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Comparison of Artificial Neural Network Method and Hidden Markov's Model in Predicting Tehran Stock Exchange index

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Abstract

The present study, entitled Comparison of artificial neural network method and hidden Markov model in predicting Tehran Stock Exchange index, was classified as applied, analytical-mathematical research, the local territory of those companies listed on the Tehran Stock Exchange and its time domain is from 2007 to 2016 that in terms of data collection, it is a post-event research, in order to analyse information from statistics and mathematics, the Markov model of secret-neural network model has been used. According to the MAPE index, the artificial neural network method has been able to improve the prediction power by 0.0343% compared to hidden Markov's model. A trained neural network can be considered as an expert in the category of information given to it for analysis. As a result, due to the complexity and heavy calculations, as well as the long computation time and the lack of access of some researchers to advanced models and Markov's secret model is recommended for those who are looking for a simple, fast and reliable method of forecasting using the artificial neural network method to predict the price of stock indices.

Keywords: Stock Index Prediction, Hidden Markov Model, Artificial Neural Network Model

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1. Introduction

Today, capital markets, as a meeting place for companies' financial and economic exchanges, play an important role in the financial sector and the prosperity of economic activities. An efficient capital market can improve economic growth and attract domestic and foreign capital by stabilizing the financial sector and providing a suitable environment and play an important role in the process of economic development (Asgari et al., 2018). The stock exchange is an organized and official market for buying and selling stocks of companies under special rules and regulations. One of the tasks of this market is to help make fairing the price of securities and to speed up transactions. The importance of the stock exchange in industrialized countries is such that today its activity is considered as one of the most important indicators of economic growth in these countries. The economic structure of our country and its characteristics have provided a situation that has made the need for development and growth of the stock exchange of special importance. A stock exchange is a private sector savings and liquidity collection center to finance long-term investment projects. On the other hand, it is a formal and reliable source for investing stagnant savings holders. The stock market is affected not only by the national economy, but also by the global economy (JAROSLAV LAJOS,2011, Bathaee et al., 2023, Nozari et al., 2016). Efforts to forecast the stock market began in the early twentieth century.

A group of securities market participants believed that the historical study of prices contained useful information for predicting future prices; therefore, by obtaining the price process, the pattern of changes is known, and this way of thinking was called Chartist because it focused on charts. In their view, fundamental analysis is not necessary, and their proponents believe that history repeats itself. From the 1930s, other studies began to oppose this view. The main focus of these studies was on the coincidence of prices and that prices do not follow a specific process (Abbasi et al.,2020). The results of these studies entered the topics of economics and investment as a strong intellectual and theoretical current and the theory of prices was formed. The principles of random patrol proved through experimental tests that consecutive price changes in short periods, such as a day, a week or a month, are independent of each other. Therefore, price changes do not follow a specific pattern and cannot be predicted (Oliver C. Ibe,2009). After the 1960s, research shifted from the statistical form of the price method study to the issue of the economic characteristics of the stock market that led to random changes and the emergence of efficient market theory. The founders believe that by analyzing key financial and economic variables, the true value of the stock can be estimated. According to this theory, no one can systematically gain more in the long run than the amount of risk he has taken. In such a market, stock prices are a reflection of information about stock price indices in all financial markets of the world, as one of the most important criteria for measuring the performance of the stock exchange, they are of great importance and attention, perhaps the most important reason for this growing attention is this, These indicators are obtained from the aggregation of stock price movements of all companies or a specific class of companies listed on the stock exchange, and as a result, it is possible to study the direction and magnitude of price movements in the stock market (Md. Rafiul Hassan et al.,2005). In fact, the development of financial theories and innovations in the last decade or two based on the pivotal role of paying attention to the general movement of the market, with an increasing tendency to calculate and

study the movement process such indicators have been associated. Measuring market movements is useful and important for several reasons (Oliver C. Ibe,2009).

1- A basis for evaluating the performance of professional investment managers

2- Supervision of index investment funds

3- Measuring market return rates in economic studies

4- Predicting future market movements

5- Examining the systematic risk of stocks in the market

Also, the group that pays a lot of attention to the index are investors, investors who are directly present on the Tehran Stock Exchange, they use indexes to compare their performance with the market average and another group that has invested indirectly in the stock market, they use the index to measure the performance of portfolio management or the management of the investment fund in which they have invested their funds (Dabo-Niang et al., 2010). On the other hand, the huge number of people who refer to the stock index are technical analysts who, by drawing various graphs and charts, predict the future movements of the market. As the last group, we should mention index funds that try to identify their movements with the stock index and want to be the mirror of the index. (Omid Farmanara et al., 2011). However, in Iran, this mirror has not been able to properly reflect the ups and downs of the index movements in the Tehran Stock Exchange, conventional models require this parameter to select a portfolio (Al Galib et al.,2014). The special importance of the capital market in economic development is undeniable through the effective management of capital and the optimal allocation of resources. Investing in the capital market requires decision-making, which in turn requires access to information about the future state of the stock market price. Therefore, if the future trend of the stock market can be predicted with appropriate methods, the investor can maximize the return on his investment (Campbell et al.,2008).

On the other hand, the stock market has always been an interesting field due to its complexity and unpredictable behavior. Knowing what the usage of index will do in the future can be very beneficial and can be one of the reasons why it is such a popular topic. Essentially this problem can be brought up, where the goal is to predict what will happen in the next step or period. Comparing neural networks methods and hidden Markov model, has led to new research dedicated to stock index forecasting.

Predicting important stock market indicators can be a step towards increasing and clarifying information be the capital market. The total share price index in the stock exchange is one of the economic indicators that shows the activity trend towards the country's capital market and the ability of the capital market to attract liquidity in society, it is a criterion for determining and completing the method of investors in the market and a guide for determining the time of buying and selling securities for them (Fadaei Nejad et al.,2018). The unknown factors affecting the changes in the index is always a reason to turn to the total index of the Tehran Stock Exchange. Today, financial managers prefer to have a mechanism that can assist them in their decision-making and for this reason, much attention has been paid to forecasting methods. Therefore, capital market experts have been studying the market for many years and identifying different patterns for forecasting that for this purpose, they have used a combination of pattern recognition and experience based on observing cause and effect relationships

There are also many software programs that help with this decision, and they are used as predictive engines (JAROSLAV LAJOS et al.,2011). Recent advancements in machine learning also have increasingly led researchers to explore various techniques utilizing artificial intelligence, particularly in emerging fields such as financial markets. (Vahidpour, et al., 2023)

Forecasting the dynamic field of economics and capital markets has been one of the most important issues discussed in the financial sciences. Predicting stock market or capital market indicators has always been the focus of studies. Theories and financial innovations of the last two decades, based on the pivotal role of paying attention to general market movements, have been accompanied by an increasing tendency to calculate and study the movement trends of the index (Ming-Chi Lee et al., 2009). This considerable attention in recent years has led to the development of patterns used in forecasting. Following the efforts of mathematical scientists and dynamic systems, new methods for predicting prices in the stock market have been created. The application of advanced techniques, although not many years ago, but in a short time has succeeded, find its place in various sciences, especially in economics (Rijeka et al.,2011). Financial markets are no exception to this rule, and systems experts have tried to explain and predict stock price behavior through advanced methods. It usually relies on information from historical events to predict what will happen in the future.

In this way, past data is analyzed, to obtain a generalizable model for the future, for this reason, in financial research, different methods for forecasting have been selected for financial forecasts, including the stock market index and finally their beneficial use. Beneficial forecasts come mainly from three sources or groups: The first group is management, the second group is financial analysts, and the third group is quantitative models of time series and network analysis which approach has been recently so powerful in stock market modeling, analysis and prediction. For this purpose, different methods and concepts were extended and applied in financial market analysis based on network approach (Ehsani 2020)

. Research comparing the predictions of these groups has yielded mixed and sometimes conflicting results. In the predictions made in the past, mainly in a one-dimensional way and using a forecasting method or Markov model or neural network model, an attempt has been made to predict stock market returns, and also this has been done in limited time periods, but this research uses both methods to predict stock returns on the stock exchange because it is both the best way to determine the best model and also wants to determine the weaknesses of each of the main stock forecasting models and strategies to integrate and improve these models

Therefore, forecasting the Tehran Stock Exchange index on market risk has a direct effect on decision making. Given that the Tehran Stock Exchange is a part-time market therefore, the answer to this question is necessary in investment analysis that in the semi-efficient market of Tehran Stock Exchange; to measure the risk of Tehran Stock Exchange, a model can be used to predict the index of Tehran Stock Exchange using artificial neural network and hidden Markov model. However, in financial processes, there are often situations that break the rules and make prediction by these methods difficult. This study aims to compare the effect of artificial neural network method and hidden Markov model in predicting the Tehran Stock Exchange index.

2- Literature Review

In recent years, many questions have been raised about the extent or efficiency of securities markets. Findings such as the effect of the end of the month, the effect of January, the riddle of investment funds, the effect of the initial public offering, etc. under the heading of market exceptions, raised new doubts about the efficient market hypothesis and capital asset pricing theory and modern financial theory in general (Adebiyi et al.,2014). However, many researchers have questioned the accuracy of the market model by providing empirical evidence and there was evidence that the market was inefficient, but the presentation of the Fama and French article had a profound effect on the views of market participants. As mentioned earlier, Fama became known as the efficient market hypothesis theorist. At the time of presenting his paper in 1965, he revolutionized the capital market. He also played an important role in creating the theory of capital asset pricing (Asgari et al.,2018 ,Fallah et al., 2021). but after Ross introduced the arbitrage pricing model in 1976, Fama and French endorsed Ross' views, they questioned the credibility of the Sharp market model. They considered the beta of the market model as a wrong criterion for risk and after announcing the results of their research, they stated that either the capital market is not efficient and either the pricing model of capital assets is invalid, or both are valid (Amiri et al.,2015). Because a well-known theorist seriously criticizes his theory, this article created another revolution in the capital market, known as the Fama Second Revolution. In addition, many researchers have reported empirical evidence of market inefficiencies such as stock price responses to new information, differences in returns of small and large companies, differences in stock returns in certain months of the year as well as certain days of the week, and the profitability of investment strategies. Observing this empirical evidence, many have questioned the rationality assumption of investors and concluded that the efficient market hypothesis is invalid, because Fama points to two very important assumptions (Fadaei Nejad et al.,2018, Nozari et al., 2023).

1- Investors behave rationally in their market decisions

2- They buy and sell based on the latest information and news and they have enough tact to determine the fairness of securities prices.

The main idea of stock market forecasting is that there is a trend of stock price changes by changes in price, volume and interest rate, etc. Predicting future price changes. Stock market forecasting is still one of the most important challenges arising from the connection of related markets. Different researchers from different places such as universities, investment funds, banks and active companies in the stock market each have different opinions on this issue, and theories are divided into two general categories: The first group of researchers believe that market movement follows certain patterns. Although these patterns can be simple or complex and easy or hard to find, but they are nonetheless patterns and can therefore be used to predict the financial market. These people believe that examining market trends and behavior in the past can identify these patterns. By finding these patterns, can talk about the future because these patterns have always been repeated throughout history. A knowledgeable investor can buy and sell based on these patterns and hope to make a profit.

The second group believes that it is not possible to predict the stock market, because you can predict the number of rolls of a dice as well as the market. These people believe that the stock index has nothing to do with its past, but it is the future events that determine the economy. If the economy grows well. Investors are hoping that this growth will affect the market and will tend to buy shares. This means that the demand for the stock market is high and therefore the index also increases.

Lotfi et al., (2016) Forecasting the Tehran Stock market by Machine Learning Methods using a New Loss Function, Stock market forecasting has attracted so many researchers and investors that many studies have been done in this field. These studies have led to the development of many predictive methods, the most widely used of which are machine learning-based methods. In machine learning-based methods, loss function has a key role in determining the model weights. In this study a new loss function is introduced, that has some special features, making investing in the stock market more accurate and profitable than other popular techniques. To assess its accuracy, a two-stage experiment has been designed using data of Tehran Stock market. In the first part of the experiment, we select the most accurate algorithm among some of the well-known machine learning algorithms based on artificial neural network, ANN, support vector machine, SVM. In the second stage of the experiment, the various popular loss functions are compared with the proposed one. As a result, we introduce a new neural network using a new loss function, which is trained based on genetic algorithm. This network has been shown to be more accurate than other well-known and common networks such as long short-term memory (LSTM) for both train and test data.

Faghihinejad et al., (2018) Prediction of Stock Market Behavior Based on Artificial Neural Networks with Intelligent Collective Learning Approach, the findings showed that the accuracy of the results and increasing the forecasting return is the most important challenge of the proposed models in the stock market. The important point for the profitability of transactions is to pay attention to the change in stock prices in price forecasting, which has received less attention in forecasting models. The proposed model using methods based on artificial intelligence shows that it is possible to predict the stock market method despite its oscillation and unstable nature. Therefore, the results of the evaluation criteria on the real stock price data show that the proposed model compared to other methods, can more accurately overcome market fluctuations and to be used as a reliable and practical method in stock markets.

Asgari, et al. (2017) in this research using K-mean clustering algorithm with hidden Markov model, on the technical variables, the percentage of daily changes in price and trading volume, the GARCH and EGARCH models of the Belgian Stock Exchange index were forecasted for the next day. The results showed that the prediction accuracy was calculated using the average of absolute error percentage. The average value of absolute errors for predicting the future value of the BEL 20 price index in the period from December 1 to December 30, 2015, is -0.03463%. Time series of index value and trading volume in the period 2012 to 2015 constitute the research sample. Data from 1/1/2012 to 11/30/2015 were used to cultivate the model and data from 11/30/2015 to 12/30/2015 were used to test the model and obtain prediction accuracy. Ultra-innovative models of harmonic search and genetic algorithm, using technical stock market indicators to predict the price index in the Tehran Stock Exchange, two hybrid neural network models were tested. Evidence from the study showed that the hybrid neural network model based on genetic algorithm and harmonic search had a lower prediction error during the test period and it has higher accuracy than the normal neural network model. Samiran Khajehzadeh et al., (2020) to predict stock returns, used regression algorithm to predict stock returns, and Markov method and spectral clustering algorithm, to select the appropriate initial data and cultural meta-processing method with prediction data, It provided the optimal portfolio of stocks for the investor group with risk-taking as well as risk-averse. The research results show that the cultural transcendental algorithm, according to Sharp's method, has the ability to create

an optimal stock portfolio using predicted data using the Marquis method for venture capitalists and risk averse investors.

Fallahpour and Pour Rikandeh (2014) in this research, the total stock index of Tehran Stock Exchange has been predicted using different models of neural networks. The research is applied, and the period of research is from the beginning of 2002 to the end of 2011. Data collection was done through statistics and data available in the database on the Tehran Stock Exchange. To create the WDBP model from db5 wavelet to de-noise the data and up to five steps have been done. The square root of the mean square error (RMSE) is the evaluation criterion for measuring the forecast error. The results of this study show that the performance of the wavelet neural network has a lower error level in predicting the stock index and is better than the neural network. Amiri and Bigleri (2013) published an article entitled Stock Price Forecast Using the Markov Model, that the Markov model, which is one of the random models, has been used to predict stock prices. For this purpose, 9 situations have been defined which have been obtained from the interaction of the variables of stock price change percentage and stock exchange volume percentage. For each of these variables, three neutral or negative states or levels are defined. In order to evaluate the efficiency of the model, a case study of the positive Dow Jones Industrial Average has been reviewed, which confirms the performance of the proposed model. Farmanara et al., (2010) Results obtained from predicting the effect of macro variables on stock price index using the neural network, it indicates the very high accuracy and extraordinary capability of the GMDH algorithm in predicting the stock price index of the Tehran Stock Exchange. So that the error resulting from forecasting the stock price index of Tehran Stock Exchange is 0.37% for annual data, 0.35% for monthly data and 2.04% for seasonal data. Alborzi et al. (2008) in the study or entitled the use of artificial neural networks in predicting cash return index and stock price, the obtained results indicate the success of the two models in predicting cash return and price index as well as the superiority of neural network performance over the multifactorial model.

Pratkashrma (2016) in a study compared the predictions of different Garch models using daily returns. In this study, each model used for forecasting has a conditional variance of 16 international stock indices for a sample period of about 14 years. The results showed that the relative predictive performance of GARCH and EGARCH models are sensitive to the selection of data loss criteria.

Also, the moving average model generally performed better than the GARCH models. The results also showed that GARCH and EGARCH models have low data outputs. Bebarta et al. (2015) in a research entitled Intelligent Prediction System for Stock Time Series Phenomenon by assimilation three Artificial Neural Network Models, genetic algorithm and hidden Markov model and applying weighting coefficients they were able to optimize the model, Which has less prediction error than artificial neural networks as well as the integrated model of Hassan et al. Al-Ghalib (2014) in a study examined the estimation of the Indian Stock Exchange index and the prediction accuracy of the hidden Markov model was compared with the prediction accuracy of the nearest neighbor algorithm. They stated in their conclusion that HMM is much more professional than its nearest neighbor. Jian Zhou Wang et al. (2012) predicted the Shanghai Stock Price Index in a study using wavelet neural network based on error reduction after propagation of error. To evaluate, they compared their model with an artificial neural network to an algorithm after the error propagation. They found that reducing data disorder could improve the prediction of artificial neural networks.

3- Society and statistical sample

The statistical population of the study includes Tehran Stock Exchange. Considering that the price index forecast is the subject of the present study, the statistical sample includes the years 2007 to 2016 for 10 years.

To obtain data, various tools such as information and data required for this research have been collected using two methods:

1- First, some information related to the theoretical topics of the research has been collected from sources in the form of books, journals, specialized publications and dissertations.

2- Then, the information and data required to analyze the relationship between the data are mainly collected from the information software of the Central Bank and the Statistical Organization.

Statistical software has also been used to calculate and process variables.

4. Methodology

The purpose of this study is to present an approach to compare the hidden Markov model - artificial intelligence. In this approach, the uncertainty of the parameters is included in the model and this will make the system data-driven. It is also a post-event research in terms of data collection that in order to analyze data from statistics and mathematics, the Markov model of hidden-neural network model was used. To find the stock market index in the current period in terms of factors (base vector) in the historical data of the time series of the total stock market index of Tehran was used. Then, using the weighted mean of the base vector, the indexes of the next period are chained; while in the model presented in this study, the concept of stock index is predicted to predict the next period of stock index and the index is used using the output of the hidden Markov model, which are the same patterns. In this research, according to the type of data and available statistical analysis methods, the combined and cross-sectional neural network method has been used to estimate the model parameters and test the hypotheses.

4.1 Hidden Markov Model (HMM)

Hidden Markov Models, as one of the successful methods today, it has found many applications in continuous and discrete signal processing applications. These models, due to their high ability to model speech features and especially dynamic speech feature, have been studied and used a lot in this field. And the memory less property of Markov process seems to be more relevant when stock market prices are analyzed for futuristic prediction. It is a stochastic process where the future probabilities are determined by the immediate present and not past values. This is suitable for the random nature of stock market fluctuations.

The hidden Markov model can be created by determining the following parameters: (Berkes et al., 2004)

● Number of possible modes: The number of modes plays an important role in the success of the model, and in a hidden Markov model each mode is matched by an event. There are

different ways to connect states, in the most general form all states are connected and continuous. (Ergodic model)

● Number of observations in each case: The number of observations is equal to the number of outputs that the modeled system will have.

● Number of model N modes

●The number of observation symbols in the alphabet is M. If the observations are discrete then M will have an infinite value.

$\Lambda = \{a_{ij}\}$

Mode transfer matrix $A = [a_{ij}]$: A set of transfer probabilities between modes●

$a_{ij} = p\{q_{t+1} = j | q_t = i\}. \quad 1 \leq i.j \leq N.$

Where q_t indicates the current state. Transfer probabilities should provide the natural constraints of a random probability distribution. These restrictions include the following:

$a_{ij} \geq 0. \quad 1 \leq i.j \leq N$

$$\sum_{j=1}^{N} a_{ij} = 1. \quad 1 \leq i \leq N$$

For Ergodic model modes for all i and j the value of a_{ij} is greater than zero and in the case where there is no connection between modes.

$a_{ij} = 0$

● Probability distribution of observations: A probability distribution for each case.

B=$\{b_j(k)\}$

$b_j(k) = p\{o_t = v_k | q_t = j\}. \quad 1 \leq j \leq N. \quad 1 \leq k \leq M$

Where v_k represents k^{th} the symbol seen in the alphabet and o_t represents the vector of the current input parameters.

In the case of probability values of states, the conditions in probability theory must also be observed. (Dabo et al. 2010)

$b_j(k) \geq 0. \quad 1 \leq j \leq N. \quad 1 \leq k \leq M$

$$\sum_{k=1}^{M} b_j(k) = 1. \quad 1 \leq j \leq N$$

If the observations are continuous, a discrete probability density function should be used instead of discrete probabilities. The probability density is usually estimated using a weighted sum of M of the normal distribution N

$$b_j(o_t) = \sum_{m=1}^{M} c_{jm} N(\mu_{jm}. \Sigma_{jm}. o_t)$$

Where $\Sigma_{jm}.\ \mu_{jm}.\ c_{jm}$ are the weight coefficient, mean vector and covariance matrix, respectively. In the above relation, the values c_{jm} must satisfy the following conditions.

$$c_{jm} \geq 0. \quad 1 \leq j \leq N. \quad 1 \leq m \leq M$$

$$\sum_{m=1}^{M} c_{jm} = 1. \quad 1 \leq j \leq N$$

The initial state probability distribution $\pi = \{\pi_i\}$ where●

$$\pi_i = p\{q_1 = i\}. \ \ 1 \leq i \leq N$$

In this way we can define a hidden Markov model with a discrete probability distribution using the following triple.

$$\lambda = (\Lambda. B. \pi)$$

Also, a hidden Markov model with continuous probability distribution is shown below. (Robiner, 1989)

$$\lambda = (\Lambda.\ c_{jm}.\ \mu_{jm}. \Sigma_{jm}\ . \pi)$$

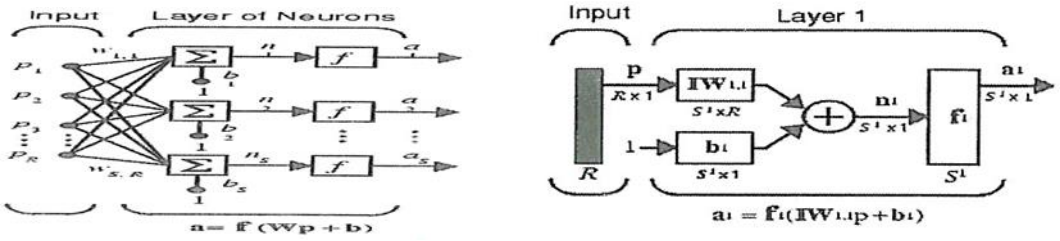
4.2 Neural network

Neural networks emerged as an applied advancement that has been utilized successfully in a variety

of fields. The most important benefit of neural networks is adaptability, independent organization, and instantaneous processing. (Safari et al., 2022) Neural networks have the ability to extract valuable features for processing the data. In both terms of structural analysis and development and in terms of hardware implementation, it is growing and progressing in terms of quantity, quality and ability and the various techniques of neural computing continue to increase in number

Scientific and practical activity has expanded into issues such as control systems, signal processing, and pattern recognition. From the brain as an information processing system with a parallel and completely complex structure that makes up two percent of the body weight and consumes more than twenty percent of the body's total oxygen, many conscious and many unconscious behaviors are used to read, breathe, move, think and explore all actions. Neurons that can be thought of as elements of a computer program or perhaps semiconductor chips. It should be noted that the artificial neural networks formed by these neurons, although they have a very high velocity (1000, 000 times) compared to biological neurons, but only a fraction use the high capacity of biological neurons. It should be noted that usually a neuron with many inputs alone is not enough to solve technical-engineering problems. For example, to model maps that have two outputs, we need two neurons to operate in parallel. In this case we will

have a layer that is composed of a community of several neurons. The simple form of a single layer neural network is as follows:



a1 = f (1w1,1p + b1) a = f (wp + b)

In this figure1, IW1, means the matrix of input weights from the origin of layer 1 (second number) to the destination of layer 1 (first number). In addition, n1 represents the number of first layer neurons and S1 represents the number of outputs of the first layer.

The input P to the neuron or the input or independent variable applied by multiplying by the weight W, is weighted. By adding bias to the structure of the neuron in the previous figure, a biased neuron is created as a right neuron. The bias input is a constant value of 1. In other words, we consider the input p with the elements p1, p2… PR and the matrix of weights W with the elements w1,1, w1,2,… .w1, R.

To apply weight values to the input values, two vectors p and W are multiplied by the matrix. Therefore, the input of the transfer function f, therefore n, will be as follows:

$$n= w_{1,1}p_1 + w_{1,2}p_2 + \ldots..+ w_{1,R}p_R + b$$

Finally, the bias value is added to the product of w multiplied by p. The amount of the bias with the sum of w.p (the same sigma considered within the implicit form of the functions) actually shifts the function to the left. w, b are two adjustable parameters in neurons, and the result is applied to the transfer function f as the input and the final output is obtained.

The combination of weights, bias, transfer function, and multiplication operations is called a layer of the network. If a special function is used for the transfer function, the symbol of that function will be placed in the box related to the function.

By comparing the proposed model with the living neuron model, the weight size w can be equated with the strength of each synaptic connection. Sigma is also identical to the cell body, and ultimately the transmission and output functions A are identical to the output signal of the neuron in the axon. The basic idea of neural networks is that by changing the values of b, w, the network adopts a method or decision. Note that bias is an adjustable parameter of neurons, not an input.

F is the transfer function, and this function should be considered as linear or nonlinear. In this section, the mathematical models used in this research are as follows:

Activation function or transfer function. The transfer function correlates the weighted sum of the units in one layer and the values of the units in the next layer, the following transfer or activator functions have been used in this research.

Hyperbolic tangent. The form of the function is as follows:

$$\gamma(c) = \frac{(e^c - e^{-c})}{(e^c + e^{-c})}$$

This function takes the actual values and converts them to values in the range (-1, 1). When the selector structure is automatic, this activation function is used for all hidden layer units.

: Sigmoid. The form of the function is as follows

$$\gamma(c) = \frac{1}{(1 + e^{-c})}$$

This function takes real values and converts them to values in the range (0, 1).

Number of units. The number of units in each hidden layer can be selected directly or determined automatically by the estimation algorithm.

The identity of the function is as follows:

$$\gamma(c) = c$$

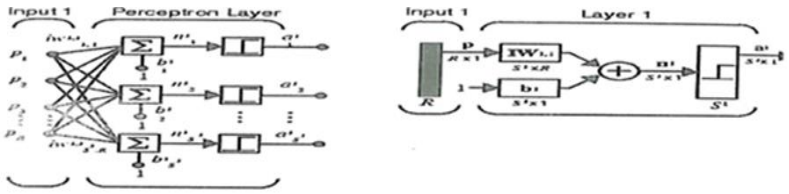
This function takes real values and returns them without change. When the auto-selector structure is used if there is a scale-dependent variable, this activation function is used for output layer units.

Softmax. The shape of the function is as follows:

$$\gamma(c_k) = \frac{exp(c_k)}{\Sigma_j exp(c_j)}$$

This function takes real values and converts them into vectors whose elements are in the range (1, 0) and the sum of them is 1. Softmax is used only when the dependent variables are absolute. When the selector structure is automatic, this activation function is used if all dependent variables are absolute.

The general structure of a single layer perceptron network is shown in the following figure:



a_1 = Transfer function ($_IW_{1.1}p_1 + b_1$)
where….
R = number of elements in Input
S_1 = number of neurons in layer1
The output of this network is determined according to the following equation:

a = Transfer function (Wp + b)

To better understand how to generate each of the network outputs, it is best to become more familiar with the factors involved in the training process. There are p1 to pk input variables versus 1 S to Sk output variables, each variable Si depends on the values of pi, from this p1,

the weighted average of all the variables p is calculated and then this average represents the input function S1. The only difference is that the input variables for each of the output variables are assigned. The following matrix is an example of these different weights. Consider that the first column is the weight that results in S1 and the second column shows S2 to Sk:

$$W = \begin{bmatrix} w_{1.1} & w_{1.2} & \dots & w_{1.R} \\ w_{2.1} & w_{2.2} & \dots & w_{2.R} \\ \vdots & \vdots & \dots & \vdots \\ w_{S.1} & w_{S.2} & \dots & w_{S.R} \end{bmatrix}$$

At the beginning of the initial w calculations, the selection is randomly determined by the computer. Then the output is calculated based on the transfer function. Therefore, the i row of the output vector is calculated as follows:

a i = Transfer function (ni) = Transfer function (iwT p + bi)

According to the definition of the transfer function, if the internal multiplication i of the row of the matrix of weights is greater than or equal to the input vector bi, the output will be 1 and otherwise the output will be zero. Therefore, each perceptron neuron divides the input space into two regions. Finally, the results of the model to evaluate the performance of this proposed model and calculate the model error, we use the indicators of accuracy and error of the method of mean absolute value, percentage of error MAPE and average squares of error MSE according to the following relationships:

$$MAPE = \left(\frac{1}{N} \sum_{j=1}^{N} \frac{|e_j|}{y_t} \right)$$

$$MSE = \left(\frac{1}{N} \sum_{j=1}^{N} (y_{tj} - y_j)^2 \right)$$

$$\bar{y} = \frac{1}{N} \sum_{j=1}^{N} [y_t]$$

$$e = y_t - y$$

5- Findings

The data used in this study are the total stock index in the relevant stock market from April 2007 to April 2016.

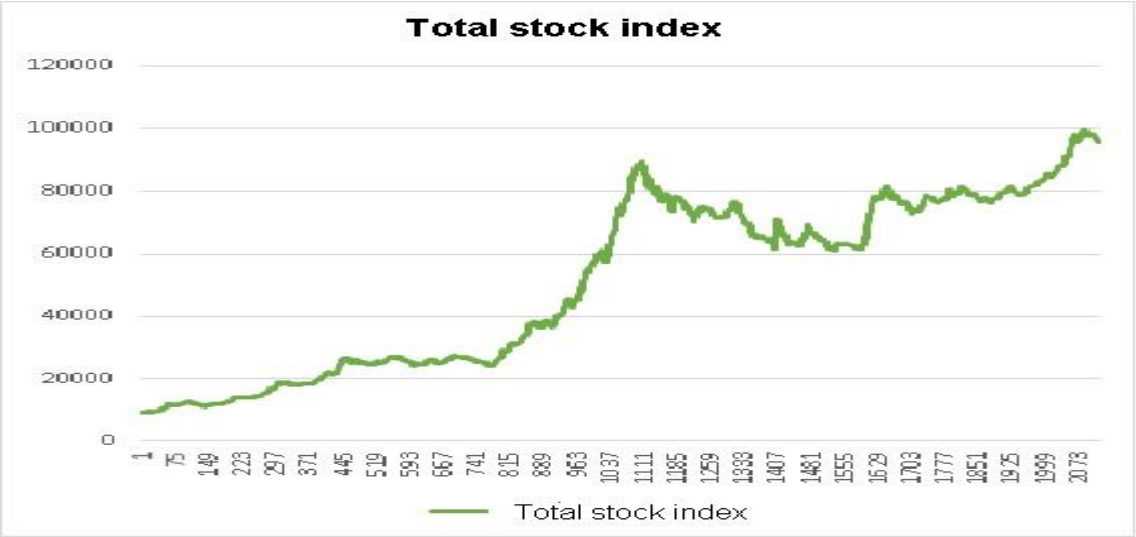


Chart 1 - Growth rate of total stock index

According to the findings of the total stock index chart, there has been an increasing trend over a period of 9 years, this trend has the highest growth in the period of 949 to 1028 (April 2013 to September 2013) and has decreased in the period of 1107 to 1581 (December 2013 to December 2015) and then grew with a smooth slope. In this study, because we use only one variable (two variables separately) the structure of the artificial neural network was NARNet which was calculated with 14 hidden and effects layers from 21 days ago under the Levenberg-Marquardt training algorithm for the next day.

Table 1 - Parameters of training neural network training

Parameter	Amount
Training function	trainlm
Performance function	Average square error Mse[28]
Hidden layer size (Figure * 1)	14
How to select data	Random
Percentage of training data selection	2121
Percentage of validation data selection	10
Percentage selection of test data	10

In figure 1 shows how the neural network connection is displayed, which includes two input columns and two output columns, hidden layers 14 are considered and the output layer is selected depending on the input column, which is number one.

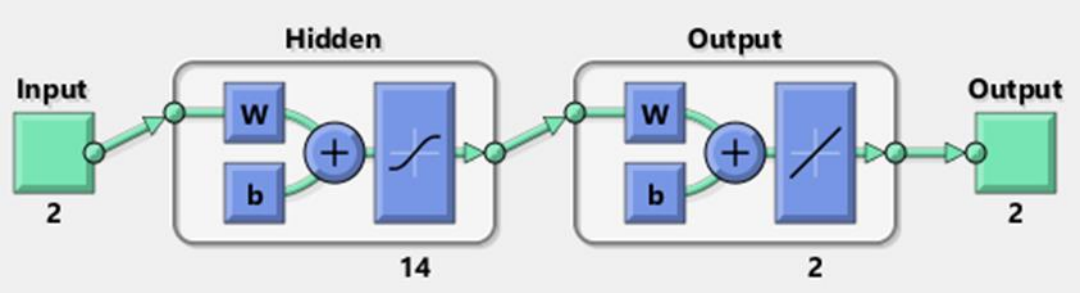


Figure 1- How to connect the neural network with hidden layers

With the implementation of the neural network and the use of data for training, validation and testing of the network end condition, the amount of time is unlimited, to be able to perform operations in a longer period of time, It should be noted that the total values of the final condition can be changed. The amount of rounds for each round of network execution and performing test operations is that if after 1000 rounds we cannot get the best and most optimal answer, the network work will end. Efficiency and slope tend to zero, and if it becomes zero, the network will end and the amount of Mu is the former Gaussian mean parameter in β, specified as a numerical scanner or vector, and finally, the maximum repetition for the obtained answers, if it is 6 repetitions, the work of the neural network is finished and the best and most optimal state is obtained.

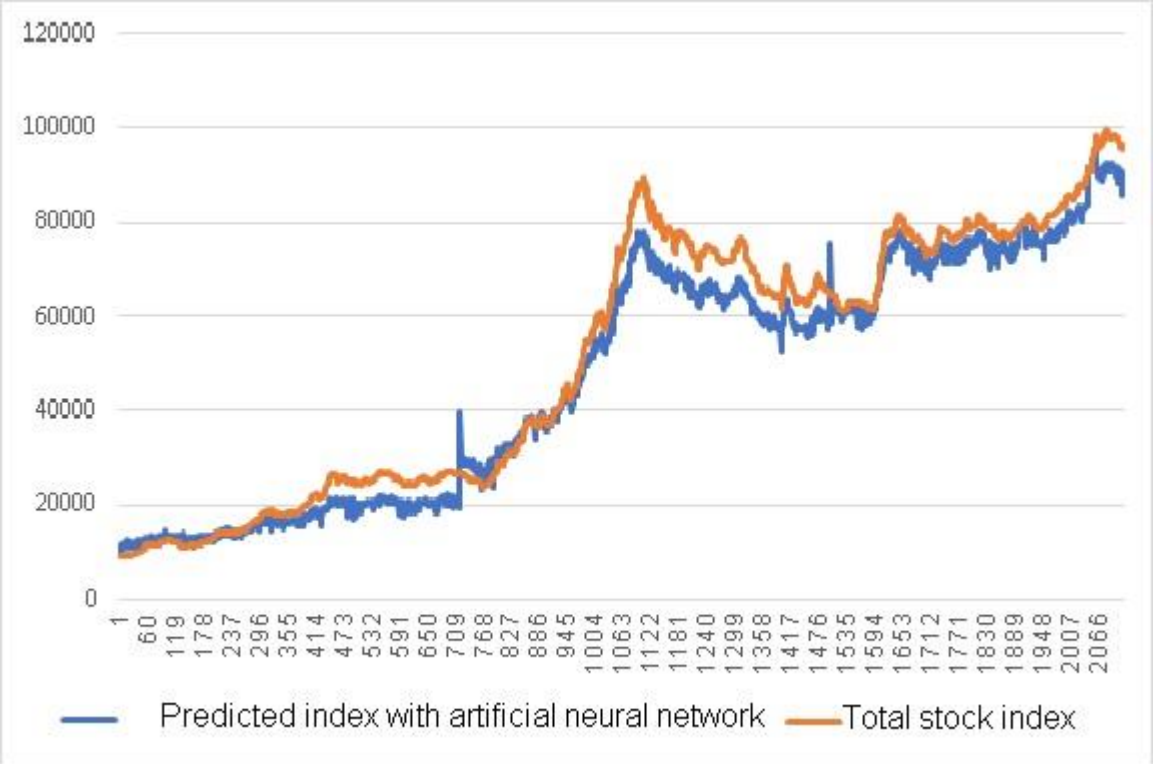


Chart 2 - Stock index forecast with neural network model

In this study, the hidden Markov model was used to predict the total stock index. This model predicts the total stock index by MATLAB statistical software. Due to the hidden Markov's model for this modeling, stock price forecasting is based only on the price of the last 21 days, and these results were obtained for seven consecutive days and with a forecast for the next day.

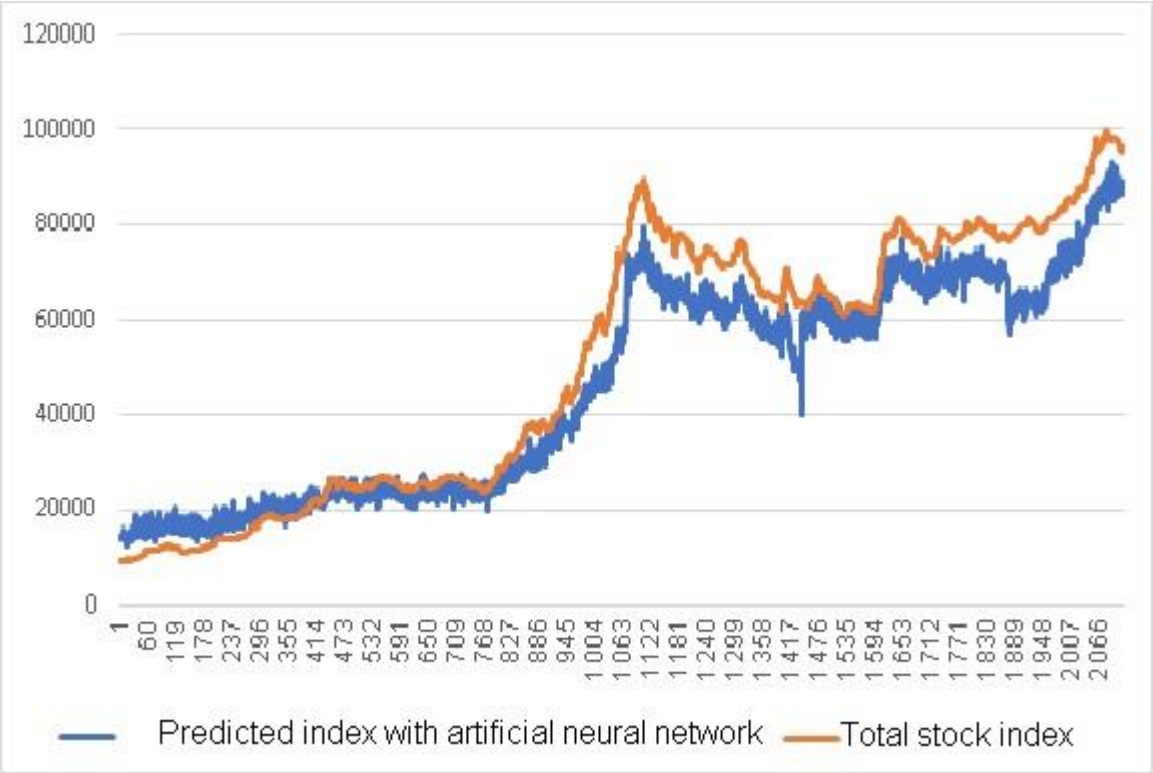


Chart 3 - Stock index forecast with Markov model

Table 2 - Comparison of total stock index forecast error index

	The absolute mean amount of the total error	MAPE	MSE
Hidden Markov's model	7436	057/0	88/2
Artificial neural network	6214	083/0	65/1

6- Conclusion

According to the research findings, the amount of prediction error with artificial neural network has a higher accuracy than hidden Markov's model. According to the MAPE index, the artificial neural network method has been able to improve the prediction power by 0.0343% compared to the hidden Markov model. Artificial neural networks are applied with the ability to infer meanings from complex or ambiguous data to extract patterns and identify methods that are very complex and difficult for humans and other computer techniques to be aware of. A trained neural network can be considered as an expert in the category of information given to it for analysis.

The findings show that due to the fact that the number of completely correct predictions in both models was very small, even considering that the artificial neural network model was very close to the correct prediction and had little error but, since the two models presented in the

research could not correctly predict the total stock index for the future days, so it can be concluded that the Tehran Stock Exchange index Has poor memory , in the other word stock index is rarely memoryless, in the sense that the distribution of future stockindex displays dependence upon past realizations, although a few persistent anomalies remain. Since the results show the findings of L-Ghalib (2014), Jian Zhou Wang et al. (2012), Jarsulaw (2011), Yakub Karaohmakaran (2011), Ming Chi Li (2009) and MT Sang et al. (2007) that artificial neural network models and hidden Markov model in other stock exchanges of the world have high predictive power, therefore, it can be said that the Tehran Stock Exchange has poor memory and its indicators are very weak in terms of diagnostic power. Finally, because of the complexity and heavy calculations as well as the long computation time and the lack of access of some researchers to advanced and hybrid models for people who are looking for a simple, fast and reliable method for forecasting, it is recommended to use the method of artificial neural network to predict the price of stock indices. According to the results of this research and reviewing the results of previous research, the following suggestions are provided for future research:

In this study, only the total stock index in the past has been used as a predictor of its future. Using other data such as cash efficiency, price index, stock index, trading volume, etc., a more accurate model can be provided.

For better performance of an economic forecast, all effective indicators in this area should be considered, therefore, researchers can study the effect of economic indicators such as currency prices, inflation, etc. in forecasting stock prices and its effect on the stock market using the artificial neural network model of this research. It is recommended that the model of this research be used to predict the price of currency, coins and oil, etc.

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