An Analysis of the Performance of Artificial Neural Network Technique for Stock Market Forecasting

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Abstract— **In this paper, we showed a method to forecast the daily stock price using neural networks and the result of the Neural Network forecast is compared with the Statistical forecasting result. Stock price prediction is one of the emerging field in neural network forecasting area. This paper also presents the Neural Networks ability to forecast the daily Stock Market Prices. Stock market prediction is very difficult since it depends on several known and unknown factors while the Artificial Neural Network is a popular technique for the stock market Forecasting. The Neural Network is based on the concept of 'Learn by Example'. In this paper, Neural Networks and Statistical techniques are employed to model and forecast the daily stock market prices and then the results of these two models are compared. The forecasting ability of these two models is accessed using MAPE, MSE and RMSE. The results show that Neural Networks, when trained with sufficient data, proper inputs and with proper architecture, can predict the stock market prices very well. Statistical technique though well built but their forecasting ability is reduced as the series become complex. Therefore, Neural Networks can be used as an better alternative technique for forecasting the daily stock market prices.**

Keywords- Foreign Investors Inflow, Mean Square Error, Sum of Square Error, Mean Absolute Error, Root Mean Squared Error, Wholesale Price Index, Money Supply Broad Money, Money Supply Narrow Money, Exchange Rate, Industrial Production.

I. INTRODUCTION *(HEADING 1)*

The Neural Networks are patterned after the parallel processing methods of the human brain. The biological brain is composed of billions of interconnected processing elements called neurons, which transmit information and strengthen when the brain learns. Neural Networks use interconnected processing elements that allow them to learn from mistakes, learn from example, recognize patterns in noisy data, and operate with incomplete information. By evaluating the processing capabilities of the human brain, neural networks attempt to overcome the limitations of traditional computers. An Artificial Neural Network (ANN) is a model composed of several highly interconnected computational units called neurons or nodes. Each node performs a simple operation on an input to generate an output that is forwarded to the next node in the sequence. This parallel processing allows for great advantages in data analysis.

Artificial Neural Network are widely used in various branches of engineering and science and their property to approximate complex and nonlinear equations makes it a useful tools in econometric analysis. Previous research has shown that artificial neural networks are suitable for pattern recognition and pattern classification tasks due to their nonlinear nonparametric adaptive-learning properties. As a useful analytical tool, ANN is widely applied in analyzing the business data stored in database or data warehouse nowadays. Customer behavior patterns identification and stock price prediction are both hot areas of neural network researching and applying. One critical step in neural network application is network training. Generally, data in company's database or data warehouse is selected and refined to form training data sets. Finally the selection of the Neural Network Architecture and training of input data is very important issue for the Neural Network based forecasting.

The study of financial data is of great importance to the researchers and to business world because of the volatile nature of the series. Statistical tools like Multiple Regression Techniques (Hair, Anderson, Tatham & Black, 1998)[1] and Time Series Analysis are the very well built methodologies used for forecasting the series, but as the series become complex their forecasting ability is reduced, Kalyani Dacha (2007)[2]. Regression models have been traditionally used to model the changes in the stock markets. Multiple regression analysis is the process of finding the least squares prediction equation, testing the adequacy of the model, and conducting tests about estimating the values of the model parameters, Mendenhall et al.[3] However, these models can predict linear patterns only. The stock market returns change in a nonlinear pattern such that neural networks are more appropriate to model these changes. The power of neural network is its ability to model a nonlinear process without a priori knowledge about the nature of the process.

Neural Network have become popular in the world of forecasting because of their non-parametric approach

(Rimpley,1996)[4], as well as their ability to learn the behavior of the series, when properly trained. Many researches Shard & Patil (1990)[5] and Tany & Fishwick, (1993)[6] have been made to compare Neural Networks with statistical tools. Neural Networks have been successfully applied to loan evaluation, signature recognitions, time series forecasting and many other difficult pattern recognition problems (Bishop, 1995; Rimpley, 1996; Sharda & Patil, 1990; and Tany & Fishwick, 1993) Kalyani Dacha(2007)[7-8]. If stock market return fluctuations are affected by their recent historic behavior, Tang(1991)[9] neural networks which can model such temporal stock market changes can prove to be better predictors, the changes in a stock market can then be learned better using networks which employ a feedback mechanism to cause sequence learning.

In general, the approaches to predict stock market could be classified into two classes, fundamental analysis and technical analysis. Fundamental analysis is based on macroeconomic data and the basic financial status of companies like money supply, interest rate, inflationary rates, dividend yields, earnings yield, cash flow yield, book to market ratio, price-earnings ratio, lagged returns (Fama and French, 1988; Lakonishok, 1994). Technical analysis is based on the rationale that history will repeat itself and that and the correlation between price and volume reveals market behavior. Prediction is made by exploiting implications hidden in past trading activities and by analyzing patterns and trends shown in price and volume charts (Smirlock and Starks, 1985; Brush 1986). The Neural Network based forecasting seems to be better predicture than the other approaches to predict stock market. In this paper, we showed a method to forecast the daily stock price using neural networks and the result of the Neural Network forecast is compared with the Statistical forecasting result.

II. MARKET LITERATURE REVIEW

Chiang et.al. (1996) used a FFNN with backpropagation (BP) to forecast the end-of-year net asset value (NAV) of mutual funds [10]. Using neural networks to predict financial markets has been an active research area in both methods, since the late 1980's (Swales and Yoon, 1992; Azoff,1994; Yao and Tan,2001; Pan, 2003a; Pan 2003b)[11-14] .

Most of these published works are targeted at US stock markets and other international financial markets. In this article our Prediction is made by exploiting implications hidden in past trading activities and by analyzing patterns and trends shown in daily stock price and Industrial Production, Wholesale Price Index, Exchange Rate, Net Investment by FIIs, Export, Import, Money Supply Narrow Money, and Money Supply Broad Money.

III. TRAINING A NEURAL NETWORK

To experiment with neural networks, we used NeuralWare, NeuralWorks Predict, (http://www.neuralware.com)[15] which provides the tools to implement and test various configurations of neural networks and learning algorithms.

IV. OBJECTIVE OF STUDY

The objective of this study is to model the daily Stock Prices data using the Statistical Technique and the Neural Networks, and then to compare the results of these two techniques.

V. NEURAL NETWORKS

Artificial Neural Network is an artificial representation of the human brain that tries to simulate its learning process. To train a network and measure how well it performs, an objective function must be defined. A commonly used performance criterion function is the sum of squares error function.

$$E = \frac{1}{2} \sum_{p=1}^{p} \sum_{i=1}^{N} \left(t_{p\,i} - y_{p\,i} \right)^2$$

Where, p represents the patterns in the training set, yp is the output vector (based on the hidden layer output), tp is the training target. The above equation represents the output nodes, tpi and ypi are, respectively, the target and actual network output for the ith output unit on the pth pattern. The network learns the problem at hand by adjusting weights. The process of adjusting the weights to make the Neural Network learn the relationship between the inputs and the targets is known as learning or training. There are several methods of finding the weights of which the gradient descent method is most common.

VI. STATISTICAL TECHNIQUE

Multiple Regression Analysis is a Multivariate Statistical technique used to examine the relationship between a single dependent variable and a set of independent variables. The objective of the multiple regression analysis is to use independent variables whose values are known to predict the single dependent variable. There may be multiple independent variable.

VII. DATA AND METHODOLOGY

A. Data Set Used

The data is collected from the NSE site (www.nseindia.com), RBI site (www.rbi.org.in), SEBI site (www.sebi.gov.in)[16-17]. The NIFTY data is from 1 April 2005 to 30 March 2007(daily data).

The stock market can display varying characteristics for various currencies, FII Flow etc. . So it is necessary to develop model for predicting daily stock return of NIFTY. The data for the study comprises the daily stock returns of NIFTY , Exchange Rate Rupee/US Dollar , FII Purchase, FII Sales from 1 April 2005 to 30 March 2007 (daily data), creating a series of 500 observations which were collected from the Reserve Bank of India website (www.rbi.org.in) , NSE site (www.nseindia.com), SEBI site (www.sebi.gov.in)[16-17].

To build the Neural Network forecasting models daily data (500 observations) is used to for the measurement of forecasting accuracy. An important first step in the analysis of the data is to determine if the series is stationary, as all other calculations of invariants presume stationarity in both linear

and nonlinear. A time series is said to be stationary if there is no systematic change in mean (no trend), in variance, and, if so, periodic variations have to be removed. To detect nonstationarity , the study uses a stationary test, called the unit root test (Augmented Dickey Fuller and Philip Perron). The null hypothesis tested here is "the series is non-stationary". If the absolute value of the statistic is greater than the critical Value , then the null hypothesis is rejected and hence the series is stationary.

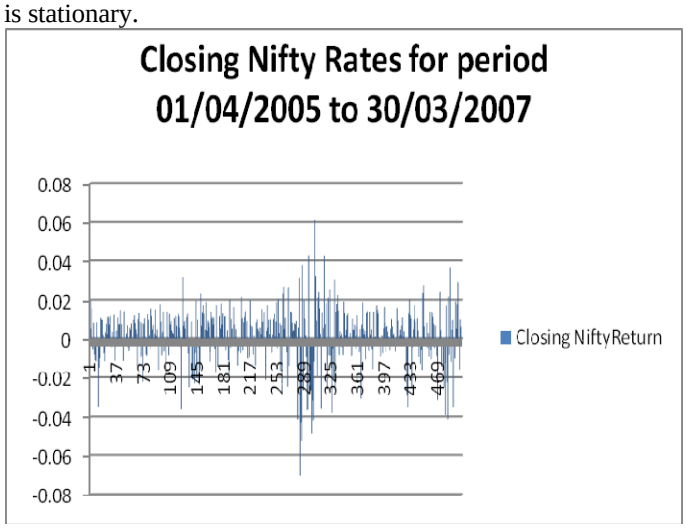

Figure 1. closing nifty rates for period 01-04-2005 to 30-03-2007

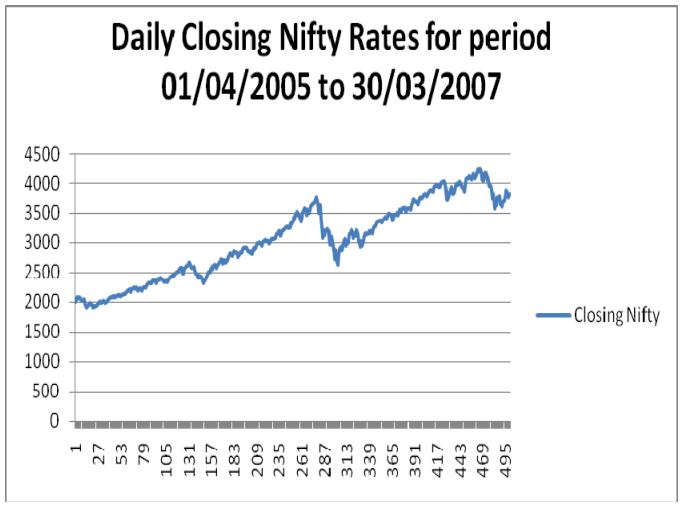

Figure 2. daily closing nifty rates for period 01-04-2005 to 30-03-2007

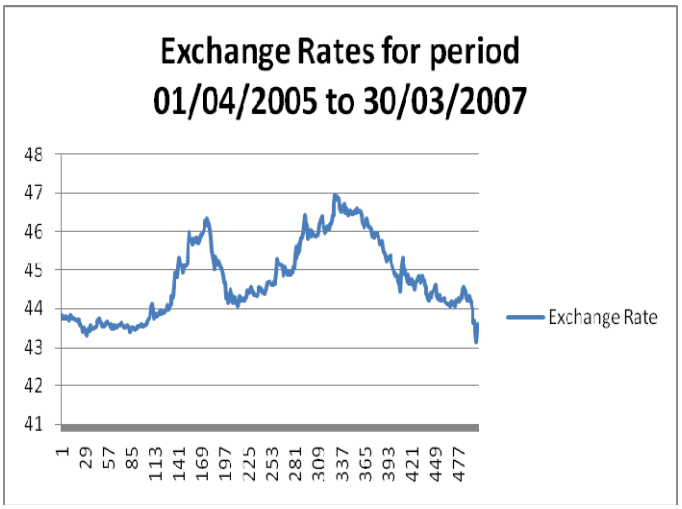

Figure 3. exchange rates for period 01-04-2005 to 30-03-2007

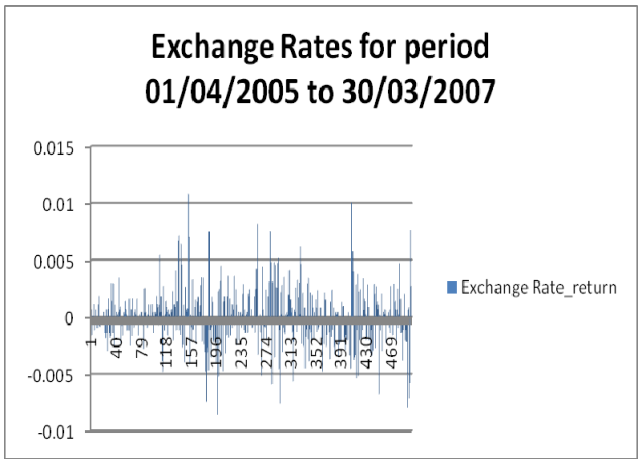

Figure 4. exchange rates for period 01-04-2005 to 30-03-2007

B. Stationarity Test:

The input and output series have been tested for Stationarity. The Augmented Dickey Fuller test and Philip Perron Test statistics as given in following table.

Method- Least Squares(NLS and ARMA)

Maximum Iterations 100

Convergence 0.001

Residual Type: Ordinary

TABLE I. UNIT ROOT TEST OF TWO SERIES

Series	Augmented Dickey Fuller Test		Philip Perron Test	
	Statistic	Critical Value (5% Critical Value)	Statistic	Critical Value (5% Critical Value)
Daily Closing Nifty	-9.563573	-2.8677	-20.91897	-2.8676
Exchange Rate	-9.106490	-2.8677	-21.35800	-2.8676
fiip	-4.298148	-2.8677	-11.24999	-2.8676
fiis	-4.414005	-2.8677	-9.641936	-2.8676

C. *Design Methodology*

It is difficult to design a Neural Network Model for a particular forecasting problem. Modeling issues must be considered carefully because it affects the performance of an ANN. One critical factor is to determine the appropriate architecture, that is, the number of layers, number of nodes in each layer. Other network design decisions include the selection of activation functions of the hidden and output nodes, the training algorithm, and performance measures. The design stage involves in this study to determine the input nodes and output nodes, Selecting the performance metrics etc. The number of input nodes corresponds to the number of variables in the input vector used to forecast future values. However currently there is no suggested systematic way to determine this number. Too few or too many input nodes can affect either the learning or prediction capability of the network. Closing NIFTY is taken as dependent variable and exchange rate, FII purchase, FII sales are taken as independent variable. For this study the output is the forecasted daily stock return.

VIII. RESULTS

A. *Neural Network Forecasting performance results*

Following figure dipicts the NN, Actual closing nifty daily prices.

The following figure depicts the Neural Network forecasting versus Actual Monthly Closing Nifty values.

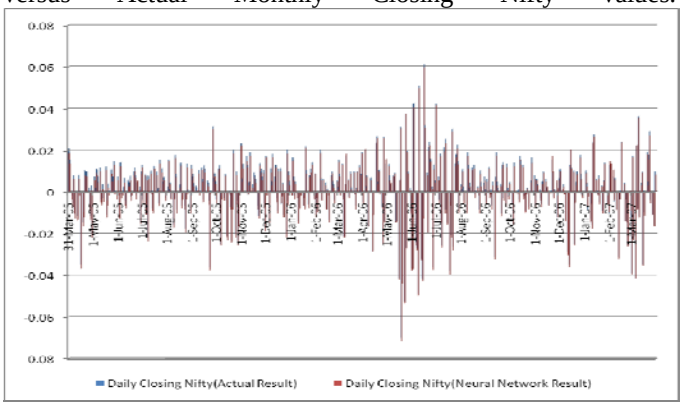

Figure 5. Fig 18.Actual Closing Nifty v/s Neural Network Forecasting

B. *Modeling & Forecasting using Multiple Regression Technique:-*

Closing nifty is taken as dependent variable and Exchange Rate Rupee/US Dollar , FII Purchase, FII Sales were taken as independent variables. The variables (closing nifty, Exchange Rate Rupee/US Dollar, FII Purchase, FII Sales) were transformed using natural log to achieve normality and linearity.

Dependent Variable: CLR
Method: Least Squares
Date: 09/23/08 Time: 13:24
Sample(adjusted): 4 502
Included observations: 499 after adjusting endpoints

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.002713	0.001414	1.918239	0.0557
ER(-1)	-0.083785	0.269279	-0.311147	0.7558
FIIP(-1)	-9.46E-07	1.24E-06	-0.760282	0.4474
FIIS(-1)	1.23E-07	1.25E-06	0.098309	0.9217

R-squared	0.002882	Mean dependent var	0.001292
AdjustedR-squared	-0.003161	S.D. dependent var	0.014577
S.E. of regression	0.014600	Akaike info criterion	-5.607589
Sum squared resid	0.105516	Schwarz criterion	-5.573821
Log likelihood	1403.094	F-statistic	0.476958
Durbin-Watson stat	1.886325	Prob(F-statistic)	0.698459

Where CLR is closing nifty, ER is Exchange Rate Rupee/US Dollar , FIIP is FII Purchase, FIIS is FII Sales.

This Model is chosen for forecasting the daily values of Nifty closing. The following table gives the forecasting results using Regression Model.

TABLE II. ACTUAL CLOSING NIFTY DAILY PRICES

	No of Obs.	SSE	MAE	MSE	RMSE
Neural Network	500	0.0011374585	0.0013799828	0.0000022795	0.001509793

TABLE III. FORECASTING RESULTS USING REGRESSION MODEL.

	No	SSE	MAE	MSE	RMSE
Regressio	15	0.105770460	0.010517453168303800	0.000211964	0.014559012

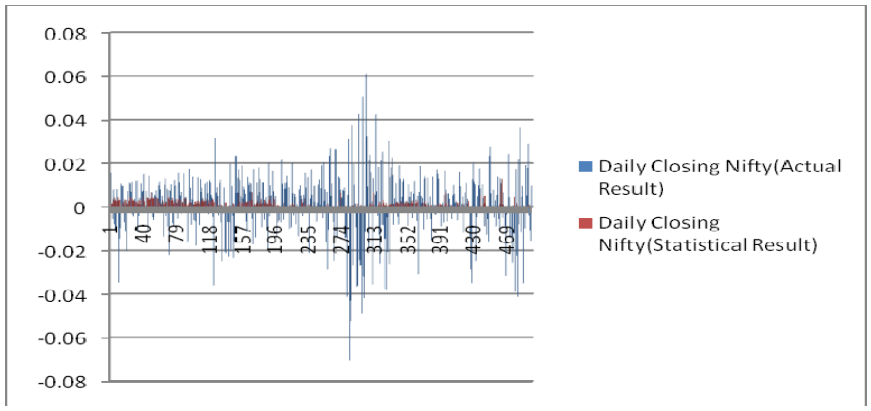

Figure 6. Fig 19.Actual Closing v/s Statistical forecasting result

The following table gives the table of comparison:-

TABLE IV. COMPARISON

	SSE	MAE	MSE	RMSE
NN	0.001137459	0.00138	2.28E-06	0.00151
REG	0.105770461	0.010517	0.000212	0.014559

Where formulae for the statistics are:
MAE = abs(Actual –Forecast)/n.
MSE = 1/n * [Actual –Forecast]2.
RMSE = SQRT(MSE).

From the above Table, Neural Networks performs well than compared to Statistical forecasting of daily closing Nifty values because the error in Neural Network is very less than the Statistical method.

The following figures shows the MAE, MSE and RMSE calculated for the forecast period using the above two forecasting techniques

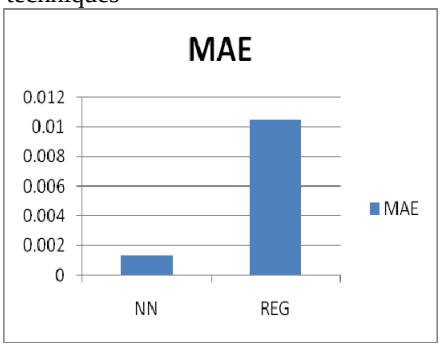

Figure 7. MAE of Neural Network and Statistical Method

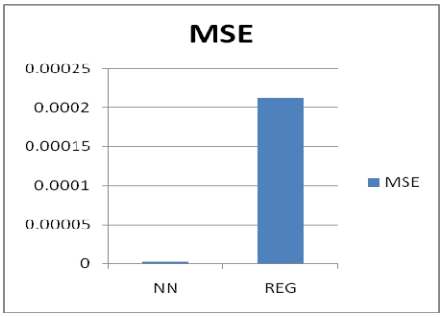

Figure 8. MSE of Neural Network and Statistical Method

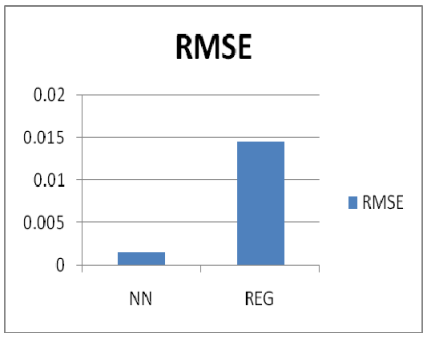

Figure 9. RMSE of Neural Network and Statistical Method

The experiments illustrate a varying degree of pridictability of the monthly stock returns. For Example based on the values of MSE, MAE, RMSE and other statistics. The above comparision of Neural Network and Statistical model clearly shows that the error in prediction of Neural Network is very less than the Statistical method therefore the Neural Networks prediction is better than the Statistical technique.

CONCLUSION AND FUTURE WORK

This paper depicts the fact that Neural Networks outperform Statistical technique in forecasting stock market prices. In this paper, two techniques for modeling and forecasting stock market prices have been shown: Neural Network and Statistical

Technique. The forecasting ability of models is accessed on the basis of MSE, MAE and RMSE.

The effectiveness of neural network can also be measured using the hit rate, which may be a better standard for determining the quality of forecast instead of the traditional measures like RMSE, SSE, and MSE. The field of neural networks is very diverse and opportunities for future research exist in many aspects, including data preprocessing and representation, architecture selection, and application. The logical next step for the research is to improve further the performance of NNs, for this application, perhaps through better training methods, better architecture selection, or better input. Artificial Neural Network also be used in various branches of engineering and science.

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