Comparison Models of Corporate Bankruptcy Prediction in Companies Listed in Tehran Stock Exchange by Particle Swarm Optimization Algorithm and Support Vector Machine Algorithm

Neda Rostami[1*], Mahdi Salehi[2], Mohammad Reza Shoorvarzy[3], Alireza Davoodi[4]

[1] Department of Accounting, Khorasan Razavi, Neyshabur, Science and Research branch, Islamic Azad University, Neyshabur, Iran, E-mail: Nrostami51@yahoo.com
[2]Assistant Professor of Accounting Ferdowsi University of Mashhad, Iran
[3]Assistance Professor Department of Accounting, Neyshabur Branch, Islamic Azad University, Khorasn Razavi, Neyshabur, Iran,
[4]Assistance Professor Applied Mathematics - Operations Research, Neyshabur Branch, Islamic Azad University, Iran

Abstract: Nowadays by rapid advancement of technology and vast environmental changes on the one hand and the development of fifth Parliament's program and also privatized most of governmental companies, on the other hand by increasing competition has led to limit of accessing to profits. Following, chance of bankruptcy will rise. Therefore, many researchers have tried to find the best predicting bankruptcy model by available information. Thus, in according to economic and financial environment, they have proposed several models. The current research was included one hypothesis which this includes an assumption that ability of particle swarm optimization algorithm and support vector machine algorithm models for predicting bankruptcy were compared and the results indicate that the Support Vector Machine algorithm had better ability for predicting bankruptcy in comparison with particle swarm optimization algorithm.

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Introduction:

Mine and Zhang argued that predicting bankruptcy model can be split in two main groups: 1) this group is based statistical, however, overall trend has shown that although the model can predict well, they also provide some restrictive assumptions of the model such as linearity, normality and independence of the predictive variables have been effective on the ways. Thus, another ways have created gradually in order to improve performance of system based on artificial intelligence. Afterwards 1990's, these models have created by developing artificial intelligence in finance and accounting systems. Due to the characteristics of this class (nonlinear and nonparametric), they are powerful tools to identify and classify Companies. Consequently, this study attempts to assess the ability of each technique (support vector machines, particle swarm optimization algorithm) for predicting bankruptcy of available companies in prior and after years of occurring and helping users, capital markets and others.

One of research division is conducted in the field is based on type of models. William Beaver research can be one of commencing models of bankruptcy predicting. Beaver is used univariate analysis for investigating ability of financial ratios in bankruptcy prediction and he also argued that bankruptcy of the companies is as result of their inability to fulfill financial obligations. Altman used for the first time the effects of compounds on corporate bankruptcy prediction. His model was known as (Z-score) as well as it has used as indicator of financial health. Deaken created a new model by combining research of Beaver and Altman, he believed that Beaver's model has higher ability, while Altman's model can predict better. Olson [21] was the first person who used the logistic regression for predicting bankruptcy. His sample consists of 2,163 healthy and unhealthy companies. Hence, his research has been the most comprehensive study until that time. Friedman, Altman and Kao [10] used a recursive partitioning algorithm and they compared its result with multiple analytical detections model for three consecutive years. Following, thanks to attempts of researchers in order to predict of bankruptcy some researchers have tried to improve the model. Adam and Sharda used neural networks in designing of predicting bankruptcy model. The results suggest, neural network models more detailed, more reliable. Bell, Ribar and Verchio and also Tam and Kiang compared the ability of neural networks

with the other models. Min and Lee developed a model by using the Support Vector Machine and show that SVM has better performance, scalability and overall accuracy in comparison with Neural Networks. Other researchers like Moradi and *et* al [19], Abdollahi *et* al [4], Min *et* al [17], Hsieh *et* al [12], Lin *et* al [14], Yang *et* al [26] studied SVM abut predicting bankruptcy. Wang and Wu [25] argued that traditional models had not high accuracy in predicting bankruptcy. In order to improve the model, PSO model is combined with the other models and then compare the accuracy. Fadaie Nezhad and Eskandari believed that the genetic algorithm and particle swarm optimization algorithm each of them have their strengths and weaknesses. Moreover, they cannot claim that one is superior to another [1] Chen Ling and et al also studied about PSO model.

Support Vector Machine:

In 1965, a Russian scientist called Vladimir Vapyng start very important step in the design of classifying. He offered statistical learning theory and Support Vector Machine offered based on learning theory, due to the characteristics of the model and high-performance operation quickly gained a high reputation and decrease validity a lot of previous algorithms. Support Vector Machine is linear method which input data as two sets of vectors in n dimensions space. Support Vector Machines can maximize margin of between the two sets. To calculate the margin, two parallel plates create on either side of two separate pages and they separate so much which data of two classes crash to each other and date hits will be called Support Vector Machine.

Suppose $\mathbf{x = \{(x\ 1,\ x\ 2)\ i = 1\ n\}}$ is learning pattern of vectors in which each $x_{i\,\varepsilon}R$ is a vector in D dimensions in the space which is labeled by Y_i And $Y_i = \{-1, +1\}$. In other words, there is n samples of learning and each of them are D features and also each belongs to class +1 or -1.To solve a set of problems, two categories of data is optimal classified. The problem of SVM in both cases will be solved by linear and nonlinear which is linear in the input space and the feature space of the nonlinear problem is solved. If the data can be separated linear following will be as follow:

(1): $\mathbf{Y = sign\left\{\sum_{i=1}^{N} \alpha_i\, y_i(x, x_i) + b\right\}}$

Where: Y Output of the equation, Y_i Class value of training x_i, or points that belongs the vector**.** Furthermore, x = (x_1, $x_{2\ldots}$, x_n) represents the input data and i = 1, N, X_I is support vectors. In equation (1), parameters of B and A set parameters of the space.

For data that are not linearly separable data in a high dimensional space can be mapped in order to find the optimum, thus the question becomes as follows:

(2): Q (a) = Q

(a)=$\sum_{i=1}^{n} \boldsymbol{\alpha_i} - \mathbf{1/2} \sum_{i,j=1}^{n} \boldsymbol{\alpha_i\, \alpha_i y_i y_i k(x_i . x_j}$

Based on: $\sum_{i=1}^{m} \boldsymbol{\alpha_i y_i} = \mathbf{0}$

$\mathbf{0 \le \alpha_i \le c\ i = 1, 2, \ldots, n}$

C is parametric error for fault training. Upper bound $\boldsymbol{\alpha}_1$ is the same of C which is determined by the user. Thus the final category is as follows:

(3): $\mathbf{Y = sign\left\{\sum_{i=1}^{N} \alpha_i\, y_i k(x, x_i) + b\right\}}$

Function **k** use as the kernal function. Equitation 4 is a linear kernal function, polynomial, Gaussian and Sigmoid. The model Support Vector Machine is used and kind of kernel function of this research is Gaussian.

$$\mathbf{k(x_i . x_j) = \exp\left(-\gamma \left\| x_i - x_j \right\|^2\right) \gamma > 0}$$

d,*γ*,r are the kernel function parameters.

Particle Swarm Optimization Algorithm:

Motion of mass particle is mass coordinated motion which is done usually by using limited connection users and limited information of members [15]. This pattern is dynamic calculating ways which is based on the initial population and it is built by Kennedy and Eberhart in 1995 [13]. Main idea is originated from behavior of fish and birds when they seek food and following a group of birds selected in randomly space. This pattern can be explained that there is one piece of food in the space and no-body of birds does not know of food place. Therefore, one of the best strategies is following a bird which has minimum distance of food place and it is essence of Considered one of the best strategies Be Following a Bird The minimum distance that a food is, the essence of this strategy is the particle swarm optimization algorithm.

In PSO algorithm, each way is equivalent to a particle. Each particle has a fitness value which is calculated by a fitness function. Furthermore, if each particle in the search space be closer to the goal, it will have greater merit. Each particle also has a speed which is directing movement of each particle and each of the particle maybe adopt itself based on searching space or the best place in neighborhood. In other words, they are using each particle based on the best amount will be update. One of the best position of the particle can be achieved is (pbest) position and the other is the best position which is achieved based on population of particles and it displays with (gbest). In according to values of (pbest) and (gbest) each particle will use to determine the position of following particle dimensional:

(4): $\mathbf{V_{ij}(t+1) = WV_{ij}(t) + C_1 r_1 (p_{ij}(t - x_{ij}(t)) + c_2 r_2 (g_{ij}(t) - x_{ij}(t))}$

(5): $\mathbf{X_{ij}(t+1) = X_{ij}(t) + V_{ij}(t+1)}$

In the above relationships, Parameter Learning c_1 and c_2 determine amount of impact on gbest and pbest which are equivalent 2. r_1 and r_2 are

random numbers in the range [0, 1]. (t) x_{ij} is Current status of each bird, V_{ij} (t) The phase velocity of the particles and W Inertia controlling factor the motion of particles at the beginning of the algorithm, in starting run of algorithm quicker and after a while to respond more will decrease slowly.

The focus of this research is to identify and establish an accurate model of predicting bankruptcy with high performance and accuracy, thereby increase amount of accuracy for classifying companies into healthy and un healthy companies. Thus, our hypothesis is:

H_1: Ability of predicting bankruptcy by Support Vector Machine is more than Particle Swarm Optimization Algorithm

Following fundamental steps are necessary for doing the research:

1 - Calculating ratio of finance ratio as independent variables during 2004-2010

2 - Separation of bankrupt and non-bankrupt samples.

3 - Run Kolmogorov- Smirnov test and parametric T-test and non-parametric Mann - Whitney test, finally deleting data from 56 financial ratios

4 - Select the final independent variables among the independent variables remaining in the third stage of the test SDA.

5 - Design and Implementation Genetic algorithm and particle swarm optimization algorithm and Support Vector Machine.

6 - Evaluation of the significance and predictive power of predicting models of particle swarm optimization algorithm and Support Vector Machine by using parametrical T-test when output of algorithm and using non-parametric Mc Nemar Test test when output data are non-normal.

The population of this study consists of companies listed on Tehran Stock Exchange. In the present study to compare models of support vector machines and Particle Swarm Optimization Algorithm requires information of two groups: Bankrupt and non-bankrupt. To determine Bankrupt companies that determination of the Iranian Commercial Code Article 141 has been used (Bankrupt company is a company which loss accumulated is half of whole equity), after choosing insolvent companies in each industry accidentally for each year and choose one health company. Therefore, our sample consist 79 healthy and 79 bankrupt companies during 2005- 2010.Since we use related models, date of in year's t must be extracted

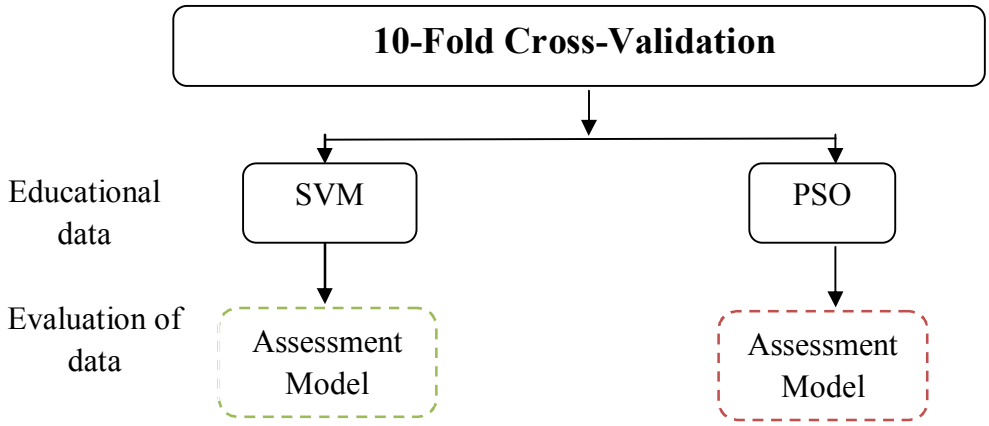
In addition, financial ratios are valuable measure to disclose financial information and assessing a company's financial position. In present research, for comparing models of Genetic algorithm and particle swarm optimization algorithm and Support Vector Machine also used as predicting variables in studying bankrupt companies. William Beaver compared 30 financial ratios of predicting unhealthy to cheek ability of financial rations as the best indicator for predicting healthy of companies to cheek ability of financial rations. He concluded that, these ratios are different in unhealthy and healthy companies. Altman's research showed that financial ratios of failure companies are considerably different with healthy companies. Hossary, investigated on 208 studies related to predicting bankruptcy during 1966-2004 and he concluded that over 79% of the studies used financial ratios for predicting bankruptcy. Chen showed that financial. Therefore, based on related and previous articles 56 financial ratios on classifying profitability, liquidity, operating and financial leverage was chosen as the independent variables. Features selected from total of 56 financial ratios from Kolmogorov-Smirnov in order test normality, Mann-Whitney nonparametric for investigating significant difference between two groups of bankrupt and non-bankrupt and in the final stage by using SDA test 9 financial ratios have selected as final predictive variable.

Table 1 Independent Variables

Return on investment	Working Capital to Sales*	Operating profit to sales
Asset returns*	Working Capital to Total Assets	Fixed assets to equity
Percent return on investment	Working capital to total liabilities	Current Assets to Sale
Capital Working ratio	Profit to gross profit	Net profit on sale
Useful measure of loan	Operating profit to equity	Collection period
Sale to inventory	Accumulated earnings to total assets*	Debt to equity ratio
Total liabilities to equity	Sale to receivable accounting	Cash adequacy ratio
Inventory to sale	Operation profit to interest expense	Liability ratio
Ratio of current assets	Gross profits to total debt	Cash ratio
Ratio of inventory to capital working	Capital Working to equity	Debt coverage ratio
The total financial cost of debt	Gross profit to total income	Working Capital
Debt cost to Gross Profit	Size	Debt to Capital*
Cash to total debt	Net Income to Total Debt	*Quick ratio

Cash to total assets	Operating profit to total assets	Cash turnover ratio
Operating cash flow to debt	Total debt to equity	The financial burden of loans
Operating cash to equity	Equity to total assets	Inventory turnover
Operating cash flow to assets	Equity to capital*	Fixed assets turnover*
Operating cash to sale	Working capital to long-term debt	Accounts receivable to total debt
	Sales to Total Assets	Current liabilities to total assets

Design and implementation of models (SVM, PSO) in during 3 process of proposed way of research which is prioritized: 1- division of data into educational and test. 2- training process of models 3- Evaluate educational data with test data which are not seen by logarithm yet.



Findings:

Three criterions are used to assess the predictor models: accuracy of the prediction, type I error and type II error. Since the normality of the outputs of the algorithms was approved by Kolmogorov-Smirnov' test, T-test is used for studying the difference of the means.

Table 2: Result of Kolmogorov – Smirnov's test

Criterion	Algorithm	Range	Mean	Standard deviation	kurtosis
Type I error	SVM	22.22	7.3285	7.60124	.731
	PSO	23.08	9.1002	7.76979	.340
Type II error	SVM	11.11	4.2063	4.5637	.217
	PSO	33.33	16.6107	9.4481	-.084
Accuracy of the prediction	SVM	13.04	94.3083	4.63648	.056
	PSO	17.39	86.8182	5.50060	.050

The above results show that output of the SVM has the lowest range, furthermore its mean in accuracy of the prediction has the highest value and in type I and II error has the lowest value. Moreover, Kurtosis also approves the normality of the observations; likewise the normality of the algorithms' output in year t-1 was approved by Kolmogorov-Smirnov's test.

Table 3: Assessing criterions in year's t and t-1

Algorithm		Accuracy of the prediction	Type I error	Type II error
Year $_t$	PSO	86.8182	16.6107	9.1002
	SVM	94.3083	4.2063	7.3285
Year $_{t-1}$	PSO	81.6206	27.0538	10.4964
	SVM	91.2253	12.0723	5.6154

As the accuracy of the prediction and type I and II error of the models are consistent, and also by higher values of accuracy of the prediction and lower values of the errors can say that support vector machine has a better performance, so by using T-test we can see that the significance levels of accuracy of

prediction, type I error in both years t and t-1 are less than.05; Therefore with the confidence of 95% we can say that the ability of support vector machine in predicting bankruptcy is higher than particle swarm optimization.

Table 4: T-test for comparing means of algorithms in year t

Criterion	t	df	p-value
Accuracy of prediction	-3.292	18	.004
Type I error	3.738	18	.002
Type II error	.515	18	.613

Table 5: T-test for comparing means of algorithms in year t-1

Criterion	t	df	p-value
Accuracy of prediction	-2.989	18	.008
Type I error	2.587	18	.019
Type II error	1	18	.330

Conclusion:

In according to an increasing competition among companies and rise of bankruptcy and impose huge losses of investors, creditors and several of decision makers; bankruptcy is important and creating a model with high ability can improve accuracy of bankruptcy and discovering more suitable models. Thus, in this research, we investigated ability of two models of SVM and PSO in field of bankruptcy prediction and results show that SVM is stronger than PSO and with composition of GA can raise ability of separating bankrupt and non bankrupt companies.

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[1] [1] - penalty parameter
[2] - kernal function
[3] -Liner
[4] -Polynominal
[Five] Gaussian -
[6] -Sigmoid
[Seventh] - Kolmogrov-Smirnov Test
[The eighth] -T-Test
[9th] -Mann-Whitney Test
[10] - Statistical Analysis Department
[11] - Mc Nemar Test
[12] **- the The final selection**