Analysis of Financial Crisis Early Warning Model of Listed Enterprises in China

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Abstract. In recent years, many studies show that corporate financial crisis usually has a long hidden period. If this hypothesis can predict the financial crisis of enterprises, it is expected to control the destructive power brought about by the financial crisis to a minimum. Therefore, this paper takes 108 listed financial crisis companies (ST companies) and 435 non-ST listed companies in China's A-share annual report in 2019 as reference samples. Then, on the basis of these indicators, the corresponding models are established. The results show that through the analysis of various indicators, we can find the potential financial crisis prediction information and predict the company's financial distress. From the results of the model analysis, we can see that in the year before the financial crisis, the variables of the financial model are the most. This shows that the closer the year of ST occurs, the higher the accuracy of the model.

1. Introduction
At present, the market is continuing to mature. China's securities industry requires listed companies to implement special treatment (ST for short) when financial or other abnormal situations occur. Effective early warning models are very important, and many scholars are conducting related research on early warning models. This article selected a total of 435 listed companies in China's A-share market in 2018, a total of 435, which improves the richness and coverage of the sample. The major financial indicators of selected companies were tested for correlation and significance, and then profile analysis and univariate analysis were used to explore the variables that have a significant impact on the financial distress of the company. Then construct discriminant analysis and logistic regression warning model based on the selected sample data.

2. Analysis of financial crisis early warning theory

2.1. Related concepts
Financial Risk: "Financial risk" is generally classified by c from two perspectives: narrowly defined financial risk can be defined as the uncertainty of loss; broadly defined financial risk is broader than the former. This article summarizes the content of narrow risk.

The Definition, Characteristics and Influencing Factors of Financial Crisis: Financial crisis refers to the difficulties and crises of enterprises unable to repay deterministic debts due to excessive debt [1]. At first it is regular financial status, after the incubation period, financial risks arise, then accumulate, financial risk become financial crisis. If resolved then the status return to normal, if not, enterprises become bankrupt and have liquidation.
2.2. Related theories of financial crisis early warning

Disequilibrium theory and diagnostic theory: (1) Disequilibrium theory [2]: If it is substituted into the early warning system, it will be more scientific and accurate to determine whether the company has a financial crisis. (2) Diagnostic theory [3]: Using diagnostic theory, it is possible to diagnose and manage the production and operation process of an enterprise from a number of different perspectives.

Financial crisis early warning workflow and function: The financial crisis early warning system refers to the pre-judgment of financial risks of an enterprise by observing changes in relevant key financial variables. In the first stage, information is collected; then information processing is performed. In the information processing process, statistical methods are used to test the significance and correlation of indicators. Factor independent analysis is used to extract model independent variables; then model analysis is performed; and then business activities are determined whether it is in a safe state, whether the company's business behaviour complies with the regulations; then draw a warning result. If the risk is small, it is successful. If the risk is medium, it may succeed or fail. If it fails, adjust it. If the risk is high, adjust it. The end result may be a fresh start or bankruptcy.

3. Choice of financial early warning model

Comparative analysis of financial crisis early warning models: The most used models are multiple linear discriminant analysis and logistic regression models [4]. The results are shown in Table 1.

| Models                                | Application conditions                          | Model overview                                                                 | Use range                                                                 | strengths and weaknesses                                                                 |
|---------------------------------------|------------------------------------------------|--------------------------------------------------------------------------------|--------------------------------------------------------------------------|------------------------------------------------------------------------------------------|
| Linear Multiple Discriminant Analysis Model | All independent variables are normally distributed with equal covariance matrices | Compare the Z discriminant value with the critical value to determine whether the company is in a financially normal or crisis state | It has a wide range of applications, and many of them are limited to approximate states | Precise prediction high accuracy, but the workload is large, and the preconditions for independent variables exist |
| Logistic Regression Model              | None                                           | Calculate the conditional probability of the observed object to determine its operating status | It has a wide range of applications and less restrictions on the distribution of independent variables | High prediction accuracy without strict assumptions                                           |

Through the comparative analysis of the above table, the logistic regression prediction has high accuracy, and there are no strict assumptions, and the application range is wide. A logistic regression model will be used, supplemented by linear multiple discriminant analysis model.

4. Analysis of the Modelling of Financial Crisis Warning for Chinese Listed Companies

4.1. Selection of study samples and financial indicator variables

The research data in this article are mainly taken from authoritative collection websites such as Oriental Fortune and Sina Finance. The specific research object is the annual report of listed companies. These include: annual report data, selection of paired samples (non-ST), and data year. According to the above criteria, 108 ST or * ST listed companies in Shanghai and Shenzhen, were selected as samples for the financial crisis of 2015-2019, and 327 non-ST listed companies were selected as normal enterprises. Meet the 1: 3 ratio principle. This article adopts the viewpoint of scholar Li Hongmei, and takes into account 25 factors [5] affecting the financial crisis and the problems of listed companies.
4.2. Model building

Multiple discriminant Analysis Model: All variable substitution models are used for multivariate discriminant analysis. Non-ST companies are assigned a value of 0 and ST companies are assigned a value of 1. The obtained prediction results show that the correct rate is below 80%, mainly due to the non-uniform variance and different prior probabilities. Improvements to this are shown in Table 2:

**Table 2. Multivariate discriminant analysis results**

| Year | Whether ST | Predicted | Percentage Correct |
|------|------------|-----------|--------------------|
|      | 0          | 1         |                    |
| 2015 | 0          | 287       | 40                | 87.8 |
|      | 1          | 26        | 44                | 62.9 |
|      | Overall Percentage | | | 78.8 |
| 2016 | 0          | 263       | 64                | 80.4 |
|      | 1          | 38        | 28                | 42.4 |
|      | Overall Percentage | | | 76.6 |
| 2017 | 0          | 298       | 29                | 91.1 |
|      | 1          | 35        | 63                | 64.3 |
|      | Overall Percentage | | | 78.4 |

Improve the discriminant analysis model: Discriminant analysis is a comprehensive modeling analysis of all indicators. The improvement mainly takes into account inconsistent variances and prior probabilities in the group. The modified model is as Table 3:

**Table 3. Improved prediction results**

| Year | Whether ST | Predicted | Percentage Correct |
|------|------------|-----------|--------------------|
|      | 0          | 1         |                    |
| 2015 | 0          | 319       | 8                  | 97.6 |
|      | 1          | 55        | 13                 | 63.4 |
|      | Overall Percentage | | | 83.1 |
| 2016 | 0          | 321       | 6                  | 98.2 |
|      | 1          | 46        | 14                 | 76.7 |
|      | Overall Percentage | | | 84.7 |
| 2017 | 0          | 324       | 3                  | 99.1 |
|      | 1          | 26        | 15                 | 80.9 |
|      | Overall Percentage | | | 92.1 |

It can be seen that the prediction accuracy rate is greatly improved, and it is higher and higher as the year approaches ST, so the final decision function is:

\[ T-1: f = -5.729X4 + 0.001X10 + 0.059X21 + 0.535X23 - 0.664X24 - 0.373 \]
\[ T-2: f = 10.838X4 - 0.024X15 - 0.035X16 + 0.04X18 + 0.295 \]
\[ T-3: f = -7.666X4 + 0.001X10 + 0.002X12 + 0.003X14 + 0.017X15 - 0.083 \]

Logistics binary regression model: Using the same samples and indicators, logistic binary regression analysis was performed; binary logistic regression was performed for 2015, 2016, and 2017
by year, and all variables were included. Non-ST companies were assigned a value of 0 and ST companies were assigned a value of 1. The method of stepping backwards (based on the Wald value) was used, with 0.05 as the entry occur, 0.1 as the rejection probability, and 0.5 as the cut value. Logistic regression was performed. The actual prediction results based on the preliminary regression results are shown in Table 4

| Year | cut value | Whether ST | Predicted | Percentage Correct |
|------|-----------|------------|-----------|--------------------|
|      |           | Whether ST | 0         | 1                  |
| 2015 | 0.5       | 0          | 322       | 5                  | 98.5 |
|      |           | 1          | 54        | 14                 | 20.6 |
|      | Overall   |            |           |                    | 85.1 |
| 2016 | 0.5       | 0          | 317       | 10                 | 96.9 |
|      |           | 1          | 44        | 16                 | 26.7 |
|      | Overall   |            |           |                    | 86.0 |
| 2017 | 0.5       | 0          | 322       | 5                  | 98.5 |
|      |           | 1          | 25        | 16                 | 39.0 |
|      | Overall   |            |           |                    | 91.8 |

It can be seen from the above table that from 2015 to 2017, the prediction accuracy rate and Nagelkerke R² increased year by year, indicating that 2017 contains more information and can more accurately predict whether ST will occur in 2018.

Try to improve the results of the logistic regression model: After drawing and observing the stem and leaf map, try to adjust the cut value to 0.14; The reason for choosing this cut value is that it is closer to 2018 and there is a higher demand for the sensitivity of forecasting ST companies, so 0.14 was chosen as the cut value, which is more demanding. After improvement, the total accuracy rate in 2015 and 2016 increased or remained unchanged. In 2017, the total percentage correct slightly decreased, but the percentage correct of prediction for ST companies increased significantly. The improved prediction results are shown in Table 5.

| Year | cut value | Whether ST | Predicted | Percentage Correct |
|------|-----------|------------|-----------|--------------------|
|      |           | Whether ST | 0         | 1                  |
| 2015 | 0.51      | 0          | 316       | 11                 | 96.6 |
|      |           | 1          | 48        | 20                 | 29.4 |
|      | Overall   |            |           |                    | 85.1 |
| 2016 | 0.42      | 0          | 320       | 7                  | 97.9 |
|      |           | 1          | 44        | 16                 | 26.7 |
|      | Overall   |            |           |                    | 86.8 |
| 2017 | 0.14      | 0          | 285       | 42                 | 87.2 |
|      |           | 1          | 7         | 34                 | 82.9 |
|      | Overall   |            |           |                    | 86.7 |

The resulting function model is:

\[ T-3: \ln(P/(1-P)) = -8.675X4-0.809X7+1.613X17+0.427X19-0.504X20+0.224X21-0.971X22+0.909X23-0.041X25 \]
T-2: ln(P/(1-P)) = -16.882X4 + 0.001X8 - 1.017X9 + 0.068X15 + 0.025X16 - 0.075X18 + 0.7X19 - 0.817X20 - 0.045X25
T-1: ln(P/(1-P)) = -0.417X2 - 2.113X7 + 0.007X124.186X13 + 0.011X14 + 0.184X15 + 3.208X17 - 0.018X181.059X19 - 1.353X20 - 0.381X21 - 1.69X22 + 1.651X23 - 1.522X24 - 0.064X25

Improve logistic regression model: mainly aim at the variables included in P < 0.05 in 2015 and 2016 to improve the accuracy of the model. Through observation, the variables in Table 6, taking into account the significant variables left over from the three-year regression model, take 2017 as the focus and include all the variables in 2017, and only the variables with P < 0.05 were included in 2015 and 2016.

After performing regression analysis again and observing the adjusted decision points, the prediction result is:

Table 6. Classification Table

| year | cut value | Predicted | Whether ST | Percentage Correct |
|------|-----------|-----------|------------|--------------------|
|      |           |           | 0  | 1                |                   |
| 2015 | 0.43      |            | 316| 11               | 96.6              |
|      |           | Overall Percentage | 83.6      |                   |
| 2016 | 0.55      |            | 320| 7                | 97.9              |
|      |           | Overall Percentage | 85.1      |                   |
| 2017 | 0.38      |            | 319| 8                | 97.6              |
|      |           | Overall Percentage | 92.8      |                   |

The improved function is:
T-3: ln(P/(1-P)) = -8.675X4 - 0.809X7 + 1.613X17 + 0.427X19 - 0.504X20 + 0.224X21 - 0.971X22 + 0.909X23 - 0.041X25

Comparative analysis of model results: The two early warning models improved by logistic regression and discriminant analysis are used to compare and analyse the forecast results of the previous year, the first two years, and the first three years. The summary results are shown in Table 7:

Table 7. Early warning model comparison analysis table

| Year | Early warning model       | Early warning accuracy |                      |                      |
|------|---------------------------|------------------------|---------------------|---------------------|
|      |                           | ST Companies | Non-ST companies | All     |
| 2015 | discriminant analysis model | 63.4       | 97.6              | 83.1   |
|      | logistic regression model  | 60.9       | 96.6              | 83.6   |
| 2016 | discriminant analysis model | 76.7       | 98.2              | 84.7   |
|      | logistic regression model  | 68.9       | 97.9              | 85.1   |
| 2017 | discriminant analysis model | 80.9       | 99.1              | 91.5   |
|      | logistic regression model  | 80.6       | 97.6              | 92.8   |
According to Table 7, on the whole, the logistic regression model is better than the discriminant analysis model; for the identification of non-ST companies, the two models have high accuracy, but the accuracy of identifying ST companies is low; at the same time, it is found that the closer the ST is to the year, the greater the difference in financial data characteristics between ST and non-ST companies, the lower the model's false positive rate and the better the effect. Comparing the results of Wu Shinong and Ren Xiumei's master thesis in 2018, as shown in Table 8, the accuracy of this model in identifying non-ST is slightly higher than the conclusions of other literatures, but it is slightly inadequate in identifying ST. It can be seen that financial indicators have the characteristics of information content and growth over time; the specificity of the discriminant analysis model is higher, and the sensitivity is lower, which may be different from ST companies and industries.

Table 8. Comparison chart of accuracy (T-1)

| Logistic Regression (T-1) | Scholar | This Paper |
|--------------------------|---------|------------|
| Identify ST              | 94.29%  | 97.6%      |
| Identify non-ST          | 85.51%  | 80.6%      |
| Logistic Regression (T-2) | Identify ST | 85% | 68.90% |
| Identify non-ST          | 82%     | 97.90%     |
| Logistic Regression (T-3) | Identify ST | 70% | 60.90% |
| Identify non-ST          | 76%     | 96.60%     |

5. Research conclusions and recommendations
Main warning indicators: The company's financial crisis is a result which is the result of the interaction of a series of processes and many related factors. From the research results of this article, the asset cash recovery rate, current asset turnover rate, operating cost rate, return on assets, net asset interest rate, equity ratio, current ratio, quick ratio, and asset-liability ratio index variables are very important for this model.

Timeliness of sample data: The amount of information contained in the company's financial indicator data gradually increases with the years of the financial crisis. It is best to distinguish between ST companies and normal companies. It is more effective to select the data for the previous year, but you can now make predictions. The company will be delayed in taking corrective action. Therefore, even if a financial crisis is discovered and appropriate measures are taken, a comprehensive analysis should be combined with years of data.

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