Research Paper

A Mathematical Model to Predict Corporate Bankruptcy Using Financial, Managerial and Economic Variables and Compare it with Other Models

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ABSTRACT

Bankruptcy prediction plays a pivotal role in aiding investors in their decision-making processes and resource allocation. While numerous studies have explored bankruptcy prediction, most have predominantly relied on financial ratios. Nevertheless, in the Iranian context, numerous non-financial factors exert significant influence on bankruptcy. This study aims to construct a comprehensive mathematical model that incorporates both financial and non-financial indicators, including management and economic factors, to enhance bankruptcy prediction accuracy. To achieve this goal, we selected 44 variables with the most substantial impact on bankruptcy forecasting. We developed a questionnaire through confirmatory factor analysis and distributed it to experts in the fields of management, accounting, and economics for ranking the influence of these variables. Our statistical sample encompassed 200 companies, both bankrupt and non-bankrupt, listed on the Tehran Stock Exchange from 2009 to 2018.

Upon collecting and analyzing the questionnaires using the Ordinary Least Squares (OLS) regression estimation method, variables with factor loads below 0.5 were excluded. The final model retained 9 key variables: Retained earnings to total assets, working capital to total assets, equity to total liabilities, retained earnings to total capital, net income to sales, total liabilities to total assets, corporate governance, social capital, and currency fluctuations. Utilizing regression analysis in Eviews, we generated 52 model outputs, further processed in Excel. The optimal output was selected as the research model, successfully identifying 95% of bankrupt companies and 93% of non-bankrupt companies with a confidence level of 95.4%. To validate our findings, we formulated two hypotheses and compared our research model to two existing models. Our proposed model exhibited a 6% higher accuracy in distinguishing bankrupt from non-bankrupt companies compared to the Pourheidari et al. model and a 9.4% improvement over Altman's model.

1 Introduction

Bankruptcy occurs when a company's debts exceed the market value of the company's assets. [13]. All stakeholders are interested in assessing a company's financial condition, because bankruptcy incurs high costs for them [1]. Bankruptcy is a vent that greatly affects management, shareholders, employees,

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creditors, customers and other stakeholders. Corporate bankruptcy therefore challenges even the country both socially and economically [3]. Preliminary studies in the field of bankruptcy prediction have mostly focused on linear methods such as multiple analysis models, logit and probit. [22]. Since he capital market in Iran is young and is not considered as an efficient market, scientific research can provide a theoretical framework for this market so that the information published by the Tehran Stock Exchange is useful in the decisions of capital owners and potential investors. Therefore, it is necessary to provide useful decision-making tools for information users. One of them are mathematical models of bankruptcy prediction. In this study, a mathematical model for predicting corporate bankruptcy is proposed. In recent years, different methods have been used based on artificial intelligence and data-mining techniques such as neural networks, genetic algorithms and systems intelligent. This is because of their ability to extract useful information from large amounts of data, as well as their lack of limiting assumptions, such as linear assumptions, and the normality of input variables in linear methods that impair the effectiveness and validity of predictions [8].

Many variables can be considered for bankruptcy prediction. For example, we can mention to corporate governance and intellectual capital. Corporate governance is a set of internal and external mechanisms that strikes the right balance between equity holders on one hand and the needs and powers of the board of directors on the other. Weak corporate governance leads to increased likelihood of financial helplessness or bankruptcy in companies [16]. Given the role of intellectual capital in organizations, companies with richer intellectual capital can be expected to have smarter strategies to avoid bankruptcy. Given the prominent role of intellectual capital and its three components (human capital, structural capital and customer or communication capital) in the success of enterprises, this issue was examined and it was proved that intellectual capital is an effective factor in predicting bankruptcy [16]. Furthermore, given the role of intellectual capital in organizations, companies with richer intellectual capital can be expected to have smarter strategies to avoid bankruptcy [2].

One of the issues in predicting bankruptcy is the lack of knowledge of the variables affecting bankruptcy. Existence of too many variables have caused managers, creditors, researchers and other stakeholders to face many problems in identifying the most important indicators of bankruptcy. By recognizing the most important and effective factors on corporate bankruptcy prediction, the financial distresses can be predicted and necessary measures can be taken. For example, a manager might focus on liquidity ratios and believes that proper liquidity and debt ratios will prevent a company from going bankrupt. However, mismanagement, along with misguided government policies, could be the cause of corporate bankruptcy [17].

Therefore, the question of the present study is whether it is possible to develop a model for predicting bankruptcy with the help of non-financial factors (i.e., managerial, economic and political along with financial factors) with high level of reliability. Domestic and foreign models focus on financial ratios, regardless of whether they are statistically linear with data mining. However, these ratios are usually not accurate in Iran, due to the use of historical information and high inflation. Mandatory use of historical cost in preparing financial statements, including the balance sheet, has made the figures in the financial statements unrealistic, which makes financial ratios ineffective in predicting future events. This has rendered aforementioned models ineffective in Iran. On the other hand, political concerns in Iran have a great impact on the economic situation of companies. It would be a more suitable and practical model, if it takes into account all the factors that relates to Iran's environment. For example, the fluctuation of currency in Iran is extremely higher than most countries. A sudden change in any of these factors alone could cause a company to go bankrupt. Since these fluctuations are frequent, it is rational

to consider them in developing the desired model. The gap of previous research that has used mathematical models to predict bankruptcy is that, to the best of our knowledge, in all existing mathematical models, only financial variables are used to predict bankruptcy, and models with non-financial variables lack a mathematical formula. However, due to the special economic and political conditions of the country, neither financial nor non-financial factors alone can be a appropriate basis for predicting bankruptcy. In this study, an attempt was made to use other non-financial factors related to bankruptcy, such as inefficient management, corporate governance, intellectual capital, economic sanctions, currency devaluation, etc., in a mathematical model along with financial variables. Therefore, the innovative aspect of this research is enhancing the existing models which solely consider financial measures. To evaluate the effectiveness of our proposed model, the results were compared with a number of common bankruptcy prediction models that only use financial variables.

The remainder of this paper is organized as flows. First, the theoretical framework is explained. Then, literature review is presented. Next, research methodologies and findings are described. Finally, some concluding remarks have been presented.

2 Theoretical Frameworks

Bankruptcy has different definitions in scientific texts. The followings are some commercial and formal definitions. Bankruptcy occurs when a company's debt exceeds the market value of the company's assets [13]. When a company's rate of return is low and the company is unable to pay its debts, it is called a bankrupt company [20]. Bankruptcy is legally possible in two ways:

- Voluntary bankruptcy: in which the company files a lawsuit to file for bankruptcy.
- Compulsory bankruptcy: In compulsory bankruptcy, at least three creditors whose claims exceed a certain amount can file a lawsuit.

In this study, companies listed on the Tehran Stock Exchange have been selected as the statistical population. In the Tehran Stock Exchange, the criterion for bankruptcy and withdrawal of companies from the stock exchange is Article 141 of the Commercial Act. The issue of liquidation or survival of the company should be discussed. Whenever the said assembly does not vote to dissolve the company, it must reduce the company's capital to the amount of the existing capital in the same meeting and in compliance with the provisions of Article 6 of this law [19]. Bankruptcy of different companies throughout history has led different businesses to predict the performance of their company and, as a result, the possibility of its bankruptcy in the future; Because bankruptcy forecasting strengthens the company's ability to think about the necessary arrangements and allows the company to make changes commensurate with the situation to avoid financial hardship and bankruptcy. Since the 1960s, researchers have developed a variety of statistical and mathematical models for predicting corporate bankruptcy. The first model was the Beaver model in 1966, and two years later, Altman presented his bankruptcy prediction model based on differential analysis. Altman's model was the basis of research by various researchers, perhaps to improve the prediction accuracy of the pattern by making changes to the original pattern; However, hypotheses such as normality and variance similarity were among the limitations of these patterns. Later, people like Olson decided to overcome these limitations by introducing logistic regression; However, the accuracy of predicting such patterns was highly questionable. Because all of them used only financial ratios as an independent variable in predicting bankruptcy [20]. In the following section we describe some of the factors that we identified as potential determinants of corporate bankruptcy.

In addition to financial factors, many non-financial factors can affect the bankruptcy of companies. By studying previous literature over a period of 20 years, the most important non-financial factors affecting bankruptcy are corporate governance, earnings management, intellectual capital, currency and gold price fluctuations, inflation, and political factors such as economic sanctions. This study tries to account for all of these factors in developing a bankruptcy prediction model.

Corporate Governance: Corporate governance is a set of control mechanisms within the company that strikes the right balance between equity on the one hand and the needs and powers of the board on the other, and ultimately these mechanisms provide reasonable assurance to shareholders that their investment will be returned at a reasonable return [5]. In recent years, attention to the concept of corporate governance has been increased. Generally, five corporate governance mechanisms are used in academic research, including: audit report type, board remuneration, institutional ownership ratio, and board independence. Previous research shows a negative relationship between corporate governance and bankruptcy. In this research we use corporate governance as a variable to predict bankruptcy [18].

Intellectual capital: Intellectual capital includes all the processes and assets that are not normally and traditionally shown on the balance sheet and also includes those intangible assets (such as trademarks or trademarks and royalties) [1]. Intellectual capital is the sum of the knowledge of the members of an organization and its practical application. Considering the prominent role of intellectual capital and its three components (human capital, structural capital and customer relationship capital) in the success of enterprises, it can be concluded that this variable can be used to predict the bankruptcy of companies [1].

Currency fluctuations: Currency fluctuations are involved in disrupting the purchase of orders and supply of machines and machines in the production cycle, and the inflammation of the foreign exchange market provides the necessary basis for disrupting the production cycle and placing factories among the loss-making and bankrupt units. Bankruptcy does not always happen due to unfavorable economic situation, sometimes the advancement of technology and the backwardness of a production unit of modern technology causes bankruptcy in unfavorable economic conditions in the country such as sanctions, inflation and recession. Previously, it has increased and other factors such as excessive imports and disruptions in the banking and monetary system are also influencing the intensification of this process [25].

Financial ratios: Accounting and financial thinkers around the world have done a lot of research in this area. The unfavorable financial situation of companies causes losses for various groups, especially investors. It is very difficult to provide an independent definition of the groups involved in the bankruptcy issue [1]. But it can be argued that management, investors, creditors and legal entities are more affected by the phenomenon. They are fractured. Therefore, it is very important for investors to be aware of the risk of bankruptcy, because not only is the risk of losing their capital minimized, but it is also used as a tool to reduce the risk of their investment portfolio. Management can also take preventive measures to prevent bankruptcy if it is informed of the risk of bankruptcy in a timely manner. Because bankruptcy imposes heavy economic and social costs on society, it is also important from a macro perspective, because the resources wasted in a crisis-ridden economic unit could be diverted to other lucrative opportunities. Find [22]. In one of the first academic studies on bankruptcy theory, it was defined as the inability of a company to be profitable, which increases the likelihood of not being able to repay interest and debt principal [11]. It has financial, managerial and economic to provide the most accurate model to predict bankruptcy and gain the trust of investors, to maintain the dynamism of the

capital market and thus provide economic prosperity. In addition, the performance of this model will be compared with the model of Pourheidari, Altman z.

3 Literature Review

Chen [20] in a study entitled Bankruptcy Prediction in Companies with Statistical and Intelligent Techniques and Comparison of Evolutionary Computational Methods to Compare Some Traditional Statistical Methods for Bankruptcy Prediction with Some Methods "Unconventional" such as decision tree classification, neural networks, and evolutionary computation techniques, using data collected from 200 Taiwan Stock Exchange (TSEC) companies. Experimental experiments were performed using 42 ratios including 33 financial indicators, 8 non-financial indicators and 1 combined macroeconomic indicator using principal component analysis (PCA) method to extract appropriate variables. This article consists of two sections: (1) It is likely that 80% less financial ratios by PCA can provide accurate predictions of financial bankruptcy. (2) They showed that traditional statistical methods are able to manage big data to predict bankruptcy, while intelligent techniques perform better using smaller data and are influenced by big data.

Pirayesh et al. [27] studied five important models of bankruptcy prediction and among the variables of five models, presented an updated model of bankruptcy prediction that includes eight variables. The main issue of this research is that by studying and analyzing the financial statements of companies listed in the Iranian capital market, it can provide a model for predicting the bankruptcy of companies. In order to design the model, he used the information of two groups of companies listed on the Tehran Stock Exchange, the first group was non-bankrupt companies and the second group was bankrupt companies. In order to design a model of eight financial ratios including ratios: working capital on total assets, interest before profit and tax on total assets, total liabilities on total market value of assets, diversification factor, cumulative annual return, stock beta, price logarithm and Weighted value of Tehran Stock Exchange index and changes in net income were used. The test results related to the ability to predict the model showed that this model can provide a correct prediction of the crisis and bankruptcy two years before the occurrence of bankruptcy in companies. By distancing itself from the time of bankruptcy due to the weakening of bankruptcy predictors, the predictive power of the model is reduced. The forecast results were 93% for one year before bankruptcy and 38% for two years before bankruptcy.

Anvari Rostami et al. [2] explained the role of intellectual capital in reducing the probability of bankruptcy of companies and concluded that intellectual capital and its components have a significant inverse effect on the probability of bankruptcy of companies on the Tehran Stock Exchange.

Meshki Miyoghi and Hashemi Saadat, examined the relationship between intellectual capital and the probability of bankruptcy and concluded that of the 5 mechanisms of corporate governance, mechanisms of audit report type, board remuneration, institutional ownership ratio and board independence, there is a significant relationship with the probability of bankruptcy. There are negatives. Therefore, it can be used as a variable to predict bankruptcy [18].

Vazifehdoost and Zanganeh, proposed a new model for bankruptcy prediction which they named GA-GMDH. This model was designed to predict the bankruptcy of TSE listed companies. According to the results of the proposed model, it has a high capability in modeling bankruptcy prediction and comparison of the results of this model with and logistic regression model backed up their claim. The GA-GMDH model was combined with the correlation matrix variable selection method (CM-GA-GMDH). This model re-adjusts the set of financial ratios selected by the correlation matrix method, and finally the financial ratios of "interest before interest and tax on assets", "total liabilities on assets", "fast assets

to current liabilities", "interest expense on gross profit" as the predictors of the bankruptcy of companies operating in the Iran capital market [29]. Ahmadpour and Shahsavari, examined the factors affecting the risk of financial bankruptcy of companies and concluded that the risk of financial bankruptcy of the company is more affected by the country's economic conditions, financing policies, company size, type of industry and improving quality characteristics based on accounting information. And among these variables, economic variables have the most impact [26].

As can be seen, in most domestic studies, models from other countries have been used and less appropriate model has been employed. Although in most of them, financial variables have been used to predict bankruptcy, but a number of studies used non-financial variables such as corporate governance, earnings management, intellectual capital and economic factors in predicting bankruptcy. Therefore, the lack of a comprehensive model that uses all of these variables motivated us to consider all type of variables, including managerial and economic variables, as well as financial ones.

4 Research Methodology

This research can be categorized as applied research and in terms of nature and method, it is descriptive and correlational. To collect data and calculate research variables we used reported financial statements, taken from Codal database and the Tehran Stock Exchange website. Excel was used to calculate the variables and Eviews 8 was used to run the statistical tests. The statistical population of this study includes all companies active in the Tehran Stock Exchange. By applying the systematic elimination method, the statistical population was reduced to companies that were present in the ten-year realm from 2009 to 2018; They were non-financial and non-intermediate, they had joint financial courses and there were no long interruptions in their stock trading. By applying these criteria, a total of 200 companies were selected. These companies were divided into two categories of bankrupt and non-bankrupt companies according to Article 141 of the Commercial Act. From the thematic scope of this research, it examines the relevant variables in the field of bankruptcy forecasting model of companies accepted in the Iranian capital market. As a result, this research falls into the field of financial accounting. Given that the purpose of the research is to develop a bankruptcy prediction model for companies, the research regression model is as follows:

$$\mathbf{B} = \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4 + \beta_5 x_5 + \beta_6 x_6 + \beta_7 x_7 + \beta_8 x_8 + \beta_9 x_9$$

In these models, the dependent variable is bankruptcy, denoted by **B** (the first letter of the word bankruptcy) and to estimate it from 9 independent variables, including accumulated profit on total assets, working capital on total assets, equity on total liabilities, accumulated profit on total capital, net profit on sale. Total liabilities are applied to total assets, corporate governance, social capital, currency fluctuations, and the coefficient β for each variable will be calculated using the OLS regression estimation method.

4.1 Variables

In this analytical study, first the researches that had the keyword bankruptcy during a period of 20 years were identified and the variables that had the highest frequency in predicting bankruptcy were selected and then screened. Then, through Delphi analysis, the level of reliability of these variables in measuring bankruptcy was determined. After defining the subject and conducting exploratory studies and primary libraries and open (qualitative) interviews, the relevant factors and components through the Delphi

method, which is considered as a qualitative research method, by a research questionnaire including answers (range of 5 options). E-Likert and an open-ended question to add possible new components) reached the opinion of academic experts and professionals familiar with the subject, and after obtaining qualitative and quantitative corrective opinions (prioritizing factors) based on statistical methods, analysis and finally during Three rounds of model fit, components and factors have reached the elite consensus. Confirmatory factor analysis of each of the research variables was performed separately by SmartPLS 3 software for each variable to determine whether the data are consistent with a certain factor structure or not.

4.2 Consensus in the Delphi way

In this study, Kendall coordination coefficient was used to determine the degree of consensus among panel members. The Kendall Coordination Coefficient is a measure of the degree of coordination and agreement Among several categories of rank related to an object or person. In fact, by applying this scale A rank correlation can be found between K rank sets. The Kendall Coefficient of Coincidence shows that individuals who have 'sorted several categories by their importance' use essentially the same criteria to judge the importance of each category and agree with each other in this regard. This scale is calculated using the following formula:

$$w = \frac{s}{\frac{1}{12}k^2(N^3 - N)}$$

Where the sum of the squares of the deviations of the Rj from the mean of the Rj is obtained from the following formula:

$$2S = \sum(Rj - \frac{\sum Rj}{N})$$

Where: Rj = sum of ranks related to a factor; K = number of rank sets; N = is the number of ranked fact

4.2.1 Delphi Method Implementation Process

In this research, first the subject and its dimensions were defined. Then, by reviewing previous researches, effective factors on bankruptcy prediction were extracted from them. Based on the definition of the subject, required specializations were determined and Delphi panel members were identified and selected using non-probabilistic sampling methods. After determining panel members, Delphi method rounds were performed. Questionnaires for each round were distributed and collected online. In the first round, a list of factors affecting bankruptcy predictions extracted from previous research was provided to respondents to determine their importance in companies listed on the Iranian capital market.
In addition, they were asked to comment on other factors influencing bankruptcy forecasts that are not on the list. In the second round, the set of factors proposed in the first round, along with the primary factors extracted from research literature, were provided to determine their importance. In the third round, members' views on factors whose importance was recognized as high and very high in the first and second rounds were received again. The Delphi method was completed after the third round and the achievement of desired consensus. "Low impact", "very low impact". In each round, in front of each

factor, the average answers of the panel members in the previous rounds and previous answers of each person were reported to the respondents separately.

4.2.2 Findings of Delphi Method Implementation

Round one: In this round, panel members identified many of factors extracted from previous research as having a very, very large impact on model design. After removing same factors, 83 factors affecting the bankruptcy prediction remained in the design of the model. Kendall's coefficient of coordination for members' responses to order of 83 factors that had a great and very high impact in this period was 0.187.

Second round: After the implementation of the first stage of assessing and evaluating the views of panel experts on factors raised and extracted from theoretical foundations, as well as receiving suggestions from panel members on other effective factors, in this round, in order to exercise caution, all factors again Extracted from theoretical foundations as well as factors suggested by the panel members about other factors affecting design of model along with average opinion of the members in the first round and previous opinion of same member was made available to all panel experts. Panelists identified 44 of the 83 factors presented in second round as having a significant impact on bankruptcy predictions. Kendall's coefficient of coordination for members' responses to order of the 44 factors that had a great and very high impact in this period was 0.414.

Third round: In third round, because according to average opinion of experts, there was no factor of medium and lower importance, no factor was removed and the list of 44 factors in the second round of Delphi by panel experts has a great and very high impact. In designing model, they were identified along with the average opinion of the members in the second round and the previous opinion of same member was provided to all panel experts. In this round, members expressed their views on impact of each of 44 factors in model design. In addition, they had to determine the order of importance of factors in their view. Kendall's coefficient of coordination for members' responses to the order of the 44 factors that had a great and very high impact in this period was 0.579.

4.3 Reasons for stopping the poll

The results of the three cycles of the Delphi method in research show that for the following reasons an opinion has been reached among the panel members and it is possible to end the repetition of the rounds: in second round more than 50% of the members, 20 factors influencing the design of the factors affecting the establishment of management they chose knowledge with an average greater than 3 as their first factor. Deviation criteria of members' responses about the importance of factors in third round compared to previous rounds decreased It has been impressive. Kendall coordination coefficient for members' answers about the order of factors in third round it is 0.579. Given that the number of panel members was more than ten, this amount Kendall coefficient is considered to be quite significant [7]. Kendall coordination coefficient for the arrangement of 83 factors affecting the design of the factors affecting the Influential in designing the model of effective factors in predicting bankruptcy in the third round compared to the second round increased by 0.165. Gives [5].

4.4 Delphi Panel Final Results

According to theoretical logic and common practice of Delphi, such as small statistical quantities and amount of specific indicators of consensus in the three Delphi periods increased, there is no need to

continue Delphi process in the fourth round and according to the agreement, Delphi panels are considered terminated; Kendall coordination coefficient values in third round are all above 0.7, which indicates a strong consensus among experts on concepts and factors presented.

4.5 Delphi Triple Rounds

Because the Kendall coordination coefficient for members' responses to order of factors in the round third shows a strong and in some cases very strong consensus among the panel members, and given this in fourth round of Delphi, results showed very little difference with the results of third round Delphi rounds stopped. results of the Delphi triple rounds include increasing indicators. Consensus is summarized in Table 1.

Table 1: Comparison of The Results of the Delphi Triple Consensus Indicators

Factor	Component	Kendall coordination coefficient		
		Delphi 1	Delphi 2	Delphi 3
Financial factors:	Retained earnings total asset			
	Working capital to total assets	0.275	0.518	0.713
	Equity to total liabilities	0.347	0.597	0.729
	Retained earnings on total capital	0.273	0.487	0.804
	Net profit to sell	0.213	0.508	0.793
	Total debt to total assets	0.300	0.601	0.759
	Current debt on all assets	0.197	0.539	0.785
	Current assets to current liabilities	0.319	0.419	0.832
	Cash flow to total assets	0.245	0.515	0.811
	Working capital to total liabilities	0.273	0.564	0.849
	Net profit on assets	0.213	0.602	0.812
	Net interest on debts	0.264	0.511	0.829
	Net sales of total assets	0.258	0.498	0.790
	Cash flows to total debts	0.216	0.453	0.765
	Long-term debt to total assets	0.198	0.514	0.795
	Current assets to total assets	0.245	0.542	0.765
Management factors:	Managerial inefficiency	0.273	0.501	0.765
	Severe currency fluctuations	0.311	0.511	0.913
	Loss of social capital	0.156	0.511	0.819
	Stock price index	0.179	0.611	0.794
	Resignation of senior managers in times of crisis	0.258	0.514	0.831
	smuggling goods	0.207	0.561	0.909
	Managerial inefficiency	0.245	0.479	0.766
	Loss of social capital	0.216	0.519	0.812
	Intellectual Capital	0.086	0.486	0.841
	Earnings management	0.328	0.528	0.906
	Corporate governance	0.197	0.597	0.798
Economic factors:	Demand elasticity	0.245	0.487	0.765
	Gold coin price	0.125	0.588	0.811
	Lack of market knowledge	0.213	0.531	0.832
	Trade fluctuations	0.198	0.498	0.198
	economic crisis	0.098	0.490	0.789
	Lack of transparency in the field of import	0.212	0.543	0.765
	currency flactuations	0.086	0.510	0.811
	Betrayal and fraud of employees	0.328	0.432	0.811
	Existence of economic rent	0.287	0.611	0/777

Table 1: Comparison of The Results of the Delphi Triple Consensus Indicators

Factor	Component	Kendall coordination coefficient		
	Timely disclosure	0.207	0.543	0/865
	Oil prices	0.211	0.600	0/902
	Lack of transparency in government policies	0.079	0.479	0/818
	Market monopoly and non-competitive market	0.216	0.511	0.765
	High interest rates on bank facilities	0.328	0.498	0.797
Other factors:	economic sanctions	0.245	0.487	0.761
	Political factors	0.328	0.541	0.905
	Natural events	0.183	0.589	0.769

Then, in order to perform confirmatory factor analysis, a questionnaire was developed to evaluate these variables and sent to experts in accounting, management and economics, and they were asked to rate the impact of these variables on bankruptcy prediction on a scale of 1 to 20. The sample size was selected based on Morgan sampling method. According to the initial estimates of the identified experts, there are about 1800 people and according to Morgan table, the sample number was 317 people and a questionnaire was sent to them. Only 101 people responded to the questionnaires. The results of this questionnaire is shown in Table 1.

Table 2: The Result of The Research Questionnaire

Variable name Factor load	Average score of 20	Factor load	Variable name Factor load	Average score of 20	Factor load
Retained earnings total asset	15.85	0.7925	High interest rates on bank facilities	6.76	0.238
Working capital to total assets	12.67	0.6335	Net profit on assets	9.66	0.483
Equity to total liabilities	14.38	0.7185	Net interest on debts	8.19	0.4095
Retained earnings on total capital	11.44	0.572	Net sales of total assets	8.27	0.4135
Net profit to sell	14.75	0.7375	Cash flows to total debts	8.78	0.439
Total debt to total assets	14.43	0.7215	Long-term debt to total assets	9.43	0.4715
Corporate governance	13.81	0.6905	Current assets to total assets	8.37	0.4185
currency flactuations	15.23	0.7615	Natural events	5.43	0.2715
Intellectual Capital	16.18	0.809	Managerial inefficiency	6.65	0.3225
Current debt on all assets	8.90	0.445	Severe currency fluctuations	15.26	0.763
Current assets to current liabilities	9.18	0.459	Loss of social capital	9.18	0.459
Cash flow to total assets	8.04	0.402	Stock price index	8.89	0.4445
Working capital to total liabilities	8.84	0.442	Resignation of senior managers in times of crisis	8.46	0.423
Increase in overdue receivables	8.83	0.4115	Betrayal and fraud of managers	8.47	0.4235
Earnings management	9.56	0.478	smuggling goods	9.45	0.4725
Betrayal and fraud of employees	7.06	0.353	Demand elasticity	7.86	0.324

Table 2: The Result of The Research Questionnaire

Variable name Factor load	Average score of 20	Factor load	Variable name Factor load	Average score of 20	Factor load
Existence of economic rent	6.86	0.343	Gold coin price	9.65	0.4825
Timely disclosure	7.64	0.382	Lack of market knowledge	8.93	0.4465
Oil prices	8.43	0.4215	Trade fluctuations	6.95	0.6475
Political factors	8.83	0.4415	economic crisis	8.54	0.4375
Market monopoly and non-competitive market	7.15	0.3575	Lack of transparency in the field of import	8.75	0.4375
Lack of specialized manpower	9.34	0.460	Lack of transparency in government policies	9.38	0.469

The results show that out of 44 selected factors, 9 main variables include total liabilities to total assets, net profit on sale, accumulated profit to total capital, working capital to total assets, accumulated profit to total assets Shareholders' equity to total debts, corporate governance, social capital, currency fluctuations are the most important causes of corporate bankruptcy. Table 2 shows the operational and conceptual definition of variables

Table 3: Conceptual and Operational Definition of Variables

Variable	Conceptual definition	Operational definition
Retained earnings / Total Assets	This ratio represents the profit of previous years to the assets, and the larger it is, the better the performance of the company in previous years[19] .	It is obtained by dividing the accumulated profit by the total assets.
Working Capital / Total Assets	This ratio indicates whether the company has sufficient current and liquid assets to cover its short-term liabilities[19] .	It is obtained by dividing working capital by total assets
Long-term debt to equity	This ratio indicates how much of the company's financial resources are provided by long-term creditors. This ratio is an important measure of the ability to pay off long-term debt[19] .	It is obtained by dividing long-term debt by equity.
Current assets to current liabilities	The larger the ratio, the less difficult it is for the company to pay its current debts. Many analysts consider the current ratio of 2 to be a standard and good ratio for companies[19] .	This ratio is obtained by dividing the total current assets by current liabilities.
Net profit to sell	This ratio shows the profitability of revenues. The higher the net profit, the higher and better this ratio is[19] .	It is obtained by dividing the net profit by the net sales.
Total debt to total assets	With this ratio, the total funds provided from the debts are calculated. If this ratio is low, it is good for creditors[19] .	This ratio is equal to the total liabilities divided by the total assets.
Corporate governance	It is a set of control mechanisms inside and outside the company that balances the equity on the one hand and the powers of the board of directors on the other[19] .	The structure of the board of directors, the remuneration of the board of directors, the ownership structure, the internal auditor, the independence of the board of directors, the type of audit report and the

Table 3: Conceptual and Operational Definition of Variables

Variable	Conceptual definition	Operational definition
		institutional ownership are its components that are between zero and one and are calculated through a questionnaire.
currency flactuations	The exchange rate is the amount of the national currency that must be paid to obtain the currency of another country [13].	It is obtained by dividing the difference between the exchange rate of the first and the last period of the period by the currency of the end of the period.
Intellectual Capital	Intellectual capital is a term for combining intangible market assets, intellectual property, human assets and structural assets that enable the organization to carry out its activities[1].	Divide the surplus of the company's return in a period by one plus the weighted average cost of the company's capital in that period.

5 Research Findings
5.1 Descriptive statistics

In the descriptive statistics section, data analysis was performed using central indicators such as mean, minimum, maximum, and scatter indices of standard deviation, skewness and elongation. A summary of the status of descriptive statistics related to research variables is presented in Table 4.

Table 4: Descriptive Indicators (Independent-Dependent-Control Variables)

Variable name	Symbol Variable	Mean	Me-dium	Maxi-mum	Mini-mum	skewness	Elon-gation	Number of views
Retained earnings / Total Assets	X_1	0.06	0.02	0.35	-0.18	1.64	./09	2000
Working Capital / Total Assets	X_2	0.039	0.41	0.71	-0.18	0.21	-0.84	2000
Equity / Total Debt	X_3	2.17	2.57	4.64	0.67	7.23	8.32	2000
Retained earnings / total capital	X_4	0.59	0.56	1.38	0.00	1.19	0.67	2000
Net profit / sales	X_5	0.22	0.08	1.82	-1.19	1.38	3.10	2000
Total liabilities / total assets	X_6	0.49	0.54	0.98	0.09	-0.24	-1.23	2000
Corporate Governance / 5 years average	X_7	1.01	1.00	2.15	0.24	0.36	-0.71	2000
Intellectual capital / average 5 years	X_8	3.06	0.47	5.65	1.38	5.86	8.46	2000
Currency fluctuations / average 5 years	X_9	2.15	0.15	0.21	0.10	-0.06	-1.53	2000

5.2 Inferential Statistics

Common econometric methods in experimental work are based on the assumptions of the significance of the studied variables. Because there is a possibility that the estimate is fictitious with unknown variables, citing the results of such estimates will lead to misleading results. Therefore, in this research, the root test of Luben Lin Cho, Fisher ADF and Fisher PP units has been used [13].

5.3 The Final Model

The data collected for the above 9 variables in the regression equation as an independent variable as well as the virtual variable zero and one (zero for non-bankrupt companies and one for bankrupt companies, as a dependent variable) is estimated using the OLS regression method estimation method. 12 of the best estimates that have a significance level of less than half a percent and have the least error in predicting bankrupt companies are listed in Table 5.

Table 5: Test Results of the Best Outputs Extracted from The Model

Variable symbol	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14	Correc…	Type	Type II
coefficient in the first model	-1.823	2.320	0.573	0.1524	-0.0044	0.649	1.580	0.044	.	0.222	-2.169	4.613	-0.76	0.0016	.	1 2	1 5
Coefficient in the second model	-1.742	2.350	0.477	0.141	-0.008	0.640	1.575	0.016	-0.770	0.210	-0.055	-0.738	0.37	0.0015	0.80	18	22
Coefficient in the Third model	-1.742	2.350	0.477	0.141	-0.008	0.640	1.575	0.0116	-0.077	0.210	-0.055	-0.638	0.370	0.0015	0.845	1 6	1 5
Coefficient in the Fourth model	1.831	2.421	1.140	0.365	-	-	3.040	-	-	0.997	-	-	-0.491	0.2229	0.885	1 2	1 1
Coefficient in the Fifth model	1.754	2.402	0.974	0.358	0.042	-	2.942	-	-	0.961	-	-	-0.480	0.0028	0.75	2 7	2 1
Coefficient in the Sixth model	-	2.395	0.411	-	0.122	-	1.620	-	-	0.263	0.273	-	0.763	0.002	0.835	1 4	1 9
Coefficient in The Seventh model	-	2.483	-	0.564	0.145	-	-	-	0.189	-	-	-	-	O.0043	0.75	22	28
Coefficient in the Eighth model	-	2.340	-	2.112	0.023	-	1.744	-	-	-0.308	-	2.541	-	00.02	0.90	11	9
Coefficient in the Ninth model	-	2.364	-	-	-	-	1.555	-	-	0.251	2.820	5.86	-0.143	0.002	0.92	7	9
Coefficient in the Tenth model	-	0.521	2030.6	-	-	-	1.454	-	-	0.226	-2.297	5.042	-	0.002	0.74	32	21
Coefficient in the Eleventh model	1.754	2.40	0.976	0.358	0.043	-	2.942	-	-	0.961	-	-	0/.	0.002	0.	5	7
Coefficient in	34	969	39	42	934		87			89			45	287	995		

Table 5: Test Results of the Best Outputs Extracted from The Model

Variable symbol	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14	Correc...	Type	Type II
the Twelfth model																	

Among these results, output number 12 was recognized as the best estimate and with the help of it, the research estimate model was presented as follows. The model presented in this study

$$B = 2.339x_1 + 0.965x_2 + 0.394x_3 + 0.042x_4 + 0.943x_5 + 2.871x_6 + 0.893x_7 + 0.0449x_8 + 0.287x_9 + 0.733$$

Where in:

X1 = Retained earningss / Total assets

X2 = Working capital to assets / total assets

X3 = Equity / Total Liabilities

X4 = = Retained earningss / total capital

X5 = Net Profit / Sales

X6 = Total liabilities / total assets

X7 = Corporate Governance / Average Corporate Governance

X8 = intellectual capital / average intellectual capital

X9 = Currency Fluctuations / Mean Currency Fluctuations

In the model derived from this research, if the B calculated for a company is equal to or less than 1, that company goes bankrupt, and if the calculated B is greater than 1, its probability of bankruptcy is very low. Then, to test the model, a sample of 200 companies active in Iranian capital market was studied and the results of this test were shown in table below.

Table 6: Results fFrom tThe Final Model Test

State of	Company	Percentage	Total
Type I error (bankrupt)	9	0.95/4	200
Type II error (non-bankrupt)	14	0./93	200

In the table describing the results of this study it was stated that type I error is only 4.6%. While the second type error is greater than 0.7 and the model is very accurate in classifying 0.93 of the whole sample. Table 7 presents the test results of the main research mode

Table 7: Coefficients and Estimation of The Regression Model of tThe Main Research Model

$B=2.339x_1+2.965x_2+0.394x_3+0.042x_4+0.943x_5+2.871x_6+0.839x_7+0.0449x_8+0.287x_9+ 0.733$					
Variable name	variable symbol	Coefficient	Statistics t	Result	Prob.
Constant	C	0./733	14.010	Significant	0.0000

Table 7: Coefficients and Estimation of The Regression Model of tThe Main Research Model

Retained earnings / Total Assets	X1	2./339	16.830	Significant	0.0182
Working Capital / Total Assets	X2	0./965	5.7624	Significant	0.0000
Equity / Total Debt	X3	0./394	5.4996	Significant	0.0231
Retained earnings / total capital	X4	0./042	2.565	Significant	0./0104
Net profit / sales	X5	0./943	5.881	Significant	0.0319
Total liabilities / total assets	X6	2.891	15.021	Significant	0.0098
Corporate Governance / 5 years average	X7	0.893	9.573	Significant	0.0261
Intellectual capital / average 5 years	X8	0.449	6.3132	Significant	0.0301
Currency fluctuations / average 5 years	X9	0./278	3.8016	Significant	0.0002
F statistics Significance level (Prob)			38.321 (0.0000)		
Durbin-Watson			1.631		
Coefficient of determination (R) Adjusted coefficient of determination (AdjR2)			0.168 1740		

5.4 Test results

According to the results of Chao test and its significance level, the panel data method can be used. Also, according to the results of Hausman test and its significance level (0.000) which is less than 0.05, it is necessary to estimate the model using the fixed effects method. Also, for the residual correlation test, the value of the Watson camera statistic is 2.139 in the range between 1.5 to 2.5, so there is no correlation between the error components of the model. Because the probability value of F statistic is less than 0.05, it is confirmed with 95% certainty that the whole model is significant. And considering the positive t-test for the coefficient of all variables, the test results show that the above variables are significantly associated with bankruptcy. The coefficient of determination and the adjusted coefficient of determination also showed that the variables entered in the regression could explain 16% of the changes of the dependent variable.

5.5 Variance Analysis

Variance analysis measures the share of each shock in the variance of the endogenous variable system. Therefore, the purpose of calculating the analysis of variance index is to determine the relative extent of the contribution and importance of an impulse caused by a variable, in its own changes and changes in other variables. The results of analysis of variance are presented in Table 8. Given that the forecast error is calculated each year based on the error of the previous year, the error always increases during the period under review. The columns of the analysis of variance table show the percentage of predicted variance due to different shocks that the sum of each row should be equal to 100%. According to the results, with increasing the period, the effect of independent variables in explaining bankruptcy increases.

Table 8: Analysis of Variance

	S.E.	B	X1	X2	X3	X4	X5	X6	X7	X8	X9
1	0.119	100	0	0	0	0	0	0	0	0	0
2	0.295	21.764	0.095	13.883	0.117	63.894	0.000	0.126	0.121	0.401	0.267
3	0.358	19.655	0.330	9.494	0.129	70.157	0.014	0.126	0.097	0.409	0.203
4	0.393	18.349	0.273	11.824	0.305	68.853	0.013	0.247	0.136	0.636	0.231
5	0.431	0.400	0.399	9.945	0.403	71.473	0.020	0.238	0.125	0.738	0.221
6	0.045	16.949	0.372	10.885	0.677	70.673	0.021	0.264	0.158	0.884	0.232
7	0.047	16.694	0.442	9.905	0.881	71.653	0.026	0.239	0.160	0.995	0.234
8	0.481	16.271	0.428	10.631	1.261	70.957	0.027	0.229	0.196	1.109	0.241
9	0.496	16.372	0.494	10.030	1.593	71.025	0.030	0.247	0.208	1.205	0.246
10	0.504	15.860	0.498	10.934	2.092	70.065	0.030	0.277	0.244	1.292	0.252

5.6 Research Hypotheses

After extracting the final model, to ensure its accuracy of prediction, by extracting two hypotheses, we compared our model with an internal bankruptcy prediction model and an external model.

5.7 Test the First Hypothesis

For the first hypothesis, the hypotheses H0 and H1 will be as follows:

H0: The Bankruptcy Prediction Model presented in this study cannot predict the bankruptcy of companies more accurately than Pourhydari et al.

H1: The Bankruptcy Prediction Model presented in this study can predict the bankruptcy of companies more accurately than Pourhydari et al.

For this comparison, we first tested Pourhydri et al .'s model with respect to the new data to ensure its predictability with respect to the test data in this study. If the result of this test is positive, we compare its prediction accuracy with the model presented in this study. The regression model for calculating the first hypothesis is as follows:

$P = 3.20784x_1 + 1.80384x_2 + 1.6163x_3 + 0.50094x_4 + 0.16903x_5 + 0.39709x_6 + 0.39709x_7 + 0.33849x_8 + 1.42363x_9$

Table 9: Results of The First Hypothesis Test

State of	Company	Percentage	Total
Type I error (bankrupt)	19	0.90/05	200
Type II error (non-bankrupt)	23	0.88/5	200

5.8 Conclusion from the First Hypothesis

We tested the data in Excel with Pourhydri et al. model and measured its prediction accuracy. The results show that the bankruptcy prediction model presented in this study can predict the bankruptcy of companies more accurately than Pourheydari et al. In their model, if the z calculated for a company is

equal or less than 1, that company goes bankrupt and if the calculated z is greater than 1, the probability of it going bankrupt is very low. We employed Pourhydry et al. model with our sample of 43 active companies. The results are presented in the following table. According to the research findings, it can be seen that the model extracted from this study is able to predict 95.4% and 93% of bankrupt and healthy companies in the base year and 2.94% in general, respectively. While the model of Pourheidari et al. Predicts 5.90 and 5.88% and 5.89% in general, respectively, of the bankrupt and non-bankrupt companies, and this finding indicates that the extraction model This study is more accurate than the model of Pourheidari et al. Also, due to the type of dependent variable and the higher importance of the accuracy of predictions of bankrupt companies than non-bankrupt companies, in this study, the low error of the first type is a priority. According to the results in Table 5, it can be seen that the percentage of error of the first type for the proposed model of this research is equal to 6.4 percent, while the percentage for the model of Pourheidari et al. In the base year is equal to 5.9 percent. Is. On the other hand, the error of the second type for the model presented in this study is equal to 7%, although the percentage for the model of Pourheidari et al. In the base year is equal to 5.11%. Therefore, due to the lower type I error and the second type error in the base year, the proposed model of this study has a higher capability for predicting bankruptcy. Therefore, hypothesis H0 is rejected and hypothesis H1 is confirmed.

Hypothesis 2: The bankruptcy prediction Model presented in this study can predict the bankruptcy of companies more accurately than Altman model.
Testing the second hypothesis
For the second hypothesis, the hypotheses H0 and H1 will be as follows:

H0: The Bankruptcy Prediction Model presented in this study can more accurately predict corporate bankruptcy than the Altman model.

H1: The Bankruptcy Prediction Model presented in this study can predict the bankruptcy of companies more accurately than Altman model.

For this comparison, we first test the Altman model with new data to find out that it has high predictability. The regression model for calculating the first hypothesis is as follows:

$$Z = 2.1x_1 + 4.1x_2 + 3.3x_3 + 6.0x_4 + x_5$$

5.9 Conclusion from the Second Hypothesis
We tested the data in Excel with Altman model and measured its prediction accuracy. The results show that the bankruptcy prediction model presented in this study can more accurately predict corporate bankruptcy than Altman model. The fitting model is as follows: In Altman's model if z calculated for a company is less than 1.81, the company is bankrupt and if z is calculated between 1.81 and 2.61, the company is in the bankruptcy area and if z is calculated. The greater the probability of bankruptcy, the greater is the probability of bankruptcy.

Table 10: The Rresults of The Second Hypothesis Test

State of	Company	Percentage	Total
Type I error (bankrupt)	15	0.85	200
Type II error (non-bankrupt)	55	0.72/5	200

According to the research findings, it can be seen that the model extracted from this study is able to accurately predict 95.4% and 93% of bankrupt and healthy companies in the base year, respectively, and in general 2.94%. While the Z ′ Altman model correctly predicts 42.96% and 5.12% and generally 54.54% of bankrupt and non-bankrupt companies, respectively, and this finding indicates that the model derived from This study is more accurate than the Z ′ Altman model. Also, due to the type of dependent variable and the higher importance of the accuracy of predictions of bankrupt companies than non-bankrupt companies, in this study, the low error of the first type is a priority. According to the results in Table 5, it can be seen that the percentage of error of the first type for the model presented in this study is equal to 6.4%, while the percentage for the Z ′ Altman model in the base year is equal to 58.3%. Is a percentage. On the other hand, the error of the second type for the proposed model of this study is equal to 7%, although this percentage for the Z ′ Altman model in the base year is equal to 5.87%, which indicates that the Z ′ Altman model has the power to determine the status of the company. Does not have unbroken .s. Therefore, due to the lower type I error and type II error in the base year, the proposed model of this study has a higher capability for predicting bankruptcy. Therefore, hypothesis H0 is rejected and hypothesis H1 is confirmed.

5.10 Up the Results of the Hypotheses

After extracting the final model for model verification, it is compared with the other four models and the result is shown in the following table.

Table 11: Summarizes the Results of the Hypothesis Testing

Result		Hypothesis
Reject	H0	Hypothesis 1: Bankruptcy Prediction Model Based on this research, it can predict the bankruptcy .of companies more accurately than Pourhidari et al
Reject	H0	Hypothesis 2: Bankruptcy Prediction Model Based on this research, it can more accurately predict .corporate bankruptcy than Altman model

6 Discussion and Conclusion

Accounting information is one of the richest sources of information in the field of economic decision making. The inability to distinguish bankrupt companies from non-bankrupt companies has had adverse economic and social effects. Therefore, designing and presenting a mathematical model for predicting the financial condition of companies can increase economic development and lead to appropriate allocation of resources in developing countries. [21]. According to the results obtained according to Table 6, it can be seen that the model extracted from this study has a high capability and can predict the occurrence of bankruptcy in companies listed on the Tehran Stock Exchange in a favorable manner. In addition to financial variables, managerial variables such as corporate governance and intellectual capital and economic variables such as currency fluctuations, which is the main cause of inflation in Iran, have been used in developing this model. Therefore, this model is a fit tool for predicting bankruptcy. Also, findings of this study suggest that the predictive power of our proposed model is higher than Pourheidari and Altman models.

Since the model of this research was developed in the form of a mathematical relation, first, qualitative variables were converted into quantitative variables using mathematical formulas. This model is a good tool for predicting bankruptcy. Because a simple mathematical formula was used to formulate it, this speeds up the identification of bankrupt and non-bankrupt companies. Another feature of this model is

that it has been compiled with data from a ten-year period, and this increases its reliability. In order to test the model, its prediction accuracy was compared with Pourheidari and Z ' Altman models under two hypotheses. The results showed that the prediction accuracy of the model derived from this study was 6% more accurate than the model of Pourheidari et al. And 9.4% more accurate than the Altman model. One of the results of this study is the use of managerial variables in predicting bankruptcy, which is in line with the results of Mashki and Hashemi-Saadat [16] and Anvari-Rostami and Moradi-Shahi-dadi [1], which examine the application of corporate governance and They invested intellectual capital in predicting the bankruptcy of companies. Also, the results of this study are in line with the results of the research of Pourheidari et al., Who examined the application of financial ratios in predicting the bankruptcy of companies. According to the results of this study, investors are recommended to use this model to evaluate Iranian companies and make decisions regarding the purchase and prevention of wastage of their capital, and to evaluate the financial situation of companies and Do not invest in bankrupt companies. Since this research has developed a mathematical model to predict the bankruptcy of companies, so it can be used for more specialized research to develop a bankruptcy forecasting model for companies in an industry. Special activities are provided. Other research-based proposals include:
- Analyzing the Impact of Bankruptcy of Companies Acting in the Iranian Capital Market on the Prices of Crude Oil, Housing, Gold, Exchange Rates, Economic Sanctions, and US Withdrawal from Nuclear deal.
- Analyzing the obstacles and challenges of changing the currency by determining its effects on the bankruptcy of companies operating in the Iranian capital market.
- The study of the impact of macroeconomic factors on the prevention of bankruptcy of companies operating in the Iranian capital market.

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