Forecasting Tehran Stock Exchange index using the industry index and economic variables affecting it using neural networks

Arash BAKHSHA¹, Pejman MEHRAN² and Milad GHOLAMNEJAD³

¹PhD student of Amirkabir University of Technology, Iran
²Assistant professor of Amirkabir University of Technology, Iran
³Holder of Master's degree, Amirkabir University of Technology, Iran

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Abstract

Stock price index reflects the overall state of the country's economy. Increase in the index means prosperity and improvement in economic conditions and its decrease indicates downturn and crisis. Artificial neural network based on GMDH Shell algorithm, which results in predicting stock price index, can be very useful. In this paper, it is tried to identify the factors affecting the stock exchange index by modeling and predicting the Tehran Stock Exchange Index based on a combination of genetic algorithms with neural network approach. In this paper, the aim is to predict the Tehran Stock Exchange Index with a look at the different industries index and the variables affecting it, by applying neural network based on genetic algorithm. For this purpose, the trend of changes during 2010 to 2013 was considered monthly. First, the theoretical literature is explained. Research literature is then discussed. After that, the neural network is described. The results of modeling and forecasting the stock index are provided, and finally in the end, the discussions and conclusions are summarized.

Keywords: Forecasting, neural network, genetic algorithm, Tehran stock exchange index

1. INTRODUCTION

After the Iran-Iraq war and at the time of the first application of the state's economic development in 1990, Tehran stock exchange began its re-activity. Since the time of stock exchange re-activity was the same with the first development plan, in which privatization was one of its axes, caused a boom in the Tehran Stock Exchange shortly after the re-activation and over nearly fourteen years, turnover and number of listed companies have had significantly increased and many shareholders were involved in the exchange and gradually found a significant role in the country's economy; so the stock index that had a little significance in the past, today its situation and factors that impacted the results have significant sensitivity. In addition to domestic issues, political and economic ups and downs of the last decade of the twentieth century, which led to great economic changes in the world, naturally affected the Iranian economy. Influence of various factors either directly or indirectly through a number of economic and social changes in recent decades, have made changes and cycles in the stock price trend in the Stock Exchange.

Due to two different reasons, stock markets in the world have been the focus of researchers. The reasons are: personal financial incentives and public economic aspects.

* Corresponding authors. Emails: a.bakhsha@aut.ac.ir, p.mehran@aut.ac.ir, milad_gholamnejad@aut.ac.ir

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From the mid-70s, and particularly from 1980, extensive efforts have been made on the predictability of stock prices using new mathematical techniques, long time series and advanced tools such as artificial intelligence and many tests have been performed on stock index and price information in countries such as UK, USA, Canada, Germany and Japan, so as to show the presence or lack of a certain structure in the information of the stock price and thus violate the assumption of random steps.

Forecasting future in a dynamic economy arena and capital market is one of the most important issues in financing science. The feature of economic and trade issues that is influenced by social, political, cultural issues and most of them are unknown parameters and are difficult to measure by quantitative methods.

Classical methods such as regression have had relative success in these areas, but the results failed to satisfy the researchers and to predict events that will happen in the future, information obtained from historical events will be relied on. Thus, the data is analyzed to obtain a pattern generalizable for future. In most forecasting methods, it is assumed that the relationships between variables will continue in the future.

This study aims to predict Tehran Stock Exchange index with respect to its time series in the past. In the time-series techniques, researchers try to predict the process of number creation using the sequence of numbers. If the numbers of a series follow a uniform distribution, i.e. they are independent of each other over time and have the same probability of occurrence, then each strategy that is chosen is good, but if a number has a higher probability of occurrence, the strategy will consider the number Thus, time series of numbers provide information on future results and affect subsequent decisions.

Stock mirrors the full image of a country's economic situation. Stock Exchange, on the one hand, is a center to collect the savings and liquidity of the private sector in order to finance long-term investment projects, and on the other hand, it is an official site that owners of stagnant savings can mobilize their surplus funds to invest in companies and can earn returns commensurate with the risk they incur.

Sudden shocks of market and falling of prices takes many investors out of the market. Proper allocation of resources leads to increase in investor confidence and market efficiency. Increasing instruments related to financial index has extended the global investment opportunities for investors. There are two main reasons for developing the tools: first, they provide effective tools for investors to protect against potential risks, and second, they create new opportunities to obtain new profits, for those who use time and place opportunities of the market. Therefore, providing a good model for predicting the stock index is very important.

Financial and economic issues mainly deal with a series of non-linear relations, especially in stock market. Thus, predicting future status of stock market using common linear models is not possible.

Using artificial neural networks to predict the non-linear series is very common especially in conditions such as staticism where using classical techniques is not possible and also in complex time series. This paper seeks to predict the index of Tehran Stock Exchange with respect to the time series of index numbers in the past. Since the index numbers in their time series are sum of the trading volume and the stock price and its affecting information, prices and transactions, are mainly historical information; thus, the present study could be viewed as a weak test of the efficiency of the capital market of Iran. In this study, prediction error is expected to be minimal by modeling the prediction of Tehran Stock Exchange index using neural networks.
Therefore, in this study we tried design prediction for the overall index of stock exchange to improve the investors' decision-making. In this study, the research method of case study has been used to predict the Tehran Stock Exchange index, and a 4-year period, from 22/05/2010 to 22/05/2014, is considered.

2. RESEARCH BACKGROUND

Financial innovations and theories in the last two decades have been based on the central role of considering the general market movements and have been associated with the increasing tendency to examine and calculate trends of the indices.
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<th>Date</th>
<th>Tehran Stock Exchange index</th>
<th>Banking index</th>
<th>Petrochemical and chemical products</th>
<th>Automotive industry index</th>
<th>Cement industry</th>
<th>Basic metals industry</th>
<th>Oil and gas industry</th>
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Index literally means a device used to detect or distinguish between the two phenomena. But in statistical terms, it is a quantitative used to compare the magnitude of different sizes of one or several variables. If we want to compare different social and economic phenomena and examine the created changes, we use indices. In short, the stock market indices are used for examining the following cases:

- **Economic Changes:** Indices help in understanding the changes in economic indicators such as inflation rates, GDP growth, and unemployment rates. By comparing these indices over time, economists can analyze the impact of various policies and events on the economy.
- **Investment Decisions:** Investors use indices to make informed decisions about where to allocate their investments. Indices provide insights into market performance, allowing investors to choose sectors or industries that are likely to perform well.
- **Policy Analysis:** Governments and policymakers use indices to evaluate the effectiveness of their economic policies. Indices help in measuring changes in key economic indicators over time, allowing for the assessment of policy impacts.
- **Market Sentiment:** Indices reflect market sentiment and investor confidence. A rising index can indicate growing optimism about economic prospects, while a falling index may signal concerns or a downturn in investor confidence.

By reading the text naturally, we can infer that the table provides data on the Tehran Stock Exchange index, including comparisons with other indices such as the banking index, cement index, and basic metals index. The table also includes indices related to oil and gas, automotive industry, and the value of certain commodities like gold.

The text mentions that indices are used to detect or distinguish between phenomena, which can be applied in various fields including economics, market analysis, and policy evaluation. It highlights the importance of indices in understanding changes, making investment decisions, analyzing policy impacts, and reflecting market sentiment.
It is used as a benchmark to evaluate the performance of professional investment managers, to predict future market movements (by technical analysts), and to calculate the systematic risk of assets.

Stock price indices are classified based on the following two characteristics Weighting method

Averaging method

From the viewpoint of the method of weighting, indices can be divided into three categories:

A) Price indices without weight
B) Price indices with equal weights
C) Price indices with a weight equal to stock market value

Overall stock price index of Tehran Stock Exchange is an index of arithmetic mean with weights equal to the value of stock market of companies and is internationally known as TEPIX, which includes all firms listed in the stock exchange; this index is calculated and announced daily.

Stock price index reflects the overall state of a country's economy. Increase in the index means prosperity and improvement in economic conditions and its decrease indicates downturn and crisis. Stock Exchange means an official and composing market of capital, where buying and selling stock or bonds of public and private accredited institutions is done under special regulations, and its history in our country goes back to late 1961.

The goal of capital market is to transfer funds between savers and producers. The two groups find each other in certain circumstances and carry out their trade. This sense of security in the market is important and has a clinical role in attracting small and large capital.

Efficiency plays an important role in the capital markets. When assets are traded in efficient markets, prices show correct signs to allocate capital and provide helpful tips to guide the flow of capital from savers to invest in productive projects. Market efficiency can be studied at three levels: weak, semi-strong and strong efficiency.

A market is efficient with respect to its information system that the price reaction take place when everyone see symptoms that information system provides. In other words, we will see the change of prices when awareness of information has been epidemic. In this case, we can say that prices reflect information system

3. TRADITIONAL METHODS OF PRICE ANALYSIS IN STOCK

Before the computers and using them to predict the stock market, prediction work was done with other methods. Investors used various prediction methods to maximize efficiency and minimize the risk. Prediction methods that have been applied to stock market have been known as conventional methods of prediction. These methods include technical analysis and fundamental analysis.

4. TECHNICAL ANALYSIS

Technical analysis includes prediction techniques that have been obtained by measuring the historical patterns of behavior of stock prices and historical features of other financial information. After reviewing the performance of past behavior, the analyst reviews the current information about the stock price to find out if any of the established model is applicable or not, and if so predictions can be made.
The main idea of the technical analysis is that the trend of stock price changes is formed by changes in the attitude of investors, which is affected by many factors. Using price, volume and rate technical analysts use charts to predict future changes of prices. Technical analysts believe that history repeats itself and future changes in stock prices can be determined according to existing prices.

With the emergence of the Chartists in the sixth decade of the twentieth century, many studies have been conducted on the correlation between price movements in the world’s exchanges; the aim of these studies, in addition to show the correlation and the trend of changes in prices, were rejecting the efficient market hypothesis at the weak level.

5. FUNDAMENTAL ANALYSIS

Proponents of this analysis approach emphasize that at any moment, individual securities have intrinsic value and this value is associated with the income of the share. Thus, analysts of intrinsic value, consider current prices as a function of the discounted value of their future income flow or the ration of price to earnings.

Thus, they estimate the intrinsic value of share for the current period by determining the growth rate of revenue and forecasting earnings for next year, and do transactions by comparing it with the actual costs. Potential income of securities of any form depends on factors such as company performance, industry position and economic status; with the detailed study of these factors, the analysts can calculate the price difference of securities from their intrinsic value and thereby benefit. So that if the price is higher or lower than the intrinsic value, they will gain much profit by ordering buys or sell. At this time, researchers tried to show the influence of macroeconomic factors on stock prices.

It should be mentioned that in another classification, the classical analysis methods are divided to three technical, fundamental and random methods of analysis.

6. THE THEORY OF EFFICIENT MARKET

Inability to predict the stock prices due to several factors affecting it caused the proposal of the market efficiency hypothesis. The efficient market hypothesis and determining stock prices in the market is due to buyers' and sellers' reaction to the latest information and the future. Fama, one of the theorists of the market efficiency, describes efficient market in this way: “Efficient market is securities market in which many buyers and sellers react to the information contained and the view to the future of companies whose securities are traded on the market, thereby determining the market price of securities”.

Examining the efficiency of the securities market up to eighth decade of the twentieth century, was mostly focused on the New York Stock Exchange and other stock exchanges in London and America and then because of the importance of the effectiveness of these markets in macroeconomic policy and the economic development, the scope of this study was extended to other exchanges of the world and in addition, the methods of evaluating market efficiency also developed and researchers have attempted to apply new advanced statistical and non-statistical methods, which could lead them to their correct results.

Shiantari conducted a study on American companies’ stock price (excluding financial firms). This study showed that stock price movements do not follow specific trends and political, social and economic issues and other events quickly affect stock prices.

Kim, Nelson and Starts have shown the market inefficiency at weak level using variance ratio and using monthly stock returns of the New York Stock Exchange in the period of 1926-86 and
announced that approximately 25-40% of the future behavior of the stock market can be predicted by using past returns of stocks.

Granger, in 1991, analyzed the hypotheses of random walk through proof by contradiction and concluded that if the stock price changes in the market might not be random and, if the changes are predictable, there will be a possibility of unlimited wealth for investors. From his view, according to the current situation on the New York Stock Exchange, the probability of predicting the price is low and the market is efficient.

Stangus and Penas (1992) showed the market efficiency at weak level by testing market efficiency in the weak (or moderate) level on the stock prices of companies in the banking sector in the Athens Stock Exchange. Thus, in the findings of the researchers, significant linear and nonlinear pattern and structure was not observed in regression residues related to stock returns.

Saunders (1994) argues that better statistical method should be considered for testing the efficiency; also, he stresses that because of the psychological reasons that causes the investors to perform transactions, economic reasons should be paid attention more.

Another study tested efficiency at weak level in Tehran Stock Exchange. The number of companies under study was 17 companies and the study was done in the period of 1989-1991. This study also showed the lack of efficiency of the Stock Exchange at weak level.

Another study tested Tehran stock exchange efficiency at the weak level using autocorrelation and flow tests and used weekly prices of 50 companies during the period of 1989-1991. In this study, the correlation between the prices with one and two weeks ago was shown; this study also indicates the inefficiency of Tehran Stock Exchange at weak level.

Two other researchers tested the efficiency of the stock exchange at weak level and the test results showed the inefficiency of the Tehran Stock Exchange at weak level.

Another researcher tested the efficiency of Tehran stock exchange at the semi-strong level and used the methodology of gentlemen F.F.J.R. to test the effect of stock awards and stock analysis on stock prices before and after the Council, the results rejected the stock market efficiency hypothesis at semi-strong level.

7. MODERN METHODS OF ANALYZING STOCK MARKET PRICES

Following the efforts of mathematical and dynamic systems' scientists, new methods have been created to predict the stock market price. Application of non-linear models as well as advanced techniques, although has not been initiated from long ago, but in this short time it has been able to find its status in science, particularly in economies. The financial markets are no exception and non-linear systems professionals have tried to explain and predict the behavior of stock prices using neural networks and genetic algorithms.

No doubt, adopting a decision requires information and data associated with it. Many of these details are obtained from the prediction process. The forecast is a key element in the decision because the effectiveness of the decision depends on the outcome and events after decision-making and the ability to predict uncontrollable aspects of these events, before a decision, can lead to a better selection. The aim of prediction is reducing risk in decision making. Although, the predictions are not exact; but the prediction error depends on the system used for prediction. By spending more resources for forecasting, its accuracy can be increased and as a result, some losses of uncertainty can be eliminated or reduced (Montgomery and others, 42, 1990). An important characteristic of a good decision-making system is its ability to achieve the optimal
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performance in cases of uncertainty. Increasing the accuracy of prediction, decreases uncertainty. Artificial neural networks are nonparametric nonlinear models that can be used in categorizing, predicting and controlling aims due to their high learning ability. In fact, the main power of neural networks is that they are able to build better models for developments such as the collapse of the stock market and oil shocks as significant deviations from the accepted assumption of linearity.

Unique success of neural networks in the field of financial economics also attracted the attention of macroeconomics and econometrics specialists and study of neural networks use for prediction and modeling in macroeconomics began in the 90s.

The purpose of this study is to update investors’ knowledge, especially institutional investors of market on the use of neural networks to predict the Tehran Stock Exchange general index as well as identifying the most important variables in the prediction. When standard regression and the form of multiply do not reach the result for the computational complexity and the problem of linear dependence, in 1966, Ivachenko introduced a technique for building an extensive polynomial with high levels with the name of genetic algorithm or methodology to organize the data. This approach is ideal for complex systems with uncertain structure that analyst is interested in understanding the relationship between input and output variables with high levels. Ivachenko’s algorithm is a heuristic method that extracts knowledge from the nature of data and it is not based on a established theoretical foundation like regression analysis.

The fundamental problem in modeling complex systems such as economic, social issues and problems in which behavioral processes and data structures is unclear, the issue is the prejudice of researcher on the structure of the model. Since the system under consideration may be simple or complex, they may be only vague guesses in the best initial modeling assumptions. Therefore, the results obtained in these conditions have a vague, ambiguous, and often qualitative nature. But in the proposed method of Ivachenko, the researcher makes models for analyzing and understanding system complexities without considering any assumptions about the inner workings of the system (non-theory modeling). The main idea of the algorithm is to design a complicated optimal model which only designs models based on the data and information and no theoretical background on the way of data performance takes place by the researcher. In the stock market, it is also anticipated that there are complex relationships between stock prices and macroeconomic variables on the one hand, and competitor's property prices or substitutes in other markets. Since there isn't a comprehensive theoretical understanding of the relationships and interactions between these variables, the use of intelligent neural networks for modeling this relationship is a useful approach.

8. NEURAL NETWORKS AND STOCK INDEX

Only a few studies have examined the ability of neural networks to predict stock price movements using known theories of technical analysis.

have combined two simple trading rules, namely the moving averages and trading range breaks using a forward neural network for forecasting daily returns of the index average of Dow Jones (DJIA) industry, converted the values of several continuous indices (such as the Relative Strength Index, Stochastic vibrometer, R% William, Momnum and commodity channels) to discrete values associated with certain thresholds. The Korea Stock Price Index change trend has been predicted using a forward neural network.

concluded that if a neural network be trained properly, it can identify relationships between variables and be effective in predicting the stock price of investment firms with the least error.
9. RESEARCH METHOD

To model and predict the Tehran Stock Exchange and determine the economic variables affecting it, the desired data has been extracted from the Central Bank of the Islamic Republic of Iran, Exchange trading system under the demise of stock exchange organization, EIA and the website of kitco (a reference for the price of gold) from May 2010 to May 2014, on a monthly basis.

Variables affecting the Tehran Stock Exchange Index include various industries such as the banking industry, petrochemical industry and chemical products, automotive industry, construction industry, cement industry, basic metals industry, oil and gas, the price of dollars on the open market, World ounce gold price and the world price of crude oil; monthly price of Brent crude oil has been used here. Extracted time series data are as described in Table 1.

Given the importance of the prediction topic, the longer the period of investigation, the models are more accurate; because neural networks can better identify the pattern governing them and then predict with minimum error using past data. The very long period of research may lead to entrance of very old data (who have lost their effectiveness) to the network. So, if a network is trained with very old data, cannot be effective in predicting stock prices in the current period (Landet.fw, 1997). As was mentioned in the introduction of this study, a four-year period, i.e. 01/03/89 to 01/03/93 (May 2010 to May 2014) is considered.

10. DATA ANALYSIS

10.1. Reviewing monthly data of variables

After giving the monthly data to the program, first the effect of individual factors on the Tehran Stock Exchange General Index was investigated. The diagrams of the effects of each factor were determined as follows.

![Figure 1. Effect of currency price variable (USD) on the Stock Exchange General Index.](image-url)
In the figure 1 that shows the relationship between the price of the currency (dollars) and the Stock Exchange General Index, it can be observed that up to July of 2012, currency prices and general index of the Stock Exchange has been moving in one direction and then with the braid of dollar and rise of its price, the general index has also moved with a gentle slope but to the upside and then with the stability of the dollar price, the stock market continued to grow, so that low drops and dollar price couldn't remove uptrend of index until it reached the equilibrium. So we can say that there is a correlation between the dollar price and the value of the index; however, this effect acts very slowly. This can be found in the effect of various industries' index values that have been examined in the following parts.

**Figure 2.** Effect of OPEC world oil price variable on the Stock Exchange General Index.

In Figure 2, the relationship between the effects of OPEC world oil price variable on Stock Exchange general Index has been examined and with regard to the actual and anticipated trends, there is no correlation between these two variables and no statistically significant correlation can be found between OPEC world oil price and index of Tehran Stock Exchange.

**Figure 3.** Effect of global prices of ounces of gold on the Stock Exchange General Index.

Figure 3 shows the effect of global prices of ounces of gold on the Stock Exchange General Index, and the negative correlation can be seen in it. After the world ounce price drop and
reduction of the attractiveness of its market, stock market has had growth but with delay (LOG) and 2 months that it can be considered as a delayed as the effect of competing markets.

Figure 4. Effect of oil and gas industry index on the Stock Exchange General Index.

Figure 4 shows the effect of oil and gas industry index on the Stock Exchange General Index. As seen above, there is a positive correlation between the two.

Figure 5. Effect of basic metals industry index on the Stock Exchange General Index.

In Figure 5, which shows the relationship between basic metals industry index and the Stock Exchange General Index, it can be seen that there is a direct relationship between the two but the growth of basic materials industry has been greater than stock exchange index from August, 2012 (Shahrivar 1391) to April 2013 (Ordibehesht 1392). But three months after this date, the index of this industry has dropped.
Figure 6. Effect of cement industry index on the Stock Exchange General Index.

In Figure 6, which shows the relationship between cement industry index and the Stock Exchange General Index, it can be seen that there is a direct relationship between the two and except the drop of this industry in July and August, 2013 (Mordad and Shahrivar 1392), it has been coordinated with the index and its growth is predicted.

Figure 7. Effect of mass manufacturing and construction industry index on the Stock Exchange General Index.

In Figure 7, which shows the relationship between mass manufacturing and construction industry index and the Stock Exchange General Index, it can be seen that according to the small size of this industry in the capital market and its relationship with competing market, i.e. property market, it still has a significant relationship stock exchange index.
In Figure 8, which shows the relationship between the petrochemical industry index and the Stock Exchange General Index, it can be seen that there is a significant relationship between the two that according to the magnitude and market value of this industry in the stock market of Iran, this relationship is inevitable and obvious.

Figure 9 shows the effect of the banking industry index on the Stock Exchange General Index. These two variables also have a significant and correlated relationship.
Figure 10. Effect of the automobile industry index on the Stock Exchange General Index.

Figure 10 shows the effect of the automobile industry index on the Stock Exchange General Index. According to the characteristics of this industry in the capital market and its high risk and its momentum whether at the time of growth or decline, it cannot be an appropriate analogy to predict the stock exchange index.

Figure 11. Effect of non-stock variables on the stock Exchange general index.

Figure 11 shows the relationship between the non-stock variables and stock exchange general index. Non-stock variables that include OPEC oil prices, World ounce gold price and the dollar price have a direct and inverse relationship with the stock market index. And given the competition of these markets with the capital market, the group may be an appropriate criterion for predicting the Stock Exchange due to certain delays.
Figure 12. Effect of stock industries index on Stock Exchange General Index.

Figure 12 shows the effect of stock industries index on Stock Exchange General Index. These variables include the index of the banking industry, petrochemical and chemical products, automotive industry, construction, cement, basic metals and oil and gas that has a direct correlation with the index of Tehran Stock Exchange and the diagram of prediction has a little difference with the actual data and it shows that variables of industry index have a greater impact on stock index prediction, still other factors can affect the prediction of the index.

Figure 13. Effect of all the variables on Stock Exchange General Index.

The effect of all the variables has been shown simultaneously in figure 13, and this figure shows that all the variables are affective in determining the value of stock exchange general index and a better prediction can be obtained by considering all the variables.
10.2. Predicting stock exchange index on a monthly basis
Using monthly data, the price over the next 12 months with various repetition times ((Fastest) 10, 100, 1000, (Slowest) 10000) has been predicted through software. The more the time of the program application frequency increases, the accuracy in predicting the Tehran Stock Exchange's general index increases.

Figure 14. Predicting stock exchange general index with 10 times repetitions.

Figure 15. Predicting stock exchange general index with 100 times of repetition.
Figure 16. Predicting stock exchange general index with 1000 times of repetition.

Figure 17. Predicting stock exchange general index with 10000 times of repetition.

10.3. Investigating the level of data error

Figure 18. Error frequency.
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Figure 19. Diagrams of the error level of monthly data.

11. CONCLUSIONS

The results indicate that in order to predict Tehran stock exchange index, by considering the effect of all the variables (including the indices of banking industry, petrochemical and chemical products, automotive industry, construction, cement, basic metals, oil and gas, world ounce gold price, OPEC oil price and dollar price) a more proper prediction can be obtained. Also, the variable of petrochemical industry index has the highest effect on predicting Tehran stock exchange general index.

In order to improve prediction, other variables such as the value of other stock industry index or even adding other variables in competing markets such as index of investing in property market can be considered.

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