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A Review of Bankruptcy Forecasting: Theories, Models, and Techniques

Haoran Yu[1,*], Victoria Nozick[2]

[1] Department of Economics and Management, Three Valleys University of China, Yichang 443002, China; FaTianYuff@163.com.
[2] Department of Operations and Information Management, Aston Business School, Aston University, Birmingham B4 7ET, United Kingdom; victoria.nozick@gmail.com.

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Abstract

Bankruptcy is an almost ancient and prevalent category. According to the law, bankruptcy means the inability of a business entity to pay its debts. Bankruptcy can be considered from two aspects: bankruptcy from an accounting perspective and bankruptcy from an international law perspective. Bankruptcy prediction models are also proposed. Bankruptcy prediction models are divided into three categories from the point of view of time interval: point models, interval models, and probabilistic models. Of course, different methods for predicting bankruptcy exist, such as ratio analysis and market risk. As mentioned above, various bankruptcy models exist, such as Altman [1–3], Springate [4], Ohlson [5], Fulmer [6], Zmijewski [7], Zavgren [8], Shirata [9], etc. This study deals with the theoretical analysis of each of these models. This study aims to present and explain models for predicting bankruptcy. Finally, it can be stated that it does not matter which model and which criterion (financial or non-financial) is used to indicate distress and bankruptcy; the important thing is to use the models for prediction and, consequently, to take the necessary and appropriate policies according to the prevailing conditions in the business unit to prevent and avert this financial event.

Keywords: Financial crisis patterns, Bankruptcy models, Bankruptcy prediction methods, Ratio analysis and market risk.

1 | Introduction

Bankruptcy is an almost ancient concept and is very common. It may occur in a small retail store that is unable to pay its rent and, therefore, closes or in a large manufacturing company due to a lack of favorable liquidity and continuous annual losses. Bankruptcy is one of the most important and influential phenomena in the economic and financial environment, and it can have wide-ranging consequences for economic firms, shareholders, and other stakeholders [10–12]. Predicting bankruptcy is a key area in accounting, finance, and

Corresponding Author: FaTianYuff@163.com
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economics studies. This helps identify financial and managerial risks and allows policymakers, managers, and investors to formulate appropriate strategies to prevent crises [13].

Over the past decades, numerous theories, models, and techniques have been developed to predict bankruptcy. These tools include traditional financial models such as the Z-Altman Score model, statistical methods, etc. This study aims to systematically review these theories, models, and techniques, examine the strengths and weaknesses of each, and identify future directions for research in this area. This study provides a comprehensive review of bankruptcy prediction theories, helping clarify this field's conceptual foundations. Examining classical and modern theories on bankruptcy will help better understand the mechanisms of risk and financial behavior of firms. Also, by identifying the limitations of previous studies, this study offers suggestions for expanding future studies.

2 | Bankruptcy Definition

Bankruptcy In financial literature, words such as unfavorable financial situation, failure, failure of business units, deterioration, bankruptcy, inability to pay debts, etc., are used to describe bankruptcy. Bankruptcy is a legal process by which the assets of a debtor who cannot pay its debts are generally seized for the benefit of creditors. Bankruptcy means helplessness in business and commerce, and it is a state of business in which a company has suffered losses and cannot pay its debts. Throughout history, there has always been bankruptcy for merchants. Still, the creditors' treatment of bankrupt debtors has been very harsh and violent, so much so that they considered themselves entitled to arrest and imprison the debtor, as well as to enslave and sell him, and even to kill bankrupt debtors [14].

Over time, the distinction between simple bankruptcy and bankruptcy due to fraud reduced the severity of creditors' actions and varied their treatment depending on the case. Bankruptcy means helplessness in business and commerce. When a company becomes insolvent in its transactions and cannot pay its debts on time, we say it is insolvent. When a company cannot meet its financial obligations to its domestic or foreign counterparties on time, we say in legal terms that it is suspended and bankrupt. Finally, according to the Bankruptcy Law, Article 412 of the Commercial Law approved on 13/12/1311, bankruptcy is defined as follows:

The bankruptcy of a businessman or commercial company results from the cessation of payment of the funds for which he is responsible.

3 | Bankruptcy from an Accounting Standpoint

Bankruptcy is possible in two ways from an accounting perspective:

I. Operational bankruptcy: when the value of a company's assets becomes less than its liabilities but continues to operate, a type of bankruptcy known as operational bankruptcy has occurred. This bankruptcy clearly indicates that the company's operations are unprofitable, but the company continues to operate anyway.

II. Liquidity bankruptcy: this type of bankruptcy occurs when a company's debts come due, and it cannot pay them. It is more common.

The two types of bankruptcy described above have different theoretical frameworks that provide financial metrics for creating bankruptcy prediction models. Since liquidity bankruptcy occurs more frequently, liquidity ratios have been hidden in the structure of bankruptcy prediction models from the perspective of the providers of these models and have been widely used so that most bankruptcy prediction models have one or more variables derived from liquidity ratios [15]. Of course, liquidity bankruptcy processes due to a decrease in the company's cash may be related to activity bankruptcy and vice versa. There are two ways in which bankruptcy is legally possible.

I. Compulsory bankruptcy: in compulsory bankruptcy, one or more creditors whose claims exceed a certain amount can file a lawsuit.

II. Voluntary bankruptcy: in voluntary bankruptcy, a person files a lawsuit in court to request a declaration of bankruptcy. For example, the bankruptcy of Sogo Corporation in Japan, which declared bankruptcy with 1.87 trillion yen ($17.3 billion) in debt.

4 | Methods for Predicting Bankruptcy

Two methods are used to predict bankruptcy: key indicators and fundamental analysis. The difference between these two methods is that key indicators indicate imminent bankruptcy, while fundamental analysis predicts the probability of bankruptcy in two to five years. However, the accuracy of fundamental analysis is lower than that of key indicators. However, many people consider its advantages greater than those of key indicators because it reflects the situation for extended periods. However, in fundamental analysis, the methods are divided into two groups: ratio analysis and market risk analysis.

5 | Analyzing Ratios

A ratio is generally a measure of the relative relationship between two variables. A ratio allows you to compare several companies, even if their activities differ. Calculating a ratio is not difficult, but interpreting it is. One of the most important goals in analyzing ratios is to help predict a company's future. Investors use several ratios to predict corporate bankruptcy, although these ratios vary from study to study. Typically, similar ratios are used, including profitability ratios, debt or leverage ratios, and liquidity ratios.

6 | Analysis of the Market Risk

The importance of this method can be seen in the probability of a company going bankrupt due to changes in market risk. Risk is the uncertainty of the return on an investment or asset. Today, most researchers associate an investment's risk with changes in market rates. That is, the more an investment's return changes, the riskier the investment. One indicator used to measure changes in returns is the standard deviation, represented by the symbol δ.

To calculate the standard deviation, you must first find the average or mean return ($\bar{r}_1$). Then you need to calculate the difference between the average returns of each period (r_n), square this value, add them together, divide the result by n-1, and then take the square root of the resulting number:

$$\delta = \frac{[r_n - \bar{r}_1]^2}{n-1}.$$

Therefore, standard deviation is a basic measure of the variability of investment returns (risk). When an investor wants to decide whether to buy a particular type of stock or bond, the standard deviation and the average returns of previous years for that type of security can provide valuable information. However, investors are also interested in knowing the future returns of bonds. After studying the effects of various economic conditions on companies' assets, analysts predict and calculate expected future stock prices and dividends [16].

The following equation is used for the calculation of the average (expected value) of the rates of return.

$$E(r_i) = \sum_{s=1}^{n} ris\pi_s.$$

In this relationship, (π_s) represents the probability of the desired event, i.e., the probability of occurrence of the state that the given economic system will face. Thus, the expected return is nothing more than the weighted average of the returns of the possible states, where the weight of each return is the percentage of the probability of its occurrence. Therefore, the variance of the possible returns is calculated as follows:

$$\delta_1^2 = \sum_{s=1}^{n} [r_{ls} - E(r_l)]^2 \ \pi_s .$$

When calculating the standard deviation, it should be noted that the greater the dispersion of values relative to the value, the larger the standard deviation will be. Therefore, more significant standard deviations indicate that these companies are morerisky and have a higher probability of bankruptcy.

7 | Predictive Models for Bankruptcy

Regarding bankruptcy prediction, various models have been expressed and explained by researchers, such as Altman [1–3], Springate [4], Ohlson [5], Fulmer [6], Zmijewski [7], Zavgren [8], Shirata [9], etc., and we will briefly describe some bankruptcy prediction models below:

7.1 | Altman Model

In 1968, Altman [1] was able to obtain acceptable results on bankruptcy based on financial ratios. Using the multiple audit analysis method and financial ratios, Altman [1] presented his Z-model bankruptcy prediction model. Altman [1] proposed his model by combining five financial ratios, which we will discuss below:

$$Z(SCORE) = 0.012 * X1 + 0.014 * X2 + 0.033 * X3 + 0.006 * X4 + 0.999 * X5.$$

X1: Working capital/total assets

X2: Retained earnings/total assets

X3: Earnings before interest and taxes/total assets

X4: Market value of equity/book value of total liabilities

X5: Sales/total assets

Altman's model concludes that companies with a Z-score of less than or equal to 1.81 often go out of business, while companies with a Z-score of more than 2.99 are in good financial shape.

In 1977, Altman proposed another model called Z' to address the problems of his model. The difference between this and the previous model was in the coefficients and the use of the book value of equity instead of its market value.

$$Z' = 717/0X_1 + 874/0X_2 + 3/1X_3 + 42/0X_4 + 998/0X_5.$$

Altman concludes from his model that companies with a Z' score of less than or equal to 1.21 often go bankrupt, and companies with a Z' score above 2.99 are in good financial shape.

In 2000, Altman [2] proposed a different model that eliminated the ratio of sales to total assets.

$$Z'' = 5/6X_1 + 26/3X_2 + 72/6X_3 + 05/1X_4.$$

Altman [2] concludes from his model that companies with a Z" score less than or equal to 1.1 often go bankrupt, and companies with a Z" score above 2.6 are in good financial condition.

7.2 | Springate Model

Springate continued Altman's studies in the area of creating a bankruptcy model. In 1978, he created a model known by his name. Springitt first selected 19 financial ratios that he considered to be the best financial ratios for determining whether a company is active or bankrupt, and then, using multivariate analysis, selected four financial ratios from them and, after finding the relevant coefficients and the range of prediction, presented the following model:

$$Z = 1.03A + 3.07B + 0.66C + 0.4D.$$

A: Working capital/total assets

B: Earnings before interest and taxes/total assets

C: Earnings before taxes current liabilities

D: Revenue/total assets

In the Springate model, a company will not go bankrupt if the calculated Z is greater than 0.862. If a company's Z is less than 0.862, it will go bankrupt. Springate tested his model on 40 companies in 1979. He obtained an accuracy rate of 92.5% for the year before bankruptcy.

7.3 | Ohlson Model

Ohlson presented a logit model that can be used to examine the effect of four main factors on the probability of bankruptcy. These four factors are the company's size, the criteria of the company's financial structure, the performance criterion, and the liquidity criterion. The following nine financial ratios were selected as independent variables representing these four factors.

X1 (size): Total assets/GDP price level index

X2 (financial structure): Total liabilities/total assets

X3 (performance measure): Working capital/total assets

X4 (liquidity measure): Current liabilities/current assets

X5 equals one if total liabilities exceed total assets and zero otherwise.

X6 is the ratio of net income to total assets.

X7 is the ratio of funds from operations to total liabilities.

X8 equals one if net income has been negative for the last two years and zero otherwise.

X9 is a measure of the change in net income.

Based on the above information, three models are proposed. *Model (A)* predicts that the company will go bankrupt within one year.

$$\text{Pattern (A)} = 32/1\text{-} - 407/0X_1 + 03/6X_2 - 43/1X_3 + 0757/0X_4 - 37/2X_5 - 83/1X_6 + 285/0X_7 + 72/1X_8 - 21/5X_9.$$

Model (B) predicts that the company will go bankrupt within two years. This is assuming that it does not go bankrupt in the first year.

$$\text{Pattern (B)} = 84/1\text{-} - 519/0X_1 + 76/4X_2 + 71/1X_3 + 297/0X_4 - 74/2X_5 - 18/2X_6 + 780/0X_7 - 98/1X_8 - 4218/0X_9.$$

Model (C), it is predicted that the company will go bankrupt within a year or two, and it is expressed in the following way.

$$\text{Pattern (C)} = 13/1\text{-} - 478/0X_1 + 29/5X_2 - 990/0X_3 + 062/0X_4 - 62/4X_5 - 25/2X_6 + 521/0X_7 - 91/1X_8 - 212/0X_9.$$

7.4 | Fulmer Model

Fulmer [6] is a professor of finance in the department of accounting and finance at the university of tennessee at chattanooga. In 1984, he developed a model for predicting corporate bankruptcy. To present this model, Falmer used multivariate analysis to evaluate the applicability of 40 financial ratios. He selected 9 of the 40 ratios using the above method to test and create a bankruptcy prediction model. To test his bankruptcy prediction model, Falmer used a sample of 60 companies, 30 of which were bankrupt and 30 of which were non-bankrupt. Falmer's model is as follows:

$$H=0.528V_1+0.212V_2+0.073V_3+1.27V_4-0.12V_5+2.335V_6+0.575V_7+1.083V_8+0.894V_9-6.075.$$

V_1: Retained earnings/total assets

V_2: Sales/total assets

V_3 : BBT/equity

V_4 : Cash flow/total debt

V_5 : Debt/total assets

V_6 : Current liabilities/total assets

V_7 : Log tangibie total assets

V_8 : Working capital/total debt

V_9 : Log EBIT/interest

In the above model, if H is less than zero, the company under study will go bankrupt; otherwise, the company will not go bankrupt. The results of Fulmer's research showed that the accuracy of this model in predicting bankruptcy for one year before bankruptcy was 98%, and for more than one year before bankruptcy was about 81%. The Fulmer model has the highest accuracy in predicting corporate bankruptcy compared to any bankruptcy prediction model created to date. This is due to Fulmer's emphasis on creating a model that minimizes Type 1 errors.

7.5 | Zmijewski Model

Zmijewski used financial ratios, liquidity, performance, and leverage in his model to achieve an overall model accuracy of 92%.

$$Z = -4.5A + 5.7B + 0.04C - 4.3.$$

A: Net income/total assets

B: Total liabilities/total assets

C: Current assets/current liabilities

In this model, any company above the 50% range is considered non-bankrupt; otherwise, it is considered bankrupt.

7.6 | Zavgren Model

In developing his model, Altman [3] assumed that the variables were selected from a population of firms with a normal distribution. Still, if not all of the variables had a normal distribution, then the results of applying the model could indicate an inappropriate set of bankrupt firms. Christian Zavgren [8] developed and proposed a new model to solve this problem. He used nonparametric statistical analysis and logit analysis to develop his model variables. He no longer relied on assuming a normal distribution of variables in the population, as Altman [3] had done. In addition, unlike Altman's and other earlier models, Zavgren's model did not purport to classify firms into bankrupt and normal (healthy) firms. Instead, he presented his model output as a number between zero and one, representing the probability of a firm going bankrupt. Since the Zavgren forecasting model does not assume normality in the formulation of the coefficients of the model variables and uses nonparametric statistics and logit analysis, its measurement accuracy is higher than that of previous models.

On the other hand, its output is not limited to two states: the company goes bankrupt or does not go bankrupt. Instead, it uses a probability number between zero and one to explain the financial stress of the firm, which gives the probability of the firm going bankrupt, which is above 0.5 for bankrupt firms and below 0.5 for normal firms. The model developed by Christian Zavgren, which uses logit statistical analysis, can be summarized as follows:

$$Y = 0.23883 - 0.108x_1 - 1.583x_2 - 10.78x_3 + 3.074x_4 + 0.486x_5 - 4.35x_6 + 0.11x_7.$$

x_1: Average inventory for sale.

x_2: Average receivables to average inventory.

x_3: Cash plus short-term investments to total assets.

x_4: Current assets to current liabilities.

x_5: operating profit to total assets excluding current liabilities.

x_6: Non-current liabilities to total assets excluding current liabilities.

x_7: Sales to net current assets plus fixed assets.

$\frac{1}{1+e^{-y}}$: Bankruptcy possibility

In the model, variables with negative coefficients increase the probability of bankruptcy because they decrease e^{-y}. Variables with positive coefficients also reduce the likelihood of bankruptcy because they push e^{-y} toward one. The output of the model, which is related to the company's likelihood of bankruptcy, is a number that ranges from zero to one. The larger the number and closer it is to one, the lower the company's bankruptcy probability.

7.7 | Shirata Model

To overcome the weaknesses of some of the models above, Shirata proposed a model in 1998 that has an accuracy of 86.14%. This model follows the method of multiple discriminant analysis.

$Z = 014/0X_1 - 003/0X_2 - 058/0X_3 - 062/0X_4 + 7416/0.$

x_1: Retained earnings to total assets.

x_2: Current year's liabilities and equity to previous year's liabilities and equity.

x_3: Interest expense to the average annual total of discounted loans, debts, bonds, and notes receivable.

x_4: Average total of accounts payable and notes payable to be sold.

In this model's analysis, any company above the 38% range is considered non-bankrupt; otherwise, it is considered bankrupt.

8 | Using Non-Financial Information to Predict Corporate Bankruptcy

Over the past sixty years, much research has been conducted on bankruptcy prediction, and various models have been proposed that use financial information to predict corporate bankruptcy. This paper examines the effect of using non-financial information to predict bankruptcy. Keasey and Watson [17] used several non-financial variables together with financial ratios and again without financial ratios and alone in predicting corporate bankruptcy.

They selected 73 bankrupt and 73 non-bankrupt companies from 1970 to 1983. In this study, the dependent variable is bankruptcy or non-bankruptcy, and the independent variables are as follows:

I. Model 1: Financial ratios only

II. Model 2: Non-financial information only

III. Model 3: Financial and non-financial information

Their research showed that the use of non-financial information along with financial ratios showed better results concerning small business failure than the use of financial ratios alone. The results of the three models were 78% for *Model (1)*, 75% for *Model (3)*, and 82% for *Model (2)*. The non-financial variables section examines factors such as the ownership structure of companies, changes in stock prices, and whether companies

changed independent auditors in the years before bankruptcy [18]. The ownership structure of companies examines the discussion of the separation of management from ownership and its problems and that the structure of the company's board of directors plays an important role in solving such issues, as well as in implementing laws, adopting appropriate policies and controls, and providing services. As a result, there is a very close relationship between board members and the company's performance. The trend of stock price changes suggests that before companies go bankrupt, adverse changes in their stock prices are likely to indicate that the company is in bad shape. Bankrupt companies are likely to change their auditors and make their accounting practices look better by changing their accounting methods and manipulating some accounts in the hope of getting a favorable audit report.

9 | Conclusion

As the definition of bankruptcy makes clear, bankruptcy is the inability of a business to pay its debts and can occur in any business entity. Several models have been proposed to predict bankruptcy. Some models based on ratio analysis have been proposed, such as Altman [1–3], Springate [4], Ohlson [5], Fulmer [6], Zmijewski [7], Zavgren [8], Shirata [9], etc. A theoretical study of each of these models was conducted. These ratios can be beneficial in predicting a company's financial distress, but they are financial measures, and there are non-financial measures that can also help us in this prediction [19]. Finally, it does not matter which model and criterion (financial or non-financial) is used to predict distress and bankruptcy because, with a certain percentage of error, all models make the prediction correctly. The important thing is to use the models for prediction and, consequently, to take the necessary and appropriate actions according to the conditions prevailing in the business unit to prevent and avert this financial event. Studies in bankruptcy prediction play an important role in financial management and economic risk reduction. This study provides a comprehensive picture of bankruptcy prediction tools by examining existing theories, models, and techniques and analyzing the advantages and disadvantages of each. The results of this review show that each model or technique has its strengths and weaknesses, and the selection of the appropriate tool depends on the specific characteristics of the firm, industry, and market conditions [20], [21].

This study's special focus on emerging markets such as Iran has provided a good opportunity to understand the challenges and limitations of bankruptcy prediction in dynamic economic environments. Given the need for indigenous strategies, the findings of this study can help formulate more efficient policies and tools. Finally, this study emphasizes the importance of combining traditional methods and modern techniques, such as machine learning, to achieve more accurate predictions. Future research should focus on analyzing real data and evaluating the practical results of these models in different industries to gain a deeper understanding of bankruptcy dynamics.

Authors' Contributions

Haoran Yu and Victoria Nozick jointly contributed to the conceptualization, methodology, analysis, and writing of this paper. Both authors reviewed and approved the final manuscript.

Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper. No personal, financial, or institutional influences have affected the objectivity and integrity of the research.

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Data Availability Statement

The data used in this study are derived from publicly available sources and have been appropriately cited. Any additional data supporting the findings of this study can be made available upon request from the corresponding author.

References

[1] Altman, E. I. (1968). Financial ratios, discriminant analysis and the prediction of corporate bankruptcy. *The journal of finance*, *23*(4), 589–609. https://doi.org/10.2307/2978933

[2] Altman, E. I., Haldeman, R. G., & Narayanan, P. (1977). Zetatm analysis a new model to identify bankruptcy risk of corporations. *Journal of banking & finance*, *1*(1), 29–54. https://doi.org/10.1016/0378-4266(77)90017-6

[3] Altman, E. (2000). Predicting financial distress of companies: Revisiting the z-score and zeta. *Handbook of research methods and applications in empirical finance*, *5*, 428–456. http://dx.doi.org/10.4337/9780857936097.00027

[4] Springate, G. L. V. (1978). *Predicting the possibility of failure in a Canadian firm: A discriminant analysis*. Simon Fraser University. https://www.scirp.org/reference/referencespapers?referenceid=3818877

[5] Ohlson, J. A. (1980). Financial ratios and the probabilistic prediction of bankruptcy. *Journal of accounting research*, *18*(1), 109–131. https://doi.org/10.2307/2490395

[6] Fulmer, J. G., Moon, J. E., Gavin, T. A., & Erwin, J. M. (1984). A bankruptcy classification mode for small firms. *The journal of commercial bank lending*, *66*(11), 25–37.

[7] Zmijewski, M. E. (1984). Methodological issues related to the estimation of financial distress prediction models. *Journal of accounting research*, *22*, 59–82. http://dx.doi.org/10.2307/2490859

[8] Zavgren, C. V. (1985). Assessing the vulnerability to failure of american industrial firms: A logistic analysis. *Journal of business finance & accounting*, *12*(1), 19–45. https://doi.org/10.1111/j.1468-5957.1985.tb00077.x

[9] Shirata, C. Y. (1998). *Financial ratios as predictors of bankruptcy in japan: An empirical research* [presentation]. Proceedings of the second asian pacific interdisciplinary research in accounting conference (pp. 437–445). https://www.researchgate.net/publication/228604054_Financial_ratios_as_Predictors

[10] Zhao, J., Ouenniche, J., & De Smedt, J. (2024). Survey, classification and critical analysis of the literature on corporate bankruptcy and financial distress prediction. *Machine learning with applications*, *15*, 100527. https://doi.org/10.1016/j.mlwa.2024.100527

[11] Song, H., & Zhao, X. (2024). The unexpected consequences of company bankruptcy: An investigation into the spillover effect of local economic liquidation. *Finance research letters*, *61*, 104992. https://doi.org/10.1016/j.frl.2024.104992

[12] Estrin, S., Mickiewicz, T., & Rebmann, A. (2017). Prospect theory and the effects of bankruptcy laws on entrepreneurial aspirations. *Small business economics*, *48*(4), 977–997. https://doi.org/10.1007/s11187-016-9810-1

[13] Thorburn, K. S. (2000). Bankruptcy auctions: Costs, debt recovery, and firm survival. *Journal of financial economics*, *58*(3), 337–368. https://doi.org/10.1016/S0304-405X(00)00075-1

[14] Rahnamay Roodposhti, F., Kharadyar, S., & Imeni, M. (2016). The historical roots of stream researches in behavioral management accounting: Theories and research methods. *Khu-aapc*, *1*(1), 25–52. http://dx.doi.org/10.18869/acadpub.aapc.1.1.25

[15] Radovanovic, J., & Haas, C. (2023). The evaluation of bankruptcy prediction models based on socio-economic costs. *Expert systems with applications*, *227*, 120275. https://doi.org/10.1016/j.eswa.2023.120275

[16] Imeni, M., Bao, Z. K., & Nozick, V. (2024). Multiscale partial correlation analysis of Tehran stock market indices: Clustering and inter-index relationships. *Journal of operational and strategic analytics*, *2*(1), 1–10. https://doi.org/10.56578/josa020101

[17] Keasey, K., & Watson, R. (1987). Non-financial symptoms and the prediction of small company failure: A test of argenti's hypotheses. *Journal of business finance & accounting*, *14*(3), 335–354. https://doi.org/10.1111/j.1468-5957.1987.tb00099.x

[18] Eghdami, E., Yousef Nezhad, S., & Pendashteh, M. (2022). Investigating the moderating role of moderation cash in the relationship between unconditional conservatism and bankruptcy risk. *Innovation management and operational strategies*, *3*(1), 82–95. (**In Persian**). https://doi.org/10.22105/imos.2021.298816.1153

[19] Shemshad, A. (2023). The effect of financial leverage and product competition on the risk of financial helplessness: Implications of capital structure in the presence of agency cost. *Financial and banking strategic studies*, *1*(1), 56-68. (**In Persian**). https://doi.org/10.22105/fbs.2023.178952

[20] Dasilas, A., & Rigani, A. (2024). Machine learning techniques in bankruptcy prediction: A systematic literature review. *Expert systems with applications*, *255*, 124761. https://doi.org/10.1016/j.eswa.2024.124761

[21] Alaka, H. A., Oyedele, L. O., Owolabi, H. A., Kumar, V., Ajayi, S. O., Akinade, O. O., & Bilal, M. (2018). Systematic review of bankruptcy prediction models: Towards a framework for tool selection. *Expert systems with applications*, *94*, 164–184. https://doi.org/10.1016/j.eswa.2017.10.040