An analysis of Short-term corporate financial distress early-warning models

by

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Abstract

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This paper introduced theoretically financial distress and early warning mechanisms, including the plight of the meaning of the formation process, diagnosis and analysis and the financial distress prediction models. It used three statistical methods of short-term corporate financial distress prediction model systems, including univariate model, Logistic regression model and Fisher's discriminant model and makes comparison and analysis of the results. According to the results, the 3 types have performed well, which the accuracy rates were basically more than 80% (Univariate model only referred to the return on total assets model).

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Chapter 1: Introduction

1.1 Overview

Financial distress is a crucial issue when it comes to the financial health of a company. It shows the inability of the company to maintain the viability of its business. If financial distress cannot be relieved, it can lead to bankruptcy. Currently, bankruptcy is not only a common phenomenon in a market economy, but also a global topic. The number of corporate bankruptcies in a country is often used as a measure of the country's economic development and economic stability indicators. In recent years, there have been global corporate bankruptcies and even some large companies cannot be spared.

In fact, corporate financial distress is a gradual process. It usually starts with financial health gradually developing into financial distress. In practice, most of the company's financial difficulties are made from the gradual deterioration, resulting in financial distress or bankruptcy. Thus, corporate financial distress has an omen and it is predictable. Correctly forecasting corporate financial distress has important practical significance for protecting the interests of investors and creditors.

1.2 Background

According to Pate (2002), 257 public companies, with total assets of $256 billion, filed for bankruptcy in the USA in 2001. That this is the highest number of bankruptcy filings since 1980 is alarming. Furthermore, it is uncomfortably large

compared to the number of filings during the last recession (125 filings in 1991 and 91 filings in 1992). Pate further estimates the likely number of public company bankruptcy filings in 2002 will be about 200, 22 percent below the 2001 level, but still well above the 1986-2000 average of 113.

Another clearly visible trend is the increase in the number of large companies going bankrupt. Altman (2000) points out that bankruptcy in firms with large asset size, while quite rare prior to 1966, became more common in the 1970s. According to Altman, since the enactment of the current U.S. Bankruptcy Code in 1978, there were at least 100 Chapter 11 bankruptcies of firms whose asset size exceeded $1 billion.

In this environment, business leaders and finance professionals would be well advised to refresh their knowledge of bankruptcy prediction models. Fortunately, those models have been around for a while.

To be able to predict corporate financial distress through accounting data, appropriate financial indicators and establishment of mathematical models, has become an important research topic. From Ramse and Foster (1931), Fitzpatrick (1932), Winakor and Smith (1935) to Merwin (1942), they have studied this subject for many years. Their research has indicated that the financial data and accounting ratios can be used to predict corporate financial distress or bankruptcy.

1.3 Purpose of the study

This paper is dedicated to establish a model for a short-term warning system

within a year based on the data of corporate financial statements. This should assist investors and stakeholders to establish a short-term financial distress prediction model system through the quarterly financial data of listed companies.

1.4 Methodology

The current mainstream financial distress prediction methods are multivariate linear discriminant (based on 1968 Altman's study) and multivariate logistic regression (based on 1980 Ohlson's study). Among them, the multivariate linear discriminant method has the advantages such as (i) It can reflect the financial situation of a number of indicators, which is widely used in financial risk prediction; (ii) It can contain independent variable; (iii) Once the model is established, it is relatively easy to use. However, the method also has some obvious limitations. Although many studies in the use of multivariate logistic regression methods have ignored the problem of multicollinearity between independent variables, this deficiency does not mean Logistic regression analysis itself flawed. This method is currently still in the mainstream of the discriminant analysis and it is also one of the basic methods used in this paper.

The paper is divided into six chapters: This chapter is an introduction, includes the background, objectives, basic framework and research methods. Chapter 2 provides theoretical analysis of financial distress and early warning mechanisms, including the meaning of the formation process, diagnosis and analysis. In Chapter 3, it focuses on the financial distress prediction models, including single-variable model,

multivariate discriminant model and multiple regression models. This chapter is the focus of this paper. Chapter 4 describes the empirical research to build the short-term early warning model preparatory work, including sample collection and data preprocessing and Chapter 5 is the core of this study. It contains three statistical methods of short-term corporate financial distress prediction model systems, including single-variable model, Logistic regression model, and Fisher's discriminant model. It makes comparisons and provides an analysis of the results. The final chapter draws conclusions of this study, and points out the inadequacies of the study.

Chapter 2: Financial distress and financial distress diagnosis

2.1 Financial distress

2.1.1 The definition of financial distress

Most researchers believe that financial distress is a condition where a company cannot meet or has difficulty paying off its financial obligations to its creditors. The chance of financial distress increases when a firm has high fixed costs, illiquid assets, or revenues that are sensitive to economic downturns. Gibson and Frishkoff (1986) think that there are a wide variety of standards in financial failure, and the confirmation of financial failure should be according to established standards. There are two main ideas to define financial distress.

First, in order to make the sample enterprises have a clearer label, many scholars define financial distress as declared bankrupt enterprises. As Altman (1968) said that "Business failure includes legal bankruptcy, receivership and reorganization." It is essentially treated the financial distress as business failures, ie, statutory bankruptcy. According to this idea, Deakin (1972) considers that a financial distressed company means bankruptcy, insolvency or liquidation of the enterprise for the benefit of creditors. Similarly, Casey and Bartczark (1984), Gentry (1985), Aziz (1988) and Gilbert (1990) also equate the financial distress to the legal bankruptcy.

Second, financial distress has different levels. The low level may be just temporary cash flow difficulties, and the high level is business failure or bankruptcy.

The performance of financial distress also appears in a variety of forms. The

enterprise development process may undergo various types of financial distress but not necessarily end with bankruptcy. In other words, financial distress is a necessary condition for bankruptcy, but not a sufficient condition. For the comprehensive study of the characteristics of distressed enterprises, many scholars have expanded the range of samples of financial distressed enterprises. Such as Beaver (1966) defined corporate distress as "bank overdrafts", "unpaid preferred stock dividends", "bond defaults" and "bankruptcy." Following this idea, Carmichael (1972) considered that corporate financial distress is due to debt delinquency and lack of liquidity, equity, and funds and also other factors, which led to the block to fulfill debt obligations. Scott (1981), Bahnson and Bartley (1992) considered it is more appropriate to define financial distress as lacking of credit and unable to repay principal and interest.

Ross (2000) further summarizes the corporate financial distress from four aspects: (1) technical failures, that is, companies cannot perform the debt contract to fulfill interest and principal in time; (2) accounting failures, the book net assets of the enterprise are a negative number, namely insolvency; (3) businesses fail, that enterprise is still unable to pay debts after liquidation; (4) legal bankruptcy, namely the enterprise or the creditor apply to the court for bankruptcy because the debtor has been unable to service the maturing debt.

A serious financial crisis such as bankruptcy may come from a minor technical failure of fund management evolved, but it does not necessarily develop into bankruptcy. This failure is often encountered in the development of enterprises, usually termed liquidity problems. Companies often use existing financial resources

or management resources to resolve the technical failure of fund management, such as the application to the bank for extension of repayment period. If an enterprise has a certain degree of financial flexibility, financial technical failure generally can be resolved.

If the financial distress is defined between slight technical failure of fund management and serious bankruptcy, it will blur the severity of financial distress and it is not easy to distinguish. Thus, from the point of view of management, financial distress should be separated from the financial crisis. The process from slight technical failure to massive restructuring is the phase of financial distress. The phase of financial crisis is the process from massive restructuring to corporate bankruptcy. This paper defines financial distress for enterprises as operating losses continue occur, so the companies have to receive outside rescue or major restructuring. If the enterprise is in such a state, it can be considered in financial distress.

2.1.2 The developing process of the financial distress

From the excellent performance to financial distress, companies will always experience a gradual and cumulative process. Once companies are in financial distress, if there is no effective measure to change or improve the situation faced by business, it will eventually move towards the ultimate stage of financial distress - bankruptcy.

Corporate financial distress is usually due to poor business management, poor adaptive capacity to changes in the external environment, leading to be caught with

serious trouble that threatens the company’s survival and development. It can be reflected in the financial statements as a continued loss without the reversing trend. The occurrence and development of financial distress is progressive. That makes it possible to predict financial distress, which is also an important part of the implicit assumptions to build financial distress prediction model.

Overall, the financial distress will generally go through the following three stages: incubation period, diffusion period and outbreak period. In the incubation period, it usually presents the competitiveness of company's products drops, market declines, corporate expenses increase, management efficiency reduces. In the diffusion period, it usually presents insufficient cash flow as a result of operating losses, inventories and receivables increases. In the outbreak period, it shows continued problems of capital flows and in financial technical failures. After that, if the company does not take reorganize or other effective measures, it will enter the stage of a financial crisis.

2.1.3 The accounting performance of financial distress

After companies have fallen into financial distress, the financial condition and other aspects are reflected in revenue declines, increased expenses, losses, deteriorating financial position, cash shortages. The relationship of them is complicated. In order to fully understand the financial distress of the evolutionary process and the reasons, one needs to study the accounting performance of corporate financial distress.

First, if the cost level goes up, this will lead to reduced profits, fund shortfalls, leading to cash flow problems. Companies will have to increase debt to make up the funding gap. Meanwhile, the debt interest payments will further lead to increased levels of corporate financial costs, creating a vicious cycle. Unable to repay the huge debt leads to corporate financial distress.

Second, if sales revenue decreases, it will bring about a decline in corporate sustainable profitability, cash inflows will decrease, cash flow problems will arise. It could also coincide with the increase the level of costs so inducing the occurrence of financial distress together.

Third, an excessive expansion strategy. It will lead to liquidity shortages. Companies have to increase debt to make up the funding gap. Meanwhile, the debt interest costs will further increase the levels of the costs. If the investment project cannot be put into operation on schedule, or investment income has a big gap compared with the expected level, companies will not be able to repay the maturing debt. There can be an immediate financial distress.

2.2 Financial distress diagnosis

2.2.1 The definition of financial distress diagnosis

Financial distress diagnosis is based on the enterprise informatization. It is a technique of monitoring, identifying and alerting potential financial risk in the operation and management activities. It is based on the use of accounting, finance, business management, marketing and other theories, using ratio analysis,

mathematical models and other methods through the analysis of financial statements, business plans and other relevant financial information to find business risks, and alert stakeholders to take appropriate countermeasures management methods.

In the late 1960s, with the development of data and technical tools, the financial distress prediction model based on financial ratios developed rapidly, and it is widely used in practice. The researchers constructed the theoretical model of enterprise failure for warning, such as Single-period models, Gambler's Ruin Models, models with perfect access to external capital and enterprise bankruptcy model of imperfect capital market. However, in general, the theoretical model of business failure is too abstract and too simple, as a complex system from corporate reality gap is too far. As Dimitras (1996) said, although researchers have made a huge effort, a unified theory of enterprise failure has not yet developed.

Relying on intuition and experience, people found that before companies dropped in financial distress, certain financial ratios or management behavior would show the abnormal occurrence. Thus, people can determine the likelihood of financial distress through some financial indicators. Theorists and practitioners are struggling to find a signal which reflects the deterioration in corporate finances, that is, an evaluation index system in order to seek a better financial early warning system and avoid business risk.

Accounting provides decision-useful information for stakeholders. Financial reports are direct products of accounting. These financial statements are in a common business language, comprehensively reflect the financial position, results of

operations and cash flow information. They also provide the raw data for the analysis of business activities and risk assessment. If there were defects and errors in enterprise resource allocation of management strategy and execution, some financial indicators began to deteriorate in the accounting system, such as the excessive expansion showed the cash shortage, the debt ratio increased, the industry downturn. Financial conditions deteriorate further cause financial distress. Therefore, inefficiency, poor management activities and related indicators in accounting system can be used as a sign of financial distress.

2.2.2 Early-warning index

There are many indicators that can be used as an early warning of a crisis, but highly efficient early warning indicators, generally have a clear meaning, scientific theory, and a high rate of correct determination.

The early warning indicators can be divided into two types of quantitative indicators and qualitative indicators. The quantitative index usually refers the unemployment rate, inflation rate, the main business income and profits and so on. In the analysis, first, set a limit for the variable, when the limit is exceeded then it issues a warning. The Altman (1968) study suggests that, if Z values are below 1.81, companies will go bankrupt.

In the quantitative indicators method, there are univariate analysis and multivariate analysis. Sometimes, univariate analysis is used to determine if the crisis will lead to contradictory results so researchers make a combination of multivariate,

such as the Z value contains five financial ratios derived by linear combination. The methods used in different industries to make crisis warning are different, such as lessons learned, statistical measurement model, computational models, and experimental determination and so on.

Chapter 3: Financial distress early-warning models

3.1 Univariate Model

A univariate model is a method to predict financial distress with a single financial ratio. Fitzpatreck (1932) found that financial distressed companies were significantly different with the normal companies. He believed that the financial ratios could reflect the financial position and predict the future of companies. On this basis, Beaver (1966) established the single-variable financial distress early-warning model and found that the debt coverage ratio was better for company's forecast.

The Univariate analysis model has evolved from the single financial ratio analysis method which is one of the traditional financial analysis methods. Traditional financial ratio analysis mainly depends on the lessons learned and induction. They have great differences in the selection of financial ratios and determining the split point.

3.1.1 Determine the financial ratio and split point

(1) Best financial ratio

The best financial ratio should have the lowest misjudgment rate in the univariate model analysis, and good adaptability. So far, in finding the best financial ratios, generally, researchers have used a combination of empirical judgments and trial-and-error methods to compare the two types of companies to choose a significant difference among the means. Then it combined with the existing research

literature and experience of the researchers to make the experiments to find out the best ratio. In general, it is usually selected from measures of profitability, liquidity and solvency.

(2) Best split point

The best split point should also have the lowest misjudgment rate. Currently, there are two main methods to determine the split point: One is the Interval estimation of mean method, and another is the sorting method. The former requires certain assumptions conditions, calculation is more complex, the latter calculation is relatively simple, but the scope is limited to descriptive statistics and lack of theoretical foundation. In the sorting method, first step is to sort (ascending or descending) the single corporate financial ratios from the samples, and then calculate the judgment rates (usually determine the highest possible financial ratio based on the experience, then calculate). And finally identify the highest judgment rate which is the split point. Since sorting is simpler, and it does not require the assumption, mostly researches currently use this method. This paper also uses this approach and the specific method steps will be described in building the model.

3.1.2 General Procedure for univariate analysis

(1) Collect samples, including sample of companies in financial distress and normal companies.

(2) Calculate the financial ratios of distressed companies and normal companies.

(3) Use calculated financial ratios to test the difference between two means,

then select the financial ratio with significantly different as variable in univariate analysis.

(4) Select the method of finding the best split point, and use this method to find the split point with smallest misjudgment rate.

(5) Calculate the rate of two types of error and total discriminant accuracy.

(6) Apply the selected financial ratio and split point to test the companies out of the samples.

3.1.3 The application of univariate analysis

Using financial ratios to predict the financial crisis originated in the 1930s. Fitzpatrick (1932) used a sample of 19 companies classified as two groups - bankruptcy and non-bankruptcy. He found that "net / Equity "and" shareholders' equity / debt" have the highest discriminant ability. Beaver (1966) published a seminal article in "Accounting Research", and proposed the use of financial ratios to predict the company's failure. He took 79 pairs of bankrupt companies and non-bankrupt companies within same industry and similar size as samples, then used Mann-Whitney-Wilcoxen to find out the best financial ratios and split point in 30 original financial ratios. The results showed that the most predictive ability for a failed enterprise is the "working capital flow / debt" indicator. The error rates in 5 years before bankruptcy were 13%, 21%, 23%, 24%, 22%.

3.1.4 The problems in the application of univariate analysis

In the practice of univariate analysis, the calculation is simple, easy to understand and apply, but there are big drawbacks:

(1) Lack of consistency. Different financial ratios derived univariate models may determine or predict conflicting conclusions. Analysts have to rely on other methods.

(2) Poor adaptability. In actual financial analysis, to solve different problems may require different ratios as the most effective indicators to create a single-variable model, the range of single financial ratio model is severely limited, and the importance of different ratio indicators can not be determined.

(3) One-sidedness. Single financial ratio cannot evaluate overall financial position of the enterprise. It also cannot interpret the interaction between financial ratios. Therefore, combined with financial ratios, different indicators ought to be put into a meaningful model to improve its explanatory ability.

3.2 Discriminant analysis

3.2.1 Overview of discriminant analysis

Discriminant analysis is a statistical and analysis technique. Through a certain number of cases of grouping variables and the corresponding multivariate known information, it can determine the grouping and other quantitative relationship between other multiple variables; establish discriminate function, and then make discriminant analysis of the known multivariate information (but grouping unknown).

Linear discriminate function (LDF) is the main tool in discriminant analysis, initially proposed by Fisher (1936). The Fisher linear discriminant function was applied for floral classification. He featured a variety of flowers (such as the color of corolla and calyx length and width, etc.) and used the linear combination method to convert these multivariate data into single variable data, and then to the linear combination of variables to determine the differences.

Discriminant analysis included two phases: first, analyze and interpret the difference of the index characteristic in each group, and establish the discriminant function. The case used to establish discriminant function must have mutually exclusive grouping attribute. That allows us to link the two parts to be summarized; the second phase to be processed is case of unknown grouping attributes. Make discriminant grouping for these cases based on the analysis in the first phase.

3.2.2 The application of discriminant analysis

In the 1960s, discriminant analysis has also been introduced for the management of enterprise financial distress discriminant and predictive analysis. The literature is mainly used in Linear Multiple Discriminate Analysis (LMDA). Altman (1968) first used multivariate analysis technique for enterprise financial crisis discriminant analysis. He used 33 bankrupt manufacturing enterprises as samples and 33 paired normal companies between 1946 and 1965, using linear multiple discriminant analysis (LMDA) to establish the Z-score model. It established a similar regression equation discriminant function to obtain a comprehensive index, called the

"Z" score. Putting sample data back into that discriminant function, we can get different "Z" values, according to two categories classification to identify the smallest "Z" value as split point.

$$Z=\beta_0+\beta_1x_1+\beta_2x_2+\ldots\ldots+\beta_nx_n \quad 3.1$$

Equation 3.1 is the discriminant function, where β_i is coefficients of the model, x_i is financial ratios. Criteria: $Z < Z_1$, as distressed corporate; $Z > Z_2$, as normal business enterprise; $Z_1 < Z < Z_2$ company is in a gray area, it needs experience to make a judgment.

The Z score model has been practiced in the actual work and is widely applied. It also has a profound impact for continued research.

3.3 Multiple regression models

3.3.1 Logistic regression analysis

According to experience, financial ratios fluctuating within a certain range is normal and does not cause a significant increase in the probability of distress. Only when the value of financial ratios is beyond a critical value, the probability of financial distress increased significantly. Such as the asset-liability ratio increasing from 50% to 60%, the probability of financial distress usually do not increase significantly. But when this ratio exceeds 70%, and irreversibly continues to grow, the occurrence of the probability of financial distress may be greatly improved. Thus, the relationship between financial ratios and the probabilities of financial distress

may be non-linear. The two classification analysis and qualitative analysis show the company can be either normal, or is likely to occur financial distress. To serve on multivariate nonlinear analysis of the qualitative dependent variable, a new method of analysis - logistic regression appeared.

This function is found in analysis of drosophila breeding used by American scholars in the 1920s and it has been applied in population estimates. With the development of hardware and software, Logistic regression has been widely used in economic research.

In determining the financial distress prediction, the Logistic model is as follows:

$$Y_i=\beta_0+\beta_1 x_{1i}+\beta_2 x_{2i}+\ldots\ldots+\beta_k x_{ki} \quad 3.2$$

$$P_i=\frac{1}{1+e^{-y_i}} \quad 3.3$$

Y_i represents if the enterprise i will be financially distressed, i = 0 or 1, 0 represents normal company, 1 represents a financial distressed company; x_{ki} means the enterprise i, financial ratios k; P_i represents the probability of financial distress the enterprises i may occur.

3.3.2 Parameter estimation of Logistic model

(1) "-2Log Likelihood" test

Logistic regression equation uses the maximum likelihood estimation method to solve the parameter, so the regression equation should be tested through the likelihood function. The function value should be in [0, 1] as it is a probability.

Statistical Product and Service Solutions (SPSS) software directly report the

value of "-2Log Likelihood" (-2LL), the larger the value, the smaller the likelihood value, the worse the fit of the model; conversely, the smaller the reported value, the regression equation likelihood value is closer to 1, the better the fit of the model.

(2) Regression coefficient test

The Wald statistic is used to test the significant degree of partial regression coefficients; it is the function of partial regression coefficient with degrees of freedom and obeys chi-square distribution. The formula is as follows:

$$\text{Wald}=(\frac{B}{S.E.})^2=(\frac{b_i}{sb_i})^2 \quad 3.4$$

The larger the Wald test value, the more significant the role of independent variables.

3.3.3 Application of logistic model

Martin (1977) introduced Logistic regression analysis to establish an enterprise financial distress early warning model with a sample period 1969 – 1974 and selected 25 financial ratios to predict the probability that banks may bankrupt after 2 years. The results show that the ratio of net profit to total assets, bad debt to operating income, expenses to operating income, total loans to total assets, commercial loans to total loans and total assets to risky assets have significant predictive ability.

Chapter 4: Model design and data processing

4.1 process design of short-term financial early warning model

The processes of establishing the short-term financial distress early-warning models are as follows:

1. Select companies as samples that the companies have been in financial distress and normal companies to pair with them;

2. Select financial ratios and calculate them based on the financial statements in short-term of the samples;

3. Test the difference in means (t-test and nonparametric test) to determine whether the financial ratios can be used as variables to construct models (Univariate model, Logistic model and Fisher's model).

4. Establish the model according to the results of the tests. If the result is significant, then build the model. If it is not significant, then give up.

In addition, the sample companies are divided into two groups; development samples and test samples. The development samples are used to construct the financial distress prediction models and test samples are used to test the effect of the models.

4.2 Data sources and the selection of sample companies

In this paper, the entire sample data were derived from the Genius Securities Information System database developed by Shenzhen Genius Information

Technology, and the paper also consulted the Shanghai Stock Exchange, Shenzhen Stock Exchange and other official sites in order to ensure the accuracy of the data.

This paper use the companies signed "* ST" (special treatment to warn the companies which has the risk of delisting) in Shanghai and Shenzhen A-share market as the financial distressed company samples because the data are easy to obtain and identify.

It selected 56 companies as the financial distressed company samples and 112 normal companies. The 168 companies were divided into two groups of which 28 financial distressed companies and 56 normal companies as the development sample group and the remaining 84 companies as the test sample group.

4.3 Data processing

4.3.1 Selection of the original financial ratios

This study selected the data from mid-term, the third quarter and annual financial reports. Six groups of 20 financial ratios (see Table 4.1) were calculated, as original variables in short-term financial distress early-warning model.

This study selected the data from mid-term, the third quarter and annual financial reports in 2012. Six groups of 20 financial ratios (see Table 4.1) were calculated, as original variables in short-term financial distress early-warning model.

Determining the financial ratios follows these principles: 1. the financial ratios meet the requirements of research methods; 2. the ratios have considerable importance and are commonly used in the literature; 3. the ratios were used in the

previous financial early warning research; 4. the ratios are basically calculated through the balance sheets, income and cash flow statements.

Table 4-1

Profitability	Operation capacity	Debt paying ability	Capital structure	Development ability	Cash flow
1.Gross profit margin 2.Main business profit margin 3.Return on total asset 4.Return on equity	1.Receivables turnover 2.Inventory turnover ratio 3.Turnover of fixed assets 4.Equity turnover 5.Capital turnover	1.Liquidity ratio 2.Quick ratio	1.Debt asset ratio 2.Equity ratio 3.Fixed assets ratio	1.Main business revenue growth rate 2.Operating profit growth rate 3.After tax profit growth rate 4.Growth rate of capital accumulation 5.Total assets growth rate	1.Cash from sales divided by main business revenue

4.3.2 Financial Ratios selection and analysis:

1. Profitability indicators

Corporate profitability indicators reflect the efficiency of enterprises. Efficiency is the premise of survival and development. From the perspective of the market, a long-term loss of a business always exits the market after its resources are depleted. Typically investors, creditors, business executives, government managers have paid more attention on corporate profitability. The financial indicators of operational efficiency were also treated as the preferred targets will establish financial distress prediction model.

(1) Gross profit margin is a financial metric used to assess a firm's financial

health by revealing the proportion of money left over from revenues after accounting for the cost of goods sold. Gross profit margin serves as the source for paying additional expenses and future savings. Sales gross margin declines usually reflect the enterprise's products lack of competitiveness. It may be important causes of financial distress.

(2) Main business profit margin (MBPM) is a ratio of main business sales profits to the main sales revenue in a certain period. Main business profit margin reflects the competitiveness of products in the market. The level of that index affects the overall operating performance of the enterprise. The steady growth of the major businesses can ensure the overall health of corporate and promote the development of other related businesses.

(3) Return on total asset is a ratio that measures a company's earnings before interest and taxes (EBIT) against its total net assets. The ratio is considered an indicator of how effectively a company is using its assets to generate earnings before contractual obligations must be paid. It shows the level of earning profits with all the assets, excluding the impact of taxation and debt leverage and fully reflects the company's profitability and status of inputs and outputs.

(4) Return on equity reflects the amount of net income returned as a percentage of shareholders equity. Return on equity measures a corporation's profitability by revealing how much profit a company generates with the money shareholders have invested. It is one of the most comprehensive and representative indicators to evaluate the company's capital and the level of accumulated earnings.

2. Operation capacity

Indicators are used to measure the efficiency of the company in asset management. The management capacity is the origin and business condition is the result. Thus, the operation capacity must be taken into the consideration.

(1) Receivables turnover is an accounting measure used to quantify a firm's effectiveness in extending credit as well as collecting debts. The receivables turnover ratio is an activity ratio, which measures how efficiently a firm uses its assets.

(2) Inventory turnover ratio is a ratio showing how many times a company's inventory is sold and replaced over a period. The days in the period can then be divided by the inventory turnover formula to calculate the days it takes to sell the inventory on hand or "inventory turnover days." The quality of this indicator reflects the level of inventory management. It affects the short-term solvency and it is also an important part of the entire enterprise management. The low inventory turnover rate is often a signal of financial distress.

(3) Turnover of fixed assets is a financial ratio of net sales to fixed assets. The fixed-asset turnover ratio measures a company's ability to generate net sales from fixed-asset investments - specifically property, plant and equipment (PPE) - net of depreciation. A higher fixed-asset turnover ratio shows that the company has been more effective in using the investment in fixed assets to generate revenues.

(4) Calculating equity turnover entails dividing the sales of a company with the average stockholder equity. The faster ratio suggests the higher operating efficiency

of capital invested by investors.

(5) Capital turnover is calculated by dividing annual sales by average stockholder equity (net worth). The ratio indicates how much a company could grow its current capital investment level. Low capital turnover generally corresponds to high profit margins.

3. Debt paying ability

In order to expand the scale of business operations or to meet working capital needs, almost every enterprise has to perform debt management. Regardless of the level of debt, repaying on time is the basic premise of normal business operations. If companies cannot repay debt, it can be taken over by creditors or adjudged bankrupt by a court. Thus, the financial indicators about debt paying ability are often used to examine corporate short-term financial distress.

(1) Liquidity ratio is a class of financial metrics that is used to determine a company's ability to pay off its short-terms debt obligations. Generally, the higher the value of the ratio, the larger the margin of safety that the company possesses to cover short-term debts.

(2) Quick ratio is an indicator of a company's short-term liquidity. The quick ratio is calculated as (Current Assets - Inventories) / Current Liabilities. The quick ratio measures a company's ability to meet its short-term obligations with its most liquid assets. The higher the quick ratio, the better the company’s situation.

4. Capital structure

(1) Debt asset ratio is a metric used to measure a company's financial risk by determining how much of the company's assets have been financed by debt. It is calculated by adding short-term and long-term debt and then dividing by the company's total assets. Moderate debt asset ratio shows the smaller investment risk and indicates that company operations is steady, effective and has a certain ability to refinance.

(2) Equity ratio (debt/equity ratio) is a measure of a company's financial leverage calculated by dividing its total liabilities by stockholders' equity. It indicates what proportion of equity and debt the company is using to finance its assets. A high debt/equity ratio generally means that a company has been aggressive in financing its growth with debt. The high ratio indicts a high risk, high reward financial structure, the low ratio shows a low risk, and low paid financial structure.

(3) Fixed Assed ratio is used to measure the fixed asset ratio over the total assets. The fixed Asset Ratio can show how much the companies depend on fixed assets to run their business. The high ratio indicates the high breakeven point of production and large scale effect.

5. Development ability

(1) Main business revenue growth rate is a ratio of the increasing amount of main business income divided by the initial main business income in a same period. Main business revenue is the major source of profits, reflecting the competitiveness of their products. It is also an important indicator of growth stage.

(2) Operating profit growth rate measures the increasing amount of operating profit divided by the initial operating profit in a same period. The indicator reflects the growth in corporate profits. A high rate shows that the costs of products are falling when company is expanding sales. To some extent, it explains their market share is increasing.

(3) After-tax profit growth rate measures the increasing amount of net profit divided by the initial net profit in a same period. The indicator reflects the growth in disposable income that can be used for dividends paid or additional investment.

(4) Growth rate of capital accumulation measures the increasing amount of capital divided by the initial capital in a same period. It reflects the company's current capital accumulation capacity.

(5) Total assets growth rate measures the increasing amount of total asset divided by the initial total asset in a same period. It reflects the degree of expansion of business scale.

6. Cash flow indicator

Cash from sales divided by main business revenue reflects the efficiency of collecting receivables and proportional relationship between cash sales and credit sales situation. The high ratio shows the company has strong ability to deploy cash.

4.3.3 Test for financial ratios

1. Test methods

Non-parametric does not make assumption on the population distribution or sample size. This is in contrast with most parametric methods in elementary statistics that assume the data are quantitative, the population has a normal distribution and the sample size is sufficiently large. In general, conclusions drawn from non-parametric methods are not as powerful as the parametric ones. However, as non-parametric methods make fewer assumptions, they are more flexible and robust, and applicable to non-quantitative data.

(1) Mann–Whitney–Wilcoxon test

Mann–Whitney–Wilcoxon test (also called the Mann–Whitney U test) is a non-parametric test of the null hypothesis.

For small samples (n<30), there is a direct method.

Choose one sample called "sample 1," and the other sample called "sample 2." The rank for sample 1 is W_1 and the rank for sample 2 is W_2,

For each observation in sample 1, count the number of observations in sample 2 that have a smaller rank, called U_1. For each observation in sample 2, count the number of observations in sample 1 that have a smaller rank, called U_2. The sum of these counts is U.

$$U_1 = \frac{n_1 n_2 + n_1(n_1+1)}{2} - W_1 \tag{4.1}$$

$$U_2 = \frac{n_1 n_2 + n_2(n_2+1)}{2} - W_2 \tag{4.2}$$

$$U = \min[U_1, U_2] \tag{4.3}$$

For larger samples:

$$E(W_1) = \frac{n_1(n+1)}{2} \quad 4.4$$

$$V(W_1) = \frac{1}{2} n_1 n_2 (n+1) \quad 4.5$$

$$Z = \frac{W_1 - E(W_1)}{\sqrt{V(W_1)}} \quad 4.6$$

When $U_1 < U_2$, W_1 is small, using the left-tailed test (H_1: $U_1 < U_2$), if $Z < Z(1-a)$, should reject H_0;

When $U_1 > U_2$, W1 is larger, using the right-tailed test (H_1: $U_1 > U_2$), if $Z > Z(1-a)$, should reject H_0;

When $U_1 \neq U_2$, using two-tailed test (H_1: $U_1 \neq U_2$), if $Z > Z(1-a/2)$ or $Z < -Z(1-a/2)$, should reject H_0.

(2) T-test

The two sample T-test is often used for evaluating the means of two variables or distinct groups, providing information as to whether the means between the two populations differs. Although this paper has mentioned that financial ratio does not meet the normal distribution assumptions, a lot of literature used the T test on financial distress projections, rather than non-parametric tests and this study uses large samples to meet the requirements of the T-test. Thus, this paper still use the T test in order to make comparison.

When using a T-test, the variance homogeneous of financial distressed company samples and normal company samples will decide the method of calculating the t

value. The F test is used for testing homogeneity of variance.

Null hypothesis is: two sample variance equal. If the P-value is less than 0.05, reject the null hypothesis. That is, there is the significant difference between the two groups variance. Otherwise, accept the null hypothesis that the variances are homogeneous. Using x_1, x_2 represents the mean of two samples; n_1, n_2 represent the number of observations for the two samples, respectively; v_1, v_2 is the variance of the two samples. F can be calculated as follows:

$$F=Max(v_1,v_2)/min(v_1,v_2) \quad 4.7$$

For homogeneous variances:

$$t=\frac{x_1-x_2}{\sqrt{s^2(\frac{1}{n_1}+\frac{1}{n_2})}} \quad 4.8$$

$$s^2=\frac{(n_1-1)v_1+(n_2-1)v_2}{n_1+n_2-2} \quad 4.9$$

For non-homogeneous variances:

$$t=\frac{x_1-x_2}{\frac{v_1}{n_1}+\frac{v_2}{n_2}} \quad 4.10$$

2. Results of the tests

(1) Nonparametric test

In t-3 period, the results of test showed that two indicators, including the fixed assets ratio and cash from sales divided by main business revenue did not pass the significance test; while the other 18 financial indicators have passed the significance

tests at the 0.01 level, see Appendix C.

In t-2 period, the results of test also showed that two indicators, including the fixed assets ratio and cash from sales divided by main business revenue did not pass the significance test; operating profit growth rate pass the significant test at the 0.05 level; while the other 18 financial indicators have passed the significance tests at the 0.01 level, see Appendix B.

In t-1 period, the results of test also showed that the fixed assets ratio, cash from sales divided by main business revenue, operating profit growth rate and after-tax profit growth rate did not pass the significance test; while the other 18 financial indicators have passed the significance tests at the 0.01 level, see Appendix A.

(2) T-test

There are many differences between the results of the T-test and non-parametric test. Some indicators passed the T-test, but did not pass the non-parametric test, such as cash from sales divided by main business revenue. Many financial indicators, such as receivable turnover, inventory turnover ratio, Turnover of fixed assets, main business revenue growth rate, growth rate of capital accumulation passed the non-parametric test, but did not pass the T-test. Fixed assets ratio showed significant difference in both the tests.

In t-3 period, the results of the test showed that 10 indicators, such as gross profit margin and MBPM had passed the significance test of at the level of 0.01. Inventory turnover ratio and quick ratio passed the significance test of at the level of

0.1, while the other 8 financial ratios did not pass the significance test. See Appendix C.

In t-2 period, the results of test showed that 10 indicators had passed the significance test of at the level of 0.01. Three indicators, including return on equity passed the significance test of at the level of 0.05. Two indicators passed the significance test of at the level of 0.1. Five financial ratios, including receivable turnover did not pass the significance test, see Appendix B.

In t-1 period, the results of the test showed that 10 indicators had passed the significance test of at the level of 0.01. The ratio of cash from sales divided by main business revenue passed the significance test of at the level of 0.05. Nine financial ratios, including receivable turnover did not pass the significance test, see Appendix A.

(3) Comparison

Through comparison of the development and changes in financial ratios over time, it showed that, the normal companies' financial ratios tend to be more stable, while the volatility of financial distressed companies' financial ratios is very high and they change greater if it is close to the occurrence of financial distress. For gross profit margin, for normal companies, the mean ratios were 24.28, 25.12 and 25.25 in t-1 period, t-2 period and t-3 period, respectively, However, for the distressed company, the mean ratios were 6.28, 11.87and 12.55 in t-1 period, t-2 period and t-3 period, respectively. See Appendices A, B and C.

It explains that the overall financial position of financial distressed companies gradually tended to be worsening. The distributions of financial indicators are not the same in different periods. It provides the basis for the necessity to establish financial distress prediction model in different periods within a year.

According to the test results above, the basic judgments can be made, many financial ratios of normal and financial distressed companies showed significant differences among their means in t-1 period, t-2 period and t-3 period as financial distress occurred. Therefore a short-term financial distress prediction model can be established to predict effectively by using appropriate statistical methods.

Chapter 5: Model building and analysis of results

5.1 Univariate model

5.1.1 Steps to build the univariate model

Based on the test results in Chapter 4, the paper selected 5 financial ratios, including return on total asset, capital turnover, liquidity ratio, debt asset ratio and growth rate of capital accumulation for univariate analysis. Calculated the best split point of financial ratios in the t-1, t-2 and t-3 period, and calculated the misjudgment rate. These are the specific steps:

1. Determined variables in univariate analysis: It required: (1) The financial ratios should have passed the significance test at the level of 0.01; (2) the correlation among the group of financial ratios selected should be low. Therefore, this study selected return on total asset, capital turnover, liquidity ratio, debt asset ratio and growth rate of capital accumulation for univariate analysis.

2. Determined the method to find the best split point. This study used sorting method by arranging those financial ratios in descending or ascending order to find boundary of the lowest error rate.

3. Calculated financial ratio values of samples. To improve the accuracy, this paper mixed the development sample and test sample groups together to make the univariate analysis.

4. Sorted the values of financial ratios calculated in ascending order by using Excel.

5. Determined the best split point. After the consecutive number 0 (represented distressed companies) occurred , number 1 (represented the normal company) continuous appeared, then select the financial ratios values of the two adjacent distressed and normal samples to calculate weighted average, the result is the best split point.

6. Calculated error rate. After determining the best split point, found out the number of normal samples in the area of distressed samples to divide it by the number of normal samples, and then we got the probability of Type II error. Then found out the number of distressed samples in the area of normal samples to divide it by the number of distressed samples, and then we got the probability of Type I error. Use the probability of Type I error and Type II error to calculate the total error rate.

For example: Univariate model in t-1 period using return on total assets. Calculate the return on total assets according to the financial statements of 168 companies of the sample. After sorting in ascending order, the minimum is -396.02, the maximum value is 17.44. After five consecutive samples of distressed companies appeared, 24 consecutive samples of normal company occurred. The return on total assets of the adjacent sample companies are -2.62 (for distressed company) and -2.42 (for normal company). Found out 6 distressed samples in the area of normal samples to divide it by 56 distressed samples, and got the probability of Type I error, 10.71%. Use 7 normal samples in the area of distressed samples to divide it by 112 normal samples, and then we got the probability of Type II error, 6.25%. Calculated the total error rate was 7.74%. See table-5.1.

Then calculate according to the above steps for other ratios in univariate models in other periods, shown in Table 5.1-5.5.

Table 5.1: Forecast accuracy using return on total assets of financial ratio

time	Best split point	Error type	Type of company		Total number	Error rate	Total error rate
			0	1			
t-1 period	-2.50	0	50	6	56	10.71%	7.74%
		1	7	105	112	6.25%	
t-2 period	0.075	0	43	12	55	21.82%	11.98%
		1	8	104	112	7.14%	
t-3 period	0.18	0	46	10	56	17.86%	13.10%
		1	12	100	112	10.71%	

Table 5.2: Forecast accuracy using capital turnover

time	Best split point	Error type	Type of company		Total number	Error rate	Total error rate
			0	1			
t-1period	-4.05	0	47	9	56	16.07%	14.29%
		1	15	97	112	13.39%	
t-2 period	-3.95	0	40	15	55	27.27%	19.75%
		1	17	90	107	15.89%	
t-3 period	-1.32	0	39	17	56	30.36%	23.03%
		1	21	88	109	19.27%	

Table 5.3: Forecast accuracy using liquidity ratio

time	Best split point	Error type	Type of company		Total number	Error rate	Total error rate
			0	1			
t-1 period	0.73	0	33	22	55	40%	20.96%
		1	13	99	112	11.61%	
t-2 period	0.795	0	25	28	53	52.83%	27.27%
		1	17	95	112	15.18%	
t-3 period	0.775	0	28	28	56	50%	27.98%
		1	19	93	112	16.96%	

Table 5.4: Forecast accuracy using debt asset ratio

time	Best split point	Error type	Type of company		Total number	Error rate	Total error rate
			0	1			
t-1 period	71.13	0	35	20	55	36.36%	16.17%
		1	7	105	112	6.25%	
t-2 period	69.21	0	25	29	54	53.7%	23.49%
		1	10	102	112	8.93%	
t-3 period	70.89	0	24	32	56	57.14%	23.21%
		1	7	105	112	6.25%	

Table 5.5: Forecast accuracy using growth rate of capital accumulation

time	Best split point	Error type	Type of company		Total number	Error rate	Total error rate
			0	1			
t-1 period	-0.83	0	47	9	56	16.07%	11.31%
		1	10	102	112	8.93%	
t-2 period	-0.83	0	49	7	56	12.50%	11.66%
		1	12	95	107	11.21%	
t-3 period	-0.48	0	48	8	56	14.29%	12.12%
		1	12	97	109	11.01%	

5.1.2 Analysis of the results

1. The best split point of univariate model showed the deteriorating trend with the financial distress gradually approaching. The best split points of return on total assets are 0.18, 0.075 and -2.5 in t-3 period, t-2 period and t-1 period model, respectively. The best split points of capital turnover are -1.32, -3.95 and -4.05 in t-3 period, t-2 period and t-1 period model, respectively. It indicates that with the passage of time, the overall financial situation of distressed companies tend to be worsen. It also proves that the model cannot be fully applicable to the financial position of the respective periods within 1 year. For different periods of financial

condition, it needs to create the different models for early warning.

2. In the selected 5 financial ratios, the accuracy rate of return on total assets to predict the financial distress was the highest which the misjudgment rates were 7.74 %, 11.98% and 13.10% in t-1 period, t-2 period and t-3 period. Meanwhile, the prediction accuracy of growth rate of capital accumulation was also high; its misjudgment rates were 11.31%, 11.66% and 12.12% in t-1 period, t-2 period and t-3 period. This indicates that the return on total assets and growth rate of capital accumulation have a certain accuracy in predicting financial distress, which can be used for companies' financial distress diagnosis.

3. The timeliness of financial ratios is very strong. The closer the occurrence periods of financial distress, the higher the rate of prediction accuracy. The results of 5 selected financial ratios have shown that the prediction accuracy rates are in ascending order in t-3 period, t-2 period and t-1 period.

4. The consistency of financial ratios in univariate forecasting is poor. It often appears diametrically opposite results when using different financial ratios of sample companies in univariate forecasting. For this reason, when using univariate model, it should analysis comprehensively combined with multiple variables.

5. The best split point in univariate prediction is unstable. The results of sample companies' univariate prediction showed that there were a large number of sample points around the best split point. Some small changes in the best split point will lead to classification differences in some companies, which directly affect the prediction accuracy.

6. It can be seen from the above tables that in the results of all the univariate forecasting of different periods, the probability of Type I error is always higher than that of Type II error. Since Type I error represents that distressed companies judged to be normal companies, its decision-making costs are clearly higher than the Type II error, thus affecting the application value of univariate model. A model such as that could not be used in practice singly. Univariate model has a certain reference value, but using it should rely on experienced judgment.

5.2 Logistic regression model

5.2.1 Select the independent variables

According to the existing literature, methods of selecting independent variables could be summarized in two ways: Empirical discriminant method and statistical software. Some researchers also use both of them. In this study, firstly, bring the variables which passed the significance test into the model directly to analyse instead of empirical judgments; secondly, use automatic filtering capabilities provided by SPSS software.

This study chose forward stepwise regression method - conditional parameter estimates principles to select independent variable. Stepwise regression includes regression models in which the choice of predictive variables is carried out by an automatic procedure. Forward selection involves starting with no variables in the model, testing the addition of each variable using a chosen model comparison criterion, adding the variable (if any) that improves the model the most, and

repeating this process until none improves the model. Other principles are also similar, but different standards are taken. The final results of principles may be different, but there is not the best way (Guo, 1999).

5.2.2 Logistic Model construction

1. Steps to build Logistic Model

Using SPSS statistical software for logistic regression analysis and according to the following steps:

(1) Input the financial ratio values of the samples into data editor. Choose “Analyze / Regression / Binary Logistic” command, open the dialog box “Logistic Regression”.

(2) Add the variable [company type] into text box “Dependent”, and input the 20 financial ratio variables to text box ”Covariates”. Select option “Forward Conditional” in the “Method” list.

(3) Click the “Save” button and select “Probabilities”, “Group membership”, “Cook's”, “Leverage values” and “DfBeta” in the dialog box.

(4) Click the OK button for analysis.

2. The model results and analysis

Using forward stepwise regression method - conditional parameter estimates principles to select variables to identify coefficients and parameters to build Logistic model, according to the financial ratios of development samples in t-1 period.

Table 5.6:

variables	coefficient	standard error	Wald's statistic	degree of freedom	Significance level	Partial correlation coefficient
Main business profit margin	.102	.049	4.416	1	.036	1.107
Return on total assets	.356	.101	12.356	1	.000	1.428
Equity ratio	.048	.018	6.719	1	.010	1.049
Main business revenue growth rate	.000	.001	.510	1	.475	1.000
absolute term	-1.145	1.105	1.074	1	.300	.318

Build the model according to Table 5.6:

$$Y=-1.145+0.102X_1+0.356X_2+0.048X_3 \quad 5.1$$

$$P=1/(1+e^{-Y}) \quad 5.2$$

In Equation 5.1, X_1 represents the main business profit margins, X_2 as return on total assets, and X_3 for equity ratio. Formula (5.2) represents the Logistic probability equation.

In this equation, the coefficients such as main business profit margins, return on total assets and equity ratio are positive. The larger value indicates that the probability of being a normal company will be greater and the probability of being financial distressed is smaller which is consistent with the common sense of management. In the Wald statistic test, return on total assets equity ratio is significant at the level of 0.01, the main business profit margin is significant at the level of 0.05, these three variables are included in the model, but main business revenue growth rate is not significant, it should be dropped. Those 3 financial ratios can provide stronger explanatory power of financial distress prediction.

I calculate the probability by putting corresponding financial ratios of development samples into the equation 5.1 and 5.2, it is normal company the probability is greater than 0.5. If it is less than 0.5, the company can be identified as distressed company. See Table 5.7:

Table 5.7

		Distressed	Normal	Total	Accuracy rate	Error rate
		0	1			
Distressed	0	22	4	26	84.62%	15.38%
Normal	1	2	53	55	96.36%	3.64%
Total				81	92.59%	7.41%

In Table 5-7, it can be seen that the Type I error is as high as 15.38% in t-1 period, but the Type II error is very low as 3.64%. Overall the correct rate is 92.59%, which represents quite high discriminatory power.

I calculate the probability by putting corresponding financial ratios of test samples into the equation 5.1 and 5.2. The results show that the Type I error is still high at 10.71% compared to the Type II error at 3.57%. Overall the correct rate is 94.05%, which represents quite high discriminatory power that can be used in practice. See Table 5.8:

Table 5.8

		Distressed	Normal	Total	Accuracy rate	Error rate
		0	1			
Distressed	0	22	4	26	84.62%	15.38%
Normal	1	2	53	55	96.36%	3.64%
Total				81	92.59%	7.41%

3. Results in t-2 and t-3 period

(1) Establish model in t-2 period using Logistic method as follows:

Table 5.9

variables	coefficient	standard error	Wald's statistic	degree of freedom	Significance level	Partial correlation coefficient
Return on total asset	1.046	.355	8.687	1	.003	2.845
Capital turnover	.070	.027	6.876	1	.009	1.073
Main business revenue growth rate	-.006	.010	.300	1	.584	.994
Absolute term	.714	.391	3.337	1	.068	2.043

I build the model according to Table 5.9:

$$Y=0.714+1.046X_1+0.070X_2-0.006X_3 \quad 5.3$$

$$P=1/(1+e^{-Y}) \quad 5.4$$

In equation 5.3, X_1 represents the return on total asset, X_2 as capital turnover, and X_3 for main business revenue growth rate. Equation 5.4 represents the Logistic probability equation.

In equation 5.3, the coefficient of main business revenue growth rate is negative. This seems to be unusual compared with common sense of management, but the level of growth does not represent actual operating level, so that the overall impact of this variable on the model can be ignored.

(2) Establish model in t-3 period using Logistic method as follows:

Table5.10

variables	coefficient	standard error	Wald's statistic	degree of freedom	Significance level	Partial correlation coefficient
Return on total asset	1.094	.295	13.744	1	.000	2.987
Equity ratio	.021	.009	5.629	1	.018	1.021
Absolute term	-.142	.452	.099	1	.753	.867

I build the model according to Table 5-10:

$$Y=-0.142+1.094X_1+0.021X_2 \quad 5.5$$

$$P=1/(1+e^{-Y}) \quad 5.6$$

In equation 5.5, X_1 represents the return on total asset, X_2 as equity ratio. Equation 5.6 represents the Logistic probability equation.

In the 3 different models in different periods, there is a common variable, the return on total assets, and its proportion in the model is also the largest of the overall discriminant model which plays the role of the most important influence.

I calculate the probability by putting corresponding financial ratios of test samples in t-2 and t-3 period into the equation 5.3-5.6. After testing, the results are shown in Table 5.11.

Table 5.11

time	Development samples				Test samples			
	Sample number	Correct rate	Type I error	Type II error	Sample number	Correct rate	Type I error	Type II error
t-2 period	80	88.75%	22.22%	5.66%	80	87.50%	15.38%	11.11%
t-3 period	81	83.95%	33.33%	7.41%	84	88.10%	28.57%	3.57%

After comparison, the overall accuracy rate of Logistic regression model in t-2

and t-3 period is over 80%. The model can be applied in practice. Meanwhile, the model in t-2 period is clearly superior to the model in t-3 period, which means its practical applicability is stronger.

5.3 Construction of Fisher's discriminant model and result analysis

1. Using SPSS software to build the Fisher's discriminant model, I follow these steps:

(1) Enter the data into the Data Editor, select command “Analyze / Classify / Discriminate”.

(2) Add the variable [company type] into text box “Grouping Variable”, and input the 20 financial ratio variables to text box “Independents”, then select “Use stepwise method”.

(3) Click “Define Range” button to set the range of 0 to 1, and then click the “Continue” button.

(4) Click the “Statistics” button, select “Means”, “Univariate ANOVAs”, “Box ’M”, “Fisher's” and “Within-groups correlation”, and click the “Continue” button.

(5) Click “Classify” button, select “Within-group”, make checks on “Casewise results” and the “Summary table”, and click “Continue” then “OK” button.

2. Model building in t-1 period and analysis of results

This study used the stepwise method and selected the Wilds Lambda to minimize Wilds’ λ. In this study, if F value is greater than 3.84, then it can be used in the model, and if F value is less than 2.71 then it is dropped from the model.

According to the design of parameters for the development samples in t-1 period to establish a non-standardized Fisher's linear discriminant function is:

$$Y=-1.595+0.04X_1+0.049X_2+0.015X_3+1.228X_4 \quad 5.7$$

Where: X_1 presents the main business profit margin, X_2 as return on total assets, X_3 for equity ratio, and X_4 for total assets growth rate.

In the Equation 5.7, four variable coefficients are positive which is consistent with the common sense of management. The proportion of total assets growth rate is the largest, indicating that this variable makes the greatest influence on the model.

With the development samples using in the discriminant function, the results show that the overall accuracy rate is 90.36%, the Type I error is 11.11% and Type II error is 8.93%, see Table 5.12.

Table 5.12

		Distressed	Normal	Total	Accuracy rate	Error rate
Distressed	0	24	3	27	88.89%	11.11%
Normal	1	5	51	56	91.07%	8.93%
Total				83	90.36%	9.64%

With the test samples using in the discriminant function, the results show that the overall accuracy rate is 93.90%, Type I error is 7.69% and Type II error is 5.36%, see Table 5.13.

Table 5.13

		Distressed	Normal	Total	Accuracy rate	Error rate
Distressed	0	24	2	26	92.31%	7.69%
Normal	1	3	53	56	94.64%	5.36%
Total				82	93.90%	6.10%

3. Model building in t-2 and t-3 period and analysis of results

For t-2 period with development samples:

$$Y=-0.91+0.03X_1+0.193X_2+0.168X_3+0.028X_4 \quad 5.8$$

where X_1 represents main business profit margin, X_2 is return on total asset, X_3 is equity turnover, and X_4 is capital turnover.

For t-3 period with development samples:

$$Y=0.076+0.027X_1+0.212X_2+0.314X_3-0.014X_4+0.001X_5 \quad 5.9$$

where X_1 represents main business profit margin, X_2 is return on total asset, X_3 is equity turnover, X_4 is debt asset ratio and X_5 is after tax profit growth rate.

I put the corresponding financial ratios of development and test samples in t-2 and t-3 period into Equation 5.8 and 5.9. The results show as Table 5.14.

Table 5.14

time	Development samples				Test samples			
	Sample number	Correct rate	Type I error	Type II error	Sample number	Correct rate	Type I error	Type II error
t-2 period	81	77.78%	14.29%	26.42%	78	84.62%	8.33%	18.52%
t-3 period	81	81.48%	22.22%	16.67%	81	82.72%	19.23%	16.36%

In Table 5-14, it can be seen that the accuracy rate for development samples in t-2 period is 77.78%; the others are more than 80%. It indicates that the two models can be applied in practice.

5.4 Comparative analysis of results

5.4.1 Comparing the total accuracy rate

This paper established univariate model, Logistic model and Fisher's discriminant model. I chose the best univariate model (return on total assets model) compared with the other 2 types of models. In t-1 period, the total accuracy rates of 3 types were 92.26%, 92.59% and 90.36% for development samples and 92.26%, 94.05% and 92.31% for test samples (see Table 5-15). The overall accuracy rate of Logistic regression model was the highest.

Table 5.15

	Development samples			Test samples		
	Univariate model	Logistic model	Fisher's model	Univariate model	Logistic model	Fisher's model
t-1 period	92.26%	92.59%	90.36%	92.26%	94.05%	92.31%
t-2 period	88.02%	88.75%	77.78%	88.02%	87.50%	84.62%
t-3 period	86.90%	83.95%	81.48%	86.90%	88.10%	82.72%

In t-2 period, the accuracy rate of return on total assets model reached 88.02%, better than the Logistic Regression model on the test sample as 87.50%, but worse than that the Logistic Regression model on the development sample as 88.75%. However, in t-3 period, the situation is the opposite. The accuracy of univariate model was 86.90%, better than Logistic regression model for the development sample as 83.95%, worse than Logistic regression model for the test sample as 88.10 %. The overall accuracy rate of the Fisher's discriminant model was the worst.

Through comparison of 3 models in different periods, the overall accuracy of 3 types has performed well, which was basically more than 80% (Univariate model only referred to the return on total assets model). Logistic regression model

performed the best, while Fisher's discriminant model performed the worst.

5.4.2 Comparing the Type I error

From the perspective of preventing corporate financial distress, the Type I error (misjudged distressed to be normal) was higher than Type II error (misjudged normal to be distressed). Altman (2000) estimated the cost of Type I error is 31 times the Type II error. Thus, the practical value of models with high Type I error will decrease. In comparing the three models according to that conclusion, in t-1 period, the Type I errors of 3 models for the development samples were 10.71%, 15.38% and 11.11%, for the test samples they were 10.71%, 10.71 % and 7.69% (see Table 5-16). The Type I error of Fisher's discriminant model was the lowest. In t-2 period, the Type I error of Fisher's discriminant model for the development and test samples was also low (14.29% and 8.33%, respectively). However, in t-3 period, the performance of univariate model was the best which the Type I errors was 17.86%.

Table 5.15

	Development samples			Test samples		
	Univariate model	Logistic model	Fisher's model	Univariate model	Logistic model	Fisher's model
t-1 period	10.71%	15.38%	11.11%	10.71%	10.71%	7.69%
t-2 period	21.82%	22.22%	14.29%	21.82%	15.38%	8.33%
t-3 period	17.86%	33.33%	22.22%	17.86%	28.57%	19.23%

Considering the accuracy rate and Type I error, in the short-term (within a year), return on total assets model, Logistic regression models, and Fisher's discriminant

model have their own advantages in practical applications should be combined with the use of different situations.

Chapter 6: Conclusions

This paper focuses on the analysis of the short-term financial distress early warning models. The main conclusions of the study include:

The best split point of univariate model showed the deteriorating trend with the financial distress gradually approaching. With the passage of time, the overall financial situation of distressed companies tends to be worsened. It also proves that the model cannot be fully applicable to the financial position of the respective periods within 1 year. For different periods of financial condition, it needs to create the different models for early warning.

The models built in this study can identify and predict if the financial distress occurred in companies. The overall accuracy of 3 types has also performed well, which was basically more than 80% (Univariate model only referred to the return on total assets model).

The corporate financial situation can be mainly reflected by 9 financial ratios. In this study, return on total asset, main business profit margins, equity ratio, main business revenue growth rate, total assets growth rate, total asset turnover, equity turnover, debt asset ratio and after tax profit growth rate are used in the early warning model, suggesting that these ratios have informational functions in predicting financial distress.

The timeliness of financial ratios is strong. As the closer occurrence periods of financial distress, the prediction accuracy rates are higher. The accuracy rates of 3

models are over 90% in t-1 period, while this dropped to 80% in t-2 and t-3 period. This result confirms that there is inverse relationship between accuracy and timeliness.

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Appendix A

Period t-1

	Normal companies	Distressed companies	non-parametric test			T test
			U value	W value	Z value	
Gross profit margin	24.2803	6.2785	1240	2725	-6.149***	-5.805***
MBPM	22.9793	6.1389	1177	2608	-6.250***	-6.164***
Return on total asset	2.8360	-34.7432	462	2058	-8.997***	-6.220***
Return on equity	4.6199	-290.6598	371	1967	-9.303***	-3.075***
Receivable turnover	40.3572	4.1341	1382.5	2867.5	-5.607***	-1.463
Inventory turnover ratio	9.9784	4.2928	1870	3355	-3.914***	-1.139
Turnover of fixed assets	4.4375	1.0902	1383	2814	-5.531***	-1.581
Equity Turnover	1.8879	9.0925	1682.5	3222.5	-4.759***	1.217
Capital turnover	16.9907	-18.6171	636	2232	-8.412***	-8.267***
Liquidity ratio	0.98647	0.54781	1262	2802	-6.191***	-4.706***

Quick ratio	1.0141	0.5193	1413.5	2898.5	-5.500***	-4.114***
Debt asset Ratio	50.1999	136.4707	1125	7453	-6.657***	4.075***
Equity ratio	46.9735	-37.3827	1173.5	2769.5	-6.603***	-4.022***
Fixed assets ratio	37.0375	36.0972	2991.5	4476.5	-0.112	-0.306
Main business revenue growth rate	42.0487	337.6327	1505	3045	-5.363***	1.220
Operating profit growth rate	-36.1275	-12.5754	2967	9295	-0.569	0.238
After-tax profit growth rate	-105.7027	-187.3257	2838	9166	-1.003	-0.522
Growth rate of capital accumulation	13.5806	-11.5070	921	2517	-7.463***	-0.767
Total assets growth rate	0.6951	0.2695	1121	2661	-6.672***	-6.276***
Cash from sales divided by main business revenue	107.7190	202.3961	2695.5	9023.5	-1.309	2.486**

Appendix B

Period t-2

	Normal companies	Distressed companies	non-parametric test			T test
			U value	W value	Z value	
Gross profit margin	25.1179	11.8696	1697	3128	-4.435***	4.278***
MBPM	23.8258	12.0169	1641	3019	-4.491***	-4.358***
Return on total asset	2.4272	-3.5140	528	2068	-8.690***	-9.654***
Return on equity	4.9851	-63.8886	416.5	2012.5	-9.15***	-2.238**
Receivable turnover	39.8338	3.0463	1325	2703	-6.608***	-1.616
Inventory turnover ratio	2.4313	1.7986	1475.5	2801.5	-4.941***	-1.525
Turnover of fixed assets	2.1924	0.7135	1321	2647	-5.494***	-3.152***
Equity Turnover	1.330	0.1331	1325	2810	-5.857***	-4.238***
Capital turnover	14.1852	-11.6355	913	2453	-7.178***	-7.038***
Liquidity ratio	1.4960	1.0230	1903.5	3334.5	-3.715***	-2.222**
Quick ratio	1.0677	0.7090	2027.5	3353.5	-2.965***	-2.068**
Balance sheet ratios	49.3433	83.0826	1770.5	8098.5	-4.321***	4.708***

Equity ratio	47.6032	14.5402	1815	3355	-4.308***	-4.643***
Fixed assets ratio	36.4569	33.1152	2655.5	4033.5	-0.906	-1.114
Main business revenue growth rate	41.9861	507.5487	1702.5	3187.5	-4.248***	1.286
Operating profit growth rate	15.2397	2195.6126	2024	3509	-3.097**	1.464
After-tax profit growth rate	23.3318	-1327.11	1467	3063	-5.343***	-3.178***
Growth rate of capital accumulation	7.8244	-230.0346	572	2168	-8.471***	-1.752*
Total Assets Growth Rate	0.4949	0.1840	1115.5	2546.5	-6.466***	-6.027***
Cash from sales divided by main business revenue	108.5762	168.8028	2840	9056	-0.357	1.964*

Appendix C

Period t-3

	Normal companies	Distressed companies	non-parametric test			T test
			U value	W value	Z value	
Gross profit margin	25.2518	12.5525	1758	3298	-4.502***	-4.303***
MBPM	24.0203	12.3432	1687	3118	-4.470***	-4.296***
Return on total asset	1.7013	-2.6509	591	2197	-8.563***	-8.803***
Return on equity	3.4629	-19.6605	450	2046	-9.038***	-4.876***
Receivable turnover	31.7975	2.1776	1461	3001	-5.460***	-1.266
Inventory turnover ratio	5.6267	1.2985	1576.5	3061.5	-4.989***	-1.716*
Turnover of fixed assets	1.5829	0.4224	1318	2803	-5.831***	-3.095***
Equity Turnover	0.8934	0.1476	1322	2862	-5.987***	-4.097***
Capital turnover	52.0212	-9.4479	1130.5	2726.5	-6.613***	-1.193
Liquidity ratio	0.6107	-0.7352	1980	3576	-3.890***	-0.776
Quick ratio	1.0964	-0.5259	2066.5	3551.5	-3.301***	-1.841*
Balance sheet	48.8580	89.1009	1805	8133	-4.478***	4.733***

ratios						
Equity ratio	48.2138	8.4268	1844	3440	-4.347***	-4.667***
Fixed assets ratio	36.2894	33.6309	2930.5	4470.5	-0.509	-0.903
Main business revenue growth rate	65.4724	8.8187	1850	3390	-3.997***	-1.294
Operating profit growth rate	47.3090	-459.9629	2104	3700	-3.262***	-1.557
After-tax profit growth rate	25.4474	-489.1179	1832	3428	-4.198***	-1.496
Growth rate of capital accumulation	13.9187	-54.6263	578	2174	-8.514***	-3.432***
Total Assets Growth Rate	0.3342	0.1187	1141	2681	-6.606***	-6.162***
Cash from sales divided by main business revenue	106.8886	1062.2648	2684	9012	-1.172	1.551