Evaluation of Back Propagation-Artificial Neural Network (BP-ANN) Fit Rate and Types of Vector Machine Algorithms in Estimating the Bankruptcy Prediction of Companies Listed on Tehran Stock Exchange

Mehrdad Shafiee[a] , Hossein Fakhari[b*]

[a]Master of Accounting, University of Parandak, Iran. Mehrdad.shafiee123@gmail.com

[b]corresponding author, Associate Professor, Department of Accounting, Faculty of Economics and Administrative Sciences, University of Mazandaran, Babolsar, Iran. h.fakhari@umz.ac.ir

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Abstract: The accurate estimation of the bankruptcy prediction is an issue that has been increasingly considered regarding the importance of companies' bankruptcy prediction from investors, companies and banks (determining credit risk). However, determining new mathematical techniques that can provide a higher fit rate for this prediction requires further researches and comparisons of algorithms fit. Accordingly, the present study aimed at comparing the fit rate in vector machine algorithms and artificial neural network (ANN) to determine the companies' bankruptcy prediction in the coming years. The financial statements of companies over 2011-2019 (end of 2019) were reviewed to collect data. Article 141 of the Commercial Code was used to determine the bankrupt companies. Then, the desired algorithms were implemented by MATLAB software. The results showed that the support vector machine algorithms had a higher fit rate in estimating the companies' bankruptcy prediction (the maximum difference in model fit was 6%).

Keywords: Prediction Fit, Artificial Neural Network (ANN), Vector Machines, Company Bankruptcy

1. Introduction

For many years, researchers have been trying to use modern mathematical knowledge and emerging algorithms with maximum fit to predict the bankruptcy and financial distress of companies (Chen et al., 2020; Jia et al., 2020) and minimum error (Zhang Et al., 2021; Balzan, 2020; Sugiyarti L. & Murwaningsari, 2020). The recent efforts show acceptable success in this field (Marso S. & EL Merouani, 2020). It has been attempted to compare prediction algorithms and determine the most appropriate ones, and different results have been obtained in this field (Marso S. & EL Merouani, 2020; Zhang et al., 2021; Kumar et al., 2021).

There have always been two major issues in companies' bankruptcy prediction; First of all, new algorithms, especially in artificial intelligence, are being upgraded every day, and it is sometimes observed that a special mathematical technique, such as a support vector machine (SVM), has a variety of algorithms. It causes more researches have to be done in this field to determine the most appropriate algorithms and compare the findings with the other ones (Ptak-Chmielewska, 2021; Cassim R. & Swanepoel, 2021; Keya et al., 2021; Kou et al., 2021). Another issue is the occurrence of contradictory findings in some studies (Gupta et al., 2021; Zhang et al., 2021); algorithms do not seem to have the necessary generalizability in all stock exchanges, for example, high price fluctuations in a stock exchange can create the efficiency of an algorithm differently than a stock exchange with low price fluctuations (Qu et al., 2019; Dawkins et al., 2007; Hosaka, 2019).

In the field of mathematical predictions, especially in the field of financial distress or companies' bankruptcy, studies show that it is not possible to predict an event or bankruptcy up to 100%. Accordingly, it is necessary to estimate the minimum error in prediction; This clarifies the need to compare prediction models (Tron, 2021; Gunawardana, 2021).

If the future situation of companies would not be accurately estimated, the investors will face several costs, and on the other hand, it should be noted that banks also take too much credit risk and companies have more difficulty in obtaining loans (Metawa et al., 2021; Sun et al., 2021). In general, it can be said that the companies' bankruptcy prediction is a multifaceted issue with multiple outputs and on the other hand, several components affect it (Antulov-Fantulin et al., 2021). An inaccurate estimate can lead to wrong decisions for individuals. The fit or prediction of the models should be as high as possible to risk less, at least for the stock portfolio (Barboza et al. 2017). The companies' executives are involved in manipulating certain financial variables in reporting; In these circumstances, the models must have achieved a high degree of capability or a good fit that can be effectively predicted (He H. & Fan, 2021; Veganzones, D. & Séverin, 2018). However, different methods have different outputs, and on the other hand, it is not possible to say exactly which of the methods can have a better fit; These models must be tested in different conditions and in different exchanges to express which of the algorithms can achieve the prediction with a higher fit (Du Jardin, 2017; Tian S. & Yu, 2017). In this regard, there is still a study gap to achieve the desired

goal, and this highlights the need for several studies to determine the most appropriate models and algorithms (Lee et al., 2018).

Recent evidence shows that ANN have a high ability to predict and estimate (Ansari et al., 2020). Bankruptcy prediction by ANN in studies has yielded good results and this has led researchers in several studies to be more inclined to use this technique to predict companies' bankruptcy (Fasya N. S. & Rikumahu, 2021; Alexandropoulos et al. 2019). ANNs have a very important advantage; these algorithms use the feedback technique and review the process and information before presenting the final results, and then confirm and announce the answer (Hosaka, 2019). ANNs with feedback are often referred to as BP-ANN. These networks have a backpropagation learning that can help to achieve an optimal response in a very desirable way (Zhai, 2021). BP algorithms are among the emerging algorithms whose high efficiency has caused researchers to pay special attention to it, especially in the field of companies' bankruptcy prediction (Azayite F. Z. & Achchab, 2018; Jin et al. 2021; Wang et al. 2019).

One of the other algorithms that has received significant attention in recent years in companies' bankruptcy prediction is the support vector machine algorithm (Shrivastav S. K. & Ramudu, 2020; Ptak-Chmielewska, 2021). Support vector machines (SVM) in most studies have reported favorable results in model fit and has led to the emergence of new algorithms from this technique (Santoso N. & Wibowo, 2018). So far, six algorithms have been proposed for SVMs, each of which can show different results depending on different conditions and have the desired efficiency (Horak et al., 2020). The six algorithms of SVMs use the optimal learning rule. They learn how to classify categories and report the best results based on a review of hundreds of examples (Kim et al. 2018; Barboza et al. 2017). With receiving a set of information of bankrupt and non-bankrupt companies, the support vector machine can determine the status of the received data set (Wyrobek, 2018; Sun et al., 2021).

The above cases show that first,Utilizing the emerging algorithms to generalize the findings requires many studies, especially in different stock exchanges in order to decide whether in different conditions, especially with high price fluctuations, these techniques are effective or not. In the Iranian stock exchange, there has always been high price fluctuations for various reasons, which can affect determining the fit of these models in the field of companies' bankruptcy prediction.secound, One of the important issues is that algorithms should be separable based on desirability in estimation (model fit) so that their results can be compared exactly on a data set. In different studies, it is not possible to make the right decision in this regard by comparing the fit of models. This intensifies the need to compare models based on artificial intelligence (in the field of machine learning).third, Six algorithms have been proposed for SVMs yet. Comparing all these algorithms together and with the other prediction models has not been studied yet; this makes clear the need for further studies in this field. And forth, considering the studies conducted in the above section, it becomes clear that the ANN of BP type and SVM algorithms are among emerging techniques in the field of predicting financial distress or bankruptcy. This study contributes to the development of literature in Iran for several reasons: Firstly this study, uses a complete set of independent variables that are compatible with the economic conditions of Iran, Second the variables are Selected the dependent variable (bankruptcy), that it is not predicted by these new method. Finally, In this regard, our use of a more complete set of variables and a novel methodology provides more favorable results than statistical methods.By this the rest of paper organized as follows, Section 2 discuses about review of literature, Section 3 provide information about research methodology along with variables and hypotheses, Section 4 provide findins and Section 5 presents discussion, and conclusion.

2. Literature Review

In spite of several theoretical and perspectives on explaining the phenomenon of bankruptcy have been presented. Here we try to provide important about some of them, Haji Hashem and Amir Hosseini (2017) conducted a study entitled "Bankruptcy Prediction and Corporate Governance Based on the Financial Ratios". In this study, four well-known prediction models have been compared, including vector machine model, ANNs, ANNs optimized with genetic algorithm and logit regression. Finally, ANNs optimized with genetic algorithm has the best performance compared to the other models. Also, the financial ratios were more effective and had valuable features for bankruptcy prediction. This algorithm achieved the highest accuracy and its error was minimal; it was considered as a reliable, stable and practical model.

Vaez Ghasemi and Ramezanpour Chahardeh (2018) conducted a study aimed at predicting the bankruptcy of companies listed on the Stock Exchange and Securities Organization using ANN. In this study, Zimansky financial ratios along with a macroeconomic variable have been used to predict the companies' bankruptcy. The multilayer perceptron neural network was used to create the prediction model and analyze the data using the back propagation algorithm. The network was trained only once using financial ratios and again with the macroeconomic variable; Finally, the hypothesis "the accuracy of network increases with the macroeconomic variable" was confirmed. The

designed model generally has an accuracy of 92.95%, and 85% of the correct prediction for one year before the bankruptcy.

Bahiraei et al. (2016) compared artificial intelligence systems (adaptive neural-fuzzy inference system and ANNs) and logit regression in predicting the financial bankruptcy of companies listed on the Tehran Stock Exchange. Findings showed that in the companies' bankruptcy prediction, the ANNs-based model was more accurate than the model based on neural-fuzzy networks and logit regression.

Nazemi Ardakani (2016) investigated the effect of corporate governance and conservatism on the predictive power of neural network-based bankruptcy models. Neural networks have been used to differentiate between weak and strong companies and prediction. The results showed that the corporate governance and conservatism variables had no effect on improving the prediction accuracy of financial performance in neural network-based models.

Ismaili and Gougherdchian (2017) predicted the financial bankruptcy using cash flow statement (artificial neural network approach). The neural network of this research was a three-layer perceptron that was trained by the propagation algorithm method. According to the results, the neural network model with the operating cash flow ratio to current liabilities, operating cash flow coverage ratio to interest, cash return ratio of assets, profit quality ratio and instantaneous ratio has the highest prediction power to company bankruptcy in Iran. Also, the findings show that the accuracy of the model prediction for the year of bankruptcy was 99% and in total the stages of bankruptcy in one, two and three years before bankruptcy were 91, 85 and 70%, respectively.

Saadatpour (2017) predicted bankruptcy and analyzed the causes using the financial ratios identified by the two-stage model of ANNs and genetic algorithm (Case study: the companies listed on the Tehran Stock Exchange). The results of the model showed that the designed model accurately predicted the bankruptcy of companies with 98.7% accuracy. It also introduced the financial ratios affecting bankruptcy in the desired conditions.

Satayesh and Ahadianpour (2017) conducted a study entitled "Bankruptcy Prediction Using Artificial Neural Network and Comparing It with Altman Multiple Point Analysis Model". The results of the ANN model showed that this model had a high ability to predict bankruptcy and could be used with high confidence. However, the companies' bankruptcy prediction with any method was only a warning about the future situation of the company and not a definite confirmation of bankruptcy. In the study, the results of the ANN model were compared with the results of the Altman multiple point analysis model. It was stated that: 1) Model derived from ANN and Altman multiple point analysis were suitable tools for companies' bankruptcy prediction, 2) The general accuracy of ANN model for bankruptcy prediction was more than the Altman multiple point analysis model.

Ekdari et al. (2017) investigated the use of SVMs in companies' bankruptcy prediction using financial ratios. In the research, the results of SVM model were compared with Logistic model. Findings showed that the SVM model is more accurate in companies' bankruptcy prediction than the Logistic model.

Alizadeh (2016) examined the companies' bankruptcy prediction listed on the stock exchange using ANN and SVM models. The findings showed that ANN can predict the bankruptcy prediction of stock companies more than 0.9 and SVM more than 0.78 based on input variables, which shows the efficiency of these models.

Bazarafkan (2014) examined the comparison of logistic regression and decision tree in predicting the financial bankruptcy of companies listed on the Tehran Stock Exchange. Four categories of financial ratios were used to determine bankruptcy. Findings indicated that logistic regression and decision tree introduced different indices but are not significantly different from each other.

These review show us In spite of existence Iranian research about bankruptcy and application of several method for prediction but there is not any research that it has investigated the bankruptcy prediction by vector machine algorithms and artificial neural network (ANN). So for better understanding of new method, we reviewed other research's that they were done in other countries, we believe this separation help us to get a better understanding of this phenomena. Ptak-Chmielewska (2021) predicted the bankruptcy of small and medium enterprises in Poland based on LDA (linear discriminant analysis) and SVM methods. The findings showed that the impact of recent financial crisis on the small and medium enterprises had varied in every country. Therefore, it is important to create a prediction model that is easily compatible with the characteristics of small and medium enterprises. Since the invention of Altman model, many studies have been written on bankruptcy prediction. Most of them involve the use of traditional methods, including linear discriminant analysis, logistic regression and Probit analysis. However, most recent bankruptcy prediction studies have focused on more advanced methods such as case-based reasoning, genetic algorithms, and neural networks.

Patak-Chamiloska study (2021), compared the effectiveness of LDA and SVM predictions. A sample of small and medium-sized companies was used in the empirical analysis, financial ratios were used, and non-financial factors were considered. Findings confirmed that in general, support vector algorithms can be more efficient in the companies' bankruptcy prediction than linear segregation analysis (higher fit in the model).

Hosaka (2019) also conducted a study entitled "Bankruptcy Prediction Using Illustrated Financial Ratios Based on Conventional Neural Networks". In the proposed method of this research, a set of financial ratios of financial statements was obtained and presented as a gray scale image. The image created by this process had been used to train and test the conventional neural network. A total of 7,520 images had been used to classify bankrupt and operating companies, to train cyclic neural networks based on Google Net. Bankruptcy prediction through the trained network showed higher performance compared to methods using decision trees, linear discriminant analysis, support vector machine, multi-layer perceptron, AdaBoost, or Altman's Z″-score.

Hardinata and Varsito (2018) examined bankruptcy predictions based on financial ratios using the Jordan recurrent neural networks (a case study of Polish companies). Analysis of the results showed that Jordan recurrent neural networks were very good at predicting bankruptcy and the average success rate was reported 81.37%.

Azayite & Achchab (2017) conducted a study entitled "The Effect of Payment Delay on Bankruptcy Prediction Based on Comparative Analysis of Variables Selection Models and Neural Networks". In this study, researchers have studied the effect of customer and supplier payment delays to predict bankruptcy by analyzing the relationship between neural network variables and variable selection techniques. These variables indicated that they were the primary warning ratios for investors and creditors to follow.

Chou et al. (2017) studied on hybrid genetic algorithm and fuzzy clustering to predict bankruptcy. In this study, a hybrid structure that integrates statistical theory and computational intelligence technique had been developed using a genetic algorithm with statistical measurements and fuzzy logic-based fit functions to select the original ratio. Fuzzy clustering algorithm is used for classifier design. In the tests, two sets of financial ratios were used to examine the proposed ratio selection schemes; one of them was extracted from the suggestions of other studies and the other one obtained using the Genetic Algorithm toolbox in the statistical software package of the statistical analysis system. For the classifier design, the developed fuzzy classifier is compared with the popular classifier of Back-Propagation Neural Networks (BPNN), which is often used in other studies. Besides, a comparison between the developed hybrid structure with other good functional structures was presented. Test results based on one to four years of pre-bankruptcy financial data were used to evaluate the performance of the proposed prediction model.

Jabeur (2017) also examined the financial bankruptcy prediction using partial least square (PLS) logistic regression. The results were satisfactory and confirmed the superiority of partial least squares logistic regression method compared to conventional methods. The proposed model provided the opportunity to take into account all indices of financial distress prediction, reducing environmental uncertainty, improving control and proportionality among different shareholders of the company.

Wang et al. (2017) studied the Gray Wolf Optimization (GWO) including the artificial neural network machine and its application to predict the bankruptcy. The results clearly showed the superiority of the developed model in terms of accuracy in classification (training, validity, test). The GWO model, nuclear neural network machine, proposed in the research acted as a powerful tool with superior performance for bankruptcy prediction.

Zhao et al. (2017) examined the effective computational model for bankruptcy prediction using the artificial neural network machine approach. A two-stage lattice search strategy that integrated search stability with the final search and was adopted in the nuclear neural network machine process. The resulting bankruptcy prediction model was compared with five other competitive methods, including support vector machines, neural network machines, random prediction, particle swarm optimization using the nearest fuzzy k coefficient, and logistics model. The results clearly showed the superiority of the developed model in terms of classification accuracy. Finally, the high-performance neural network machine approach was a very powerful tool in predicting companies' financial bankruptcy.

3. Method

This research was conducted within the deductive-inductive reasoning framework. Also, this research is post-event in terms of data collection method. In this method (post-event method), data is collected and analyzed from past events that occurred without the intervention of the researcher system (in this study, based on companies'

financial statements reported in previous years). Accordingly (based on the post-event approach) it is not possible to manipulate variables. In the present study, past information about the research community (companies listed on the Tehran stock exchange over 2011-2019) have been collected and analyzed.

At first, the list of companies was selected according to the systematic removal method. In the next step, based on the Article 141 of the Commercial Code, it is determined which companies are bankrupt in the desired time series according to this article. Then, using the Altman method, the bankruptcy of companies was predicted and the percentage of correct and incorrect answers was determined. To do this, the prediction results of the Altman model were aligned with the existing reality (which companies are bankrupt based on the Article 141), and finally using methods such as machine learning (vector machine and artificial neural network) as well as the percentage of correct and incorrect answers, the degree of the model fit was determined. With comparing the results obtained from the two methods, it was turned out that the dynamic methods such as vector machine and artificial neural network reported higher accuracy than the linear method (Altman).

As mentioned, the statistical population of this study consisted of listed companies (Tehran Securities) over 2011-2019. The total number of companies surveyed was 784 ones. To determine the sample, the following conditions were considered: (1) the fiscal year ended at the end of March and it has not been changed in the period under review. (2) The financial and budgetary information is available and the annual financial statements are regularly submitted. (3) The stock transactions have not been stopped more than six months during the research period on Tehran Stock Exchange. (4) They are not part of investment or financial intermediation companies. The total number of samples in this study was 169 companies over nine years. Accordingly, the total number of samples in this study was equal to 1521 companies; 118 ones were declared as non-bankrupt companies and 51 ones as bankrupt companies in accordance with Article 141 of the Commercial Code.

In this study, the following Altman model (1968) was used for the companies' bankruptcy prediction:

$$Z' = 0.717x1 + 0.847x2 + 3.107x3 + 0.42x4 + 0.995x5 \quad (1)$$

- X1: Working capital to total assets

- X2: Retained earnings on total assets

- X3: Earnings before interest and taxes on total assets

- X4: Book value of shareholders' equity on book value of debt ()

- X5: Sale on total assets

Matlab2017 software was used to analyze the data. Accordingly, with entering the obtained data based on Altman variables, two algorithms were tested and compared to determine the extent of correct and incorrect answers (the degree of the model fit).

4. Findings

4. 1. ANN-Based Prediction

Each ANN can be made up of a number of different neurons and hidden layers. In this study, 1521 vectors were used as input signals with seven attributes (five attributes as Altman variables and two attributes based on bankrupt and non-bankrupt companies).

The number of hidden layers must be estimated based on trial and error to the best value and approximate so that ANN can receive the correct training. In this section, after various studies and estimating the accuracy of the network, four hidden layers have been determined. The network is designed to predict bankrupt and non-bankrupt companies as presented in Figure 1.

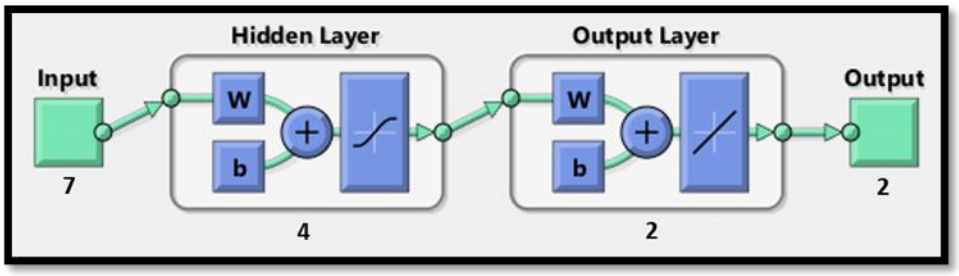

Figure 1. ANN model with four hidden layers

The network training based on the above architecture and its performance is presented in the following. In the programming done in MATLAB, it was determined that the neural network continues to train until it reaches the lowest appropriate value; During six stages of training, if the number of errors is continually increased from the real values, the process is stopped. This is illustrated in the figure below for training a network with three hidden neurons.

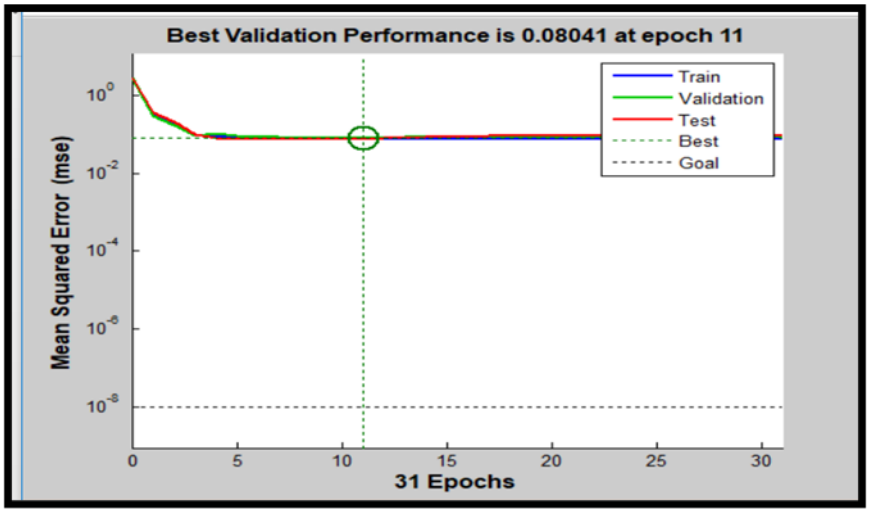

Figure 2. The best validation of epochs of ANN training

As observed in the diagram, the mean squared error starts from a large value and gradually decreases. This means that the network learning routine has improved. The above diagram consists of three lines in which 1521 input and target vectors are randomly organized and divided into three training (70%), evaluation (15%) and test (15%) sets. The evaluation set is used to retain the generality of the network. The training routine continues until the network error is reduced about the evaluation network. This prevents over-fit of the network on the training set. The performance of the company should be examined, which is presented in the following.

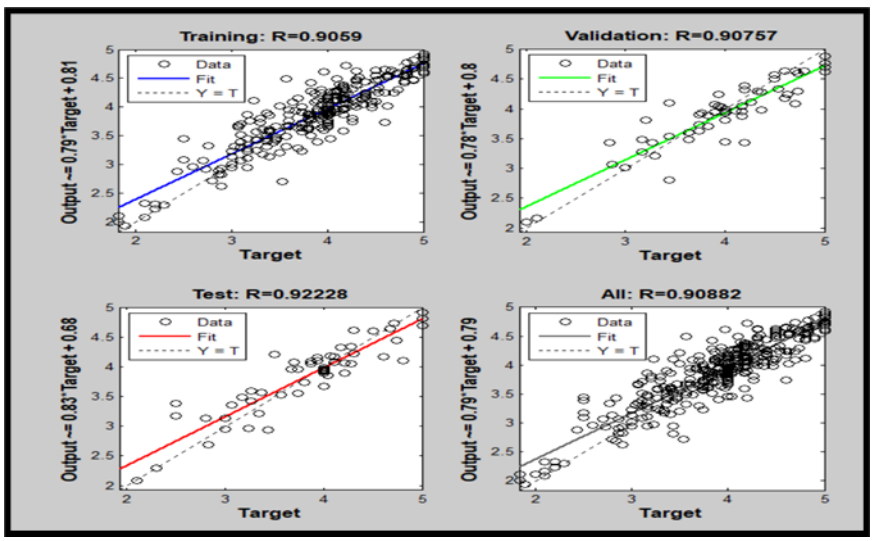

Figure 3. ANN model fit by data types

As observed in the diagrams above, the output of training, evaluation and test sets are well matched to the target vectors and the R-value is greater than 0.90. The histogram diagram of errors is designed based on all three sets to examine the incidence of errors in each data; it is presented in Figure 4.

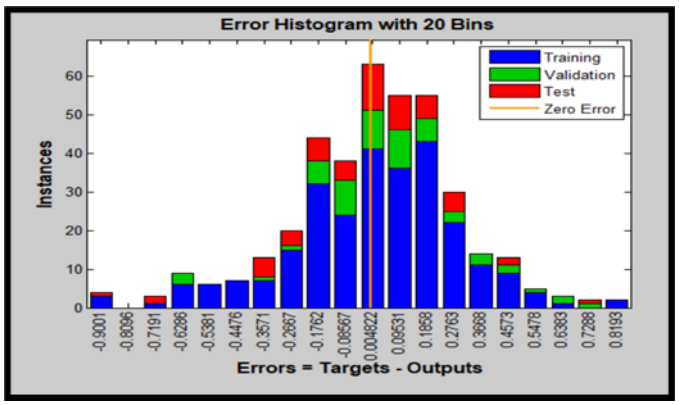

Figure 4. Histogram of errors in the trained network

As observed in the above diagram, all three sets have normal distribution of errors in terms of the degree of compliance of the outputs with the target (observed data). In most cases, most aggregation of distributed data has been close to the zero-error axis. In each set, four diagrams related to data adaptation rate, data distribution rate, the number of error and the histogram of the remaining errors are plotted.

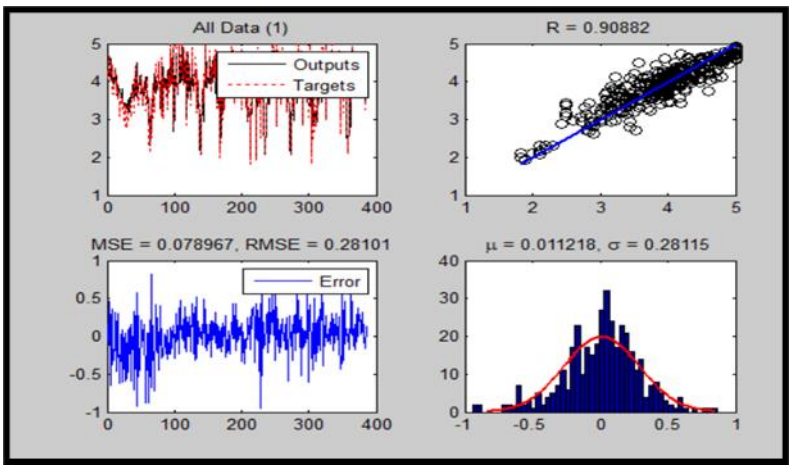

Figure 5. Overall performance of BP-ANN based on bankruptcy criteria

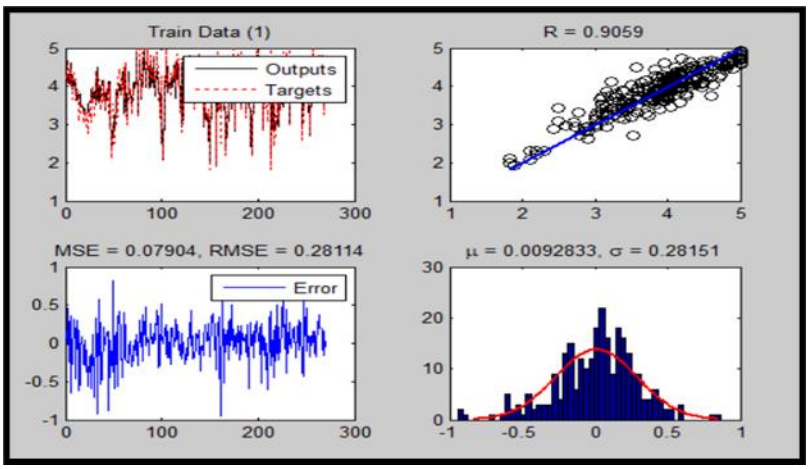

Figure 6. Performance of BP-ANN training set based on bankruptcy criteria

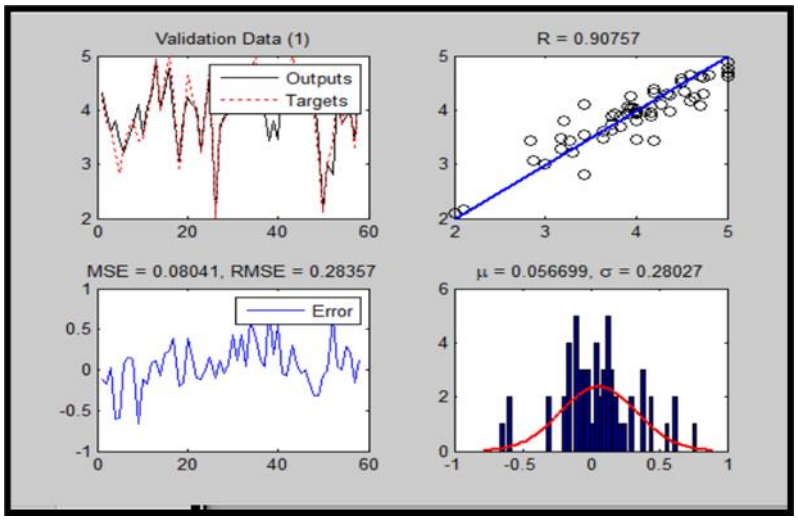

Figure 7. Performance of BP-ANN evaluation set based on bankruptcy criteria

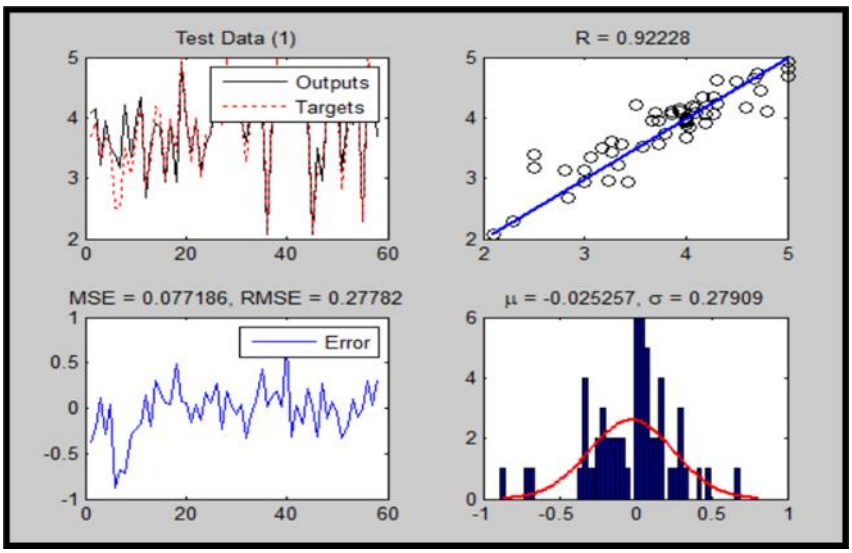

Figure 8. Performance of BP-ANN test set based on bankruptcy criteria

Accordingly, considering the findings obtained in this section, it can be stated that the final fit based on the selected data test was equal to 92%.

4. 2. Support Machine Vector-Based Prediction

Support vector machine as an unimaginable method is one of the most important machine learning methods that has high power in data classification and clustering. In this section, there are various methods for estimating with high accuracy, and each of them has high-level mathematical framework. All existing algorithms in the support vector machine method are used in this section, and the results are presented separately for each estimation method:

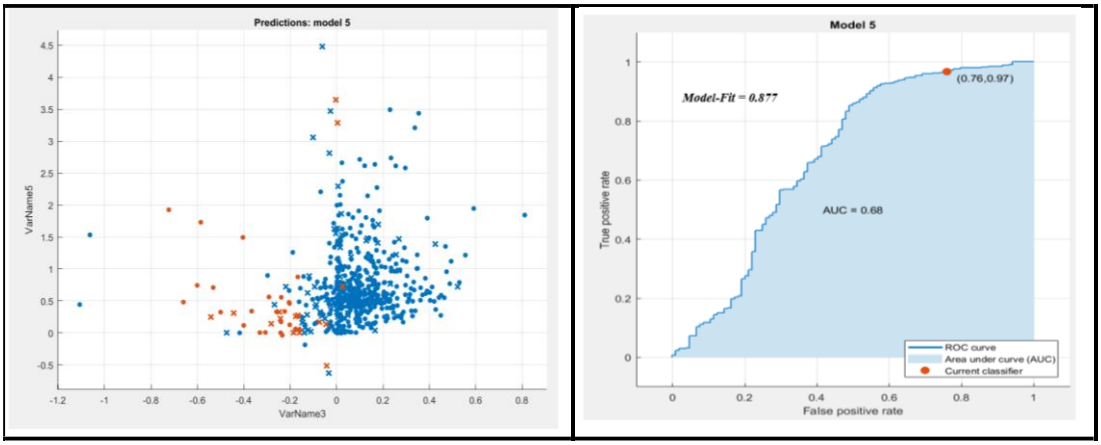

Figure 9. Companies' bankruptcy prediction with vector machine by linear estimation method

According to the results of the report in MATLAB software, the estimation accuracy of the linear model was equal to 87.7%. In other words, the rate of correct answers in the prediction was approximately equal to 88%.

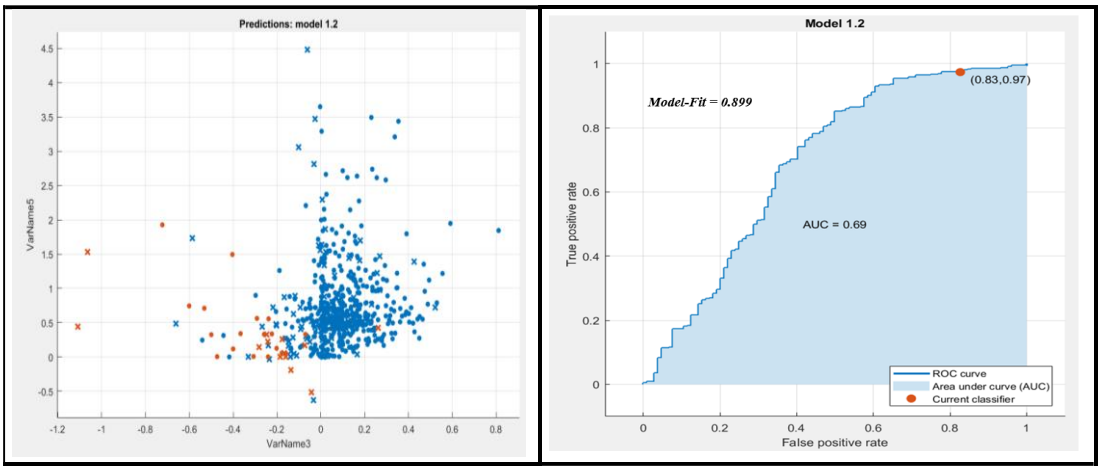

Figure 10. Companies' bankruptcy prediction with vector machine by quadratic estimation method

According to the results of the report in MATLAB software (Figure 10), the accuracy of estimating the quadratic model was equal to 89.9% (the model fit in this section was close to 90%).

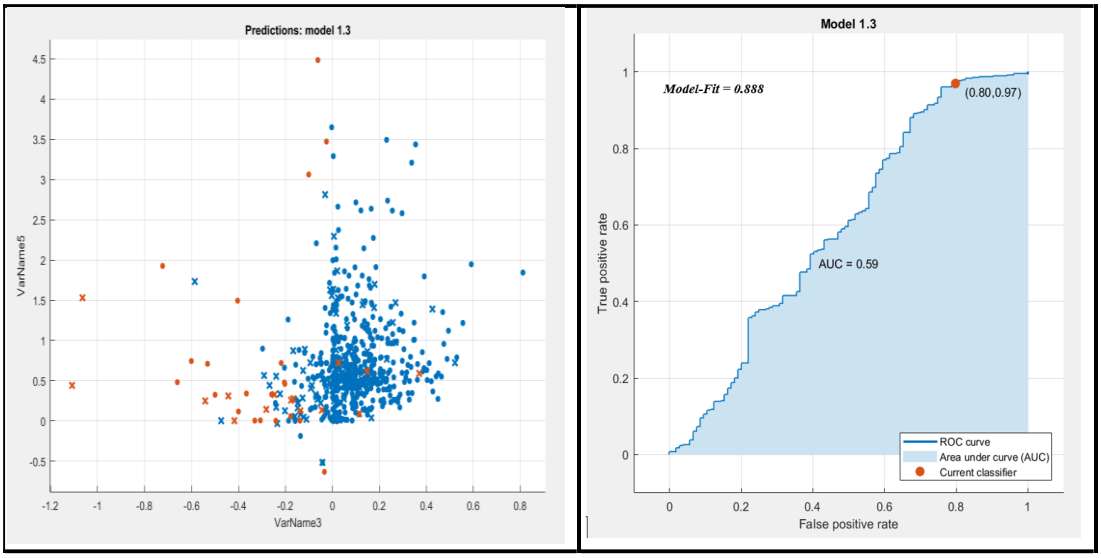

Figure 11. Companies' bankruptcy prediction with vector machine by polynomial estimation method

According to the results of the report in MATLAB software, the estimation accuracy of the polynomial model was equal to 88.8%.

Figure 12. Companies' bankruptcy prediction with vector machine by low-width Gaussian estimation method

According to the report from Figure 12, the estimation accuracy of the low-width Gaussian model was equal to 98.2% (compared to the ANN method, 6% better fit was reported).

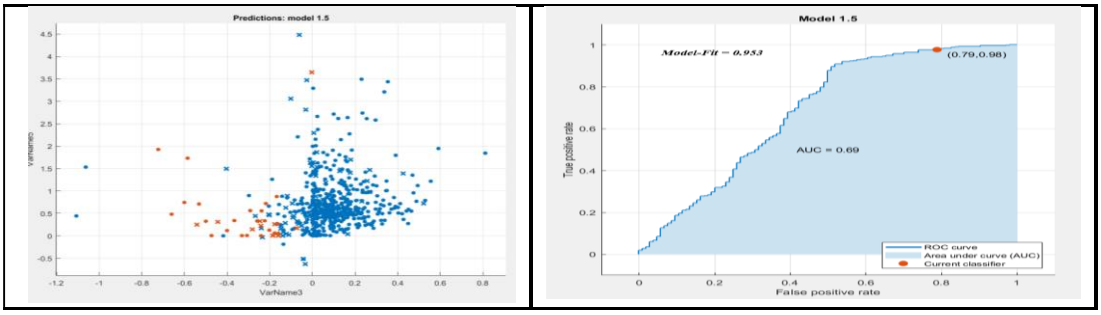

Figure 13. Companies' bankruptcy prediction with vector machine by medium-width Gaussian estimation method

According to the results in Figure 13, it can be stated that the estimation accuracy of medium-width Gaussian model was 95.3%.

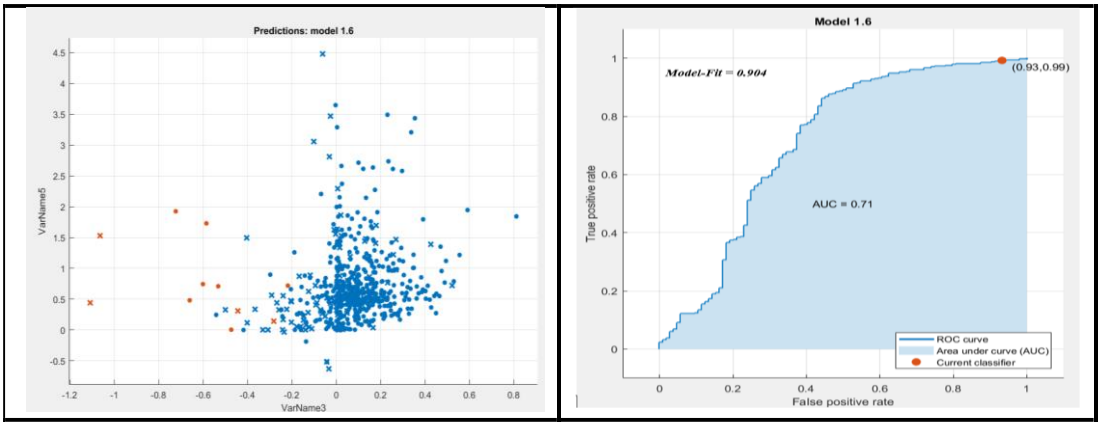

Figure 14. Companies' bankruptcy prediction with vector machine by wide-width Gaussian estimation method

Finally, according to the results of the report in MATLAB software, as reported in Figure 14, the estimation accuracy of wide-width Gaussian model was equal to 90.4%. Therefore, it can be said that the vector machine algorithm based on the estimation of the low-width Gaussian model, has a higher accuracy than the other algorithms as well as ANN one.

5. Conclusion

The bankruptcy and failure of companies has always been considered as an undesirable financial phenomenon. The likelihood of companies' bankruptcy has increased due to the rapid advances in technology since the beginning of the nineteenth century, environmental changes and increasing competition among the companies. On the other hand, with the emergence of joint-stock companies and their increasing growth and their need to finance outside the company, the issue of evaluating the financial situation of the company by investors and suppliers of companies is raised, so that they can take more confident decide to invest in these companies. Of course, all businesses plan to succeed and direct their operations towards the implementation of plans, but some of them take risky operations to achieve the goals, which leads to bankruptcy. It is the unexpected aspect of bankruptcy that makes it even more dangerous. However, not all business units that are not continuing to operate, are considered bankrupt. Bankruptcy is an event that has a profound effect on management, shareholders, employees, creditors, customers, and other stakeholders. Bankruptcy challenges the country both socially and economically. The more bankruptcy is recognized in the early stages, the more it can be prevented. With simpler solutions, it can be avoided and its economic and social consequences can be reduced or even prevented.

The problem of not accurately predicting the state of financial helplessness and bankruptcy of companies, causes investors to have a perceived risk continuously in relation to their capital. However, the prosperity in this field is seriously affected by the accuracy of companies' bankruptcy prediction methods, especially in the long run. Recent evidence suggests that as much as the bankruptcy of companies are predicted using accurate computational methods (methods in the group of deep learning models), the predictions are more accurate in a longer time. This can solve the problem of inefficiency of prediction methods in the field of financial bankruptcy of companies in the long run. Using deep learning techniques and algorithms, the first problem, i.e., the need for long-term study and long-term forecasting, has been solved, and it is possible to use mathematical techniques and algorithms based on deep learning or machine learning and achieve the accurate estimates. As observed, the vector machine algorithm based on Gaussian model estimation with a small width can have a higher accuracy than the other algorithms; Its estimation compared to the ANN technique is also higher by 6%. The model fit for this algorithm is estimated to be 98.2%, which is a significant value. We believe our finding can help investor also policy maker in prediction of bankruptcy.it also provide new information for all of the stockholders of financial information..

References

1. Ismaili S. and Goghardchian A. (2017). "Predicting Financial Bankruptcy Using Cash Flow Statement: An Artificial Neural Network Approach" Organizational Culture Management, 15 (4): 879-901.

2. Ekdari A. R. Khanka A. K. And Barzegar Khandouzi A. (2017). "Application Of Support Vector Machine In Predicting Companies' Bankruptcy Using Financial Ratios" Third National Conference On New Topics In Accounting, Management And Entrepreneurship, Minoodasht, Islamic Azad University, Minoodasht Branch.
3. Bahiraei A. Etemadi K. Gerami-asl A. (2016). Comparison Of Artificial Intelligence Systems (ANFIS And ANN) And Logit Regression In Predicting Financial Bankruptcy Of Companies Listed On The Tehran Stock Exchange. Modern Marketing Research, Year 6, Issue 2 (Series 21), 153-166.
4. Bazrafkan Z. (2014). Comparison Of Logistic Regression And Decision Tree In Predicting Financial Bankruptcy Of Companies Listed On The Tehran Stock Exchange" Master Thesis, Faculty Of Educational Sciences And Psychology, Islamic Azad University, Marvdasht Branch.
5. Haji Hashem M. and Amir Hosseini Z. (2019). Bankruptcy Prediction And Corporate Governance Based On The View Of Financial Ratios, Journal Of Management Accounting And Auditing Knowledge, 8 (30): 201-220.
6. Satayesh M. R. and Ahadianpour D. (2017). "Bankruptcy Prediction Using Artificial Neural Network And Comparison With Altman Multiple Point Analysis Model" Journal Of Future Management Research, 19 (3): 63-81.
7. Saadatpour M. (2017). "Bankruptcy Prediction And Analysis Of Its Causes Using The Financial Ratios Identified By The Two-Stage Model Of Artificial Neural Network And Genetic Algorithm (Case Study Of Companies Listed On The Tehran Stock Exchange) " Master Thesis, Islamic Azad University Of Najafabad.
8. Alizadeh R. (2016). "Predicting The Bankruptcy Of Companies Listed On The Stock Exchange Using Artificial Neural Network And Support Vector Machine Methods" International Conference On Industrial Engineering And Management, Tehran, Permanent Secretariat Of The Conference.
9. Nazemi Ardakani M. (2016). Investigating The Impact Of Corporate Governance And Conservatism On The Predictability Of Bankruptcy Models Based On Neural Networks, Journal Of Experimental Accounting Research, 5 (4): 113-132.
10. Vaez Ghasemi M. And Ramezanpour Chahardeh S. (2018). Predicting Bankruptcy Of Companies Listed In The Stock Exchange And Securities Organization Using Artificial Neural Network, Investment Knowledge Quarterly, 7 (26): 277-296.
11. Alexandropoulos, S. A. N., Aridas, C. K., Kotsiantis, S. B., & Vrahatis, M. N. (2019, May). A deep dense neural network for bankruptcy prediction. In International Conference on Engineering Applications of Neural Networks (pp. 435-444). Springer, Cham.
12. Ansari, A., Ahmad, I. S., Bakar, A. A., & Yaakub, M. R. (2020). A Hybrid Metaheuristic Method in Training Artificial Neural Network for Bankruptcy Prediction. IEEE Access, 8, 176640-176650.
13. Antulov-Fantulin, N., Lagravinese, R., & Resce, G. (2021). Predicting bankruptcy of local government: A machine learning approach. Journal of Economic Behavior & Organization, 183, 681-699.
14. Azayite, F. Z., & Achchab, S. (2017, October). The impact of payment delays on bankruptcy prediction: A comparative analysis of variables selection models and neural networks. In 2017 3rd International Conference of Cloud Computing Technologies and Applications (CloudTech) (pp. 1-7). IEEE.
15. Azayite, F. Z., & Achchab, S. (2018, May). Topology design of bankruptcy prediction neural networks using Particle swarm optimization and backpropagation. In Proceedings of the International Conference on Learning and Optimization Algorithms: Theory and Applications (pp. 1-6).
16. Balzan, E. (2020). Corporate failure prediction: assessing the accuracy of different bankruptcy prediction models on Maltese SMEs (Master's thesis, University of Malta).

17. Barboza, F., Kimura, H., & Altman, E. (2017). Machine learning models and bankruptcy prediction. Expert Systems with Applications, 83, 405-417.
18. Barboza, F., Kimura, H., & Altman, E. (2017). Machine learning models and bankruptcy prediction. Expert Systems with Applications, 83, 405-417.
19. Cassim, R. J., & Swanepoel, M. J. (2021). The bankruptcy prediction approach: An empirical study of comparison between the emerging market score model and bankruptcy prediction indicators approach in the Johannesburg Stock Exchange. Journal of Economic and Financial Sciences, 14(1), 539.
20. Chen, Z., Chen, W., & Shi, Y. (2020). Ensemble learning with label proportions for bankruptcy prediction. Expert Systems with Applications, 146, 113155.
21. Chou, C. H., Hsieh, S. C., & Qiu, C. J. (2017). Hybrid genetic algorithm and fuzzy clustering for bankruptcy prediction. Applied Soft Computing, 56, 298-316.
22. Dabag, R., & Sheikhbeiglou, S. (2021). Bankruptcy Prediction of listed Companies in Tehran's Stock Exchange by Artificial Neural Network (ANN) and Fulmer Model. Journal of Development and Capital, 6(2), 93-108.
23. Dawkins, M. C., Bhattacharya, N., & Bamber, L. S. (2007). Systematic share price fluctuations after bankruptcy filings and the investors who drive them. Journal of Financial and Quantitative Analysis, 399-419.
24. Du Jardin, P. (2017). Dynamics of firm financial evolution and bankruptcy prediction. Expert Systems with Applications, 75, 25-43.
25. Fasya, N. S., & Rikumahu, B. (2021). Analysis of Financial Distress Prediction Using Artificial Neural Network in Retail Companies Registered in Indonesia Stock Exchange. International Journal of Advanced Research in Economics and Finance, 3(1), 121-128.
26. Gunawardana, K. D. (2021). An Analysis of Financial Distress Prediction of Selected Listed Companies in Colombo Stock Exchange. International Journal of Sociotechnology and Knowledge Development (IJSKD), 13(2), 48-70.
27. Gupta, D., Borah, P., Sharma, U. M., & Prasad, M. (2021). Data-driven mechanism based on fuzzy Lagrangian twin parametric-margin support vector machine for biomedical data analysis. Neural Computing and Applications, 1-11 .
28. Hardinata, L., & Warsito, B. (2018, May). Bankruptcy prediction based on financial ratios using Jordan Recurrent Neural Networks: a case study in Polish companies. In Journal of Physics: Conference Series (Vol. 1025, No. 1, p. 012098). IOP Publishing.
29. He, H., & Fan, Y. (2021). A novel hybrid ensemble model based on tree-based method and deep learning method for default prediction. Expert Systems with Applications, 176, 114899.
30. Horak, J., Vrbka, J., & Suler, P. (2020). Support vector machine methods and artificial neural networks used for the development of bankruptcy prediction models and their comparison. Journal of Risk and Financial Management, 13(3), 60.
31. Hosaka, T. (2019). Bankruptcy prediction using imaged financial ratios and convolutional neural networks. Expert systems with applications, 117, 287-299.
32. Jabeur, S. B. (2017). Bankruptcy prediction using partial least squares logistic r
33. Jia, Z., Shi, Y., Yan, C., & Duygun, M. (2020). Bankruptcy prediction with financial systemic risk. The European Journal of Finance, 26(7-8), 666-690.
34. Jin, X., Liu, Q., & Long, H. (2021). Impact of cost–benefit analysis on financial benefit evaluation of investment projects under back propagation neural network. Journal of Computational and Applied Mathematics, 384, 113172.
35. Keya, M. S., Akter, H., Rahman, M. A., Rahman, M. M., Emon, M. U., & Zulfiker, M. S. (2021, January). Comparison of Different Machine Learning Algorithms for Detecting Bankruptcy. In 2021 6th International Conference on Inventive Computation Technologies (ICICT) (pp. 705-712). IEEE.

36. Kim, S., Mun, B. M., & Bae, S. J. (2018). Data depth based support vector machines for predicting corporate bankruptcy. Applied Intelligence, 48(3), 791-804.
37. Kou, G., Xu, Y., Peng, Y., Shen, F., Chen, Y., Chang, K., & Kou, S. (2021). Bankruptcy prediction for SMEs using transactional data and two-stage multiobjective feature selection. Decision Support Systems, 140, 113429.
38. Kumar, J., Kumar, V., Verma, D., & Sharma, S. (2021). Prediction of Corporate Bankruptcy Based on Financial Ratios using Binary Logistic Regression. International Journal of Statistics and Reliability Engineering, 7(3), 376-381.
39. Le, T., Lee, M. Y., Park, J. R., & Baik, S. W. (2018). Oversampling techniques for bankruptcy prediction: novel features from a transaction dataset. Symmetry, 10(4), 79.
40. Marso, S., & EL Merouani, M. (2020). Bankruptcy Prediction using Hybrid Neural Networks with Artificial Bee Colony. Engineering Letters, 28.(4)
41. Metawa, N., Pustokhina, I. V., Pustokhin, D. A., Shankar, K., & Elhoseny, M. (2021). Computational Intelligence-Based Financial Crisis Prediction Model Using Feature Subset Selection with Optimal Deep Belief Network. Big Data, 9(2), 100-115.
42. Ptak-Chmielewska, A. (2021). Bankruptcy prediction of small-and medium-sized enterprises in Poland based on the LDA and SVM methods. Statistics in Transition New Series, 22(1), 179-195.
43. Ptak-Chmielewska, A. (2021). Bankruptcy prediction of small-and medium-sized enterprises in Poland based on the LDA and SVM methods. Statistics in Transition New Series, 22(1), 179-195.
44. Qu, Y., Quan, P., Lei, M., & Shi, Y. (2019). Review of bankruptcy prediction using machine learning and deep learning techniques. Procedia Computer Science, 162, 895-899.
45. Santoso, N., & Wibowo, W. (2018, March). Financial distress prediction using linear discriminant analysis and support vector machine. In Journal of Physics: Conference Series (Vol. 979, No. 1, p. 012089). IOP Publishing.
46. Shrivastav, S. K., & Ramudu, P. J. (2020). Bankruptcy prediction and stress quantification using support vector machine: Evidence from Indian banks. Risks, 8(2), 1-52.
47. Sugiyarti, L., & Murwaningsari, E. (2020). Comparison of Bankruptcy and Sustainability Prediction: Altman Z Score Versus Grover Model. Selangor Business Review, 5(2), 56-72.
48. Sun, J., Fujita, H., Zheng, Y., & Ai, W. (2021). Multi-class financial distress prediction based on support vector machines integrated with the decomposition and fusion methods. Information Sciences, 559, 153-170.
49. Tian, S., & Yu, Y. (2017). Financial ratios and bankruptcy predictions: An international evidence. International Review of Economics & Finance, 51, 510-526.
50. Tron, A. (2021). Common Characteristics of Firms in Financial Distress and Prediction of Bankruptcy or Recovery: An Empirical Research Carried out in Italy. Corporate Financial Distress, 67-99 .
51. Veganzones, D., & Séverin, E. (2018). An investigation of bankruptcy prediction in imbalanced datasets. Decision Support Systems, 112, 111-124.
52. Wang, C., Wang, Y., Yan, L., Ye, Z., Cai, W., & Wu, P. (2019, September). Financial Early Warning of Listed Companies Based on Fireworks Algorithm Optimized Back-Propagation Neural Network. In 2019 10th IEEE International Conference on Intelligent Data Acquisition and Advanced Computing Systems: Technology and Applications (IDAACS) (Vol. 2, pp. 927-932). IEEE.
53. Wang, M., Chen, H., Li, H., Cai, Z., Zhao, X., Tong, C., ... & Xu, X. (2017). Grey wolf optimization evolving kernel extreme learning machine: Application to bankruptcy prediction. Engineering Applications of Artificial Intelligence, 63, 54-68.

54. Wyrobek, J. (2018). Predicting bankruptcy at polish companies: A comparison of selected machine learning and deep learning algorithms. Zeszyty Naukowe Uniwersytetu Ekonomicznego w Krakowie, 978(6), 41-60.
55. Zhai, M. (2021). Risk Prediction and Response Strategies in Corporate Financial Management Based on Optimized BP Neural Network. Complexity, 2021.
56. Zhang, Y., Liu, R., Heidari, A. A., Wang, X., Chen, Y., Wang, M., & Chen, H. (2021). Towards augmented kernel extreme learning models for bankruptcy prediction: algorithmic behavior and comprehensive analysis. Neurocomputing, 430, 185-212.
57. Zhao, D., Huang, C., Wei, Y., Yu, F., Wang, M., & Chen, H. (2017). An effective computational model for bankruptcy prediction using kernel extreme learning machine approach. Computational Economics, 49(2), 325-341.