Doctorial School of
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THESIS COLLECTION

for the Ph.D. thesis of

Tamás Kristóf

Corporate survival and solvency prediction

Research supervisor:

Erzsébet Nováky, DSc

university professor, head of department

Budapest, 2008

Corvinus University of Budapest
Futures Studies Department

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I. Research preliminaries, justification of the topic

The aim of the PhD thesis is to underpin corporate survival and solvency prediction with new theoretical approaches, and to develop forecast methodology. The PhD thesis primarily attempts to explore the insolvency of business partners/clients from creditor point of view.

The actuality of the selected topic is given by the fact that in Hungary – like in other countries – companies facing bankruptcy procedure, liquidation or winding up can be met every day[1]. Due to the frequent insolvency events the demand for up-to-date, reliable bankruptcy prediction models is increasing.

Bankruptcy forecasting is in itself not a new topic in Hungary. What still makes it new; however, is the fact that the PhD thesis does not neglect organizational theoretical underpinning. Another novelty in Hungary lies in the applied methodology, since so far nobody has applied simultaneously six modeling procedures on the same bankruptcy prediction database, including the most contemporary ones, which were not used in Hungarian practice up to the last years.

Corporate survival and solvency prediction is a complex problem. Researching this field is encumbered and at the same time challenged by the ascertainments that no unified theory exists to explain and understand organizational survival, no method exists to guarantee unambiguous survival prediction, and it might occur that different empirical researches arrive at contradicting conclusions. Throughout the 40-year-history of bankruptcy forecasting no agreement was made among scholars in the field what explanatory variables provide the most reliable prediction. It is argued that no model exists independent of time, space and economic environment.

As a consequence competitive and supplementary theoretical and methodological approaches coexist in the field. Accepting the incommensurability criterion of *Feyerabend* the possibility to directly compare different theoretical approaches was excluded, however, it does not refer to the applied forecast and visual clustering methods. Since it would have been unreasonable to define a unified, generally acceptable system of theoretical-methodological perspectives, the PhD thesis conspicuously focused on methodological comparison and improvement.

[1] In 2007 altogether 75% more bankruptcy procedures, liquidation procedures and winding ups were declared than in 2000, and 24% more than in 2006.

The spectacular improvement of bankruptcy forecast methods has been observable since the end of 1960s and the pace of development has boosted since the 1990s. Analyzing the historical background of methodological improvement starting from the simple comparison of financial ratios to the intelligent systems picture can be gained on the most important milestones, perceived methodological problems and the reasons for striving to further methodological developments.

A comparative analysis of bankruptcy forecast methods was elaborated using the results of the most important international and Hungarian empirical researches available since the beginning of 1990s and on the basis of an earlier own small-sample empirical research. International and Hungarian empirical results provided evidence that simulation and artificial intelligence based techniques possess higher classification accuracy and predictive power; however, there were also some findings that no substantial difference exists between the performances of methods.

On the basis of theories, methods and earlier empirical researches no clear answer was found to the question how it is possible to predict corporate solvency with the highest reliability according to contemporary scientific development, and how to best estimate probability of survival values for individual companies. Taking into account the application assumptions of bankruptcy forecast methods, experiences gained from international empirical researches and the results of the small-sample empirical research it was regarded as indispensable and desirable from the viewpoint of improving this scientific field to explore the validity of theoretical considerations and methodological analyses by accomplishing a new empirical research under the Hungarian circumstances in the second half of the first decade in the 2000s.

II. Applied methods

Corporate survival can be examined at macro level through sampling procedures, or through organization-specific case studies. In the PhD thesis the first solution was selected concentrating on multivariate statistical methods and public information available for any company.

The objective of bankruptcy modeling is to find out from cross-section data with the highest reliability whether a company is expected to go into bankruptcy within one year after the turning day of its last annual report. In the PhD thesis emphasis was laid on multivariate bankruptcy forecast methods (discriminant analysis, logistic regression analysis, recursive partitioning algorithm, neural networks) and multivariate visual clustering techniques (self-organizing maps, multidimensional scaling).

II.1. Hypotheses

The accomplishment of empirical research is supported by drawing and examining six hypotheses. Empirical research is based on inductive hypothesis-examination.

Table 1. Contents and backgrounds of hypotheses

Hypothesis	Explanation
H1: Corporate size is a significant explanatory variable of expected solvency in case of Hungarian limited liability companies and corporations.	According to the liability-of-smallness tenet of the evolutionary approach smaller organizations has higher likelihood of death – regardless of their age – than the larger ones. Since larger companies are better diversified and might easier receive credit, in principle they really less face the danger of bankruptcy. Negative relationship between corporate size and probability of bankruptcy was proven by many authors. It should not be forgotten, however, that under insolvent circumstances saving a larger company requires substantially more resources than a smaller, as financial distress of larger companies might also be more stable. Relationship between size and solvency is ambiguous; therefore its empirical research is needed. During hypothesis-examination answer is sought to the problem whether the natural logarithm of net sales revenue and total assets expressing corporate size, and size factor in the case of principal component analysis (PCA) based models are significant and/or relevant[2] explanatory variables when applying different bankruptcy forecast methods.

[2] term 'significance' does not make sence in the case of simulation procedures

H2: Financial ratios expressing profit-generating capability better explain expected solvency than liquidity ratios expressing the financing capability of liabilities.	In financial analysis literature the danger of bankruptcy had been equated to negative equity and the inability to pay back short term liabilities for a long time, therefore emphasis was laid on examining liquidity in the 1980s and the 1990s. However, tendencies of the 2000s fundamentally questioned the applicability of liquidity ratios due to their static, historic nature and their period-end relevance. Consequently international analyses began to focus on profitability and cash flow indicators when determining expected liquidity. The validity of the hypothesis might be proven by the model variables of the four prediction models and the results of visual clustering. If the majority of forecast methods do not regard liquidity ratios (liquidity factor in case of PCA based models) as significant/relevant, but they do that of profitability and/or cash flow ratios (profitability and/or cash flow factors in case of PCA based models, the latter factor contains dynamic profitability ratio as well), then according to the empirical research international tendencies are found to be valid also in Hungary.
H3: Modeling with less number of variables (factors) constructed by principal component analysis results in a more reliable bankruptcy prediction than by applying the original financial ratios.	Efficient application of multivariate statistical methods requires the reasonable reduction of available explanatory variables, which necessarily leads to information loss. This problem is attempted to be mitigated by PCA, with the help of which substantially less number of hypothetical components (factors) might be determined. Original variables are substituted by factors embodying a great part of system's information quantity. PCA might be applied effectively if variables can be compressed well and linear relationships are strong. Expected results are increasing reliability and managing multicollinearity. It is an interesting object of research, whether PCA improves or reduces model performance of certain methods. The hypothesis presumes that models in case of each method become more complicated, at the same time more reliable. Reliability is expressed by classification accuracy, area under ROC[3] curve and the difference between errors of training and testing sets.
H4: Simulation forecast methods (decision tree, neural network) enable a more reliable bankruptcy prediction than traditional mathematical-statistical methods (discriminant analysis, logistic regression).	Comparing the application assumptions of the selected forecast methods and the results of small-sample empirical research inspire that neural networks provide a more reliable prediction than discriminant analysis or logistic regression, and recursive partitioning is at least equal-ranking to the two traditional methods. However, it is not reasonable to generalize from the small-sample empirical research and every method has advantages and disadvantages when considering application assumptions. Reliability is expressed by Type I error, Type II error, classification accuracy, area under ROC curve and difference between the errors of training and testing sets. The results of Hypothesis 3 concerning PCA are also evaluated within the framework of this hypothesis.

[3] ROC = Receiver Operating Characteristic

H5: Financial ratios contributing to distinguish solvent and insolvent zones on the self-organizing maps are in accordance with significant/relevant model variables of the four forecast models.	Self-organizing maps attempt to cluster the companies on the basis of ratio-differences; the topological representation is derived from the transformation of explanatory variables. A fundamentally different approach from that of the four forecast methods is that the output variable (fact of solvency) is not considered during clustering, hence self-organizing maps do not optimize to a priori known solvency. Accordingly it is an interesting object of research, whether the self-organizing maps illustrated per variable match the map plotted for the dummy variable of solvency. If the self-organizing maps of variables regarded as significant/relevant by the forecast methods can similarly differentiate between solvent and insolvent zones, and non significant/relevant ones cannot, then it can be concluded that simulated self-organizing maps having unsupervised learning feature consider the same explanatory variables to be important, thereby the variable selection of forecast methods might be validated in another approach.
H6: Multidimensional scaling enables a more exact clustering of solvent and insolvent observations than each forecast method.	Application of multidimensional scaling in bankruptcy modeling has a very narrow literature. However, available empirical results indicate that multidimensional scaling possesses at least equal-ranking clustering capability with the more frequently applied forecast methods. The term 'clustering' is not accidental in the hypothesis, since multidimensional scaling does not lead to a prediction model, therefore it cannot be applied directly on classifying new observations. This problem can be solved by including the new observations into the sample and studying their location on the scaling map. Decision on validating or falsifying the hypothesis is made on the basis of studying dimension-pair maps and the logistic regression model built on the dimension coordinates.

II.2. Size and breakdown of the sample, explanatory variables

Relating to data collection it was set as a requirement that data available for modeling has to come from public annual reports and company register. Balance sheets and profit&loss statements from 2004 were collected within the framework of informal data gathering. The sample contained 504 companies from which 437 was solvent and 67 insolvent. From the insolvent observations 1 fell under bankruptcy procedure, 29 declared winding-up and liquidation procedure was announced against 37 companies. The legal category of insolvency was not differentiated later.

Distribution of companies in the sample could be classified into 10 national economic branches, 41 industries and 164 special-branches[4]. Manufacturing companies represented themselves in the greatest share within the sample. To compare financial ratios of companies

[4] four digit Standard Sectoral Classification of Economic Activities (SSCEA) code breakdown

operating in different industries the differences from special-branch averages were considered instead of pure financial ratio-values. Consequently the empirical research did not consider individual financial ratio-values, but their variance from their special-branch averages. The requirement of minimum 100 million HUF total assets and net sales revenue was set for data collection.

To validate models and avoid overtraining the sample was partitioned on the basis of simple random selection to a 75% training and a 25% testing set. It is a thumb rule of bankruptcy prediction that if the modeling database (training set) contains less than 50 insolvent observations, it is not reasonable to apply multivariate statistical methods. This requirement was barely met in the empirical research, as within the training sample containing 371 observations 320 were solvent and 51 were insolvent, and within the testing sample containing 133 observations 117 were solvent and 16 were insolvent.

Corporate failure can be defined in many ways. Empirical research in the PhD thesis equated corporate failure to the legal possibilities of insolvency, namely the declaration of bankruptcy procedure, liquidation or winding up. These three cases can be measured well empirically, and surely mean insolvency. This became the output variable of each model. Explanatory variables were defined using information expressing corporate size, industrial classification, legal form, profitability, turnover, liquidity, capital structure, debt, cash flow and annual growth. Variable selection was preceded by an in-depth professional analysis. During data preparation before modeling it was necessary to discard three financial ratios, and missing value imputation was necessary in case of two financial ratios using data mining practices.

II.3. Applied multivariate statistical methods

The following points briefly analyze the application assumptions, advantages and drawbacks of the applied multivariate statistical forecast and visual clustering methods.

II.3.1. Discriminant analysis (DA)

Multivariate discriminant analysis simultaneously analyses the distribution of more independent, quantitative variables and sets up a classification rule, which contains the weighted independent variables in the form of linear combination, which best discriminates between the predefined classes. The preconditions of application are that ratio-values must

follow a multidimensional normal distribution in both classes, covariant matrices must be identical in both classes, and ratios must be statistically independent of each other.

The advantages of the method are robustness, exact appearance of relative contributions and easy interpretation. Drawbacks are linearity, the violation of normality especially in the insolvent class, and the accidental emergence of multicollinearity. Discriminant analysis can be used to estimate probability of survival/bankruptcy values by the standardized canonical procedure. Probability-calibration might be necessary to handle the difference between the solvency rate of the population and the sample, if any.

II.3.2. Logistic regression analysis (Logit)

Logistic regression analysis is a widely used approach to model relationships between explanatory variables and the likelihood of a binary response. The procedure orders probability of survival/bankruptcy values to the weighted independent variables by fitting a logistic regression function estimated by the maximum likelihood method.

The advantages of the method are robustness, exact appearance of relative contributions and easy interpretation. Drawbacks are the possibility of small-sample biasedness, the sensitivity to outliers, the accidental emergence of multicollinearity and the application of predefined function-type. If the solvency rate of the sample differs from that of population, the estimated probability of survival values might be modified by probability-calibration in such a way that the average probability of survival value equals to the desired rate, at the same time the order of probabilities estimated for the observations must be preserved.

II.3.3. Recursive partitioning algorithm (RPA)

The recursive partitioning algorithm attempts to build a decision tree by iteration, using single-variable partitioning, setting simple decision rules, and constructing branches. The aim is to establish the most homogeneous classes. The algorithm establishes branches as long as it finds partitioning variables. The first partitioning variable is found at the top of the tree. The roots of tree mean the solvent and insolvent classes after the partitioning.

The advantages of the method are the few application assumptions and the obvious interpretation of the decision rules. Drawbacks are the accidental appearance of overtraining, the assumption of discrete classification capability and non-overlapping between the groups, no statistical testing can be carried out on the model, and the relative contribution of variables

cannot be unambiguously determined. Probability of survival values can be estimated on the basis of decision rules.

II.3.4. Neural networks (NN)

Neural networks are information processing systems constructed on the basis of biological neural systems having the capability to operate simultaneously in a shared way. Networks consist of interconnected, parallel functioning neurons, and gain their problem-solving capability by learning. Fundamental components of neural networks are the elementary neurons, which are organized in layers. Weighting of the networks is established through the learning (training) process.

The advantages of the method are the few application assumptions, the intelligent learning of relationships and the universal approximation feature. Drawbacks are the black box problem, the accidental appearance of overtraining, arriving at local minima, the indirect determination of relative contributions and the inability to carry out statistical tests. Neural networks can automatically estimate probability of survival/bankruptcy values. If the solvency rate of the population and the sample substantially differs from each other probability-calibration might be necessary.

II.3.5. Self-organizing maps (SOM)

Self-organizing maps belong to the unsupervised learning type neural network family. During the self-organizing process original data is transformed into a two-dimensional topological representation. Self-organizing maps attempt to project the multidimensional input layer into the output layer in a way that companies having similar features from the aspect of solvency will be situated close to each other on the output map.

The procedure is not forecasting but clustering technique. The advantages of the method are the spectacular appearance of ratio-clustering capability and the classification capacity without considering output variable. Drawbacks are the black box problem, the use of prefixed map-structure and the inability to carry out statistical tests.

II.3.6. Multidimensional scaling (MDS)

Multidimensional scaling examines differences between proximities measured on original data, and derives coordinates from them on a scale-map in a way that similar objects are situated close to each other. The task of scaling is to find a set of points in a minimum number of dimensions so that distances in space are the monotone function of the data dissimilarities.

The advantages of the method are the easily interpretable statistical map, insensitivity to outliers and loose application assumptions. Scaling only requires that data should bring message in them and they should have the same unit of measurement. A drawback is, however, that the elaborated scaling model is only indirectly adequate to predict the solvency of new observations. Contents and interpretation of dimensions are further disadvantages.

II.4. Applied reliability-examination methods

Reliability-examination is an equal-ranking task to constructing prediction models. Reliability-examination has to be carried out preliminary, retrospectively, directly and indirectly, therefore reliability-examination requires a complex approach. In case of bankruptcy forecasting it should not be hauled up from predictions whether they took place in reality, but whether they provided appropriate information to make the necessary decisions (e.g. credit appraisal).

Reliability of the sample and the database is evaluated by meeting the criteria set by the applied methods. Reliability of methodology might be judged by analyzing whether application assumptions are met, and using the experiences of international empirical researches. The reliability-examination of the elaborated bankruptcy models involves testing model significance, evaluating Type I error, Type II error and classification accuracy, examining ROC curves and areas under ROC curves, analyzing the variance between the errors of training and testing sets, and the expert judgement of visual clustering.

III. Outcomes of the PhD thesis

The outcomes of the PhD thesis can be evaluated first based on the results of hypothesis-examination, second on the basis how successful it was to meet the objectives (novel theoretical underpinning, methodological improvement, normative proposals to practical bankruptcy modeling) set in the PhD thesis.

III.1. Results of hypothesis-examination

To support decision-making on validating or falsifying the six hypotheses it is essential to compare the breakdown and reliability of the four-four bankruptcy prediction models, and evaluate the results of the two visual clustering techniques. The first two hypotheses explore the significance/relevance of certain explanatory variables (size, profitability, cash flow, liquidity) in case of each method. Hypothesis 3 and Hypothesis 4 examine the reliability of bankruptcy prediction models, whereas Hypothesis 5 and Hypothesis 6 the reliability of visual clustering models.

III.1.1. Result of examining Hypothesis 1

Natural logarithm of total assets and/or net sales revenue, and size factor in case of PCA were regarded as significant/relevant model variables in case of each forecast method. With respect to size indicators it can be concluded that discriminant analysis, logistic regression and recursive partitioning found the total assets, whereas neural networks the net sales revenue as relevant model variable. The relevance of size indicators can be related also to the inspection that smaller companies might easier become insolvent than larger ones. Size factor represented itself in all PCA based bankruptcy model. Consequently size is regarded as significant from the viewpoint of survival, therefore Hypothesis 1 is accepted. Self-organizing maps plotted for individual variables confirmed the result.

III.1.2. Result of examining Hypothesis 2

It is interesting that discriminant analysis put nine, and the other three methods five variables into the models. Three of the four methods selected the dynamic profitability ratio, the total assets and the indebtedness ratio to be model variables, so these three can be

regarded as the most critical variables to predict solvency. Two models involve the equity ratio, the long-term indebtedness and the Ltd_Co dummy variable. The other variables were presented in only one or neither model.

Liquidity ratios and liquidity factor in case of PCA were relevant model variables only in the decision tree. Dynamic liquidity ratio within the decision tree managed to play a role only in splitting eight observations, and the current ratio was included at the second level. Emphasis was undoubtedly laid on size, cash flow and debt ratios; the explanatory power of dynamic profitability ratio is particularly outstanding. Results of self-organizing maps also contributed to validate the hypothesis. The majority of companies in the sample possess liquidity ratio-values similar to their special-branch averages; therefore the liquidity of insolvent companies is not notably worse. These facts underpin the validity of Hypothesis 2 to a great extent.

III.1.3. Result of examining Hypothesis 3

On the basis of classification accuracy and area under ROC curve indicators it is evident that the performance of discriminant analysis and logistic regression is improved, and that of recursive partitioning algorithm and neural networks is worsened by PCA. It is also observable that PCA balances the perceived performance-differences of the methods (see Table 2). Hence the hypothesis is true for traditional mathematical-statistical methods, but not true for simulation methods. It is important to note that the lack of linearity reduces the applicability of PCA. The combination of PCA presuming homogeneity and classification procedures presuming subsamples might lead to the confusion of subsamples.

Based on the classification accuracy of PCA based bankruptcy models it can be concluded that PCA smoothes away the performance-differences among the methods. Consequently worse-performing methods on the original data improve from all aspects, at the same time well-performing methods decline considering the same aspects.

With regard to the expedience of applying PCA it might be concluded that its application does not automatically results in a better prediction. Hence the result of examining Hypothesis 3 shows a two-faced picture. It is true for traditional mathematical-statistical methods but false for simulation methods. Since the hypothesis expected a better performance everywhere, according to the empirical research Hypothesis 3 has to be rejected, as PCA does not guarantee a more reliable prediction.

Table 2. Summary reliability-evaluation of bankruptcy models (brackets mean sequence, bold figures mark the positive impact of PCA)

Aspect	DA		Logit		RPA		NN	
	w/o PCA	with PCA	w/o PCA	with PCA	w/o PCA	with PCA	w/o PCA	with PCA
Area under ROC curve – total sample	0.768 (3.)	**0.791 (4.)**	0.683 (4.)	**0.866 (2.)**	0.855 (2.)	0.855 (3.)	0.898 (1.)	0.894 (1.)
Area under ROC curve – testing set	0.731 (3.)	**0.775 (3.)**	0.563 (4.)	**0.828 (2.)**	0.808 (2.)	0.770 (4.)	0.846 (1.)	0.836 (1.)
Classification accuracy – total sample	0.863 (3.)	**0.887 (1.)**	0.792 (4.)	**0.873 (2.)**	0.903 (1.)	0.855 (4.)	0.899 (2.)	0.871 (3.)
Classification accuracy – testing set	0.835 (3.)	**0.917 (1.)**	0.752 (4.)	**0.865 (2.)**	0.872 (2.)	0.820 (4.)	0.902 (1.)	0.850 (3.)

III.1.4. Result of examining Hypothesis 4

On the basis of classification accuracy and area under ROC curve a sequence can be set to the performance of the four methods (Table 2). Model calculations without PCA prove that recursive partitioning algorithm and neural network belonging to the family of simulation procedures enable a more reliable bankruptcy prediction than traditional mathematical-statistical methods. The extremely low classification level of insolvent observations in case of discriminant analysis and logistic regression is distressing: it is practically worse than random guessing. ROC curves showing model-fit makes one draw the conclusion that recursive partitioning algorithm and neural network models without PCA perform very well, whereas the ROC curves of discriminant analysis and logistic regression fall under the critical 45°-line up to 10% probability of survival percentile. However, through the examination of Hypothesis 3 it was visible that PCA creates a new situation.

On the basis of empirical research it can be concluded that the assertion of Hypothesis 4 is only true if PCA is not carried out. If the same chance is given to models with and without PCA, then according to the ROC curve the neural network without PCA, according to the classification accuracy of the total sample the decision tree without PCA, and according to the classification accuracy of the testing set the discriminant analysis with PCA provide the best performance. Therefore the unambiguous dominance of simulation procedures was not validated during the empirical research.

III.1.5. Result of examining Hypothesis 5

With respect to self-organizing maps it has been proven that they can be excellently applied for variable selection and to control the variable selection of other procedures, despite the fact that – in contrast to forecast methods – no output variable is taken into account through clustering, exclusively the variances of ratio-values. Analyzing the variable level self-organizing maps it is the task to find a solvent and insolvent zone with the help of more variables, and to finally compare the results to the self-organizing map plotted on the dummy variable of solvency.

Based on the empirical research it is clear that only five variables contribute to find an insolvent zone, and the results are in accordance with the self-organizing map of the output variable. It also happened that some financial ratios (e.g. total assets turnover, current assets ratio) managed to distinguish a worse zone, but it was not located on the right part of the map, or it formed a larger part than it would have been realistic. Size, cash flow and debt ratios have considerably higher role in differentiating insolvent companies than liquidity, turnover and capital structure ratios. With respect to the latter ones better solvent companies might be classified into a zone, but in case of bankruptcy modeling the task is not this.

All in all it can be concluded that on the self-organizing maps financial ratios contributing to distinguish between solvent and insolvent zones are in accordance with the ratios found significant/relevant by the four forecast methods, therefore Hypothesis 5 is accepted.

III.1.6. Result of examining Hypothesis 6

Studying the coordinates of dimension-pairs estimated by multidimensional scaling and logistic regression model constructed using the coordinates it is clear that multidimensional scaling unambiguously has its role within multivariate bankruptcy forecast methods. Multidimensional scaling results in a relatively exact clustering despite the fact that it exclusively uses the proximity matrix derived from financial ratio-values, i.e. it does not take into account the fact of solvency when determining the coordinates. The empirical research resulted in a three-dimensional solution, but Dimension 1 in itself already showed an almost perfect clustering.

Empirical research revealed that multidimensional scaling is a very good data reduction procedure. Supplemented by logistic regression run on the coordinates multidimensional scaling – apart from its limitation to automatically apply on new observations – meets every

criterion of bankruptcy prediction. The 94% classification accuracy and 99% area under ROC curve are excellent results on the sample containing 100 observations. Neither forecast method can be proud of such result, therefore Hypothesis 6 is accepted.

However, estimation power and interpretation of the scaling model is somewhat shadowed by its obstacle of application on new observations, since multidimensional coordinates cannot be automatically calculated from the financial ratio-values of unknown companies. This problem can be resolved by including the new company into the sample and rerun the modeling. If the financial ratio-values of the new observation better resembles solvent companies already in the sample then it will receive dimensional coordinates similar to the solvent observations. However, carrying out such examination requires multivariate statistical skills which are usually not possessed by end-users.

III.2. Accomplishment of objectives set in the PhD thesis

On the basis of studying the ten most relevant organizational theoretical schools[5] related to organizational survival it can be contended that different organizational theoretical approaches substantially describe the same organizational failure process from different perspectives. Therefore it can be concluded that organization researchers and managers might get closer to reality if all the ten approaches are considered simultaneously instead of just a few of them. All approaches have equal-ranking role in explaining and examining organizational survival. Taking out either paradigmatic view might lead to partial truth, and subjective judgements would surely come to the front. The PhD thesis drew the conclusion that the presence of contradicting conclusions, competitive and partly complementary standpoints is useful and desirable for the development of this professional field. The hypothesis-examination arrived at similar conclusions with respect to methods.

In accordance with the set objectives the PhD thesis has managed to derive invaluable foundations from relevant organizational theoretical and corporate financial approaches relevant for corporate survival and solvency prediction, together with contemporary forecast methodology and practical needs. In light of the impossibility to make universal prediction the key to solve the research-problem was multi-sided theory-building, concurrent observance of more approaches, and simultaneous application of more forecast methods.

[5] contingency, transaction cost, principal-agent, political, life cycle, cognitive, structural, resource-based, evolutionary and decision theoretic

On the basis of hypothesis-examination it is also clear the fundamental objective of bankruptcy modeling and the PhD thesis – finding out with the highest reliability from cross-sectional data, whether a company becomes insolvent one year after its last annual report – has been accomplished. However, no method was found which might perform unambiguously better than the others. Like there is no dominant theory, there is no dominant method either to predict corporate survival and solvency.

Results achieved in this PhD thesis provide practitioners with methodological guidelines, normative proposals and concrete modeling techniques. Company-specific probability of survival values can be estimated by all the four forecast methods. The elaboration and evaluation of bankruptcy models encompassed a wide range of forecast and reliability-examination techniques.

Considering the Hungarian tendency of insolvencies it is anticipated that in Hungary bankruptcy forecasting will be needed in the short, mid and long run as well. Hence the knowledge about factors having impact on corporate survival and solvency, tracking of them and the capability to distinguish between solvent and insolvent companies to the best extent might be the key to success and survival in business life. Therefore the results of the PhD thesis might be widely used in practice.

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V. Publication list related to the topic of PhD thesis

V.1. Publications in English

1. Kristóf, T. [2006]: Is it possible to make scientific forecasts in social sciences? *Futures*, Vol. 38, No. 5, pp. 561-574. (impact factor: 0.738)
2. Virág, M. – Kristóf, T. [2005]: Neural networks in bankruptcy prediction – a comparative study on the basis of the first Hungarian bankruptcy model, *Acta Oeconomica*, Vol. 55, No. 4, pp. 403-425. (impact factor: 0.324)

V.2. Publications in Hungarian

V.2.1. Journal articles

1. Kristóf, T. [2008]: A csődelőrejelzés és a nem fizetési valószínűség számításának módszertani kérdéseiről [On methodological problems of bankruptcy prediction and probability of default prediction], *Közgazdasági Szemle*, Vol. 55, No. 5, pp. 441-461.
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V.2.3. Studies

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V.2.4. Proceedings

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