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Literature Review and Comparative Analysis on Finance Early Warning Models

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Abstract: The establishment of financial crisis early warning mechanism plays an essential important role in avoiding financial crisis. The predictive accuracy of financial crisis early warning depends on two factors: first, early warning variable; second, early warning model. The study on finance early warning has been gradually developed and innovated on both financial crisis early warning indexes selected and the construction of financial crisis early warning model from single variable model to survival analysis model. Through literature review related to early warning indexes and early warning models, firstly, this paper concludes a literature review on warning indicators and early warning models. Secondly, some typical financial crisis early warning models are contracted and analyzed. Finally, some enlightenment and prospect of financial crisis warning models are presented.

Keywords: Early warning models, financial crisis early warning, survival analysis model

I. Introduction

Risks exist in all development stages of any enterprise, which can be described as ever-present and everywhere. When accumulated to a certain stage, risks are more prone to lead to a financial crisis. Consequently, the establishment of appropriate financial early warning model for enterprises is of great importance. Within early warning research in corporate finance, Fetter Patrick's [1] research is recognized as ground breaking work about financial crisis early warning. Since then, the international academic research on financial early warning can be described in the ascendant. Both domestic and foreign scholars in this field have made unremitting exploration.

II. Literature Review on Financial Crisis Early Warning Indexes

A. Research Based on Financial Status Indexes

On the selected metrics, research on financial crisis early warning indexes based on financial status indexes mainly takes listed companies financial statements data onto the material. Within the literatures abroad, Altman and other scholars [2, 3] used conventional financial indicators, such as working capital total assets ratio, current ratio, total asset turnovers rate, ROE and so on, as the financial crisis early warning variables to predict financial crisis. After a lot of empirical research, Hammer [4] have suggested that relative independence of selected financial indicators of early warning can largely improving the predictive ability of the model. Poriz [5] selected as many as 65 financial indexes as the warning indexes.

Domestic scholar Zhang Ling [6] have constructed discriminate model by using Fisher II linear model with four financial indicators, including total return on assets, debt ratio, working capital / total assets, retained earnings / total assets. Cheng Yu-shu and Liu Yi-pei [7] have selected debt ratio, total asset turnover, inventory turnover ratio, liquidity ratio and other indicators as explanatory variables, finding that prediction accuracy rate of debt ratio and operating margin in the quarter before the bankruptcy is up to 90%.

B. Research Based on Corporate Governance Indexes

In recent years, a number of non-financial indicators, such as corporate governance indicators have been introduced to the warning indicator system in the past. Meanwhile, board independence and concentration ratio of shares have been incorporated in financial early warning indicators in order to expand early warning information and improve early warning model.

Within study abroad, Olson have suggested that the current liquidity of assets, capital structure and the

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size of the company have significant impact on corporate bankruptcy by introducing non-financial indicators into financial early warning model firstly. According to Whitaker [8], management failure can explain financial crisis better than financial difficulties. According to Fifer [9], in those companies that corporate performance declines, the proportion of internal staff who hold the post of board officer is relatively higher compared with the well-functioning companies.

Domestic scholars Wu Chao-peng and Wu Shi-nong [10] have introduced corporate governance variables and external governance variables based on original financial variables and constructed financial crisis prediction model by making use of artificial neural network method. The empirical results have indicated that improvement of corporate governance and financial variables (e.g. returns ratio of total assets) can help to improve the corporate financial situation.

C. *Research based on Cash Flow Indexes*

In the present economic climate, "cash is king" business theory is of increasingly popular. Scholars have slowly shifted their research perspectives from traditional financial index to cash flow index on cash basis in order to make up for the insufficiency of financial indexes and improve financial early warning indexes [11].

Within study abroad, Beaver [12] is recognized as a pioneer in the area of the cash flows introduction of financial early warning indexes, using 79 companies as the research sample, the results have indicated that cash flows / total debt can be a good predictor for corporate financial position. Lawson et al have suggested that enterprise value is determined by cash flows on cash basis rather than the profit on accrual basis.

In China, since Ministry of Finance stipulated that corporate cash flow statement shall be prepared in1998, domestic research about financial early warning based on cash flow is relatively late and limit limited. Some scholars regard cash as maintained "blood" of normal production and operation, accordingly, the cash flow statement considered as " blood test report" , in order to judge company's daily production and operation healthy or not. Qian Ai-min have taken A shares listed manufacturing companies as research samples, establishing early warning model on principal component analysis and Logit regression analysis by selecting 13 free cash flow indexes, which can fully reflect the company's earnings quality, debt paying ability and so on [13]. According to the study, free cash flow indexes system shows higher prediction accuracy rate in two years before company breaking out financial crisis. Moreover, early warning model presents different results with ST and non ST different sample proportion.

III. Literature Review on Financial Crisis Early Warning Model

A. *Discriminate Analysis Model*

The connotation of discrimination class model is to find out the financial indexes which have significant differences between well-functioning companies and those in crisis in order to predict financial crisis. According to the number of indexes found out, discrimination class model is divided into single variable model and multivariate model.

Z fraction model series established by Atman and his partners on discriminate analysis, including Z-Sore model, Z′-Sore model, Z″-Sore model and ZETE model, and have more influence in the world at present. Fetter Patrick is extolled as the founder to predicting the financial crisis by using single variable model. According to Beaver, who has thoroughly used the university analysis firstly, if Return on total assets and cash flow / total debt as a warning are taken as early warning variable, the error rate in the year before the crisis had better controlled as 10%. Moreover, company's likelihood of crisis either great or small, which has fully indicated that financial indexes help to improve researchers' prior probability, thereby providing useful information.

The single variable model studies of Beaver have lay foundation for financial crisis warning. Within domestic study, influential researchers are according to Chen Jing, which found that return on total assets has nice effects on financial crisis early warning.

B. *Conditional Probability Model*

Compared to multivariate discriminate model, conditional probability model is introduced to predict the financial crisis and favored by scholars largely because of its looser assumptions. It consists of two models: Logistic model (logistic regression model) and Probit model (multivariate probability ratio), some scholars believe that they are the same kind of models.

Within study abroad, Martin is recognized the earliest researcher who adopts banks using Logistic model to predict financial crisis of banks. However, the study on financial crisis prediction of enterprise investigated by Olsen is regarded as the most influential study, which used U.S. industrial listed companies data in 1970-1977, and took a certain number of bankrupt and non-bankrupt companies as samples, thus finding out that indicated that current assets capability, performance, capital structure and company size has a significant impact on enterprise bankruptcy.

Within domestic study, Li Wei-an and Xie Yong-zhen [14, 15] firstly expatiated on the connotation of corporate governance risk from a systemic perspective, and then constructed the early warning indexes system according to six dimensions of CCGINK and early warning models based on conditional probability model.

C. Artificial Neural Network (ANN) Model

In addition to these two classic warning models, some scholars have converted research perspective of financial crisis early warning on artificial neural network (ANN) model, which is a dynamic model formed by simulating human brain system.

Foreign scholars Tang Mo acted as pioneer in applying neural network theory to predict the financial crisis. His empirical results [16] have verified the feasibility of the application of ANN method to financial crisis early warning, and the prediction accuracy is higher. Subsequently, Coates and Font have adopted ANN analysis method to predict financial crisis between 47 healthy companies and 47 distressed company. The results have showed that the prediction accuracy rate is more than 91% for both healthy and distressed companies.

Within domestic studies, Yang Shu-e and Huang Li have constructed a BP neural network prediction model based on system financial crisis sectional data by taking 120 listed companies as modeling samples and introducing the date of other 60 listed companies during the same period into the model, thus finding out that its prediction accuracy rate both of modeling samples and prediction samples is all more than 90%, which is higher than the accuracy of the model based on principal component analysis.

D. Survival Analysis Model

The difference between survival analysis methods (Survival Analysis) and other multi-variable analysis method is that it takes the length of each sample observations experience time when it appears a result into account. Since the birth of life cycle theory, more and more scholars, investors and entrepreneurs have focused on the life of business or product [17]. Accordingly, the survival analysis method has been widely applied in many areas, including clinical medicine, biomedical statistics and Sociology, and the effect of survival analysis model prediction is better, and it provides a new train of thought for the diversification of financial early warning research of biological pharmaceutical industry. In recent years, it have gradually penetrated into all areas of urban transport, insurance, actuarial science, economics and the like.

Within study abroad, Wesley and Lane Rooney [18] firstly introduce survival analysis into the financial early warning, taking 21 financial indexes as explanatory variables in order to construct COX model, on which Chen and Lee investigate 75 oil and gas companies from 1980 to 1988 in the 1980s. Evidences show that corporate history and scale, mining success rate, liquidity ratio, and financial leverage ratio of operating cash flow have a significant impact on the survival rate of enterprises. Li, Shang et al apply survival model to investigate survival data of the U.S. 870 IT companies from 1995 to 2007 in the resource-based perspective. The study reveals that a high operational capacity can help develop the company's survival rate compared to many other influencing factors (such as high-Marketing, R & D capability) [19].

In domestic researches, Song Xue-feng and Yang Chao-jun apply COX model to analyze financial crisis prediction focusing on credit companies for Chinese commercial banks. Chen Lei [20] takes 233 companies (including 133 modeling samples and 100 predictive samples) as research subjects. 36 indexes selected are treated by principal component analysis. Finally, he carried out regressing analyses on 9 principal components obtained by COX method. The results have indicate that COX model shows a higher prediction accuracy in modeling and testing samples 3 years in advance, and prediction accuracy is the highest 1 year in advance, thus indicating that COX model has a higher application value.

IV. Comparative Analysis of Financial Early Warning Models

A. Overview on Methods for Financial Crisis Early Warning

1) Overview on financial crisis early warning indexes: In the previous study of financial early warning, traditional financial indexes are in widespread adoption. In the context of emerging economy and comprehensive demands for financial early warning information promoted by stakeholders, scholars are slowly beginning to pay attention to other types of financial crisis early warning indexes, such as cash flow indexes, non-financial indexes, in order to supplement and improve early warning indexes system, finally realizing the improvement of prediction accuracy. Because of the differences in economic environment, researches on cash flow indexes alone or acted as the main index for the financial early warning are of increasingly rare, most of which take traditional financial indexes as the research subject and take Cash flow and other non-financial indexes as auxiliary indexes. Although the indexes system is constantly improving, sometimes it still a certain system failed to fully embody specific features (for example, a specific industry) of research

samples, this is equivalent to saying that indexes are rarely combined with characteristics of the object [21].

2) Overview on financial crisis early warning models: From the literature review above warning model, it can be seen that scholars on early warning especially financial crisis early warning of enterprise is a fruitful area. Domestic and foreign scholars have made a lot of contributions, and accumulated a large amount of experience and lessons. Consequently, the suitable early warning ideas and methods in China are summed up.

At present, more popular domestic warning model are as follows: single variable and multivariate discriminate analysis model, multivariate logistic regression model, BP neural network model and survival analysis model. With the rapid development of statistical techniques and computer technology, financial early warning model is gradually improving. Compared with traditional model of financial early warning, few scholars apply survival analysis method to financial early warning model. Nevertheless, survival analysis has been much praised by domestic and foreign scholars for its unique characteristics of flexibility and survivability of its statistical data in recent years.

B. Comparative Analysis on the Current Financial Crisis Early Warning Methods

Currently, the study of financial early warning model has been highly concerned by domestic and foreign experts, scholars and the whole academic community, and has made good progress. Research methods of financial early warning have been developed from the single variable methods to artificial intelligence methods and survival analysis finally. Correspondingly, financial early warning prediction accuracy is improving. However, different theories and methods have different advantages and disadvantages. Reflected in the following aspects:

1) Assumptions of financial crisis early warning models: In terms of the model prerequisite assumptions, single variable discriminate analysis model discriminate model hasn't special provisions. Explanatory variables of multivariate discriminate analysis model must be normal distributed, and two groups of sample have co-variance. Accordingly, multivariate discriminate analysis model has the most stringent assumptions; conditional probability model co-variance requires two samples have co-variance; moreover, its explanatory variables are not exactly distributed in a nearly normal fashion. The assumption of conditional probability model is relatively loose; artificial neural network model has no assumptions; survival analysis model has a loose prerequisite, without the demand from paired samples. Meanwhile, distribution pattern of the survival function is not required.

2) Applications of financial crisis early warning models: In practical applications, discriminate analysis model and conditional probability model is also widely adopted in many areas; artificial neural network model, due to its inconspicuous advantages in science and accuracy and relatively abstract theory, therefore affecting its effect on the applicability; By comparison, survival analysis model can apply to most data situations because of its loose prerequisite. Moreover, the estimated value in survival analysis model is relatively ideal, thus increasing the stability of the model and compensating for the limitations of traditional financial early-warning model. Therefore, survival analysis model has been widely applied to many fields, such as various types of clinical trials, sociology, insurance, traffic studies, economy and many other industries and fields.

3) Overall analysis of financial crisis early warning models: In terms of overall evaluation of the model, the single variable model of discriminant analysis model need to find a single financial index that make difference between well-functioning companies and companies in crisis, and then use the single financial index to predict whether enterprise has the financial crisis, so the operation workload is relatively small and comparable. However, the model is vulnerable to subjective factors, potentially affecting the predictive objectivity and accuracy of financial early warning model; Multivariate discriminate model needs to find several financial indexes that make significant differences between well – functioning companies and companies in crisis. Therefore, its workload is bigger, while affecting its scope of application to some extent. However, since financial indexes can reflect the business conditions in different aspects as well as its clear theory, to a certain extent, it overcomes the subjectivity of the model and enhance the accuracy of the model prediction.

Conditional probability model overcomes the limitations that predictor variables of multiple discriminant model must have a strict "joint normal distribution", and does not require strict assumptions. Conditional probability model reveals business failure probability by explanatory variables of financial ratio based on the probability function with bigger workload, however, its predictive accuracy is relatively higher.

Without strict assumptions, artificial neural network model simulates human nerve system, thus possess a higher predictive accuracy. Moreover, it is provided with highly error correction and fault tolerance. Artificial neural network model is a

dynamic financial pre-warning model and shows increasing value in the fast-changing operating environment.

Few scholars apply survival analysis to financial early warning model, of which data type is a "binary variables Y + surviving time". It indicates that the time result of observation object is taken into account as well as the length of the observation object's surviving time. Dependent variable of survival analysis model is the company survival time, taking into the objective factor that financial ratios will vary with the course of time. In this sense, the estimation bias of survival analysis model can be reduced to a certain degree. Survival analysis method compensates the limitations of traditional financial models to a great extent, outshining other financial early warning models.

V. Implications and Prospects for Financial Early Warning Models

There exists an evolutionary process before company is put in a tight spot, more than an emergency, while in traditional financial early warning models, dichotomy is applied to classify a company's current condition: either well – functioning or in crisis. It can only diagnoses the company current survival condition but trends or probability in the future. In this kind of meaning, the relationship between surviving time of company and crises should be considered in financial early warning models and the surviving time of crisis.

On the aspect of selecting indexes of financial early warning model, requires static analysis as well as dynamic analysis. It is necessary to the static indexes as well as dynamic indexes into account; moreover, financial indexes and non- financial indexes (such as corporate governance index, corporate medium environment and macroeconomic environment) should be combined in order to investigate current and future integrated state of company more comprehensively.

In future research, on the one hand, macroeconomic indexes of financial early warning model should be taken into account in order to establish the indexes system of financial early warning model more scientifically. Consequently, the predictive accuracy for financial early warning model can be improved to some extent; on the other hand, it is necessary to lay more emphasis on dynamic indexes of financial early warning model, in this kind of meaning, process of enterprises is beset with financial crisis more realistically and reflect ti more directly.

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