POSSIBILITIES OF QUALITATIVE MODELING IN BANKRUPTCY PREDICTIONS

Jaroslav Krejčíř, Hana Rašková, Mirko Dohnal

Brno University of Technology, Faculty of Business and Management, Department of Economics

Abstract: *The issue of bankruptcy has long been paid a considerable interest at practical and theoretical levels using more sophisticated tools such as genetic algorithms, neural networks, statistical methods etc. This article describes application of less a used method of Qualitative models which can forecast changes in trends and thus contribute to solving the selected problem even without entirely accurate knowledge of the quantitative data. The model is based on three qualitative values only: increasing, constant, decreasing used to describe the corresponding trends. The result presents eleven possible scenarios and sixteen transitions among them.*

Keywords: *Bankruptcy, Prediction, Qualitative Modeling, Scenario.*

JEL Classification: *C65, G33.*

1. Introduction

Much attention is devoted to probability of bankruptcy of a company in literature. Most of the published models are based on available data, either for specific companies or on statistical data for the entire industry, nation states and economic communities. A substantial part of these models are time series in which future is often predicted. For data analysis and prediction there are many different ever more sophisticated tools applied. At present, the literature most often presents genetic algorithms, see e.g. (Ahn, Kim, 2008], neural networks, see e.g. (Pendharkar, 2005), support-vector machine, see e.g. (Chaudhuri, De 2010) or Bayesian networks, see e.g. (Sun, Prakash, 2007). All the methods are discussed in an article by (Tsai, 2009). Using the latest techniques, previously used bankruptcy models are tested too, one of the best known and most used is Altman's Z-score, see e.g. (Griece, Ingram, 2001) or Zmijevski and Ohlson bankruptcy prediction models, see e.g. (Griece, Gugan, 2003).

Qualitative modeling, unlike other quoted methods, provides possibilities, how to determine possible scenarios that may occur even at ignorance of the exact data. For general information about this topic, see e.g. (Hnise, Durig, 2000) and specifically for application in the economic field, see e.g. (Vicha, Dohnal, 2008). The main advantage of qualitative modeling is generating a trend, knowledge of which in many areas is an important condition for decision making.

2. Qualitative modeling methodology

2.1 Equationless relations

Modern computers provide a powerful basis for number manipulations but their contribution to problem solving based on common sense has been very small, see e.g. (Vicha, Dohnal, 2008). However a methodology of applied soft modelling (e.g. fuzzy logic, qualitative modelling, and rough sets) is gradually being built up and can be used to develop such complex models which incorporate some aspects of political risks / macroeconomics relations.

The Fig. 1 gives examples of six equationless relations. Each graph represents a certain shape and not numerical values. This is the reason why the given graphs in Fig. 1 are suitable to formalise such non-numerical information items which have no forms of traditional equations. For example the following heuristic is a suitable candidate:

If the panic on financial markets X is increasing then the share price is decreasing and there is a lower limit Y. (1)

The shape 24, Fig. 1 can be used to formalise the heuristic (1). Models based on such equationless relations are studied in this paper.

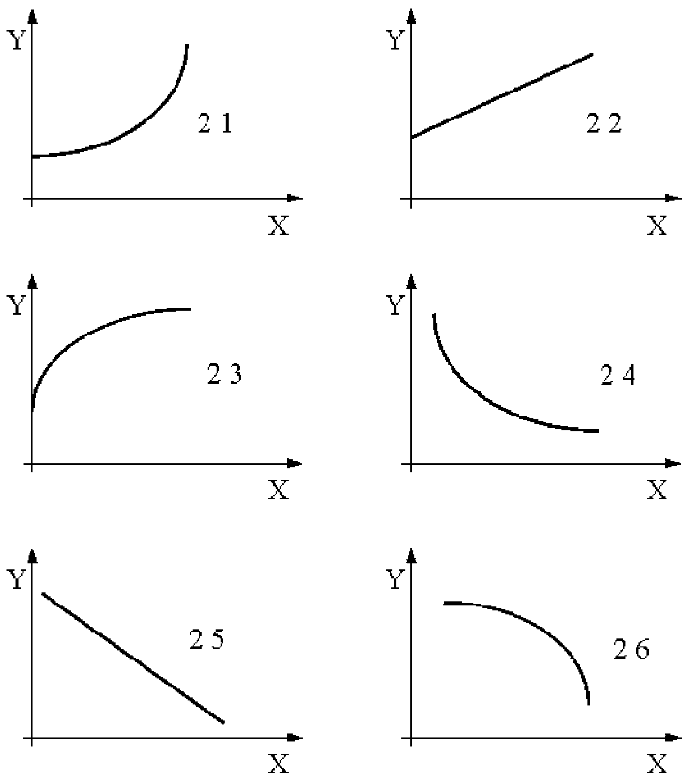

Fig. 1: Equationless relations between X and Y

Source: (Vicha, Dohnal, 2008 + Authors)

All pairwise relations X, Y, see Fig. 1, are qualitative relations. It means that nothing is qualitatively known. For example the relation 22 indicates that:

- the relation is increasing
- there is a linear relationship between Y and X
- If X = 0 then Y is positive.

No numbers are required to describe qualitative relations.

2.2 Algebra of qualitative modeling

There are just four qualitative quantifiers, see e.g. (Vicha, Dohnal, 2008):

Values:	Positive	Zero	Negative	Anything
Derivatives:	Increasing	Constant	Decreasing	Any direction

A set of m qualitative n-dimensional scenarios is described by the following set of triplets:

$[(X_1, DX_1, DDX_1), (X_2, DX_2, DDX_2), \ldots (X_n, DX_n, DDX_n)]_j$(2)

$j = 1, 2, \ldots, m.$

where X_i is the i-th variable and DX_i and DDX_i are the first qualitative and second qualitative derivations with respect to time t.

Any set of scenarios (2) is a finite set. Let set $S(m, n)$ of m qualitative n-dimensional scenarios (2)

$$S(m, n) \tag{3}$$

$j = 1, 2, \ldots, m.$

be a solution of a qualitative n dimensional model M

$$M(r, n) \tag{4}$$

where r is the number of its equationless relations.

The set of scenarios (3) is not the only result of the qualitative modeling. It is possible to identify all possible time transitiv among them. This is avery usfeul additionl information. For example, if a scenário No. 1 is a desirable scenario and the scenario No. 10 is the current scenario, then it is clear how reach the scenario No. 1 starting from the scenario No. 10. All possible paths are identified.

A complete set of all possible one dimensional transitions is given in the following table:

Tab. 1: A list of all one dimensional transitions

	From		To	Or	Or	Or	Or	Or	Or
1	+ + +	→	+ + 0						
2	+ + 0	→	+ + +	+ + -					
3	+ + -	→	+ + 0	+ 0 -	+ 0 0				
4	+ 0 +	→	+ + +						
5	+ 0 0	→	+ + +	+ - -					
6	+ 0 -	→	+ - -						
7	+ - +	→	+ - 0	+ 0 +	+ 0 0	0 - +	0 0 +	0 0 0	0 - 0
8	+ - 0	→	+ - +	+ - -	0 - 0				
9	+ - -	→	+ - 0	0 - -	0 - 0				
10	0 + +	→	+ + 0	+ + -	+ + +				
11	0 + 0	→	+ + 0	+ + -	+ + +				
12	0 + -	→	+ + -						
13	0 0 +	→	+ + +						
14	0 0 0	→	+ + +	- - -					
15	0 0 -	→	- - -						
16	0 - +	→	- - +						
17	0 - 0	→	- - 0	- - +	- - -				
18	0 - -	→	- - 0	- - +	- - -				
19	- + +	→	- + 0	0 + +	0 + 0				
20	- + 0	→	- + -	- + +	0 + 0				
21	- + -	→	- + 0	- 0 -	- 0 0	0 + -	0 0 -	0 0 0	0 + 0
22	- 0 +	→	- + +						
23	- 0 0	→	- + +	- - -					
24	- 0 -	→	- - -						
25	- - +	→	- - 0	- 0 +	- 0 0				
26	- - 0	→	- - -	- - +					
27	- - -	→	- - 0						

Source: (Vicha, Dohnal, 2008)

The third line of Tab. 1 indicates that it is possible to transfer the triplet (+ + -) into the triplet (+ 0 -), see the transitiv 3b, Fig. 2.

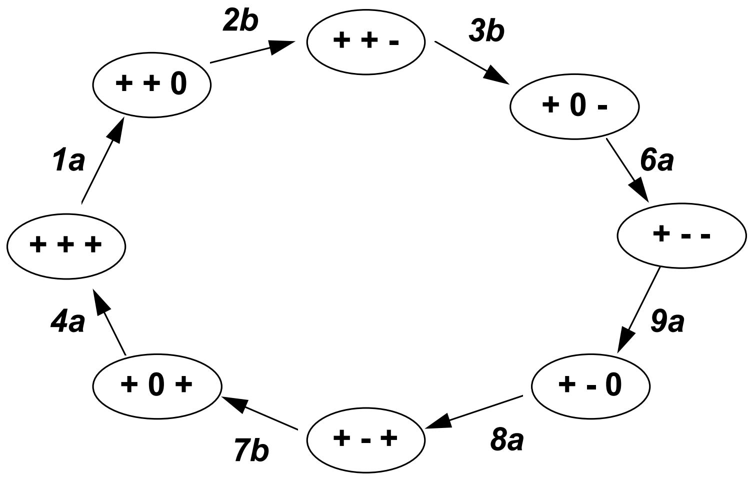

Fig. 2 One dimensional qualitative time record

Source: (Vicha, Dohnal, 2008 + Authors)

This transition is not the only possible. There are two more. Fig.2 gives a qualitative description of an oscillation using the one dimensional triplets $n = 1$ (2).

There are several one dimensional transitions presented in the graphical form, see Fig. 2. For example the following transition (+ 0 -) → (+ - -) represents the transition from the peak, see the transitiv 6a, Fig.2. All these transitions correspond to the Tab. 1.

Tab. 1 is not a dogma. It could be modified on ad hoc basis. The only requirement is that the transitions must satisfy the common sense reasoning of a user.

A transitional graph G is an oriented graph. Its nodes are the set of scenarios S (3) and oriented arcs are the transitions T. However, the set of transitions T can be easily generated by the corresponding set of scenarios S using Tab. 1:

$$G(S, T(S)) \tag{5}$$

An example of a simple oriented graph is given in Fig. 2.

3. Specific Use of Qualitative Models (Case study)

3.1 Possibilities of Qualitative Models in Forecasting Bankruptcy

Areas of bankruptcy forecast, as already mentioned in the introduction, are devoted a significant attention. The aim of theoretical studies is to find a model that would most likely forecast bankruptcy of a company or a bank and more recently of a nation state. The biggest problem in most of these models is relatively high demands on precise information without which the models are not fully applicable. This disadvantage largely disappear in qualitative models that are capable, even at a limited knowledge of the data or a very vague information, to generate scenarios and links between them. These scenarios and links and their subsequent analysis and interpretation are able to provide relevant and valuable information. The result of qualitative modeling is the ability to at least discern a trend in the researched field. This trend can often be a final critical parameter in complex decision making in terms of ever-changing contemporary economic realities.

3.1.1 Determination and Definition of Variables Used

For needs of a particular qualitative model it is necessary to determine the variables to be be analyzed. In the selected model, the X-axis includes variables, whose influencing by both the companies and national or supranational authorities is very difficult to impossible, at most it is indirect or using non-standard tools. The Y-axis than includes variables that are dependent on the behavior of the X-axis variables and their development is influenced decisively by them.

Variables used in the next part of the part of the case study were identified by a team of experts based on the works described below. Summary of variables used in the model and the coding is as follows:

a) Variables directly non-influencable by the government or the company

OS – Cyclical Fluctuation

SG – Panic in Financial Markets

BM – Bank Mistrust

PM – Turbulence of Property Market

TS – Turbulence of Stock Market

CD – Consumer Demand

b) Variables dependent on directly non-influencable variables:

FI – Financial Costs (6)

PS – Stock Price

BE – Bond Upgrades

FR – Financial Ratios

MS – Market Share

BA – Probability of Bankruptcy

UP – Pressure for Premature Debt Repayment

RO – Return of Investment

Characteristics of individual variables and the relationship between them are derived from scientific articles dealing with bankruptcy. These are works dealing more broadly with the methodology, see e.g. (Crouchy, Galay, Mark, 2001), or legal issues, see e.g. (Gutiérrez, Olalla, Olmo, 2009). Further, works for specific phenomena such as bond rating, see e.g. (Kim, Nabar, 2007), evaluation of prediction models and methodologies, see e.g. (Griece, Dugan, 2003), (Griece, Ingram, 2001), (Tsai, 2009), or aspects of the bankruptcy in Czech economy during the last cyclical downturn, see e.g. (Kraftová, Šustrová, 2010).

With the use of these resources, applied variables can be characterized as follows:

Cyclical fluctuation – the impact of the economic cycle phase according to current definition, thus what stage of the economic cycle there is depending on the growth or decline in GDP

Panic in financial markets – in financial markets there is a rise in interest rates, a drop in investor confidence

Bank mistrust – reduction of willingness of banks to lend funds in both interbank and commercial markets

Turbulence of property market – there is a decrease in property prices, fall in the demand for real estates, longer projects' return, a stop in investing activities

Turbulence of stock market – there is a decrease in stock prices, falling stock market indices, excess of supply over demand, decrease of the volume of transactions

Consumer Demand – the final consumer demand is weakening, confidence in the economic system declines, volume of consumer loans is decreasing

Financial costs – the cost of finance depending on other variables decrease or increase, the interest rate varies mainly according to the situation in financial markets and bank mistrust

Price stock – stock price is based mainly on the (in-)stability of financial and equity markets, but also on the stage of economic cycle

Bond Upgrades – yield of bonds for the issuer similar to the stock price mainly depends on the stability of financial and equity markets

Financial ratios – financial indicators widely used in forecasting bankruptcies, there is generally included either improvement or deterioration in these indicators that to a certain extent depends on all the directly non-influencable variables

Market Share – an indicator of describing the market share, which is derived primarily from the phase of economic cycle, the unwillingness of banks to lend and consumer confidence

Probability of Bankruptcy – probability of insolvency, thus the bankruptcy, is derived from all four: the phase of the economic cycle and the unwillingness of banks to lend money, stock market turbulence (in the Czech economy this dependence is more difficult to prove) and consumer confidence

Pressure for Premature Debt Repayment – in case of deterioration of the economic results and banks mistrust it leads to demands for early debt repayment and enhancing business problems

Return of Investment – while worsening economic environment the return of investment projects becomes longer.

3.1.2 Model Compilation

In compiling a model, individual variables are given to mutual dependence and they are assigned a numerical identifier (see Fig. 1) which determines their specific interdependence. In the selected model there are the following dependences:

See Fig. 1		X (horizontal axis)	Y (vertical axis)	
1	21	OS	FI	
2	24	OS	PS	
3	25	OS	BE	
4	24	OS	FR	
5	25	OS	MS	
6	23	OS	BA	
7	22	OS	UP	
8	26	OS	RO	
9	21	SG	FI	
10	24	SG	PS	
11	26	SG	BE	
12	24	SG	FR	
13	23	SG	UP	
14	22	BM	FI	
15	25	BM	FR	
16	24	BM	MS	(7)
17	21	BM	BA	
18	22	BM	UP	
19	23	PM	FI	
20	24	PM	PS	
21	24	PM	BE	
22	24	PM	FR	
23	23	TS	FI	
24	25	TS	PS	
25	24	TS	FR	
26	21	TS	BA	
27	21	TS	UP	
28	24	TS	RO	
29	25	CD	FR	
30	24	CD	MS	

31	21	CD	BA
32	26	CD	RO

3.1.3 Result of the Model

Model (7) generates a total of eleven scenarios, see Tab. 2.

Tab. 2: Resulting scenarios of model

	OS	BM	FI	FR	MS	BA	UP	RO
1	+++	+++	+++	+--	+-+	+++	+++	+--
2	+++	+++	+++	+--	+-0	+++	+++	+--
3	+++	+++	+++	+--	+--	+++	+++	+--
4	++-	++-	++-	+-+	+-+	++-	++-	+-+
5	+0+	+0+	+0+	+0-	+0-	+0+	+0+	+0-
6	+00	+00	+00	+00	+00	+00	+00	+00
7	+0-	+0-	+0-	+0+	+0+	+0-	+0-	+0+
8	+-+	+-+	+-+	++-	+++	+-+	+-+	++-
9	+-+	+-+	+-+	++-	++0	+-+	+-+	++-
10	+-+	+-+	+-+	++-	++-	+-+	+-+	++-
11	+--	+--	+--	+++	+++	+--	+--	+++

Source: (Authors)

Among these scenarios exists sixteen possible transitions among them, see Tab. 3. In the Tab. 2 there are listed different scenarios, in the Tab. 3 there are relations amnog individual scenarios and in the Fig. 3 there is graphical interpretation of all transitions amnog the scenarios.

Tab. 3: Transitions among scenarios of Tab. 2

From	To
1	2
2	1
2	3
3	2
4	6
4	7
5	3
6	3
6	11
7	11
8	9
9	8
9	10
10	5
10	6
10	9

Source: (Authors)

Tab. 3 is converted into a oriented graph, see (5). For example, this chart immediately indicates that the scenario number eleven (see Tab. 2) is so called Chernobyl scenario. It means there is no escape from the scenario.

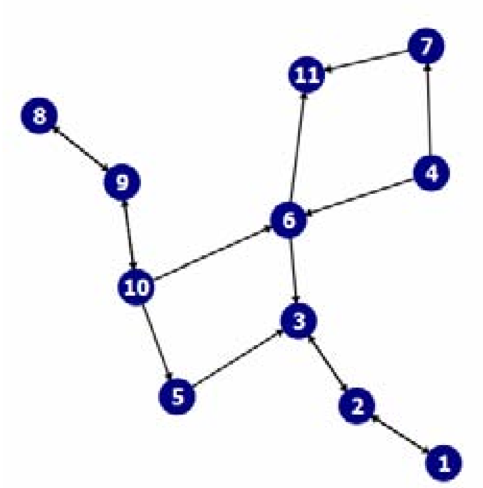

Fig. 3: Oriented graph transitions among scenarios

Source: (Authors)

3.1.4 Interpretation of Results of the Model

It follows from the nature of qualitative modeling it is possible to rely on the fact that all possible scenarios are identified. All variables (6) are taken into account. The results given by the query formulated in the model on the impact of cyclical fluctuations and the unwillingness of banks to lend funds indicate that these entered queries about variables have the same impact on the cost of finance, financial ratios, market position, probability of insolvency proceedings, pressure for premature debt repayment and return of projects. Similar impact on the variables is generated by panic in financial markets and consumer confidence.

If we analyze individual scenarios and in particular the links between them, we find that the first three scenarios, in this case the worst ones, indicate accelerating recession, banks' reluctance to credit operations and a fall in all financial indicators. For these scenarios one cannot get better options, because the economy is in a deepening recession and seeks only to its bottom given by the cyclical developments. see Tab. 3 or Fig. 3.

$$4 \rightarrow 7 \rightarrow 11 \quad (8)$$

The links between individual scenarios, and thus the possibility to influence the transition to the growth stage of the economic cycle and the associated lower probability of bankruptcy, can be seen from scenario No. 4 through scenario No. 11 (8). This scenario shows a stop of deterioration of all parameters and return to the stagnation phase. Transition from this scenario is possible to the best scenario No. 11 already through the scenario number 7, thus in case of return to improving indicators of the variables of financial indicators, company market position and return of projects. Similarly, there are improvements, i.e. decrease in variables of cost of finance, probability of bankruptcy and pressure for premature debt repayment.

The resulting scenarios and links generated between them apparently show the dependence of company status and the likelihood of bankruptcy on the phase of the cycle of economic development on one hand, and on the unwillingness of banks to lend on the other. It can be stated that in case of the selected model, approximating to the reality of the selected variables, one cannot only respond to the cyclical fluctuations of the economy, but regulatory authorities should also consider whether it is practical and appropriate to respond to changes in attitude and behavior especially in banking institutions while in stable economic situation.

You cannot ignore, however, that the directly non-influencable variables used in this model can be influenced very hard or not at all by regulators with the tools currently used in control. In the case of efforts to achieve improvements in these variables, therefore, the regulatory authority has to proceed to non-standard steps, which may to some extent, reduce market-based economy. There is a big unknown to what extent, in the event of a non-standard regulation, will bankruptcy be possibly limited to a long or a short-term period.

For this issue it is possible to create a qualitative model using other variables, possibly supplemented by variables already used in the presented model with other links between them. The results show that the output of this model cannot be generalized and take as a decisive one, though many suggest and at least give hints for answers to the most pressing questions about the functioning of the contemporary economy.

4. Conclusion

The very nature of such object of models as bankruptcy and political risks makes their study difficult. Models of complex, highly non linear and multidimensional systems of interdisciplinary nature have many setbacks. They are rather heterogeneous collections of items of different credibility. The concept of qualitative models is a simple formal tool which can integrate all such items. A meaningful interpretation of the resulting sets of scenarios is an ad hoc task.

The key advantages of qualitative models are that forecasts or decisions are based on provably complete set of scenarios. No scenario can be overlooked. The key disadvantage is that the results are qualitative; it means that just qualitative answers are offered.

The qualitative modeling itself is very flexible. It is possible to perform any union or intersection of different models. The sub models can be either equationless or based on sets of quantitative equations. This is a very useful feature for verification of macroeconomic models and their simplifications. There are usually not sufficiently rich data sets to use statistical methods. It is therefore very useful to learn all possible consequences if some variables or equations are ignored. This aspect is important for development of classical quantitative models.

In this particular application, qualitative modeling techniques were used in modeling the impact of the economic cycle phase and bank unwillingness to lend free funds on critical business indicators, including the likelihood of bankruptcy. The result present eleven scenarios and sixteen transitions between them. Both of these variables have a similar effect on the company. In the real economic situation using standard methods by regulatory authorities, their development is very difficult to influence directly. When using non-standard methods, this model cannot estimate trends in the economic behavior of individual entities in the economic environment in the future. At least the possibility to model these trends provides an opportunity to further expansion or modification of the presented model.

References

[1] AHN, H., KIM, K-J,. Bankruptcy prediction modeling with hybrid case-based reasoning and genetic algorithms approach. *Applied Soft Computing*. 2009, Vol. 9, Iss. 2, pp.457–862, p.599–607. doi:10.1016/j.asoc.2008.08.002.

[2] CHAUDHURI, A., DE, K. Fuzzy Support Vector Machine for bankruptcy prediction. Applied Soft Computing. 2011, Vol. 11, Iss. 2, pp.1491–2934, p.2472–2486. doi:10.1016/j.asoc.2010.10.003.

[3] CROUCHY, M., GALAI, D., MARK, R. Prototype risk rating system. Journal of Banking & Finance. 2001, Vol. 25, Iss. 1, pp. 1–270, p.47–95. PII: S0378-4266(00)00117-5.

[4] GRIECE, S. J., DUGAN, M. T. Re-estimation of the Zmijewski and Ohlson bankruptcy prediction models. Advances in Accounting. 2003, Vol. 20, pp. I–XVIII, 1–290, I–II, p.77–93. doi:10.1016/S0882-6110(03)20004-3.

[5] GRIECE, S. J., INGRAM, R. W. Tests of the generalizability of Altman's bankruptcy prediction model. Journal of Business Research. 2001, Vol. 54, Iss. 1, pp. 1–86, p. 53-61. PII: S0148-2963(00)00126-0.

[6] HEISE, D. R., DURIG, A. Qualitative models. 2000. [cit. 2010-08-25]. Dostupné na WWW: < http://www.indiana.edu/~socpsy/papers/QualEncyclo.htm >.

[7] GUTIÉRREZ, C. L., OLALLA, M. G., OLMO, B.T. The influence of bankruptcy law on equity value of financially distressed firms: A European comparative analysis. International Review of Law and Economics. 2009, Vol. 29, Iss. 3, pp.179–280, p.229–243. doi:10.1016/j.irle.2009.02.002

[8] KIM Y., NABAR, S. Bankruptcy probability changes and the differential informativeness of bond upgrades and downgrades. Journal of Banking & Finance. 2007, Vol. 31, Iss.12, pp.3539–3908, p.3843–3861. doi:10.1016/j.jbankfin.2007.02.008

[9] KRAFTOVÁ, I., ŠUSTROVÁ, E. Mezoekonomické aspekty cyklického charakteru bankrotů v ČR. SCIENTIFIC PAPERS OF THE UNIVERSITY OF PARDUBICE. Series D. 2010, No. 3, p.125-137. ISSN 1211–555X.

[10] PENDHARKAR, P. C. A threesold-varying artificial neural network approach for classification and its application to bankruptcy prediction problem. Computers & Operations Research. 2005, Vol. 32, Iss. 10, pp. 2495–2730, p.2561–2582. doi:10.1016/j.cor.2004.06.023

[11] SUN, L., PRAKASH, P. S. Using Bayesian network for bankruptcy prediction: Some methodological issues. European Journal of Operational Research. 2007, Vol. 180, Iss. 2, pp. 491–970, p.738–753. doi:10.1016/j.ejor.2006.04.019.

[12] TSAI, C. - F. Feature selection in bankruptcy prediction. Knowledge-Based Systems. 2009, Vol. 22, Iss. 2, pp. 115–128, p.120–127. doi:10.1016/j.knosys.2008.08.002.

[13] VICHA, T., DOHNAL, M. Qualitative identification of chaotic systems behaviours. Chaos, Solitons and Fractals. 2008. Vol. 38, Iss. 1, pp. 1–308, p.70-78. doi:10.1016/j.chaos.2008.01.027.

Contact Address

Ing. Jaroslav Krejčíř
Brno University of Technology, Faculty of Business and Management
Kolejní 2906/4, 612 00 Brno, Czech Republic
E-mail: krejcir@fbm.vutbr.cz
Phone number: +420 541 142 638

Ing. Hana Rašková
Brno University of Technology, Faculty of Business and Management
Kolejní 2906/4, 612 00 Brno, Czech Republic
E-mail: raskovah@std.fbm.vutbr.cz

Prof. Ing. Mirko Dohnal, DrSc.
Brno University of Technology, Faculty of Business and Management
Kolejní 2906/4, 612 00 Brno, Czech Republic
E-mail: dohnal@fbm.vutbr.cz
Phone number: +420 541 146 908