

# Applying Grey Relation Analysis to Establish the Financial Distress Prediction Model for Electronic Companies in Taiwan

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## Abstract

The majority of past research has focused on the use of literature feedback or factor analysis as metrics for financial distress prediction. The theoretical basis for the former is relatively thin, while the latter is severely limited by data requirements. As such, this paper will instead use grey relation analysis to determine several indices with high levels of relation, and to select several representative indicators. This method will provide the indicators under a more sound theoretical basis, while also overcoming issues of time constraints on data collection or unknown data distribution types. Additionally, unlike previous financial distress prediction models which have frequently overlooked the differences between industries, this paper will use logistic regression analysis in the use of 26 electronics companies as research subjects, and after removing from the sample those with inadequate data, a total of nine companies will be analyzed according to applied finance and corporate governance indicators, building a financial distress prediction model for the electronics industry and then comparing the rate of error in both this and the traditional document-based model. Results show that 9 indicators are applicable to financial distress prediction in the electronics industry— 7 financial indicators and 2 corporate governance indicators. In terms of rate of error, over one year the two models' determinations of financial distress are minimally different, but going back over two years, the GRA model is less likely to be incorrect. As the number of years involved increases, so does the difference in error rate.

**Keywords** Grey Relation Analysis, Financial Distress Prediction, Logistic Regression Model.

## 1. Introduction

Previous research into financial distress has largely relied on document feedback or factor analysis for the determination of financial distress prediction indicators. However, the former has a relatively small theoretical foundation, while the latter requires

comparatively large amounts of data, placing limits on the applicability of either. Additionally, the financial distress indicators of different industries have their own unique elements and adjustments, and thus one cannot easily combine different industries and obtain practical results. This paper will take as its subject the electronics industry in Taiwan, using grey relation analysis to determine a selection of indicators with a high relation grade and select from these representative indicators. Through this these indicators will have a more sound theoretical foundation, while also overcoming problems caused by insufficient data. Then, through logistic regression, a financial distress model will be established, and then used to determine the predictive capabilities of grey relation analysis versus models created through the critical factors determined through previous research.

## 2. Literature Review

The financial predictive capabilities of logistic regression models developed through factor analysis of financial and non-financial factors are comparatively lower than those determined through prime variable analysis [12], and the K-W tests and M-W tests performed on financial indicators of different financial stages through non-parameter static method are significant [13]. In the one to three years preceding financial crises, after principal component analysis of financial and non-financial indicators, the predictive capabilities of logistic regression are less than those of stepwise regression [6].

In terms of indicator selection, the most important consideration is the use of financial and corporate governance indicators for use in financial distress prediction. The former was put forward by Smith and Winkor [10], suggesting that the use of financial ratios could predict business effectiveness. Through the use of univariate analysis to analyze financial reports we can see that cash flow/total debts is the best indicator of predicted business effectiveness [2], and the gradual selection of indicators through

multivariable determinate analysis and the establishment of a Z-Score is feasible for the prediction of risk. Within this, the independent factors most representative in factor analysis can be categorized as liquidity, profitability, solvency, financial leverage, and turnover rate [1].

At the same time, bearing in mind the characteristics of the financial indicators and the factors that cause financial crises to occur, the prediction capability of the model constructed by classified sample is better than the non-classified one [11]. However, financial reports can be subject to manipulation and window-dressing, and must be considered on many levels. Research on corporate governance indicators states that the possibility of corporate crises is correlated with low levels of shareholding and high pledge ratio, and the simultaneous holding of both CEO and GM positions by the same person [9]. Furthermore, financial distress is related to weak corporate governance, namely, the percentage of directors occupied by the controlling shareholder, the percentage the controlling shareholders shareholding pledged for bank loans, and the deviation in control away from the cash flow rights. The evidence suggests that the three variables mentioned above are positively related to the risk for financial distress in the following year[8]. Incorporating non-financial report information with financial information in the construction of a model increases the level of said model's predictive accuracy with regard to crises [7][14][3].

### 3. Research Method

The selection of financial distress prediction indicators for the electronics industry through documentary feedback and factor analysis gives said indicators a relatively thin theoretical foundation and is limited by the demand for high levels of data. Representative indicators will be selected through grey relation analysis and a financial distress prediction model will be created through logistic regression.

#### 3.1 Grey Relation Analysis

Grey system theory analysis was proposed by J.L. Deng of Huazhong Institute of Technology in 1982[4], and is primarily aimed at systems with uncertainty and incomplete data sets, enabling relational analysis of the system and the creation of models from such, and using

predictive and decision-making methods to investigate the situation of the system. According to Professor Deng's definition, the grey relational coefficient of subsequence  $x_i$  of sequence  $x_0$  at point P is:

$$\gamma(x_0(p), x_i(p)) =$$

$$\frac{\min_i \min_p |x_0(p) - x_i(p)| + \xi \max_i \max_p |x_0(p) - x_i(p)|}{|x_0(p) - x_i(p)| + \xi \max_i \max_p |x_0(p) - x_i(p)|}$$

$\xi \in [0, 1]$  here is the distinguished coefficient, which acts as a control on the comparison sequence and reference sequence sizes. It can be adjusted as practical demands dictate, changing the relative size values but not influencing the relational sorting. The coefficient is generally set at a value of 0.5. The level of grey relation between each factor,  $\gamma(x_0, x_i)$ , can also be found from averaging the grey relational coefficient, with the threshold value generally defined as a grey relational coefficient of 0.75 or mathematically stated,

$$\gamma(x_0, x_i) = \frac{1}{m} \sum_{p=1}^m \gamma(x_0(p), x_i(p))$$

#### 3.2 Logistic Regression Model

Put forward in 1944 by J. Berkson, this model differs from ordinary linear models in that its probability valued is set between 0 and 1, can be categorized according to two variables, and its empirical data does not need to conform to the limits of normal distribution

### 4. Research Design

#### 4.1 Data

The corporate financial distress data used by this research comes from Operating Articles 49, 50, and 51-1 of the Taiwan Stock Exchange Corporation. The companies' delisting dates and first recorded full delivery date were taken as standard dates, and data collection and sample taking commenced from there.

#### 4.2 Sample selection

From the TEJ data bank, a database of delisted managed full-delivery stocks, companies that suffered financial crises between 1990 and Sept.

2005 were selected, and then data for the three years preceding their financial crises was obtained. Collection method 1:1 Samples, grouped according to industry and similarity, were collected including public data from the crisis period and during ordinary operations. After removing gaps and omissions in data from the sample, a total of 26 companies that have suffered financial crises remained, with another 26 sample companies at normal operational levels, making a total sample size of 52. Data source: Data was selected from the TEJ data bank collection of listed and OTC companies and previously listed companies, aggregated industry reports, insider holdings, and full holdings. Sampling coordination was via the Taiwan Stock Exchange Corporation's listed companies database, law and rules database, and Market Observation Post System

### 4.3 Indicator Selection

Previous literature has focused on 10 primary indicators—six financial ratios and four corporate governance indicators, specifically: cash flow ratio, debt ratio, turnover frequency of total assets, return on assets, sales growth rate, net worth growth ratio, the shareholding ratio of large shareholders, the shareholding ratio of managers, the shareholding ratio of boards and directors, and stock pledge ratio. Through grey relation analysis we have selected nine indicators—seven financial ratios and two corporate governance indicators, specifically: return on assets, gross profit margin, cash flow ratio, total assets growth ratio, net worth growth ratio, quick ratio, turnover frequency of total assets, the shareholding ratio of managers, and stock pledge ratio.

### 4.4 Model Construction

For the formula for the model established with indicators found through previous research, refer to Formula 1. For the model established according to indicators determined through grey relation analysis, see Formula 2. The proof for the financial distress prediction model built through logistic regression of the factors used in the latter is as follows:

$$Y_i = \alpha_0 + \sum_{x=1}^6 \beta_{x,t} FV_{x,i,t-n} + \sum_{y=1}^4 \gamma_{y,i} CG_{y,i,t-n} + \varepsilon_i \quad (1)$$

$$Y_i = \alpha_0 + \sum_{x=1}^7 \beta_{x,t} FV_{x,i,t-n} + \sum_{y=1}^2 \gamma_{y,i} CG_{y,i,t-n} + \varepsilon_i \quad (2)$$

$Y_i$  : 1 indicates that company  $i$  is in a state of financial distress, while 0 indicates that company  $i$  is in a state of ordinary operations.

$FV_{x,i,t-n}$  and  $CG_{y,i,t-n}$  represent company  $i$ 's financial and corporate governance indicators respectively for the first, second, and third years.

$\alpha_0$  =company  $i$ 's point of interception;

$\varepsilon_i$  =company  $i$ 's point of divergence.

## 5. Empirical Analysis

From this research design we can see that indicators selected through grey relation analysis are largely similar to those used in previous research. Through logistic regression we establish a financial distress prediction model which shows clear significance. Amongst the financial indicators, gross profit margin shows high levels of significance through years one to three prior to financial crisis, and as such gross profit margin is an importance representative indicator of financial distress in the electronics industry. Additionally, return on assets shows significance for the two years immediately preceding financial crisis, and can provide investors a valuable reference for short-term investment decision-making.

With regard to corporate governance indicators, the two models both show significance in the one-year period immediately prior to financial crisis, indicating that corporate governance factors can reflect the current situation. The shareholding ratio of managers and stock pledge ratio show a clear effect, and for a representative indicator of corporate outcomes, internal factors such as stock pledge ratio and the shareholding ratio of managers can be effective.

From the simple model error analysis we see that the error rate amongst indicators determined through grey relation analysis is relatively lower, and that the more distant from the financial crisis one goes, the more error-prone the model is. Thus we can see that the close one is to financial crisis in the electronics industry, the more easily one can predict its probability of occurring.

## 6. Conclusion

Different industries require models for financial distress prediction that objectively reflect their distinctive characteristics. Through the use of grey relation analysis, this paper has selected indicators and provided a theoretical underpinning for the model, overcoming the

restrictions of insufficient data, and through logistic regression has established a financial distress prediction model. This model has been compared with factor analysis and documentary feedback based predictive models from previous research, and the results show that models built through grey relation analysis for the electronic industry include a total of nine financial distress prediction indicators—seven financial ratios and two corporate governance indicators. Of these, gross profit margin is the most predictive, while return on assets can provide investors with a valuable reference for short-term investment decision-making. The two models both show that corporate governance factors can reflect current situations, and the shareholding ratio of managers and stock pledge ratio can provide a conspectus for corporate effectiveness.

In the year immediately preceding a financial crisis in the electronics industry, the two models show no tremendous difference in error percentage; one further year prior, the GRA model shows less error, and can be relied upon to predict the probability of financial distress in those first two preceding years. Additionally, the two models show an increasing difference in error percentage as time continues to proceed. In other words, the closer a company in the electronics industry comes to financial distress, the higher the level of predictive effectiveness.

## 7. References

- [1] Altman, E. I., "Financial Ratios, Discriminant Analysis and the Prediction of Corporate Bankruptcy," *Journal of Finance*, Vol. 23, pp.589-609, 1968.
- [2] Beaver, W. H., "Financial Ratios as Predictors of Failure," *Journal of Accounting Research*, Vol. 4, pp.71-102, 1966.
- [3] Chen, C. P., "Study of Including Corporate Governance Variables into Financial Crisis Prediction Model: Application Logistic Model," Master Thesis, *Graduate Institute of Banking and Finance, Tamkang University*, 2003.
- [4] Deng, J. L., "Control problems of grey systems," *Systems and Controls Letters* 5, pp. 288-294, 1982.
- [5] Hu, W. C., "Alerting Model on Business Failure-A Study of Electronic Company in Taiwan," Master Thesis, *Graduate School of Business Administration, Chung Yuan Christian University*, 2004.
- [6] Kao, W. B., "Prediction of Corporate Financial Distress," Master Thesis, *Institute of Finance, National Sun Yat-sen University*, 2001.
- [7] Lee, T. S. and Yeh, Y. H., "Corporate Governance and Financial Distress: evidence from Taiwan," *Corporate Governance*, Vol. 12, 2004, pp. 378-388
- [8] Lin, C. Y., "A Study on Characteristics of Financially Distressed Company and Corporate Governance," Mater Thesis, *Graduate Institute of Accounting, National Taiwan University*, 2002.
- [9] Smith, R. F. and Arthur, H. W., "Change in Financial Structure of Unsuccessful Industrial Corporations," *University of Illinois, Bureau of Business Research*, Bulletin No.51, 1930.
- [10] Teng, C. H. "Using divided samples to detect financial-distress company--new financial distress forecasting model," Master Thesis, *Graduate Institute of Money and Banking, National Cheng Chi University*, 2000.
- [11] Tseng, S. G., "Investigation of the forecasting model for the financial crisis in problematic enterprises Evidence from Taiwan listed and OTC stocks in electronic category," *Mater Thesis, Institute of Business Administration, Shih Chien University*, 2004.
- [12] Wu, C. H., "The Comparative of Financial Ratios as Predictors of Failure in Taiwan Electrical and Plastic Industries," Master Thesis, *Institute of Business Administration, National PingTung University of Science and Tchnology*, 2004.
- [13] Yang, E., "Incorporating Financial Manipulation and Consolidated Financial Statements into the Financial Distress Model," Master Thesis, *Graduate Institution of finance, National Central University*, 2001.