STOCK EXCHANGE INDEX PREDICTION USING HYBRID MODELS

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ABSTRACT

Prediction of stock price index and the direction of its movement are regarded as one of the most challenging applications of time series. In this study, Tehran Stock Exchange index is predicted for 5 next periods, using data from gold price, Europe Brent oil price index, New York Stock Exchange and the exchange rate, using single, hybrid and combination model, in which they are used, the multi-layer neural network and time series models.

KEYWORDS: Hybrid Prediction Methods, Neural Network, Time Series, Stock Exchange Index

Predictions about the dynamic aspects of economic and capital market, is one of the most important issues in financial sciences. Economic and commercial properties, is, are influenced by social, political and cultural, highly and many of the parameters is unknown and quantitative methods are measurable, barely. Classical methods such as regression, however, have a relative of success in this field, but the results do not make the researchers in this field satisfied. Usually, in order to predict future events occur, it is relying on the information obtained from historical events. Thus, the past data be analyze until then, gets a repeatable pattern for the future, most forecasting methods, it is assumed that the relationship between variables will continue in the future.

Tehran Stock Exchange began its work; at the same time with the first program of the state's economic development in 1990. The simultaneous reactivation of the Exchange, with the First Development Plan, which was one of the axes of privatization, it will cause a boom in the Tehran Stock Exchange, after a short period of reactivation over nearly fourteen years, turnover and number of listed companies, will benefit from increased dramatically Many real and legal shareholder engaged in stock and It gradually became a significant place in the economy of the country, So that the index was not important in the past, nowadays the situation and its causes and consequences of the changes have been of considerable sensitivity. In addition to domestic issues, political and economic ups and downs in the last decade of the twentieth century, which will cause tremendous changes in the world economy, naturally, has no effect on the Iranian economy. Influence of various factors, and economic and social developments, whether directly or indirectly, that their numbers were not low in recent years, has caused changes and periods in the price of shares on the Stock Exchange. Separately for two reasons, the stock markets in the world have been the under the researchers' focus; Individual material incentives and general economic aspects. The mid-70s, and especially since 1980, efforts began in the predictability of stock prices, using mathematical methods, time series longer and more advanced tools such as artificial intelligence and several tests were carried out on information on stock price indices in countries like UK, USA, Canada, Germany, Japan to show the presence or absence of a certain structure, the stock price information and in this way would violate the assumptions of random step.

METHODS OF STOCK ANALYSIS

Traditional methods of price analysis in stock exchange

Before computers, and use it to predict the stock market, the prediction be done by other methods. Investors used different methods of forecasting to maximize returns and minimize risk. Estimation methods, which are used in the stock market, came to be known as traditional methods of prediction. These methods include technical analysis and fundamental analysis.

Technical analysis

Analysis is a technique that includes prediction techniques, which are obtained by measuring the historical patterns in stock price behavior, and other historical financial information. The analyst study current information about the stock price, after evaluating the behavior to understand that, is it applicable to any of the
established pattern? If the answer is yes, can made predictions. The main idea of technical analysis is that, the trend changes in stock prices are formed by the changing attitudes of investors, which are influenced by several factors. Technical analysts use the charts to predict future price changes, using price, volume and interest rates. Technical analysts believe that history will repeat itself, and future changes in stock price could be determined, according to former stock prices. In sixth decade of the twentieth century, with the emergence of the Chartist, numerous studies have been done on the correlation between price changes in the stock of several of the world, that the purpose of these studies in addition to showing correlation between price changes and trends has been rejection of the efficient market hypothesis, at a low level.

**Fundamental Analysis**

Proponents of this method of analysis emphasized that the individual securities have a value inherent in every moment and this value is associated with a revenue share. Thus, analysts intrinsic value, know, current prices, as a function of the discounted value of its future income stream, or the ratio of price to earnings. Thus, they estimate, the intrinsic value of the stock for the current period, by revenue growth rate and forecasting revenue next year, and act on transactions by comparing actual costs. Potential revenue per sheet securities is dependent on factors such as company performance, industry conditions and economic conditions; with the detailed study of these factors, users can analyze, calculate the difference between the prices of securities and benefit from its intrinsic value, result of this. Thus, if the price is higher or lower than the intrinsic value, with orders to sell or buy, the money will be a huge benefit. Researchers tried, at this time, to show the influence of macroeconomic factors on stock prices. In another division, traditional methods of analysis are divided into the three methods of analysis: technical analysis, fundamental analysis, stochastic analysis.

**LITERATURE**

Evaluation of the securities market until the eighth decade of the twentieth century, most focused on the New York Stock Exchange and other American Stock Exchange and the London Stock Exchange then, the efficiency of these markets, macroeconomic policy, and the subsequent economic development, the scope of the study expanded to other shooters of the world; in addition, market efficiency test methods, as well as progress and researchers have tried, in applying advanced statistical and non-statistical methods, in order to direct it to the correct results. [3]

Shiantari, did a study on stock prices of U.S. companies (excluding financial firms). This study showed that stock price movements, does not follow any particular trend, and political, economic, social and various events have an impact, on the stock price, quickly. [11]

Kim, Nelson, and starts, showed the inefficiency of the market, using monthly returns compared using ANOVA and the New York Stock Exchange in the period 1986-1926, at a low level and announced that approximately 40-25% of the stock's future behavior of the market can be predicted by using past stock returns. [20]

Granger in 2005, was analyzed, the random walk hypothesis, by reductio ad absurdum, and came to the conclusion that, if the price changes were not random, in the stock market and if they can be predicted, there will be a possibility of unlimited wealth for investors. According to him, given the present state of the New York Stock Exchange, the predicted probability is low and market prices are efficient. [14]

Stengos and Panas, 2007, showed the weakest performance in the market through market efficiency tests at a low level (and average) on stock prices of companies from the banking sector in the Athens Stock Exchange. In this case, the findings of this research, there is no pattern of significant linear and nonlinear structure, the residual of the regression of stock returns. [30]

**Modern methods of analysis, prices, stock market**

Following the efforts of scientists, mathematicians and dynamic systems, has developed new methods for prediction of stock market prices. Application of non-linear models as well as advanced techniques, although not long, but in this short time, has been able, to find its place in the sciences, particularly in economics. Financial markets, not the exception, experts in non-linear systems, have tried to explain the behavior of stock prices, and predict it through advanced nonlinear methods. Using chaos theory and artificial intelligence techniques are among these activities. [9]
Artificial Intelligence

Scientists and researchers in the last decade of the twentieth century, mainly, were believed to the principle that, assuming the reasonableness of investment, which is a non-negligible in the modern financial investment, and is one of the main assumptions of the efficient market and the market model, due to complex factors involved in the equity markets, are not realistic. They have concluded that the capital market is no specific order and the use of complex mathematics, nonlinear and dynamic system, can cause model that, to override the previous theories.

In recent years, the progress that was made in the field of computers and artificial intelligence, as well as to explore the relationship of chaos in nonlinear time series, activities were carried out, in order to predict prices in the stock exchange in different countries. Artificial intelligence techniques, which include neural networks, genetic algorithms and fuzzy logic, have earned, successful results, in the context of solving complex problems. First time, White, uses neural networks for forecasting in the stock market. He was followed by the question whether the neural network is able to identify non-linear rules, in the time series of the unknown rules, the movements of asset prices, and changes in stock prices?

The purpose of this white paper will show this, how a neural network Pishdad able to do this. He proved his point by giving an example of the daily price of IBM [25]. After this initial study in 1988, neural networks enter to the financial field and numerous studies conducted in this field worldwide. Period 1995-1988, in total, took 213 scientific activities in the field of neural networks in the field of commerce; of these numbers, 54 activities were in the financial field and 2 activities were in the field of forecasting and time series analysis.

Chiang and et al took advantage of back-propagation neural networks to predict the net price of property investment companies, at the end of the year. The data network and the results of their work were compared with results obtained from traditional econometric techniques. And found that the neural networks, when the data are limited, they are significantly better than the regression methods. [6]

In another study, the insertion of the qualitative factors, such as political effects, along with quantitative factors, those were produced by the combination of a neural network, neural network and fuzzy Delphi model. This shape of the network became a base for qualitative networks. They tried his model for the Taiwan stock market.

Icon and Basat, used a prior neural network that was trained with the genetic algorithm to predict the interest rate the U.S. Treasury, and concluded that the neural network can be suitable for this job. [2]

Garliuskas applied time series forecasting stock markets, using a computational algorithm of neural network related kernel function prediction methods return an error, he concluded that the financial time series prediction is performed, by the neural network is better than classical statistical models and other models. [12]

Chan can be predicted, financial time series using neural networks and daily data of Shanghai stock exchanges. They used the gradient descent algorithm and multiple linear regressions to determine the weight, in order to speed up convergence. They concluded that neural network can predict time series to more satisfactorily and the selection of weights, the method led to lower computing costs. [6]

Kim and Han, they used a modified neural network, genetic algorithm, for predicting stock index, in this case, we used the genetic algorithm, to reduce the complexity of future price time series. [19]

Carlos Baptiste, trying to predict the stock market price index in the Philippines, using artificial neural network, realized that this prediction using neural networks, in short interruptions, there is no significant differences with random walk hypothesis But in the longer interruption, neural networks can be used to predict the index better than method of random walk.

Lendasse predicted the index using neural networks The data, the network was included in both exogenous and endogenous data Exogenous economic data, are included in international stock price indices, conversion rate (dollar / mark, dollar / yen) and interest rates And endogenous data, are included, the historical values of the index, They concluded from their research that the use of neural networks behave better than linear methods. [21]

Egeli et al have attempted to predict, a daily index of the Istanbul Stock Exchange. Their Input data to
the network included, rate dollar / pound, in the days before the index day before, swap rates, and dummy variables for five days a week. The result of their research was that the neural networks have a more accurate prediction than, 5-day and 10-day moving average. [9]

Hybrid models

Previous studies have shown that, combining several models can improve the accuracy of the predictions. Combining this structure helps to investigators, more efficient models. In addition, the use of different models, or models that are inconsistent with each other, also increases the efficiency of the forecast.

Many studies have proposed the use of, hybrid models, such as AMIRA link and ANN. Zheng, has used its hybrid model, based on three sets of data: data on wolf sunspot, data canduan lynx, and Great Britain Pounds exchange ratio, the America dollar. He took advantage of back-propagation learning algorithm AMIRA., to model the resulting waste[17].

Pie and Lim used a model consisting of hybrid SVM, and peremptory model to predict daily stock. Lu and colleagues also used a model compound for forecasting daily stock data. Shamseddin and arshad used the model MARMA, to predict natural plastics prices in the domestic market, And use of models, ARMA, to explain the residual multivariate regression model. Woven show that the prediction error obtained with the model MARMA, has fallen about 4.5 percent, compared with an econometric model. [24]

THEORETICAL FOUNDATIONS

Artificial Neural Networks

Neural network is one of the most dynamic areas of research in contemporary which has attracted many people from different scientific disciplines. Biologists, have studied neural networks to boil vajiki, over the years, the human brain is an example of these networks. Achieve, the way the brain works, has been an effort, more than 2000 years ago, started by Aristotle and Heraclitus And has continued, with other scientists, like Romney Kajal, and Kalgi and Hab.

Over the past few years has been trying seriously to model a normal neurons. The result has been considerable progress in this regard that can be used in a mathematical model, which can describe the characteristics of a biological system. ANN modeling is performed to form a layer-structured model, and considering, parallel processing, an image of the human brain.

An artificial neural network consists of a large number of nodes and directional segments, which are connected, the nodes together. Nodes that are located in the input layer of sensory nodes, and nodes in the output layer, are called nodes respondents. Between input and output neurons, are also hidden neurons. Information enters into the network through the input node, Then, the connections are connected to the hidden layer; finally, the output of the network, are believed to result from the nodes in the output layer. This is the same process, human biological neural networks.

Hybrid models

Hybrid models primarily arise from the linking, two linear and nonlinear time series, previously predicted, it must first be separated, linear and nonlinear components. It is necessary to ensure, each of the linear or nonlinear. Hybrid models combine different ways, to improve accuracy.

Composite models, they can be similar, hybrid models, and all models.

Hybrid models can be completed, in three ways:

- Linear
- Non-linear models
- The combination of linear and nonlinear models

In combined forecast method also has been used to model non-linear, for example, combining ANN with genetic algorithms, fuzzy logic (FL), and a rough surface (RS)

Linear and nonlinear separation of patterns

This method assumes that the patterns governing research data, is composed of two parts. The first part is linear patterns, by methods such as ARIMA and multivariate regression (MR), we can identify them. The second part is devoted to non-linear models, which can be identified, by methods of artificial intelligence. So, in this way, we can predict stock prices, using the AMIRA.

Then is calculated by subtracting the actual values and the predicted values.

These values are the inputs of the neural network.
In fact, the linear and non-linear patterns, are separated from each other.

The error of this model is different from the actual value, with a total way of AMIRA, and the way the neural network. In other words, will be established, the following equation (Equation 1):

\[ Z_t = Y_t + N_t \]

In this model, \( Y_t \) is the linear part, and \( N_t \) is non-linear part of hybrid model. In this model, \( Y \) and \( N \), are estimated from the data set. \( Y_t \) is a ARIMA anticipated model, at time \( t \), and \( \epsilon_t \) is the amount remaining of time \( t \), obtained from the model ARIMA. So we have (Equation 2):

\[ \epsilon_t = Z_t - Y_t \]

The amount remaining is modeled, using a neural network, as follows: (Equation 3):

\[ \epsilon_t = f(\epsilon_{t-1}, \epsilon_{t-2}, ..., \epsilon_{t-n}) + \Delta t \]

Function \( f \), is a nonlinear function, and modeling, the neural network and \( \Delta t \), is the random error. Therefore, the hybrid model predictions, is:

\[ Z_t = Y_t + N_t \]

Where \( N_t \) is the value predicted by Equation 3.

RESULTS OF RESEARCH

In this research, a hybrid model checking, and compared them with other forecasting methods, such as individual models, and hybrid models, is trying to provide a model with the lowest prediction error. In the hybrid model, it is assumed that the time series used in this study is comprised of two parts, linear and non-linear data. Therefore the series, separate, ways, into two parts, and each part, predicted by the model, that is, the ability to predict it fits. But it would be virtually impossible. Time series forecasting with econometric methods, which are often seen that different models have residues, and the forecasts do not fully. These methods generally have a good ability in forecasting nonlinear data, and you can imagine the waste of these models may be non-linear part in the data model.

In the hybrid model, we would predict using a model. Then the residues that are predicted by another model and finally, with link these two areas, the forecast is perfect.

Given the above, a simple comparison can be found, applying the term hybrid model, for these models is not correct because, hybrid models, are actually combination of predictions of two different models. In other words, the combined models, each method separately, the doing, the forecasting process, the various methods are combined, the results and forecasts, to be sure.

In this study, a sample of 260 data, daily basis, were collected from Tehran Stock Exchange (tepix), related to the year 2011, and other variables, such as, New York Stock Exchange Index (nys), cash price Europe Brent crude oil, the global price of an ounce of gold, and the exchange rate announced by the Central Bank of Iran (arz), and was used to predict the index of Tehran Stock Exchange.

**Table 1: Maximum mode of both original and cluttered time-series**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Maximum mode of each original time series</th>
<th>Maximum mode of each cluttered time series</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tepix</td>
<td>0.99</td>
<td>0.71</td>
</tr>
<tr>
<td>Gold</td>
<td>0.98</td>
<td>0.61</td>
</tr>
<tr>
<td>Arz</td>
<td>0.97</td>
<td>0.93</td>
</tr>
<tr>
<td>Oil</td>
<td>0.99</td>
<td>0.62</td>
</tr>
<tr>
<td>Nys</td>
<td>0.99</td>
<td>0.67</td>
</tr>
</tbody>
</table>

Note that the values in Table 1 are larger than 1, it can be said that the data used, they are capable, long-term memory, and properly it can get, given the larger the amount of mode of each original series, from mode of cluttered, series.

**Forecasting Index, Tehran Stock Exchange (TEPIX)**

In the stock exchange and listed companies, it is done, a variety of studies that a number of these studies have been conducted to evaluate the ability to predict,

And many others were conducted to evaluate the efficiency and predictability of index prices and yields of securities.

Prediction models fall into three categories:

- Single model
Hybrid models

The individual models are used exclusively, to a method of forecasting, econometric and neural network. In order to introduce an example of a single model, we noted the following:

- **ARIMA models**
- **Artificial Neural Network ANN**
- **Self-Explain model, VECM Vector**
- **Artificial neural network model with multi-input MANN**

Hybrid models essentially are obtained by combining two separate models. Act in combination, may be done in combination, vertical or horizontal composition. Horizontal composition means that the results predicted by two different methods, are combined together with such arithmetic mean. But the method of vertical composition, is the case where the data is projected from a procedure, we entered into another model to predict this. In this study, we have used the following hybrid model:

- **ARIMA** → **ANN**
- **ARIMA** ↔ **ANN**

Hybrid model, unlike the model compound, acts to predicted, in the first; and the residues, expect, with the other model. This study used two hybrid model. In the first model, the prediction is, by the way VEC, and the second stage is used, the ANN. (VEC ↔ ANN)

In the second model, we used the GRANN and then we will use AMIRA;

(GRAN ↔ ARIMA). Finally, using multiple regressions, forecasting process, is completed.

After performing, for all models, test results of prediction errors come in Table 3, respectively, from lowest error, from top to bottom.

<table>
<thead>
<tr>
<th>model</th>
<th>MSE</th>
<th>RMSE</th>
<th>MAD</th>
<th>MAPE</th>
</tr>
</thead>
<tbody>
<tr>
<td>AMIRA → ANN</td>
<td>1246</td>
<td>35</td>
<td>32</td>
<td>10</td>
</tr>
<tr>
<td>VEC → ANN</td>
<td>1801</td>
<td>42</td>
<td>38</td>
<td>14</td>
</tr>
<tr>
<td>VEC ↔ MANN</td>
<td>2467</td>
<td>50</td>
<td>40</td>
<td>20</td>
</tr>
<tr>
<td>ARIMA</td>
<td>2737</td>
<td>52</td>
<td>39</td>
<td>22</td>
</tr>
<tr>
<td>GRAN ↔ ARIMA</td>
<td>3818</td>
<td>62</td>
<td>45</td>
<td>31</td>
</tr>
<tr>
<td>ARIMA ↔ ANN</td>
<td>5808</td>
<td>76</td>
<td>66</td>
<td>46</td>
</tr>
<tr>
<td>ANN</td>
<td>11469</td>
<td>107</td>
<td>96</td>
<td>92</td>
</tr>
<tr>
<td>MANN</td>
<td>14093</td>
<td>119</td>
<td>110</td>
<td>112</td>
</tr>
<tr>
<td>VEC</td>
<td>33890</td>
<td>184</td>
<td>180</td>
<td>271</td>
</tr>
</tbody>
</table>

Results of comparing predictions of single hybrid and combined models, for Exchange index data, suggests that hybrid prediction model, VEC-ANN and GRAN-ARIMA, were more correct compared to the other models. So generally speaking, forecasting, stock index, hybrid models have more carefully other models.

**CONCLUSION**

In this study, we assess the performance of single and combination and hybrid models in forecasting Index Tehran Stock Exchange.

The results illustrate that, in multivariate models, ranging from individual models, hybrid and linkage, which is expected to have better results, offered poorer results than the models, where only the use of historical data and indicators bag (one variable). The results show that the hybrid model, has, more accuracy, in presentation of Index Stock Exchange, compared with other prediction methods.

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