T.C.
ISTANBUL KÜLTÜR UNIVERSITY
INSTITUTE OF GRADUATE STUDIES

PREDICTION OF FOOD INDUSTRY PRICE INDEX USING ARTIFICIAL NEURAL NETWORKS (CASE STUDY: INDEX OF TEHRAN STOCK EXCHANGE)

MASTER OF THESIS

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JAN 2024

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Name: AMIRMASOUD NAZZARI

Kisa ozet

Toplam borsa endeksini tahmin etmek zorlu bir görevdir. Yatırımcıların performansı için endeksin hareketinin doğru bir şekilde tahmin edilmesi, borsa piyasasının karmaşıklığı, yönetim eksikliği ve kritik zamanlarda sorunların ortaya çıkması nedeniyle faydalı bir tahmin modeli geliştirmeyi zorlaştırmaktadır. Yatırım kararlarında kullanılan önemli araçlardan biri olan tahmin teknikleri, karar verme ve kontrol sürecinin ayrılmaz bir parçasıdır ve karar verme riskini doğrudan etkiler. Bu, tahmin ne kadar doğru olursa, belirsizlik koşullarında karar verme kaynaklı kayıp veya risk o kadar azalır demektir. Toplam borsa endeksini tahmin etmek için bilinen ve yeni yöntemlerden biri de yapay sinir ağları (ANN) yöntemidir. Bu araştırmanın temel amacı, yapay sinir ağlarını kullanarak, gayri lineer zaman serilerini tahmin etmek için optimal bir model sunmaktır (Vaka çalışması: Tehran Borsa Endeksi). Bu araştırma, anket çalışmasına dayalı olarak tanımlayıcıdır ve anket yöntemi açısından analitik-matematikseldir. Araştırmanın istatistiksel populasyonu, 1990'den 2020'e kadar Tehran Borsası toplam endeksidir. Bu araştırmada, istenen değişkenleri ölçmek ve ölçmek için kullanılan araçlar, Tehran Borsa belgeleri ve istatistikleri ile veri analizidir. Bu araştırma, tanımlayıcı istatistikler ve Ks, t, r ve (Dickey-Fuller Testi) testlerinin tümevarım istatistiklerini, ayrıca çok katmanlı algılayıcı sinir ağı algoritmasını kullanır. Tahran, diğer lineer yöntemlerle karşılaştırıldığında ve tasarlanan sinir ağı modelinin toplam endeksi %1,7'ye kadar bir hata ile tahmin etme gücüne sahip olduğu, ayrıca Tehran Borsa endeksinin gayri lineer bir süreci izlediği ve son olarak modelin sonuçlarının önerilerin sonunda değerlendirildiği belirtilmektedir. Kullanıcılar ve araştırmacılar için bir uygulama sunulmuştur.

Anahtar Kelimeler: toplam endeks tahmini, Tehran borsa endeksi, Çok katmanlı algılayıcı sinir ağı

Abstract

Forecasting the total stock index is a challenging task, an accurate forecast of the movement of the index is very important for the performance of investors, due to the complexity of the stock market the lack of management, and the occurrence of problems in critical times, it is challenging to develop a useful model for forecasting. One of the important tools used for investment decisions is forecasting techniques, which is an integral part of the decision-making and control process, on the other hand, it has a direct relationship with decision-making risk. This means that the more accurate the prediction is, the loss or risk caused by decision-making in conditions of uncertainty is reduced. One of the well-known and new methods of predicting the total stock index is the artificial neural network (ANN) method. The main goal of this research is to present the optimal model of using artificial neural networks to predict non-linear time series (case study: Tehran Stock Exchange Index). This research is descriptive based on the survey and is analytical-mathematical in terms of the survey method. The statistical population of this research is the total index of the Tehran Stock Exchange from 1991 to 2021. In this research, the tools used to measure and measure the desired variables are the documents and statistics of the Tehran Stock Exchange and for data analysis. This research uses descriptive statistics and inferential statistics of Ks, t, r, and (Dickey-Fuller Test) tests, as well as a multi-layer perceptron neural network algorithm. Tehran compared to other linear methods and the fact that the designed neural network model has the power to predict the total index up to 1.7% error, also the Tehran Stock Exchange stock index follows a non-linear process and finally evaluates the results of the model at the end of the suggestions. An application was presented for users and researchers.

Keywords: prediction of total index, Tehran stock exchange, Multilayer perceptron neural network

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Abbreviation

ROC : Receiver operating characteristic curve

LMS : least mean square

RBF : Radial basis function

BP : Backpropagation

NYSE : New York Stock Exchange

ARCH/GARCH : Auto regressive conditionally heteroscedastic

SCG : Scaled Conjugate Gradient

RBF : Radial basis functions

PPP : Purchasing power parity.

ANN : Artificial neural network

GDP : Gross domestic product

ISE : Istanbul stock market exchange

ARIMA : Autoregressive integrated moving average

TEDPIX : Tehran Exchange Dividend and Price Index

TDN : Time delay network

RMSE : root mean squared error

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List of symbols

M	: The number of proposed neurons is the hidden layer
A	: It is a coefficient that is usually considered 4
Na	: The number of neurons in the output layer
Np	: The number of input layer neurons
N	: The number of network inputs
Wt	: Weight matrix
P	: represents the price of the i-th company at time t
Q	: represents the number of issued shares of the i-th company
RD	: the basic indicator of the price index and cash yield

Introduction

For a long time in scientific and even professional circles, the use of nonclassical methods to identify models and predict how complex systems behave has become widespread. In many complex systems and especially non-linear modeling followed by their prediction and control through classical and analytical methods it is very difficult and even sometimes impossible, from the non-classical methods that have some features it is used as intelligence, based on knowledge and expertise.(Mojtaba Bahmani, et al, 2020) Neural Networks, one of these novel and evolving methods are the recognition of various subjects such as modeling patterns, clustering, and prediction have been used and have had useful results. In this research, neural networks use economic data in forecasting time series. In this regard, various structural factors, different methods of learning neural networks, and selecting and using appropriate data in forecasting are evaluated and reviewed.

The majority of researchers think that there is no linear process in the Financial Markets (Thomaidis, 2017) Therefore, a suitable outcome for the analysis of the Future Path of Financial Variables via Linear Estimates cannot be obtained. A model of artificial neural networks is one of the most important nonlinear models that have been widely used for financial markets in recent years, and which has had positive results. In the field of predicting and classifying variables on monetary and financial markets such as stock prices or exchange rates, neural network models have often been used in economics. Neural networks have been widely used to predict time series in variable nonstationary conditions, lack of justification for classical methods, or the complexity of them. The main reason is the existence of a lot of statistics in these markets and the insufficient ability to exist, models, to explain and predict the behavior of monetary variables. A large number of statistics on these markets and a lack of models capable of explaining and predicting the behaviour of money variables are major reasons for this. For the first time, White wanted to know if neural networks could predict nonlinear rules in a temporal series and unknown rules for asset price movements or stock price changes? In the presentation of this article, White's objective was to demonstrate how a Neural Network could do so (Schwartz, 2019)

1.General Research

1.1 Problem statement

Recent studies in the field of artificial neural networks show that neural networks are a powerful tool for pattern identification, classification, and prediction due to their non-linear and non-parametric characteristics (Makian and Karimi, 2018).

AI networks, which are used for the purpose of transferring knowledge or law hidden behind data to a network structure by abstracting its experiments, shall be regarded as Free Model Intelligent Dynamic Systems. These systems based on computational intelligence try to model the neuro-synaptic structure of the human brain. (S. Abbasi, et al, 2023)

Artificial neural networks are used for a wide range of business issues and this technique is used especially in accounting and finance. Various research has shown that neural networks perform better than traditional statistical techniques such as multivariate regression and, like many machine learning techniques, are suitable for a large and diverse set of problems. (Hasan Qolipour and Miri, 2016) Neural networks have been largely seen as a black box that defines the complex pattern of relationships between data, and learning through training is one of its basic features (Soleimani, 2016). Although it has not been more than 50 years since the birth of computational methods based on artificial neural networks, these networks, due to features such as parallel processing, intelligence, and flexibility, can be used in complex problems such as pattern recognition, clustering, modeling, estimation, and identification and prediction has opened for itself. Neural network in application acts like a "living mind" in some ways. In the sense that he makes judgments from his abstract observations. Therefore, the neural network spends some time in training, and then it is used in practice. In neural network training, the more complete the observations, the more accurate the abstract will be. Of course, there is a possibility that some observations were misleading and not consistent with the general method of observations. Therefore, what is provided to the neural network as training samples should be refined and matched as much as possible. The neural network remembers what it observes in the form of internal parameters. The repetition of each of the observations changes the

internal parameters of the network in order to maintain the relations governing the observations. What is stored in the mind of the neural network is not individual observations, but the general method and conclusion of the observations. This is the reason why the neural network sometimes reacts with a negligible error when faced with training examples again, but it has the stability in practice that in dealing with the generality of similar examples, it performs well and with a negligible error. Observations or neural network training samples can be accompanied by a pre-judgment or without pre-judgment. In other words, neural network training can be done with or without a teacher. In training together with the teacher, what is taught to the network as a training set is along with the judgment that the teacher expects, therefore, the examples are taught along with the predetermined judgment so that in the future, if the network encounters the example The new ones should act according to the procedure that has been taught. In some cases, the samples are provided to the neural network without preliminary judgment, so that it can categorize and finally make a general abstraction from them with consecutive observations. (Shahram Saeidi, 2023)

Each neural network consists of simple processing components called neurons that are interconnected. Each neuron can be thought of as a small component and each connection between two neurons can be thought of as a layer. In addition, each layer has a weight that indicates the degree of influence of each neuron on each other, so if this weight is higher, it shows that two neurons have a stronger influence on each other and a stronger signal pass through this layer. In general, the neuron is the smallest unit of information processing that forms the basis of the functioning of neural networks (Arab Mazar and Akbari, 2017).

The results of studies show that these methods are not successful enough to predict the stock market and other economic variables, although technical and structural models have been widely used. Time series models and artificial neural networks have been used by researchers to improve their predictions as a result of scientific progress. The univariate time series model presumes that the investigated variable is a sequence of observations over time, based on its past values, and can be predicted for future sequences. However, an examination of financial variables such as interest rates, exchange rates, stock prices, etc. shows that the average and

variance of these variables are not constant over time. In other words, although many time series has an upward trend; the trend of some series fluctuates over time and there are periods with low or high fluctuations. A random variable that has constant variance over time is called homogeneous variance, and if its variance is not constant over time, it is called heterogeneous variance. (2019, Lawrence). Tan, Prokhoff, and Wench (2010) have designed a system that predicts significant short-term changes in stock prices. In the first place, the data are preprocessed, and then a neural network model is created, which estimates very profitable situations. Garliaskas anticipated the time arrangement of the stock market by utilizing the neural network calculation algorithm related to the Kernel function and the blunder return expectation strategy, he concluded that the forecast of the financial time arrangement by neural networks is way better than the classical measurable models and other models. Ku, Chen, and Huang (2011) in an article entitled "An Intelligent decision support system for stock transactions by using and combining genetic algorithms based on fuzzy neural network and artificial neural network" create an advisory system regarding the maintenance have sold or bought shares in the stock market. The feature of the created system is to provide the possibility of quantifying the qualitative variables involved in stock price prediction. In 2011, this researcher wrote an article with the same title without considering genetic algorithms. In the mentioned article, a questionnaire with the fuzzy Delphi method is used to use the opinion of experts in predicting the stock price. Sotomayor (2014) predicted the direction of the Brazilian stock price index by using fuzzy logic, and finally, the result of the prediction was evaluated as appropriate. In order to improve existing methods, Ayodele Adebia (2000) used a hybrid method that used a combination of variables from technical and fundamental analyses of stock market indices to predict future stock prices. The focus of this article in order to improve the accuracy of stock price prediction was to use a hybrid method that combines variables from technical and fundamental analysis to create a neural network model for stock price prediction. The variables of technical analysis in his review are the core of the index stock market (current stock price, opening price, closing price, volume, highest price, and lowest price, etc.) while the fundamental variables of the analysis of the company's performance indicators (price in annual profit, rumor/news, book value, and financial status, etc.) the hybridization method was

tested with published stock data and the obtained results showed a significant improvement using only technical analysis variables. Also, the prediction with the hybridization method is satisfactory. enough, as a guide for traders and investors in making quality decisions.

Giovanis (2019) in an article investigated stock prices in the Athens Stock Exchange during January 1, 2012. It paid for Dionic and Coca-Cola companies until June 30, 2018, and then predicted stock price values in the period from July 1 to July 24, 2018. In the case of Coca-Cola stocks, he used the OLS method, and in the case of Dionic stocks, the generalized autoregressive conditional heteroskedasticity variance (GARCH) due to the existence of the heteroskedasticity variance, and he used the prediction results using the feed-forward neural network model with active function. It has a simulated hyperbolic tangent, an error backpropagation algorithm, and 15 hidden layers. Finally, he compared the prediction obtained from the neural network model with the predictions obtained from the OLS and GARCH models. The results show that the neural network model had less error than the two mentioned models and was relatively superior.

Gorka and Smith (2010) in an article used the multi-layer neural network model trained by the back-propagation method as well as the ARIMA model to forecast the exchange rate in Poland. They mentioned four methods for rate forecasting, which are: technical analysis, fundamental analysis, econometric analysis, and artificial intelligence methods. In the mentioned research, a multilayer neural network model with different numbers of layers, different types of activation functions, different numbers of neurons in layers and different input information have been used. In all networks, there are five output variables that represent the rates of the same day, one, two, three, and four days later. To avoid prediction errors based on neural networks, the learning process (and prediction) has been repeated three times for all types of networks. For comparison, the results of the first and second stages have been compared with the ARIMA process. Finally, they have concluded that although the neural network model is a useful tool for economists; it cannot always be a substitute for classical statistical models. Igli, Azturan, and Bedur (2003) in an article dealt with the prediction of the Istanbul Stock Market Index (ISE) using neural networks. They have mentioned the importance of predicting stock returns in the financial sector as the purpose of this research. The research variables include the

value of the index on the previous day, the exchange rate on the previous day, the overnight interest rate on the previous day, and five virtual variables (working days of the week) that the data is daily and in the years 2001 to 2003 (totally 417 data) have been collected. 90% of the data were used in the training set and the rest in the test set. The neural network used was a multi-layer perceptron type, as well as a generalized feedforward network, and the activation function used was a sigmoid type. Finally, neural network models have been compared with two moving average models (5 and 10 days). The results indicate that two neural network models perform better when a hidden layer exists in the network. By comparing the errors, it can be seen that neural network models have fewer errors and, as a result, better performance than moving average models.

In their article Ghadimi and Moshiri compare the efficiency of a neural network model with a linear regression model for predicting the economic growth rate in Iran. The investigated period is 1937-2002, which includes 66 annual data. In this study, the per capita GDP growth rate variable was used as the dependent variable, and human capital variables, inflation rate, investment rate, and virtual war years variable were used as independent variables. First, a growth regression model has been estimated for the period 1995-1997, and the period 1998-2002 has been selected as the test set. Next, a neural network with the same (input variables) is estimated. The designed neural network was of feedforward type with a hidden layer and hyperbolic tangent activation function. Based on all the conventional evaluation criteria, the neural network model has a better performance compared to the regression model.

Marzban, Akbarian, and Javaheri (2013) in their article the performance of five Box-Jenkins models (autocorrelated cumulative moving average model), Random step and three different specifications based on purchasing power parity theory (PPP) have been investigated in comparison with artificial neural networks for forecasting the monthly nominal exchange rate. The neural network used was a feedforward network with an error backpropagation algorithm. The purpose of this article is to test whether artificial neural networks have better results in predicting exchange rates. In this study, from the monthly data of the nominal exchange rate in the black market for the period from October 1981 to January 2003, the data of the monthly

consumer price index of Iran (the base year 1998), and the data related to the consumer price index The United States of America (the base year 1996) is used, and all variables are considered logarithmically. Explanatory variables used in linear models are used as input of the neural network. The results show that compared to linear econometric models such as structural and time series models, the neural network model is more powerful in predicting the exchange rate.

Many questions are raised daily about the future behavior of the phenomena around us, the answer to which depends on the knowledge and sufficient awareness of the mechanism of the occurrence of those phenomena. The weather forecast, stock price forecast, global oil price forecast, and dozens of similar items are among our favorite questions. In a classical scientific view, to answer each of the mentioned cases, it is necessary to have enough knowledge about the mechanism of occurrence of each of the phenomena and the influence of each factor in its occurrence in an analytical way. Obtaining these mechanisms is very difficult and unattainable in many cases, if not impossible. In a different view, if each of the events is examined as a sequence in the form of numbers and quantity, it can be a solution to predict its future values. These sequences are analyzed and analyzed under the name of "time series", regardless of whether they are related to what phenomenon, arise from what mechanism, and are affected by what factors. Of course, many assumptions and information about a phenomenon can be used in the analysis of the related time series. In single-variable quantitative methods, time series data is used for forecasting. In a general definition, a time series is a collection of observations arranged by time. In other words, time series is the time sequence of observations related to a given variable. To find a model that is effective in providing the desired forecast, we examine the time series data. The analysis of time series is related to data that are not independent and are sequentially dependent; Analysis of time series, dependence between consecutive observations is considered and used. It is one of the applications of predictive time series analysis, which forms a wide field of practical statistics and applied economics (Anderson, 2017).

In economic research, the most used forecasting models have been econometric models, recently the artificial neural network has entered the literature of applied economics along with the traditional models. The basis of these networks is artificial intelligence. By using artificial intelligence, the relationships between variables, even if they are complex, can be learned by the computer and used to predict future values. The important advantage of an artificial neural network model is that there is no need to make special statistical assumptions about the behavior of variables. An artificial neural network is divided into static and dynamic models in a classification. In static models, the route of information processing is from data to columns; Without there being a return in the communication system of the units. While in dynamic models, there are return paths from the data vector or intermediate units vector to the data vector. These return paths can be compared to the delay variables in the regression model; Because in this case, the data, in addition to being a function of the data, are also a function of the data created in the previous step. Due to the novelty of these models and their high efficiency and accuracy in forecasting, the purpose of this research is to use neural networks and artificial intelligence to predict the time series of food industry prices and how to use them in the stock market index. Tehran to introduce non-linear time series.

1.2 The importance and necessity of conducting research

In the field of forecasting time series from a methodological aspect, techniques such as diagnostic analysis, logit regression, and neural networks are the most used to solve this problem. In the opinion of researchers, the neural network is relatively more efficient than other methods (Charalmbous, 2020; Boyacioglu et al., 2019) and is more accurate in financial and non-financial fields (Anandarajan, 2011). Its other advantages can be listed as follows: greater ability to investigate and study and discover the relationships of variables in the field of business and especially in the field of bankruptcy (Charalmbous et al., 2020), easy application for non-linear data, without the need to have Previous knowledge about the assumptions of data distribution and data characteristics (Brothers et al., 2009; Lu & Wu, 2011) and the relationship between independent and dependent variables (Yan & Gu, 2010). Neural networks are widely used in business-related issues as well as two-level dependent variables (Tsai and Hasio, 2010). A neural network has been welcomed as a useful tool in research and flexible and non-

parametric modeling, and along with the knowledge and experience of managers, it has a helpful role in improving performance and improving the quality of decision-making (Charalmbous et al., 2000; Tang & Chi, 2005; Chang et al., 2008). Along with these positive features, in this research, with the help of a multi-layer neural network, we will present a model for predicting non-linear time series. They should buy and sell stocks more carefully to minimize the risk to their portfolio.

1.3 The aspect of novelty and innovation in research

Forecasting the future in various fields has always been interesting and attractive for humans. It can be said with certainty that predicting the future and the process of changes in all fields is one of the main and constant concerns of high and middle-level managers. But there have always been many problems that have made it almost impossible to make accurate and reliable predictions. They do not have and cannot compensate for the research costs. Numerous shreds of evidence from all over the world indicate that although many researchers have been successful from a technical point of view, only a small percentage of them have been successful in terms of application and commercialization. In this regard, identifying predictor variables of macroeconomic components such as non-linear time series and predicting its possible possibilities using the combination of management science and artificial intelligence can help managers and investors in preventing recessions and economic problems.

1.4 Research objectives

1.4.1 Scientific goals

Developing the methodology of using neural networks and artificial intelligence to predict non-linear time series (food industry price index of Tehran Stock Exchange)

1.4.2 Practical purposes

1. Prediction of the price index of the food industry in the Tehran Stock Exchange by using neural networks and artificial intelligence

2. Comparison of forecast results with real data

3. Determining the non-linearity of the time series process of food industry stock prices in the Tehran Stock Exchange

1.4.3 ideal goal

The most ideal goal of this research is to develop and present a reliable model for predicting the time series of the stock index of the Tehran Food Industry Exchange. Finally, it can pave the way for using methods with a higher degree of confidence to predict non-linear time series by creating a suitable background for further research.

1.5 Research Questions and Hypotheses

The main question

How can neural networks and artificial intelligence be used to predict non-linear time series and what is their methodology?

Sub questions

1. At what level is the prediction of the food industry price index of the Tehran Stock Exchange using neural networks and artificial intelligence?

2. Does the artificial neural network provide better predictions than linear methods?

3. What is the difference between the results of the predictions and the real data?

4. Do the food industry price index of the Tehran Stock Exchange follow a non-linear process?

1.6 Scope of research

Thematic area of research

The subject area of the research is in the field of management knowledge, especially industrial management, and it examines the prediction of non-linear time series and helps to make economic management decisions.

The spatial territory of research

The geographical scope of the research includes the Tehran Stock Exchange.

Time domain of research

This research started at the beginning of November 2022 and will end in April 2023, and the time domain of the information and data used in this research is related to the statistical data (time series) related to the stock index of the Tehran Stock Exchange, during 30 Last year (from 1991 to 2021) is available in the Statistics Center and the Central Bank of the Islamic Republic of Iran.

1.7 Definition of technical and specialized words and terms

Artificial Neural Networks: Artificial neural networks, like the nervous systems of living beings, consist of neurons connected, which can process or change information. The traditional view was that artificial neural networks are programs that imitate biological neural networks and learn how to recognize patterns in data and classify data. Artificial neural networks are nothing but dynamic systems. They are considered to be free model intelligence, which transfers the knowledge or law hidden behind the data to the network structure by processing the experimental data. These systems based on computational intelligence try to model the neuro-synaptic structure of the human brain. Artificial neural networks are used for a wide range of business issues and this technique is used especially in accounting and finance. Learning through training is one of the basic characteristics of neural networks, and they have been largely seen as a black box that defines the complex pattern of relationships between data (Qalipour, 2018).

TEDPIX total index: In Tehran Stock Exchange, the yield index or the price and cash yield index is known as TEDPIX. This index is the same index that is always mentioned in the news and media as the index of the Tehran Stock Exchange. The total index is one of the most used indices among market participants and investors. This index expresses the general level of price and dividends of companies listed on the stock exchange, in other words, changes in the total index represent the average return of investors on the stock exchange. To understand the concept of the total index more easily, suppose that you have all listed companies in proportion to their weight in the stock market. Buy the total stock market index, in this case, the changes in the total stock market index will be equal to the yield of your stock portfolio. The index

calculates the total changes in stock prices and annual dividends that companies pay you. The total index is also known as the price index and cash yield. The point that we should pay more attention to when examining the index is the number of changes in the total index. For example, if the total index of the stock market goes from 80,000 to 120,000 units in one year, it indicates that the average return of the stock market in the last year has been equal to 50%. According to the calculation formula of the total index, the bigger the companies and the more capital they have, the more impact they will have on the total index.

1.8 Research structure

The next four chapters of the research are presented as follows:

In the second chapter, we first discuss the theoretical foundations of the stock market, types of indicators, time series and its forecasting, and artificial neural networks, and a brief description of this technique and its types. The subject of the research is examined. The third chapter is devoted to the description of the research methodology. First, the research questions are stated and also how to collect data and select variables and research methods are described. The results of information analysis based on the methods presented in the third chapter are presented in the fourth chapter so that based on the analysis of the collected information, we can provide a model for predicting non-linear time series. The fifth chapter also includes conclusions, a research summary, and suggestions.

1.9 Summary

The topics that were discussed in this chapter are mainly related to the statement of the problem and the importance and necessity of the research, the objectives, the statement of the basic questions of the research, the definition of the words, and finally the structure of the research. In the research structure section, the items that will be discussed in chapters two to five are briefly stated.

2. Literature Review

2.1 Introduction

Forecasting is a problem that has occupied the human mind for a long time. In general, it can be stated that one of the most important tasks of science in various fields is to try to find connections between different phenomena to predict the future (Zahri and Afshar Kazemi, 2013). Investments need to take advantage of relative advantages and potential economic opportunities if sustainable development is to be achieved. In order to achieve the objectives and needs of national development, experts have considered investment as a way out of the gap between available funds and required resources (Kazemi et al., 2013). Therefore, making a decision and investing in the stock exchange as one of the most famous investment institutions with less risk and more yield is the dream of every investor. Therefore, forecasting changes in the stock index is a great help for decision-makers and investors, which is the final goal of this research.

On this chapter, we try to discuss the literature and history related to the predicting variables of the food industries stock index and different definitions and different methods of measuring the variables and then the artificial neural network in detail, and finally, the research done by domestic researchers and the foreigner investigated and studied will be brought as the study background of the research.

2.2 Theoretical Foundations of Research

2.2.1 definition of forecast

One of the important management tools is the use of different forecasting methods. To make decisions, managers need to estimate future events using past information. Foresight is the concept of the previous study, calculation, and guessing of future situations and conditions, and someone who is aware of these calculations - which often relies on current statistics and information - and relies on his vision about the future, sits down to make a judgment, deals with prediction.

A forecast talks about what may happen in the future. Most forecasts are based on experience or knowledge. There are differences between forecast and prediction. A forecast is the expression of events that are expected to happen, but prediction covers a wider range and may refer to things that are not expected. There is no guarantee that forecasts will be correct, but forecasting is very important in planning. Howard Stevenson writes about forecasting in business: "...forecasting has at least two characteristics: important and difficult."

Another definition of forecasting: The forecasting process is a method of predicting the unknown situations. Forecasts predict future events and can turn past experiences into predictions of future events. The forecasting method of demand planning has been adopted by manufacturers' daily business practices over the past few years.

2.2.2 Forecasting goals

In general, two basic goals are pursued in forecasting: The first goal is proper planning. Planning means formulating and designing policies, models, plans, and ideas for the future to achieve organizational goals or system goals, so it can be said that planning is a kind of prediction. The second goal is to learn about and apply predictive decision-making techniques. In a comprehensive definition, decision-making is the process of problem diagnosis and problem-solving. Therefore, forecasting helps this important thing that is related to all the four duties of managers.

2.2.3 Effective Factors in Choosing a suitable forecasting model

Currently, management scholars have invented various techniques for forecasting, each of these techniques has its own application, and by knowing their group, more successful forecasts can be made. Managers should try to choose a forecasting model that can meet the needs of the organization and suit its activities. To choose the right model, it is necessary to pay attention to the following points.

Time range: In general, if we want to predict a relatively distant period, it is better to use quantitative methods, and on the contrary, if we want to make medium and short-term predictions, it is better to use qualitative methods of prediction.

Given statistics and figures: The method of prediction differs according to the type of past statistics. Sometimes the statistics have seasonal fluctuations or follow a series of random and irregular fluctuations.

Correlation of information with the desired variable: sometimes statistics and information related to the desired variable are not available, and information related to another variable that is related to the said variable should be used, for example, to predict the number of cars in the city, it is possible to use information about the amount of tire consumption.

Cost: Different forecasting models have different characteristics and create different costs.

Accuracy: Some models forecast the situation in the future with 90% accuracy and some with less accuracy. We can choose the desired model according to our expectation of the accuracy of the model.

Simplicity: Although some models are very accurate, they cannot be used in all organizations due to their complexity.

Forecasting is used more for selection. Institutions and organizations use surveys and forecasting techniques to forecast the results and use them to achieve their goals.

2.3 Neural network

Multicellular animals need communication agents and devices to establish coordination between the actions of their cells and different organs. This coordination was made possible by a nervous system with its specific structure and function. Neurons send nerve messages to tissues and organs of the body, such as muscles, glands, and other neurons, and in this way communicate with them.

Each neuron may have a very large number of neurons, and the overall number of neurons as well as their connections to each other can be great. The connections, also called synapses, are made up of the fibers that come out of the neuron's cell body. These fibers are of two types: dendrites and axons. Dendrites receive the messages and carry them to the cell body. These appendages are generally short, but sometimes they are long, in which case they are similar to axons in terms of structure. Axons conduct the nerve message from the cell body to the axon terminals. The length of an axon can be short or long (for example, it can vary from a few microns to a meter). Sometimes a branch or branches from an axon come out as lateral branches (for example, in pyramidal neurons of the cerebral cortex). The functions of the nervous system depend on the interconnection between millions of neurons.

The figure below shows a biological neuron.

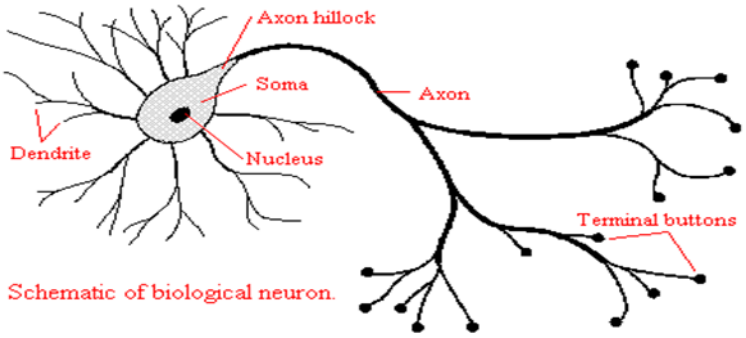


Figure 2.1 Image of a biological neuron (Sayadi, 2017)

The central nervous system is composed of the brain and spinal cord, which are centers for monitoring activity in the body. The device is able to read and respond to the information received from the environment and in the body. There are two parts of the central nervous system: gray matter, which is mostly composed of neurons' cells and white matter, a collection of myelinated neuron sections. There are many nerves in the peripheral nervous system that collect information and pass it on to the central nervous system. There are about 100 billion neurons in the human brain, and it weighs approximately 1.5 kg.

The name of the nervous system is derived from nerves. The biological neural network generally consists of a collection or series of neurons that are physically interconnected and functionally dependent. There may be a very large number of neurons connected to each other, and the total number of neurons as well as their connections can be enormous. These connections, which are usually composed of axons and dendrites, are called synapses (Sayadi, 2017)

Artificial intelligence and cognitive modeling try to simulate some properties of neural networks. Although both methods are similar, the objective of artificial intelligence is to solve

specific problems, while the objective of cognitive modelling is to create mathematical models of biological neural systems.

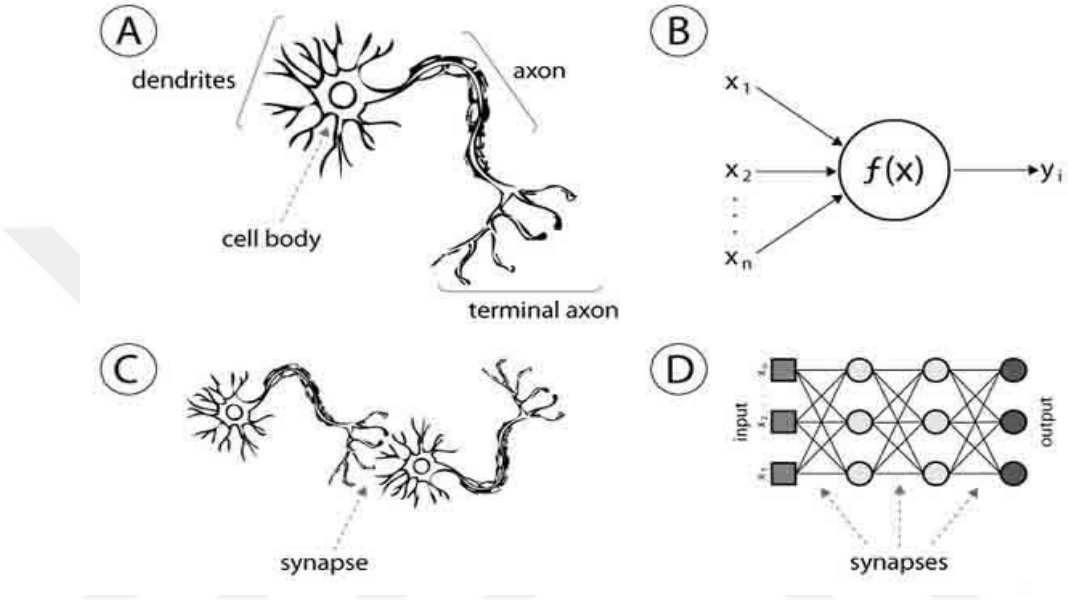


Figure 2.2 modeling artificial neural networks

2.3.1 Artificial Neural Networks

In the field of science, neural networks are a kind of simple model for actual nervous systems which is widely used to deal with different problems. The field of application of these networks is so wide that it includes classification applications to applications such as interpolation, estimation, detection, etc. Their broad capabilities and ease of use may be the most important advantage to these networks. (Sayadi 2017)

In order to understand and describe each of these subparagraphs more easily, one useful method for solving complex problems is to break them down into simpler ones. The network is a collection of these simplest structures which are combined to describe the overall complex system. Different types of networks are available, but they all come with two components:

A set of nodes; each node is a network unit that receives inputs and processes them in order to produce outputs. The simplest type of processing, such as the collection of inputs, may be included in the calculations carried out by this node. In a special case, an additional network may also be included on the node itself.

Connection between nodes; this connection determines how information flows from one node to the next. Generally, the connection is bidirectional or unidirectional. The network's general behaviour cannot be seen by any of the network elements, as a result of interactions between nodes via these connections. The network is a powerful tool due to the comprehensiveness of these general behaviours for each node's performance. In other words, a simple set of elements, when they are in the form of a network, can show a behavior that none of those elements alone could show such a characteristic.

An artificial neural network is a data processing system that takes ideas from the human brain and entrusts data processing to several small processors that act on a network connection and parallel to each other to solve a problem. With the help of programming knowledge, called a neuron data structure, it is designed to act like neurons in these networks. Then they train the network by creating a network between the neurons and using a training algorithm. (Salmanpour and Shekarzadeh, 2018)

In this memory or neural network, neurons have two active states (on or 1) and inactive (off or 0) and each edge (synapse or connection between nodes) has a weight. Edges with positive weights trigger or activate the next inactive node, and edges with negative weights disable or inhibit the next connected node if it is active.

2.3.2 History of artificial neural network

In 1949, the MP model of artificial neural networks was proposed by McCulloch and Pitt, which was a simple linear model. Then Perceptron presented learning algorithms. In 1969, the temporary decline of neural networks began. Because the inability of neural networks to solve non-linear problems was revealed. The artificial neural networks of that time were only able to

solve problems that we could separate the answers of that problem by a line in the coordinate axis. In 1982, Hopfield presented a solution for solving nonlinear cases by introducing multilayer networks and learning algorithms with feedback. It was at this time that recurrent networks, self-organizing, RBF, autoregressive and Hebbian learning methods were proposed. (Ali Mostafaeipour et al., 2018)

From the mid-nineties, the third generation of artificial neural networks was proposed, which included:

- Determining the theoretical and practical limitations of the network

- Generality and its limits

- Genetic algorithms, Artificial neural networks, and fuzzy logic

- Finally, the practical use and commercial implementation of artificial neural networks have become possible.

2.3.3 The Emergence of artificial neural networks

The human brain, according to many scientists, is the most complex system ever seen and studied in space. But this most complex system does not have gigantic dimensions, nor the number of its components, more than the processors of today's supercomputers. It is a unique system that has several interconnections, which makes it very complicated. What distinguishes the human brain from all the other systems is that it's a 1400-gram brain.

The brain is in charge of all the consciousness and unconscious processes that are going on inside our body's geographic limits. Some processes are so complex that no computer or supercomputer in the world is able to process them and execute them. However, research has shown that the building blocks of the human brain are about a million times slower than silicon chip transistors.

The massive connections that exist between the cells of the brain, which make up the human brain, result in very high processing speed and power for humans, but also reduce them to a common system without any current ability.

In addition, the most important goal of hardware and software architects is to simulate the brain and its capabilities, given its excellent ability to solve all kinds of problems and its high efficiency. There's going to be a great revolution in science, industry, and of course human life if the day comes, which isn't too far away, when we can build a computer that's the complexity of a human brain.

In the direction of simulating the computational behavior of the human brain, since the last few decades, when computers made it possible to implement computational algorithms, research works have been started by computer science experts, engineers, and mathematicians, whose work, in A branch of the science of artificial intelligence, and under the branch of computational intelligence, is classified under the subject of "Artificial Neural Networks" or ANNs for short. In the topic of artificial neural networks, many mathematical and software models inspired by the human brain have been proposed, which are used to solve a wide range of scientific, engineering, and practical problems in different fields. (Sayadi, 2017)

2.3.4 Definition of artificial neural networks

Artificial neural networks are a structure (networks) made up of several units (artificial neurons) that are connected inside the network. Each unit has an input/output (I/O) characteristic and performs a detailed calculation or operation. The output of each unit is determined according to its (I/O) characteristic, its internal connections to other units, and (possibly) external inputs. Since manual training of the network is possible, hence the network usually obtains a general performance from one mode or more modes of training.

ANN does not consist of one network, but a family of different networks. The overall performance of artificial neural networks is determined by network topology, individual neuron characteristics, and learning tactics and training data. (Salmanpour and Shekarzadeh, 2018).

2.3.5 Artificial neuron

An artificial neuron is a system with many inputs and only one output. The neuron has two modes, training mode, and performance mode. In the training mode, the neuron learns to fire in response to specific input patterns. In operation mode, when a recognized input pattern is entered, the corresponding output is provided. If the input is not among the pre-detected inputs, the fire rules decide whether to trigger or not.

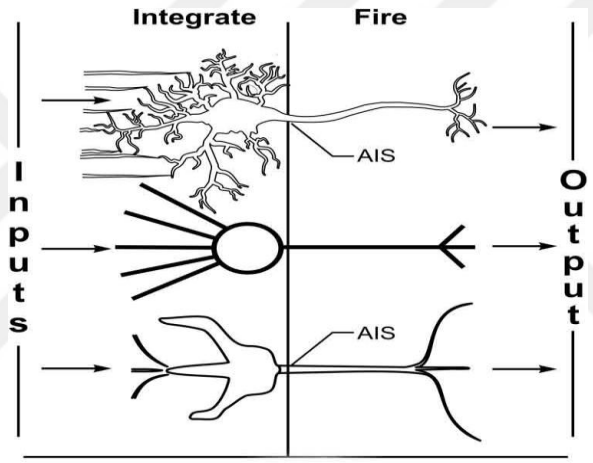


Figure 2.3Training mode and neuron performance

Among the capabilities of neural networks, the following can be mentioned:

- Calculation of a known function

- approximation of an unknown function

- Pattern recognition

- signal processing

- learner

2.3.6 Components of artificial neural networks

Input:

The inputs in the neural network can be the output of other layers or can be raw in the first layer and the following forms:

Numerical data - literary and technical texts

Weights:

In a nervous system, the influence of input x on output y is measured by weight.

Sum function:

In networks with only one neuron, the output sum function determines the problem to some extent, and multi-neuron networks also determine the sum function of the activity of neuron j in the inner layers.

Conversion function:

It should be noted that the sum function is not the answer expected by the network, and for this reason, the conversion function is considered an essential member of neural networks, and different types of transformation functions are used based on the nature of the problem. Of course, this function is determined by the designer of the problem and is adjusted based on the selection of the learning algorithm, the parameters of the problem, or the same weights.

Output:

In a neural system, the output of the problem is the same as the answer to the problem.

2.3.7 Working with any neural network consists of three stages: learning, generalization, and execution

In the learning phase, the network learns the patterns in the input data. Each neural network uses a specific rule to learn.

Generalization is the power of the neural network to generate acceptable responses for inputs that were not members of the training set.

In the implementation phase, the neural network is used for the function designed for that purpose.

2.4 Types of neural networks

Various types of computational models, which can be used for a set of applications and are inspired by certain aspects of the human brain's capabilities and features, have been introduced under the general term Artificial Neural Networks. All these models show the right structure of mathematics.

A look at the learning process, which of course can be displayed graphically, has a series of parameters and adjustment screws. This general structure is adjusted and optimized by a learning or training algorithm to the extent that it can also show the behavior of the human brain that we also experience a process similar to this in our brain and all skills, knowledge, and memories We are formed as a result of weakening or strengthening the communication between nerve cells in the brain. By adjusting a parameter known as weight, this strengthening and weakening are simulated and described in mathematics.

But the way of looking at different models of artificial neural networks is completely different and each one has targeted and imitated a part of the learning and adaptation capabilities of the human brain. In the following, there is an overview of different types of neural networks, the study of which will be very effective in creating an initial acquaintance.

1- Perceptron

2- Hopfield

3- Hamming

4- Cohen

5- Back propagation neural network

6- Carpenter and Grossberg neural network

1- Perceptron neural network

Frank Rosenblatt created and invented the perceptron by connecting these neurons in a simple way, and for the first time simulated this model in digital computers and formally analyzed them.

The neural network is based on a computation unit called Perceptron. A perceptron will take a vector of real valued inputs and calculate the continuous combination of these inputs. The perceptron's output shall be equal to 1, if the result exceeds a threshold value, or it shall be equivalent to -1. One of the most practical neural networks is perceptron neural networks, especially multilayered perceptron neural networks, which, by choosing the appropriate number of layers and neurons, which are often not many, can perform a linear mapping with desired accuracy. (Shiri, 2018)

Multilayer perceptron neural network is used with error backpropagation method and in the form of training with the presence of an observer in the form of the following structure and architecture:

Hidden layer: The presence of a hidden layer in the neural network architecture is sufficient to approximate linear and nonlinear functions with appropriate accuracy (Keyvanpour, 2016; Lu Wu, 2011). In this research, a hidden layer will be used.

Input and output layer neurons: the number of neurons in the input layer is equal to the independent variables of the research. (Keyvanpour, 2016).

In this research, the number of neurons in the input layer will be the number of identified factors, and the number of neurons in the output layer will be automatically determined by the network based on the nature of the target variable.

Hidden layer neuron: There is no general rule for determining the number of hidden layer neurons (Tsai and Hasio, 2014), however, it has been proven experimentally that if the number

of hidden layer neurons is determined based on the formula, multilayer perceptron networks will be efficient.

$$m = a\sqrt{np * na} \quad (1)$$

In this formula, **m** is the proposed number of neurons in the hidden layer, **a** is a coefficient that is usually considered 4, **np** is the number of neurons in the input layer, and **na** is the number of neurons in the output layer (Keyvanpour et al., 2016; Tang and Mak Linan, 2015)

The number of hidden layer nodes should be at least equal to the input variables to explain about 70-90% of the variance of the input data (Brouthers et al., 2019). The number of hidden layer neurons for small inputs (less than five) is almost twice that of inputs. Of course, with the increase in the number of entries, this ratio decreases (Priddy and Keller, 2005). The number of neurons of the hidden layer is determined based on the formulas n/2, 2n/3.n, n+1, 2n+1.

In the mentioned relationship, n is the number of network inputs (Tang and Chai, 2005) the most appropriate number of neurons in the hidden layer is the highest classification accuracy (Youn and Gu, 2010), in the present research, determine the number of neurons in the hidden layer, first based on The mentioned formulas will be determined, then based on trial and error and based on the mean squared error criteria, the prediction accuracy percentage and also the ROC curve, the most suitable value for the hidden layer will be determined.

In the application of the "error backpropagation" algorithm to optimize the weights, there are two methods: online or stepwise, and offline or cumulative (Wu et al., 2011; Nakama, 2009). In the online method, network weights immediately after Each input (learning) are readjusted and corrected. And in the offline method, the weights are not adjusted at the end of each learning, but after gathering and presenting all the inputs, it is time to do this. In the context of the relative superiority of each of these methods, there is neither a specific theoretical guideline nor an empirical agreement, but various arguments have been put forward in this field (Nakama, 2019; Fischer and Staufer, 1999). However, it seems that the method Online is more suitable for large networks and the aggregate method for small networks (Wilson and Martinez, 2013; Magolas et al., 2014)

Regardless of whether the network is trained stepwise or cumulatively, there are mathematically different algorithms for optimizing the network, of which the SCG method and the Lunberg-Marcard method are two examples, and usually when the approach of adjusting the weights is of an off-line type. and cumulative, they are used (Beale et al., 2010, IBM, 2011) There is no definitive conclusion about which algorithm is better.

According to some researchers, the SCG method is almost completely automatic and independent of the user in supervised training, which is considered an advantage (Moller, 1993). In many types of research, feed-forward networks have been trained with the SCG algorithm (Khatai and kasiri, 2018), which is a desirable algorithm for explaining pattern-finding problems (Beale et al., 2020).

The transfer function (activation): The choice of function depends on the nature of the network output. Usually the ly, the sigmoid function is used in pattern-finding problems and when the network output is in the range of zero and one (Anandarjan, 2019; Beil et al., 2019). In this search, the sigmoid function will be used.

Allocation of data: usually samples are divided into three sets: training (learning), validation, and testing. In this research, through trial and error and based on network performance criteria as well as the ROC curve, 60% of the sample volume of investment plans will be allocated to training, 20% to validation, and 20% to network testing, which this ratio in Other researches (Min and Lee, 2015) can also be seen. Finally, after the network architecture and training, we will test the designed network with several new projects and designs.

Sensitivity analysis: determining the relative importance of variables in a specific model is called (Hunter et al., 2019) and is used to determine the importance of input variables in predicting the output variable (Lee and Hsiung, 2019)

Single layer perceptron:

The first network we examine is the single-layer perceptron, whose structure is as follows:

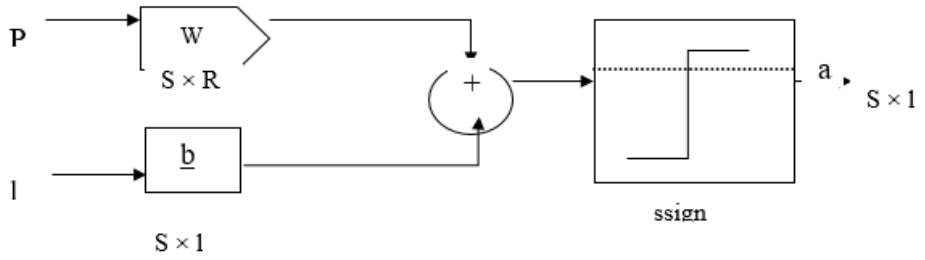


Figure 2.4 Single-layer perceptron neural network structure

Perceptron learning consists of finding correct values for W. Therefore, the hypothesis space H in perceptron learning is the set of all possible true values for the weight vectors. The output of the perceptron is determined by this relationship:

$$y_i = ActivationFunction(\sum_{j=1}^{n} x_i w_{ij})$$

$$\begin{cases} 1 & \text{if } w0 + w1x1 + w2x2 + \ldots + wnxn > 0 \\ & \text{The perceptron is capable of learning} \\ -1 & \text{otherwise} \end{cases}$$

(2)

A perceptron can only learn linearly separable functions. Such examples are those that can be completely isolated by a hyperplane.

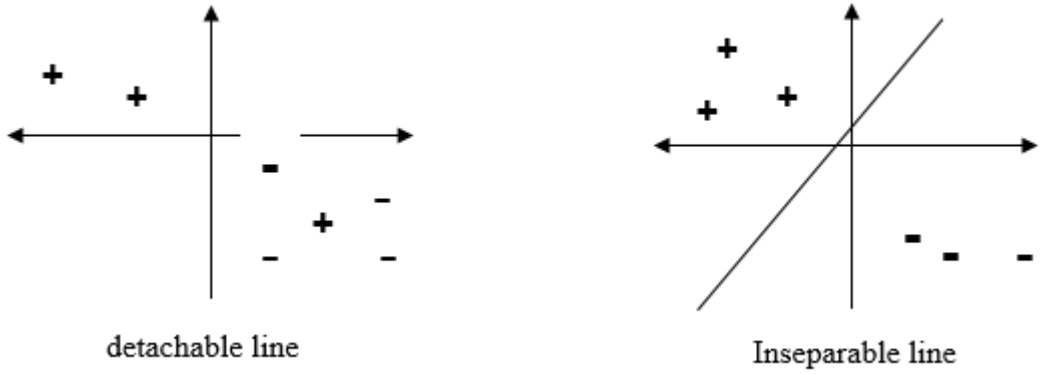


Figure 2.5An example of a separable and inseparable line diagram of a perceptron

Boolean and perceptron functions:

The perceptron is capable of displaying a number of string functions, e.g. NOR, NAND, OR and AND but cannot display the XOR function. A two Boolean level network of perceptrons can represent any function.

Multi-layer networks:

Unlike perceptrons, multilayer networks can be used to learn non-linear problems as well as multiple decision problems.

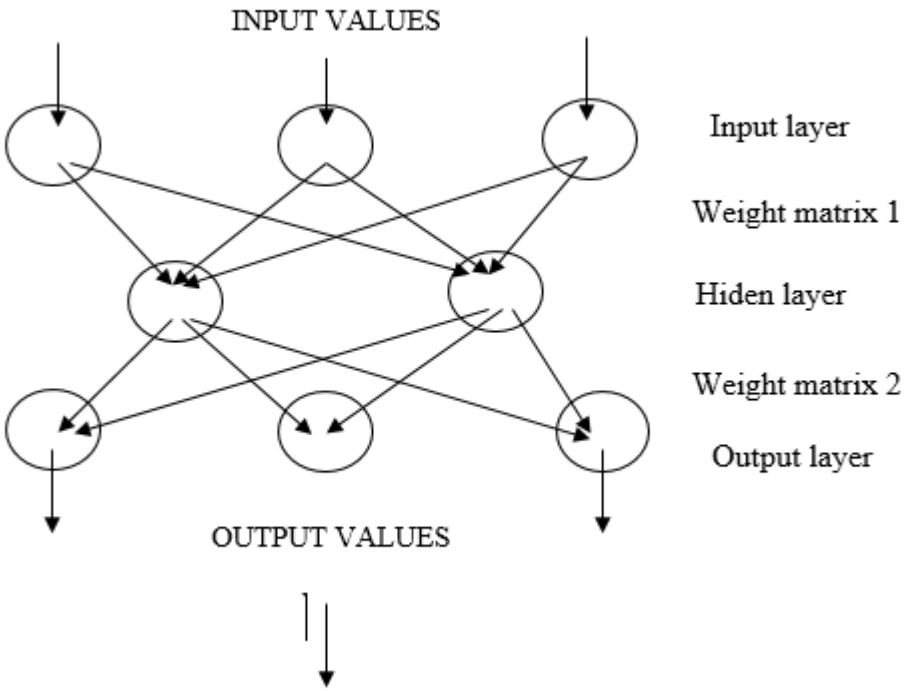


Figure 2.6 Multi-layer networks

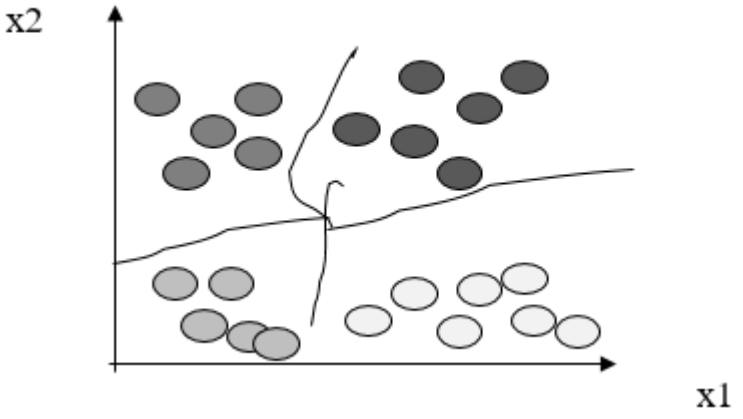


Figure 2.7 A diagram of multilayer networks

Example of a single cell:

To be able to separate the decision space non-linearly, it is necessary to define each unit cell as a non-linear function. An example of such a cell can be a Sigmund unit:

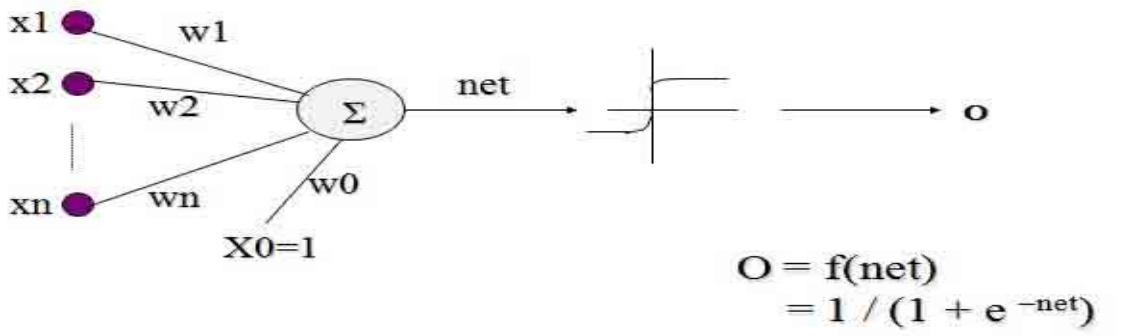


Figure 2.8 A Sigmund unit

2- Hopfield neural network

The Hopfield network has a special architecture that separates it from other networks. This type of network has a layer of input neurons to input neurons and in a way, it can be said that the input neurons are the same as the output neurons.

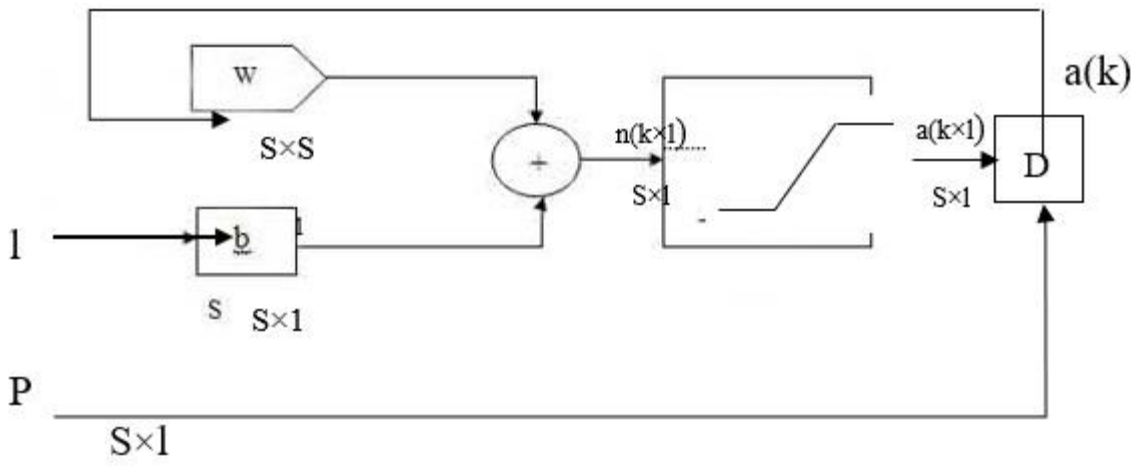


Figure 2.9 Hopfield neural network

Unlike other networks, in the training algorithm, this network does not determine its weights by repetition, but it does this with a special formula, and in the identification algorithm, the

input changes and reaches a certain shape by repetition. In these networks, only one neuron is active, and other neurons are inactive at all times, in other words, because one neuron is receiving input from other neurons, so that neuron changes, and other neurons remain constant. In order to remove noise from images or other models, these types of networks are usually used. (Adel Azar et al., 2014)

3- Hamming neural network

Steinbuch first proposed this network in 1961 and over the last few years it has been revised by researchers such as Lippmann. This network is basically to solve the problem of identifying binary patterns (vector patterns whose elements accept only two values of 1 or -1) designed. Because it consists of a series of neurons as nodes and a series of communication weights between nodes, it is also part of the neural network.

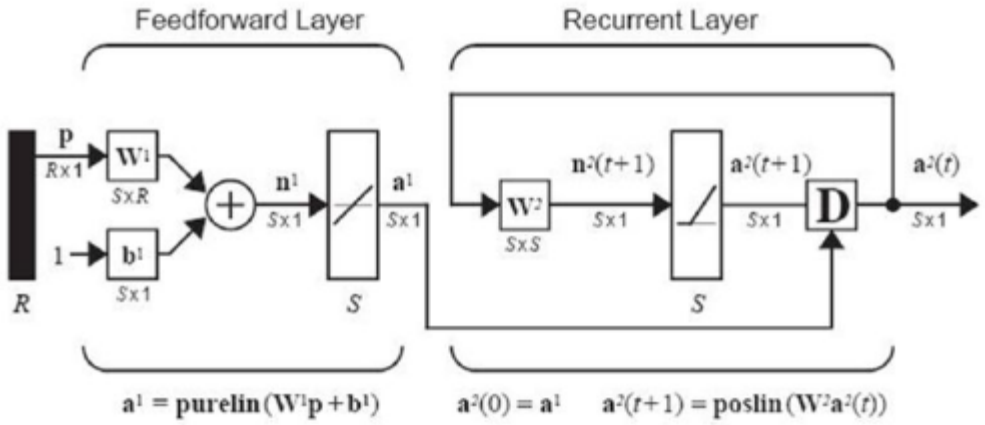


Figure 2.10 Hamming neural network

There's an active surface on every node that produces the neuron's output. Both feedforward and recurrent structures form part of the Hamming network. The goal of a Hamming network is to detect which reference pattern matches the input pattern and display it as outputs. The Hamming network consists of three layers:

Feedforward layer: to calculate the internally multiplication of reference vectors and input vectors, a first feedforward layer representing weight matrix Wt, bias vector or CRL function shall be established. A weight matrix Wt is used to store reference patterns on the network.

Reversal layer WTA: There is a reversible structure in the middle layer of the Hamming network. This structure is the competitive structure, and that's why the middle layer of the Hamming network has also been referred to as a competition layer.

The second subnetwork takes action and considers the values of the output layer of the first layer to be its initial values when the first Hamming layer has calculated the number of reference vectors or network storage capacity. then returns its feedback in each repetition of the inputs decreases and repeats this operation until the outputs in all cells except the winning cell (which indicates the most similarity of the reference pattern with the input vector) become zero. is reached and it is useless to continue repeating in the middle layer, called WTA type operation. At the end of it, there is a competition among neurons in the central layer, one neuron winning and others losing.

The third layer: This layer in the Hamming network is a feedforward layer with a weight matrix of W^3 and a two-dimensional symmetric threshold transformation function. The third layer's task is to display the stored reference vector in the network's output when the second layer converges. Suppose the 2nd layer shows recognition of an apple reference pattern in input, then the 3rd layer takes its vector as input and turns it into a P vector that can be applied to network outputs. (Adel Azar et al., 2014).

4- The self-organizing neural network of ten Kohonen models

This network is one of the most difficult single layer networks by scholars. A network, who’s only known parameter is input neurons, has been designed by Kohonnen. However, unknown parameters need to be identified for the weights and outputs of neurons. Its own organization is the most important feature of this network.

Kohonnen's method is to select a number for the number of output neurons and derive the geometric distance of the pattern from simple logic. The input and output neurons are set in binary values. Reducing the distance from the input pattern is a basis for network activities. The value of the weights is determined by the value of the network, which is not linear. Kohonen's model is an external observer model. In this model, some nerve cells that normally alternate

between each other in the flat topology act as a network of their own and interact with one another. (Adel Azar et al., 2014)

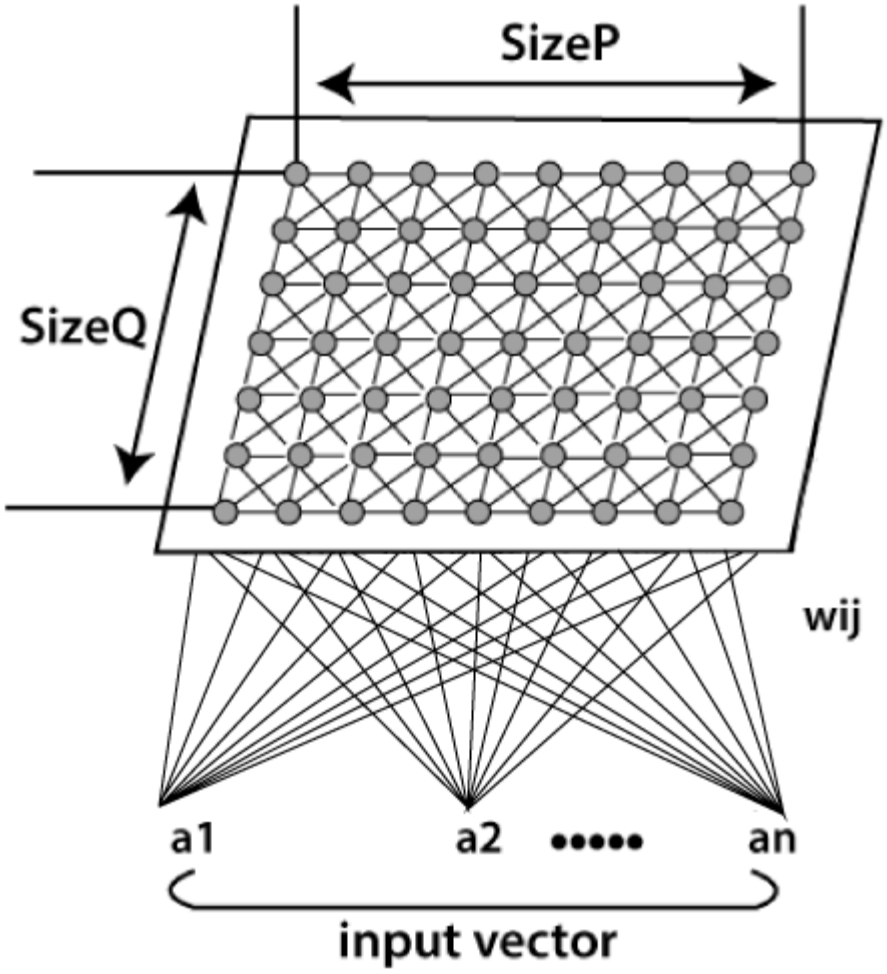


Figure 2.11 The self-organizing neural network of Kohonen's model

5- Time delay neural networks

It is a kind of multilayer neural network that's capable of dealing with an unpredictable type of sample data and input signal. The following characteristics exist in multilayer neuron networks:

1- There are multiple layers and, in each layer, there is enough neural connections to learn the levels of complex nonlinear decisions that can be learned from a network.

2- The temporal changes in the characteristics of the samples have an influence on network behavior.

3- The exact timing of the sample inputs is a sensitive parameter in the network learning method.

The time-delay network (TDN) was first used by Weibel in 1988 and has remained the same until now, consisting of three layers whose weights are coupled with time-delay cells. The driving function of each TDN cell is the sigmoid function and they are weighted per input. In this network, we can see the structure of neurons:

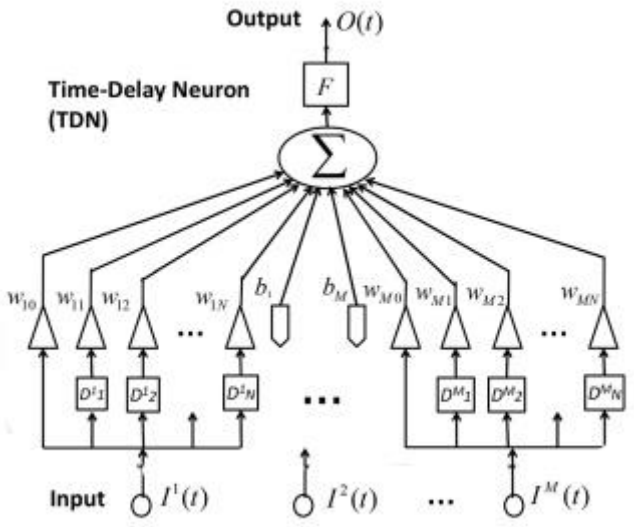


Figure 2.12 Time delay neural network

In the design of the neural network and especially the time delay neural network, the designer is faced with the problem of choosing a suitable network for his design. (Maryam Malekabadi et al.,2018)

A network with the lowest complexity and minimum parameter which is most accurate for determining input patterns should be regarded as an appropriate network. In theory, if a problem can be solved by a network, it can also be solved by a larger hub network. But due to the lack of a single solution for the optimal weights, learning algorithms for larger networks usually result in opposite weights of 0. Therefore, it is faced with difficulties in detecting a network of

smaller size to resolve the problem. If we reduce the number of neurons of the network layers used in a particular problem, the network will not be able to learn because the number of super-pages and, as a result, the super-volumes necessary to divide the input space into different classes will not be enough. On the other hand, due to the increase in the number of calculations, the number of neurons in the hidden layer is not appropriate, which results in a longer network training period. In addition, considering that the training of the network is based on a limited set of training patterns, if the network is too large, it will try to maintain the exact training patterns, and this will reduce the power of generalization and interpolation of the network to detect new external patterns. It's from a collection of educational material. For each particular application, it is therefore necessary to find a crucial number of hidden layers. The number of hidden layer neurons, simulating various networks and measuring the accuracy and correlation between them in patterns that are not part of their training set. In order to solve a specific problem, the number of neurons in the output layer or other words corresponding to the type of coding in the output should be appropriate. The best way to encode the output classes is to use primitive vectors. (Adel Azar et al., 2014)

6-Backward propagation network

Unlike the previous networks, this network consists of several layers, and in addition to the input and output layers, it includes the so-called hidden layer. This network works in a supervisory manner and is not self-organized. One of the prominent features that separate it from other networks is that the input neuron values are continuous, which means that non-binary values can be given as input to the network. This network is one of the most practical networks because it can solve highly nonlinear and monitoring problems. (Adel Azar et al., 2014)

2.5 Classification of neural networks based on the training method

They are divided into four categories based on the teaching method:

1. Fixed weight: there is no training, and the values of the weights are not updated. Application: optimization of information (volume reduction, resolution, and compression) and corresponding memories.

2. Unsupervised training: The weights are adjusted only based on inputs, when comparing network outputs to them and determining their error values, no desired output is being modified. Only the input pattern information is used to update the weight. The aim is to extract the characteristics of input patterns by means of a clustering strategy or categorization and recognition of similarity among groups with similar pattern formation, without outputs or classes corresponding to inputs which are known in advance. The method of best matching is usually used to carry out this learning. In order to receive the correct response for this input in a subsequent encounter, an unsupervised network is changing its weights according to the output received. This results in the network learning how to respond to the input. Basically, the goal is to select the neuron that has the most initial stimulation with the dominant neuron technique. Therefore, in unsupervised networks, finding the dominant neuron is one of the most important tasks.

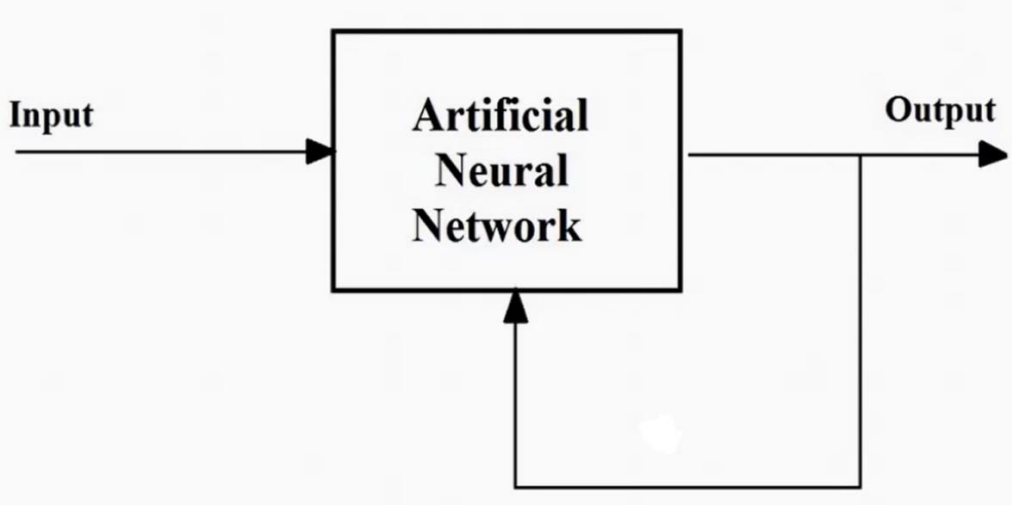


Figure 2.13 Training an unsupervised network

3. Supervised training:

For each category of input patterns, the corresponding outputs are also shown to the network, and the weights are changed until the difference between the output of the network for the training patterns and the desired outputs is within an acceptable error. In these methods, either there is a connection from the outputs to the weights, or the vacuum is distributed as backpropagation from the output layer to the input and the weights are modified. The objective of the design of the network is to train it first, using available training data, and then to recognize its class by providing the input vector to the network that the network may or may not have learned before. (Mohammad Behdad Jamshidi et al., 2018)

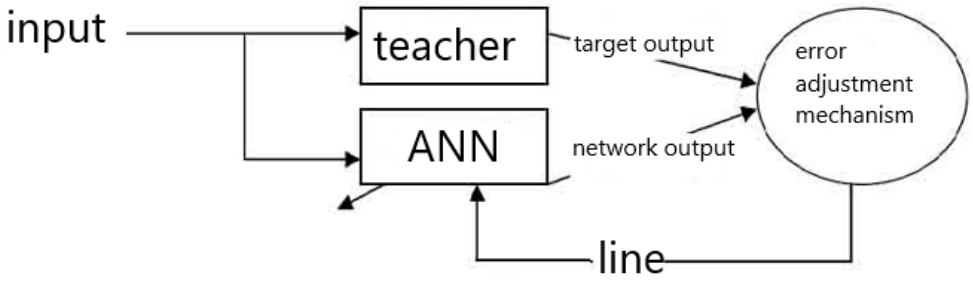


Figure 2.14 Supervised training network

4. Reinforcement training:

The performance quality of the system improves step by step over time. There are no training models, but by using a signal called a critic, an expression of the good or bad behavior of the system is obtained (a state between supervised and unsupervised learning) (Kristjanpoler and Minotello, 2019).

2.6 Network topologies and features

In a quantitative approach to topologies and network structures based on the functions of internal connections of each unit, we can define several concepts:

1- Return networks

2- non-return networks

3- Layered, sequential networks or other similar network structures

4- Interlinked competitive structures

Types 1 and 2 are mutually exclusive; However, types 3 and 4 may use both recursive and non-recursive structures. It deeply examines this issue, which includes creating "layers" and "pieces" and distinguishing symmetrical from asymmetrical internal connections. (Salmanpour and Shekarzadeh, 2018)

2.7 Combination of networks and variable topologies

We already mentioned that the ANN designer must design or select a distinct topology for the network. Recent efforts have indicated that another level of training exists to evaluate (and perhaps combine) multiple topologies for a single application; Although the studies are in the initial stage, this theory is applied to optimal (linear) combinations of networks with trained components. The combination of partial networks provides the total output of the network for a given input by weighting the outputs of the partial networks. Optimization is done on the set of training and inputs. The training algorithm should choose an appropriate emphasis for each component network. Of course, the expansion of nonlinear combinations is also significant.

2.8 ANN learning criteria

The meaning of learning in ANN is to adjust the weights and biases of the network.

• The goal of network training is to reach the conditions where the network can respond correctly to the data presented in the network training (memorization) and also similar and different data from the inputs that were used for network training. (Shahram Saeidi, 2023)

• The main advantage of trained neural networks over classical calculations is that the required results can be obtained with less effort and in less time. As a result, these advantages are very useful and effective, especially for problems that require long calculations.

generally: Perceptron learning is finding correct values for W

Finally, most readers will find a subtle distinction between the concepts of teaching, learning, and understanding, Although the terms used are interchangeable. The concept of training can be based on the application of the information to create or modify the behavior of the current mapping, $\underline{f}_A$, to $\underline{f}_D$. For pattern-matching applications, H can often be used to modify $\underline{f}_D$ by comparing the actual response of an untrained system, denoted by $\underline{r}_a$.

$$\underline{r}_a = \underline{f}_A (s) \quad (3)$$

with the target response or desired response denoted by $\underline{r}_d$,

$$\underline{r}_d = \underline{f}_D (s) \quad (4)$$

"Approaching" $\underline{f}_A$ towards $\underline{f}_D$ is done through training. Of course, a considerable amount of "precision" must be used.

Learning may be based on dereministic methods, such as error backpropagation or Hebbian criteria, or stochastic criteria, such as genetic algorithms or simulated annealing. (Salmanpour and Shekarzadeh, 2018)

2.9 Training in artificial neural networks

A- Training with a teacher

Most neural networks are trained using a pair of sample vectors so that each input vector is assigned a specific output vector. By presenting this set of vectors to the network, the weights are modified based on the network's learning algorithm. This kind of training is called training with a teacher.

The most common learning algorithms with this method are Delta, Adaline, Madaline, Radial Basis Function (RBF), and Backpropagation (BP) networks, which we briefly explain below.

Delta Learning Law: This algorithm, sometimes called least mean square (LMS), is used when the error signal is minimized so that the difference between the actual output of the network and the expected (desired) output is minimal. In this method, the error signal is

propagated backward to correct the weights and biases of the neurons. The post-error propagation algorithm is the most common implementation method of the delta learning law, which is used in at least 75% of artificial neural network applications.

Error Backpropagation Algorithm: This algorithm, which was proposed by Rumelhart and MC Kleland in 1986, is used in feed forward neural networks. It means that the artificial neurons are placed in successive layers and send their output (signal) forward. The term backpropagation also means that the errors are fed back into the network to correct the weights and then the input repeats its forward path to the output.

The error backpropagation method is one of the supervised methods in the sense that the input samples are labeled and the expected output of each of them is known in advance. Therefore, the network output is compared with these ideal outputs and the network error is calculated. In this algorithm, it is first assumed that the weights of the network are chosen randomly. In each step, the output of the network is calculated and according to the amount of its difference from the desired output, the correct weights are set so that this error is minimized. In the error propagation algorithm, the excitation function of each nerve is considered as a weighted sum of the inputs of that nerve. In this way, assuming that w is the corresponding weight between the input layer and the next layer, we can write:

$$A_j(\overline{x},\overline{w}) = \sum_{i=0}^{n} x_i w_{ji} \tag{5}$$

It can be seen that the output of the neural drive function depends only on the input and the corresponding weights. Assuming that the output function is Sigmund, the output of the jth nerve can be written as follows:

$$O_j(\overline{x},\overline{w}) = sgm\left(A_j(\overline{x},\overline{w})\right) = \frac{1}{1+e^{A_j(\overline{x},\overline{w})}} \tag{6}$$

Also, carefully in the above relationship, we find that the output depends only on the value of the excitation function, which in turn is related to the input and weights. Therefore, to change

the output, the weights must change. As stated before, the goal of the education process is to reach a desired or close to the desired outcome. (Sayadi 2017)

B- Education without a teacher

In this type of training, the input vectors to the network are provided without the output vectors related to the network, and the weights of the network are modified in such a way that similar input vectors are grouped. The response of the network will be based on the closest vector to the input vector. Unsupervised learning is also called self-learning. Among the networks using the unsupervised algorithm, we can refer to Hebb, Kohonen, and Hopfield networks.

2.10 The steps of designing a neural network model for classification or prediction (estimation).

1- Knowing the input and output variables

2- Converting the input and output values to the range of zero to one

3- Choosing the appropriate geometry (topology) for the neural network

4- Training with representative training data

5- Network test with independent data from the training set and if necessary, continue training and adjust training examples, network topology, and its parameters. (Zahri and Afshar Kazemi, 2017)

2.11 Advantages of artificial neural networks

Neural networks, with a significant ability to derive meanings from complex or ambiguous data, are used to extract patterns and identify methods that are very complex and difficult for humans and other computer techniques to understand. A trained neural network can be considered an expert in the category of information it is given to analyze. This expert can be used to create new desired situations and answer "what if" questions.

Its other advantages include the following:

Adaptive learning: the ability to learn how to perform tasks based on the information given for practice and preliminary experiences.

Self-organization: An ANN can create its organization or presentation for the information it finds during the learning process.

Real-time performance: ANN calculations can be performed in parallel, and special hardware has been designed and built that can take advantage of this capability.

Fault tolerance without interrupting information encoding: A minor failure of a network results in corresponding performance degradation, although some network capabilities may remain even with major damage.

2.12 Applications of artificial neural networks

Today, the use of intelligent systems, especially artificial neural networks, is so widespread that these tools can be classified as general and common tools in the line of basic mathematical operations. Because few academic fields require analysis, decision-making, estimation, prediction, design, and construction, and in which the subject of neural networks is not used. The following table is not a complete list, but it illustrates to a large extent the extent of the applications of artificial neural networks.

TABLE 2.1

general context	Application
computer science	Classification of documents and information in computer networks and the Internet Development of surveillance software and antiviruses
Technical and engineering sciences	Reverse engineering and systems modeling Prediction of electric load consumption Troubleshooting industrial and technical systems Designing all kinds of control systems Design and optimization of technical and engineering systems Optimal decision-making in engineering projects
Basic science and astronomy	Prediction of test results Evaluating and estimating the validity of hypotheses and theories Modeling complex physical phenomena
Medical sciences	Modeling biomedical processes Diagnosis of diseases according to the results of medical tests and imaging Predicting the results of treatment and surgery Implementation of patient-specific treatment tools and patterns

Experimental and biological sciences	Modeling and prediction of biological and environmental phenomena Prediction of time series with application in bio-environmental sciences Classification of findings resulting from experimental observations Identifying hidden and recurring patterns in nature
Economic and financial sciences	Prediction of stock price and stock market index Classification of signs and symbols of the stock market Risk analysis and assessment Allocation of capital and credit
Social sciences and psychology	Classification and clustering of people and groups Modeling and prediction of individual and social behaviors
Art and literature	Predicting the success and general acceptance of works of art Extracting basic components from literary texts and works of art. Classification and exploration of literary texts
Military Sciences	Targeting and tracking in missile weapons Implementation of defense systems and intelligent defense Predicting the behavior of the attacking force and the enemy Implementation of attacks and defense systems in electronic warfare (jungle)

2.13 Stock market and index

A- The history of the world stock market

In the 15th century, Belgian merchants and money changers gathered in the city of Bourges in front of the house of a man named "Fan der Bourse" (Vander Bourse) and trading. In this way, the name of the activity that later included the organized market in 1460 was taken from the name of that Belgian man.

The first stock exchange in the world was established in the city of Amsterdam by the first multinational company called the Dutch East India Company. Similarly, the Dutch East India Company was the first company to issue shares. The Dutch East India Company had several factors to achieve success: 50,000 civilian employees with a private army consisting of 40 frigates, 30 sailors, and 10,000 crew, and of course the increasing turnover of profits. With a market for its stocks and bonds, it has probably had the strongest economy in the history of the world. The key to the success of this company has actually been the presence of the "public" in its ownership.

Due to the formation of the London Stock Exchange before the 19th century, no formal regulations or membership were observed in the London Stock Exchange until 1801. While the biggest steps of change in the history of the world were taking place, some people still believed that buying and selling stocks is considered immoral and evil.

At the same time as the list of financial instruments was published in a coffee house in London, stockbrokers organized a meeting under a tree on New York's Wall Street to trade stocks. Wall Street was a strong wall in New York that was built by the Dutch for whatever reason. In 1792, 24 stockbrokers signed an agreement that was later replaced by the New York Stock and Exchange Board, which later became the New York Stock Exchange (NYSE).

The "Buttonwood" agreement not only led to the creation of the New York Stock Exchange but was considered undeniable evidence of the development of the United States and its transformation into an economic superpower. It is interesting that Wall Street, along with other

symbols of the United States, i.e., skyscrapers, is considered a symbol of the country's power and money.

Today, the role of stock exchanges in the world economy is undeniable. Perhaps the researchers also never imagined that the work that a company invented 400 years ago would cover the whole world.

B- History of the Iran Stock Exchange

Tehran Stock Exchange was established in February 1967 based on the law approved in May 1966. The activity period of the stock exchange can be divided into four periods: the first period (1967-1978), the second period (1979-1988), the third period (1989-2004), and the fourth period (from 2004 to now). (Reza Ghaffari Gol Afshani et al., 2023)

But the Iranian stock exchange's origins go back to 1936. At the request of the Iranian government this year, a Belgian expert named Ron Luterfeld, together with a Dutch expert, has been studying the establishment of the stock exchange and has prepared a business plan and statutes. In the same year, an expert group within the National Bank examined this issue and produced a complete report on stock market information in 1938.

But the beginning of the Second World War took away the opportunity to continue the activity from the experts. The resumption of studies in this field needed a more suitable opportunity, which was created after the coup d'état on August 19, 1953, and relative peace reigned over Iran for the Chamber of Commerce, the Chamber of Industries and Mines, the Central Bank, and the Ministry of Commerce to spend several years investigating the This market and the conditions of Iran will pay for its formation.

In 1966, they prepared the law and regulations for the formation of the stock exchange and sent the relevant bill to the National Assembly. The aforementioned bill was approved in May 1966, but due to the lack of preparation of the industrial and commercial sector of the Tehran Stock Exchange, it started its activity on the 15th of February 1967 with the entry of the shares of Sanat and Mine Bank as the largest complex of production and economic units at that time.

The first period (1968-1979):

After the entry of Sanat and Mine Bank on February 4th, 1968, Pars Oil Company, government bonds, treasury documents, Industrial Property Development Organization bonds, and Abbas Abad bonds entered the Tehran Stock Exchange. During the 11 years of stock exchange activity before the Islamic revolution in Iran (1968 to 1979), the number of accepted companies, banks, and insurance companies increased from 6 economic enterprises in 1968 to 105 in 1979.

The second period (1979-1988):

The victory of the Islamic revolution and the occurrence of an imposed war in this period was followed by many events and developments. From the point of view of the developments related to the stock exchange, the first event was the approval of the Bank Administration Law on June 7th, 1979 by the Revolutionary Council, according to which 36 commercial and specialized banks of the country within the framework of 9 banks, including 6 commercial banks and 3 specialized integrated and national banks became Sometime later and following that, insurance companies were also merged and became government-owned, and also the approval of the Law on the Protection and Development of Iranian Industries in July 1979 caused a large number of economic enterprises admitted to the stock market to withdraw from it. So their number decreased from 105 companies and economic institutions in 1979 to 56 companies at the end of 1988.

The third period (1988-2004):

According to the country's economic policymakers, the stock exchange activity renewed in 1989, and the number of companies increased from 56 companies in 1988 to 249 companies in 1996. On the other hand, the fluctuating activity of the Tehran Stock Exchange in the years

1990 to 1996, especially the extreme and one-sided fluctuations of the prices in the years 1991, 1994, and 1995, have resulted in significant periodic drops and fluctuations, which result in investors' expectations and uncertainty. The ruler of this market has ended.

1991 was a prosperous year for the capital market. This year, there was a significant increase in the value and volume of market transactions. This growth is due to the supply of shares on a large scale by government organizations, the entry of 29 new companies into the list of companies admitted to the stock exchange, the supply of shares relatively widely across the country through the banking network, and the supply of shares to workers at preferential rates based on temporary approval. Because in 1992, the country's economy suffered relative stagnation.

The main reason for the increase in the volume of transactions was mainly related to the last four months of 1994 and was caused by the lack of stock supply by major government suppliers, the increase in the floating price of foreign currencies, and the escalation of inflation, which caused queues of demand this year.

1995 was the year of the establishment of public investment companies. In this year, 4 new investment companies were established, also a regional development company was established in the form of public shares in Fars province, among other events of 1995 was the increase in investment in the public sector, which had a significant impact on the growth of the stock market.

The stock market situation in 1996 was dual. In the first half of the year, the movement trends of the previous year continued and various indicators of activity in the stock market had an increasing trend. In the second half of the year, the one-way acceleration of price fluctuations in the Tehran Stock Exchange slowed down and the stock price index increased from October to the end of the year. It decreased by 9.6 percent that year.

In 1997, the organization of the notification situation has been considered one of the most important measures to restore the normal functions of the Tehran Stock Exchange. In this regard, to provide easy and quick access to various users to correct, accurate, and timely

statistical information, the quantity and quality of the information provided in the framework of periodical statistical publications of the stock exchange were reviewed and improved.

The rapid improvement of the indices, the increase in the value of transactions, the increase in the volume of stock trading, the rapid growth of prices, the daily presence of a large number of shareholders in the stock market, the increase in the number of buyers and other developments were indicative of the growth and development of the Iranian capital market. The increasing growth of the stock market showed the important position of this institution in the promotion and development of the national economy in the coming years.

The growth of the Tehran Stock Exchange continued in 1999. And this growth in 2000 caused a brilliant year in the case of the Tehran Stock Exchange. This year, the return of the stock market reached 59.86%, which was very noteworthy compared to other investment opportunities and 12.6% inflation this year. In 2001, the stock market also followed a growing trend.

2002 was a turbulent year for the stock market. The total index of the stock market increased until September of this year. This year, the behavior of investors has gradually changed and although the expectation of a relative decrease in the share price of companies due to the distribution of profits was expected in normal meetings, in practice the market faced a different behavior that was seemingly contradictory to the learned and common methods of the behavior of investors.

2003 was the year of new records in the Tehran Stock Exchange. This year, all the major indicators of the activity have reached the new quorum, which has been unprecedented since the beginning of the activity of the Tehran Stock Exchange.

The activity of the Tehran Stock Exchange during 2004 can be analyzed in two distinct sectors: prosperity and relative stagnation of the market. The performance of the Tehran Stock Exchange in the first half of the year, despite two significant drops in May and August, was still affected by the movement trends of the previous year, and the various indicators of the stock exchange activity had an increasing trend so that the trading volume and the stock price

index in this period reached its highest level in all the years of the stock exchange. In the same year, the Iranian Agricultural Commodity Exchange Brokers Organization was established.

The fourth period (from 2005 to now):

In 2005, the various indicators of the stock exchange activity, continuing the trend of the second half of 2004, were still under the influence of various domestic and foreign events and the excessive increase of the indices in the previous years, and this trend, except for a short period in December until the end of the year was remarkable. Since December 2005, the policies and efforts of the government and the stock exchange organization have slowed down the downward trend of the stock exchange activity criteria, in such a way that the approval of the securities market law, the change in the internal policies of the stock exchange organization and the prediction of the liberalization of the price of cement due to the entry of this product into the metal exchange, have caused The price index increased by 6.6 percent in December 2005 compared to the previous month.

The significant decrease in stock transactions in 2005, due to the aforementioned effective measures, reached a relative balance in 2006. The number of companies admitted to the stock exchange increased from 422 companies at the end of 2004 to 435 companies at the end of 2006. (Iran Stock Exchange website)

Among the main events of this period are:

1- Approval of the Securities Market Law of the Islamic Republic of Iran (1/9/84)

2- Formation of the Supreme Council of the Stock Exchange and Securities

3- Formation of the stock exchange and securities organization

4- Establishment of the Tehran Stock Exchange (public company)

5- Establishment of the central securities depository and funds settlement company

In 2007, the stock market followed a relatively growing trend. Perhaps one of the reasons for this can be the transfer of state-owned companies to the stock market. In the same year, the agricultural, metal, and oil derivatives exchanges were merged in the form of commodity exchange to increase the efficiency of the market. This trend was followed in 2008 as well and caused a high total index for the stock market. This year, 5% of telecommunication shares entered the stock market. In this year, the number of listed companies reached 445 companies with the entry of Kurdistan Cement Company in October 2008.

One of the most important criteria for evaluating the performance of investing in the stock market and even non-financial investments is the stock market indices and especially the total index.

2.13.1 Total Index of Tehran Stock Exchange and its calculation method

With the restart of the Tehran Stock Exchange in 1989, the need to calculate the stock price index was placed on the agenda of the Tehran Stock Exchange Organization, and the stock price index in the stock exchange has been known internationally since the first of 1970 with the name TEPIX. The abbreviation TEPIX is a result of the TEHRAN PRICE INDEX. Following this, the traded shares actually started in the second half of 1989. From the beginning of 1992, the decision was made to calculate the index of the Tehran Stock Exchange from the beginning of 1990 based on the average weighting base price of the formula, from the number of traded shares to the number of issued shares by the companies admitted to the stock exchange, the general formula for preparing the index was changed The weighted average in Tehran Stock Exchange, like other stock exchanges in the world, is based on Laspierre's formula, which is summarized as:

The current value of the issued shares of accepted companies divided by the basic value of the issued shares of accepted companies multiplied by 100

In general, the variable of the total index of the stock market indicates the general situation of the stock market, in advanced economies, the increase of this index means economic prosperity and its decrease indicates stagnation. To calculate the stock price index, we must

have the latest information on stock price changes and their trading volume. The basis of calculation is the base year. This index shows that the total value of the market has multiplied compared to the base year. Supposedly, the index of 12700 shows that the market value has increased 127 times compared to year x, which is the base year.

There is no complete correlation between the increase in the price of ordinary shares of companies and the general price index. The percentage change in the price of common stocks is usually more than the percentage change in the general price level index. Along with inflation and rising interest rates, the rate of return expected by the shareholders increases and as a result, the price of ordinary shares decreases. In evaluating the investor's environment, several factors must be considered; For example: the phenomenon of inflation, interest rate, return risk, and commercial risk. Factors such as the stability of retail and wholesale prices and the stability of interest rates increase the value of shares in the market, on the contrary, inflation, instability of profits, and increase in interest rates are considered unfavorable factors and cause a decrease in the price of shares (Jahankhani, 2016).

2.13.2 The Concept of the stock index

An index is a statistical measure that shows the change in the movement and direction of an economy or a stock market. Each index has a specific calculation methodology that is usually expressed in terms of change from a base value. For example, the total index of the Tehran Stock Exchange is calculated based on the Laspierres formula with quantitative adjustment and based on the value of 100.

What cannot be obtained through general, industry and financial indicators include the following:

A) The indices do not show the reasons for the price movements.

B) The index is not a benchmark for measuring investors' portfolio performance.

C) The index lacks comparability in the long term.

D) The smaller the indices are in the relevant industries and classes, the more useful they are in investment decisions.

In each stock market, many indicators can be defined and calculated according to the need and efficiency. Many indexes are calculated for different groups and companies in all stock markets of the world.

For example, in the American stock market, the Dow Jones index (DOW & JONES) shows the changes in 30 industrial companies, 20 transportation companies, and 15 service companies, and the NASDAQ index (NASDAQ) shows the changes in off-exchange stocks. Other famous indices of some of the stock markets in the world include the New York Stock Exchange S&P250 which is calculated for 250 companies and the S&P500 which is calculated for 500 companies. The London Stock Exchange is FTSE, Tokyo NIKIIE and TOPIX, Amsterdam AEX, France CAC, and Germany DAX.

In the Tehran Stock Exchange, many indicators are calculated that each person or group uses according to their needs.

A: The following indices are calculated in the Tehran Stock Exchange:

Total price index, industry index, fifty most active companies index, price and cash yield index, and cash yield index

Total price index:

The total price index in Tehran Stock Exchange is calculated for three groups, which are:

- Total market price index: In its calculation, the share price of all traded companies is affected.

- The price index of the main board: in its calculation, only the stock prices of the companies traded in the main board are affected

- Sub-board price index: In its calculation, only the stock prices of companies traded in the sub-board are affected.

Total price index adjustments:

Normally, the following causes the index base to be adjusted:

1- Increasing the capital of companies from cash income

2- Increasing the number of companies included in the index

3- Reducing the number of companies included in the index

4- Decomposition of companies

5- Merger of companies

6- Payment of cash interest (only to adjust the basis of the total income index)

Total price index formula:

$$TEDPIX_t = \frac{\sum_{i=1}^{n} p_{it} q_{it}}{RD_t} \times 100 \qquad (7)$$

so that:

p: represents the price of the i-th company at time t

q: represents the number of issued shares of the i-th company at time t

RD: the basic indicator of the price index and cash yield

Suppose that the whole market from 2019 until now consists of only three stocks A, B, and C. The stock information for that year is as follows.

Share A: 1000 shares each worth 1000 Rials

Share B: 2000 shares each worth 3000 Rials

Share C: 2000 shares each worth 2000 Rials

As a result, the current value of the market in 2020 will be equal in our example

(1000×1000) +(2000×3000) +(2000×2000)=1000000+6000000+4000000=

11000000

Therefore, the current value of the market in 2020 was equal to 11 million rials, and according to the index formula, the index figure for that year is 100 units. Now suppose that in 1991 the stock price of A is 2000 Rials; B shares should increase to 2,750 Rials and P shares should increase to 2,500 Rials. Therefore, the current value of the stock market in 2021 will be:

(1000×2000) +(2000×2750) +(2000×2500) =2000000+5500000+5000000=

12500000

Therefore, as you can see in the above calculations, the current value of the stock market in our example has increased to 2500000 in the year 2021. Now, if we calculate the total price index, we see a 14% growth in the total price index.

(12500000/11000000) ×100=114

As you can see above, the total index has increased by about 14 points compared to 2020, which shows a 14% growth in the stock market index.

B: Important points regarding the total price index:

- In this index, it is adjusted when the companies bring in cash and the demands of the shareholders increase the capital, or the number of companies increases or decreases, which is avoided due to the complexity of the calculations.

- When a share is for various reasons such as clarification; Holding a normal or extraordinary general assembly, the closing price of the last trading day is considered as the price basis of that share in the index.

- Since the total index is affected by the number of shares of different companies, and therefore larger companies cause larger changes in the stock market index, it should not be based solely on the changes of this index, and to analyze and evaluate the overall market situation, other indices should also be used. One of the common occurrences in the market is that the overall market is bearish, but because three to five large market shares have had a heavy rise, the total index registers significant growth.

- The stock exchange and securities organization divides the shares accepted in the stock market based on liquidity, share float percentage, profitability status, number of shares, etc. in the first and second markets. The total price index for the shares accepted in each of these markets is calculated separately and it is referred to as the index of the first market and the second market.

Total balance index:

The method of calculating the equal-weight total index is similar to the total price index, with the difference that the number of shares of the company is used in calculating the index. In fact, in this index, regardless of the size of the companies, they will have the same effect, while in the price index, the total number of shares of a company as the price weight has an important effect in the calculations. Considering the above explanations, we will calculate the equal weight index again.

The year 2020:

Share A:1000

Share B:3000

Share C:2000

Equal weight index in 2020:

((1000 + 3000 + 2000) / (1000 + 3000 + 2000)) ×100 = 100

The year 2021:

Share A:2000

Share B:2750

Share C:2500

Equal weight index in 2021:

((2000 + 2750 + 2500) / (1000 + 3000 + 2000)) ×100 = 121

As you can see, the equal weight index shows a more significant growth than the total price index in the normal state. (Abde Tabrizi, 2015)

C: simultaneous important interpretations of the total price index and the total equal weight index:

In the stock market, simultaneous interpretations of the total price index and equal weight index are very common.

- When the overall index is rising but the weighted index is falling, it means that most of the market shares have declined, while the overall index has become positive due to the growth of several important index-making stocks.

- When the overall index is down and the weighted index is up, it means that the index-making and large market stocks have declined for various reasons, and as a result, the overall

index has decreased, but the general market stocks have experienced a price increase. If this situation happens within two to four working days, it means that investors should lean towards small and medium stocks to earn profit.

If both indicators fall together, the issue happens for several days in a row, and depending on the conditions governing the market, the interpretation may be created that the market is moving towards stagnation.

If both indices rise, then the stock market shares will rise, and the occurrence of this situation within a few days can determine whether the market will be bullish in the coming days or months.

D: What are the price index and cash yield?

This index only calculates the yield resulting from the profit approved by the assemblies, which is known as cash profit, and from this point of view, it calculates the yield resulting from all the profits paid by stock companies. The important thing is that when this index goes down, it means that less interest will be paid in the meetings, and these situations, we should not expect too much cash profit and we should modify our expectations or our trading style.

E: Industry index and financial index

Before we want to tell you about these two indicators, it is necessary to point out that companies can be divided based on the nature of their activities. Production and service companies include the two main categories of listed companies. More than 60% of the active companies in the stock market are manufacturing companies. Also, financial consulting and capital-providing companies are considered financial services. The companies in the first category are divided into the industry index and the companies in the second category are divided into the financial index. For example, Zagros Petrochemical Company and Fanavaran Petrochemical Company, which are involved in methanol production, are classified in the industry index, and Navin Capital Funding Company and Lotus Parsian Funding Company are divided in the financial index. It should be noted that the method of calculating both indices is based on the weighted average of active companies in that index they are calculated similarly

to the total price index and their difference with the said index is the number of companies present in that industry. (Abdo Tabrizi, 2014).

F: free-floating stock index (TEFIX)

Generally, some law firms are the main and major owners of joint stock companies. When a company or legal or natural person owns a high percentage of a company's shares, it is known as the main shareholder of that company, and the shares owned by them are usually not considered among the shares that are actively traded in the market. Share float refers to the percentage of a company's shares that are held by retail investors (mostly real) and can be resold in the near future, and shares are not purchased to maintain or increase control and influence in the company. The float percentage of a share is displayed on the website of the stock exchange. The free float index calculates the changes in that portion of a company's stock that is traded by retail investors. The method of calculation is similar to the total price index, and the difference with that index is the number of shares that are included as the price coefficient. (Abdah Tabrizi, 2014)

G: Top 50 companies index

Every three months, the stock exchange organization presents the list of the top 50 stock exchange companies that have the highest degree of liquidity. The top 50 companies index presents the weighted average of these 50 companies. Therefore, the method of calculating this index is similar to the total price index, with the difference that the number of companies included in this index is only 50 companies, while more than 100 companies are included in the total index.

2.14 Glimpses at the volatility of stock prices in the capital markets

In semi-strong efficient capital markets, stock prices reflect all information that is published and available to the public. (Such as the financial statements of companies, the status of competitors, the economic conditions of the country, etc.) in such markets, stock prices react to new relevant information, and price changes will be proportional to the received information. But in some markets, procedures have been established to control stock price changes and are

used by stock exchange officials, which are called automatic stops (preventing transactions from being carried out automatically in necessary conditions). This type of stock price control makes the stock price does not reflect the published information and the market becomes inefficient.

According to the market efficiency hypothesis, any artificial interruption prevents the stock price and intrinsic value from quickly matching. Therefore, the existence of automatic stops can prevent the change of stock prices based on new information and cause problems in market efficiency. (Abde Tabrizi, 2014)

In markets where automatic stops are used, the share price is affected to some extent by the latest information available in the market. But the main question is how much the stock price is influenced by new information and does the stock price always react correctly and logically to new information.

In financial markets, experience has shown that the volatility of stock prices is not always in the best possible way and response to real information, because:

- First: In some cases, the market does not react properly to new information and overreacts. In other words, compared to a piece of positive news, the stock price increases a lot or suddenly decreases with the publication of negative news, without measuring the real impact of the new news on the mentioned stocks.

- Second: There is a possibility that the new information published in the market is incorrect or that it is accompanied by misleading rumors. Therefore, there is always the possibility of incorrect and illogical reactions to this type of information. Of course, this issue is not the same in different financial markets and it is different according to the ability to trust news sources and the level of financial analysis in each market. If in a market:

- There should be diverse and reliable news sources.

- Information should be published transparently.

- Many financial analysts, market makers, and market specialists process information.

Then the possibility of irrational fluctuations in the stock price and overreaction will be reduced. But since all the above factors are not fully present in emerging markets, it is tried to fill the existing vacuum by applying certain procedures. One of the most famous of these procedures is automatic stops. Automatic stops How stock market officials deal with irrational stock price fluctuations in developed markets, as well as emerging markets around the world, has attracted a lot of attention.

Especially, after the financial crisis of October 19, 1987, this issue has been raised more extremely. In organized financial markets, to deal with irrational changes in stock prices, generally, procedures have been considered that in case of large (severe) changes in Stock, prices are implemented and automatically stop the flow of transactions.

Automatic stops are generally used to protect investors against sudden changes in the price of securities and emergencies. Two of the most popular types of automatic stops are "price swing limits" and "trading stops".

In the 1990s, automatic stops attracted the attention of many financial researchers, and the tendency to create limits against large price changes to prevent financial crises increased. All the research conducted in the field of automatic stops emphasizes the point that irrational fluctuations in stock prices cause ambiguity in the optimal allocation of resources. This uncertainty can increase the expected rate of return of investors in holding stocks, which increase the expected rate of return will mean an increase in the capital cost of companies and a decrease in the number of investment funds.

Against these problems and concerns, some other financial researchers have proposed the use of automatic stops as mechanisms to reduce or control stock price fluctuations and ultimately protect the market system. Automakers were concerned that the existence of automatic stops (in conditions of uncertainty) provides a timely opportunity for information to be fully disseminated and for all market participants to obtain the same information about the transaction being made. Thus, the price offers to the buyer and the seller will be very close to the equilibrium prices and it is expected that the transactions will be done more fairly. In the financial markets, automatic stops are used in two main ways, which are:

A) Suspension of trading: Preventing the trading of a security at a certain time under necessary conditions or based on the opinion of market officials.

B) The maximum allowed price change or stock price volatility limit: determining the ceiling and floor of the trading price for a security sheet in one day. Among them, the most common and perhaps the most basic type of automatic stop is the stock price volatility limit, which is more common in newly emerging securities markets. And it is used in futures markets (Lee, 2019).

2.15 The Background of internal research

The classification of research history based on content and date is as follows.

Predicting the bankruptcy of a manufacturing company using artificial neural networks (case study: manufacturing companies in Kerman province) Dr. Seyed Nizamuddin Makian and Salim Karimi Teklo, (2009) research to predict bankruptcy, the neural network model used two methods They compared logistic regression statistics and audit analysis and in addition to introducing neural network models, they designed a neural network model to predict the bankruptcy of manufacturing companies. The information used is related to Kerman province from 1995 to 2007. In this research, they used the ratios of current assets to current liabilities, profit before interest and tax to total assets, equity to debt, working capital to assets, profit before interest, and sales tax. The results of their research showed that the designed neural network model is more accurate in prediction than the other two statistical methods.

Tavakoli et al. (2011) in an article stated that forecasting is the process of creating a picture of the future situation using existing data. The prediction of time series, especially in financial management, has been of interest for more than a decade. The artificial neural network is a flexible learning method for predicting time series. It is possible to predict the stock price by discovering behavioral patterns that generate the stock price. In this research, an innovative model based on artificial neural networks has been developed to predict stock price behavior. This combined model has a two-tier structure: first-tier neural networks or basic independent predictors are responsible for daily forecasting of stock prices, trading volume, and price changes. On the second floor, another network as a combiner performs the final prediction using

the outputs of the first-floor predictors. For this purpose, three types of market data from the Tehran Stock Exchange, which are reported daily, have been used. One of the objectives of the research is to use different data from the stock market to obtain better results in forecasting. The experimental results of the research show that the proposed model has high accuracy and is suitable for stock price prediction.

Mohammad Reza Asghari oskoi (2012) in research has concluded that: in many complexes and especially non-linear systems that are modeled and following that, predicting and controlling them through classical and analytical methods is very difficult and even sometimes impossible, non-classical methods are used which have features such as intelligence, based on knowledge and expertise. Neural networks are one of these novels and evolving methods that have been used in various topics such as pattern making, pattern recognition, clustering, and prediction and have had useful results. In this article, we have used neural networks in predicting time series of economic data. In this regard, various structural factors, different learning methods of neural networks, and the appropriate selection and application of data in the forecasting process have been evaluated and investigated.

Pourtahari et al. (2012) presented a model for determining the success of agricultural investment projects: the application of a perceptron multilayer neural network. Based on the results obtained from the network test data, the presented model has more power to predict and classify unsuccessful samples compared to successful samples (79.2% vs. 75%). Also, in this research, to evaluate the applicability of the network, 31 new samples were presented offline to the network. The result shows that the presented model can classify 64.5% of the samples correctly. With the designed model, the probability of failure or success of each of the new plans and projects can be estimated based on predicting variables, and thus it can be used with the knowledge and expertise of the decision-makers and the trustees of rural development and Agriculture, and the managers of financial and credit institutions were used as a suitable tool for choosing optimal projects and plans for investment and providing facilities to them. Different stages of training, testing, validation, and network application or so-called network simulation have been done using MATLAB software.

Khaki Sediq Ali et al. (2012) in an article used time series information on stock prices and returns of several companies in the Tehran Stock Exchange. Bini share price and how to provide the optimal payment model. The forecasting methods used in the research are divided into three categories: forecasting methods based on linear models (short-term and long-term), forecasting methods based on nonlinear models (non-linear neural networks), and neural network models with a proposed structure. In each case, the obtained results are drawn. Using the mentioned predictions, it is shown that the stock price and return (in all 6 shares related to different industries) are created from complex nonlinear and chaotic mappings, and basically, it is not correct to use different types of linear methods. It is also shown that the use of non-degenerate methods of neural networks by itself and in a conventional way does not lead to significant improvement. By presenting the proposal of the new structure, it is possible to estimate the price and yield well in the two modes of forecasting the next day and forecasting thirty days later.

Kamijani et al. (2015) have studied the use of neural network models in predicting the economic bankruptcy of stock market companies. According to the research results, the main structure of three- and four-layer perceptron for predicting bankruptcy of companies leads to similar models, in which the three-layer network has more predictive power than the four-layer network. This research shows that "the use of models based on the neural network increases the ability of financial management to deal with economic fluctuations and bankruptcy compared to competing models". Forecasting the economic bankruptcy of stock market companies in 2016 and 2017 and charting the process of bankruptcy of these companies in the period of 1990-2007 is another part of this article. The results show that in 2016, under the influence of transparency policies, the process of economic bankruptcy of companies will increase significantly, and this trend will be partially adjusted in 2017 as companies adapt to new conditions.

Jeong et al. (2021) in research combined an artificial neural network with a collective model and genetic algorithm. To predict the bankruptcy of these companies, they used this combined algorithm and collective models to determine the input variables. In this model, they used the

ratio of cost of goods sold, current liabilities to total assets, interest cost to sales, and current liabilities to total assets to predict the bankruptcy of companies. Comparison of this algorithm with a decision tree, decision models, collective Heli model, multivariate analysis, and various linear models showed the superiority of the combined algorithm.

Lopez and Pastor (2019) researched predicting the bankruptcy of the United States of America banks in the period from 2000 to 2018 and considering the characteristics of the recent American bank crisis. In their research, they combined multi-layer perceptron with self-organizing maps and presented a model for predicting bankruptcy in the short, medium, and long term. In this research, they used 32 financial variables, which after forecasting the factors are clustered into three groups. The first group of variables has high predictive power, the second group of variables reduces predictive power, and the third group of variables increases predictive power. Finally, it was concluded that the main reason for the bankruptcy of banks was their focus on real estate loans.

2.16 conceptual models of Research

2.16.1 Conceptual Model of artificial neural network

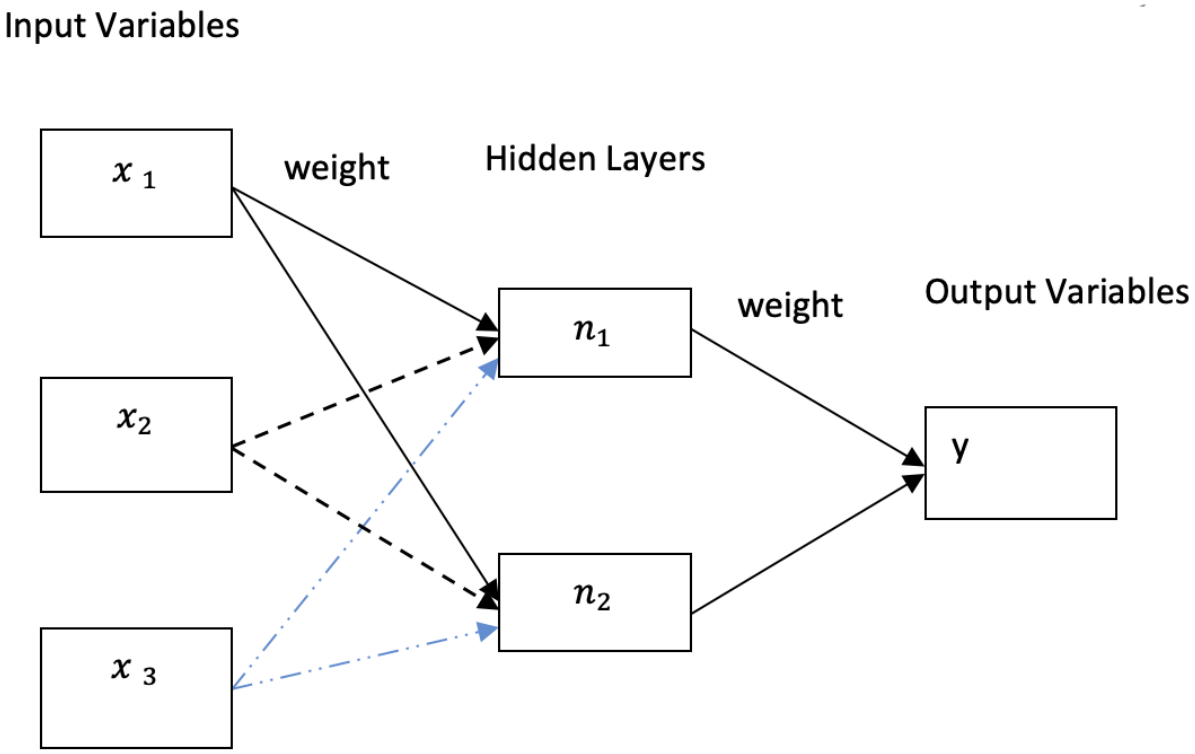


Figure 2.15 Research conceptual model for artificial neural network (Kristjanpoller and Minutolo, 2015)

2.16.2 Research conceptual model for artificial neural network

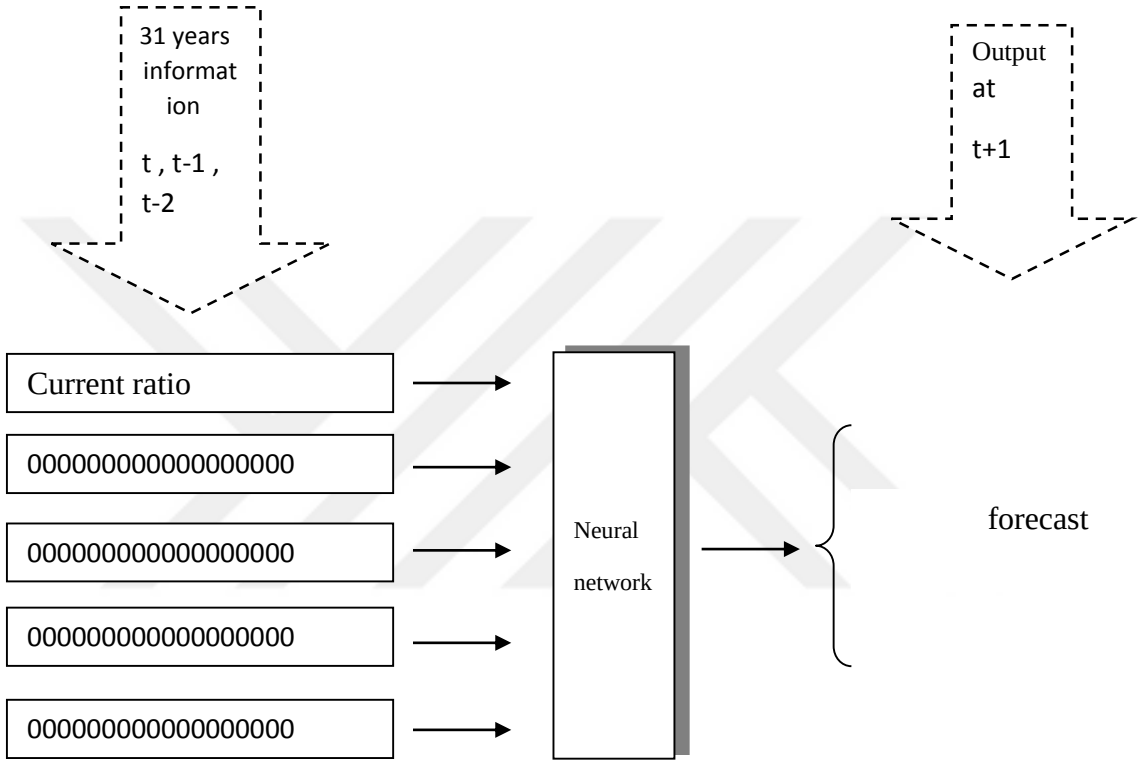


Figure 2.16 Using the information of thirty years ago and entering it into the network for prediction

2.17 Summary

At the beginning of this chapter, we examined the concepts and theoretical foundations of neural networks and their forecasting methods, and we also got acquainted with the basic concepts of the stock market and its evaluation indices. At the end of the chapter, we examined the records of domestic and foreign research, and finally, conceptual research models were presented.

3. Data and Methodology

3.1 Introduction

In this chapter, the structure of the research method is explained. First, the research method, information gathering method and tool, statistical scope and sampling method and sample size, the main significance of the research, etc. are stated, and then the research objectives, and the method of preparing and analyzing the network model and network to predict the series Time has been paid.

3.2 Research Methodology

The research method is a category that neglecting it may produce results other than the actual results of the research. The choice of research method depends on the nature of the research topic and its implementation possibilities. Therefore, it is possible to decide on the method of investigating and conducting research when the nature, subject of the research, goals, and scope are clear, and in other words, the purpose of choosing the research method is for the researcher to determine what method to start. Help him find the answer or answers he is looking to the research questions as accurately, easily, and quickly as possible.

This research is exploratory and practical in terms of its purpose, and according to the nature, goals, number, and type of variables in the current research, the research method of the current research is descriptive based on the survey, because the researcher's goal in conducting this research is to describe the prediction of the total index. It is the stock of the stock exchange and in terms of the investigation method, it is analytical-mathematical, in terms of statistics, it is modeling and in terms of the method of data collection, it is of the type of experimental research based on the analysis of information collected from the desired statistical population.

3.3 Methods and tools of data collection

The method of data collection in this research is to cover the discussion of research theory, specialized and general books, specialized articles and publications, and for data collection, from the documents of the past 30 years (from 1990 to 2020) available in the Central Bank and Statistics Center of the Islamic Republic of Iran is used.

In short, in this research, the following methods are used to collect information:

Library studies: literature and the basis of research opinion will be obtained by studying books, domestic and foreign publications, and topics related to marketing based on strategic cooperation and extracting related articles from scientific sites.

Documents: In the above research, the important and influential quantitative and numerical components, indicators, and limitations are obtained through the documents and documents available in the Iranian Statistics Center and the desired central bank.

3.4 Statistical population and sampling method and sample size

A statistical population is a set of individuals or units that have at least one common trait. Usually, in any research, the population under study is the statistical population that the researcher wants to study about the variable characteristics of its units.

To achieve the objectives of the research, we must first define the society from which we intend to select the study sample. This definition must be clear enough that there is no question about the generalizability or application of the results to any member of the society should not be mentioned.

The statistical population and statistical sample in this research are the statistical data (time series) related to the stock index of the Tehran Stock Exchange, during the last 30 years (from 1990 to 2020), available in the Statistics Center and the Central Bank of the Islamic Republic of Iran.

3.5 Data analysis method

To analyze the data and information in the documents, descriptive statistics of data are used.

Then the research findings based on the technique of neural networks and artificial intelligence according to the presented model (for prediction) and the Dickey-Fuller test (to compare its linear results with the nonlinear results of the neural network) and Student's t-test and correlation (to test hypotheses) The use and general analysis of the data of this research has been done using descriptive statistics and inferential statistics using MATLAB and SPSS software.

3.6 Multilayer perceptron or MLP artificial neural network algorithm for stock index prediction

Artificial neural networks are an abstract of the computational model of the human brain. The human brain has10^{11} small units called neurons, which relate to10^{15} communication links. Like the human brain, artificial neural networks are composed of small computing units called nodes. Each node accepts input variables and processes them and then produces an output and makes it available to other processor elements for use. Artificial neural networks consist of different layers. They can have a different number of layers, which necessarily consist of three input, intermediate (hidden), and output layers. The number of intermediate layers in the network can be changed. Each layer in the neural network consists of nodes. The nodes of the input layer represent the used input variables and the nodes of the output layer represent the output variables (target variables). The nodes of each layer relate to all the nodes of the next layer. In other words, each node of the input layer relates to all the nodes of the middle layer, and each node of the middle layer is connected with all the nodes of the next layer. Each connection between nodes has a weight (w_{ij}). In the first round of network training, the weights between the nodes are randomly determined in the range of zero to one. The technique of artificial neural networks is referred to as a supervised learning technique. This technique needs a training data set to learn to build the model. (Shiri, 2015)

For example, in the field of bank loans, to approve a loan, the personal information of the applicant and his economic information are used as input variables, and decisions related to loan approval are used as output variables of the network. In the network creation process, the main goal is to reduce the size of the errors between the actual output and the expected output. (Arab Mazar and Akbari 2010)

In general, the activity starts with the entry of variables x_1 tox_n and each of the input variables is multiplied by its weight, w_1 to w_n. The sum of this set is called the network value:

$$NET_i = X_0 \times W_0 + X_1 \times W_1 + X_2 \times W_2 + \cdots + X_n \times W_n = \Sigma X_i \times W_{ij}$$

Then the Sigmund function is used as the transfer function Y = F (NET_i)

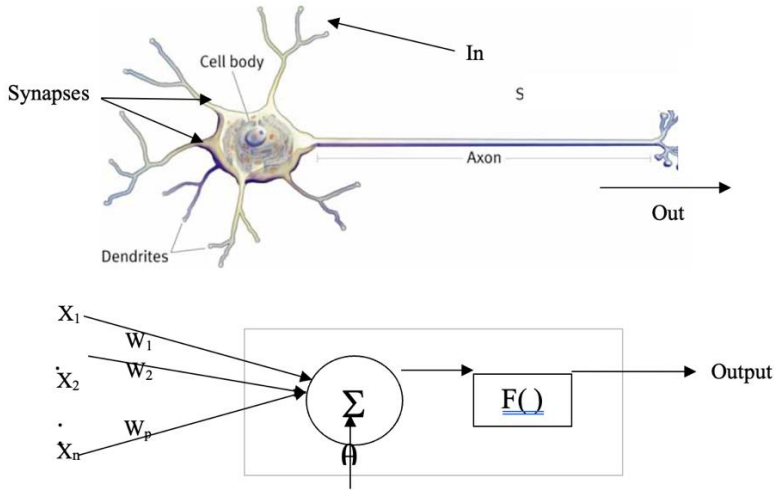


Figure 3.17 The structure of a neuron and sigmoid function (Behzad Shiri, 2015)

In building an artificial neural network model, specifying the network topology (determining the number of network layers and nodes and most importantly the number of hidden layers and hidden nodes) is of great importance. Because these nodes and hidden layers allow the network to discover and identify the characteristics of the data and thereby establish complex non-linear mappings between the input and output variables. Most researchers have used the trial-and-error method to determine the network topology. (Khajavi and Amiri, 2013)

Of course, in this context, a series of rules of thumb such as $\frac{n}{2}$, n, n+1 and n+2 nodes (n represents the number of nodes in the input layer), but to increase the accuracy of the model and reach a more accurate answer, the number of neurons in the layer can be increased the middle. The only problem that may occur in this is the increase in the complexity of the model. In classification problems, the number of input layer nodes is equal to the number of independent variables and the number of output layer nodes is equal to the number of target variables. (Vakili Fard et al., 2013)

Multilayer Perceptron or MLP:

One of the most basic neural models available is the Multi-Layer Perceptron model (MLP) which simulates the transmission function of the human brain. In this type of neural network, the behavior of the human brain and the propagation of signals are considered, which is why they are sometimes called feedforward neural networks. Each of the nerve cells of the human brain, called a neuron, after receiving an input (from a nerve or non-neuronal cell), processes it and transmits the result to another cell (neuronal or non-neuronal). This behavior continues until a certain result is achieved, which will probably lead to a decision, processing, thinking, or movement. (Sayadi 2018).

Algorithm after error propagation:

This algorithm, which was proposed by Rommel Hart and McClelland in 1986, is used in forward neural networks. Being forward means that artificial neurons are placed in successive layers (Feedforward) and send their output (signal) forward. The term backpropagation also means that the errors are backward in the feed network and are used to correct the weights and after that, it repeats the input of the path in front of it until the output. The error backpropagation method is one of the supervised methods in the sense that the input samples are labeled and the expected output of each of them is known in advance. Therefore, the output of the network is compared with these ideal outputs and the error of the network is calculated. In this algorithm, it is first assumed that the weights of the network are chosen randomly. At each step, the output of the network is calculated and according to the amount of its difference from the desired output, the weights are corrected so that this error is minimized. In the post-error propagation algorithm, the excitation function of each nerve is considered as the weighted sum of the inputs of that nerve. Thus, assuming that W is the corresponding weight between the input layer and the next layer, we can write:

$$A_j(\overline{x}, \overline{w}) = \sum_{i=0}^{n} x_i w_{ji} \quad (5)$$

The output of the nerve stimulation function depends only on the input and the corresponding weights. Assuming that the output function is Sigmund, the output of the jth nerve can be written as follows:

$$O_j(\bar{x},\bar{w}) = sgm\left(A_j(\bar{x},\bar{w})\right) = \frac{1}{1+e^{A_j(\bar{x},\bar{w})}} \quad (6)$$

Also, carefully in the above relationship, we find that the output depends only on the value of the excitation function, which in turn is related to the input and weights. Therefore, to change the output, the weights must change. As stated before, the goal of the education process is to reach a desired or close to the desired outcome. (Sayadi 2017)

A summary of the learning algorithm:

A: As the first step, at t = 0, the weights are set randomly. At this moment, the maximum possible iteration is defined in the network training.

B: An input vector x is entered into the network and calculations are performed to find the closest matching unit to the given pattern.

C: Then the weight vector is updated and the winning neuron that matches the most is allowed to focus

D: This process continues according to an iterative process until the unit t reaches its maximum number of iterations and then jumps to the second step (Flix and Ivan, 2018).

And finally, after performing the calculations by the artificial neural network, the weight of the input and output variables and the coefficients of the input variables will be calculated, and a model will be presented which is obtained from the following relationship:

$$\mathbf{F(Y)} = \boldsymbol{b_2} + \boldsymbol{L_W} \times \mathbf{tanh}\ (\boldsymbol{b_1} + \boldsymbol{I_W} \times \mathbf{X}) \quad \mathbf{(7)}$$

It is a universal approximate model that can be accurately derived for bounded continuous functions from the real physical or mathematical functional form of the relation y = f(x, parameters).

$\boldsymbol{I_W}$- input weight matrix

$\boldsymbol{b_1}$ - input bias weight

$\boldsymbol{L_W}$ - output layer weight matrix

$\boldsymbol{b_2}$ - output bias weight

According to the results of most of the previous research, it is enough to have a hidden network layer in the network to solve this type of problem. In classification-type problems, the number of neurons in the input layer is equal to the number of predictor variables. Considering that the network has one output, then the number of neurons in the output layer is equal to one. But the number of neurons in the middle layer is not an easy task and it is through trial and error that the network is improved, and the best performance of the network is achieved. The method of working with artificial neural networks is presented in the figure below, which returns the results as a successful and unsuccessful plan as output.

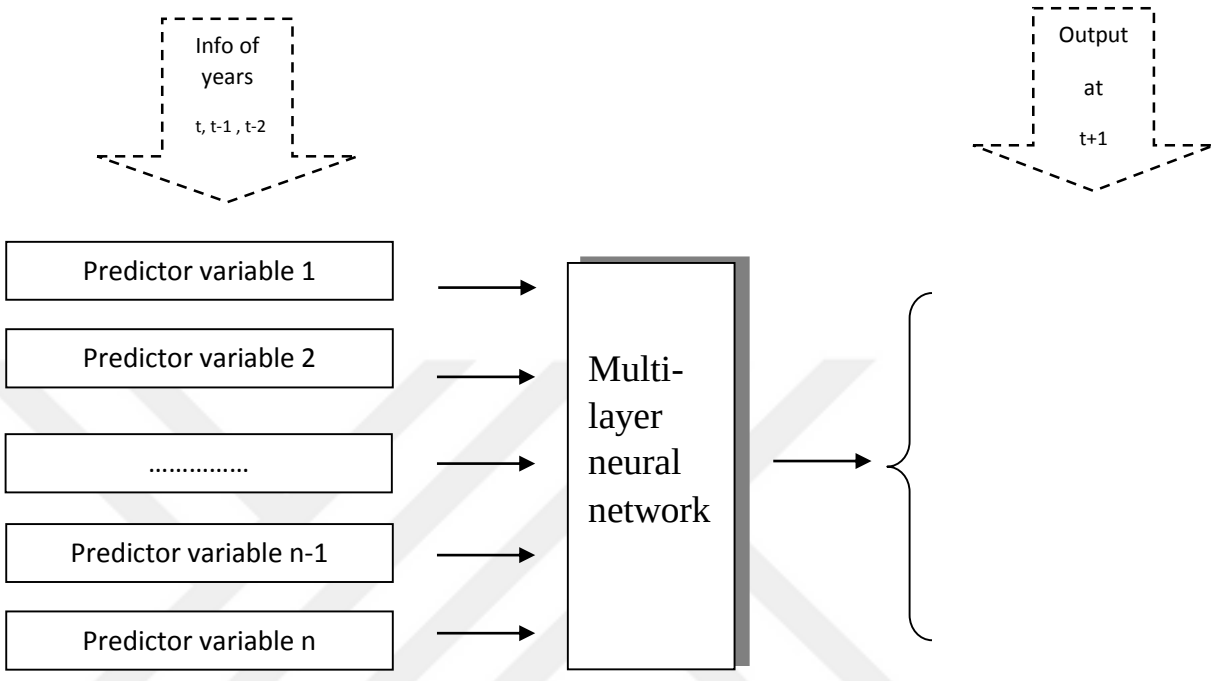


Figure 3.18 Using information to predict success (Khajavi and Amiri, 2013)

In addition, in modeling studies, they use the ROC curve and the area under the curve to measure the accuracy of the model and the prediction made. The closer the area under the curve is to 1, the accuracy of the model in choosing a good criterion, and the closer this number is to 0.5, it indicates the low accuracy of the model and the inappropriate prediction of the model.

3.7 Model evaluation

Finally, the model is evaluated to determine whether it meets the main purpose of the research or not. In other words, it should be determined whether the model is useful for meeting the business needs of the stock exchange and investment. The evaluation of the model may lead to a revision of the goals set in the first stage. For this purpose, the following steps are taken:

3.7.1 Evaluation of Results

To evaluate the results of the used algorithms, the models obtained from the training data are tested by data that have not been encountered so far (test data). In other words, the built models are implemented in the experimental data and the results are compared with the real results in the experimental data thus the accuracy of the models is determined.

3.7.2 Application of the model

The idea of this model is to use the potential of the extracted model, combine it with the decision-making processes of the organization, provide reports about the extracted knowledge, etc. At this stage, the model is implemented and executed, and usually, a suitable graphic interface is also designed for users.

3.7.3 Produce the final report

In the last step, the final report of the product, which is the knowledge discovered, can be provided to the users to make decisions about the use of the results. Because this research is applied research, therefore, its results can be provided as a system for predicting the stock index of the stock exchange in the hands of the companies and investors.

3.8 Summary

In this chapter, the methods used in compiling this research have been presented. First, information was presented about the data used in the research, the type of research, the

population, and the statistical sample, and then the tools and methods of data collection and the explanation of the research method and the data analysis method were discussed.

4. Data analysis

4.1 Introduction

One of the key foundations for all research activities, which are monitored and guided until results are obtained, is data analysis as an early stage in a Scientific Research Process. After the researcher has established his research method and has collected the data necessary to test the hypotheses or questions, by means of the appropriate statistical techniques of the collected data, this chapter shall be devoted to presenting the analysis of the findings of the research. categorize and analyze research questions Finally, the research questions are answered. In this research, there are two separate sections, one of which is related to the general index forecasting community, and the other is related to the determination of the forecasting pattern of the total index in the Tehran Stock Exchange.

4.2 Descriptive statistics related to the total index of the stock exchange.

After the revolution, the base year for calculating the total index was the year 1990, which was established during the reign of Rajaei Salmasi and was closed at the figure of 189 units by the end of the same year. At the end of 1991, the total index reached 472 units, and after a year, 435 units were recorded for the total index, and at the end of 1993, the total index reached a figure equal to 403 units, but it passed the year 1994 with a significant increase and the figure was 694 units. In 1974, the index reached 1549 units, and at the end of 1995, it increased to 1937 units. The recorded figure for the total index in 1997 was 1653 units and for 1998 it was 1538 units. The trend of this index shows that the Tehran Stock Exchange had an increasing trend during the years 1999-2003. It was quiet, but in 2003, it experienced a sharp jump that lasted until 2005. In these three years, the stock market witnessed a sharp increase in the prices of companies' shares, this variable reached 2206 units in 1999 and 2978 units in 2000. The total index reached 3759 units at the end of 2001 and 5063 units in 2002. The total index of 2003 rose up to 11 thousand 379 units in a stunning leap and finished its work in 2004 with the number of 12 thousand 113 units. Meanwhile, after the mentioned period, the stock market entered a phase of recession. It continued until 2007. The formation of a bubble in the market and the unrealistic growth of the company's stock prices in this year was the most important

factor in the downward trend of the index and the withdrawal of investors from the stock exchange. After that and at the same time with the entry of large companies subject to Article 44, the index began to grow gradually and slowly. The arrival of new financial instruments, the variety of market products, the formation of mutual investment funds, the return of trust in the market, the stagnation of parallel markets, the entry of stray liquidity into the stock market and the growth of the price of basic metals were among the most important factors of the upward trend of the market. Since the beginning of 2010, with the increase in the global prices of raw materials and the relative withdrawal of European and American countries from the global financial crisis, the index increased its upward speed and recorded new records with greater speed. So, the index exceeded 21 thousand units and continues to grow with the influence of large companies. The upward trend of this index continued and reached 26,849 units in 2004. At the end of 2005, this variable exceeded 30,781 units and reached 36,193 units in 2006. Meanwhile, with the market recession in 2007, the cash profit and price index decreased to 32,117 units, but in 2008, it increased to 51,006 units. At the end of January 2008, this index was 82,212 units. Meanwhile, with the change in the trading system of the stock exchange on 6th December 2008, it was not possible to calculate the index in the old way. In addition, the authorities of the stock exchange decided to calculate the total index in such a way as to show the return of the entire market, therefore, in addition to the stock price changes, the dividends of accepted companies are also included in the calculation of the index in order to show the return of the market. to reflect and finally during the second administration of Mr. Rouhani, the stock market index reached 1500,000 and finally, with a sharp drop in 2019, in December of 1400 (the end of the research studies) after severe fluctuations, it reached 1265,234 units.

Table 4-1 descriptive statistics of information related to the total index in the last 30 years

variables	amount	measurement
Total stock market index in 2021	12652341	units
Mean	260158	units
median	26849	units
Standard deviation	454218	units
maximum	1447120	units
minimum	189	units

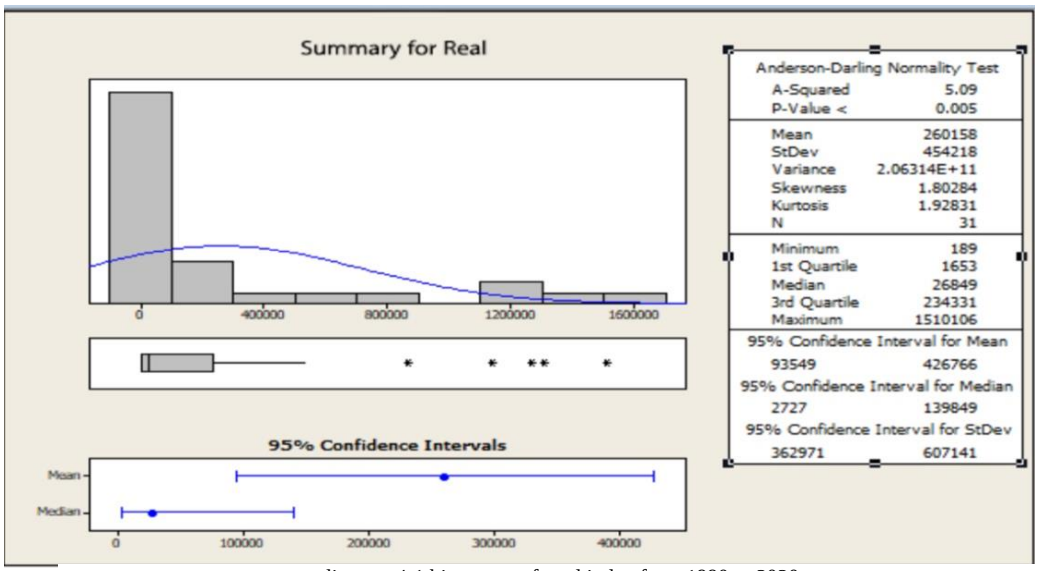


diagram 4-1 histogram of total index from 1990 to 2020

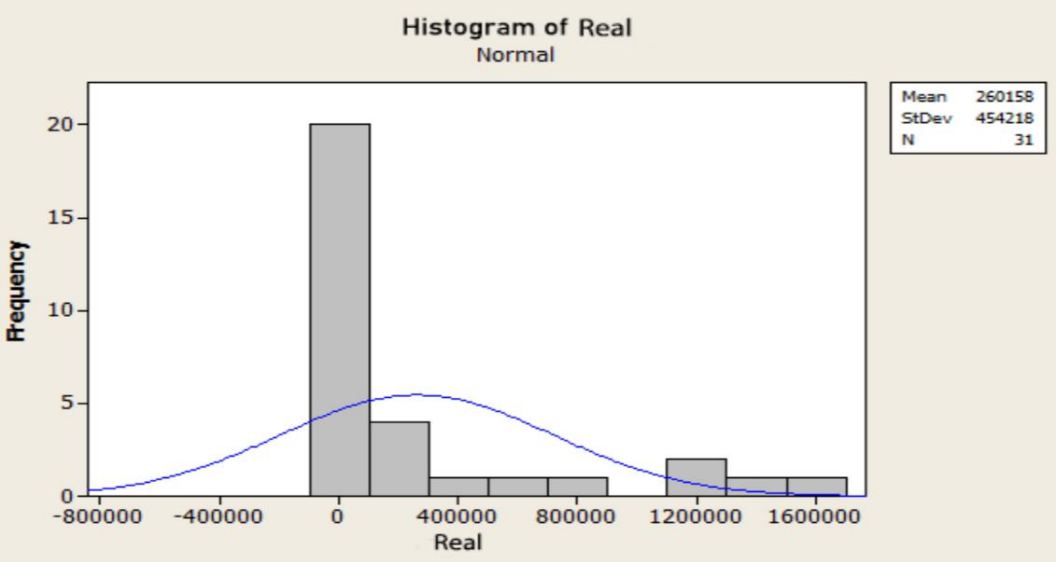


diagram 4-2 dispersion of the total index from 1990 to 2020

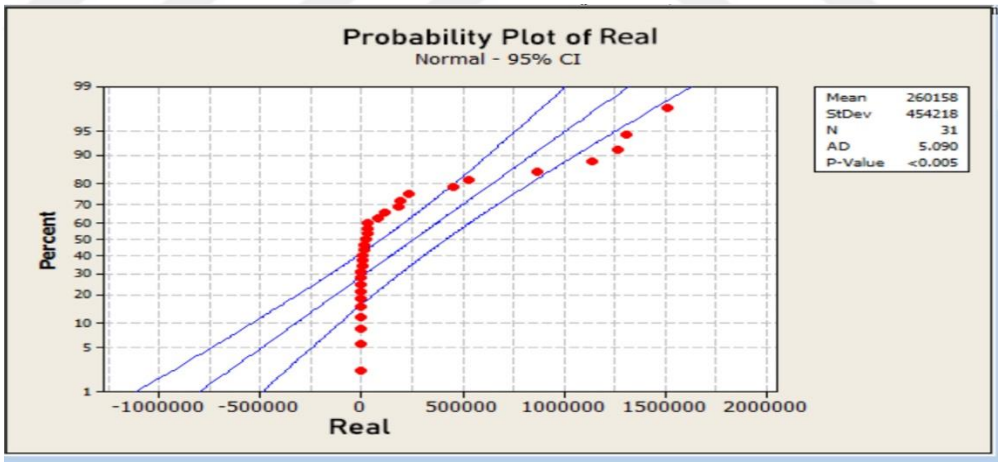


diagram 4-3 normality test of the total (real) index from 1990 to 2020

Descriptive statistics of the total index from 1990 to 2020 and scatter charts and histograms show that the total index had very strong fluctuations during this period because the standard deviation of the total index was 454,218 units, so the average index during this period was 260,158 units. The very large distance between the lower limit of the average and the upper limit of the average in 95% emphasizes this theory (93549.426766) and also the scatter diagram

shows the significance of the changes (the significance level is equal to 0.005 and less than 5 hundredths). Because it is during the time series, and finally the mentioned.

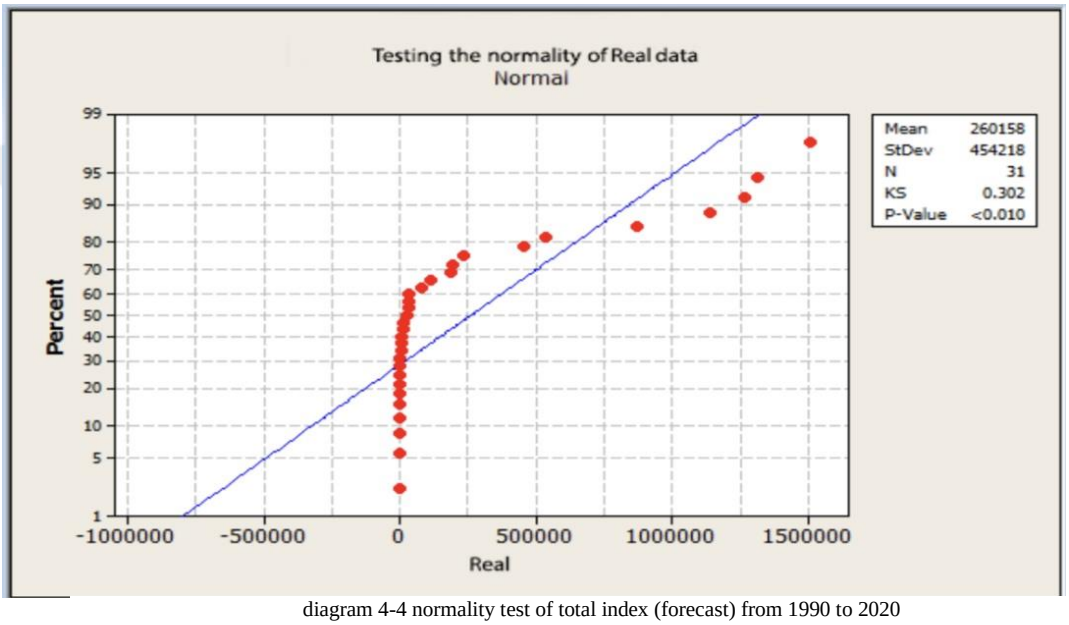


diagram 4-4 normality test of total index (forecast) from 1990 to 2020

changes indicate a lot of turbulence in the country's macroeconomics during the last thirty years.

Examining the Kolmogorov-Smirnov test on the total index data (real) from 1990 to 2020 shows that the distribution of the data does not have a normal distribution because the significance level is equal to 0.01 and is less than 0.05, in other words, the data with the combination The normal distribution has a significant difference, and this problem reconfirms the existence of overdispersion of the total index during the time series.

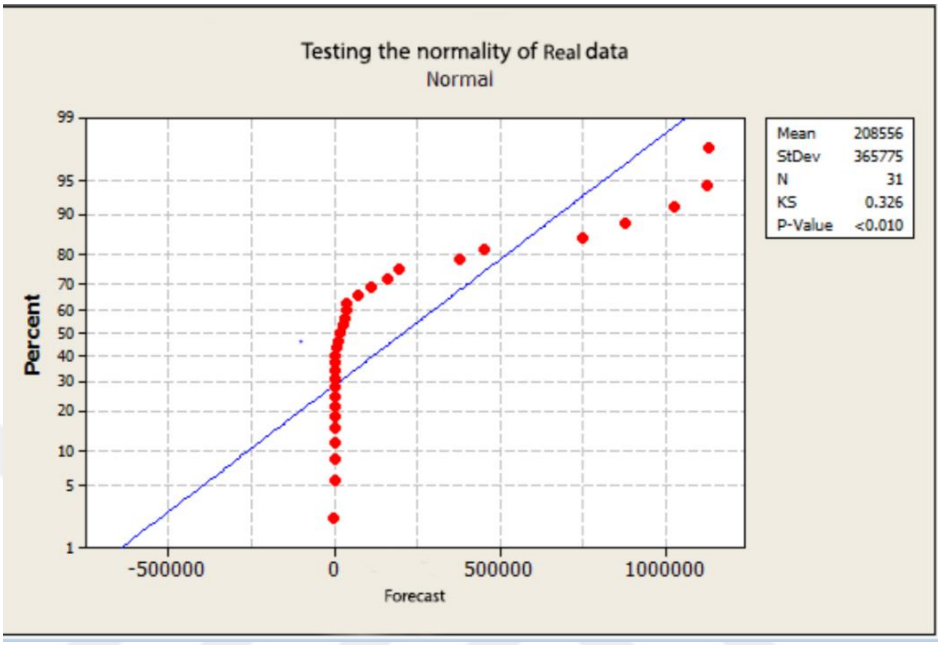
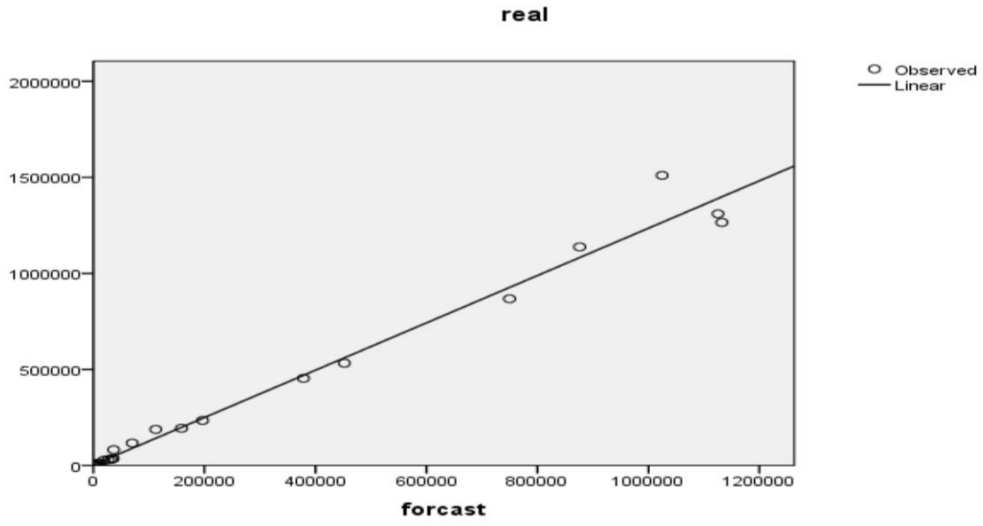


diagram 4-5 regression chart of actual data compared to total index forecast data



This graph shows the very high correlation between real data and predicted data, the value of which is 0.992 with an explanation coefficient of 0.984.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.992[a]	.984	.984	57583.648

4.3 Presentation of research results

In response to the first question of the research, which was raised as follows:

1- At what level is the prediction of stock index of Tehran Stock Exchange using neural networks?

Quantitative results of artificial neural network modeling after error propagation have been used in this research using MATLAB software to create neural network after error propagation and modeling the changes of total index. Due to the large amount of data (11,160 daily indices for thirty-one years), prediction of Tehran Stock Exchange index using 6000 data, 80% for training, 15% for evaluation and 5% data for testing the model. The criterion used to validate the model is the root mean square error (RMSE) of the experimental data. To obtain the best values of model parameters, the following steps have been implemented.

1- First, the learning rate and the number of training courses were determined as 0.3 and 8000 respectively. Then the effect of different amounts of processing elements in the hidden layer has been analyzed.

2-Based on the values of the appropriate processing elements obtained from step one, the effect of different learning rates on the results of the model has been investigated in the second step.

3- In the third step, two tests have been performed for 1 and 2 hidden layers in order to draw conclusions about the best number of hidden layers.

4- In the end, the selected model is trained in the above steps during 8000 training sessions to reduce the probability of being in local minimum points.

First, the neural network model with a learning rate of 0.3, and the number of training courses of 8000 and six resistance values of the processing elements has been created. The results are shown in the table below.

By entering the data of the first variable, the network randomly divides this data into three groups.

The first group - which are used for training, are the training group. The network learns using the information of this group and improves itself by trial and error, that is, if an error occurs, it goes back (algorithm after error propagation) and then moves forward (forward network) and this time it tries She will not make that mistake again.

The second group - is the validation group at this stage, we randomly enter the information of several companies into the network to evaluate the performance of the designed network.

The third group - is called the testing group and is used to test the results of the network.

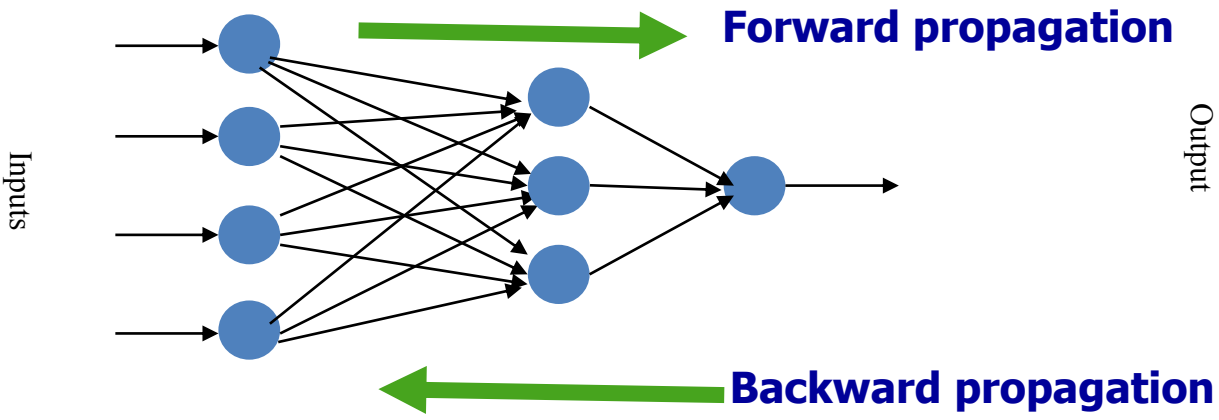


diagram 4-6 shows the post-propagation algorithm and the forward network.

Table 4-2 shows the number of tests of processing elements and the number of hidden layers

number of hidden leyers=1 Education courses=8000					
R 2	RMSE	MSE	Data collection	Processing elements	test
%79.2	11521	132733441	education	1	1
%81.1	14542	211469764	test		
%97.7	654	427716	education	2	2
%84.6	684	467856	test		
%85.2	541	292681	education	3	3
%99.8	311	96721	test		
%79.9	8457	71520849	education	4	4
%88.8	6589	43414921	test		
%89.0	11463	131400369	education	5	5
%91.2	10695	114383025	test		
%76.7	4234	17926756	education	6	6
%79.9	419	175561	test		

As can be seen, the lowest RMSE is equal to 311, which happened with the number of processing elements three. Therefore, three processing elements are used in testing other parameters. In the second step, six tests with different learning rates with three test elements, the accuracy of the model is checked.

Table 4-3 shows the second step, the number of tests of processing elements and the number of hidden layers

Education courses=8000 number of hidden leyers=1 the number of processing elements=3					
R 2	RMSE	MSE	Data collection	Learning rate	test
%99.1	1205	132733441	education	0.01	1
%82.4	1008	211469764	test		
%99.8	477	427716	education	0.05	2
%97.1	413	467856	test		
%92.4	892	292681	education	0.1	3
%88.3	1327	96721	test		
%79.7	645	71520849	education	0.3	4
%81.3	652	43414921	test		
%89.0	2499	131400369	education	0.5	5
%91.2	1879	114383025	test		
%86.8	1921	17926756	education	0.7	6
%79.9	4174	175561	test		

As Table 2 shows, the lowest RMSE which is equal to 413 was obtained at the learning rate of 0.05. Therefore, in the next step, three processing elements, learning rate and number of one

and two hidden layers are used. At this stage, first, the model is set with three processing elements, learning rate 0.05, 8000 training courses.

Table 4-4 showing the third step, the number of tests of processing elements and the number of hidden layers

education courses=8000 number of hidden leyers=1 and 2 number of processing elements=3					
R 2	**RMSE**	**MSE**	**Data collection**	**Number of hidden leyers**	**test**
%99.8	**477**	**427716**	education	**1**	**1**
%97.1	**413**	**467856**	test		
%99.6	**635**	**427716**	education	**2**	**2**
%93.3	**563**	**467856**	test		

As Table 4-4 shows, the lowest RMSE, which is equal to 413, occurs in the model with a hidden layer. The results of the investigation of the neural network model with the following parameters.

Number of data=6000 datas
Educational data=4800
Evaluation data=900 datas
Transfer function=sigmoid
The number of processing elements=3
Learning rate=0/05
Number of hidden leyers=1 leyer
Educational courses=8000

Chart number 7-4 and table 5-4 show the results of the post-propagation neural network model with the performance obtained whit the aforementioned parameters.

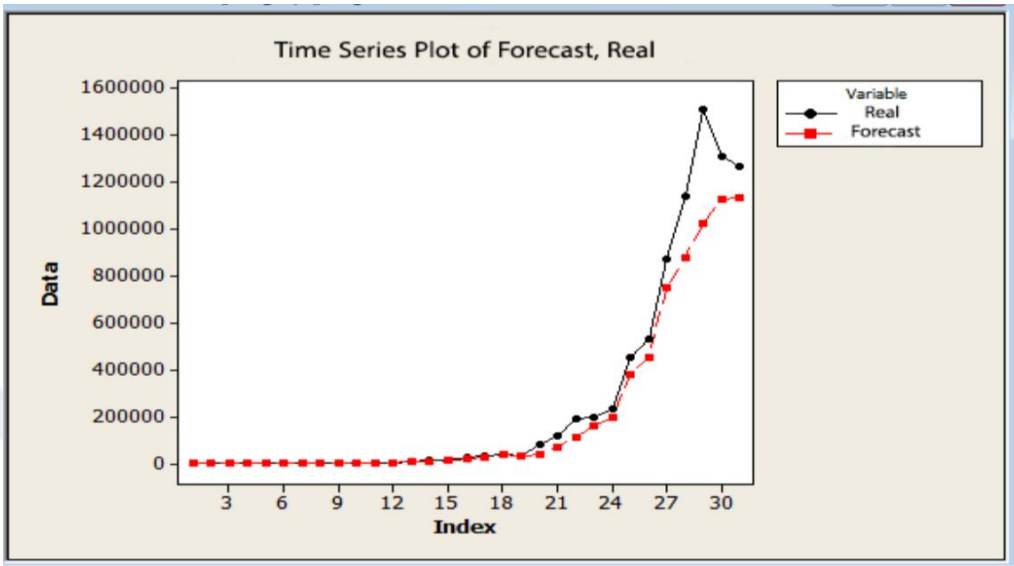


diagram 4.7 of the comparison plot of the actual total index and forecast from 1990 to 2020

Table 5.1 comparison of actual and forecast total index from 1990 to 2020

row	Number of processing layers	Learning rate	Number of hidden leyers	Predicted for the next periods(months)	RMSE	R 2
1	3	0/05	1	1275685	489	0/981
2	3	0/05	1	1285613	552	0/934
3	3	0/05	1	1290080	509	0/944
4	3	0/05	1	1323687	688	0/929
5	3	0/05	1	1325001	571	0/942
6	3	0/05	1	1329964	609	0/937

The second question of the project:

In response to the second question of the research, which was raised as follows:

2- Do artificial neural networks provide better predictions than risk methods?

The prediction of the total stock index is a challenging task, an accurate prediction of the movement of the index is very important for the performance of investors, due to the complexity of the stock market and the lack of management and the occurrence of problems in critical times, it is very difficult to develop a useful model for prediction. One of the important tools used for investment decisions is forecasting techniques, which is an integral part of the decision-making and control process, on the other hand, it has a direct relationship with decision-making

risk. This means that the more accurate the forecast, the less the loss or risk caused by decision-making in conditions of uncertainty. The Tehran stock market is a non-linear and chaotic system that is affected by political, psychological and economic conditions; therefore, it can be used from the moving average auto-regression model (ARIMA), the asymmetric conditional variance auto-regression model (ARCH) and simple regression and neural networks. (ANN) was used to predict the total index.

Moving autoregression model: (ARIMA) is a stochastic linear model that is one of the oldest time series forecasting models in economics. which is used for predictions that are not valid but can be made by differentiation with the correct order of the midwife. Box-Jenkins methodology is used for forecasting using the mentioned method.

Conditional Variance Inhomogeneous Autoregression Model (ARCH): This method is used for cases where the statistical distribution of the index has more skewness and elongation than the normal distribution. is used. The ARCH model uses previous information related to the variances of time series to predict the variance of future values.

Simple linear regression: Linear regression is one of the methods of regression analysis. Regressio

n is a type of statistical model for predicting one variable from one or more other variables. Linear regression is a type of linear predictive function in which the dependent variable (the variable to be predicted) is predicted as a linear combination of independent variables. This means that each of the independent variables is multiplied by the coefficient obtained in the estimation process for that variable, the final answer will be the sum of the products plus a constant value that is also obtained in the estimation process. The simplest type of linear regression is simple linear regression, which, unlike multiple linear regression, has only one independent variable.

According to the question raised in this research that "artificial neural network provides better prediction than linear methods", the following results show better prediction of neural networks (ANN) compared to other linear methods because RSME is less than other methods. There is a raised line.

Table 4-6 Artificial neural network results compared to linear forecasting methods

Model name	Moving average autoregressive model	Conditional variance heterogeneity regression model	Simple linear regression	Articial neural network
Predicted value	**1258740**	**1495875**	**1489752**	**1275685**
RMSE	**1789**	**2754**	**3125**	**489**

The third research question:

In response to the third question of the research, which is raised as follows:

3- What is the difference between the results of the predictions and the real data?

In order to show and answer the question of what is the difference between the real data and the predicted data, paired t-tests and correlation are used.

Paired T for forecast-real

	N	Mean	StDev	SE Mean
Real	31	260158	454218	81540

Forecast	31	208556	365775	65695
Difference	31	51601	102047	18328

95% CI for mean difference: (14170, 89032)

T-Test of mean difference = 0 (vs not = 0): T-Value = 2.82 P-Value = 0.109

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	forcast - real	-5.160E4	102046.827	18328.151	-89032.240	-14170.083	-2.815	30	.109

Considering that the significance level is greater than 0.05 (0.109), the null hypothesis is accepted, which means that there is no significant difference between the predicted values and the actual values, in other words, the predicted values are in line with the actual values, which means that the accuracy It has also been confirmed in question number 1.

Also, according to the results of the Pearson correlation test, there is a high correlation between the real data and the forecast data (0.992) and the significance level (0.000) also shows that there is a significant correlation between the real data and the forecast data.

R-test

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	forcast & real	31	.992	.000

The fourth research question:

In response to the fourth question of the research, which was raised as follows:

4- Does the stock index of Tehran Stock Exchange follow a non-linear process?

The artificial neural network model can be used as a test to find a dynamic nonlinear process, including the chaotic process, in the data. Artificial neural network models are flexible nonlinear models that are able to estimate and predict complex nonlinear time series with acceptable accuracy. Neural network models often include three input, intermediate and output layers. The input data are directly and indirectly linked to the output layer through transfer functions in the middle section. The direct connection of the linear part and the connection through the middle layer define the non-linear part of the model. Tests were proposed in the literature to investigate the predictability and non-linearity of time series, which include: Keenen's test, Tsai and Ramsey's reordering, Nij's bispectral test, Dickey Fuller's test, etc. Here, for the high accuracy of the Dickey-Fuller test, it has been used to show the linearity and non-linearity of the data.

Dickey-Fuller's test is one of the most widely used tests to check the mean in experimental works. It is based on the assumption that the time series variables used are mean. The first step in determining the mean of a variable is to observe the time series graph of that variable to recognize the existence of a random process in a variable. The time series is easily tested through the unit root test.

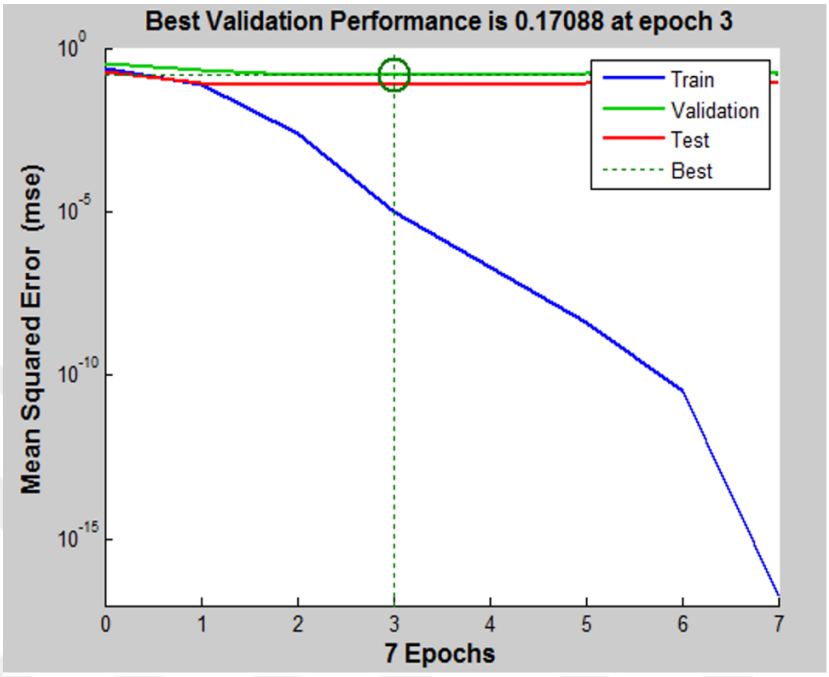
The results of Table 4-7 show that at the significance level of 1%, 5% and 10%, the growth of the stock price index of the Tehran Stock Exchange is greater than the critical values and is significant, so the H0 hypothesis is based on the existence of a unit root is rejected. The results of the tests indicated that the stock price index process in the Tehran stock market in the period

from 1990 to 2020 is a product of a certain dynamic non-linear variable and can predict in the short term. After conducting the tests and confirming that the stock price index is non-random and has a non-linear structure, and the presence of confusion in this series was confirmed because the absolute value of the test statistic is greater than the critical values in order to predict the stock price index in the period Neural network model was used in the future.

Table 4-7 results of unit root test (non-linearity of time series)

Case study data	Test statistics DFT	McKinnon's critical values	Level of significance
Stock price index	-16.35	-3.24 -2.69 -2.51	%1 %5 %10

Fifth: evaluation of the prediction model



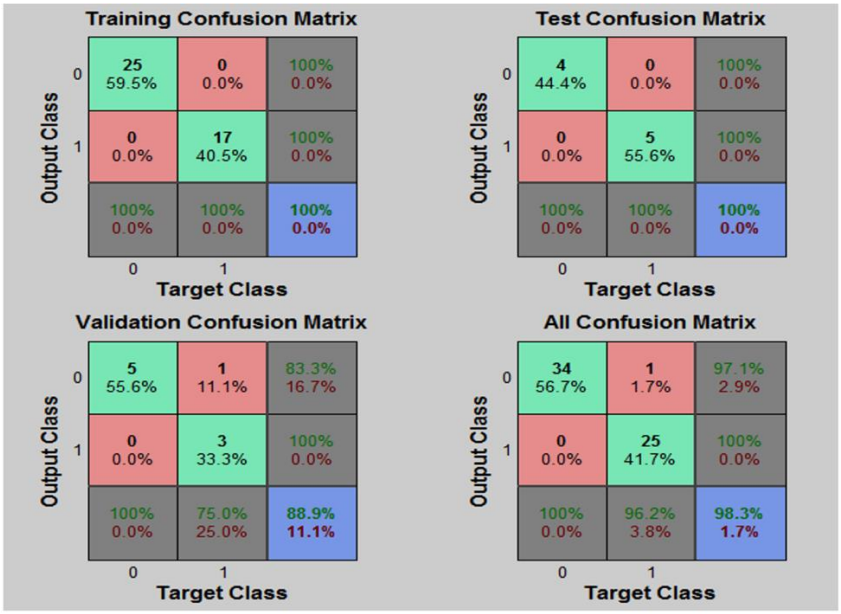


diagram 4-8 Error function graph

Also, the method of judging the accuracy of the prediction will be as described in the table below.

Table 4-8 Judging forecasting performance

Judging about forecasting performance	MAPE
Extreme attention	Less than 10%
Good forecast	Between 11 to 20%
Defensible forecast	Between 21 to 50%
Inaccurate forecast	More than 51%

As can be seen in diagram 4-8, the output of the software, after entering the last variable into the network, the test sample has 100% correct prediction and 0% error in predicting the total stock index, the training sample has 100% correct prediction and 0% error. Validation sample has 88.9% correct prediction and 11.1% error. The general result after entering the first variable shows that it has 0.981% correct prediction and 1.7% error and with RMSE equal to 489 in predicting the total stock index of Tehran Stock Exchange. According to the results of the perceptron multi-layer neural network outputs at each stage, it can be concluded that the network has an error of up to 1.7% in predicting the total stock index of the Tehran Stock Exchange using artificial neural network, which shows the above prediction power. It is extremely high in predicting the total stock index of Tehran Stock Exchange. Therefore, the power of the presented model is proven. The model designed in this research is shown in the figure below.

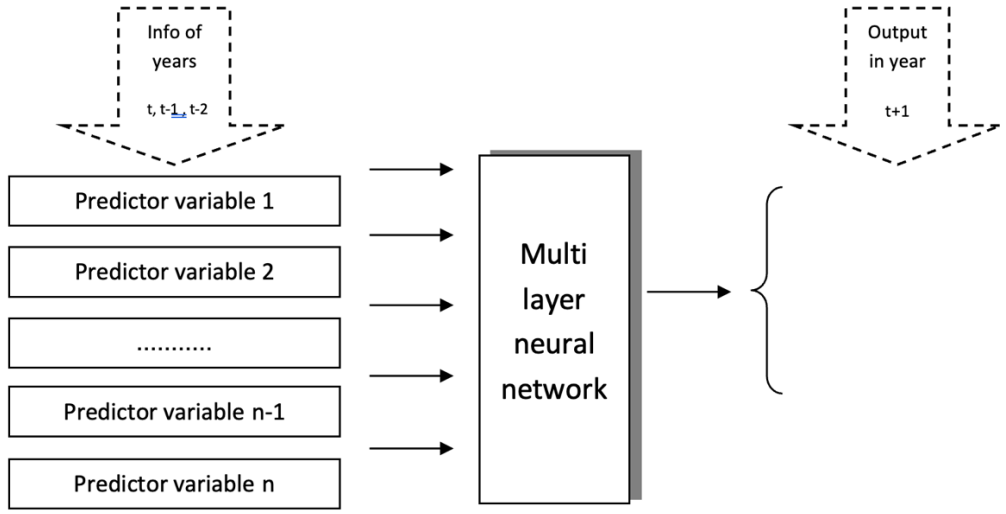


Figure 4-1 designed and evaluated research model

4.4 Summary

In this chapter, when all the research data are ready for processing, first, descriptive statistics of the research data were presented to understand the general content of the data. Then the results of the research questions were explained separately. In response to the first question, the results of the used documentary data were discussed. In response to the second question, "Artificial neural network provides better prediction than linear methods", the results of neural networks were compared with linear methods. The third question that the final goal of this difference between the results of the predictions and the real data was presented, which is able to predict the total stock index with 98.1%. And at the end of the fourth research question that "Tehran stock index follows a non-linear process" its non-linearity was confirmed by statistical calculations. Finally, she evaluated the model using error functions in a schematic way.

5. Conclusion and Recommendations

The result of every scientific research is crystallized in its conclusion section. In this section, the results of the tests and the model used are interpreted, and a comparative review of the research findings with other similar research is undertaken, then a general conclusion of the research is made, and in accordance with the research results, scientific proposals are made to the interested groups and Application is provided. In the following, the existing obstacles and limitations for the generalization of the results are discussed, and in the last part, the suggestions and future research related to the subject of this research, which will be a way forward in the development of scientific knowledge, are mentioned. In this section, what has been done from the beginning to the end of this research is reviewed, in order to provide a systematic classification and a clear view of the entire research.

1-1 Descriptive statistics results

The results obtained from the descriptive statistics for the research variables show that the total index from 1990 to 2020 and the scatter diagrams and histograms show that the total index had very strong fluctuations during this period because the standard deviation of the total index was 454,218 units so that that the average index during this period was equal to 260158 units, also the very large distance between the lower limit of the average and the upper limit of the average in 95% confirms this theory (93549, 426766) and also the scatter diagram shows the significance of the changes (significance level equal to 0.005 and is less than 5 hundredths) is high during the time series and finally the mentioned changes indicate large turbulences in the country's macroeconomics during the past 31 years.

1-2 Results of inferential statistics

1) The results obtained from the Kolmogorov-Smirnov test indicate that the examination of the Kolmogorov-Smirnov test on the total (real) index data from 1990 to 2020 shows that the distribution of the data does not have a normal distribution because the significance level is equal to 0.01 and it is less than 0.05, in other words, the data have a significant difference with the combination of normal distribution, and this issue confirms the existence of excessive dispersion of the total index during the time series.

2) In the next step, using 4800 training data and 900 evaluation data, using the sigmoid function and the number of three processing elements, with a learning rate of 0.05 and a hidden layer with 8000 training sessions, the results of the post-error propagation neural network model have the best The prediction calculations were performed with the above-mentioned parameters with the lowest RMSE which was equal to 413. These results are consistent with the research results of Prokhoff and Wench (2000), who designed a system that predicts significant short-term changes in stock prices to estimate very good profit margins. It is also consistent with the research results of Ayodel Adabiya (2014) who used a hybridization method with a combination of variables from technical and fundamental analysis of stock market indicators to predict stock prices in the future in order to improve existing methods.

3) In the third step, in response to the second question of the research, the artificial neural network provides a better prediction than linear methods, from the comparison of the results of linear methods such as the moving average autoregression model (ARIMA), the asymmetric autoregression model of the conditional variance (ARCH) and the regression Simple and neural networks (ANN) showed that the results of neural networks (ANN) are better and less error than the prediction results of the mentioned linear methods. These results are with the research results of Jeang et al. (2018) who in a research combined artificial neural network with collective model and genetic algorithm and comparing this algorithm with various linear models showed the superiority of the combined algorithm for predicting the bankruptcy of manufacturing companies. Combining neural networks with genetic algorithm is better than

linear methods. Also, with the results of the research of Riefens, Zapranis and Francis (2016), who modeled the stock price behavior by neural networks and compared its performance with regression models. In this research, neural networks have been used as an alternative for predicting stocks of large companies. The results showed that the performance of neural networks in prediction was better than other statistical techniques.

4) In the fourth step, in response to the third question of the research, what is the difference between the results of the predictions and the actual data, using the student's t-test and the correlation test, it was shown that there is no significant difference between the predicted values and the actual values. Other predicted values are in line with the actual values, the accuracy of which has been confirmed in question one.

5) In the fifth step, in response to the fourth question of the research, that the stock index of the Tehran Stock Exchange follows a non-linear process, using the Dickey-Fuller test, the results of the tests indicated that the stock price index process in the Tehran Stock Exchange market in the period of 1369 Until 2019, the product is a certain dynamic non-linear process and has the ability to predict in the short term. After conducting the tests and confirming that the stock price index is non-random and has a non-linear structure, and the presence of confusion in this series was confirmed because the absolute value of the test statistic is greater than the critical values in order to predict the stock price index in the period in the future, the neural network model was used.

6) In the sixth step, in order to evaluate the prediction model, it was evaluated using the error function graphs that based on the results of the error functions, the working result after entering the first variable shows that 1.98% of the prediction is correct and 1.7% of the error in It has the prediction of the total stock index of Tehran Stock Exchange. According to the results of the perceptron multi-layer neural network outputs at each stage, it can be concluded that the network has an error of up to 1.7% in the prediction power of the total stock index of the Tehran

Stock Exchange using artificial neural network, which shows the above prediction power. It is extremely high.

The suggestions of this research regarding providing a model to predict the total stock index are as follows:

With data collection and analysis, the power of neural networks in predicting the total stock index was proved. In order to implement and apply the results of this research, dynamic systems can be designed and implemented that users can easily use. For example, it is possible to design, install and use the necessary systems to build the presented model dynamically in the financial system of companies, or even in stock market support institutions, etc., with not much cost. The meaning of system dynamics is that the database used to build the model will receive the required information online and up to date at any moment and create and process the desired models moment by moment with new data. In fact, it can be said that the presented model has been turned into an up-to-date and online software and used in companies and organizations related to the capital market.

Due to the high prediction accuracy of the model used in this research, economic managers can make decisions based on macro-economic variables, where the only channel of access to information is the time series of variables from the model of this research for other variables such as interest rates. Use inflation, growth rate and other capital market indicators.

It is recommended for future researchers:

- Continue this research in the phase environment and compare the results of phase and non-phase artificial neural networks.

- To further check the accuracy of the results of this research, a comparative study can be done on the use of genetic algorithm compared to artificial neural network in order to make a more accurate judgment about the best method of predicting the total stock index.

- Due to the high variance and standard deviation of the data over the past 31 years in the total capital market index and according to the theory of chaos, if the data is obtained from a chaotic nonlinear dynamic system, the possibility of accurate modeling and prediction There will be a short term of the future behavior of the system because in fact the irregular behavior of a volatile system results from its non-linearity. If it is proven that the data generating system is unstable, maybe the use of non-linear dynamic models can be used to predict with high accuracy. Conducting this research and comparing its results is one of the researcher's recommendations to other colleagues.

Finally, in this chapter, after the interpretation of each and every result obtained from the research questions, it was tried to continue the discussion and final conclusion, and finally, suggestions were also presented based on the results of the research and for researchers in the relevant field.

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