

# Explanation of optimal financial performance forecasting model based on QTobins ratio by using data mining techniques

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## Abstract

The current research is based on the explanation of the optimal model for predicting the performance of companies using data mining techniques. The method of this research is of the applied type, in terms of the way of doing the work, it is of the descriptive-causal research type, and in terms of the time dimension, it is of the post-event research type. In the first step, by referring to databases such as thesis, articles and similar researches, the required literature was collected in order to write the theoretical foundations and background of the research. In the following, the information of the investigated companies selected as a statistical sample, whose information is available in the form of data banks on CDs and is under the supervision and review of the responsible institutions, was audited by referring to the financial statements and new implementation software was compiled. The mentioned information included the financial data of the companies admitted to the Tehran Stock Exchange for a period of 10 years from the beginning of 2011 to the end of 2014. Finally, the findings showed that the firefly algorithm, genetic algorithm and evolutionary algorithm were effective in predicting the ratio of QTobins, return on equity and return on equity, and the firefly algorithm had a higher power to predict the ratio of QTobins, return on equity and return. has shares.

Keywords: QTobins ratio, Caustic dada technique, Firefly algorithm, Magnetic algorithm, Integrative algorithm  
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## 1 Introduction

Just as the government must respond to the citizens, the company must be able to be accountable for its performance in front of the shareholders, customers, employees and the public. Because managers are responsible for this responsibility, they must provide timely information. As the business unit gets bigger, the control of the shareholders on the activities of the companies decreases and the responsibility is placed on the shoulders of the managers. The shareholders are the owners of the company, and the managers on behalf of the shareholders must allocate the benefits in the best way so that the highest income is given to the shareholders. From an economic point of view, assuming the rationality of people's behavior, it is assumed that everyone seeks to maximize their own interests in the first place, and managers are no exception to this rule [22]. In order to maximize personal benefits, social welfare and stabilize their job position, managers are interested in presenting a favorable picture of the financial status of the business unit to the shareholders and other stakeholders, but in some cases, it is necessary to increase the wealth of managers

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in order to increase the wealth of other groups, including They are not shareholders. On the other hand, the most important goal of investing in the stock exchange is to get returns; Given that stock returns are one of the performance criteria of companies, its prediction can be very important for investors; For this purpose, all investors are facing an important problem under the title of predicting performance criteria. In the past, various forecasting models have been used, the most important of which are linear or polynomial regression techniques, automatic regression, moving average, Box and Jenkins models, structural models and time series [1]. But these models had weaknesses that do not allow the researcher to consider complex and non-linear factors affecting the prediction. In recent decades, a new method of forecasting called artificial intelligence has emerged, which, by adapting the learning process of the human brain, can discover the relationships between variables - even though it is complex and non-linear. Therefore, if the performance evaluation criteria of companies can be properly predicted, without a doubt, decision making for investors will improve [14].

Therefore, in this research, we will try to explain the optimal model for predicting the Qotubin ratio of companies using data mining techniques.

## 2 Theoretical

Decision making is one of the most important aspects of investment management. Basically, the decisions are related to the future, which today due to the discontinuous and non-linear changes in the environment of companies and institutions, are placed in an aura of uncertainty, and therefore, predicting the future and the changes that will occur in the future will occur, it is of particular importance to make a proper decision. With planning, you can show appropriate reactions before facing adverse economic events. To increase the effectiveness of planning, you must improve the ability of correct and continuous forecasting, which is necessary for it. In this way, it will be an efficient and effective decision that is made based on predictions that are based on correctness. Therefore, predicting the future has always been a necessity in business and social life in many sciences. One of the fields in which forecasting is of particular importance today is financial and economic issues, especially capital markets [16]. In the past decades, financial forecasts have been the subject of many researches in accounting and finance, for example, forecasting profit per share, stock price, profit management, financial bankruptcy, etc. Many researches in this field have been done using statistical approaches and artificial intelligence approaches. Among the methods used, traditional statistical methods are highly dependent on hypotheses such as: linearity, normality, independence of predictor variables, etc. [17]. Previous researches (such as Huang and Wang [10], Furlaneto et al. [7], and Cunado and Garcia [4], showed that data mining techniques including neural network approaches and evolutionary algorithms compared to models Statistics are more predictable. Also, if two or more models are combined, the probability of achieving the best prediction increases. In the stock exchange, deciding on the best investment options is a big issue for investors. In general and based on the decision theory, the decision-maker wants to choose the best among the available options according to the uncertain conditions. These decisions are wise. In other words, the decision-maker considers the highest utility in his decisions. Considering the uncertainty affecting their decisions and in order to reduce it, investors always adjust their previous expectations by acquiring new information and using Bayes' rule and try to maximize their utility [20]. But one of the questions raised is, what is the selection and evaluation criteria of investors when choosing company stocks? It seems that one of the most important indicators that investors pay attention to in this market is the performance evaluation criteria of companies; In other words, performance evaluation criteria play an important role in investors' financial decisions. So far, different approaches and models have been proposed to estimate the performance of companies. Based on the researches and studies, four approaches have been proposed to evaluate the performance criteria, including the accounting approach, the economic approach, the integrated approach and the financial management approach [23]. Based on the accounting approach, the performance is evaluated through the figures included in the financial statements, such as the rate of return on equity. Based on the economic approach, the performance of companies is evaluated by emphasizing the profitability of the company, such as the rate of return on shares. Based on the integrated approach, a combination of accounting and market information, such as the Qotubin ratio, is used to evaluate the performance of companies, and finally, the financial management approach, which often uses financial management theories, such as the pricing model of capital assets, to evaluate the performance of companies. It can be done [15]. Therefore, according to the criticisms that have been made to the previous models of predicting the performance criteria of companies and considering the importance and influence of the factors of financial statements, the quality of disclosure and corporate governance mechanisms on the performance criteria of companies. and investors' decision-making, as well as taking into account the fact that the research conducted in Iran's stock market has not yet explained a model for predicting the company's performance criteria using data mining, this research considers Using neural network techniques and evolutionary algorithms, he is trying to explain an optimal

model for predicting the Kitobin ratio criterion for the performance of companies admitted to the Tehran Stock Exchange.

### 3 Performance indicators

#### 3.1 Financial approach

The indicators used in the evaluation of financial performance have achieved a high diversity and generally work in parallel with the development of technology. According to this approach, financial management theories such as profit volatility and capital asset pricing model (CAPM) and the concepts of risk and return are often used. The main emphasis of this approach is on determining the additional yield of each share. In the current research, profit volatility has been investigated as an index derived from the financial approach

#### 3.2 Profit volatility

A greater change in profit with positive bankruptcy costs indicates a higher probability of bankruptcy and indicates a lower debt rate. Therefore, a negative coefficient on profit variance may indicate the existence of bankruptcy costs or financial stagnation, and the value of this coefficient measures the importance of bankruptcy costs in determining the optimal capital structure [2]. They used profit before interest and taxes divided by total assets and changes in the standard deviation of operating income rate divided by total assets as indicators of volatility. They check the volatility of profit as follows.

$$\overline{VOL} = \sigma \left( \Delta \left( \frac{\overline{OI}}{\overline{TA}} \right) \right) \quad (3.1)$$

In the formula above, VOL is the average volatility in previous years **It is the average standard deviation of operating profit to asset return** Financial performance indicators based on accounting

In this approach, figures included in financial statements such as profit, profit per share, operating cash flows, return on assets and return on equity are used to evaluate performance.

#### 3.3 Return on equity

Among accounting performance criteria, return on equity is one of the most popular and widely used accounting performance criteria. some

Researchers have considered the possibility of separating equity returns into profitability ratios, asset turnover and financial leverage through DuPont analysis as the reasons for the popularity of this measure among analysts, financial managers and shareholders [5]. Return on equity is indicative of how much return has been created by investors for the funds invested by them. It is appropriate to use this criterion in departments where managers have a lot of influence in decisions related to the acquisition of assets, purchases, credit aspects, cash management and the level of current liabilities. Return on equity represents the actual cost of using money.

Considering that ROE is useful for comparing the profitability of companies in a sector, it is a very good and practical index in manufacturing companies. This index is calculated as follows.

$$ROE = \frac{\text{Net Income (After Tax)}}{\text{Stockholder Equity}} \quad (3.2)$$

In the above formula, ROE is equity, Net Income is income after tax deduction, and Stockholder Equity is the value of equity.

#### 3.4 Return on assets

This criterion emerged in a system called the DuPont system and was considered as a basis for evaluating the performance of companies. In the past, managers gave importance to the earned profit margin and ignored the turnover frequency, while one of the important duties of managers is monitoring operational assets. If additional assets are used in operations, it is as if we have increased operating costs. In other words, the rate of return on assets is one of the accounting criteria that shows the efficiency of management in using available resources to obtain profit,

and it is one of the profitability ratios, which in its analysis is the source of a period of time. The growth of profit per share due to the increase in profit does not take into account the amount of capital used to increase profit. In some cases, the increase in profits may be caused by the increase in non-economic investments, so that the returns obtained from these investments do not cover the cost of capital [12].

How to calculate this criterion is as follows:

$$ROE = \frac{\text{Net Income (After Tax)}}{\text{Total Assets}} \quad (3.3)$$

In the above formula, ROA is return on assets, Income Net is the income after tax deduction, and Assets Total is total assets.

### 3.5 Earnings per share

Another important index in the accounting approach is the EPS index, which shows the strength of the company. How to calculate this variable is defined as follows:

$$EPS = \frac{\text{Net Income (After Tax)}}{\text{Number of Shares Outstanding}} \quad (3.4)$$

In the above formula, EPS is profit per share, Net Income is the income after tax deduction, outstanding shares of Number is the number of shares in the hands of shareholders [11].

### 3.6 Economic added value

How to calculate this criterion is as follows:

$$EVA = NOPAT - [IC_{t-1} \times WACC]. \quad (3.5)$$

In the above formula, EVA is economic added value, NONPAT t-1 is operating profit after tax deduction, IC is the amount of capital employed in the previous year, and WACC is the weighted average cost of capital [3].

### 3.7 Market added value

How to calculate this criterion is as follows:

$$MVA = NOPAT - [(TD + TE) + (MVE - TE) \times WACC]. \quad (3.6)$$

In the above formula, MVA is market value added, NONPAT operating profit after tax deduction, TD total debt, TE total equity, MVE stock market value and WACC weighted average cost of capital [13].

### 3.8 Cytobin

Simon [19], states that if Tobin's Q index is greater than one, it means that the company has intangible assets. In fact, it can be said:

- a) If Tobin's Q is greater than one, then the value of the company is positive.
- b) If Tobin's Q is equal to one, then the value of the company is equal to zero.
- c) If Tobin's Q is less than one, then the value of the company is negative.

How to calculate the Q-Tobin ratio is the following formula:

$$Q_{TOBIN} = \frac{MVE + TD}{TA}. \quad (3.7)$$

where QTOBIN formula is Q-Tobin ratio, MVE of market value, TD of total debt, TA of total assets

### 3.9 Working capital management

The concept of cash conversion cycle (CCC) has been used as an indicator of working capital management. In fact, the cash conversion cycle is equal to the sum of the inventory turnover period (INV) and the receivables collection period (AR) minus the debt payment period (AP), which is presented in the following relationship;

$$CCC = AR + INV - AP \quad (3.8)$$

that each component of the relationship is measured as follows;

$(AR(365) \times \text{sales}/\text{accounts receivable}) = \text{receivables collection period.}$

$(INV(365) \times \text{cost of goods sold} / \text{inventory}) = \text{inventory turnover period commodity.}$

$(AP(365) \times \text{cost of goods sold} / \text{accounts payable}) = \text{debt payment period.}$

## 4 Related records

### 4.1 Internal records

Salimzadeh [18], compared statistical algorithms and machine learning to predict the financial performance of companies. He concluded that financial performance is one of the most important structures discussed in management researches and without a doubt it is considered the most important measure of success in commercial companies. In an economic enterprise whose goal is to increase the wealth of the owners, paying attention to the increase in profit provides the means to achieve the goal. Calculating financial performance means achieving organizational goals.

Pasha [16], used the probabilistic approach to improve the prediction of financial performance of companies. He explained that one of the challenging issues for investors and experts is the appropriate models for evaluating the financial status of companies. In this regard, many models have been derived by researchers using different financial ratios to solve these problems. However, choosing a model based on the conditions and needs of users is complicated. The results showed that environmental uncertainty and company size positively improve the power of predicting the company's financial performance, and business strategy and business competition do not improve the power of predicting the company's financial performance. Also, the statistical regression results showed that environmental uncertainty, business strategy and company size improve the power of predicting the company's financial performance. But commercial competition does not improve the predictive power of the model. The

Mohammadi Karizek [14], investigated the impact of new product strategy on company performance with the moderating role of CEO optimism. One of the main and at the same time most sensitive duties of a manager is to make a decision, so adopting methods that lead this process to the most ideal result will be of particular importance. With the passage of time, we are witnessing many transformations in various scientific fields, in such a way that neglecting these developments and new tools will ultimately cause uncertainty in decision-making. Therefore, management theorists try to equip decision makers with these new techniques and tools.

Motallebi [15], presented a model for predicting the performance of products by considering environmental and weather factors at the same time. The data of Amirkabir Sugarcane Cultivation and Industry Company in the period of 1389-1396, which includes 3223 samples, was used for the present research. For modeling, four algorithms of random forest machine learning, AdBoost, gradient boosting XGBoost and support vector machine have been used. Algorithms XGB and random forest with accuracy rate of 82.6% and 92.2% respectively for predicting the yield of sugarcane and extractable sugar have better ability to predict among the presented models.

Farshadi [6], analyzed the performance of insurance companies and predicting future performance: a combined approach of fuzzy TOPSIS and artificial neural networks. In the mentioned research, 13 indicators have been used to evaluate the performance, and the indicators have been used to measure the performance of the market in three dimensions: financial, human resources, and market. In the next step, the performance of the companies in the coming years has been predicted using the neural network. In the results of the research, the index of the number of agencies to the total number of insurance agencies has been selected as the most important performance evaluation index. The results of the neural network prediction also showed that if the current trend among the investigated companies continues in the coming years, the statistical population under study will have a better situation than It will be found in the past and the general trend of the investigated insurance companies is growing.

## 4.2 Foreign records

Ashtiani and Raahmei [1], dealt with intelligent prediction of performance based on financial market news using text mining and machine learning. They learned to predict the financial market by analyzing textual data (such as news articles and social media) and numerical data (such as hourly stock prices and moving averages). Among textual data, while many articles have been published analyzing social media, news content has received limited attention in predicting financial performance. On the other hand, the results showed that collecting news data can be costly and time-consuming, however, financial news databases are available that can significantly facilitate news gathering. Also, the results showed that regression and gradient increase models have been developed for financial performance in the last four years.

Yolcu and Yolcu [23], presented a new intuitive fuzzy time series forecasting model with a cascade structure for financial time series. They found that financial time series forecasting problems are always critical for decision makers because they have a wide range of applications in the public and private sectors. In this thesis; The proposed forecasting model had the ability to jointly and simultaneously model linear and non-linear relationships in financial time series. Therefore, it was able to adapt to both linear and non-linear levels of data and can produce satisfactory forecasts for financial time series. The results were evaluated in terms of RMSE, MAPE and MDRAE criteria and some other points of view, and the proposed forecasting model achieved an improvement in forecasting performance of about 60%.

Vogl et al. [20], discussed financial performance prediction based on wavelet neural networks and other neural network topologies. In this study, the beneficial effects of neural networks in combination with wavelet functions on the performance of financial market forecasts were analyzed. In this way; Different approaches were implemented in several experiments and their forecasting abilities were tested with different financial time series. The results showed that both wavelet neural networks and neural networks with data preprocessed by wavelets outperform classical network topologies. However, it was also concluded that the accuracy of the predictions made in the implementation of neural network algorithms still suggests the potential for further refinement and improvement.

Yang and Wang [22], forecast financial performance based on hybrid wavelet neural network by analyzing the empirical state of the financial group and evaluating MCID. Considering the characteristics of nonlinear data and the influence of historical data, this paper combines the ensemble empirical mode decomposition (EEMD) into the wavelet neural network with random effective time (WNNRT) to develop a hybrid neural network prediction model to improve the energy prediction accuracy. . The financial performance based on the EEMD method is a noise-assisted data analysis method, because it can effectively suppress pattern confusion and recover the essence of the signal; On the other hand, different from traditional models, effective stochastic time function, which takes into account the timeliness of historical data and the random change of the market environment, is applied to the wavelet neural network to create the WNNRT model. Is.

Peng et al. [17], selected features and deep neural networks to predict the direction of financial performance using technical analysis indicators. In this research; A set of 124 technical analysis indicators were examined and as explanatory variables; Specialized commercial websites and literature have been used. In this way, three feature selection methods are used to shrink the set of features with the aim of removing redundant information from similar indexes, and using daily data from the stocks of seven global market indexes between 2008 and 2019, neural networks with different settings of hidden layers and Dropout rate was tested. The results showed that the variables were not uniformly selected by the feature selection algorithms and the out-of-sample prediction accuracy converged to two values. It was also concluded that the strategies' profitability could not significantly outperform the buy-and-hold strategy, even showing relatively large negative values for some meta-parameter combinations.

Hypothesis 1: The firefly algorithm is effective in predicting the ratio of cytochrome.

Hypothesis 2: The genetic algorithm is effective in predicting the ratio of cytochrome.

Hypothesis 3: The evolutionary algorithm is effective in predicting the ratio of cytochrome.

Hypothesis 4: The firefly algorithm has a higher ability to predict the ratio of cytochrome compared to the genetic algorithm and the combined algorithm.

## 5 Variables

### 5.1 Input variables

The first group: based on the factor of financial statements: financial statements are the result of the accounting process and one of the sources of information that external users such as investors and creditors use in their analysis.

Among all the information available to the public, rational investors rely on the company's financial reports and disclosures to assess risk and return and determine the company's value. High-quality accounting information is a necessary condition for the healthy functioning of financial and economic markets and is very important for investors, lenders, companies and developers of accounting standards. Many researches in recent years have shown that financial statement items play an important role in the formation of stock market value. In this regard, some studies have pointed out the relationship between stock returns and financial statement items such as book value of assets, net profit, operating cash flow, debt to equity ratio, operating profit and accruals. Also, some others have mentioned the market's reaction to dividends. Therefore, in this research, net profit, operating profit, net operating cash flow, accruals, dividend and debt ratio will be considered as effective factors in predicting the performance of companies.

The second group: based on corporate governance mechanisms: corporate governance is considered one of the important aspects of business and has received much attention in recent years. Corporate governance is a mechanism based on which companies are managed and controlled. Among the effective corporate governance mechanisms are non-commissioned members of the board of directors, independent members of the board of directors, audit committee, appointment committee, risk committee, institutional investors, major shareholders, voting rights of shareholders in controlling the company, family ownership and state ownership. The conducted researches have shown that establishing a management system in the company is of special importance for investors and causes the growth of the stock value. This platform system provides easier access to financial resources, lower capital cost and better performance for the beneficiaries. Therefore, in this research, the percentage of non-executive members of the board of directors, the percentage of ownership by institutional shareholders, family ownership, ownership of non-governmental public institutions, government ownership and government institutions will be considered effective factors in predicting the performance of companies.

The third group: based on the disclosure quality factor: one of the most important reasons for the occurrence of financial crises in national and international markets is the presence of non-transparent and insufficient financial information. Therefore, one of the most important concerns of investors is clarifying information to improve the competitive environment, changing business conditions, credibility and level of acceptability of companies, and it is of special importance for them. Empirical studies on disclosure have shown that increasing public information increases the company's value by reducing the company's cost of capital or increasing the company's cash flows or both. Also, the type of disclosure (voluntary disclosure or mandatory disclosure) can also be considered important in the analysis of the company's shares. One of the most important criteria for the quality of financial information disclosure is its timeliness and reliability. Therefore, in this research, the reliability of information and the timeliness of information will be considered as effective factors in predicting the performance of companies.

## 5.2 The dependent variable

### 5.2.1 Cytobin ratio

Cytobin ratio can be calculated from the following equation:

$$Q_{i,t} = \frac{\text{COMVAL} + \text{SBOND} + \text{STDEPT}}{\text{SRC}}. \quad (5.1)$$

In this regard:

Qit: Qotubin ratio, COMVAL: market value of common stock, SBOND: book value of long-term liabilities, STDEPT: book value of short-term liabilities and SRC: book value of bank assets.

## 6 Research methodology

The current research method is of applied type, in terms of the way of doing the work, it is of descriptive-causal type of research and in terms of time dimension, it is of post-event type of research. At first, by referring to databases such as thesis, articles and similar researches, the required literature is collected in order to write the theoretical foundations and background of the research. In the following, the information of the investigated companies selected as a statistical sample, whose information is available in the form of data banks on compact discs and is under the supervision and review of the responsible institutions, will be collected by referring to the audited financial statements and the new Rahvard software. became. In the next step, after compiling the literature related to the theoretical foundations and background of the research, by referring to related databases and previous researches; The necessary information to measure the defined variables will be collected by referring to the audited financial statements and

the new Rahvard software. In the following, using the defined relationships and Excel software, we will calculate the variables mathematically and finally, the calculations will be entered into the software and we will test the developed hypotheses using econometric techniques.

### 6.1 Society and the statistical sample of the research

The statistical population of this research includes all the companies accepted in the Tehran Stock Exchange for a period of ten years (from the beginning of 2011 to the end of 2014). In this study, in order for the research sample to be a suitable representative of the desired statistical population, the screening (elimination) method was used to select the sample. For this purpose, the following criteria have been taken into consideration and if a company has met all the criteria, it has been selected as one of the sample companies. In this way; The statistical population has been adjusted using the following restrictions:

1. Ten-year membership of sample companies (during 2012-2021) in Tehran Stock Exchange.
2. Having a financial year ending at the end of March 29.
3. Having enough financial information to measure the defined variables.
4. Not changing the financial year,
5. Lack of activity in the field of banks and other financial institutions, investment and mediation companies, holding and leasing.

### 6.2 The selection method of the screened statistical population

Table 1: The selection method of the screened statistical population

498	All companies admitted to Tehran Stock Exchange from the beginning to the end of 2021
81	Companies whose financial year does not end at the end of March every year.
76	Companies that have not maintained their ten-year membership in the stock exchange.
83	Companies whose financial information was not enough to measure the variables.
74	Companies that have changed their financial year in the period under review.
77	Companies that were among banks and credit institutions, mediation, insurance and holding.
391	All companies that were not eligible for sampling.
107	The selection method of the screened statistical population

## 7 Predictive patterns

### 7.1 Data analysis

Data mining is the concept of extracting hidden information or specific patterns and relationships in a large amount of data in one or more large databases. The philosophy of data mining is that the future is very similar to the past. If you know the past well, you can predict the future. Data mining analyzes databases and massive data sets in order to discover and extract knowledge.

### 7.2 Features of data mining

Data mining refers to the use of data analysis tools in order to discover valid patterns and relationships that have been unknown until now. These tools may be statistical models, mathematical algorithms, and learning methods that improve their work automatically based on experience gained through neural networks or decision trees. Data mining is not limited to data collection and management and includes information analysis and prediction.

### 7.3 Data mining algorithms

Data mining techniques include various algorithms, some of which will be used in this research as follows:



### 7.3.1 Firefly algorithm

Firefly Algorithm or Firefly Algorithm (abbreviated as FA) was introduced in late 2007 by Xin-She Yang [21], whose main idea is inspired by optical communication between fireflies. This algorithm can be seen as a manifestation of swarm intelligence, in which a higher level of intelligence is created from the cooperation of simple and low-intelligence members, which definitely cannot be achieved by any of the components. The FA algorithm is a meta-heuristic algorithm, inspired by the behaviors of artificial fireflies. This algorithm is formulated with the following hypothesis:

All fireflies are sexual, so that one firefly attracts all other fireflies. Attraction is proportional to its brightness, and for both fireflies the less bright one will attract (and therefore move) the brighter one, however, the wand's brightness will increase or decrease as their distance. If there is a firefly brighter than the given firefly, it will move it randomly. Lighting should be related to the objective function.

The FA algorithm looks for the optimal solution by modeling the behavior of a set of fireflies and assigning a value related to the fitness of the location of each firefly as a model for the amount of firefly pigments and updating the location of the fireflies in successive iterations of the algorithm. In fact, the two main steps of the algorithm in each iteration are the pigment updating phase and the movement phase. Fireflies move towards other more pigmented fireflies in their neighborhood. In this way, during successive iterations, the collection tends towards a better answer.

#### The first phase is to update the pigment

The FA algorithm starts by randomly placing a population of  $n$  members of fireflies in different points of the search space of the optimization problem. Initially, all worms have the same amount of luciferin (light-producing substance) as  $L$ . Each iteration of the algorithm includes one phase of updating Luciferin and one phase of updating the location of worms.

$$l_i(t) = (1 - \rho) l_i(t - 1) + \gamma J(x_i(t)) \quad (7.1)$$

where  $l_i(t)$ ,  $l_i(t-1)$ ,  $J(x_i(t))$  are, respectively, the new value of luciferin, the previous value of luciferin and the fitness of the location of worm  $i$  in iteration  $t$  of the algorithm, and  $\rho$  and  $\gamma$  are constant numbers to model the gradual decline and effect of fitness on Lucy Frain.

#### The second phase of movement

During the movement phase, each worm probabilistically moves towards one of its neighbors with a higher lucy ferrin. In this way, the worms move towards the neighbors with more brightness. In the figure below, a representation of neighborhoods, the concepts of decision radius and sensing radius of worms can be seen.

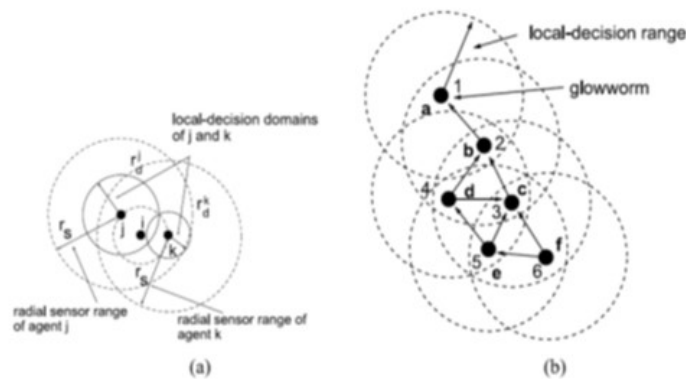


Figure 1: Representation of neighborhoods, the concepts of decision radius and sensing radius of worms

In part b of this figure, the worms are ranked by the amount of luciferin, with worm number 1 being the most luminous. The decision radius  $r_d$  actually specifies the range in which the worms in the neighboring range are compared for the level of luciferin with the target worm. The sensing radius  $r_s$  specifies the upper limit for the decision radius. In fact, during the iterations of the FA algorithm, the decision radius of the worms changes depending on the conditions they are in; But in any case, the decision radius of each worm does not exceed its sensing radius. The sensing radius models the maximum ability of worms to observe other worms.

In Figure (1), fireflies a, b, c, d have more luciferin than firefly e, but firefly e is only within the observation range of fireflies c and d, and therefore there are two possible directions to choose in order to move towards the firefly. It is

brighter ahead. For each firefly  $i$ , the probability of moving to the brighter neighbor  $j$  is defined as follows:

$$p_{ij}(t) = \frac{\ell_j(t) - \ell_i(t)}{\sum_{k \in N_i(t)} \ell_k(t) - \ell_i(t)}. \quad (7.2)$$

In this regard,  $(N_i(t))$  is the set of fireflies neighboring firefly  $i$  at time  $(t)$ ,  $d_{ij}(t)$  is the Euclidean distance between fireflies  $i$  and  $j$  at time  $t$  and  $(r_{di}(t))$  represents the variable neighborhood range related to firefly  $i$  at time  $t$ . Assuming that firefly  $j$  is selected by firefly  $i$  (with probability  $p$  obtained from the above equation), the discrete-time motion equation of the firefly can be written as follows:

#### Time-discrete equation of motion of the firefly

$$x_i(t+1) = x_i(t) + s \left( \frac{x_j(t) - x_i(t)}{\|x_j(t) - x_i(t)\|} \right) \quad (7.3)$$

where  $x_i(t)$  is the  $m$ -dimensional vector of the location of firefly  $i$  at time  $t$ ,  $\| \cdot \|$  represents the smooth Euclidean operator and  $s$  is the step size of the movement.

### 7.3.2 Genetic algorithm

The basic principles of genetic algorithm were first invented by John Holland [9], at the University of Michigan and the concepts of genetic algorithm were developed by Goldberg et al. [8]. Genetic algorithm is a probabilistic search method that uses biological and natural evolutionary simulation. Genetic algorithms operate by using the principle of survival of the fittest to generate the best estimates of an answer on a population of potential answers. In each generation, a set of estimates is created by the process of selecting individuals according to their fitness level in the problem domain and breeding them together using operators taken from natural genetics. This process leads us to the evolution of populations of individuals who are better adapted to their respective environments than their parents.

#### The general structure of the genetic algorithm

The general structure of the genetic algorithm is as follows:

- a) Gene and Chromosome: Gene is the smallest building block of the genetic algorithm. In fact, genes are parameters to show the coded form. A string of genes is called a chromosome. In this research, each chromosome is an answer to a problem that can be justified or unjustified.
- b) Population: a set of chromosomes is called a population. One of the characteristics of the genetic algorithm is that instead of focusing on a point of the search space or a chromosome, it works on a population of chromosomes.
- c) Suitability (objective) function: The objective function is used to determine how people play a role within the scope of the problem.
- d) Genetic operators: To produce new chromosomes (children) through some old chromosomes, we need a series of operators, which we will discuss further.

**Intersection operator:** The intersection operator is applied to two chromosomes at one time and creates two children by combining the structure of two chromosomes. An important concept related to this operator is the intersection rate. Crossover rate is defined as the ratio of the number of offspring produced in each generation to the size of the original population.

**Mutation operator:** In the course of natural evolution, mutation is a random process in which the content of one gene is replaced by another gene to produce a new genetic structure. The role of mutation is often as a guarantee that the probability of searching the string never becomes zero.

**Generation:** Each iteration of the algorithm that leads to the creation of a new population is called a generation.

### 7.3.3 Multiple diagnosis pattern

Multiple diagnostic analysis is a combination of two or more independent variables that best shows the difference between two groups. This issue is done by maximizing the variance between groups compared to the variance within the groups based on a statistical decision rule, which is the ratio of the variance between groups to the variance within the groups. Therefore, when we have a hypothesis that the means of two or multiple groups are equal, multiple diagnostic analysis can be used to test it. For this, the diagnostic analysis technique multiplies each independent variable by its weight and adds them together. The obtained result is actually a composite difference (diagnosis) for

each of the observations included in the analysis. By calculating the average of the differences of all people in a group, the average of the above group is obtained. will be the average of the opinion group. The comparison of the center of gravity of the groups also shows that each position is actually considered as a center of gravity. The center of gravity indicates the specific position of each person in relation to the group in relation to the dimensions under investigation.

### 7.3.4 Evolutionary Algorithms

Evolutionary algorithms include a fitness function (cost) and try to optimize this fitness function by searching for different points from the set of possible solutions in each neighborhood of the iteration; Genetic algorithm and artificial bee colony algorithm are examples of this type of algorithms.

The first step will be to transform the research variables in a way that can be processed by the hybrid evolutionary algorithm (ABC-GA) (Data Transformation). The inputs of the proposed algorithm include independent variables for the year  $t$  and dependent variables for the year  $t+$ , so that the independent variables of the neural network inputs and the dependent variable are considered as the target label of the multilayer neural network (MLP). It is worth mentioning that every time the effective features are randomly selected, these features are trained in the cost function of the proposed algorithm by the neural network and its mean square error (MSE) is calculated and returned to the proposed algorithm as the value of the cost function. .

In this research, we try to find the most effective top features in a way that does not have a significant impact on the prediction performance of the systems, but at the same time, the prediction speed also increases.

Feature selection is one of the problems that is used in various fields and no definitive solution has been provided for it. But we can turn feature selection into an optimization problem and entrust its solution to an intelligent algorithm and somehow use intelligent systems to solve this difficult problem. In general, feature selection is an optimization problem, because we are looking for a series of features from a set of features, in a way that satisfies a goal. Reducing the specificity can lead to reducing the costs of predicting the performance of companies.

The evaluation criterion, the average absolute error, is calculated from the following equation:

$$\text{MSE} = \frac{1}{N} \sum_{i=1}^N e^2 \quad (7.4)$$

which in the above relation:  $N$  is the number of inputs of the neural network and  $e$  is equal to the error resulting from the difference between the absolute value of the target and the output of the neural network. Artificial bee colony algorithm is an optimization algorithm based on collective intelligence and intelligent bee population behavior. which was first developed in 2005. This algorithm simulates the foraging behavior of bee groups. The initial version of this algorithm performs a type of local search that is combined with random (random) search and can be used for combined optimization with functional optimization. However, despite the great power of this algorithm in searching for optimal solutions, after searching for some time, it may get stuck in a local minimum, and in this way, the algorithm converges and fails to find more optimal solutions, and this point, when the speed of finding the optimal solution by adjusting the relevant parameters, it shows itself more. The genetic algorithm uses one of the advanced biology techniques such as inheritance and mutation, and it can come with the help of the artificial bee colony algorithm when the artificial bee algorithm gets stuck in the local minimum and have the chance to search for other points of the set of optimal possible solutions. be Therefore, we use the combination of two artificial bee colony algorithms and genetics to detect the number of features and select the best features.

## 8 Research findings

### 8.1 Prediction of cytochrome ratio using firefly algorithm

At first, we introduce the network input data including independent variables to the network. The neural network model consists of two stages.

- 1- Education and learning
- 2-Testing weights and error calculation

Based on the firefly model, we define 70%  $x$  in the input and output layers. The network defines a set of weights by using training and artificial intelligence, and in the next step, these weights are combined with the remaining 30% of  $x$ 's; It tests and obtains the ratio of cytochrome and the test is done to determine how close the predicted value is to

the reality and to calculate the error. The action network has done the training until it reaches the optimal point of training (the optimal point of training is the level of training where the network was able to estimate the best weights using training and learning). When we test the weights with 30% of the remaining  $x$ 's; The predicted values have the least difference with the reality. In order to prevent the network from being over-trained, a number of repetitions are gradually trained and then tested with the data to find at least a few errors on the page, and the lowest of these is considered as the optimal training of the network. It is selected based on them. After training in different times, the best training is selected. Here, 55 times the training was done, and in the 47th time, the learning was better than the next times. So set 47 is selected as network learning.

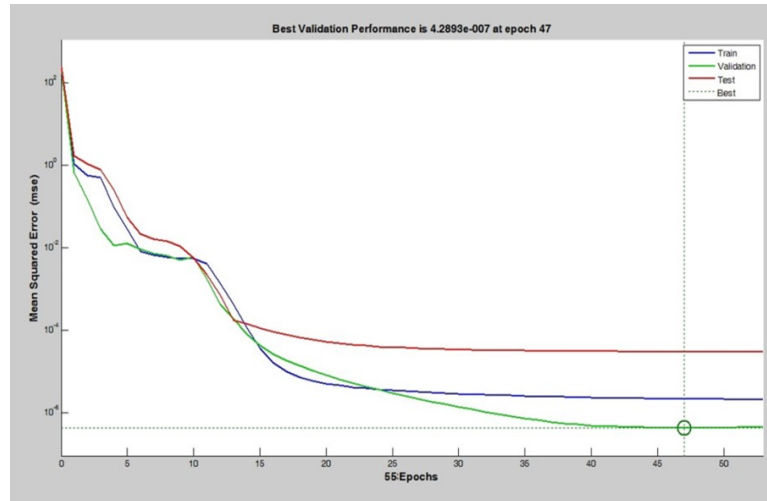


Figure 2: Neural network training diagram of firefly algorithm

The optimal amount of teaching in learning is given in the form of a diagram. The goodness of their fit has also been determined and the input and target data have been matched. The results of neural network training are network weights that sit on the communication lines between neurons and other components, both input and output.

The results of neural network training are network weights that sit on the communication lines between neurons and other components (both input and output). The weights between the input layer and the hidden layer are listed in the corresponding table. According to the table of weights, it is possible to predict the ratio of cytoxin using the firefly algorithm. The graph above shows the prediction of the network based on the input data and comparing them with the actual values. The red graph (left) is the prediction with the neural network, and the blue graph (right) is the color of the actual values.

## 8.2 Prediction of cytoxin ratio using genetic algorithm

First, using the text toolbox; We design the neural network framework. We also introduce the input data of the network, which includes independent variables, to the network and specify it for it. Now training should be done using this network toolbox. Network training is done using genetic algorithm. The neural network model consists of two stages.

- 1- Education and learning
- 2-Testing weights and error calculation

Based on the genetic model, we define 70% of  $x$  and  $y$  (cytoxin ratio) in the input and output layers. The network defines some weights by using training and artificial intelligence, and in the next step, it tests these weights with the remaining 30% of  $x$ 's (independent variables) and obtains the Qotubin ratio and tests it to determine How close the predicted value is to reality and calculate the error. The network has done the training until it reaches the optimal point of training (the optimal point of training is the level of training where the network was able to estimate the best weights using training and learning). When we test the weights with the remaining 30% of the  $x$ 's, the predicted values have the least difference with the reality. In order to prevent the network from being over-trained, a number of repetitions are gradually trained and then tested with the data to find at least a few errors on the page, and the lowest of these is considered as the optimal training of the network. It is selected based on them.

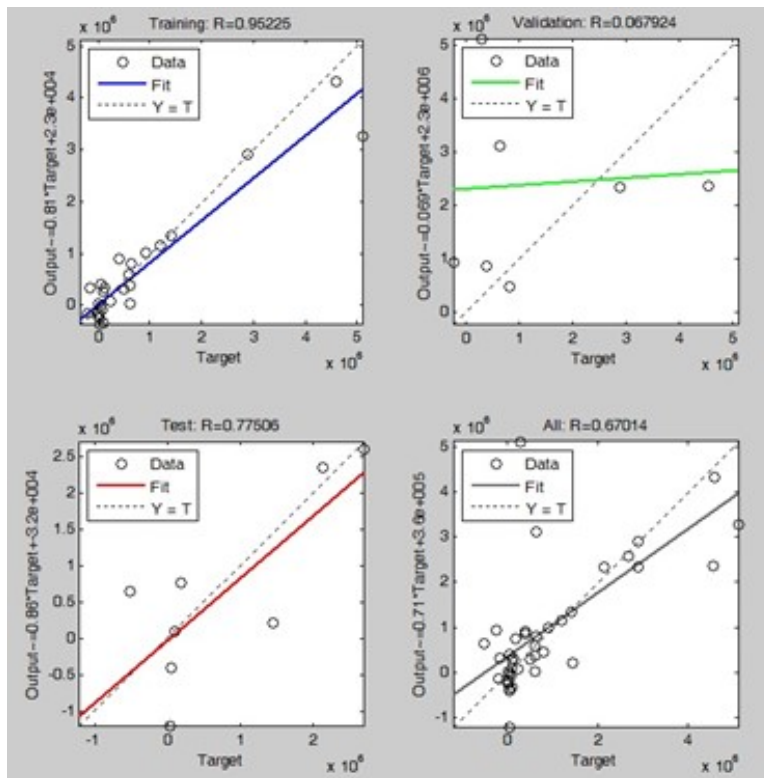


Figure 3: Neural network training diagram

After training in different times, the best training is selected. Here, 26 times the training was done, which was better in the 10th order than the next times. So set 10 is selected as network learning.

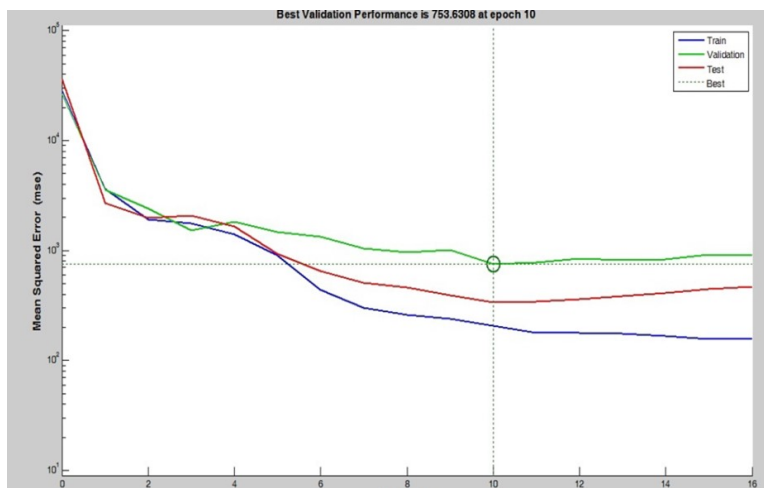


Figure 4: Genetic Algorithm neural network training diagram

The optimal amount of teaching in learning is given in the form of a diagram. The goodness of their fit has also been determined and the input and target data have been matched. The results of neural network training are network weights that sit on the communication lines between neurons and other components, both input and output.

The optimal amount of teaching in learning is given in the form of a diagram. The goodness of their fit has also been determined and the input and target data have been matched. The results of neural network training are network weights that sit on the communication lines between neurons and other components, both input and output. The weights between the input layer and the hidden layer are listed in the mentioned table. According to the weight table, it is possible to predict the ratio of cytoxin using genetics. The graph above shows the prediction of the network based

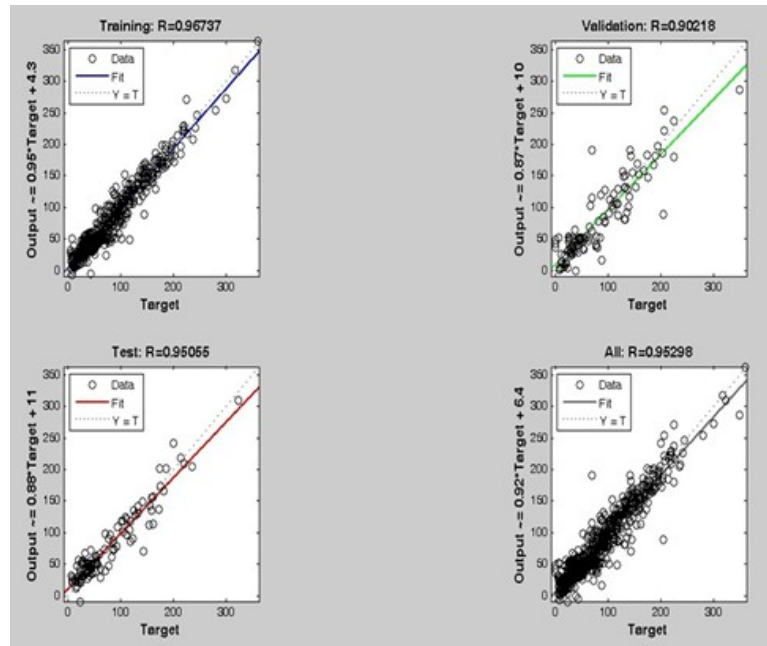


Figure 5: Genetic Algorithm neural network training diagram

on the input data and comparing them with the actual values. The red graph (left) is the neural network prediction and the blue graph (right) is the actual values.

### 8.3 Prediction of cytotobin ratio using hybrid model

First, using the text tool; We design the neural network framework. We also introduce the network input data to the network and specify it for it. Based on the combined pattern, we define 70% of  $x$  and  $y$  (kitobin ratio) in input and output layers. The network defines some weights by using training and artificial intelligence, and in the next step, it tests these weights with the remaining 30% of  $x$ 's (independent variables) and obtains the Qotubin ratio and tests it to determine How close the predicted value is to reality and calculate the error. The network has done the training until it reaches the optimal point of training, (the optimal point of training is a level of training where the network was able to estimate the best weights using training and learning). When we test the weights with the remaining 30% of the  $x$ 's, the predicted values have the least difference with the reality. In order to prevent the network from being over-trained, a number of repetitions are gradually trained and then tested with the data to find at least a few errors on the page, and the lowest of these is considered as the optimal training of the network. It is selected based on them. After training in different times, the best training is selected. Here, 55 times the training was done, which was better in the 19th order than the next times. So set 19 is selected as network learning.

The optimal amount of teaching in learning is given in the form of a diagram. The goodness of their fit has also been determined and the input and target data have been matched. The results of neural network training are network weights that sit on the communication lines between neurons and other components, both input and output.

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In order to get better and more specific results, first the real values were compared with the predicted values in all three models and they are summarized in the following table:

The results of the above table show that the firefly algorithm has a higher ability to predict the ratio of cytotobin compared to the genetic algorithm and the combined algorithm.

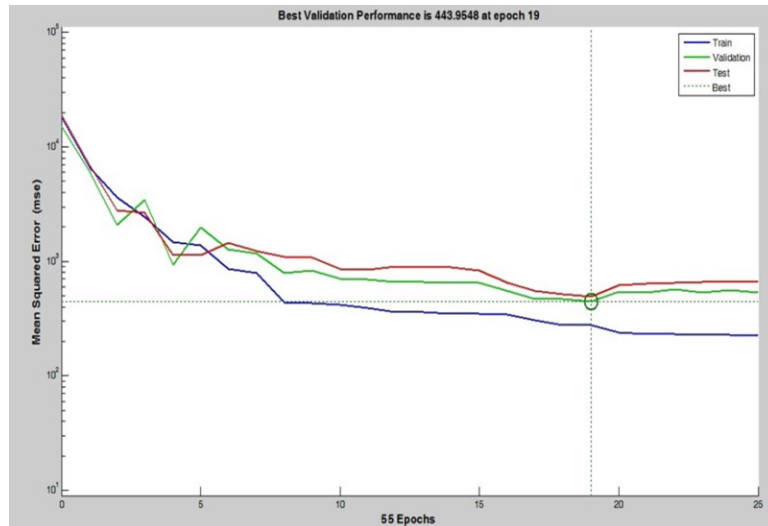


Figure 6: Combined pattern neural network training diagram

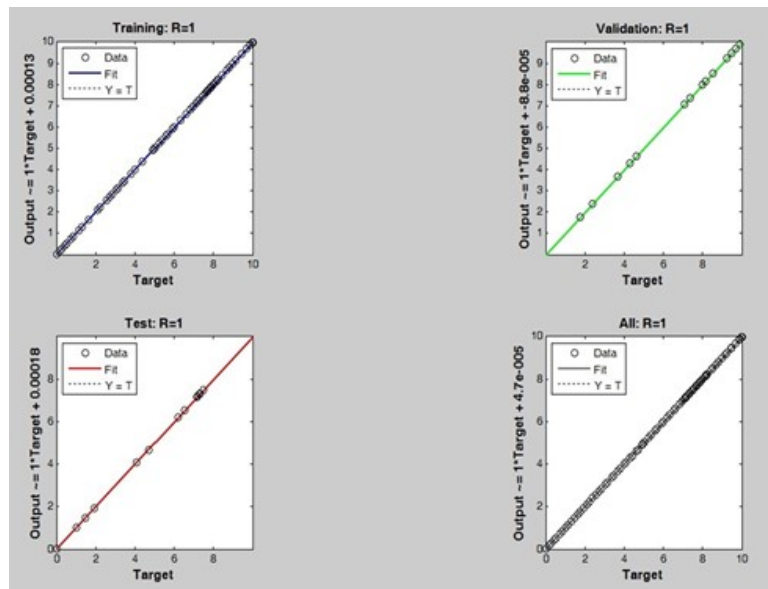


Figure 7: Combined pattern neural network training diagram

Table 2: Summary of neural network results

Variable	Real	Firefly algorithm	Genetic algorithm	Hybrid algorithm
Cytobin ratio	-0.999	-0.251	0.414	0.546

## 9 Analysis of findings

The need of organizations to adapt to today’s dynamic and complex business environment, in order to continue to survive, which is caused by the development of competitive markets, on the one hand, and the pressure of investor associations on managers to determine the value and explain accurate and transparent measurement criteria, on the other hand, caused companies to develop systems Review and re-examine traditional reward and performance appraisals; Whether they were a correct and reliable basis for decision-making or not? Currently, performance measurement techniques are based on economic theories rather than accounting principles. It should be noted that the development of capital markets has increased the pressure on companies for better performance by increasing the awareness of shareholders. Company managers are currently facing an era that requires them to establish a new economic framework in their companies, which better reflects value and profitability. As the owners of the business

unit, the shareholders seek to increase their wealth, considering that the increase in wealth is the result of the optimal performance of the business unit, the valuation of the business unit is very important for the owners. On the other hand, the lack of a proper method to evaluate the financial performance of different listed companies makes investors unable to distinguish efficient companies from non-efficient ones, and as a result, they randomly invest in companies' shares. Obviously, this increases the investment risk to a great extent and also causes a part of the financial resources to be transferred to ineffective activities. On the other hand, if there is no proper evaluation of the company's performance, company managers cannot identify their strengths and weaknesses, and as a result, the movement towards the anticipated goals becomes slow or even impossible. Performance is considered as a subjective measure that shows how well a company can use its initial business assets and generate revenue. The term is also used as a general measure of a company's overall financial health over a given period. Analysts and investors use financial performance to compare similar companies in the same industry or to compare industries or sectors as a whole. Investors make decisions about whether to buy or sell a company's stocks and bonds based on financial performance information, but investors aren't the only ones who care about financial performance. Managers use this information to determine how to allocate company resources, analysts use financial performance data to forecast future earnings and growth, lenders use this information to assess a company's creditworthiness. Forecasting and reasonable evaluation of the future financial performance of business units is one of the important elements in making investment decisions, and financial management experts around the world are thinking of providing models to predict financial performance.

## 10 Suggestions

### 10.1 A suggestion based on the findings

It is suggested to the managers of business units that through the precise determination of the strategic goals of the business and informing and organizing all the business departments for their role in achieving the goals, aligning the resources of the organization in order to achieve the strategic goals, changing the corporate and managerial structure. In order for the organization to grow permanently and sustainably, optimize business costs and increase productivity, have an effective marketing and sales strategy, redesign and optimize processes and operations in line with strategic goals, employ qualified employees for strategic goals, 360-degree performance evaluation and Business moment, recognizing possible deviations of the organization from the goals using performance measurement tools, appropriate reaction to the opportunities and threats ahead, focusing on the future and business goals instead of dealing with the day-to-day issues of the organization and developing the manager and leader of the organization into a world-class manager. Provide areas for improving financial performance.

Investors and stock market participants are suggested to rank their investment target companies based on their financial performance and invest in units that are at a high level in terms of said performance; Because according to this, in such units; The probability of success of investment activities is at a favorable level and this can facilitate successful investment activities.

It is suggested to the standardization authorities to develop specific, codified and enforceable standards for correct measurement of financial performance.

### 10.2 Future offers

1. Explaining the optimal model for predicting the performance of companies using data mining techniques in the life cycle of companies.
2. Explaining the optimal model for predicting the performance of companies using data mining techniques during the business cycle.
3. Explaining the optimal model for predicting the performance of companies using data mining techniques in the period of record and economic prosperity.

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