



Innovative Applications of O.R.

Prediction of financial distress: An empirical study of listed Chinese companies using data mining

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ABSTRACT

The deterioration in profitability of listed companies not only threatens the interests of the enterprise and internal staff, but also makes investors face significant financial loss. It is important to establish an effective early warning system for prediction of financial crisis for better corporate governance. This paper studies the phenomenon of financial distress for 107 Chinese companies that received the label 'special treatment' from 2001 to 2008 by the Shanghai Stock Exchange and the Shenzhen Stock Exchange. We use data mining techniques to build financial distress warning models based on 31 financial indicators and three different time windows by comparing these 107 firms to a control group of firms. We observe that the performance of neural networks is more accurate than other classifiers, such as decision trees and support vector machines, as well as an ensemble of multiple classifiers combined using majority voting. An important contribution of the paper is to discover that financial indicators, such as net profit margin of total assets, return on total assets, earnings per share, and cash flow per share, play an important role in prediction of deterioration in profitability. This paper provides a suitable method for prediction of financial distress for listed companies in China.

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1. Introduction

Prediction of financial distress has been a topic of interest over the decades because of its great importance to listed companies, interested stakeholders and even the economy of a country (Wanke, Barros, & Faria, 2014). If the prediction of financial distress is reliable, managers of firms can initiate remedial measures to avoid deterioration before the crisis, and investors can grasp the profitability situation of the listed companies and adjust their investment strategies to reduce anticipated investment related losses. However, the rapid development of the capital market and the integration of the global economy have increased the number of companies that suffer from financial distress over the years. In October 2007, the stock market in China crashed and wiped out more than two-thirds of its market value. According to the NASDAQ Company List, among 578 listed companies in 2008, the number of loss-making enterprises reached 278. Besides, Begbies Traynor's latest Red Flag Alert shows a 24% increase in the UK companies facing 'critical' levels of financial distress in the last

quarter of 2011 compared to the last quarter of 2010. It is not a surprise that numerous companies have faced consecutive years of loss, business damage, interests and assets shrinking, suspension of listing every year from 2000 to 2011. With the emergence of China as one of the leading markets for international investors, financial distress of Chinese companies has attracted increasing attention. Therefore, discovery of a suitable model for predicting the financial distress of listed Chinese companies is likely to be of great significance to global investors.

Financial distress of a company usually refers to the situation that operating cash flow of a company cannot supersede the negative net assets of the firm. Different countries have different accounting procedures and rules, and the definition of financial distress put forward by different scholars is not always the same. It is generally agreed on that financial failure leads to substantive weakening of profitability of the company over time. Bankruptcy is the most widely used outcome of financial distress of a company. Ball and Foster (1982) pointed out that taking bankruptcy as a criterion ignored other options that a firm had, such as reducing its scale of operations, liquidating all of its assets and seeking a merger, if it faced "long-term cash flow problems". China Securities Regulatory Commission carries out a 'Special Treatment' (ST) warning mechanism to indicate abnormalities in a listed companies' financial status. The aim of ST is to warn the managers

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and investors and also to use external mechanism to force the firm to enhance its operating performance.

Empirical studies using bankruptcy as the outcome of financial distress has occupied a major part of literature related to this area. However, scholars in China have found it difficult to get enough bankruptcy related data due to the late implementation and incompleteness of the Chinese bankruptcy law. It is believed that ST regulation in the China's stock market provided a unique opportunity to provide early warning of impending financial crisis to be faced by company. According to the Chinese Stock Listing Exchange Rule, there are three main reasons for designation of a company as ST: (1) a listed company has negative net profits for 2 years consecutively; (2) the shareholders' equity of the company is lower than the registered capital; and (3) a firm's operations have stopped and there is no hope of restoring operations in the next 3 months due to natural disasters, serious accidents, or lawsuits and arbitration. There are three types of ST labels to represent different levels of financial distress, that is, ST, *ST, and S*ST. ST means special treatment due to loss for two consecutive years. *ST represents delisting warning due to loss for three consecutive years. S*ST indicates *ST stocks which are yet to restructure share rights. According to the Chinese regulation, if a ST firm cannot improve its performance within the next 3 years, it is labeled as PT (Particular Transfer) and may be delisted from the stock market. Once the companies are delisted, the stockholders suffer severe losses. So identifying firms that are likely to be labeled ST in advance is an important activity for investors.

The connection between financial distress and bad profitability has been studied in extant research on Chinese firms. Ding, Song, and Zen (2008) discovered that Chinese ST companies that showed the sign of deterioration in the year before receiving such a label had a high probability of falling into financial distress in the following year. Prediction of ST could provide an earlier warning about bankruptcy by reminding the firms to pay attention to their profitability. So we chose to use ST companies as examples of financially distressed firms who could move on to become bankrupt in future. The objective of this paper is to apply data mining models to forecast which companies are likely to receive the ST label. Such models can be useful in helping investors manage risks and make decisions in a more informed way. We aim to answer three questions in this paper: which data mining models can predict financial distress of Chinese firms most accurately; which financial indicators are most effective in this prediction; and how early can we foresee the sign of deterioration of profitability of the company? The results of this research can provide an early warning to listed companies so that they can take corrective actions in order to avoid financial distress and delisting.

The remainder of this paper is organized as follow. In Section 2 related studies on prediction of financial distress using data mining techniques are reviewed. The research framework and empirical data collected for ST prediction are described in Section 3. Results of the numerical experiments are described in Section 4. Finally, discussion of the empirical results and their implications are presented in Sections 5 and 6.

2. Literature review

Financial distress is a broad concept that contains several situations in which firms face financial difficulty. The most common terms used to describe these situations are 'bankruptcy', 'failure', 'insolvency', and 'default'. Altman (1993) put forward a complete description and definition of financial distress and pointed out that bankruptcy was closest to the legal definition of financial distress. Zmijewski (1984) defined financial distress as the act of filing a petition for bankruptcy. However, many financially distressed

firms never filed for bankruptcy, due to acquisition or privatization, whereas healthy firms often filed for bankruptcy to avoid taxes and expensive lawsuits (Theodossiou, Kahya, Saidi, & Philippatos, 1996). On the other hand, 'failure' was a situation where a firm could not pay lenders, preferred stock shareholders, suppliers, etc., or a bill was overdrawn, or the firm was bankrupt. All these situations resulted in a discontinuity of the firm's operations (Dimitras, Zanakis, & Zopounidis, 1996). However, Altman (1993) defined 'failure' as the situation where "the realized rate of return on invested capital, with allowances for risk consideration, is significantly and continually lower than prevailing rates of similar investments", which did not indicate the discontinuity of a firm. For example, when Washington Mutual failed in 2008, the FDIC was able to broker a deal in which JP Morgan Chase bought the assets of Washington Mutual for US\$ 1.9 billion (Palmeri, 2008). 'failure Insolvency' represented negative performance indicating problems related to liquidity and was synonymous with negative net worth (Zopounidis & Dimitras, 1998). Entities most commonly became insolvent by taking on too much debt. One example of insolvency was Almeico Ltd. that failed to pay Fimbank a debt that was due in 2013 (Orr, 2003). 'Default' referred to a situation where a firm violated the condition of an agreement with a creditor that resulted in legal action. For example, the Ministry of Corporate Affairs in India published a list of companies that defaulted in the past (Ministry of Corporate Affairs, 2014). Ross, Westerfield, and Jaffe (2002) stated that "financial distress is a situation where a firm's operating cash flows were not sufficient to satisfy current obligation (such as trade credit or interest expenses) and the firm is forced to take corrective action". To summarize, 'default' essentially meant a debtor had not paid a debt which he or she was required to have paid. 'Insolvency' was a legal term meaning that a debtor was unable to pay his or her debts. 'Bankruptcy' was a legal finding that imposed court supervision over the financial affairs of those firms that were insolvent or were in default.

ST label has been used as the symbol of financial distress in several studies related to Chinese firms (Altman, Heine, Zhang, & Yen, 2007; Bailey, Huang, & Yang, 2011; Sun & Li, 2008a). ST firms go through one or more of four stages that include omission or reduction of the annual dividend payment due to cash shortage, default on loan payments leading to a lawsuit, reorganization or take over and deletion from a stock exchange, and transfer to Asset Management Companies for disposal (Altman et al., 2007). There are two main reasons for taking ST companies as examples as financially distressed firms. Firstly, the financial deterioration of a company is generally considered to be a gradual process. ST as an *ex ante* event of bankruptcy is a good representation of financial distress. In fact, the symptoms of Chinese ST companies are close to the definition of financial distress given by Newton (1975), Gestel et al. (2006), and Lau (1987). Secondly, researchers in China find it difficult to obtain data related to bankrupt firms due to the process of bankruptcy in China. Dairui and Jia (2009) define financially distressed companies as ST and PT companies because they lacked a database of bankruptcy related information on Chinese listed companies.

Statistical techniques have been commonly used for prediction of business failure. Discriminant analysis has been the most frequently used method before 1980s (Altman, 1968; Beaver, 1966). This method has been criticized for its unrealistic assumptions, such as linear separability, multivariate normality, and independent predictor variables, which did not hold in case of real applications. At the same time this method did not provide any estimate of the associated risk of failure. To overcome such limitations, researchers have proposed linear conditional probability models (LPM) and logit or probit regression analysis. Meyer and Pifer (1970) employed LPM for prediction of bankruptcy. Logit analysis was proposed by Martin (1977) for the prediction of bank failures,

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