Predicting Tehran Stock Exchange Index Based On The Effect Of Macroeconomic Variables On The Stock Index And Using Artificial Neural Network With Multilayer Perception

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Abstract

Given the key role of macroeconomic variables and their impaction the Stock Exchange index, and considering the nonlinear behaviour and nonparametric of the Stock Exchange index, investors, financial managers and economic agents will practically experience high risks, so predicting the index trend as one of the most controversial issues in the financial affairs is of crucial importance. In order to analysis the Exchange index, the statistical data of the Tehran Stock Exchange, the macroeconomic variables of foreign exchange, gold, inflation, oil, export, import were extracted from 2014to2018, and then the prediction of the stock exchange index was conducted over these years. Artificial neural Network with a multilayer perception (MLP) structure was used in this study. The results indicate that: the macroeconomic variables affect Tehran Stock Exchange index; and neural networks have the ability to predict a stock index in time intervals with acceptable error rate.

Keywords: Tehran Stock Exchange, multiply perception neural networks, inflation rate, gold rate, exchange rate.

1. Introduction

The stock price index trend is one of the most important factors affecting investors' decisions to invest in the stock market. Therefore, knowledge of factors influencing the stock index is important. Usually, the price of assets will react to economic news. Experience has shown that the price of the assets is influenced by a wide spectrum of unforeseen events and the impact of some of these events is more than other events. Macroeconomic variables are among the most influential factors in the stock index trend which in recent decades, countless studies have been conducted on the impact of macroeconomic variables on the performance of the stock market.

If the stock price reflects exactly the status of the fundamental variables of the economy, it should be considered as the indicator of the overall economic situation. Therefore, developing the dynamic mutual relationship between the macroeconomic variables and the stock market is important to regulate the macroeconomic policies (Mayasami and Koh 2000).

According to Obrouc (2004), some of the economic factors driven from the research in world financial market are known as economic factors affecting the stock price index which are exchange rate, inflation, interest rate, gold price, GDP, export, import, New Year effect, previous Stock values, money volume, unemployment, trading deficit and oil prices and other macroeconomic variables. Over the last decade, we have been witnessing the successful presence of artificial neural networks. It has been very challenging to have a training perspective to solving problems and identify complex and nonlinear patterns for academic researchers. Neural networks are computational tools for testing data and creating a model of data structure. They use educational data to learn the existing patterns, and can be used to achieve outputs and various results.

Developing and expanding the application of computers in all aspects of human knowledge, including financial and investment Management, has created novel applications of new technology.

Artificial neural networks are one of the last achievements of this rapid progression. Since the mid-70sand especially since 1980,the enormous efforts have been made in the field of predicting stock prices using new mathematical methods, long time series and more advanced tools such as artificial intelligence began and a large number of tests have been conducted on price information and stock index in countries like England, the United States, Canada, Germany, and Japan took to show the existence or lack of a specific structure in price information and stock index, and this way was used to disprove random steps (Pinches 1970).

The main objective of this study is to look into the possibility of predicting stock index based on the effect of macroeconomic variables on it, using artificial neural network with multilayer perceptron.

2. Literature Review

The first stock price index was used in the United States in 1884. This index was achieved in the railway industry of the simple average of eleven companies. In total, the stock price index in all the world's financial markets constitutes one of the most important criteria for assessing the performance of the stock exchange.

Perhaps the most important reason for this increasing attention is that the mentioned index is obtained from the conclusion of the price trends of the shares of all companies or a certain class of companies in the market, and consequently, the evaluation of the direction and size of the price trends in the stock market. In fact, the development of financial theories and innovation in the past two decades were based on the central role of attention to the market general trend with a growing trend in calculating and reviewing and the trend of such indices (Raei and Talangi 2004). The application of neural networks in economics and econometric began in the late 80 with White (1988) study in the financial markets and IBM Corporation. Of course, the main objective of this study was to test the hypothesis of the market efficiency, although the results of this study showed that algorithms-econometric is better than the algorithms of the neural network, but because of the simple network usage, the results of this study by different researchers was disputed. After White (1988), several studies on the application of artificial neural network were successful, but the success of neural networks in the field of financial economics attracted the attention of macroeconomic and econometric experts and the use of neural networks in different variables including the success of the study by Kohzadi et al (1995). In 1990, Takoha, Yuda, Asakawa, Kimoto launched the system of predicting the stock market, which used the neural network. In this study, while comparing the expert systems and neural systems, the nonlinear learning of artificial neural networks was noted as the high ability of these sites (Schwartz and Whitcomb 1977). In another research by Leung et al. (2001), the Taiwan stock index market forecast was performed using artificial neural network and the result was the method of artificial neural network being more efficient compared to filter methods and random walk model. In another research by Heydari and Kordloee (2010) the stock price forecast was performed using artificial neural network, which showed efficiency of neural network models much higher than simple regression models. Raee and Chavoshi (2004) forecast the behaviour of stock returns in Tehran Stock Exchange by a linear factor model and artificial neural networks. In order to test this issue, the daily stock of Behshahr industrial development company was selected as sample and the independent variables (entries) constituted five macroeconomic variables, namely "The total price index of Tehran Stock", "exchange rate (USD)"in the free market, "oil prices" and "gold prices".

Also, for fitting a factor model of multivariate linear regression and for neural network model, (MLP) architecture with error back propagation was used (Raee and Chavoshi 2004). In their review, Chen and Goachang (2007) concluded that accounting variables predicted stock price movements. Rapach (2001) states that dramatic shocks affect the price of shares.

Cheng and Liv (1996) tried to determine the forecast model of stock prices based on fuzzy based on the important variables and with the accuracy of 97.6 percent, so that the sample was the Taiwan electronic

Companies being accepted in the Taiwan Exchange (Shanker et al. 1996). In their research, Bordman and Claude (2000) studied the impact of different time intervals on stock prices and confirmed its impact on the dependent variable.

In a research by Rahnamay Rood Poshti et al. (2005), The effect of macroeconomic variables on the shares of investment companies accepted in Tehran Stock Exchange was investigated, which resulted in a positive effect of non-oil exports and liquidity volume and the negative effect of the consumer and import price index. Pourzamani et al. (2011) conducted a research aimed to investigate the impact of fluctuations in economic indicators on stock returns. The results of this study showed that the growth rate of employment without the impact of the gross domestic product was limited and the inflation had a negative impact on stock returns.

By reviewing the stock price index in the Tehran Stock Exchange, we understand that the UPS and the most important market is the sudden collapse of the price index in the mid-decade of 1991, 2001 and early 2011. This can be caused by the lack of financial knowledge, financial analysis techniques and a tool that may minimize human error. In such circumstances, the existence of a proper prediction model makes capital market efficient. But which model is appropriate for the prediction can be a new chapter to devise containing various discussions.

3. Financial Analysis Methods

Prior to the appearance of computers, the issue off are casting the stock exchange was done using other types of methods. Methods used in the stock market in the traditional analysis methods are famous and analyzed by two methods of technical analysis and fundamental analysis.

3.1. Technical Analysis

Technical analysis includes a prediction technique that has been derived from the historical patterns of stock price behaviour and historical characteristics of other financial information. After reviewing the performance of past behaviour, the current information on the stock price will be examined to determine whether any patterns can be applied. If so, you can do so. The main view of the technical analysis is that the stock price changes trend is formed by changes in investors' attitudes that are influenced by several factors. Technical analysts use price, volume, and interest rate of charts to forecast future price changes. They are of the opinion that history repeats and future price changes of shares can be determined according to the previous prices of shares (Eyden and Robert 1996).

In the sixth decade of the twentieth century, with the emergence of chartists, several studies were conducted on the existence, correlation and price changes in the world's stock exchange markets, and the purpose of these studies was in addition to showing the existence of coordination and trend in pricing changes to reject the efficient market hypothesis (Sounders 1994).

3.2. Fundamental Analysis

The fans of fundamental analysis emphasize that at any moment the individual bonds have an inherent value, and this value is associated with the income of the share. As a result, analysts of the intrinsic value consider the value of the current income as a function of their future revenue or price ratio.

Thus, by determining the growth rate and the income prediction of the next year, they estimated the intrinsic price of shares for the current period and by comparing it with real prices, they did their transactions. The potential income of each stock sheet depends on factors such as the company's performance, industry success and economic situation. By carefully studying these factors, analysts can calculate the price difference of the bonds intrinsic value and take advantage of this method, so that if

the price is higher or lower than the inherent value, they will be able to install a lot of profits by selling or purchasing orders.

At this time, researchers tried to demonstrate the influence of macroeconomic factors on the exchange prices (Jones 1999).

4. Method

Scientific research is a systematic, controlled and experimental study of the phenomena whose relationship is directed through hypothesis and theory. In order to respond to research questions or proposed contexts, the data must be collected and analyzed and interpreted; in this process, the conversion of data to information is called the research method (Bazargan and Hejazi 2001). The current research is descriptive-inferential, aiming to be practical and qualitative as follows.

5. Data collection

The method of collecting data in this study is field study. The research time zone is from 2014 to 2018. The information required for this research on macroeconomic and economic variables of the securities index of the information were collected from Tehran stock exchange organization, the statistics organization and some reputable Internet sites and using the facilities of the database management software, the database has been created appropriately.

6. Conducting the Analysis

After collecting the data required by the research, they are all encrypted, Then entered into software Mathlab R 2018a and according to their classification and processing, the model was extracted. Finally, there was a comparative study between results of the model and the actual results. The subject area of the present study comprised of issues related to the stock market and in particular, the price index and location of the Tehran Stock Exchange.

6.1. Artificial Neural Network

The new perspective of artificial neural networks (ANN) began in the 1940s when the Mc Culloch and Pitts provided a mathematical model of the neuron. Warren Mc Culloch and Dalter Pitts introduced a computational element model which was a combination of these computational elements used to perform a logical calculation series. In this model, the neuron will shoot if the total of the stimuli exceeds the amount of the intake. In this model, it makes no difference how complicated the structure and timing of the activity and flexibility of the actual neurons are given, and therefore it is merely a model and not a simulation version of the Bio Neuron (Smith et al. 1993). In 1949, the Heb Learning rule, which is based on the strengthening of synaptic communication between two active neurons, was proposed. The law was the basis of learning rules in the studies of neural networks (Fausett 1996). The first application of artificial neural network was proposed by Frank Rozenblat in 1958 AD (Haykin 1994). In the Preceptron model, the weights were set up by the Perceptron Learning rule. Rozenblat showed that The Perceptron is a reparable, i.e. if the perception will give a certain response to an entry, the same answer will be given in the event of receiving the same entry that has not been trained. The Perceptions can learn and Rozenblat himself introduced a few different learning systems in terms of statistics and math (Smith et al. 1993). To teach multi-layer perceptron neural Networks, the Learning rule is used after the back propagation.

The first path is the forwarding pass path in which the input is applied to the network (MLP) and the effect is released through the medial overtones to the output layer (Haykin 1994). The second path is called the return path. In this path, the network parameters (MLP) are set up and this setting is based on the law of error Correction. An error vector contains the difference between the desired response and the actual network response. Error rate, after calculating, is distributed on the back path of the output layer and via network layers on the entire network. This distribution is contrary to the path of synapses weight; therefore, the word after publishing the error to modify the network behaviour has been selected.

666

6.2. Data Normalization

Data normalization, which means pre-processing and post-processing of data, improves network performance. Pre-processing data that usually done before network training, means making conversions on network inputs and outputs, in order to extract features from the inputs and converting outputs into a more understandable way for the network. After training and extracting the results from the network, the network outputs are converted to their original form, which is referred to as post-processing.

Shanker et al. (1996) believe that data normalization generally improves network performance. However, in cases where the number of data is increasing, data normalization is not very useful.

Normalization of data also reduces the speed of network training. There are various methods for data normalization, but one of the common methods in this field is statistical normalization. If this conversion is used, the mean of the data will be zero and their standard deviation will be equal to one. The following relationship can be used for this purpose:

$$X_n =)X_0 - \overline{\mathrm{X}}(/S \tag{1}$$

Where X, X0, Xn, S are normalized data, original, mean data and standard deviation. In this study, the data were also normalized based on the above relationship. For this purpose, pre-processing training data and post-training training data were pre-processed before network training.

6.3. Review the power of forecast

To evaluate the strength of the prediction, different criteria, including determination coefficient (R2), mean square error (MSE) were used. These criteria can be shown as follows:

$$MSE = \frac{\sum_{i=1}^{n} e^2 i}{n} \tag{2}$$

$$R^2 = 1\text{-}NMSE \tag{3}$$

In this regard, n is the number of their predictions and errors, which are the difference of the number of predicted and the actual values obtained.

In the above equation, the Normalized Mean Square Error (NMSE) is the Mean Square Error (MSE).

7. Modeling and prediction

7.1. Artificial neural network

The available information is for the years 2014-2018 which is obtained from the national port of the statistics and Central Bank (Central Bank of the Islamic Republic of Iran 2019; National Statistics Portal 2019). The Stock Exchange organization, and the gold price website. This section used Excel software and MatlabR2018a to analyze data and also to determine the model. One of the problems of working with artificial neural networks is the optimal amount of replication in the network training phase. How to provide examples to the network for training can be clustered and cyclical.

Now, if the number of visits to the network is more than necessary, the network starts to learn the error and it is literally called memorizing. There are several ways to avoid this:
1- Automated regularization
2. Early stopping

In the present research, the second method has been used. In this method, we need to separate a number of training set data as a set of assessments. In this study, a multi-layer perception neural Networks (MLP) has been used with an error-releasing learning algorithm.

Based on the classification of collected data, 2014 to 2018, the total data in education and testing was used for model processing.

Currency prices, inflation, exports, imports, gold and oil and the total indices of the stock exchange were used as input variables. For analysis, two models were considered. In the first model, with data entry of macroeconomic variables and exchange index, the possibility of focuses correlation between input the dependent variable and independent variables were investigated; sensitivity analysis for each input variables were investigated based on the trained model.

The feed forward neural network was created with a plan of 1-1-5-6. The network has six input layers for 6 independent variables and one-layer single-neuronal output for Tehran Stock Exchange index. The hidden overtones also have 110 neurons with the conversion Sigmoid Functions. R and R2 statistical coefficients have also been shown in the form of Neural Network (Bazargan and Hejazi 2001) (Figure 1).


```
Final report : estimate Value by neural networ
===============================================
|------------------------------------------------|
| Neural network       | valume  :   type    |
|------------------------------------------------|
| Network type         | feedforwardnet_trainlm |
| hidden Layer Size    |                5    |
| Max Epochs           |              110    |
| No. of input         |                6    |
|_____|
===============================================
|------------------------------------------------|
| Static Info          |     value           |
|------------------------------------------------|
| R      : Train    |      0.99961        |
| R2     : Train    |      0.99922        |
|_____|
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Figure 1 The feed forward neural network specifications

The proximity of the coefficient of determination to 1 indicates a strong correlation between the macroeconomic variables and Tehran Stock Exchange index in the years 2018 to 2014.

The proximity of the MSE to 09 (MSE= 0.0279) indicates a lower error rate. According to the results of this stage, the authentication model is a function of converting the output layer and output model as in the figure of function # 1 (Figure 2).
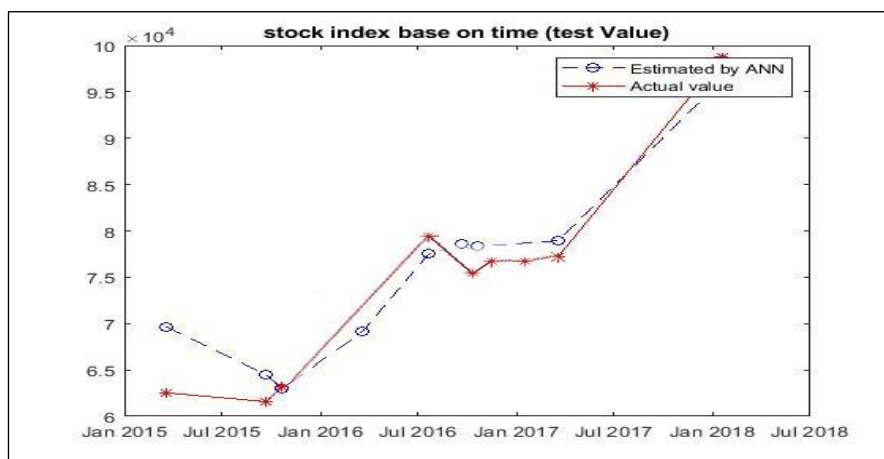

Figure 2 Function #1: the output of the model

668

In the second model, with the entry of the macroeconomic variables and the stock index, 2014-2018, and after testing obtain estimated index model by the network with the model of the number of 2 hidden overtones, 70 neurons and 6 estimated inputs are obtained which is the main purpose of the study. R and R2 Statistical coefficients also reveal the feed forward network specifications neural network as shown in Figure 3.

```
Final report : estimate Value by neural networ
=================================================
|-----------------------------------------------|
| Neural network      | valume  :   type     |
|-----------------------------------------------|
| Network type        | feedforwardnet_trainlm  |
| hidden Layer Size   |            5    3     |
| Max Epochs          |               70     |
| No. of input        |                6     |
| No. of train        |   35 : 79.5455 %     |
|                                               |
=================================================
|-----------------------------------------------|
| Static Info         |      valume           |
|-----------------------------------------------|
| R       : Train     |      0.99937          |
| R2      : Train     |      0.99874          |
| R       : Test      |      0.97559          |
| R2      : Test      |      0.94348          |
```

Figure 3 The specifications of feed forward neural network

The proximity of the coefficient of determining the test to 1 indicates the high strength of the model prediction. Also, the proximity of MSE to the zero (MSE = 0.2377) shows a lower error rate and

acceptable performance of the model. According to the results of this stage, the authentication model is a function of converting the output layer and output model to function number (Raei and Talangi 2004: 67) (Figure 4).
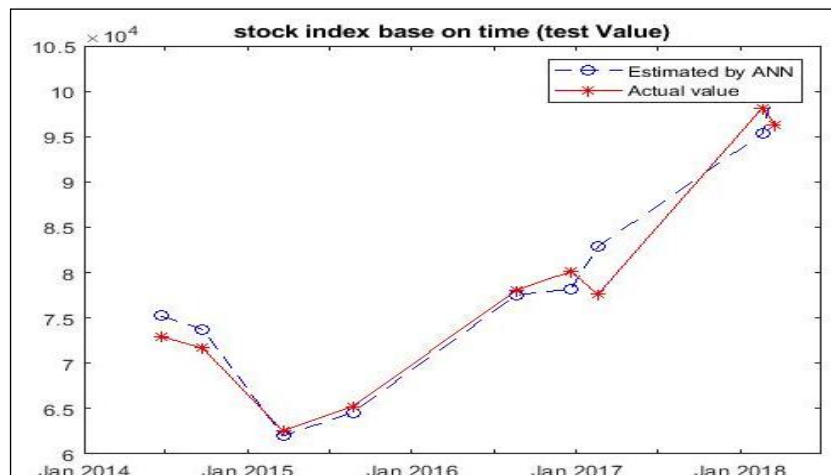

Figure 4. Function 2: the output of the model

Notable content in the above-mentioned charts is the actual mismatch of the real index with the total index estimated by a multilayer perception neural network in the late 2015. The cause of this difference was such as the opening of important symbols such as the Mellat Bank and Tejarat Bank, dollar rate

fluctuations (Market Analysis Report 2016), which have a stronger effect compared to other factors affecting the stock Exchange index.

8. Conclusions

Chianak et al. (1996) were using an error back propagation network for net price of investment companies at the end of the year. They compared the network data and their results with the results of traditional econometric techniques, and found that in neural networks when data is limited, it is significantly better than regression methods. Garlyasgus (1999) forecast the time series of the stock market using the computational neural network algorithm associated with the kernel function and the error reversal method. He concluded that the prediction of financial time series by neural networks is better than classic statistical models and other models, which is consistent with the results of the present research. Given the analysis of the proposed model, the error criteria of artificial neural networks method in comparison with other means is negligible and have a better performance than them and can reduce the prediction error significantly.

Emphasizing on the overall goal of the research and the results of similar research, it can be found that macroeconomic variables are effective on the stock Exchange index, and with the values of these variables, estimating the total index of the stock exchange is possible. Also, considering that the total index of the stock Exchange is also considered as a tool of recognition of the economic situation of the country, therefore, with the reflection in its movement, it can be necessary to adopt a sudden adjustment of shocks. Therefore, according to the process of what was stated, it can be obtained that the general index can be used as a guideline for making appropriate decisions at different levels. Considering that the general index in this study, except for the early period to mid-2015 shows an acceptable match with the actual index, the model can be divided into two time periods, namely before and after the non-compliance period.

All in all, it is obvious that the findings cannot be judged or even predicted based on a single aspect, and therefore, the influence of other effective variables of this research need to be considered. According to what is stated, it is recommended that the economic and special authorities of the Tehran Stock Exchange adopt the necessary measures to maintain the balance and stability and the importance of the role of macroeconomic variables in the general index.

Also, since various factors affect the index, we should control the variables as much as we can in order to meet the needs of the Stock Exchange and especially win the investors trust so that we can progress, be dynamic and develop the stock market.

Given the proofs provided in this article, the following recommendations are presented for future research related to the subject of the present article,
1- Investigating the economic macroeconomic variables affecting the total price index of the stock and modern scientific techniques.
2- Identifying and ranking macroeconomic variables affecting the recession or growth of the stock exchange.
3- Investigating and presenting strategies to stop recession in the stock exchange.

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