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Implementing machine learning methods in the prediction of the financial constraints of the companies listed on Tehran's stock exchange

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ABSTRACT

One of the main issues in the prediction of financial constraints is the choice of predictor variables. In this study we used machine learning Gussian process and radial neural network to predict the financial constraints. The statistical society consists of 208 companies from 2011 to 2017 and considering the availability of the information all the companies were analyzed as the statistical samples. The results of this study show that machine learning methods can predict the financial constraints of the companies listed on Tehran's stock exchange. Therefore the main hypothesis of this study is confirmed and machine learning methods are an effective method to predict the financial constraints. Also the results of this study show that the value of the company, the ratio of operating cash to assets, financial leverage, return on assets and the percentage of institutional owners are the main variables in predicting the financial constraints.

Keywords

financial constraint, machine learning method, radial neural network, Gussian process regression.

1. Introduction

The financial constraints are one the main issues for all companies . In the recent decades various companies had problems in financing because of the recurring financial crises in Europe and Asia. Considering these crises, the issue of companies' financing is one of the main issues in financial literature. The turbulent and changing economic environment with market globalization, changing customer needs and increasing competition has forced the companies to search for ways to improve their performance. In this ways the companies need enough financial resources for their activities and programs [1]. Economic institutions and enterprises especially industrial activists need macro capital for their survival and production activities and improving their activities. Also these economic institutions and enterprises are so much dependent on the financial markets for their capital financing. The role of these markets is to provide the necessary capital for the institutions and companies. One of the main concerns of the financial managers of the enterprises is the methods and financing. We should consider that financing by companies is not limited and the companies have financing constraints. Financial constraints not only cause lost investment opportunity and have negative effect on the performance and improvement of the enterprise through limiting the access to funds needed for capital but also they may have negative effect on the stock returns of the company. The financing by companies is not limited and companies have some limitations in this case. The companies which have low and costly access to external financing resources have financial constraints. Therefore we can call every company as having financial constraints, but the financial constraints levels are different. Generally the companies without financial constraints or with low financial constraints are those which have high liquidity capability and net assets. Therefore the financial constraints are those barring the needed financing for favorable investment [10]. The companies with financial constraints have more market failure and have limited access to external financing which in long term will have negative effect on companies' profitability, improvement and therefore financial situation and this may cause the company to miss the competition and get eliminated in the market [24]. As a result these companies keep more cash and exclude profitable investment opportunities to finance the investment projects. Fazari belives that the companies face financing constraints when there is a gap between the internally financed resources and external resources. The constraints determine each system function and each system has the minimum constraints. In other words we can determine each system function by assessing the constraints managements and there is no constraint-free system. Therefore predicting the financial constraints is important for investors, creditors and other users of financial information.

In the Iranian market, due to limited resources for investors and managers, and the lack of economic prosperity for some companies, they are having difficulty with financing. Therefore, the need for identifying the effective variables in Tehran Stock Exchange, and seeking variables to remove the effects of financial constraints is more than ever, and with the shortage of resources, managers have to use internal resources for investments, As a result, some investments may be lost due to limited financial resources [20].

Considering the importance of financing and its significant role in corporate success, through identifying variables affecting it, we can provide important information to investors and financial analysts to evaluate the future status of the company. Therefore according to the description given, and whether or not there is a financial constraint in companies from the perspective of investors and managers, this study seeks to identify the factors affecting financial constraint and also predicting future financial constraints as well as the next two years of the companies listed on the Tehran Stock Exchange. What distinguishes the present study from other studies is that this research for the first time using machine learning methods anticipates the financial constraint of companies for future periods.

2. Theoretical Foundations and Research Background

Financial constraint means that there are constraints in financing all the favorable investments . The most clear and complete definition of financial constraint is the situation in which there is a gap between the internal and external expenditure. Based on this definition all the companies have financial constraints, but the levels of financial constraints are

different. The company with more problems accessing the external resources of investment market finances more by internal resources, therefore it cannot access cash by getting a loan from external resources and will have financial constraint. These constraints are categorized as external and internal constraints [1]. Internal financial constraints are those concerning the internal resources (cash) of the business unit and can be referred to in representation theory. External financial constraints are those concerning the financial resources outside the business unit and are caused by issuing bonds and etc. We can consider this constraint in the theory of information asymmetry. Based on this theory the information which the managers have is more than the information of the investments outside the institution [25].Those companies with financial constraint have a kind of gap between the internal and external banks of allocated fund. When the difference of internal and external banks of allocated funds is high, that company is more financially constrained [25].Financial constraint means there are some factors which block the necessary funding for favorable investments[14].state that financially constrained companies tend to initially invest their cash on financing profitable projects and then on fixed assets or working capital. They invest their cash in such a way that it will be a guarantee to get new loan.

Companies tend to increase their evident fixed assets to confront the financing problem in future [22].Financial constraints in Iran have caused a kind of competition and conflict between the current and future investments and in spite of the future cash flow risk, motivates the managers to have precautionary savings, therefore when there are not enough resources, the managers are forced to use internal resources for investments and they may lose some of the investments because of low financial resources. Capital market deficiencies in Iran can cause cost gap between internal and external financing that creates some problems in companies' financing and blocks favorable investment funding. Inability to fund for investments may be because of bad credit or inability to get loan or inability to release new stock or unaudited assets that create financial constraints for companies. Generally the companies with no or low financial constraint have highly liquid assets and high net assets. Therefore financial constraints block funding for favorable investments. It is not easy to determine the exact causes of financial constraints and problems in each special case. Mostly there are different reasons for financial constraints [22].

If capital markets are efficient, and investors act rational, there should be no positive or negative governance relationship between future returns and investment; because investors anticipate the impact of the company's investment when it is announced, but if the market is inefficient, and investors do not fully understand the differentiate between the impact of investing on the future performance of a company with financial constraints and a company without financial constraints, increased investment in companies with financial constraints compared to companies without financial constraints is more likely to increase future stock returns. Accounting and performance metrics affect the extent of corporate financial constraints [9].

According to Francis, B. et al. [11]. Superior corporate governance can reduce the extent to which controlling shareholders can engage in expropriation and thereby decrease the firm's financial constraints. For instance, if management is more committed to emphasizing shareholder value and financial discipline, the company has a more transparent information environment, and the board of directors is more independent of controlling shareholders, it is more difficult for the controlling shareholders to expropriate from minority shareholders[5].. Also, if the company has strong corporate governance, the Equity market imposes higher values for holding cash. Compared to companies with unlimited financing, others rely more on cash holding to provide investment opportunities. Therefore companies with financial constraints should benefit from a stronger governance system, which is because raising cash is more efficient in companies with strong governance systems [6]. According to Gugler, K [12]. Ginglinger, E., and Saddour, K [13]. Kalatzis, A. G., et al. [17]. Nosrat and Badavar Nahandi [29]., Jafari et al [15]. Rahimian and Janfada [30]. who examined the impact of the governance system on financial constraints, the researcher uses corporate governance as one of the variables affecting financial constraints in this research.Companies with financial constraints, have more capital market failures and have limited access to external financing which in long term undermines their ability of profitability, growth, and therefore the financial status of companies and this may cause the company to lag behind the competition and even their exclusion from the market [27].What we mean by the

financial constraint is that some factors prevent funding for all desirable investments. Gracia and Mirasogorb [14]. state that companies with financial constraints desire to invest their cash primarily to finance profitable projects and then in fixed assets or working capital. They invest their cash in such a way that is a guarantee for getting a new loan. Because of the financing problems they will face in the future, companies are more inclined to increase tangible fixed assets. Financial constraints can harm the ability of profitability, growth, and consequently, financial condition and stock returns in the long term and this may cause the company to lag behind the competition and even company's exclusion from the market (Navissi, F et al. [28]. This restricts managers' access to external financing and forces them to rely much more on limited domestic resources also limits their ability to accept projects with a positive net present value. Companies can use a model with the highest predictive power and establish their position in different areas of financial constraint and be liberated from possible negative consequences and its' huge financial costs. In this research using artificial intelligence technique, accounting standards and corporate governance we have predicted financial constraints with the highest power and the lowest error.

Machine Learning refers to a family of effective and effcient algorithms for real-world problems. These algorithms are constantly updating prediction models whenever training data is received. The pattern recognition methods try to minimize the error of prediction on the training set. Linear inseparability of data is one of the problems of learning-based methods. There are two ways in the literature to address this problem. 1) Modify or generate regression algorithms in a way that is capable of separating nonlinear data, such as decision tree algorithms (Breiman 2017). 2) Mapping the data from the input space to the feature space where the data are linearly inseparable. The second method, in most machine learning algorithms including neural networks and support vector machines (SVMs) and its variants (Cortes 1995, Scholkopf 2001, Shawe Taylor2004) Widely used.

2.1. Research background

Salmanian et al[31] provided a financial constraint forecasting model in government-listed companies in Tehran Stock Exchange during the period 2011-2012 using 288 years/company financial information. The results indicate the effect of fixed asset turnover, conditional conservatism, The ratio of operating cash to assets, Company size and stock price over financial constraints among other proposed variables. Jahanshad & Shabani [16] stated that institutional investors don't have a negative and significant impact on the sensitivity of investment cash flows in companies with limited financing and a significant effect in companies without financial constraints. Dastgir & Vahedpour [7] indicated that companies with financial constraint and high investment opportunities have higher returns during the reporting period, invest more in capital assets and have more return on assets. Karimpour et al[19] tried to provide a model for financial constraints. The results indicated that among 19 factors identified, the following Affect financial constraints based on operating cash flow: return on assets, company size, Tobin's Q, cash on all assets, institution sales growth, working capital to total assets, Earnings before interest and taxes, Sales to total assets, And the financial costs to total debt. Lari Dasht Bayaz et al[22] indicated that corporate financial constraint in relation to total collateralized assets has a positive and significant effect on financial leverage and components of collateralized assets (property, equipment and machinery, Inventory of goods and accounts receivable). Karimi and Ghanbari [21] have predicted future cash using the artificial intelligence algorithm. The results indicated that artificial intelligence algorithms have the ability to predict future cash and it can be seen that prediction based on historical operating profit used in the research has less prediction error compared to the cash model used in the study. Driver & Muñoz-Bugarin, [8] indicated in their research that the relationship between the financial crisis and financial constraint is affected by the size of the company. Balimer and Whitedead [4] developed a new approach to measure financial constraints and analyzed its relationship with stock returns. Results indicated the relationship between the financial constraint and the stock returns of the companies studied. Francis et al[11] also in research on the topic of corporate governance and the sensitivity of investing to cash flow, examined the impact of the corporate governance system on financial constraints. The results of their research showed that better corporate governance, has reduced corporate dependency on internal cash flows and

financial constraints. Rahimian and Janfada [30] examined corporate governance and financial constraints. The results show that the number of major shareholders and the independence of the board, have a significant impact on the financial constraints of listed companies in Tehran Stock Exchange.

3. Research methodology

Hypotheses

Relief is an algorithm developed by Kira and Rendell in 1992 that takes a filter-method approach to feature selection that is notably sensitive to feature interactions . Their strengths are that they are not dependent on heuristics, they run in low-order polynomial time, and they are noise-tolerant and robust to feature interactions, as well as being applicable for binary or continuous data; however, it does not discriminate between redundant features, and low numbers of training instances fool the algorithm.

Given the theoretical foundations and the aims of the research, using two types of accounting criteria and corporate governance as well as artificial intelligence algorithms, financial constraint is anticipated in this research for the first time in Iran.

Considering the mentioned literature and the goal of this study these hypotheses are presented.

1) Gussian process Machine learning method has a high potential to predict the financial constraints of the companies listed in Tehran stock exchange.
2) Radial neural network learning method has a high potential to predict the financial constraints of the companies listed in Tehran stock exchange.
3) Gussian process Machine learning method has more potential to predict the financial constraints of the companies listed in Tehran stock exchange than the radial neural network learning method.

Data and statistical sample of the study

This study is applied, field and library research using historical and post-event data. The study society includes all the companies listed on Tehran stock exchange. The study samples are chosen by systematic removal method. To do this five criteria are considered and of a company has all the criteria it will be selected as a sample.

- ✓ The company must have been listed in stock exchange since 2011 and be active until 2017.
- ✓ The company must not be one of the investing, holding or financial intermediary companies.
- ✓ In this period the company's fiscal year must have not changed.
- ✓ The financial information of the companies must be available.

After considering all these criteria, 208 companies were selected as the samples.

variables

The study variables are categorized in three groups as corporate governance criteria, performance measurement criteria and financial ratios based on Emamali Sahyati Ghareh et al [10] , Ahmadpur and Rahmani firuzjaei (2007), Lee and Park [23], Kalatzis et al [17] Badavar nahandi and Darkho [3] studies and they are mentioned in table number (1).

Table 1: study variables

Operational definition	Quantitative variable	Source
Net profit/total assets	Asset returns	Dastgir & Vahedpour(2017)
Net profit/equity	Return on equity	Dastgir & Vahedpour(2017)
Annual stock returns of annual	Stock returns	Hadian et al (2017)
Total debt/total assets	Financial leverage	Lari Dashtbayaz et al (2018)
Total debt/total equity	Debt to equity ratio	Lari Dashtbayaz et al (2018)
Total sales/total assets	Asset flow ratio	Karimpour(2017)
Natural logarithm of the market value of the company	Value of the company	Emami, & Farid,(2016)
Net profit/net sales	Return on sales	Khajavi& salhinia (2015)
Operating cash / assets	Operating cash flow ratio to total assets	Karim Pour et al (2018)
Long-term debt / total assets	Long-term debt ratio to total assets	Lin et al (2012)
Short-term debt / total assets	Short-term debt ratio to total assets	Beck, at el. (2005)
The natural logarithm of the total assets	size of the company	Beck, at el. (2005)

Operational definition	Quantitative variable	Source
Dividend Per Share / Total Assets	Dividend benefit ratio	meshki miavaghi & sarfehjoo(2017)
The systematic risk is the degree to which the return on investment is a specific investment relative to the return on investment in the market and is measured by the β index. β = Cov (R_m, R_i) / (δ ^ 2 R_m)	Systematic risk	Razavi and Fathi(2013)
The dividend is based on the earnings per share.	The ratio of the price to the profit of each share	Maleki, at el. (2015)
The number of the board of directors of the company	Board size	Mahdavi& Rezaei (2015)
By deviding the number of non-executive directors to the entire board of directors	Non-obligated managers ratio	Heidary et al(2017)
Total shareholders' equity of more than 5%	The proportion of institutional owners	Heidary et al(2017) Jahanshad & Shabani (2015)
Dependent variables		
Boomihesar model	Financial constraint	
Using neural network machine learning, radial base functions and Gaussian process regression	Study method	
2017-2011 (a 7 years period)	research period	
Two-stage approach, 1- feature selection method based on Relief-F, 2- predicting financial constraints using neural network machine learning by radial base functions and Gaussian process regression	Research design	

4. Results

Variable selection (feature selection method based on Relief-F)

This method is a statistical solution for feature selection. This method is an algorithm based on weighting independent variables and it is based on sample based algorithms. This algorithm selects a company subset among a set of D educational samples. The algorithm selects a company-year from the subset as a sample, and then finds the near hit and near miss based on the attributes of this sample (independent variables) and Euclidean distance estimation function. The near hit is a sample (company-year) that has the lowest Euclidean distance among other samples of the same class. To be of the same class means if the selected sample was profit smoothing, it searches a company-year having the same attributes and its independent variables are close to the selected company-year based on Euclidean distance. The near miss is also a company-year having the lowest Euclidean distance among the samples that are not of the same class with the selected sample. The main idea of this algorithm is that the lower the difference of the size of a characteristic in selected company-year and the lower the near hit, the better the characteristic and a good characteristic is the one with greater size and near miss difference.

$$\boldsymbol{Reliet\ (D, S, NoSamle, Threshold}$$

(1) $T = \emptyset$

(2) $Initialize\ all\ weights, W_i\ ti\ zero.$

(3) $For\ i = 1\ to\ NoSamloe\ /* Arbirarily\ chosen\ */$

$Randomly\ choose\ an\ instance\ x\ in\ D$

$Finds\ its\ near\ Hit\ and\ near\ Miss$

$For\ j = 1\ To\ N$

$W_j = W_j - diff\ (x_j, nearHit_j)^2 + diff\ (x_j, nearMiss_j)^2$

(4) $For\ j = 1\ to\ N$

$If\ W_j \geq Threshold$

$Append\ feature\ f_j\ to\ T$

(5) $Return\ T$

Picture 1: Relief algorithm

In this algorithm each independent variable has a weight that at first its value algorithm equals zero. After determining the near hit and near miss the algorithm will update the attribute weights. In this update the square of the value of attribute in selected sample and the near hit sample difference is reduced from the attribute weight and the square of the value of attribute in selected sample and the near miss sample difference is added to the attribute weight. The more this weight the better the considered attributes can separate the companies of the same class from other companies. After determining the distance for all the available company-years among samples, it will exclude (f) attributes with the same or lower weight than threshold and negative value and other attributes come back as a subset of the answer attribute (T). The threshold is determined by the user; however it can be determined by a function of all the attributes' number or through trial and error. Relief is appropriate for noise and correlation attributes and the complexity of its time as a linear function of the number of attributes and no sample. This algorithm is appropriate for the samples with correlated and nominal attributes. One of the main constraints of this algorithm is that it does not find the redundant attributes and therefore it finds non-optimal sets with redundancy. We can solve this problem by subsequent exhaustive search for the subsets selected by algorithm. In addition the other problem of this algorithm is that it works well in two class issues. This constraint has been created by Relief-F algorithm and with the new algorithm we do not have the incomplete data problem (incomplete educational samples). There is also another version of this algorithm named RRelief-F for the regression issues. The company-year data for stock return dependent variable is put in RRelief-F feature selection algorithm and KNN algorithm with K=200 is applied to find the near hit and near miss. Table 2 presents the selected independent variables to start machine learning methods.

Table 2: independent variables selected by RRelief-F algorithm

Company value	X1
Operating cash flow ratio	X2
Financial leverage	X3
Return on assets	X4
Institutional owners percent	X5

After selecting the independent variables of the question, these independent variables are added to machine learning methods to create a model.

Gaussian process regression

Gaussian process regressions are probabilistic models based on nonparametric core. Consider a series of company-years as $\{(x_i, y_i), i = 1,2, \dots, n\}$ with unknown distribution function. $x_i \in R^d$ represents the company's independent variables vector and $y_i \in R$ is dependent variable or financial constraint. GPR model predicts the value of continuous dependent variable based on selected independent variables. Linear regression model GPR is as follows:

$$y(x) = \beta^T x + \epsilon$$

Where $\epsilon \sim N(0, \sigma^2)$. Error variance σ^2 and β coefficients are estimated using GPR based on company-year. A GPR model explains the answer by presenting latent variables, $f(x_i), i = 1,2, \dots, n$, based on a Gaussian process and explicit basic functions, h. the covariance function is smoothing latent variables and basis variables figures the x input into an attribute environment p dimension. The Gaussian model is series of accidental variables such that any limited number of then has Gaussian joint distribution. If $\{f(x), x \in R^d\}$ is a Gaussian process, then with n company-year $x_1, x_2, \dots, x_n$ are the accidental variables of Gaussian joint distribution $f(x_1), f(x_2), \dots, f(x_n)$.

the Gaussian model is determined by average function m(x) and covariance function $k(x, x')$. In other words if $\{f(x), x \in R^d\}$ is a Gaussian process, then $E\big(f(x)\big) = m(x)$

And

$Cov[f(x), f(x')] = E[\{f(x) - m(x)\}\{f(x') - m(x')\}] = k(x, x')$.

Now consider this model:

$$h(x)^T \beta + f(x)$$

where $f(x) \sim GP\big(0, k(x, x')\big)$, i.e. f(x) is a Gaussian process with zero average and $k(x, x')$ variance. h(x)s are basis functions which transfer company-year attribute vector (i. e. independent variables of each company in R^d input space) to the new attribute vector h(x) in R^p space. β are the basis function coefficients with p.1 dimensions.

Each company-year with dependent variable is modeled as below:

$$P(y_i|f(x_i),x_i)\sim N(y_i|h(x_i)^T\beta+f(x_i),\sigma^2)$$

Therefore the Gaussian process model is a probabilistic model [4]. For each $x_i$there is a latent variable $f(x_i)$ which creates a nonparametric GPR. This model vector is as follows

$$P(y|f,X)\sim N(y|H\beta+f,\sigma^2 I)$$

Where

$$X=\begin{pmatrix}x_1^T\\ \vdots\\ x_n^T\end{pmatrix},y=\begin{pmatrix}y_1\\ \vdots\\ y_n\end{pmatrix},H=\begin{pmatrix}h(x_1^T)\\ \vdots\\ h(x_n^T)\end{pmatrix},f=\begin{pmatrix}f(x_1)\\ \vdots\\ f(x_n)\end{pmatrix}$$

The joint distribution of latent variables $f(x_1),f(x_2),\dots,f(x_n)$

in GPR model is as follows:

$$P\,(f|X)\sim N\big(f|0,K(X,X)\big)$$

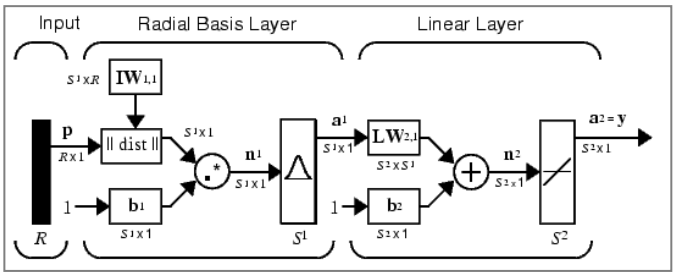
Where

$$K(X,X)=\begin{bmatrix}k\,(x_1,x_1) & \cdots & k\,(x_1,x_n)\\ \vdots & \vdots & \vdots\\ k\,(x_n,x_1) & \cdots & k\,(x_n,x_n)\end{bmatrix}$$

The covariance function $k(x,x')$ is usually parameterized by θ parametric series. $k(x,x')$ is often written as $k(x,x'|\theta)$. The goal of GPR algorithm is to estimate the basis functions coefficients β, noise variance σ^2 and θ parameter from educational data.

Neural network of radial base functions

One of the most efficient artificial neural networks is the radial basis function neural network. This network is basically used for regression and mapping between input and output vectors. The mentioned model is a feed forward neural network and has two layers consisting of an intermediate layer with radial basis function and an external linear layer. In this network the transition function input is the result of the distance between the weight and input vectors multiplied by bios.



Picture 2: a general model of a RBF network with R input data

In these networks if the function input is zero, the maximum value of radial basis function will be one and the less the distance between weight and inputs, the more the output. Therefore in a RBF network, neuron acts as a detector and when the input equals its weight, the result will be one. Bios adjust the sensitivity of radial basis function neurons. Radial basis function has the ability to estimate the functions, while Sigmund functions used in returning error dissemination neural networks do not have such ability. For all the intermediate layer neurons, the Gauss exponential function is used instead of Sigmund and hyperbolic tangents functions. This function is nonlinear and it is as follows:

$$g=exp\left(-\frac{||x_i-c||^2}{2\times r^2}\right)$$

Where x_i is the selected independent variable. In these networks there is no calculation attribute in inner layer, in the intermediate layer there are radial basis function neurons with Gauss stimulation function and the stimulation function of outer layer is linear. The reaction of intermediate layer neurons will be analyzed in a limited range. In other words each neuron makes

the local intermediate layer ready for the input vectors. This numerical range which has radial symmetry and is represented by σ parameter is named receptive field. Receptive field has the center c and width δ and the overlap of each intermediate layer neuron and the adjacent neurons determines the width δ. The more the network input vector is nearer to the nonlinear function center of the neuron, the bigger the intermediate layer will be and vice versa. The calculation criterion for this distance is the oqladian geometry.The number of neurons in the intermediate layer equals the number of input vectors which are the educational couples in the teaching institution. The number of RB functions of each intermediate layer neuron is the same as the number of network inputs. In the outer layer there are the same number of neurons and target vector components. The neurons of the radial basis function (in the intermediate layer) and the linear neurons (in the outer layer) are defined by a matrix which includes the network weights. Threshold function is as follows:

$$a_{ij} = \psi_j\left(\frac{x_i - c_{ij}}{\delta_{ij}}\right)$$

In this relation a_{ij} is the function output, x is the input vector to the intermediate layer neuron and c and δ are the center and the width of the i[th] threshold function of the j[th] intermediate layer neuron respectively. As it was mentioned Ψ is a function of the distance between the input vector and the center of the threshold function. If this distance is constant by changing the input vector, the value of the basis function will be constant. In other words input vectors with the same distance from the threshold function center create the same output, so these networks are called radial symmetry networks. RBF network output is a linear function of the intermediate layer neuron output. This network teaching is done with supervisor or without supervisor. It is important to know that RBF networks normally do not need too much layers because one intermediate layer is selected and the learning speed will increase.

Selecting independent variables by RRelief-F method

The company-year data for financial constraint in current year is put in RRelief-F feature selection algorithm and KNN algorithm is used to find the near hit and near miss, where K=200 and 9 independent variables are selected. The importance of each independent variable in predicting financial constraint prediction is shown in picture 1. By selecting 0.01 as the threshold and based on picture 1, there are only 9 variables with a weight more than 0.01, therefore these 9 variables are selected for prediction. The results to predict the dependent variables in the next part confirm these selections. The selected independent variables are presented in order of importance. The less the weight of the variable is, the less its importance in prediction will be. RRelief-F algorithm does not show the direction of the variable since it does not used KNN algorithm and weighting.To predict financial constraint, variable selecting is done only in the current year and the selected independent variables are used to predict in the next year and the year later.

The evaluation method of GPR and RBF model

GPR and RBF algorithms are used to predict the mentioned dependent variable. 10-Fold Cross-Validation method is also used for performance and evaluation. In GPR algorithm the Gaussian kernel is used to mention the similarities.

$$K(x_i, x_j) = \exp\left(-\frac{||x_i - x_j||^2}{2 \times \sigma^2}\right)$$

Where σ value is determined automatically and x_i represents the selected independent variables. In addition the categorized folds of the company-years are considered the same in 10-Fold Cross-Validation for all the models without losing generality.

Prediction assessment criteria

After categorizing the company-years into two groups of learning and test data using 10-Fold Cross-Validation method, an assessment criterion named mean absolute error (MAE) is used to assess the models which is calculated using the below relation.

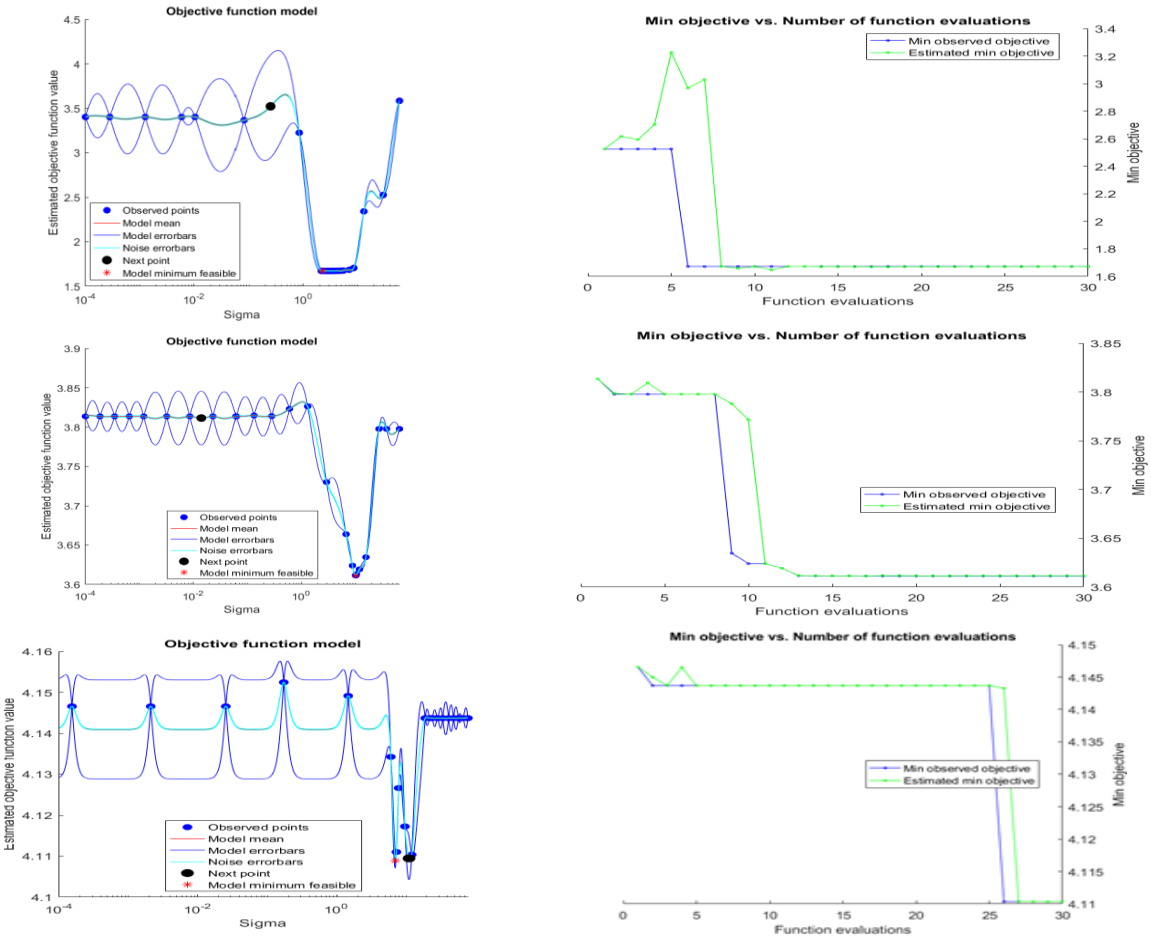
$$MAE = \frac{1}{n}\sum_{i=1}^{n}|y_i - d_i|$$

In the a bow relation y_i و d_i are the real dependent variable and the estimated dependent variable by the algorithms for i[th] company-year

respectively and n is the number of company-years (in teaching or test stage) and $\bar{y}$ and $\bar{d}$ are the average real and estimated dependent variables respectively.

The results of RBF and GPR estimation

The educational data and the categorized assessment by 10-Fold Cross-Validation are put in RBF and GPR. In each of the performance folds, the optimized parameter σ of GPR algorithm is searched and found by bayes algorithm. For example in the first performance fold, every three years of minimum target function graph against the number of GPR assessments are presented in picture 3 in the right column. Each line of this picture is related to a year. Two pictures of the first line are related to the current year, two pictures of the intermediate line is related to the nest year and finally two pictures of the last line are related to the year after that. By assessing the function more by different values of σ parameter, the value of target function (GPR algorithm error) will decrease. In the left column of this diagram, the examined σ are presented for estimated target function value by bayes algorithm. The blue circles are the analyzed sigma points and the black points are the next sigma value to be analyzed and the red star shows the optimized sigma value and the lines show the target function error in analyses. In the current year the sigma value equals 23066, the next year is 101631 and the year after that is 71139. Based on right diagrams, the estimation error in current year is less than the next year and both of them are less than the next two year.



Picture3: finding sigma parameter in GPR algorithm by bayes algorithm of the current year first line, next year second line, next two year third line in the first Fold

After performing the models learning process, first the leaning data which was put in the algorithms to learn their own model parameters is put as the assessment sample in the model with learnt parameters to examine how successful were the models in the learning process, but this time the models estimate the value of dependent variable, then the average of 10 error criterion is calculated by 10-Fold Cross-Validation method and it is reported on table 2. In this table the MAE error is just presented. The more these errors are closer to zero, the better these models are learnt. We can see that GPR probabilistic algorithm error is lower than RBF neural network algorithm in every three years and the current year error is lower than the next year and both of them are lower than the next two year. Therefore GPR probabilistic algorithm is better than the RBF neural network algorithm and it can predict the financial constraint. The more the intervals of the years from the current year is, the lower the estimation accuracy will be.

But should be concerned about overfitting, so a model has been presented to analyze the generality, MAE error is calculated to estimate the dependent variable of financial constraint for the test company-years (those company-year which have been put aside in each repetition by 10-fold cross-validation method and never have been put in algorithms). For each error criterion, there are 10 errors which have been reported by 10-fold cross-validation method and the average of these errors is shown in table 3. It is concluded that the achieved models have generality which is the same a previous results and it means that the work well for the company-years they have never seen before and there is no overfitting because the difference of assessment and teaching data error criteria is insignificant. In addition all the previous data are true here.

Table 3: MAE error average to investigate models' teaching for different years

Next two year		Next year		Current year		MAE
RBF	GPR	RBF	GPR	RBF	GPR	Fold
5.763	5.584	3.465	3.501	2.400	1.150	1
5.722	5.005	3.454	3.559	2.415	1.169	2
5.754	5.195	3.475	3.458	2.415	1.118	3
5.680	5.080	4.459	3.409	2.377	1.168	4
5.792	5.814	3.463	3.394	2.415	1.161	5
5.888	5.924	3.502	3.521	2.419	1.155	6
5.609	5.074	3.447	3.083	2.414	1.134	7
5.798	5.128	3.471	3.628	2.405	1.155	8
5.740	5.051	3.554	3.525	2.396	1.174	9
5.646	4.938	4.503	2.869	2.391	1.155	10
5.739	5.279	3.679	3.395	2.405	1.154	average

Table 4: the average MAE error to assess the ability to estimate the models for different years

Next two year		Next year		Current year		MAE
RBF	GPR	RBF	GPR	RBF	GPR	Fold
5.944	5.928	4.283	3.150	2.493	1.189	1
5.688	5.124	3.510	2.826	2.460	1.043	2
5.724	4.898	3.939	3.507	2.796	1.486	3
6.476	5.641	4.576	3.644	3.230	1.025	4
5.486	5.403	5.474	3.828	3.166	1.095	5
4.429	4.426	4.805	4.064	3.996	1.113	6
6.511	5.589	4.158	3.033	3.124	1.299	7
5.000	5.552	3.767	2.883	3.516	1.172	8
5.448	5.354	5.428	4.102	2.618	1.939	9
6.854	5.609	3.683	3.727	2.470	1.162	10
5.756	5.352	4.362	3.476	2.987	1.252	average

5. Discussion and Conclusions

Cash is one of the important and essential resources in each profit unit, and balancing the available cash and cash needs is the main financial issue in each profit unit. Since both the companies that do not maintain sufficient cash and companies that hold a large amount of cash, have several problems, determining the exact cause or causes of financial constraints and problems in each special case is not easy. In most of the cases there are several reasons to create financial constraints. Changing the companies' principles refers to determining the goals and investable property and determining the potential types of financial property for investment. Appropriate tools and models for the assessment of financial situation and the state of the companies can help the investors in decision making. One of the tools in investment decision making are the models which estimate the financial constraints of the companies. The growing financial activities and events have several positive and negative consequences. One of the main negative consequences of these changes is the increase in competitions to gain financial resources and limited profit for firms and enterprises. One of the main concerns of financial managers of companies is financing. Financial managers of the companies often need financing for development plans and providing daily working capital. One of the main issues for the financial managers of the enterprises is financing methods. In other hand the companies have always some kind of limitation for financing these resources which is called financial constraints [17] In this study we aim to estimate financial constraints using financial data and management system features of the companies listed in stock exchange from 2011 to 2017 and machine learning methods. The primary results of the study based on variable selection method from RRelief-F shows that the company value variables, operating cash flow ratio, financial leverage, return on assets and percentage of institutional owners are the most important in estimating financial constraints. Based on the results it can be analyzed that although corporate governance criteria have a regulatory role, it is still said that they do not perform their monitoring role well and are still far from their ideal goals and financial criteria have a stronger effect on financial constraints than corporate governance criteria. The results of this study are consistent with the results of Lari Dasht Bayaz et al[22] Karimpour et al. [19] Dastgir & Vahedpour [7] Jahanshad and Shabani [16] According to preliminary results of the research that indicated financial variables are of more importance than corporate governance variables in explaining financial constraints, therefore, managers of active companies in the capital market are recommended to consider the variables mentioned to make decisions about financing and investing which is related to the level of corporate financial constraint. Tehran Stock Exchange is recommended to increase corporate governance mechanisms' efficiency, through formulating laws and regulations, to play a more effective role in preventing corporate financial constraints.Also considering the results of the study it can be said that Machine learning methods to predict corporate financial constraints are very efficient therefore managers are recommended to take advantage of the mentioned methods especially the non-linear method for future forecasts of the company's financial constraints .The results of this research can be applied by company executives so that by predicting financial constraints and working on the factors affecting it, help reduce the risk of financial crises and help investors avoid major stock market losses.Tehran Stock Exchange is recommended to predict the future financial constraint of companies and inform the users in the form of a supplemental report.

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