Neural Networks and Stock Market: Efficiency Hypothesis: A Case of Pakistan

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Abstract

Stock market prediction is among the significant factors determining the decision to invest in the stock market. The motive of earning more and getting maximum profits from the investments in the stock market has led the investors, researchers and financial analysts to devise the methods to predict the price change of the commodities which are in circulation in the market, and the need for understanding forecasting techniques became even more crucial as the level of trading and investment in the stock market grew. The desire for optimizing gains and minimizing risk factor can also be considered as a motive of applying and devising the new techniques for forecasting. This study uses a totally different method to forecast and predict stock returns in Karachi Stock Exchange. The study has applied three years data on monthly basis of Karachi Stock Exchange-100 index for forecastimg. The data range is June 2011 to July 2014 consisting of 36 observations. A Multilayer Perceptron Neural Network technique is applied for prediction. The study concludes that the Karachi Stock Exchange 100 index is not efficient and that returns can be forecastedby applying other methods for prediction and Multilayer Neural Network is among the methods. In the circumstances, buying and holding stocks is the most appropriate strategy.

Keywords: Stock Market, Returns, Efficient Market Hypothesis, Neural Networks

Introduction

The prediction of stock returns is a very important factor for many financial decisions. On the basis of predictions, decisions related to money matters, could be better made. Stock returns prediction is not just a regulatory requirement but is the base of a successful business strategy. Stock return prediction is carried as the main objective behind it is to predict future performance of the stock and to make the appropriate "buy", "sell", or "hold" decision about the stock in order to gain maximum profit. It is the human being's behavior to have more monetary asstes and earn high profits in their businesses as compared to others. This way to achieve this objective, they follow and innovate the methods to get them high profits and also minimizing the chances of getting loss in the upcoming years.

The Efficient Market Hypothesis (EMH) states that at any given time, the price of a security/share fully reflects all the available information related to that security/share .i.e.

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all the past information (publically available information and privately available information) about it. For the EMH to be true, it is mandatory that investor's actions should follow a random walk and show normally distributed patternsfor the over-all impact on market shares. It may not be efficiently forecasted to earn abnormal profits, while considering the transaction's cost (inclusive of commissions). Those who are investing in the stock marketsbe able to have efficient decision about their investments only when they are having good and the most recent knowledge and information about the market and its deriving forces. According to Fama (1970) the EMH has three different forms named as weakform efficiency, semistrongform efficiency and strongform efficiency, having differentiated applications for the functioning of the markets.

EMH asserts that an opportunity for profit in the stock market is exploited as soon as it appears and after that it disappears immediately. The supporters of EMH are of the view that market is so much informationally efficient that it is not possible for an investor to consistently buy and sell the securities/shares in such a quick manner which consistently benefits him.

EMH says that stock market is informationally efficient and that the prices does not show any pattern among them i.e. they show a random behavior, so, they can't be appropriately predicted for the future. If one considers it to be very much true then he/she is not in the position to expect as well as earn a considerable amount of profit to get maximum benefits and outperform others in the stock market. The motive of earning more and getting maximum profits from the investments in the stock market has derived the investors, researchers and financial analysts to find ways and methods to predict the behavior of the commodities which are in circulation in the market, and the need for these stock market return prediction techniques became even more crucial as the level of trading and investment in the stock market grew. The desire for increased gains and minimizing the risk factor can also be regarded as a motive of devising such techniques. Previously different approaches used for the forecasting of future direction of stock market prices were of two types i.e. the financial analysis & the fundamental analysis but now a third type of stock market analysis has emerged recently which can be named as the technological analysis.

The *technological analysis* based upon the view that current prices of the stocks is having a significant effect of its past prices and that the stock's price shows a pattern. The basic assumption on which the technical analysis is based upon is that the "history repeats itself" and that the market is not informational efficient so, it clearly contradicts with the EMH. The input for this analysis includes past prices, trading volume and interest rates and gives the output in the form of charts. So, this type of analysis is highly subjective in nature & different individuals can interpret these charts in different ways.

The *fundamental analysis* is based on the view that stock's future return can be predicted with the help of externally available information. This information may include knowledge about company's performance and its profitability, interest rate, price and

return from alternate assets and different macroeconomic indicatorss. The basic assumption on which the fundamental analysis is based is that a stock market's current pricesare dependent upon its basic value and the projected return on investments i.e. as soon as the new information related to a company's status is thrown in the market, the expected return on its share will change, effecting the stock prices.

The *technological analysis* is the most recent approach for stock return predictions in the stock market. Fundamental analysis strives to mock-up and stimulate as precisely as possible the behavior of the stock markets by using various methods. In their paper, Armano, Marchesi and Murru (2005) genetic and neural techniques for stock return forecasting purpose and their results showed that genetic and neural technologies are more reliable. Chen and Liao (2005) have used genetic programming in their analysis. Gradojevic (2006) found that the neural networks comulatedwith fuzzy logic controller provides a better group of investment strategies with the help of which an investor can earn high returnsrelative to simple buy-and-hold strategy. Binner, Kenedal and Chen (2004) viewed that different data driven techniques like neural networks, genetic algorithms, fuzzy logic and probabilistic belief networks can be very helpful in the field of finance and economics.

Literature Review

Eugene, F. (1960) gave the concept of efficient markets. Form efficiency of market he means that market is informational efficient. The degree of efficiency depends on appropriate information available in market. So, according to him, EMH has three forms reliant upon the amount of available information within the market. These forms are: 1) Weakform, 2) Semi strong form and 3) Strongform efficiencies.

Weak-form of EMH suggests thatmarket prices fully use all the historically available information about the security/share. Semi-strong form of EMH says that market price of security or share fully reflects all the publically available information about it. Investors will make the decisions depending upon the past stock prices plus the different signals which are available for the general public in the market about the particular security's/share's price. So, no individual in the stock market can enjoy extra gains from this information. Fama (1970) carried out efforts for testing semi-strong form of EMH. There exists a strong form efficient market when the information set available in the market reflects all the past, public and privately available information related to the various commodities which are traded in the market. Bechev (2003) is of the view that the testing of strong form of EMH depends upon the fact that whether the investor in the market is having personal access to the information other than that is publically available; which is relevant in value configuration of a security/share and it is not fully revealed in the market prices. The title suggested by Fama (1970) for this category is *tests for private information.* Grossman & Stiglitz (1980) are of the viewthat in no way market can be informational efficient. As the information is very costly, so it is impossible for the share's price reflecting the information available and if in case it happens, then the investors, who have invested their money and time to obtaining and analyzing the information, will get no return from this effort. So, a rational framework of attaining

equilibrium in the market must give some incentives to gather sources of information. French and Roll (1986) says that the volatility of asset's price tends to be high at the time of trade in the market relative to the time when there is no trade and this fact is because of trade based on privately available information-the market generates its own reports and information.

Laffont and Maskin (1990) rejects strongly the Random-Walk Hypothesis regarding returns on weekly basis conducting Variance Ratio test. On the basis of imperfect competition, reversal in weekly security returns and strong evidences of predictive behavior of security returns. Laffont and Maskin (1990), Lehmann (1990) and Jegadeesh (1990) rejected the EMH. Chen and Yeh (2002) showed that EMH satisfaction can be ahieved by utilizing some segments of artificial time series. Another proponent of EMH, Malkiel (2003), found that stock market is much more efficient and extremely less predicted as compared to the findings of some current academic papers. Schwert (2003) concluded that the findings of the researches causeshigh efficiency in market i.e. the market anomalies subsequently weakens and disappears. Bechev (2003) says that it is difficult to check that a market is efficient or not. But relative efficiency among the markets can be measured i.e. one market is efficient or the other. Pajuste et al. (2000) examined the obviousness of stock market returns for the Central and Eastern Europe Countries (CEECs) with the help of index data related to the period June 1994 to July 1998. They used simple OLS regressions to find out that the returns in the WSE could be consistently predictable and found some evidences for insider trading in the PSE, characterizing it as "disorder for the outsider, sweet profit for insider". ANN acquires knowledge as human brain doesi.e.acquisition of knowledge through learning and experience. During the learning process the weights of nodes are adjusted as they are the inputs for the network and an expected output value is also given. The network usually comprises of 3 different types of layers i.e. the input-layer, the output-layer and the hidden-layer. Hidden-layer can be one or more. As the number of hidden-layers and number of Neurons increases, the complexity also increases. Nygren (2004) worked on predicting stocks through the Neural-Network technique. He claimed that time series data of stock is very difficult to be analyzed, so no approach is suitable technique to analyze time series data. He used two different network structures to analysis the weekly and daily stock returns for Swedish firms. He found that concerning daily data, SXGE does not give the expected excellent results. In weekly prediction, he found that there is smaller deviation from previous research's results. Finally, he concluded that neither weekly nor daily model gave the maximum results and has to be made modified.

Shapiro (2003) worked on capital market applications of NNs. He worked on the two dimensions of the capital market applications of NNs. First he worked to contribute to the implementation of NNs in capital market, then he worked to contribute how the hybrid of these technologies used to get maximum results. He formed a theoretical framework to understand the uses of technologies in the capital market. On the basis of the literature he concluded that soft computing is very important in understanding the capital market. Sharma (2012) worked on application of Artificial Neural Networks in business applications submitted in crossroad magazine, ACM. They claimed that due to the use of

computer technologies in the business, the way of running business is also changed. They used NNs approach and he concluded that finance is an emerging pasture of research due to easy and massive availability of data related to finance and the description capability of neural networks to identify and incorporate relations among a large numbers of variables. Ravichandran et al. (2005) worked to estimate returns in the stock marketsby applying ANN. Traditionally, the stock market is predicted through historical prices but now there are different techniques starting from unpolluted mathematical models to logical networks. They proposed in their study a newly NNs methodology in which NNs is used for decision making for all sort of investors not considering high low indexes in stock market. They found that ANNs have high capability to forecast stock's returns in stock market. They also concluded that returns are ambiguous and doubtful, no traditional technique gives the true results in this scenario, so a logical model is best option to estimate the stock returns either in smooth or disturb situations. Olivier (1998) says that the selection of proper and more relevant input variables count a lot for the most accurate prediction of stock movements. Stock price is an important variable in this regard but it is not applied directly as it is in raw form and is preprocessed, for maximizing accuracy of the output, for data normalization to remove the noisy data or for any missing data.

Three type of ANNs are commonly used by researchers for stock market predictions: 1) Multilayer Perceptron; 2) Generalized feed-forward networks, and 3) Radial basis function. Some important points which should be taken care of, while modeling a Neural Network for stock market predictions includes determining the correct number of Input-Neurons, Output Neurons, Hidden-layers, hidden-neurons, and transfer functions. After the selection of inputs the next step is to train the network and the main motive behind this training is to minimize the error function but the adjustment of error function itself is a problem. One solution to this problem can be Back Propagation Algorithm in which the error is back propagated even to the Hidden-Neurons, minimizing the error function. In the process of back propagation, the learning rate must be carefully and appropriately chosen i.e. not too small or not too large. In Genetic Algorithm based Neural Networks, population having random generated weightages is developed and a growth (evolution) algorithm is used on it in order to get most appropriate sets of weights. Schierholt & Cihan (1996) have used two Neural Network classifications named "Multilayer perceptron architecture" and "Probabilistic neural network" to forecast the increase, decrease or the steadiness in the indexes. After comparing the results of the decision taken according to the predictions of these NNs with the maximum possible performance and the performance of the index. The results showed that both the networks are good performers but Probabilistic Neural Network performs slightly better than the multilayer perceptron. The main focus of the authors was to maximize the performance of the portfolio rather than maximizing the percentage of correct judgments, as a single gone (missed) option can give more harm than several negligible missed opportunities.

Justification of the Study

Despite the propositions of EMH, many traders continue to trade and make decisions based upon the available historical data. For this purpose they try to find out patterns in the available data which can prove to be helpful to get foresight about the future

movements of the stock's prices and their returns. Previously those patterns were identified and discovered through technical analysis or fundamental analysis but now analysts and researchers are increasingly using a new and modern technique called the Artificial Neural Networks (ANNs), the appropriate technique to forecast relative to others. Neural networks works on the same lines as the human brain. The present study is applying ANN approach to the stock market in Pakistan.

Objectives of the Research

The main objective of the research are:

- To analyze the extent to which technological analysis (neural networks) can be a best technique for stock market return forecasting in Pakistan;
- To suggest in which form of Efficiency Market Hypothesis does the Pakistani Stock Market lies.

Methodology

The methodology used in this paper is Multilayer Perceptron with 1 hidden layer. Closing prices of KSE-100 index for 156 months (3 years) from June 2011 to July 2014 are used as input to the network. Literature has shown that in case of data having short intervals like daily or weekly data, the performance of traditional forecasting techniques like Regression, ARCH, GARCH, and ARIMA etc is better than the forecasts of Neural Networks. But for long intervals like monthly or yearly data neural networks out performs the traditional forecasting techniques. First of all an expected series of returns is formed by using bootstrapping procedure and after this the bootstrapped expected series is compared with the original series to check significant differences between them.

Results and Discussion

The results of multilayer Perceptron neural networks are as below:

Descriptive Statistics

Table 1 Descriptive Statistics

Mean	0.000107
SD	0.018047
Error Mean	0.000108
Error SD	0.018062
Abs E mean	0.013029
SD ratio	1.000871
Correlation	-0.763559

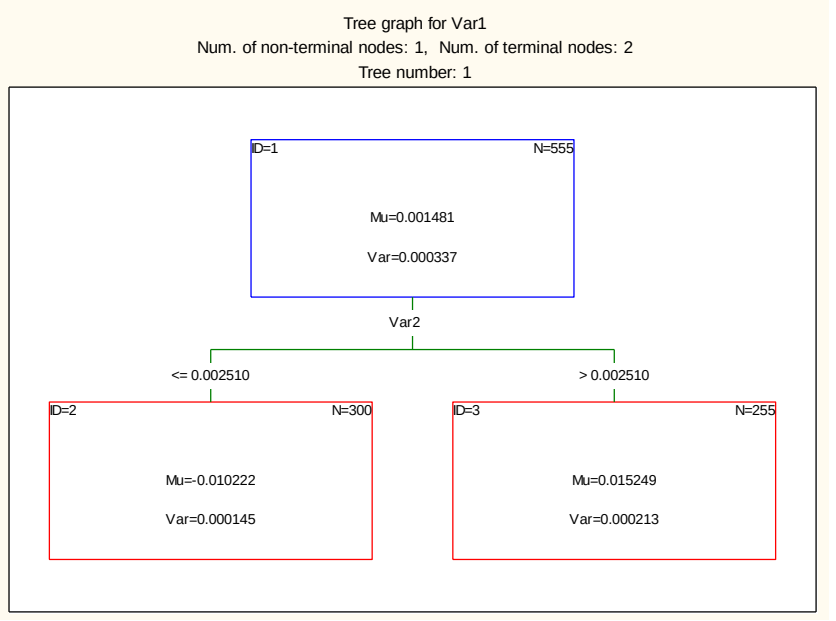
The motive of using regression in neural networks is to map out the continuous variable(s) from the input variable(s).

Mean: the average value of the target output variable is very low.

S.D: the standard deviation of the target output variable here in this case is not very high, so it can be said that neural networks can readily predict for the future values of stock returns.

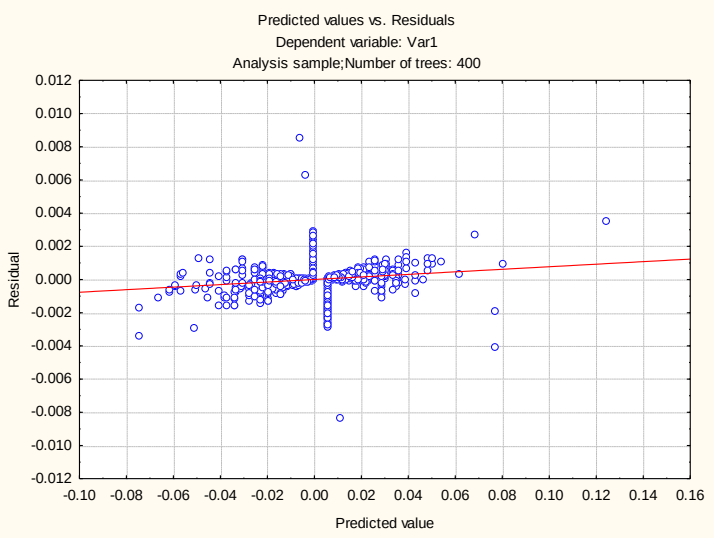
Error Mean: its value is very low in this case that is the expected results and the results of neural networks are not much different. There is a little deviation from the standard.

Error S.D: S.D of error from output variable is not very high. Pearson correlation r is negative.

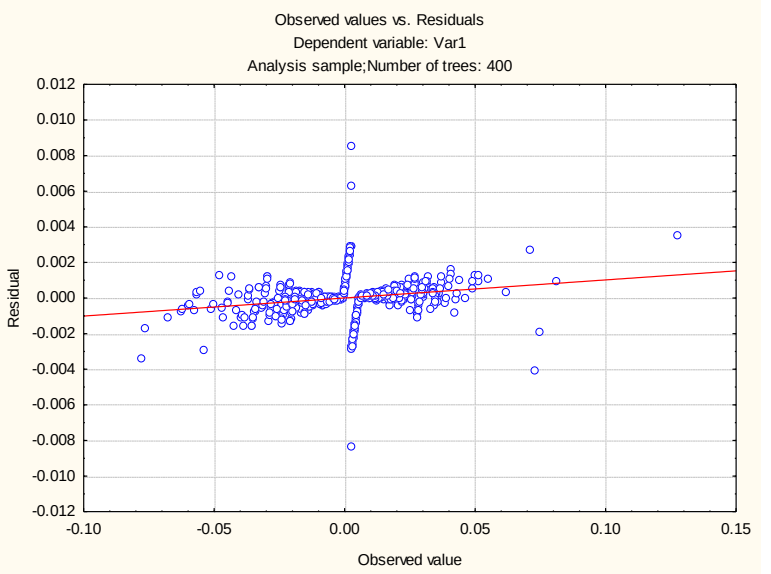


Interpretation of the results from tree structure is straight forward. Here the tree graph shows two different types of outputs. It is evident from the structure that the cases where the percentage of prediction is greater than 0.025%, future prediction of the results can be effectively done i.e.the market is not efficient and when it is less than 0.025% which shows that there is not any possibility of any outstanding profits from forecasting. Node 1 is a non-terminal node as node 2 and node 3 originates from it having no sub nodes.

Predicted v/s Residual

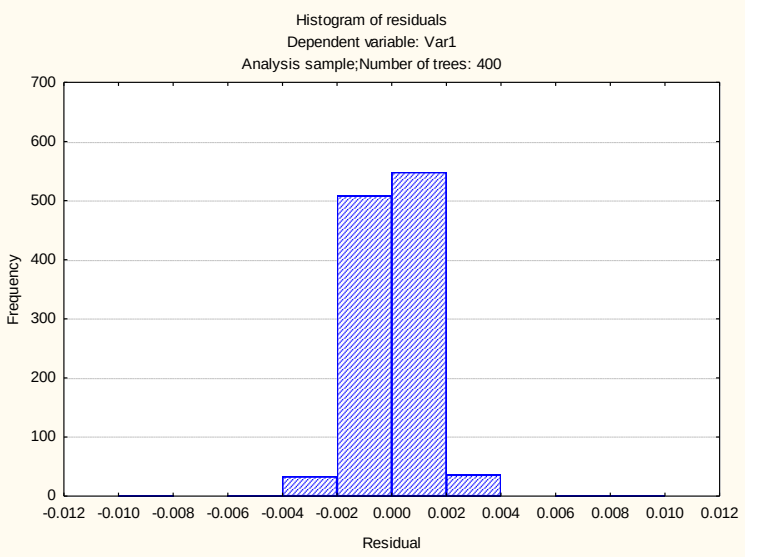


Here in case of predicted versus residuals again most of the residuals are almost near thepredicted values i.e. they are not much dispersed from the predicted values. This graph is almost same as the graph of residuals versus observed values.



Residuals are the difference between predicted and the observed value because no linear regression model completely fits the data as there remains always a residual or outlier. In

the probability graph of residuals, residuals are plotted at Y-axis and observed values are at X-axis. Here in this graph it is clear that most of the residuals are near the observed values showing that there are not much variations between the expected and the observed values. A very small number of residuals is far from the observed values.

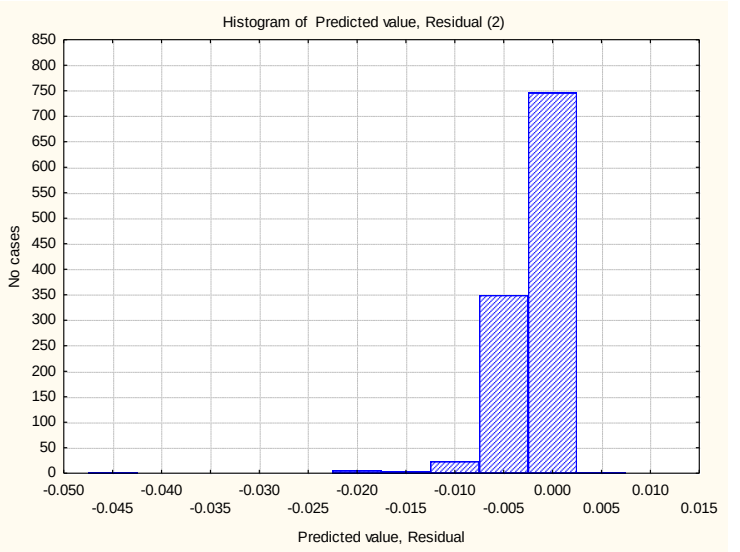


Graph is leptokurtic in shape. Values range from -0.004 to +0.004 and most of the values are concentrated at the centre and are not much dispersed.

Neural Network (MLP_Back Propagation Method)

Profile	Train perf	Select Perf	Test Perf	Train Error	Select Error	Test Error	Training Members	Input	Hidden (1)	Hidden (2)
MLP 1:1-2-1:1	1.001 000	1.001 008	1.000 512	0.114 464	0.124 343	0.123 673	BP9 5b	1	2	0

Histogram: Predicted v/s Residual



The predicted values of residuals lie between the range of -.0225 and +.oo75 and it is clearly evident that the values is not normally distributed. Most of the predicted values of residuals are zero.

Conclusions

From the results it can be concluded that KSE-100 index is not an informationally efficient and expected future outcomes may be forecasted by applying various methods and multi-layer-Neural-Network is among these mathods. KSE-100 is not even a weak form efficient market. So, such situations, the efficient strategy isBuy-Hold strategy. This study apply a new method for prediction of return in Karachi Stock Exchange. Monthly data from June 2011 to July 2014 is applied. A Multi-layer Perceptron Neural Network technique is applied to predict the future returns. Results of the study concludes that Karachi Stock Exchange market is not significantly effective and expected returns may be forecasted through applying various other approaches for predictionlike Multi-layer Neural Network. The results of the study are in accordance with the studies of Karsten and Cihan (1996), Olivier (1998), and Ravichandran et al. (2005).

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