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Stock Price Prediction using Neural Network with Hybridized Market Indicators

[1]Adebiyi Ayodele A., [1]Ayo Charles K., [1]Adebiyi Marion O., and [2]Otokiti Sunday O.
[1]*Department of Computer and Information Sciences, Covenant University, Ota, Nigeria*
[2]*Department of Business Studies, Covenant University, Ota, Nigeria*
ayo_adebiyi@covenantuniversity.edu.ng, ckayome@yahoo.com, onlimarion@yahoo.com, dr_atoki@yahoo.com

Corresponding Author: ayo_adebiyi@covenantuniversity.edu.ng

ABSTRACT

Stock prediction with data mining techniques is one of the most important issues in finance being investigated by researchers across the globe. Data mining techniques can be used extensively in the financial markets to help investors make qualitative decision. One of the techniques is artificial neural network (ANN). However, in the application of ANN for predicting the financial market the use of technical analysis variables for stock prediction is predominant. In this paper, we present a hybridized approach which combines the use of the variables of technical and fundamental analysis of stock market indicators for prediction of future price of stock in order to improve on the existing approaches. The hybridized approach was tested with published stock data and the results obtained showed remarkable improvement over the use of only technical analysis variables. Also, the prediction from hybridized approach was found satisfactorily adequate as a guide for traders and investors in making qualitative decisions.

Keywords: *Stock Prediction, Artificial Neural Networks, Decision Support, Market Indicators.*

1. INTRODUCTION

Stock price prediction is one of the most important topics in finance and business. However, the stock market domain is dynamic and unpredictable [1, 2, 3, 4]. Several research efforts have been carried out to predict the market in order to make profit using different techniques ranging from statistical analysis, technical analysis, to fundamental analysis among others, with different results [3]. These techniques cannot provide deeper analysis that is required and therefore not effective in predicting stock market prices.

Artificial neural network (ANN) technique is one of data mining techniques that is gaining increasing acceptance in the business area due to its ability to learn and detect relationship among nonlinear variables. Also, it allows deeper analysis of large set of data especially those that have the tendency to fluctuate within a short of period of time. This makes ANN a candidate for stock market prediction. Much research efforts have been made to improve the predictive accuracy and computational efficiency of share values [5].

The elasticity and adaptability advantages of the artificial neural network models have attracted the interest of many other researchers. Apart from business and banking domain, other interested disciplines where ANN are being engaged include the electrical engineering, robotics and computer engineering, oil and medical industries. Since the last decade, the artificial neural network models have been used extensively in the fields of business, finance and economics for several purposes like time series forecasting and performance measurement [6].

Financial forecasting is of considerable practical interest and due to artificial neural networks' ability to mine valuable information from a mass history of data; its applications to financial forecasting have been very popular over the last few years [4, 7, 8, 9, 10].

However, the focus of this paper is to improve the accuracy of stock price prediction by using the hybrid approach that combines the variables of technical and fundamental analysis for the creation of neural network predictive model for stock price prediction. The technical analysis variables are the core stock market indices (current stock price, opening price, closing price, volume, highest price and lowest price etc.) while the fundamental analysis variables are company performance indices (price per annual earning, rumor/news, book value and financial status etc.).

The rest of the paper is organized as follows. Section 2 presents a review of related work. Section 3 describes the research methodology used, while section 4 discussed the results obtained. The paper is concluded in section 5.

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2. REVIEW OF RELATED WORKS

Investors in stock market primarily traded stocks based on intuition before the advent of computers. The continuous growth level of investing and trading necessitate a search for better tools to accurately predict the market in order to increase profits and reduce losses. Statistics, technical analysis, fundamental analysis, time series analysis, chaos theory and linear regression are some of the techniques that have been adopted to predict the market direction [11]. However, none of these techniques has been able to consistently produce correct prediction of the stock market, and many analysts remain doubtful of the usefulness of many of these approaches. However, these methods represented a base-level standard which neural networks must outperform to command relevance in stock market prediction.

Although the concept of artificial neural networks (ANN) has been around for almost half a century, only in the late 1980s could one ascertain that it gained significant use in scientific and technical presentations. There are quite a lot of research works on the application of neural networks in economics and finance [12].

According to [6], White [13] published the first significant study on the application of the neural network models for stock market forecasting. Following White's study, several research efforts were carried out to examine the forecasting effectiveness of the neural network models in stock markets. Among the earlier studies, the work in [14] and [15] can be mentioned. However, in another contribution, Yoda in [16] investigated the predictive capacity of the neural network models for the Tokyo Stock Exchange. In [17] neural network models was used to forecast various US stock returns. Also, in [18] neural network models was used to select the stock from the Canadian companies.

In [6], it was stated that the study of stock prediction can be broadly divided into two schools of thought. One focuses on computer experiments in virtual/artificial markets. This is often the case when researchers model the complex movements in the market economics [19]. The other school focuses on stock prediction based on real-life financial data as exemplified in [20, 21].

According to [6], different studies examined the stock market forecasting applications of neural network models from different perspective. Some studies considered the effects of modelling preferences on one type of neural network models. Other studies that examined variation of effects are: architecture [22], training algorithms [23], and input variables [24]. On the other hand, some other studies were devoted to investigating the forecast performance differences among different neural network models [25]. Other than the modelling issues, several studies evaluated the profitability of neural network models in stock markets. Among these studies, [7] and [26] reported that the technical trading strategy guided by feedforward neural network model was superior to buy-and-hold strategy.

However, previous efforts on stock market prediction have engaged predominantly the variables of technical analysis. The impact of fundamental analysis variables has been largely ignored. In this work, we explore the combination of the technical analysis and fundamental analysis variables for stock market prediction with the objective of attaining improved stock market prediction.

3. METHODOLOGY

The objective of this research work is to improve the accuracy of daily stock price prediction of stock market indices using artificial neural networks. The study used three-layer (one hidden layer) multilayer perceptron models (a feedforward neural network model) trained with backpropagation algorithm. Historical stock prices of different companies were obtained frorm published stock data on the Internet. The learning function or the activation function that was used is sigmoid function,

$f(x) = 1/(1+e^{-\beta x})$ because it was found from literature on related problem domain to be most widely used and perform better than other functions such as the Unit Step function, Piecewise linear function, Binary Transfer function, and Gaussian function [27].

The figure 1 depicts the basic model used in this study. The input layer consist of N units of x_i (i=1,2,3…N) and the hidden layer consist of P processing entities of k_m (m=1,2,3..P) and one output layer O_d. The output for the model could be presented in the functional form as:

$$y = g\left[\sum_{m=0}^{P} w_{md}\, g\left(\sum_{i=0}^{N} w_{im} x_i\right)\right]^f \quad \text{…Equation 1}$$

where, w_m is the connection weights between input units and hidden processing units, w_{md} is the connection weights between hidden processing units and the output unit, g(.) and $g(.)^f$ were the activation functions for hidden processing elements and output unit respectively.

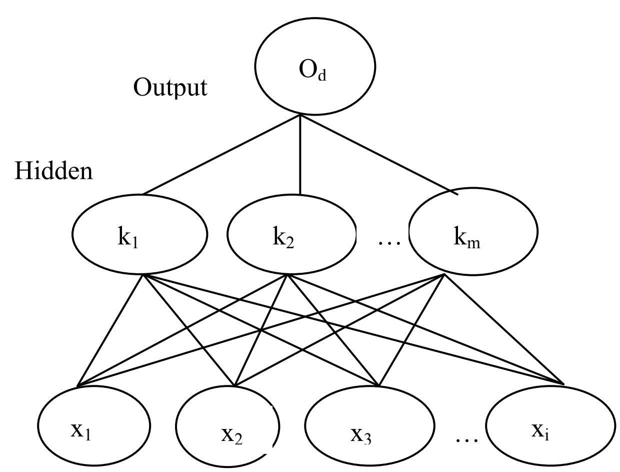

Figure 1: Multilayer perceptron model

For our hybridized approach we identified 18 input variables to train the network comprising both technical variables and fundamental analysis variables.

The technical analysis variables are:

O_{i-1} the opening price of day *i-1*
O_{i-2} the opening price of day *i-2*
H_{i-1} the daily high price of day *i-1*
H_{i-2} the daily high price of day *i-2*
L_{i-1} the daily low price of day *i-1*
L_{i-2} the daily low price of day *i-2*
C_{i-1} the closing price of day *i-1*
C_{i-1} the closing price of day *i-2*
V_{i-1} the trading volume of day *i-1*
V_{i-2} the trading volume of day *i-2*

The fundamental analysis variables are:

P_{i-1} the price per annual earning of year *i-1*
P_{i-2} the price per annual earning of year *i-2*
R_{i-1} the rumor or news to buy/sell of day *i-1*
R_{i-2} the rumor or news to buy/sell of day *i-2*
B_{i-1} the book value of the trading year *i-1*
B_{i-2} the book value of the trading year *i-2*
F_{i-1} the financial status of a company trading year *i-1*
F_{i-2} the financial status of a company trading year i-*2*

Generally, the algorithm for our ANN experiment is shown in figure 2 below.

(1) Define the output
(2) Choose the appropriate network architecture and algorithm. Multi-layer perceptron model trained with backpropagation algorithm was primarily chosen.
(3) Determine the input data and preprocess if necessary.
(4) Choose appropriate learning function.
(5) Choose the appropriate network structure.
(6) Perform the training and testing for each cycle.
(7) If the network produce acceptable results for all cycles, perform step 8 else perform step 5 to try other appropriate network structures else perform step 4 to try with other learning algorithm else perform step 3 to add or remove from input set. Otherwise, go back to step 2 to try different neural network architecture.
(8) Finish - record the results.

Figure 2: Algorithm for ANN predictive model.

For the implementation of our hybridized approach, we experimented with the following different neural network model configurations 18-18-1, 18-19-1, 18-20-1, 18-21-1, 18-22-1, 18-23-1, 18-24-1, 18-25-1, 18-26-1 using the Matlab Neural Network Tools Box version 7. 18 represent the number of input variables, the varying values in the middle of the configuration are the number of hidden neurons, and 1 depicts the expected single output of the ANN.

Similarly, we also carried out an experiment using only technical analysis variables for prediction. We experimented with the following different neural network model configurations 10-10-1, 10-11-1, 10-12-1, 10-13-1, 10-14-1, 10-15-1, 10-16-1, 10-17-1, 10-18-1.

Training data and testing data was carefully selected and we observed the various outcomes of the different network structure models implemented with Matlab Neural Network Tools Box version 7. In training our network model, the test data are not used. It was trained for 10,000 epochs for each training set.

The output of neural network model was analysed by comparing the predicted values with the actual values over a sample period. For our output to be considered useful for trading decision support, overall hit rate of level of accuracy should be considerably high enough to be acceptable.

The empirical results are presented in the next section.

4. RESULTS AND DISCUSSION

After several experiments with different network architectures, the network predictive model that gave the most accurate daily stock price prediction was 18-24-1 backpropagation network (BPN) using the hybridized approach that combines the variables of technical and fundamental analysis, while 10-17-1 gave the best result when technical analysis variables were used. The results presented in table 1 were the findings from testing period (out of sample test data) over different network structures when hybridized approach was used. Similarly, the results presented in table 2 were the findings when technical analysis was used.

Figure 3-11 illustrates the correlation of the level accuracy among different network structure with the hybridized approach by comparing the actual stock prices with the predicted values of stock prices. Over time, the network structure 18-24-1(figure 9) gave impressive results over different data set of different sample periods.

Also, figure 12-20 depicts the correlation level of accuracy among different network structure when technical analysis variable was used by comparing the actual prices with the predicted values of stock prices. The structure that gave us the best result was the network structure 10-17-1 (figure 19).

The best outputs of the two approaches (hybridized and technical analysis) are compared, that is, figure 9 and 19. We found out that the accuracy level of the hybridized approach is better than the technical analysis approach.

Similarly, by the comparing the other figures in hybridized approach with the technical analysis approach. The prediction accuracy of hybridized approach was better off. Hence, the hybridized approach can be used successfully as decision-support in real-life trading in a way that will enhance the profiting of investors or traders on daily trading. The level of accuracy of the different ANN configurations is presented in the table 1.

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Table 1: Sample of Empirical Results of using Hybrid Approach on different Neural Network Predictive Models.

Sample of Daily Stock Price prediction										
Sample Period	Actual Value	Predicted Values with Different Neural Network Predictive Models								
		18-18-1	**18-19-1**	**18-20-1**	**18-21-1**	**18-22-1**	**18-23-1**	**18-24-1**	**18-25-1**	**18-26-1**
12/10/2008	**18.03**	17.72	18.04	19.71	17.70	19.06	18.43	**18.04**	17.86	17.42
12/11/2008	**17.4**	17.84	17.58	17.07	17.19	17.63	17.97	**17.17**	18.11	17.35
12/12/2008	**16.6**	16.53	16.98	17.59	16.29	17.63	16.90	**16.65**	17.44	15.77
12/15/2008	**16.95**	16.42	16.89	17.50	16.40	17.98	16.01	**16.87**	16.89	17.33
12/16/2008	**17.13**	18.23	17.75	16.77	16.67	17.86	18.48	**16.96**	17.32	16.54
12/17/2008	**17.62**	16.99	17.18	17.98	17.36	18.65	16.58	**17.58**	17.62	18.13
12/18/2008	**17.54**	16.73	17.05	18.89	17.25	19.21	16.78	**17.94**	17.00	17.00
12/19/2008	**16.16**	16.95	16.96	16.68	15.51	15.82	17.69	**15.62**	16.04	16.05
12/22/2008	**16.56**	16.65	16.82	16.01	16.71	16.82	17.14	**16.85**	15.89	15.44
12/23/2008	**16.27**	16.80	16.93	16.27	15.58	16.39	17.16	**15.96**	16.06	16.06
12/24/2008	**16.1**	15.40	16.25	16.82	15.65	17.10	15.77	**16.24**	16.51	15.36
12/26/2008	**16.05**	15.43	16.25	17.00	15.32	17.24	15.49	**16.09**	16.12	15.72
12/29/2008	**15.95**	16.30	16.54	15.61	15.50	16.38	16.21	**15.91**	15.62	15.58
12/30/2008	**15.8**	15.15	16.09	16.75	14.87	16.78	15.28	**15.73**	15.61	15.64

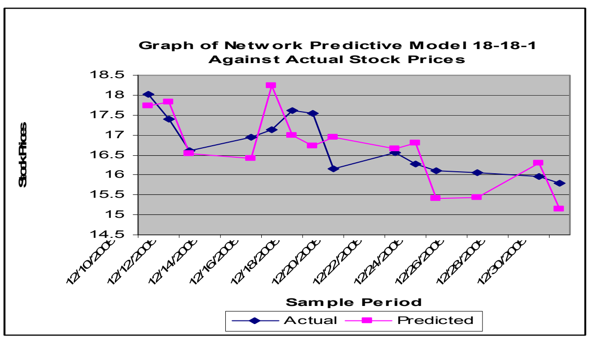

Figure 3: Network Predictive Model 18-18-1

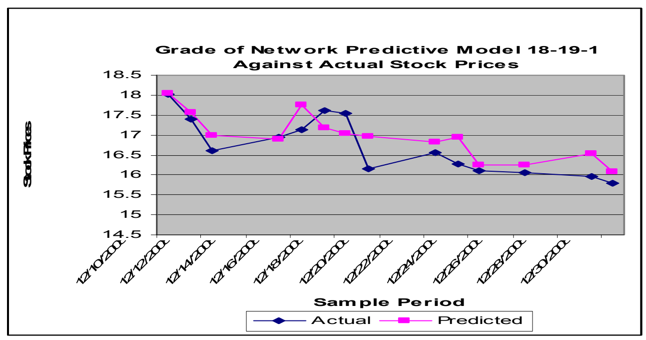

Figure 4: Network Predictive Model 18-19-1

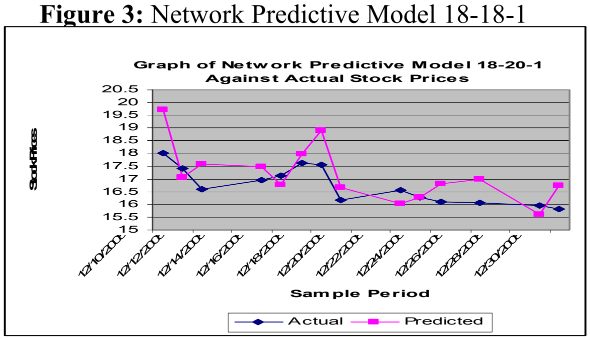

Figure 5: Network Predictive Model 18-20-1

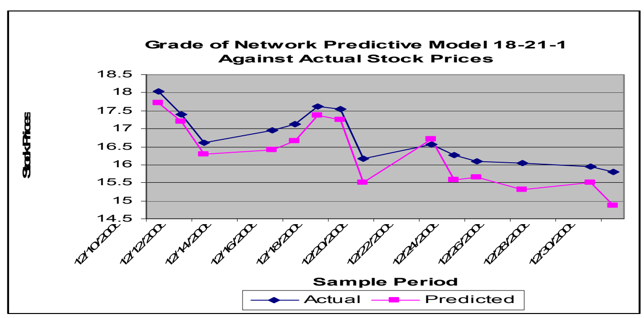

Figure 6: Network Predictive Model 18-21-1

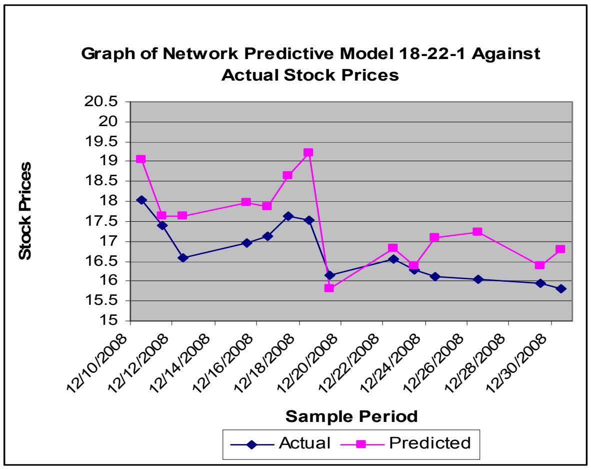

Figure 7: Network Predictive Model 18-22-1

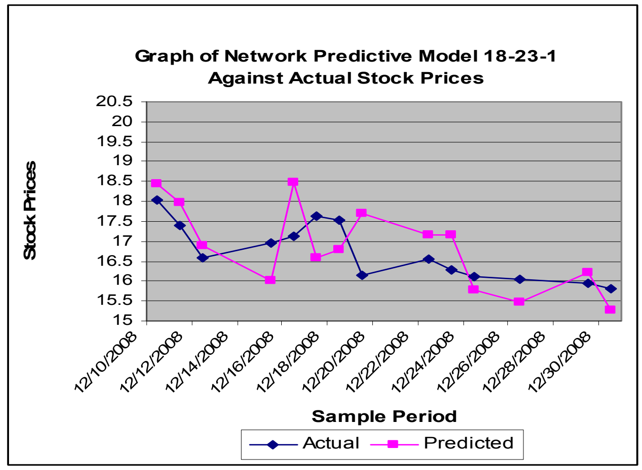

Figure 8: Network Predictive Model 18-23-1

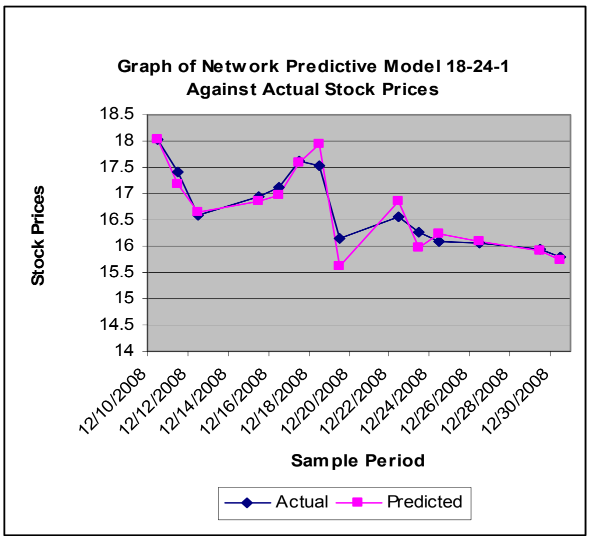

Figure 9: Network Predictive Model 18-24-1

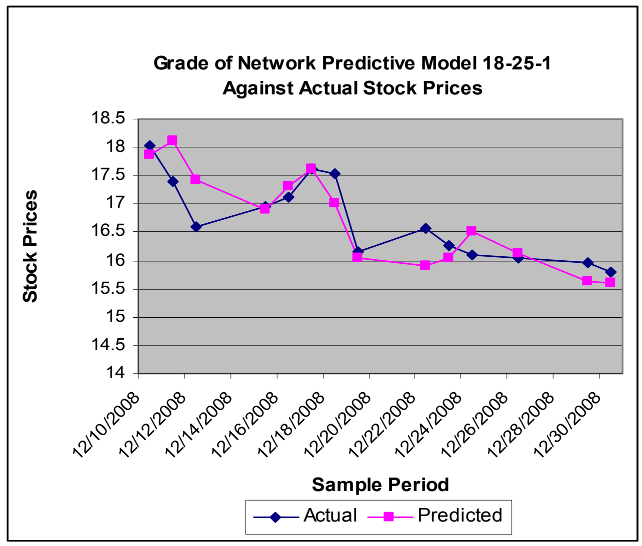

Figure 10: Network Predictive Model 18-25-1

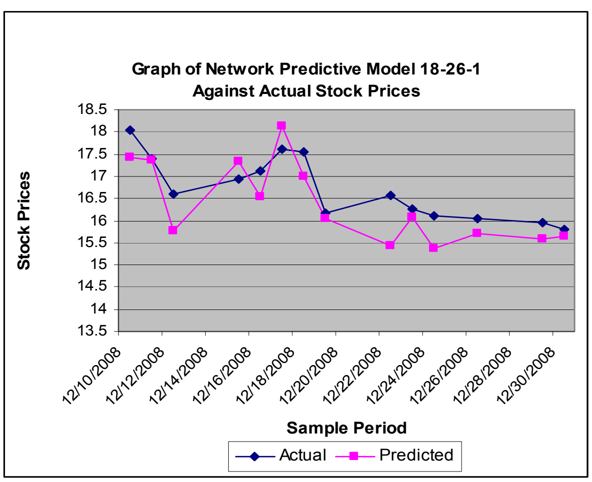

Figure 11: Network Predictive Model 18-26-1

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Table 2: Sample of Empirical Results using Technical Analysis with different Neural Network Predictive Models.

Sample of Daily Stock Price prediction										
Sample Period	Actual Value	**Predicted Values with Different Neural Network Predictive Models**								
		10-10-1	**10-11-1**	**10-12-1**	**10-13-1**	**10-14-1**	**10-15-1**	**10-16-1**	**10-17-1**	**10-18-1**
12/10/2008	**18.03**	17.94	17.94	18.25	17.96	18.20	17.51	18.08	**18.03**	18.72
12/11/2008	**17.4**	17.42	17.58	17.66	17.77	16.57	17.44	17.73	**17.82**	17.29
12/12/2008	**16.6**	16.91	16.60	16.35	17.36	15.80	16.44	17.18	**16.63**	16.36
12/15/2008	**16.95**	16.67	17.08	17.22	17.00	16.77	16.99	17.41	**17.27**	16.51
12/16/2008	**17.13**	17.18	17.26	17.37	17.37	16.40	16.93	17.19	**17.27**	17.27
12/17/2008	**17.62**	17.41	17.57	17.94	17.31	17.31	18.13	18.13	**18.24**	17.14
12/18/2008	**17.54**	17.27	17.05	17.50	16.48	17.92	17.60	17.44	**17.73**	17.47
12/19/2008	**16.16**	15.89	16.86	16.89	16.94	16.23	14.77	15.92	**15.82**	17.37
12/22/2008	**16.56**	16.18	16.00	16.54	15.68	16.68	16.35	17.43	**16.85**	15.94
12/23/2008	**16.27**	15.84	16.69	16.85	16.58	16.21	15.27	16.37	**16.20**	16.66
12/24/2008	**16.1**	15.88	16.02	16.18	16.23	15.58	15.73	17.00	**16.37**	15.51
12/26/2008	**16.05**	15.69	16.13	16.25	16.19	15.86	15.54	16.60	**16.19**	15.69
12/29/2008	**15.95**	15.58	15.97	16.04	15.96	15.93	15.50	16.45	**16.01**	15.46
12/30/2008	**15.8**	15.25	16.11	16.28	15.95	15.80	14.89	16.19	**15.79**	15.71

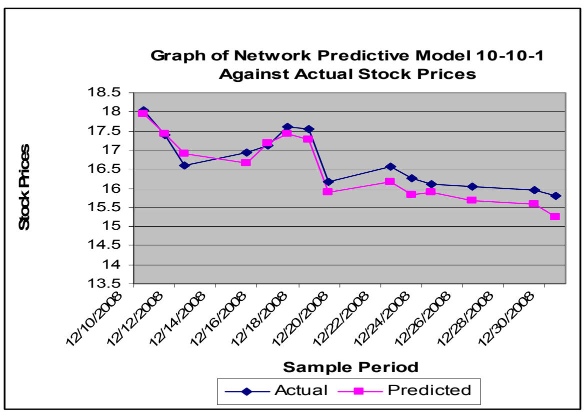

Figure 12: Network Predictive Model 10-10-1

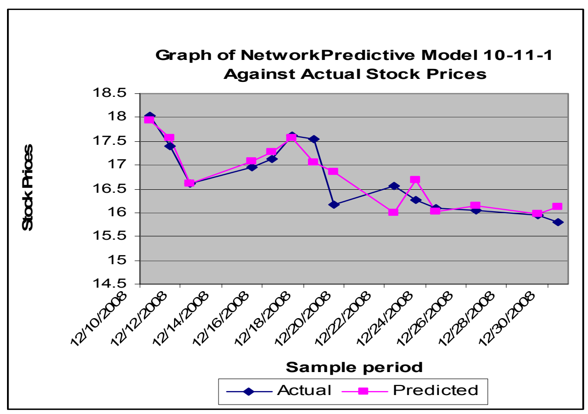

Figure 13: Network Predictive Model 10-11-1

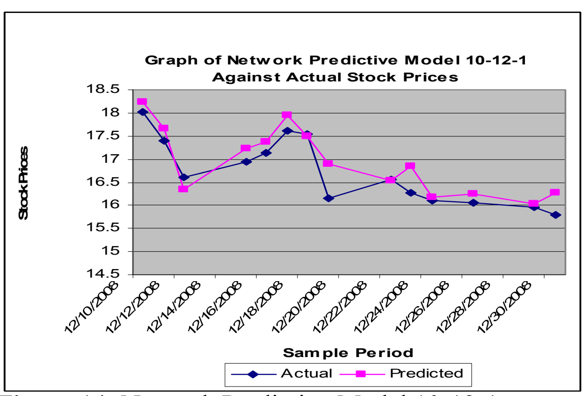

Figure 14: Network Predictive Model 10-12-1

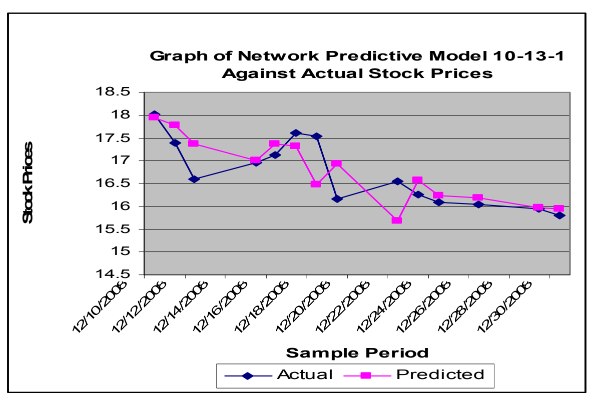

Figure 15: Network Predictive Model 10-13-1

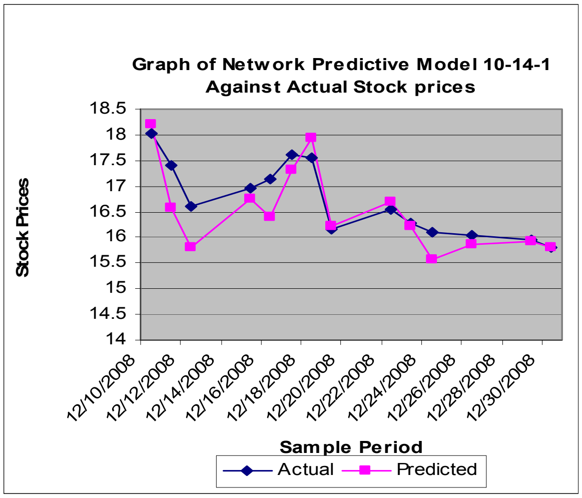

Figure 16: Network Predictive Model 10-14-1

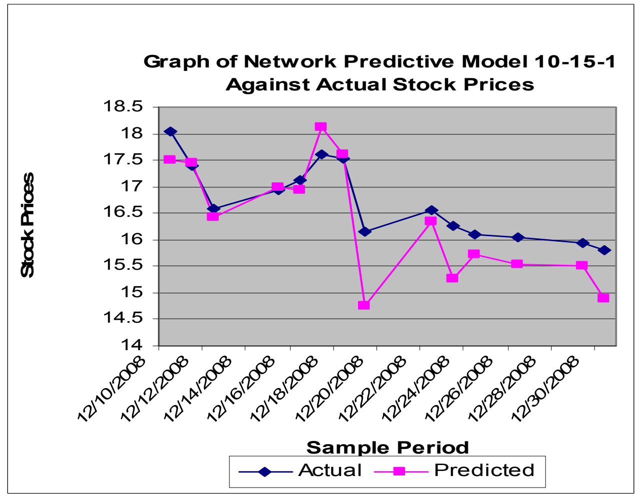

Figure 17: Network Predictive Model 10-15-1

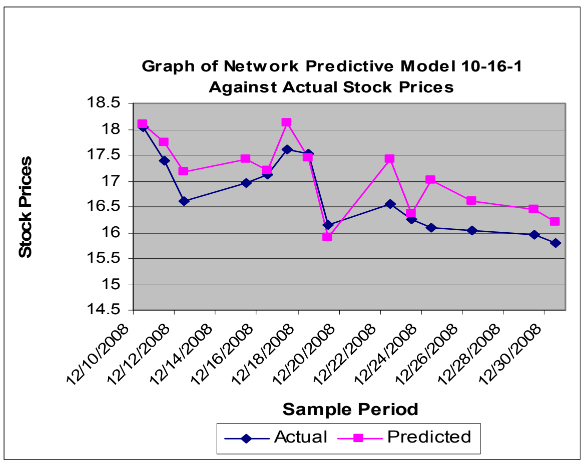

Figure 18: Network Predictive Model 10-16-1

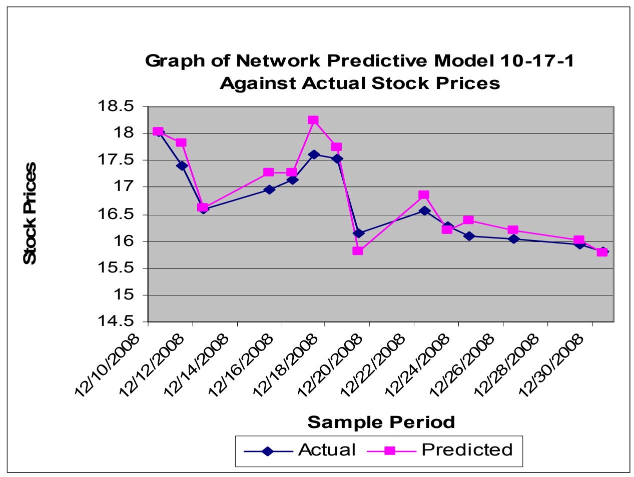

Figure 19: Network Predictive Model 10-17-1

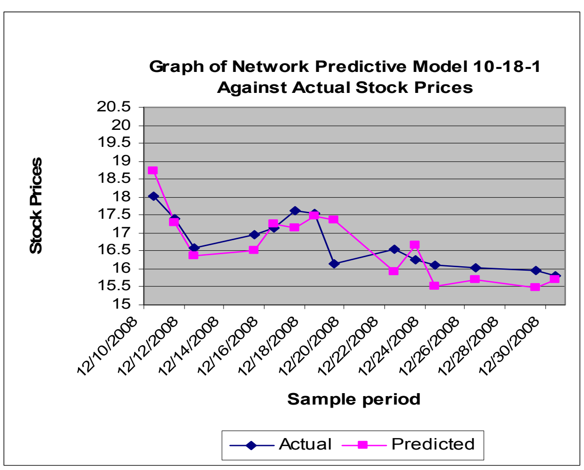

Figure 20: Network Predictive Model 10-18-1

5. CONCLUSION

This paper presents a hybridized approach of the combination of the variables of technical analysis and fundamental analysis to create a feed forward multilayer perceptron neural network predictive model trained with backprogation algorithm for improved accuracy of stock prediction. To determine the performance of our model, an empirical study was carried out with the published stock data obtained from the Internet, where the hybridized approach was compared with the use of only technical analysis. The empirical results obtained showed high level of accuracy for daily stock price prediction with hybridized approach performing better than technical analysis approach.

Therefore, the hybridized approach has the potential to enhance the quality of decision making of investors in the stock market by offering more accurate stock prediction compared to existing technical analysis based approach.

In future work, we intend to determine the critical impact of specific fundamental analysis variables on quality of stock price prediction.

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