Stock Price Prediction using Artificial Neural Networks: Case Study – Karachi Stock Exchange

Shams Naveed Zia* and Muhammad Zia**
SZABIST
Karachi, Pakistan

Abstract:
Stock Price Prediction has always fascinated researchers because it not only involves the satisfaction of 'beating the market' but also the financial gains. Research and Market Data have proved that Efficient Market Hypothesis can be wrong. Various techniques have been used to predict stock prices. The techniques could be divided into two basic categories: which are Technical Analysis and Fundamental Analysis. Technical Analysis [1][2] involves historical data, trends, and their analysis. Where as Fundamental Analysis [1][3] involves analysis of Dividend Yield, Sector's Performance, Company's Performance, and Economic Outlook etc. Analysts use Statistical Tools, Expert Systems, and Linear Analysis Tools to predict stock prices. However, it has been proved that Neural Networks are more capable of predicting stock prices [4]. The reason is that stock markets are not linear in their behavior and often behave in chaotic manner. Neural Networks are non-linear and can perform with insufficient data.

In this backdrop authors chose to apply Neural Network Techniques in Karachi Stock Exchange to predict stock prices. We have selected Backpropagation as it is the most widely used Neural Network Technique used today [5]. Backpropagation network has three types of layers: Input Layer, Hidden Layer, and Output Layer. Inputs for the Input Layer are indicators like Relative Strength Index (RSI), Moving Average Convergence Divergence (MACD) and Time Series Analysis using Hurst Exponent [6]. The steps involved in our analysis are: Pre-Processing of Data, Feed Processed Data as Input in Input Layer, Feed-Forward the results to Hidden Layer, Generate output, Backpropagation to adjust weights, and Using Gradient-Descendent to reach to optimal value. The stages in our analysis are Training and Testing the Network.

1. INTRODUCTION

Although there has been work done in different areas of Karachi Stock Exchange and its returns [7] but a very little or no work has been carried out on stock price prediction using Karachi Stock Exchange as a test case.

Small investors make their decision either on advice or their own gut feeling. They usually do not have the skills or expertise to correctly analyze the market. Recent Stock Market Crash is a very good example of this in which most of the losers were small investors. So a tool with which they can easily manage their holdings would be very beneficial for them.

Currently analysts use conventional methods of stock price analysis and forecasting. A tool based on Neural Network Framework will provide a better analytical environment to the security analysts.

2. LITERATURE REVIEW

Stock Price Prediction has been a major research area in Computer Science Research. Earlier work done has been done to apply various techniques.

Earlier work was focused on Technical Analysis using Statistical Techniques. In the recent years much of the focus has been on Artificial Neural Networks.

Firstly, ANN more or less resembles the processing of a human brain. The word 'Neural' is taken from the structure of neurons in the human brain.

Secondly, real life situations are much more complex and cannot be easily handled by conventional techniques. In real-life situations there is incomplete data with which a decision needs to be taken. Conventional computational methods work on ON/OFF paradigm. If there is incomplete data, then it might not give the result at all. As compared to that, ANN can work on incomplete data and can give solutions which might not be optimal but can be near to optimal.

Thirdly, conventional methods work on linear methods. ANN can work in non-linear environment [8] and can work with fuzzy logic and rough sets.

Finally, ANN can work with little or no human intervention. This can go a long way in implementation of Automated Trading Systems.

3. BACKPROPAGATION

Backpropagation theory works according to a Neural Network Model. It basically has three layers namely Input, Hidden, and Output Layer. There can be 'n' layers within Hidden Layer. It can accept n inputs and produce n outputs. Our proposed model will produce one output.

* State Bank of Pakistan
** Usman Institute of Technology, Karachi, Pakistan.

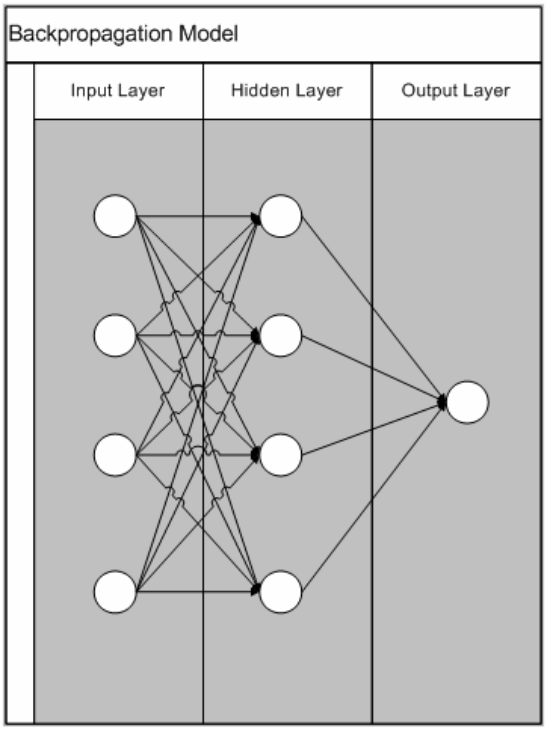

Figure (a)

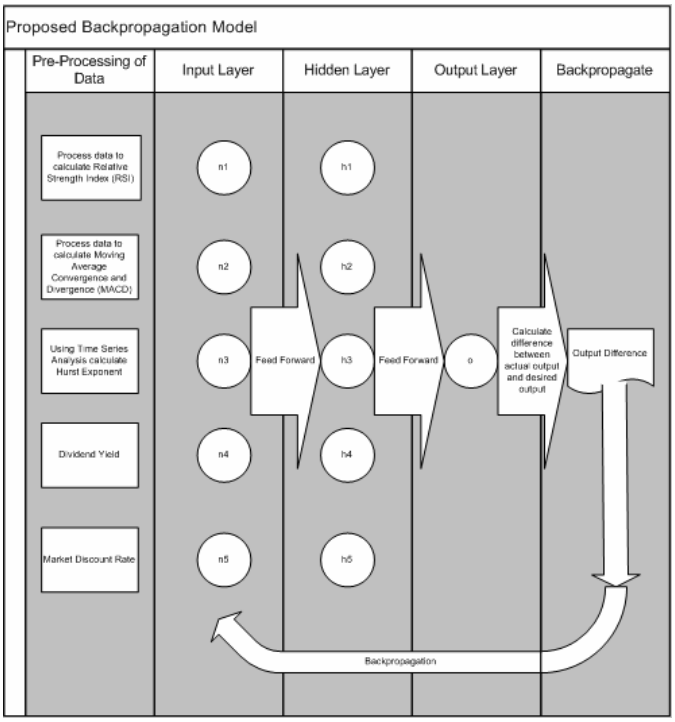

Figure (b)

4. PROPOSED BACKPROPAGATION MODEL

Proposed Model consists of the following stages:

1. Pre-Processing of Data
2. Feed Processed Data as Input in Input Layer
3. Feed-Forward the results to Hidden Layer
4. Generate output
5. Backpropagation to adjust weights
6. Using Gradient-Descendent to reach to optimal value.

Pre-processing of Data consists of calculation of various inputs to the network. We have chosen five inputs to the neural network. They are:

(a) Relative Strength Index
(b) Moving Average Convergence Divergence
(c) Hurst Exponent
(d) Dividend Yield
(e) Market Discount Rate

5. KNOWLEDGE BASE

(a) What formulas will be applied on the knowledge sources?

   i. Moving Average Convergence Divergence on Historical Price
   ii. Weighted Moving Average on Historical Price
   iii. Factor Based Information
   iv. Sentiments Based Information
   v. What weight will be assigned to each formula?
   vi. How new formulas can be added?
   vii. How weights can be changed manually or automatically to reduce variance between predicted and actual share price?

Apply Synaptic Weights Using Linear Combiner

A linear combiner takes all the inputs and their associated weights and combines them to a single value.

$$\mathbf{X = \sum FO_n * w_n} \qquad \textbf{(i)}$$

Where FO = Fuzzy Output Value of each of the input
w = weight assigned to each input
n = input number

Activation Function

The Activation function performs the final threshold function on the single outcome and on that basis produces the output.

Training

On the basis of output, error is calculated which is the difference between system's output and actual value of the stock. Mathematically this equation can be represented in the following manner:

$$f_{error} = AV - SO \qquad \textbf{(ii)}$$

Where

f_{error} = Error Value
AV = Actual Value of Script
SO = System Generated Output

Forward Feed is a technique in which results of one function are analyzed and then inputs are modified to reduce the error. Its an iterative process to reduce error to a minimum value.

$$\sum_{i=0 \text{ to } n} 1 / f_{error} \rightarrow \alpha \qquad \textbf{(iii)}$$

This objective is achieved by two variables called Adjustment Factor and Learning Rate.

$$NR = CV * AF * LR \qquad \textbf{(iv)}$$

Where NR = New Rule
CV = Conditional Value
AF = Adjustment Factor
LR = Improvement Factor for each Cycle

The same formula applies to Threshold values.

Based on Back Propagation Algorithm, results were achieved which were much better than simple Statistical Model.

An error value of more than 2.5% means wrong prediction and it will result in LOSS for the trader. An error value between 0 to 2.5% means GAIN for the trader.

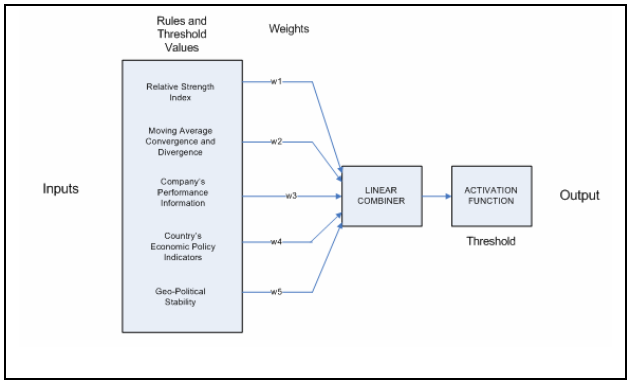

Figure (c)

6. ALGORITHM EVALUATION AND KNOWLEDGE BASE ENHANCEMENT WITH TEST DATA

Through these formulae, we test six months' data of three volume leader scripts using algorithm defined in the knowledge base.

Algorithm has been evaluated in each cycle and weights have been update iteratively. With each cycle results have been checked to identify variance. Against this variance individual components are identified upon which the total assessment was made. Then variance for each item is identified. Against this variance weights are adjusted and new weights are assigned for future references.

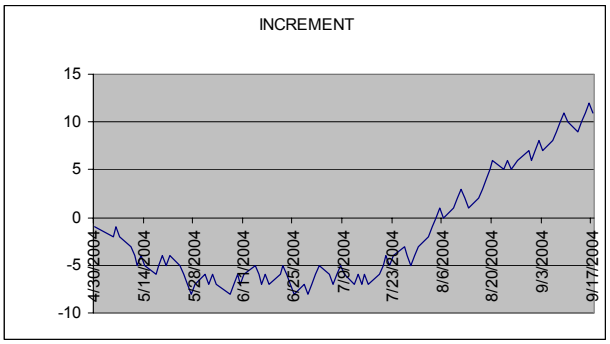

Figure (d)

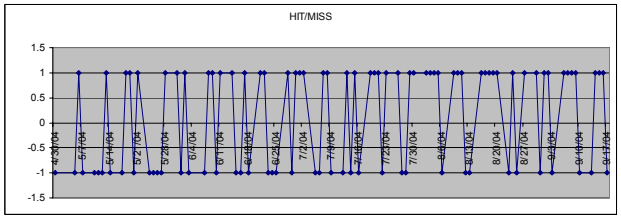

Figure (e)

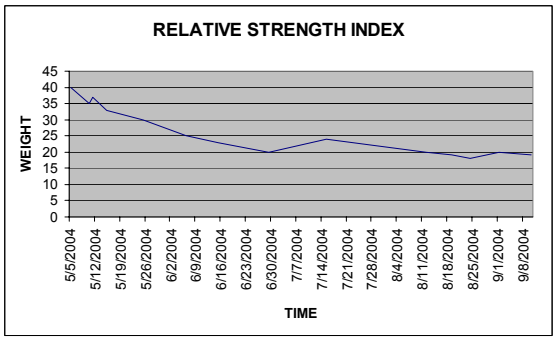

Figure (f)

7. FINDINGS

Following are the findings of the tests performed on the data:

- Results in the initial phase were not encouraging, but as the parameters were tuned, results became more positive i.e. Hit Ratio increased
- Due to lack of market and insider information the results might not be very accurate. But if these factors can be added the result would be much better
- Framework carries a very small network and system load, so this framework can be applied to online trading applications.

8. CONCLUSION

- Initial results showed losses or there were some marginal profits.

- As the weights were adjusted results were positive and it showed better margins are reduced risks for the investor.

REFERENCES

[1] Ramon Lawrence, *Using Neural Networks to Forecast Stock Market Prices*

[2] *A View on Technical Indicators and Trading Systems* http://www.abg-analytics.com

[3] Mark, N. C. 1995. Exchange rates and fundamentals: Evidence on long-horizon predictability. *The American Economic Review* 85: 201-218

[4] Jason e. Kutsurelis, *Forecasting Financial Markets using neural networks: an analysis of methods and accuracy*

[5] Zuriahati Mohd Yunos, Syed Taha Syed Zaid, Rihana Jamaluddin, Siti Mariyam Hj Shamsuddin, Roselina Sallehuddin, and Razana Alwi, *Development Of Intelligent System For Predicting Stock Market Returns*

[6] A. Cargone and G. Castelli, *Time-Dependent Hurst Exponent in financial Time Series*

[7] Key Fundamental Factors and Long-run Price Changes in An Emerging Market: A Case Study of Karachi Stock Exchange.

[8] Rumelhart, D. and J. McClelland, *Parallel Distributed Processing*, Cambridge: MIT Press, 1986.

[9] Jonathan Lewellen and Jay Shanken, *Estimation Risk, Market Efficiency, and The Predictability of Returns*

[10] Marijana Zekic, MS, *Neural Network Applications in Stock Market Predictions - A Methodology Analysis*

[11] Stock Price Forecasting: Autoregressive Modeling and Fuzzy Neural Network

[12] Alexandra Cristea, P. Cristea, *Sub-symbolic to symbolic knowledge conversion*

[13] Marc-André Mittermayer, *Forecasting Intraday Stock Price Trends with Text Mining Techniques*

[14] K. Bechmann, *Short sales, price pressure, and the stock price response to convertible bond calls*

[15] Robert A. Pearso, *Tree structures for predicting stock price behaviour*

[16] Nathan S. Balke and Mark E. Wohar, *Explaining Stock Price Movements:Is There a Case for Fundamentals?*