLOGY

Artificial Neural Networks have been successfully applied to signature identification, time series forecasting, classification analysis and many difficult pattern recognition problems. Artificial Neural Networks models have been suggested and used for the forecasting purpose. The successful and popular one is the feed forward multilayer network or the multilayer perceptron (MLP). The MLP is typically a combination of many layers of nodes. The first layer is an input layer where external information is received. The last layer is an output layer where the problem result is obtained.

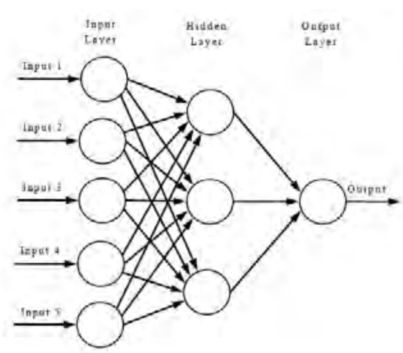

Fig.1. Fully connected feed forward neural network

The input layer and output layer are separated by one or more intermediate layers called the hidden layers. The nodes in adjacent layers are usually fully connected by acyclic arcs from an input layer to output layer .The knowledge learned by a network is accumulated in the arcs and the nodes in the form of arc weights and node biases which will be estimated in the neural network training process. Fig.1. is shows an example of a fully connected MLP with one hidden layer.

A. BACK PROPAGATION NEURAL NETWORK

BPNN is probably the most commonly used multilayer neural network type. BPNN is characterized by hidden layers and the generalized delta rule for learning: If there is a difference between the actual output produced and the desired output pattern during training, then the connection weights have to be readjusted to minimize the differences. The process of weight adjustment is continued until the error is less than some desired limit. Afterwards, the actual output is compared to the desired value (T). The error value is computed for the input pattern X as the difference between the actual output (Y) and T:

$$ERROR = T - Y \tag{1}$$

After error has been calculated, the Delta rule is applied giving the change in weights, represented by,

$$W_{new} - W_{old} = \frac{\beta.ERROR.X}{X^2} \tag{2}$$

Where, X – input data

W - Weight and

β-Constant

BPNN has three layers, namely input, hidden and output. The hidden layer plays a very important role, since it enables the ANN to extract patterns and to generalize. Even though a hidden layer should be large, one must be careful not to deprive the network of its generalizing ability when the network starts memorizing, rather than deducing. On the other hand, a hidden layer is too small could reduce the accuracy of recall. The connections are only feed forwarded between the adjacent layers.

The learning algorithm that controls back propagation follows a number of steps:

1) Initialize connection weights to small random values.

2) Introduce the continuous data set of inputs and actual outputs to the back propagation network.

3) Calculate the outputs, and adjust the connection weights many times applying the current network error.

4) Adjust the activation thresholds and weights of the neurons in the hidden layer according to the Delta rule.

5) Repeat steps (2) to (4) to converge to the minimum error.

IV. EXPERIMENTAL RESULTS AND DISCUSSION

In this investigation, an artificial neural network used to predict the exchange rate of foreign currency against INR is carried out. To obtain the least error convergence, the configurations of the BPNN are set by selecting learning rate, momentum coefficients, the number of hidden layers and number of hidden nodes. In order to get the well structure of the BPNN model, the sensitivity of the model is examined for different hidden nodes, which are randomly selected in the hidden layer. The BPNN is formed for PS, USD, EURO and JYEN by using single input layer, four hidden layers and one output unit. We first find out the suitable structure to forecast exchange rate and then we use the same for training and testing process. The detail descriptions of these results are explained below:

A. DATA COLLECTION

Data collection plays a vital role in the success of neural network solution. The availability, quality and reliability of the data used to develop and run the proposed system are critical to its success. For the implementation of forecasting, real data for five years from January 2008 to December 2012 was collected from Reserve Bank of India. A 1-4-1 layer network, with tansig transfer function in the hidden layer and linear transfer function in the output layer, is used to approximate the trend of the exchange rate. This whole data set was divided into two sets, training and testing.

B. PERFORMANCE METRICS

The forecasting performance of the proposed system is evaluated against a number of widely used three statistical metrics, namely, Root Mean Square Error (RMSE), Mean Absolute Error (MAE) and Mean Absolute Percentage Error (MAPE).The results of these metrics are reported in Table 1. These forecasting accuracy measures are listed as follows.

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

$$RMSE = \sqrt{\frac{1}{N}\sum_{k=1}^{N}(|A_k - P_k|)^2} \quad (3)$$

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

$$MAE = \frac{1}{N}\sum_{k=1}^{N}|A_k - P_k| \quad (4)$$

3. MAPE: mean absolute percentage error between actual and predicted values is calculated as

$$MAPE = \frac{1}{N}\sum_{k=1}^{N}\left|\frac{A_k - P_k}{A_k}\right| X\ 100 \quad (5)$$

Where A_k is the actual value, P_k is the predicted value and N is the number of data.

TABLE 1: MEASUREMENT OF PREDICTION PERFORMANCE

S.NO	CURRENCY	ALGORITHM	RMSE	MAE	MAPE
1	PS	GD	0.1382	0.1109	3.451
		GDA	0.0843	0.0647	2.024
		RP	0.0374	0.0274	0.845
2	USD	GD	0.12	0.0956	3.596
		GDA	0.0837	0.0665	2.491
		RP	0.02	0.0141	0.526
3	EURO	GD	0.1575	0.125	3.246
		GDA	0.0954	0.0763	1.971
		RP	0.0346	0.0256	0.661
4	JYEN	GD	0.2771	0.0768	3.246
		GDA	0.2317	0.0537	3.709
		RP	0.1323	0.0175	1.226

Table I lists the algorithms that are tested and the acronyms we use to identify them.

GD: traingd- Batch gradient descent

GDA: traingda- Batch gradient descent with adaptive learning

RP: trainrp –Resilient Back propagation

Table I shows the results of input sample of 1205 observations. A MAPE below 5% is the measure of a highly accurate prediction. From the table, it is observed that RB algorithm consistently performs better than other algorithms in terms of performance metrics for all currency exchange rates. For example, in case of forecasting USD rate, MSE, MAE and MAPE achieved by RB algorithm 0.0004, 0.0141 and 0.526 respectively. Smaller values of these metrics indicate higher accuracy in forecasting. This means that RB algorithm is capable of predicting exchange rate more closely than GD and GDA.

V. CONCLUSION

Artificial neural networks are a class of nonlinear model that can approximate any nonlinear function to an arbitrary degree of accuracy and have the potential to be used as forecasting tools in several areas. This paper has presented and compared three different neural network models to perform foreign currency exchange forecasting using historical data. A neural network model was trained with inputs, four hidden layer and an output unit to predict the exchange rate. The predictive performance of each model was assessed using three statistical measures. From the results, it is observed that Resilient Back propagation based model achieves closer prediction of all the four currencies than other models. It has been demonstrated that RB neural network model achieves very close prediction in terms of RMSE, MAE and MAPE metrics. It is concluded that the predicted data generated by the RB based model is evidently suitable for forecasting currency exchange rate PS, USD, EURO and JYEN against Indian Rupee. The proposed method improves the forecasting significantly by adequate training and testing. The empirical findings suggest that neural network is sophisticated method in forecasting exchange rate in India. The advantage of this model is that the information that is hidden in exchange rate could be better extracted by using artificial neural network.

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