



Financial early warning system model and data mining application for risk detection

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ABSTRACT

One of the biggest problems of SMEs is their tendencies to financial distress because of insufficient finance background. In this study, an early warning system (EWS) model based on data mining for financial risk detection is presented. CHAID algorithm has been used for development of the EWS. Developed EWS can be served like a tailor made financial advisor in decision making process of the firms with its automated nature to the ones who have inadequate financial background. Besides, an application of the model implemented which covered 7853 SMEs based on Turkish Central Bank (TCB) 2007 data. By using EWS model, 31 risk profiles, 15 risk indicators, 2 early warning signals, and 4 financial road maps has been determined for financial risk mitigation.

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1. Introduction

All enterprises especially SMEs need to think about global dimensions of their business earlier than ever. Especially in developing countries, in addition to the administrative insufficiencies, competition, economical conditions, the permanent threat towards SMEs from globalization, and financial crisis have caused distress and affect firms' performance.

SMEs are defined as enterprises in the non-financial business economy (NACE, *Nomenclature statistique des activités économiques dans la Communauté européenne* (Statistical classification of economic activities in the European Community)) that employ less than 250 persons. The complements of SMEs – enterprises that employ 250 or more persons – are large scale enterprises (LSEs). Within the SME sector, the following size-classes are distinguished:

- Micro enterprises, employing less than 10 persons.
- Small enterprises, employing at least 10 but less than 50 persons.
- Medium-sized enterprises that employ between 50 and 250 persons.

This definition is used for statistical reasons. In the European definition of SMEs two additional criteria are added: annual turnover should be less than 50 million €, and balance sheet total should be less than 43 million € (Commission Recommendation, 2003/361/EC).

SMEs play a significant role in all economies and are the key generators of employment and income, and drivers of innovation

and growth. Access to financing is the most significant challenges for the creation, survival and growth of SMEs, especially innovative ones. The problem is strongly exacerbated by the financial and economic crisis as SMEs have suffered a double shock: a drastic drop in demand for goods and services and a tightening in credit terms, which are severely affecting their cash flows (OECD, 2009). As a result, all these factors throw SMEs in financial distress.

The failure of a business is an event which can produce substantial losses to all parties like creditors, investors, auditors, financial institutions, stockholders, employees, and customers, and it undoubtedly reflects the economics of the countries concerned. When a business with financial problems is not able to pay its financial obligations, the business may be driven into the situation of becoming a non-performing loan business and, finally, if the problems cannot be solved, the business may become bankrupt and forced to close down. Those business failures inevitably influence all businesses as a whole. Direct and indirect bankruptcy costs are incurred which include the expenses of either liquidating or an attempting to reorganize businesses, accounting fees, legal fees and other professional service costs and the disaster broadens to other businesses and the economics of the countries involved (Ross, Westerfield, & Jordan, 2008; Terdpaopong, 2008; Warner, 1977).

The awareness of factors that contribute to making a business successful is important; it is also applicable for all the related parties to have an understanding of financial performance and bankruptcy. It is also important for a financial manager of successful firms to know their firm's possible actions that should be taken when their customers, or suppliers, go into bankruptcy. Similarly, firms should be aware of their own status, of when and where they should take necessary actions in response to their financial

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problems, as soon as possible rather than when the problems are beyond their control and reach a crisis.

Therefore, to bring out the financial distress risk factors into open as early warning signals have a vital importance for SMEs as all enterprises. There is no specific method for total prevention for a financial crisis of enterprises. The important point is to set the factors that cause the condition with calmness, to take corrective precautions for a long term, to make a flexible emergency plan towards the potential future crisis.

The aim of this paper is to present an EWS model based on data mining. EWS model was developed for SMEs to detect risk profiles, risk indicators and early warning signs. Chi-Square Automatic Interaction Detector (CHAID) Decision Tree Algorithm was in the study as a data mining method. Remaining of this paper is organized as follows: Section 2 presents definition of EWS. Section 3 contains data mining model for risk detection and early warning system. Implementation of data mining for risk detection and early warning signals is presented in Section 4. Concluding remarks and strategies were suggested in Section 5.

2. Financial early warning systems

An early warning system (EWS) is a system which is using for predicting the success level, probable anomalies and is reducing crisis risk of cases, affairs transactions, systems, phenomena, firms and people. Furthermore, their current situations and probable risks can be identified quantitatively (Ozgulbas & Koyuncugil, 2010). Financial EWS is a monitoring and reporting system that alerts for the probability of problems, risks and opportunities before they affect the financial statements of firms. EWSs are used for detecting financial performance, financial risk and potential bankruptcies. EWSs give a chance to management to take advantage of opportunities to avoid or mitigate potential problems. Nearly, all of the financial EWSs are based on financial statements. Balance sheets and income tables are the data sources that reflect the financial truth for early warning systems. In essence, the early warning system is a financial analysis technique, and it identifies the achievement analysis of enterprise due to its industry with the help of financial ratios.

The efforts towards the separation of distressed enterprises started with the z-score that are based on the usage of ratios by Beaver (1966) for single and multiple discriminant analysis of Altman in 1968. The examples of other important studies that used multi variable statistical models, are given by Deakin (1972), Altman, Haldeman, and Narayanan (1977), Taffler and Tisshaw (1977) with the usage of multiple discriminant model; are also given by Zmijewski (1984), Zavgren (1985), Jones (1987), Pantalone and Platt (1987), with the usage of logit and probit models; are at the same time given by Meyer and Pifer (1970) with the usage of multiple regression model. Beside the business distressed studies, researchers focused on monitoring ongoing situations to detect sudden changes or unexpected risk factors of enterprises. These attempts made important the early warning systems for research. Some of previous studies conducted in SMEs, banks, insurers, i.e., and their research methods are presented below.

Brockett and Cooper (1990) developed an EWS by using neural network method. The model was developed with 24 variables firstly, and then the numbers of variables were decreased to 8. These variables were equities, capitalization ratio, return on assets, turnover of assets, account receivables to equities, changing of loses, and debt to current assets.

Lee and Urrutia (1996) compared the models of logit, hazard, neural networks and discriminant for developing an early warning system. They found different indicators or signs for each model. Also they determined that forecast power of all models were same.

Barniv and Hathorn (1997) developed an early warning model based on logistic regression by evaluating the studies of Trieschmann and Pinches (1973), Ambrose and Seward (1998), and Barniv and McDonald (1992) in insurance firms.

Laitinen and Chong (1999) presented a model for predicting crises in small businesses using early-warning signals. Study summarized the results of two separate studies carried out in Finland (with 72% response) and the UK (26%) on the decision process of corporate analysts (Finland) and bank managers (UK) in predicting the failure of small and medium-sized enterprises (SMEs). Both studies consisted of seven main headings and over 40 sub-headings of possible factors leading to failure. Weighted averages were used for both studies to show the importance of these factors. There were significant similarities in the results of the two studies. Management incompetence was regarded as the most important factor, followed by deficiencies in the accounting system and attitude towards customers. However, low accounting staff morale was considered a very important factor in Finland but not in the UK.

Yang, Ling, Hai, and Jing (2001) used artificial neural networks (ANN) for detecting financial risk of banks as an early warning, and tested the method.

Salas and Saurina (2002) compared the determinants of problem loans of Spanish commercial and savings banks in the period 1985–1997, taking into account both macroeconomic and individual bank level variables. The GDP growth rate, firms, and family indebtedness, rapid past credit or branch expansion, inefficiency, portfolio composition, size, net interest margin, capital ratio, and market power are variables that explain credit risk. The findings raised important bank supervisory policy issues: the use of bank level variables as early warning indicators, the advantages of bank mergers from different regions, and the role of banking competition and ownership in determining credit risk.

Edison (2003) developed an operational early warning system (EWS) that can detect financial crises. The system monitored several indicators that tend to exhibit an unusual behavior in the periods preceding a crisis. When an indicator exceeded (or falls below) a threshold, then it was said to issue a “signal” that a currency crisis may occur within a given period. The model was tested in 1997/1998 crises, but several weaknesses to the approach were identified. The paper also evaluated how this system can be applied to an individual country. The results suggested that an early warning system should be thought of as a useful diagnostic tool.

El-Shazly (2003) investigated the predictive power of an empirical model for an early warning system of currency crises. EWS employed qualitative response models within a signals framework that monitors the behavior of key economic variables and issues a warning when their values exceed certain critical levels. Author conducted a case study in Egypt. Results showed that this model, and in particular the extreme value model, captured to a good extent the turbulence in the foreign exchange market and the onset of crises.

Jacobs and Kuper (2004) presented an EWS for six countries in Asia. Financial crises were distinguished in three types; currency crises, banking crises, and debt crises. The significance of the indicator groups was tested in a multivariate logit model on a panel of six Asian countries for the period 1970–2001. Author founded that some currency crises dating schemes outperform others by using EWS.

Berg, Borensztein, and Pattillo (2004), developed early warning system models of currency crisis for Mexican and Asian crisis. Since the beginning of 1999, IMF staff has been systematically tracking, on an ongoing basis, various models developed in-house and by private institutions, as part of its broader forward-looking vulnerability assessment. This study examined in detail at the performance of these models in practice. The forecasts of the in-house model were statistically and economically significant predictors of

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