Qualitative Models of Bankruptcy Proceedings Integrating Psychological and Economic Aspects

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There is a broad spectrum of BP (Bankruptcy Proceedings) models. They are unique, partially subjective, inconsistent, vague and multidimensional. BPs development suffers from IS (Information Shortage). IS often eliminates straightforward application of traditional statistical methods. It is therefore often prohibitively difficult to analyse them using numerical quantifiers. Oversimplified or highly specific BPs are sometimes obtained. Their practical applicability is therefore (very) limited. Artificial Intelligence has developed a number of tools to solve such problems. Qualitative reasoning is one of them. It is based on the least information intensive quantifiers i.e. trends. There are just three trend / qualitative values used to quantify variables and their derivatives: plus/increasing; zero/constant; negative/decreasing. There are qualitative BP knowledge items in equationless forms such as heuristics. For example – *if standard of ensured justice is increasing then level of creditors bullying is decreasing*. Such verbal knowledge item cannot be incorporated into a traditional numerical model. Qualitative models must be used. A qualitative model can be developed under conditions when the relevant quantitative model must be heavily simplified. The key information input into BPs is expert knowledge. The case study presents a model based on integration of equationless relations using 8 variables e.g. *selling of assets, bullying of creditors or ensured justice*. The result is represented by 11 scenarios. The paper is self-contained, no a prior knowledge of qualitative models is required. The result is represented by 11 scenarios. The paper is self-contained, no a prior knowledge of qualitative models is required.

Key-Words: Insolvency; qualitative variables; bankruptcy related knowledge; bankruptcy proceedings; decision making;

1 Introduction

Deep knowledge items are such laws which reflect undisputed elements of the corresponding theory. E. g., the Newton's law of mechanics is an example of a deep knowledge item. A deep knowledge item is usually available in a form of a differential and / or algebraic equation.

A shallow knowledge item is a heuristic or a result of a statistical analysis of passive observations; e.g. macroeconomics does not allow active experimentations This is the reason why new formal tools are used more and more frequently, see e.g. fuzzy and / or rough sets (Dočekalová and Kocmanová, 2016), (Zhang et al., 2016). A shallow knowledge item has usually (many) exceptions (Orrell, McSharry, 2009). Many shallow knowledge items are available just as verbal descriptions. The following two types of pairwise proportionalities / relations between variables X and Y are considered in this paper:

An increase in (X) has a supporting effect on (Y) An increase in (X) has a reducing effect on (Y)

The optimal use of all these data of different natures, ranges, sets of independent variables and accuracies is for conventional algorithms, e.g. statistical analysis prohibitively difficult or impossible.

Common sense formalization has attracted attention long time ago; see e.g. ideas related to naive physics, see e.g. (Lipmann, Bogen, 1923), (Bredeweg, Salles, 2009). Common sense algorithms based just on four values - positive, zero, negative, anything – are studied in this paper.

Different quantifiers are differently information intensive. The least information intensive are trends – decreasing, constant increasing. A trend is the first time derivative quantified by + or 0 or -. If a trend cannot be quantified then nothing can be measured, simulated, predicted (Dohnal, 1985).

Problems related to bankruptcy proceedings and insolvencies often incorporate many prohibitively vague variables. These variables are of interdisciplinary nature. Important part of them are psychology based variables which have been previously used similar research as important inputs for personal financial decisions (Delis; Mylonidis 2015). It is a well-known fact that such variable are difficult to quantify. A formal application of some branches of psychology requires formalisation of psychology itself, see e.g. (Townsend, 2008).

Decision making within bankruptcy proceedings and related disciplines are often based on models of unique systems. It means that conventional statistical methods which are, directly or indirectly, related to the basic law of large numbers are difficult or impossible to apply, see e.g. (Sen; Singer 1994). It means that knowledge items of different levels of subjectivity must be taken into consideration to develop the best possible model of a unique task under study.

Bankruptcy experts, especially at the very beginning of any analysis / decision making, do not use mathematical models as the basic framework for their reasoning. Experts draw heavily on knowledge represented by common-sense. However, any efficient integration of knowledge items of different origins requires common sense reasoning see e.g. (Choueiry, 2005), Džeroski et al., 1997).

There is a long tradition of common-sense and related types of reasoning's, see e.g. (Lipmann, Bogen, Forbus 1996).

Many BRK (Bankruptcy related knowledge) items are available just as verbal descriptions based on trends: *plus/increasing; zero/constant; negative/decreasing*. For example:

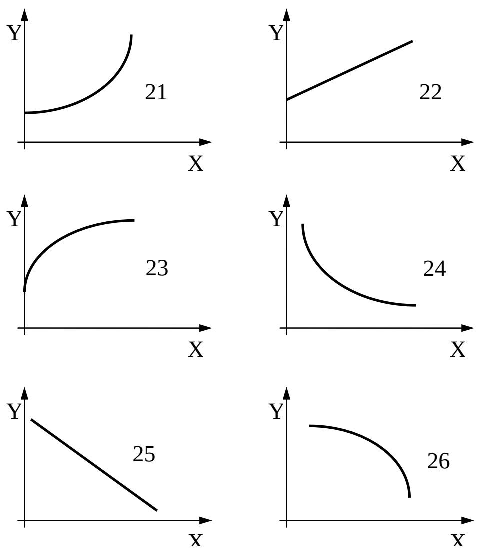
If Corporate indebtedness is increasing then Long-run average revenue is decreasing more and more rapidly (1)

Such BRK items as (1) are used to develop models.

BRK models are based on shallow knowledge items, e.g. verbal descriptions using linguistic quantification. This is the main reason why simple qualitative shapes/relations are used. All pairwise relations X and Y given in Fig. 1 are qualitative relations. It means that nothing is quantitatively known.

Six examples of quantifier-less pairwise trend relations are given in the Fig. 1.

Fig. 1 - Examples of qualitative pair wise relations



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All pair wise relations *X*, *Y* in Fig. 1 are trend relations. It means that they are based on trends only:

Increasing, constant, decreasing (2)

For example the relation 22 indicates that:

- The relation is increasing
- There is a linear relationship between Y and X (3)
- If X = 0 then Y is positive.

The heuristic (1) is represented by the shape No. 21, see Fig. 1.

2 Qualitative Models

New formal theories will be accepted by a broad spectrum of users if they do not require extensive study of and the results can be easily rechecked using just common sense. This is the reason why qualitative reasoning is used in this paper, see e.g. (Bredeweg, 2006), (Vicha, Dohnal, 2008).

There are four qualitative values:

Positive	Zero	Negative	Any Value	
+	0	-	*	(4)

An equationless qualitative model M is a set of w pair wise relations

$M = P_s (X_i, X_j)$ (5)

s = 1, 2, ……w

Examples / shapes of the relations P (5) are given in Fig. 1.

An algorithm which can be used to solve the model (5) is based on pruning of a specially generated tree of combinations. It is not the goal of this paper to describe such algorithm as it is a purely combinatorial task, see e.g. (Vicha; Dohnal, 2008).

To simplify the problem let us suppose that all variables X (5) are positive. For example, if X_1 is a Demand of creditors then it is always positive. Therefore the following triplet is used (+, DX_1, DDX_1), where DX_1 is the first and DDX_1 is the second derivative of X_1.

Another simplification is that the second derivative is ignored if the studied BRK information items are so poorly known that the second derivatives cannot be evaluated. It means that just the following triplet is used:

(+, DX_1, Ignore) = (+, DX_1, *), see (4) (6)

If the second derivatives are ignored or unknown then the model (5) cannot be described by the shapes given in Fig. 1. Qualitative proportionalities are therefore introduced. DQP is a direct qualitative proportionality and IQP is an indirect qualitative proportionality:

DQP If *X* is increasing then Y is increasing

If *X* is decreasing then Y is decreasing DX = DY

If *X* is increasing then Y is increasing

If *X* is decreasing then Y is decreasing (7)

IQP If *X* is increasing then Y is decreasing

If *X* is decreasing then Y is increasing DX = - DY

If *X* is increasing then Y is decreasing

If *X* is decreasing then Y is increasing

DQP represents the following three shapes, see Fig. 1: 21, 22, and 23. IQP represents 24, 25, and 26. If a BRK information items is so vague that it is not possible distinguish the shapes 21, 22 and 23 then DQP is used.

Human beings are not computers and cannot take into consideration complex qualitative relations. The result is that newly developed models have often no solution. The following simple model is used as a demonstration:

Demands of creditor	DOC	
Selling of assets	SOA	(8)
Trends of market	TRM	

	See (7)	X	Y
1	DQP	SOA	DOC
2	IQP	SOA	TRM
3	DQP	TRM	DOC

Let us verify the model (8) by choosing e.g. the increasing SOA. The relation No. 1 (8), sub-Fig. 2a, indicates that DOC is increasing. It means that TRM is increasing as well, see the relation No. 2 (8), and sub-Figure 2c. The chart Fig.2b indicates that there is a contradiction in the model (8).

If sub-Fig. 2b is ignored then the following set of three scenarios is obtained:

	SOA	DOC	TRM	
1	++*	++*	++*	
2	+0*	+0*	+0*	(9)
3	+-*	+-*	+-*	

A set S of m qualitative n-dimensional scenarios is described by a sequence of qualitative triplets, for details see (Vicha; Dohnal, 2008):

$$S = \{(X_1, DX_1, DDX_1), (X_2, DX_2, DDX_2), \ldots (X_n, DX_n, DDX_n)\}_j ; j = 1, 2, \ldots, m \qquad (10)$$

where DX is the first and *DDX* is the second time qualitative derivatives.

A qualitative description of a variable *Demands of creditors* - DOC using a triplet (+ + -) means that:

DOC = +

D(DOC) = + (11)

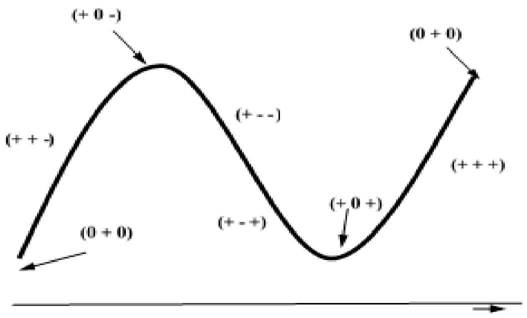
DD(DOC) = -

The very nature of DOC indicates that DOC is positive see (11a). Negative DOC does not exist. Let us suppose that time behaviour of DOC is described by equations (11b, 11c). The positive first time derivative (2), see (11b), indicates that the DOC is increasing. The negative value of the second derivative (11c) signals that the increase is slowing down. It means that there is a DOC upper limit.

Transitional Graphs

The set of scenarios **S** (4) is not the only result of a qualitative modelling. It is possible to generate transitions among the set of scenarios.

Fig. 2 A qualitative description of a quantitative oscillation



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The triplets given Fig. 3 describe a broad spectrum of different oscillations.

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
1	+ + +	→	+ + 0			
2	+ + 0	→	+ + +	+ + -		
3	+ + -	→	+ + 0	+ 0 -	+ 0 0	
4	+ 0 +	→	+ + +			
5	+ 0 0	→	+ + +	+ - -		
6	+ 0 -	→	+ - -			
7	+ - +	→	+ - 0	+ 0 +	+ 0 0	0 - +
8	+ - 0	→	+ - +	+ - -	0 - 0	
9	+ - -	→	+ - 0	0 - -	0 - 0	

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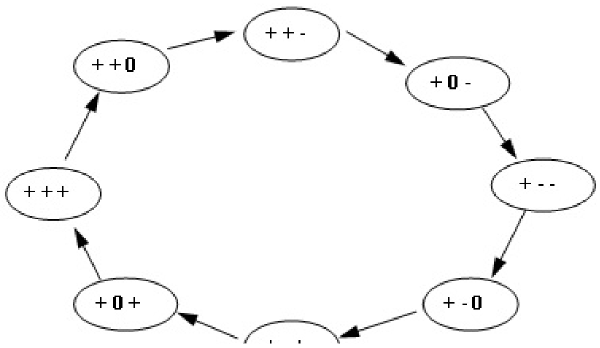
The third line of Tab. 1 indicates that it is possible to transfer the triplet (+ + –) into the triplet (+0–). This transition is not the only possible. There are two more possible transitions. Fig. 2 gives a qualitative description of an oscillation using the one dimensional triplets. Tab. 1 is not a dogma. It could be modified on ad hoc basis. The only requirement is that the transitions must satisfy the common sense feeling of a user.

Any quantitative one-dimensional oscillation, see e.g. Fig. 1 and Fig. 2, can be represented by a simple oriented graph, see Fig. 3. The transition from the triplet (+ + +) to the triplet (+ + 0), see Fig. 3, is based on the first row of Tab. 1, see the first and only possible transition.

Fig. 3 Transitional graph – oscillation and transitions given in Tab. 1



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For example the transition (+ 0 -) → (+ - -) represents the transition from the peak, see Fig. 2. All these transitions correspond to the Tab. 1.

Case Study

The case study focuses on BP and some difficult to quantify variables. The presented case study is used as an example to demonstrate advantages and disadvantages of qualitative models using bankruptcy related knowledge and some possible interpretations of the qualitative results.

Bankruptcy negotiations can influence a lot of objects both internally and externally. A team of experts decided to use the following set of variables:

Selling of assets	SOA	
Tax Load	TAX	
Improvement of political		
and social changes	PSC	
Bullying of creditors	BUL	
Level of greed	GRD	
Debt reorganization	REO	(12)
Ensured justice	ENJ	
Trends of market	TRD	

The following set of relations is used as the studied qualitative model (5), w = 19:

See Fig.1	X	Y
See (7)		

1	21	PSC	SOA	
2*	24	BUL	SOA	
3	24	GRD	SOA	
4*	IQP	REO	SOA	
5*	IQP	EIN	SOA	
6	DQP	ENJ	SOA	
7*	DQP	TRD	SOA	
8	21	BUL	TAX	
9	22	GRD	TAX	
10*	22	REO	TAX	
11*	22	EIN	TAX	
12	22	TRD	TAX	
13*	IQP	BUL	PSC	
14*	DQP	GRD	PSC	(13)
5	DQP	REO	PSC	
16*	DQP	TRD	PSC	
17	21	GRD	BUL	
18*	DQP	EIN	BUL	
19	IQP	ENJ	BUL	
20*	25	TRD	BUL	
21*	22	REO	GRD	
22*	DQP	EIN	GRD	
23	26	ENJ	GRD	
24	22	TRD	GRD	
25*	DQP	TRD	REO	
26*	22	EIN	EIN	
27*	DQP	TRD	EIN	
28*	DQP	TRD	ENJ	

The model has no solution. There are inconstancies, see Fig. 1. It is a complex problem to remove them. A team of experts suggested to remove all such relations which are * marked, see (13). Moreover, relations No2. 19, 24 (13) are made conditional:

19 If D(GRD) = + then

	IQP	ENJ	BUL	(14)

24 If D(ENJ) = + then

	22	TRD	GRD

The modified model (13, 14) is solved and the set of 11 scenarios is obtained, m = 11 (9);

	ENJ PSC	SOA GRD	REO TRD	BUL	TAX
1	+++ +++	+++ +--	+++ +--	+--	+--
2	+++ ++0	+++ +--	++0 +--	+--	+--
3	+++ ++-	+++ +--	++- +--	+--	+--
4	++-	++-	++-	+-+	+-+

	++-	+-+	+-+			
5	+0+	+0+	+0+	+0-	+0-	
	+0+	+0-	+0-			
6	+00	+00	+00	+00	+00	
	+00	+00	+00			(15)
7	+0-	+0-	+0-	+0+	+0+	
	+0-	+0+	+0+			
8	+-+	+-+	+-+	++-	++-	
	+-+	++-	++-			
9	+-+	+-+	+-0	++-	++-	
	+-0	++-	++-			
10	+-+	+-+	+--	++-	++-	
	+--	++-	++-			
11	+--	+--	+--	+++	+++	
	+--	+++	+++			

The set of scenarios is the complete set of all possible scenarios which satisfy the relations given in the model (13, 14). For example, the scenario No. 6 has the entire first and the second derivatives zeros. It is therefore the qualitative steady state.

The set of scenarios (15) can be used to answer qualitative questions, for example:

Is it possible to? :

Increase	ENJ AND	i.e.	D(ENJ) = +	
Increase	SOA AND	i.e	D(SOA) = +	(16)
Increase	REO AND	i.e	D(TRD) = +	
Decrease	BUL AND	i.e	D(BUL) = -	
Keep constant	TRD	i.e	D(TRD) = 0	

If the studied query (16) is confronted with the set of scenarios (15) then it is clear that there is not such scenario. It means that the answer to the query (16) is NO.

The variables (12) are into two subsets of variables UN, OU:

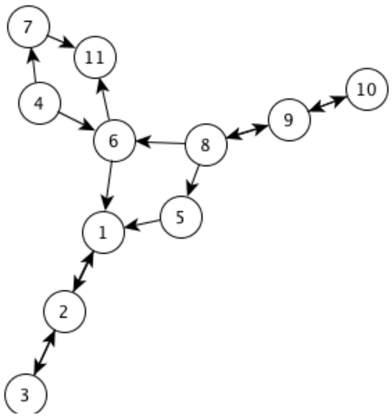
UN (Under control of a decision maker):
REO, GRD, SOA (17)

OC (Outside control):
TAX, PSC, BUL, TRD, ENJ

This variable splitting (17) represents a point of view and is done on an ad hoc basis. It means that different decision makers can choose different UN and OC sub sets.

Fig. 4 represents the transitional graph based on the set of scenarios (15) and the Tab. 1.

Fig. 4 Transitional graph based on the scenarios (15).



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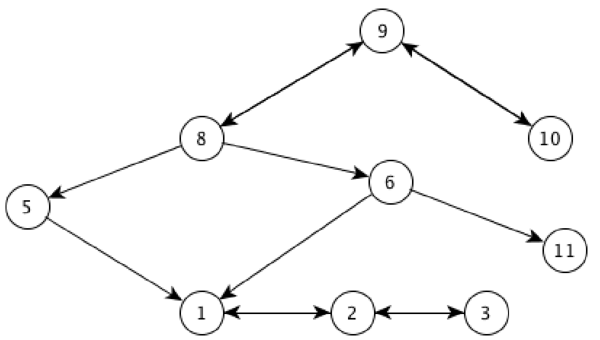
Let us suppose that the current situation / scenario under study corresponds to the scenario No. 9 (15). It means that the scenarios No. 4 and 7 cannot be reached. The reachable relevant sub graph is given in Fig. 6.

Fig. 5 A reachable sub graph of the complete transitional graph, see Fig. 5



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There are reasons why the path (18) is attractive.

$$9 \rightarrow 8 \rightarrow 6 \rightarrow 1 \quad (18)$$

The scenario No. 9 represents an indebted object at the worst possible situation. The scenario No. 1 is the best variant. The path (18) leads from the very problematic situation to the optimal one.

However, a decision maker has no free choice to change the variables (12) to follow the path (18). Some variables are not under his/her control (17). Moreover, the valid model represents a set of restrictions and just the transitions given in Fig. 5 are possible. The first step 9 →8 (18) requires changes of the following variables REO and PSC. The rest of variables are kept constant, see (15, 18).

	ENJ	SOA	REO	BUL	TAX	PSC	GRD	TRD
	OC	UN	UN	OC	OC	OC	UN	OC
9	+-+	+-+	+-0	++-	++-	+-0	++-	++-
8	+-+	+-+	+-+	++-	++-	+-+	++-	++-
6	+00	+00	+00	+00	+00	+00	+00	+00
1	+++	+++	+++	+--	+--	+++	+--	+--

(OC, UN: see (17)) (19)

The decision maker controls just the variable REO. Therefore hi/she cannot guarantee the transition 9 →8.

4 Results and interpretations

At present, most of the techniques employed for various analyses of BP problems are of analytical and/or statistical natures. Unfortunately these precise mathematical tools do not always contribute as much as is expected towards a full understanding of BP tasks. It is no paradox that less information-intensive methods of analysis often achieve more realistic results in cases in which the system that is being modelled is highly complex and/or little known.

The main advantage of a qualitative BP analysis is that no numerical values of constants and parameters are needed and the set of qualitative solutions is a superset of all meaningful scenarios, i.e. forecasts. No reasonable forecast can be missed if the analysis is based on a good qualitative model.

A decision maker requires transparent and easy to understand explanations why different algorithms generate some forecast. If formal tools are mathematically too demanding then it is very difficult to introduce them into the BI community. Qualitative models are difficult to solve but easy to interpret.

There are several unsolved problems of qualitative modelling and therefore results of qualitative approximations of some qualitative models can be problematic.

If there is no scenario, m = 0 (9), then the studied model itself is not consistent. The consistency represents a very important obstacle. If there is no scenario then it is a reliable indication that a serious mistake was made in process of model development.

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References:

[1] Bredeweg, B., Bouwer, A., Jellema, J., Bertels, D., Linnebank, F. F., & Liem, J. (2007). Garp3. Proceedings of the 4th international conference on Knowledge capture - K-CAP 07. doi:10.1145/1298406.1298445

[2] Choueiry, B.Y., Iwasaki, Y., McIlraith, S., 2005. Towards a practical theory of reformulation for reasoning about physical systems. Artif. Intell., Reformulation 162, 145–204. doi:10.1016/j.artint.2004.01.004.

[3] Dočekalová, M.P., Kocmanová, A., 2016. Composite indicator for measuring corporate sustainability. Ecol. Indic. 61, Part 2, 612–623. doi:10.1016/j.ecolind.2015.10.012

[4] Dohnal, M., 1985. Applications of a universal expert system in industry. Comput. Ind. 6, 115–121. doi:10.1016/0166-3615(85)90017-X

[5] Džeroski, S., Grbović, J., Walley, W.J., Kompare, B., 1997. Using machine learning

techniques in the construction of models. II. Data analysis with rule induction. Ecol. Model. 95, 95–111. doi:10.1016/S0304-3800(96)00029-4.

[6] Leoni, P. L. (n.d.). Psychological Determinants of Occurrence and Magnitude of Market Crashes. SSRN Electronic Journal. doi:10.2139/ssrn.1439314

[7] Lipmann O., Bogen H., 1996 Naive Physik. Arbeiten aus dem Instuut fur angewandte Psychologie in Berlin. Theoretische und experimentele Untersuchungen fuer die Feihigkeit zu intelligentem Handeln (Leipzig, Johann Ambrosius Barth)

[8] Sen, P.K., Singer, J.M., 1994. Large Sample Methods in Statistics: An Introduction with Applications. CRC Press.

[9] Orrell, D., McSharry, P., 2009. System economics: Overcoming the pitfalls of forecasting models via a multidisciplinary approach. Int. J. Forecast., Special section: Decision making and planning under low levels of predictability 25, 734–743. doi:10.1016/j.ijforecast.2009.05.002

[10] Vicha, T., & Dohnal, M. (2008). Qualitative identification of chaotic systems behaviours. Chaos, Solitons & Fractals, 38(1), 70-78. doi:10.1016/j.chaos.2008.01.027

[11] Vicha, T., & Dohnal, M. (2008). Qualitative feature extractions of chaotic systems. Chaos, Solitons & Fractals, 38(2), 364-373. doi:10.1016/j.chaos.2008.01.008

[12] Delis, M. D., & Mylonidis, N. (2015). Trust, happiness, and households' financial decisions. Journal of Financial Stability, 20, 82-92. doi:10.1016/j.jfs.2015.08.002

[13] Forbus, K. D. (1984). Qualitative Process Theory. Qualitative Reasoning About Physical Systems, 85-168. doi:10.1016/b978-0-444-87670-6.50006-6

[14] Townsend, J. T. (2008). Mathematical psychology: Prospects for the 21st century: A guest editorial. Journal of Mathematical Psychology, 52(5), 269-280. doi:10.1016/j.jmp.2008.05.001