TAUTSAIMNIECĪBAS ATTĪSTĪBAS PROBLĒMAS UN RISINĀJUMI

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BANKROTU DATU ANALĪZES VEIKŠANAS IESPĒJAS AR LAIKRINDU KLASTERIZĀCIJAS PALĪDZĪBU

Outline

- **Overview of bankruptcy financial ratios**
- **Bankruptcy prediction methods**
  - **Multivariate discriminant analysis**
  - **Potential function method**
  - **Neural network approaches**
  - **Time Series clustering**
- **Experiment**

Introduction

- **Bankruptcy prediction has been an important decision-making process for financial analysts**
- **Many techniques have been proposed for helping financial analysts in this process**
- **The status of a firm analyzed is modeled by its financial ratios**

Two basic approaches to bankruptcy prediction

- First approach is based on financial data and comprises working with different ratios

- The second approach uses the data on bankrupt companies that were then compared to the data of the company under consideration

Bankruptcy financial ratios

- In the analysis of the general financial situation of the company a separate group of financial ratios is made, using which it is possible to reason about the threat of bankruptcy
- In general case there is no theoretical background as to which financial ratios might be used in different bankruptcy studying models
- A lot of researchers performing an analysis of the bankrupt enterprise proceed in this way: they calculate several ratios and then select potentially most significant of them

Example: Altman's Z-score

- In Altman's model Z-score operates with five financial ratios
- Altman (1968) supposes that these are the ratios that have the largest prediction possibility:

Altman's Z-score

1. X1= Working capital/total assets (WC/TA)
2. X2= Retained earnings / total assets (RE/TA)
3. X3= Earnings before interest and taxes / total assets (EBIT/TA)
4. X4= Market value equity / book value of total liabilities (MVE/TL)
5. X5= Sales / total assets (S/TA)

Altman's Z-score (cont.)

All the ratios(X1, X2, X3, X4 and X5) are consolidated in Z-number, after they have been multiplied by certain correlation coefficient whose value can give evidence for the importance of the specific ratio.

Z – number is expressed by formula:

$$Z = 1{,}2 * X1 + 1{,}4 * X2 + 3{,}3 * X3 + 0{,}6 * X4 + X5$$

The calculation of the above ratios enables firm's executives to estimate their activities and financial ratios, and to respond to the problems appeared in proper time.

Altman's Z-score (cont.)

- If Z>3, the possibility of bankruptcy is low and it is not necessary to perform further analysis of the financial situation
- If $2.7 < Z \leq 3$, bankruptcy may occur. The firm has faced certain problems concerning paying capacity that cannot be diminished
- If $1.8 < Z \leq 2.7$, the possibility of bankruptcy is high. The firm has serious financial problems. A thorough analysis of the financial situation is necessary
- If $0 < Z \leq 1.8$, the possibility of bankruptcy is very high. The firm's financial situation can only be improved by radical changes in the area of finance and investments

Financial ratios in previous bankruptcy prediction studies

Ratios	Study		Ratios	Study
R1 Cash/Current Liabilities	E, D		**R17** Net Income/Total Assets	B, D
R2 Cash Flow/Current Liabilities	E		**R18** Net Quick Assets/Inventory	Bl
R3 Cash Flow/Total Assets	E-M		**R19** Net Sales/Total Assets	R-F, A
R4 Cash Flow/Total Debt	Bl, B, D		**R20** Operating Income/Total Assets	A, T, A-H-N
R5 Cash/Net Sales	D		**R21** EBIT/Total Interest Payments	A-H-N
R6 Cash/Total Assets	D		**R22** Quick Assets/Current Liabilities	D, E-M
R7 Current Assets/Current Liabilities	M, B, D, A-H-N		**R23** Quick Assets/Net sales	D
R8 Current Assets/Net Sales	D		**R24** Quick Assets/Total Assets	D, T, E-M
R9 Current Assets/Total Assets	D,E-M		**R25** Rate of Return to Common Stock	Bl
R10 Current Liabilities/Equity	E		**R26** Retained Earnings/Total Assets	A, A-H-N
R11 Equity/Fixed Assets	F		**R27** Return on Stock	F, T
R12 Equity/Net Sales	R-F, E		**R28** Total Debt/Total Assets	B, D
R13 Inventory/Net sales	E		**R29** Working Capital/Net sales	E, D
R14 Long Term Debt/Equity	E-M		**R30** Working Capital/Equity	T
R15 MV of Equity/Book Value of Debt	A, A-H-N		**R31** Working Capital/Total Assets	W-S,M,B,A,D
R16 Total Debt/Equity	M			

Note: R2, R3, R7, R9, R31 was used in experimental part !

Bancruptcy prediction methods

- Early empirical approaches
  - Multivariate discriminant analysis (MDA)
  - Potential functions
- Neural Network approaches
- Other approaches
  - Genetic algorithms (GA)
  - Rule-based learning
  - ID3
  - Time series clustering

I Empirical approaches

Beaver was one of the first who has applied balance sheet data in bankruptcy research. His analysis was comparatively simple and was based on studying one financial ratio and comparing it with other ratios. He has concluded that ratio R4: Cash flow / Total debt is a very essential indicator which has to be accounted in bankruptcy analysis. Beaver's works became a beginning of multicriteria analysis application, which was later developed by Altman et al.

II Neural Network approaches

- Odom and Sharda were one of those who first employed NN techniques in bankruptcy analysis. In the input of the network, Altman's Z-scores about 128 companies were used. It was shown that neural network approach yields better results than MDA
- Tam and Kiang have compared different techniques applied in bankruptcy diagnostics (MDA, LA, ID3, single layer network and multilayer network) and have shown that in the „one-year-ahead" data the multilayer network was most effective whereas in the "two-year-ahead" data the LA method turned to be most effective

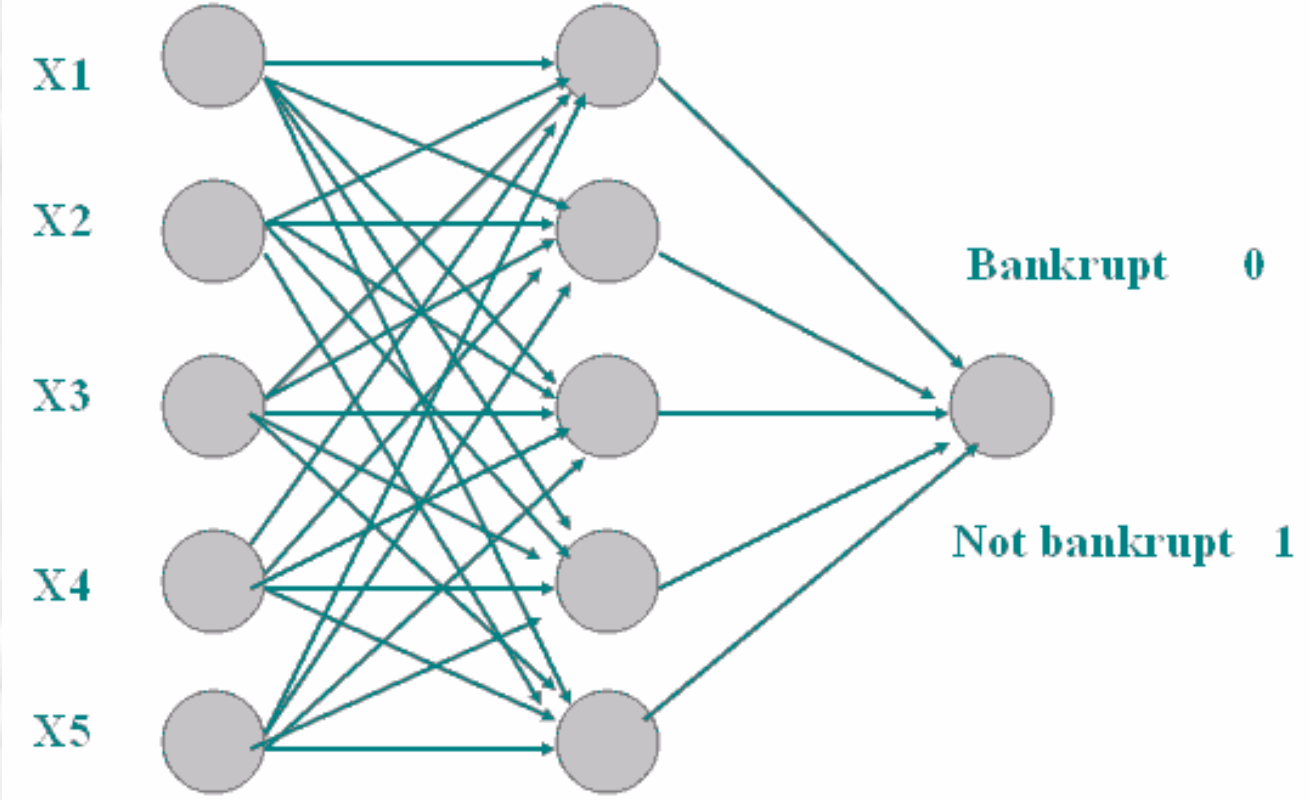
II Neural Network approaches(cont.)

Analysing the NN network application in bankruptcy analysis, these conclusions were made:

- NN ensure approximately 90% accuracy compared to the 80-85% accuracy of other methods (MDA, LA, and ID3)
- Bankruptcy can be predicted several years before it happens, the accuracy of prediction being practically the same for the “one-year-ahead” data and for the “two-year-ahead”

II Architecture of the Bankruptcy Prediction Neural Network

- Multilayer network MLP with error back propagation learning



Experimental part

- Main motivation – compare ability of methods
- Dataset
- Environment – SPSS (for MDA) and Matlab

Data

Balance sheet data of 63 companies were used (46 - bankruptcy and 17 - not bankruptcy).
It was decided to calculate the following financial ratios on the basis of the data available and further use them in all the experiments:

- R2: Cash Flow / Current Liabilities;
- R3: Cash Flow / Total Assets;
- R7: Current Assets / Current Liabilities;
- R9: Current Assets / Total Assets;
- R31: Working capital / Total assets.

Experiment I - MDA

To accomplish the MDA, the SPSS statistical package was used. Discriminant analysis classification results:

			Predicted Group Membership		Total
		Bankrupt	0	1	
Original	Count	0	39	7	46
		1	4	13	17
	%	0	84.8	15.2	100.0
		1	23.5	76.5	100.0

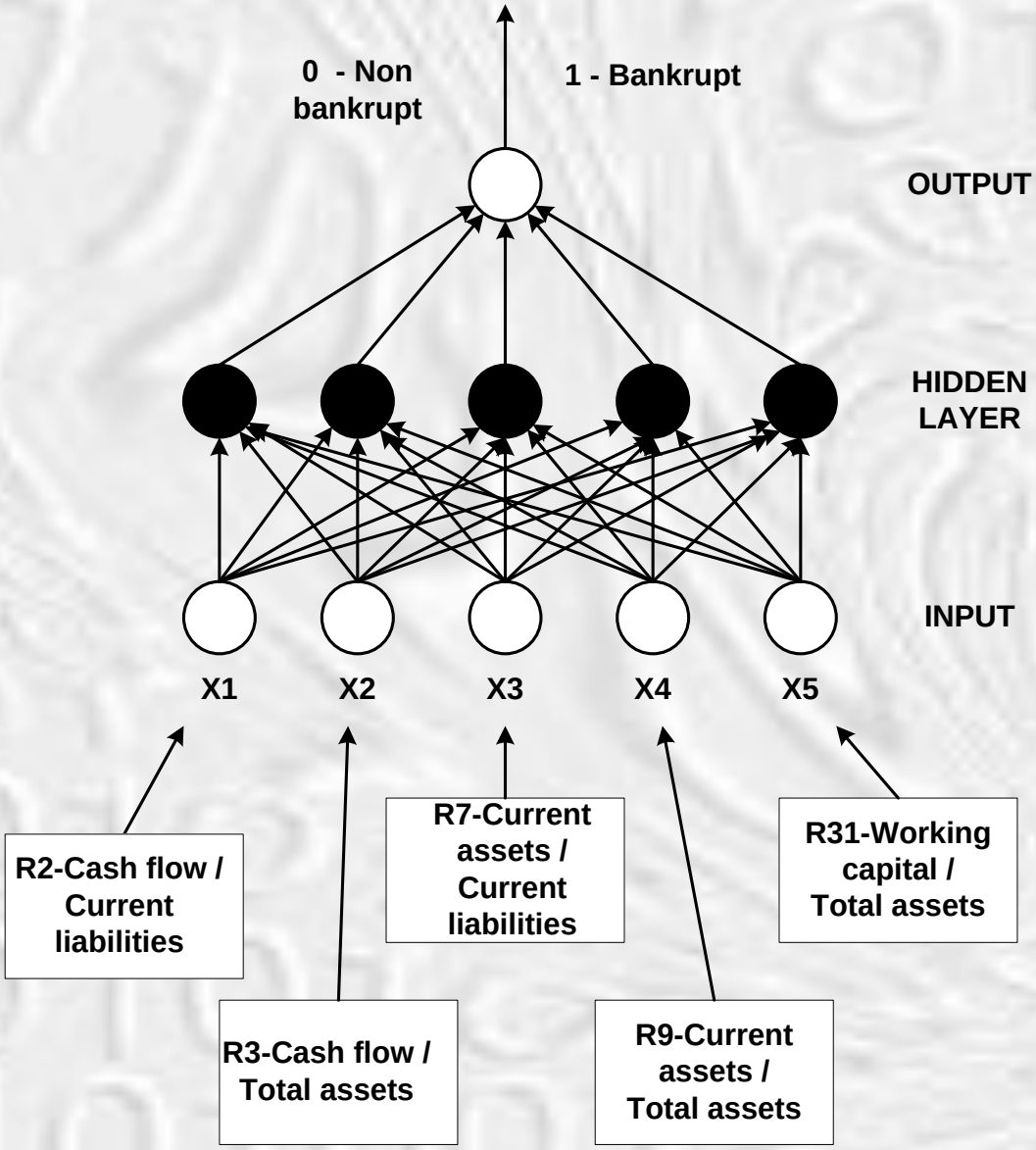
- **82.5 % of original grouped cases correctly classified**

- **Misclassified cases are: 14, 26, 28, 35, 36, 37, 41, 58, 59, 60, 62.**

Experiment II –Multilayer feedforward NN

- Input nodes - 5 neurons
- Hidden layer - 5 neurons
- Output nodes - 1 neuron (1- bankrupt, 0 - not bankrupt)
- Learning rate - 0.25
- Stopping condition - the training is stopped if MSE=0.5
- Momentum rate - α
- Slope of the tanh activation function - β

Experiment II – Architecture



Experiment II – Results

Experimental results (parameters α, β and its misclassified cases)

Parameter α	Parameter β	Epochs	No. of misclassified cases	Cases
α = 0.8	β = 0.8	41	9	14,26,36,37,41,58,59,60,62
	β = 0.9	889	6	37,50,58,59,60,62
α = 0.9	β = 0.8	46	9	14,26,35,36,37,41,58,59,62
	β = 0.9	1489	7	37,50,58,59,60,62,63

Summary table about used methods and misclassified cases

Method		Misclassified cases														
MDA				14	26	28	35	36	37	41		58	59	60	62	
Potential		4	8	14	26				37		50		59			
NN-1	$\alpha = 0.8, \beta = 0.8$			14	26			36	37	41		58	59	60	62	
NN-2	$\alpha = 0.8, \beta = 0.9$								37		50	58	59	60	62	
NN-3	$\alpha = 0.9, \beta = 0.8$			14	26		35	36	37	41		58	59		62	
NN-4	$\alpha = 0.9, \beta = 0.9$								37		50	58	59	60	62	63

- For the specific bankruptcy data sample, all the methods are unable to classify data vectors 37 and 59.
- Calculating in absolute numbers, we obtain that NN-2 correctly classified 90.5% cases
- The potential function method and NN-4 - 89% cases
- NN-1 and NN-3 - 85.7%
- MDA - 82.5%.

It can be concluded that for the given data sample the NN method performs bankruptcy data classification more effectively, which actually corresponds to the conclusions about the results achieved by Tam and Kiang.

III Alternatives

- Genetic algorithms (GA)
- Rule-based learning
- ID3
- Time series clustering

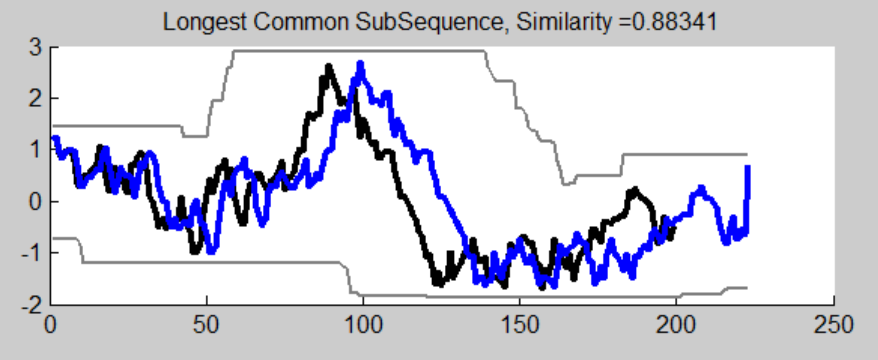
Similarity measures

- Euclidian distance

$$D(Q,S) = \sqrt{\sum_{i=1}^{n}(q_i - s_i)^2}$$

- Least Common Subsequnce (LCSS)

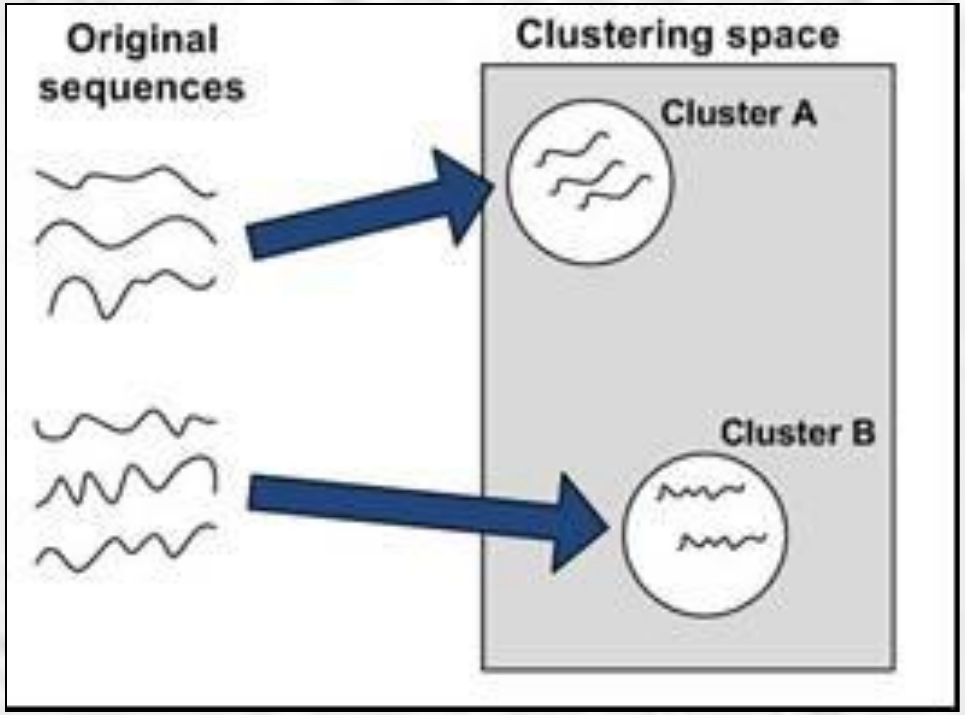
$$LCSS[i,j] = \begin{cases} 0 & if\ i = 0\ or\ j = 0 \\ 1 + LCSS[i-1, j-1] & if\ a_i = b_i \\ \max(LCSS[i-1, j], LCSS[i, j-1]) & otherwise \end{cases}$$



Clustering idea

- K-means, Hierarchical clustering

K-means clustering
1. Decide on a value for k. 2. Initialize the k cluster centers (randomly, if necessary). 3. Decide the class memberships of the N objects by assigning them to the nearest cluster center. 4. Re-estimate the k cluster centers, by assuming the memberships found above are correct. 5. If none of the N objects changed membership in the last iteration, exit. Otherwise goto 3.



Financial Ratios

	Financial ratios					
Firms	R2	R3	R7	R9	R31	State
Firm1(B)	0	0	175	67	29	Bankruptcy
Firm2(B)	13	8	175	65	28	Bankruptcy
Firm3(B)	14	8	277	58	37	Bankruptcy
Firm47(N)	4	4	101	93	1	Non-Bankruptcy
Firm48(N)	5	5	104	97	4	Non-Bankruptcy
Firm49(N)	4	4	105	95	5	Non-Bankruptcy

LCSS

	Firm1(B)	Firm2 (B)	Firm3(B)	Firm47(N)	Firm48(N)	Firm49(N)
Firm1 (B)	1	0,4	0,4			
Firm2 (B)	0,4	1	0,4			
Firm3 (B)	0,4	0,4	1			
Firm47 (N)				1	0,5	0,4
Firm48 (N)				0,5	1	0,8
firm49 (N)				0,4	0,8	1

Clustering

- K-means clustering algorithm for two clusters (bankruptcy or non-bankruptcy) has been applied. As a result of the algorithm's activity

one cluster has been attributed time series Firm1, Firm2 and Firm3 data,

second cluster – Firm47, Firm48 and Firm49 data.

Cluster centres obtained are as follows:

[9; 5; 209; 63; 31] and [4; 4; 103; 95; 3].

Conclusions

- The experiments have shown that neural networks and potential functions can be viewed as alternatives to traditional bankruptcy risk prediction methods
- As a result of the experiment a conclusion has been drawn that the results of time series clustering using k-means algorithm correspond to the results obtained with LCSS method, thus the clustering results of the specific bankruptcy data time series are adequate.

Thanks for attention !