INCORPORATING FINANCIAL RATIOS AND INTELLECTUAL CAPITAL IN BANKRUPTCY REDICTIONS

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ABSTRACT

Intellectual capital represents assets that frequently do not appear in the balance sheet. Intellectual capital has gained more and more attention since it is the core competence for many companies nowadays. The main purpose of this paper is to explore the performance of bankruptcy predictions incorporating financial ratios and intellectual capital by integrating artificial neural networks with the multivariate adaptive regression spines (MARS) approach. The obtained results are expected to greatly expand the application of neural networks and MARS in bankruptcy predictions.

Key words: bankruptcy prediction, financial ratios, intellectual capital, neural networks, multivariate adaptive regression splines

INTRODUCTION

Bankruptcy predictions have long become important research topics after Beaver (1966) and Altman (1968) used the financial ratios methodology in predicting business failures. Many different useful techniques, known as the bankruptcy prediction models, have been developed by researchers in order to solve the problems involved during the evaluation process. After we carefully review the literature of bankruptcy prediction models, several important conclusions can be observed. Firstly, after Beaver (1966) and Altman (1968) used the financial ratios methodology in conducting bankruptcy predictions, almost all the literature only considered financial ratios as independent variables (input variables for As intangible assets (intellectual capital, IC) are often the major artificial neural networks). determinants of a company's competitiveness, factors other than financial ratios may also need to be incorporated in predicting business failures. Secondly, almost all the literature adopted the same cross sectional research design during the empirical study stage. It means that they use independent variables one, two or even three years prior to the bankruptcy, a fixed point before the bankruptcy happens, in predicting the status-healthy or bankruptcy of a company. However, bankruptcy is a continuous process. Even though the appraisal of bankruptcy happens at a certain time, it is the result of some policies of that company for a number of years. Therefore, the independent variables used in bankruptcy predictions should be observed over time to provide full information about the progress of a company (Dimitras et al., 1996). Besides, as the influence of different variables in different time lags to the status of a company may not be the same, the traditional cross sectional analysis approach suffers from the fact that some important variables, in different time lags, may not be included in the final prediction models during the variables selection procedure. In order to solve the above-mentioned drawbacks, this paper tries to handle this issue in a totally different alternative. All the independent variables used in the prediction model will consist 8 consecutive quarterly data points before the bankruptcy occurred. Finally, the most commonly discussed classification techniques in building bankruptcy prediction models are linear discriminant analysis (LDA), logistic regression analysis, and artificial neural networks (ANNs). Basically, both LDA and logistic regression are designed for the case when the relationship between variables are linear and therefore are reported to be lack of enough

classification accuracy in modeling bankruptcy prediction problems. Artificial neural networks provide a new alternative to LDA and logistic regression, particularly in situations where the dependent and independent variables exhibit complex nonlinear relationships. Even though neural networks have shown to have better predictive capability than LDA and logistic regression in modeling bankruptcy prediction problems, it is, however, also being criticized for its long training process in designing the optimal network's topology, hard to identify the relative importance of potential input variables and certain interpretative difficulties, and hence limiting its applicability in handling the bankruptcy prediction problems (Laitinen and Laitinen, 2000). In addition to the above-mentioned techniques, multivariate adaptive regression splines (MARS) is another commonly discussed classification technique nowadays. MARS is widely accepted by researchers and practitioners for the following facts. Firstly, MARS is capable of modeling complex nonlinear relationship among variables without strong model assumptions. Besides, MARS can identify "important" independent variables through the built basis functions when there are many potential independent variables. Thirdly, the training time for MARS is significantly shorter than neural networks and hence can save lots of model building time. Finally, one strong advantage of MARS over other classification techniques is the resulting model can be easily interpreted. It not only points out which variables are important in classifying objects/observations, but also indicates a particular object/observation belongs to a specific class when the built rules are satisfied. The final fact has important managerial implications and can help make better/appropriate decisions.

Aiming at improving the above-mentioned drawbacks of neural networks and increasing the classification accuracy of the existing approaches, the objective of the proposed study is to explore the performance of bankruptcy predictions using both financial ratios and intellectual capital variables with a two-stage hybrid modeling procedure in integrating MARS with neural networks technique. The rationale underlying the analyses is firstly to use MARS in modeling the bankruptcy prediction problems with both financial ratios and intellectual capital variables as independent variables. Then the obtained significant independent variables are served as the input nodes of the designed neural networks model. To demonstrate the feasibility and effectiveness of the proposed approach, bankruptcy prediction tasks are performed using the public companies filing bankruptcy between 1998 and 2000 in Taiwan.

EMPIRICAL RESULTS AND DISCUSSION

In order to verify the feasibility and effectiveness of the proposed two-stage hybrid modeling procedure, the public companies filing bankruptcy between 1998 and 2000 in Taiwan are used in this study. There are totally 35 companies filing bankruptcy during the studying period, 70 companies in the same industry which have in business for at least two years, with similar total assets and number of employees are used as the matched sample. Among the 105 companies used in this study, 23 bankrupted and 46 healthy companies (two thirds of the total sample size) are randomly selected as the training sample while the remaining 12 bankrupted and 24 healthy companies (one third of the sample size) are retained as the testing sample. As to the independent variables to be included in the prediction model, several factors have contributed to the difficulty in collecting the required variables. After deleting variables with too many missing values, the experiences from past decisions, and the domain knowledge of financial experts in that industry, 10 financial ratios and 9 IC variables can be obtained (as we have discussed before, each variable will consist 8 quarterly data points before the bankruptcy occurred).

The main purpose of this article is to test whether intellectual capital will be helpful in predicting business failures, and hence our approach is based on the rationale that with financial ratios already been included as independent variables, to test whether the inclusion of IC variables will provide extra

information in improving the classification accuracy of the prediction model. As we also like to see whether MARS can be a good supporting tool in designing the topology of the neural networks prediction model, therefore the empirical study will firstly build two MARS prediction models. The first built model solely using financial ratios while the second one considers both financial ratios and intellectual capital variables as independent variables. In doing so, we can observe the prediction results of two MARS models as well as the obtained significant independent variables. The second stage of the study will use the obtained significant independent variables from MARS prediction models as inputs of two neural networks models. The obtained results can then be compared to see whether the one including IC variables will give better classification accuracy or not. Finally, in order to evaluate the effectiveness of the proposed two-stage prediction model, the results will also be compared with those using discriminant analysis, logistic regression, and solely using neural networks.

The prediction results of the testing sample (the confusion matrix) with only financial ratios as input variables and with both financial ratios and IC variables as inputs using the obtained MARS, two-stage hybrid models, discriminant analysis, logistic regression, and neural networks can be summarized in tables 1 and 2, respectively. After comparing the results in table 4 and table 5, several conclusions can be observed. Firstly, the models including both financial ratios and IC variables provide better classification results than the corresponding models only using financial ratios. The above phenomenon implies that IC variables do provide valuable information in predicting bankruptcies. Secondly, like similar results reported in the literature, BPN still provides better classification results than those using linear discriminant analysis and logistic regression approaches, no matter when only considering financial ratios or the model including both financial ratios and intellectual capital variables. Finally, both the two-stage hybrid model and the model solely using BPN obtain identical results for cases no matter including IC variables or not. However, we believe the two-stage hybrid model should be a better alternative since it exhibits the capability in identifying important independent variables which may provide valuable information for further diagnostic purposes.

CONCLUSIONS AND AREAS OF FUTURE RESEARCH

In order to improve the drawbacks of only using financial ratios as independent variables, using the cross sectional research design, the shortcomings of neural networks and increasing the classification accuracy of the existing approaches, the objective of the proposed study is to explore the performance of bankruptcy predictions using both financial ratios and intellectual capital variables with a two-stage hybrid modeling procedure in integrating multivariate adaptive regression splines with neural networks technique. The rationale underlying the analyses is firstly to use MARS in modeling the bankruptcy prediction problems with both financial ratios and intellectual capital variables as independent variables. Then the obtained significant independent variables are served as the input nodes of the designed neural networks model. For verifying the feasibility on this proposed two-stage hybrid approach, bankruptcy prediction tasks are performed using the public companies filing bankruptcy between 1998 and 2000 in The research findings can be summarized as follows. Firstly, IC variables do provide Taiwan. valuable information other than financial ratios in bankruptcy predictions. Secondly, as the time lags of almost all the important variables are not same and the same variable in different time lags are all significant, the traditional cross sectional research design may need to be modified. Thirdly, the two-stage hybrid model and the model solely using BPN have higher average correct classification rate in comparison with those using linear discriminant analysis, logistic regression, and MARS approaches. However, the two-stage hybrid model should be an efficient alternative since it can identify important independent variables in predicting bankruptcies and contribute to better managerial implications.