# Financial Ratios as Predictors of Bankruptcy in Japan: An Empirical Research

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**Abstract:**

After the burst of the bubble economy in 1990, the Japanese economy has been on a downward slide and many companies have been faced with financial difficulties. Hence, a certain prediction model to assess the financial distress of Japanese firms is required. This paper presents some empirical results of a study regarding financial ratios as predictors of Japanese corporate failure, evidenced by bankruptcy. A few empirical studies of corporate bankruptcy in Japan have been undertaken. However, the results of these studies are not generalizable, due to the limited size of their samples. In contrast, the model proposed in this study is a universal model which is independent of industry and size. The study proves that the model can predict bankruptcy with more than 86.14% accuracy regardless of industry and size.

**Key words:** Financial Ratios, Bankruptcy, Multivariate Discriminant Analysis, Empirical Research in Japan

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Cindy Yoshiko Shirata[1]

## INTRODUCTION AND PURPOSE OF THE STUDY

Corporate Bankruptcies in 1997 recorded 16,365 cases, over 12.5% from 1996's figure of 14,544 and amount of debts was the highest in history, 14.21 trillion yen in Japan. After the burst of the bubble economy in 1990, the Japanese economy has been on a downward slide and many companies have been faced with financial difficulties. Hence, a certain prediction model to assess the financial distress of Japanese firms is required. This paper presents some empirical results of a study regarding predictors of Japanese corporate failure as evidenced by the event of bankruptcy.

A few empirical studies of corporate bankruptcy in Japan have been undertaken. However, the results of these studies are not generalizable due to the limited size of their samples. In contrast, this study proposes a generalizable bankruptcy prediction model based on observations of 686 firms which went bankrupt, and 300 non-bankrupt firms which were extracted from 107,034 non-bankrupt firms by systematic sampling method.

This study is comprised of two stages. First, I attempted to obtain a set of the financial ratios to best predict Japanese corporate bankruptcy using data mining technique without any initial hypothesis. After the variables (financial ratios) selection, I hypothesized that (1) the linear Multivariate Discriminant Analysis (MDA, for short) model is suitable and useful for Japanese corporate bankruptcy prediction while a quadratic model and other non-parametric model are not, and (2) a model using certain ratios must be a universal model independent of industry or company size.

## QUESTIONS REGARDING PREVIOUS STUDIES

There have been a fair number of previous studies addressing the prediction of bankruptcy in the USA: well-known published contributions are Beaver [1966], Beaver[1968], Altman [1968], Meyer & Pifer [1970], Deakin[1972], Edmister [1972], Altman & McGough [1974] and Altman, Haldeman, and Narayanan [1977]. Some other notable contributions developing probabilistic prediction models are Martin [1977], Ohlson [1980], Zavgren [1985] and Lau [1987]. In Japan, there are also a few notable studies: Takahashi, Kurokawa & Watase [1979], Toda[1984] and Gotoh[1989].

I pose some questions to the previous studies both from a statistical point of view and from an accounting point of view.

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*Statistical issues*

(1) In previous studies, the method used to select variables is not clear. It is difficult to obtain the best set of variables at one try using statistical methods. However, previous studies never mentioned how to reduce or select the final set of variables from the initial variable set.

(2) It has not been proven whether paired sampling is advantageous or not. All researches using linear MDA typically use the paired sampling method matching bankrupt and non-bankrupt firms according to criteria such as industry and size. However, the criteria were made by researchers' arbitrary decision. Sample selection biases might also occur. Hence, in this study, samples of bankrupt and non-bankrupt firms are not matched at all

(3) In the previous studies, the sample of bankrupt firms were small, e.g. 20 firms to 150 firms. It is difficult to clarify the financial characteristics of bankrupt firms with such a small sample. In contrast, this study uses a large number of bankrupt firms which failed in Japan during the period between 1986 to 1996, and thus develops a more generalizable model.

*Accounting issues*

Each previous study mentions the list of all variables but does not clearly mention the detail computation steps to obtain the variables. Income Statement shows a summary of revenue and expenses of a business entity for a specific period of time, such as a year. On the other hand, Balance Sheet shows a list of the assets, liabilities and owner's equity of a business entity as of a specific date, usually at the close of the last day of a fiscal year. Hence, the statements can not be compared or computed directly. To compute the financial ratios using Balance Sheet accounts, it is necessary to use averages during the period to obtain accurate ratios. There are no previous studies mentioning this point.

## METHODOLOGY

*Variable selection*

Several previous studies had used a brute empirical approach of initially choosing variables followed by Stepwise procedure to select the variables in the final discriminant function. However, these studies are limited in their ability to provide generalaizable results as to what financial variables can consistently predict financial distress. Therefore, in this study, the following systematic statistical approach is taken to select the best set of variables for predicting bankruptcy.

(1) Data Mining Approach

Data mining was used to select the best set of the variables. The most popular and

powerful data mining tool is Classification And Regression Tree model (CART model for short) which is now available with S-Plus or SAS program. The purpose of a classification study can be to produce either an accurate classifier or to uncover the structure of bankruptcy. This study aims for the latter, and tries to get an understanding of what variables or interactions of variables cause bankruptcy.

CART model selects the variables accurately without any requirements of statistical assumption, therefore, all collected data can be used. In this study, when CART model was used to selects the variables, the variables were also selected by Stepwise procedure to compare the results. Stepwise procedure requires the statistical assumption that the variables are normally distributed. To satisfy this hypothesis, data were trimmed off in groups of 20 from each end of the ordered data.

The reason two different techniques were used to select the variables was to confirm the accuracy of variable selection through comparison of the results of the two techniques.

(2) Original financial ratios

The original sixty-one financial ratios are listed in appendix A with certain relevant statistics. The ratios were chosen on the basis of (1) popularity in literature, (2) usage by the Japan Development Bank, (3) usage by Teikoku Data Bank of its Cosmos 1 credit database, and (4) the author's initiated hypothesis. The variables can be classified into the following categories (1) popularity in the literature (X1-X8), (2) growth (X9-X12), (3) capital efficiency (X13-X16), (4) profitability (X17-X24), (5) activity (X25-X38), (6) productivity (X39-X43), (7) liquidity (X44-X53) and (8) coverage and other earnings relative to leverage measures (X49-X61).

*Sample design*

The samples include all bankrupt firms obtained from Teikoku Data Bank Cosmos1 Database[2]. The data set for this study is 686 bankrupt firms and 300 non-bankrupt firms. The 300 non-bankrupt firms were extracted from 107,034 non-bankrupt firms by systematic sampling method. All the bankrupt firms had failed between 1986 to 1996 in Japan. Although almost all the firms in the sample were unlisted companies, the average size of their assets were 3,757 million yen (bankrupt firms) and 3,847 million yen (non-bankrupt firms). As an exception, financial service companies (bank, insurance and securities firms) and construction companies were excluded. Companies in these industries are structurally different and have a different bankruptcy environment. In particular, according to Japanese Accounting Principles, construction companies can choose to define the value of their total sales either on a basis of percent completion or on a basis of completed construction. This makes it difficult to compare operational performances with companies in other industries.

In this study, the definition of failure is purely legalistic, however, the sample also includes cases of composition undertaken without courtroom procedures.

[2] About 1,000,000,000 financial statements of 250,000 Japanese firms (all industry and size) are stored in Teikoku Data Bank's Cosmos1Data Base. The company also has the Bankruptcy Data File which contains the name of failed firms, the date of filing and reason for bankruptcy.

## EMPIRICAL STUDY IN JAPAN

### *The first stage of reducing variables*

The result of the first stage of variable reduction was that almost half of the variables chosen by the CART model and Stepwise procedure were the same. However the ratios indicating the strongest discriminant power were different for each procedure. CART model gave X2 (Retained earnings to total assets) as the strongest predictor, and Stepwise procedure gave X50 (Equity to Liabilities and shareholders) as the strongest predictor. I attempted to compare the characteristics of these two variables to understand why each procedure chose different variables as the most powerful predictor. First, the correlation matrices between the two variables were examined. Table I presents the result of correlation tests for both variables.

Take in Table I

The tests confirm that both X2 and X50 have strong positive correlation and that the two procedures selected accurate variables because they have almost the same characteristics from a statistical point of view. However, from an accounting point of view, they have the different characteristics. If a company increases its capital during the period and retained earnings is unchanged, X2 decreases while X50 increases. Here, I investigated how many bankrupt firms increased their capital during the period previous to bankruptcy. It was found that 17.4% of the bankrupt firms, one hundred firms, increased their capital in the period previous to bankruptcy. Companies tried to increase their capital not only when facing financial distress but also during their growth stage. Hence, taking the conservative position to predict bankruptcy, I omitted X50 (Equity to Liabilities and shareholders) as this variable can potentially mislead the information user. Here, X2 and other 42 variables which were selected by one of the two procedures were retained.

### *The second stage of reducing variables*

In the second stage, among the top seven variables chosen by both procedures six were the same. From a statistical point of view, it is certain that these six variables are strong indicators of bankruptcy. These variables were X2, X10, X24, X36, X39 and X53. However, it is believed that two of these, X39 (Sales Per one Employee) and X53 (Fix assets to Long-term capital) are not suitable variables as a predictor of bankruptcy. The statistical significance does not always follow accounting logic. I strongly point out here that it is dangerous to select the variables using only statistical logic.

The reason why X39 and X53 are not suitable variables as predictors of bankruptcy, even though they appear to strongly discriminate between bankrupt and non-bankrupt firms, is explained as follows: It is widely believed that ratio of Sales per one Employee should be higher and ratio of Fixed Assets to Long-term capital should be lower when a firm is financially healthy. However, for all practical purposes, the ratios for the bankrupt sample

indicated a better condition than those for the non-bankrupt sample. The reason for this is that firms facing financial distress tried to reduce organizational redundancy or sell fixed assets to improve cash flow. Companies facing financial distress and companies in health financial condition, both indicated better ratios for these variables. The drawback of statistical analysis is that it can lead to incorrect conclusion. Therefore, I omitted these kinds of variables from the variable set carefully following accounting logic.

There were also another 15 variables commonly selected by both techniques. Therefore, a total of 19 variables were retained for the final reduction stage.

### *Final stage of reducing variables*

The results of the final stage of variable's reduction by both procedures are illustrated in Table II.

Take in Table II

As shown in the table, the first four variables chosen by both procedures are the same and exhibit strong discriminant power at the second stage. As the variables could not be reduced further by analytical techniques, the final set of variables was selected at this stage. Hence, I chose the first four variables, X2, X24, X36 and X10, for the discriminant function. I tried to add other variables, however, I could not significantly improve upon the results by adding or changing the set of variables.

As the result of both procedures was almost the same, I could confirm that the selected variable set is reliable and consistent from both statistical and accounting view points.

## EVALUATION OF SELECTED VARIABLES

### *Independency of each variable*

The correlation among the selected variables was evaluated, as it is probable that some of the financial ratios have a high degree of correlation. If some variables are highly correlated, they have the same influence on the financial position of the firm. Bankruptcy is caused by many different factors. Therefore, it is desirable to assess a firm from many different positions. Shirata [1996] pointed out that the set of variables used by Altman model [1968] could be classified into two groups by principal coordinates analysis. This means that the five variables chosen in his study have two different characteristics and can assess firms from two different positions. If the set of four variables chosen in this study do not have a high degree of correlation, they have different characteristics and can assess firms from four different positions. Table III & Table IV present the results of the correlation analysis on the four variables chosen in this study. The upper line shows the correlation coefficient by Pearson and Spearman methods, and bottom line shows the significance probability for the null hypothesis that the value of correlation coefficient equals zero.

Take in Table III

Take in Table IV

The results of this examination prove that the characteristics of these four variables are independent because they are uncorrelated. This also proves that the selected variables in this study can assess firms from four different positions.

*Evaluation of discriminant power*

The discriminant power of the set of variables which were selected in this study and the set of variables which were used in previous studies [Altman 1967] and Toda [1985] were compared. Both previous models consisted of five variables. One of the five variables, Market value equity per value of debt, used in both previous studies could not be used with the sample of this study. Therefore, the discriminant power of four variables set were compared. The procedure of comparison was (1) to trim away 20 outliers from each end of the ordered data, (2) to divide all samples into two groups for modeling data and test data and (3) to set the cut-off point at 50%. Table V illustrates the results of the evaluation of misclassification of bankruptcy and non-bankruptcy using the three sets of variables.

Take in Table V

The result of this evaluation proves that the set of variables selected in this study has the power of discriminant between bankrupt firms and non-bankrupt firms as the misclassification ratio was just 15.96%. Altman [1968] stated that the misclassification ratio using the financial ratios he selected one year prior to bankruptcy was 4% for the bankrupt group and 21% for the non-bankrupt group. However, the analysis of his study was done with just 33 manufacturing firms using paired sampling method. Accordingly, his model is not generalizable due to the limited size of his sample using paired sampling method. In contrast, the variable set selected in this study is more reliable and generalizable because the analysis was done with more than 520 firms from many different industries including manufacturing, wholesale, retail and service.

Another examination of the discriminant analysis for the mean value of each group, bankrupt firms and non-bankrupt firms was also undertaken. The result showed that the mean value for the bankrupt group was 98.05% bankrupt probability, and the mean value for the non-bankrupt group was 74.24% non-bankrupt probability, with a 50% cut-off point. Even though the cut-off point was 50%, the type I error is smaller than the type II error, which is preferable.

*Evaluation of the influence of industry and size*

It is widely believed that industry and size influence the relationship between financial ratios and bankruptcy status. However, Altman [1968] pointed out in his study that ”it is not

completely clear what the relationship is between size and ratio" and "matching exact asset size of the two groups seemed unnecessary." Therefore, this study hypothesizes that there is no influence between the selected variables in this study and industry or size.
Before starting the analysis, all samples were classified by industry and size. It must be mentioned here that it is popular to classify firms not by asset size but by capital size in Japan. Therefore, they were classified by capital size in this study. Table-6 illustrates the result of classification.

Take in Table VI

There were three classifications for industry. The Wholesale & Retail group consisted of 390 wholesalers and 67 retailers. The others group consisted of 50 transportation firms, 127 service industries and 8 firms from other industries.

At first, the results of discriminant analysis for each industry group and for each capital group were compared, and the mean value of each group was analyzed. The results of the analysis are presented in Table VII and Table VIII.

Take in Table VII

Take in Table VIII

The mean value for each of the bankrupt groups was more than 92% bankruptcy probability. Only the non-bankrupt firms of the other industry group showed 48.8% non-bankrupt probability. However, the purpose for assessing the firms was to predict bankruptcy, and the cost of type I error was more expensive than type II error. Therefore, the results of this examination prove that the set of variables selected in this study can significantly discriminate the bankrupt group independent of industry and size. The reason why the discriminant power of the variables set was significant is that these four variables are not influenced by industry or size.

In this study, I also attempted to find which variables are influenced by industry and size through data mining technique, CART.

Take in Table IX

It is clear that if the variables presented in Table IX were selected for the discriminant function, the result of the discriminant analysis would be affected by industry and size. On the other hand, the variables selected in this study do not include these variables. Therefore I can conclude here that (1) it could not be proved that industry and size influence the bankruptcy phenomenon more than the four selected variables and (2) the variables which are influenced by industry and size are not included among the selected variables of this study. Therefore, the variables selected in this study are the universal predictor of bankruptcy beyond industry and size.

## MULTIVARIATE DISCRIMINANT ANALYSIS MODEL

### *Suitable Model*

I attempt to develop the MDA model using the selected four financial ratios. Before developing the model, there is the question of whether a linear model is suitable than quadratic or other non-parametric model, normal kernel method model[3]. Altman [1968] pointed out in his study that the holdout sample tests indicate a clear superiority of linear frameworks. This should also be verified using the four financial ratios selected in this study. To verify this, I assessed eleven Japanese bankrupt firms which were not included in the original sample with linear, quadratic and normal kernel method model using the four selected variables (refer to Appendix B). These eleven firms had been listed in the Japanese stock market when they went bankrupt during the period between 1986 - 1996.

The most notable result was the bankruptcy probability of Ga-jo-en Kanko K.K. which entered into arrangement procedures in January 1997. The ratio of Retained earnings to total assets (X2) of firm was -102.89 one year prior to bankruptcy which leaves no doubt regarding its impending insolvency. However, the bankruptcy probability indicated by the quadratic model and the normal kernel method were 0%. On the other hand, the linear model estimated its bankruptcy probability as 99.99%. The results of these three models were completely opposite. And it is clear that the linear model is the superior model for predicting bankruptcy in Japan.

### *Modeling and cut-off point*

Since the accuracy and reliability of the four selected variables have been proven, I developed the linear MDA function as follow:

$$\mathbf{Z = 0.014X2 - 0.058X24 - 0.062X36 - 0.003X10 + 0.7416}$$

I analyze the distribution of the Z score for both bankrupt and non-bankrupt groups to fix the cut-off point. Classification accuracy of the model will change depending on the cut-off point. The balance of type I error cost and type II error cost should be considered. Finally, 0.38 was chosen as the Z value that best discriminates bankrupt firms and non-bankrupt firms with the lowest misclassification cost. Firms with Z values less than 0.38 have a high probability (86.14%) of going bankrupt. However, it must not be forgotten that the most important point is not the cut-off point, but which variables to use for the function.

## CHARACTERISTICS OF BANKRUPTCY IN JAPAN

### *Characteristics of Corporate Behavior*

[3] Normal Kernel method with diameter r=0.4 which is the best cut-off point of discrimination.

Having selected the variable set for the prediction model, I can explain corporate behavior facing financial distress in Japan as follow;

> *When the cumulative profitability of a firm decreases (the ratio of "X2 Retained earnings to total assets" decreases), it asks its suppliers to extend the date for payment to increase its cash flow (the ratio of "X36 Note payable + accounts payable x12 to Sales" is larger). However once it asks its suppliers to extend the date for payment, news of bad credit travels through the market. This news makes its Bank anxious about its financial condition. Therefore, the Bank requests that it pays an additional premium for its loan (the ratio of "X24 Interest and discount expense to borrowings + corporate bond + note receivable discounted" increases). Cash spending increases and the company tries to raise funds, increasing liabilities or capital in a year (the ratio of "X10 Current gross capital to Previous gross capital -1" increases).*

It should be specially noted that among the four variables of the model, profitability is not included. The major cause of decreasing cumulative profitability (reducing X2) is decreasing profitability. However, even though a company's profitability decreases, it can have plenty of cumulative profitability and may not go bankrupt.

*Transition of Z score of Japanese Bankrupt Firms*

I examine eleven Japanese listed bankrupt firms to determine the overall effectiveness of the model for a longer period of time prior to their bankruptcies. Altman [1968] mentioned in his study that after three years prior to the bankruptcy, the discriminant model becomes unreliable in its predictive ability.

Take in Graph I

Graph I presents the transition of Z score of eleven firms for ten years prior to their bankruptcies. It was found that almost all firms had shown worse Z score for ten years continuously. I suppose that this is one of the typical financial characteristics of Japanese bankrupt firms. Because the majority of corporate stockholders of listed firms in Japan are banks and other corporation. It is called cross-shareholding, MOCHIAI. It's easier for firms to obtain financing from a bank which is a shareholder even though the financial condition of the firm were getting worse. Hence, suitable size firms like listed companies cannot go bankrupt as soon as they failed in their business. This means if you assess firms with the certain model, you can recognize the sing of their failures for a considerable time prior to actual bankruptcies.

## CONCLUSIONS

The model developed in this paper is significantly more accurate in predicting bankruptcy for Japan firms than existing models.

One of the notable points is that the variables selected in this study do not include profitability and liquidity ratios. It is widely believed that profitability and liquidity ratios can predict bankruptcy to a certain extent. However, it is proven in this study that these financial ratios could not expose the financial distress of Japanese firms. Another noteworthy point is that the model proposed in this study is a universal model which is not influenced by industry and size. I proved that the model could classify bankrupt firms with more than 86.14% accuracy independent of industry and size. I also proved that the Japanese bankrupt firms had indicated their worse financial position for a considerable time before they actually went bankrupt.

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**Appendix A Listing all variables, Univariate W:Normal, T-value based on one year prior to bankruptcy data**

| Valiable | | unit | W:Normal (%)** | | T-value |
|---|---|---|---|---|---|
| No. | Name | | Failed | Nonfailed | |
| X1 | Net income before tax/Sales | % | 60 | 89 | -4.5857*** |
| X2 | Retained earnings*/total assets* | % | 85 | 97 | -8.9932 |
| X3 | Quick assets*/current liability* | % | 97 | 96 | -3.6720*** |
| X4 | Interest and discount expense/Sales | % | 92 | 86 | 8.2369 |
| X5 | Working capital*/total assets* | % | 97 | 98 | 2.3931*** |
| X6 | EBIT/total assets* | % | 87 | 94 | 0.3243*** |
| X7 | Sales/total assets* | % | 90 | 89 | -1.1084 |
| X8 | Net income before tax/total assets* | % | 69 | 93 | -6.0700*** |
| X9 | (Sales at beginning of a period/Sales at end of a period)-1 | % | 90 | 91 | 3.2464 |
| X10 | (Current period liabilities and shareholders equity/Previous period liability and shareholders equity)-1 | % | 88 | 97 | 4.4717 |
| X11 | (Current period equity/Previous period equity)-1 | % | 66 | 81 | -1.9230 |
| X12 | (Current period operating income/ Previous period operating income)-1 | % | 69 | 70 | -1.1676 |
| X13 | Operating income/Liabilities and shareholders equity* | % | 73 | 95 | -5.6935*** |
| X14 | (Operating income + interest and discount expense)/Liabilities and shareholders equity* | % | 89 | 96 | 0.5517*** |
| X15 | Operating income/Equity* | % | 75 | 91 | -3.1305 |
| X16 | Net income after tax/Equity* | % | 65 | 87 | -2.9970 |
| X17 | Operating expense/Sales | % | 92 | 97 | -0.4641 |
| X18 | Non-operating revenue/Sales | % | 73 | 63 | 0.8115*** |
| X19 | Non-operating expense/Sales | % | 92 | 88 | 7.7245 |
| X20 | Operating income/Sales | % | 64 | 92 | -4.4375*** |
| X21 | Net income after tax/Sales | % | 53 | 74 | -3.4192 |
| X22 | (Interest income - interest and discount expense)/Sales | % | 91 | 85 | -7.5267 |
| X23 | Interest income/(Short term loans + long term loans + securities + fixed assets investment + investment + cash)* | % | 88 | 90 | 6.5135 |
| X24 | Interest and discount expense/ (Short term borrowings + long term borrowings + corporate bond + convertible bond + note receivable discounted)* | % | 94 | 90 | 9.4707 |
| X25 | Liabilities and shareholders equity* x12/Sales* | month | 93 | 91 | 0.4467*** |
| X26 | Fix assets* x 12/Sales | month | 80 | 92 | -3.4507*** |
| X27 | Current assets* x 12/sales | month | 93 | 90 | 4.3516*** |
| X28 | Tangible fixed assets* x 12/sales | month | 76 | 84 | -3.5704*** |
| X29 | (Note receivable + accounts receivable )* x 12/Sales | month | 95 | 95 | 1.1382*** |

| Valiable | | unit | W:Normal (%)** | | T-value |
|---|---|---|---|---|---|
| No. | Name | | Failed | Nonfailed | |
| X30 | (Note receivable + accounts receivable + note receivable discounted)* x12/Sales | month | 98 | 95 | 5.7244*** |
| X31 | (Note receivable + note receivable discounted)* x12/Sales | month | 94 | 85 | 5.4292*** |
| X32 | Note receivable discounted* x 12/ Sales | month | 82 | 81 | -1.2495*** |
| X33 | Accounts receivable x 12/Sales | month | 92 | 83 | 2.4612*** |
| X34 | Inventory* x 12/Sales | month | 79 | 73 | 4.6638 |
| X35 | Finished goods* x 12/Sales | month | 70 | 60 | |
| X36 | Note payable + accounts payable)* x 12/Sales | month | 97 | 95 | 6.1259*** |
| X37 | Note payable* x 12/Sales | month | 97 | 90 | 7.6018*** |
| X38 | Accounts payable* x 12/Sales | month | 92 | 94 | -3.0767*** |
| X39 | Sales/Number of Employee s* | bill. Yen | 70 | 66 | 3.7484 |
| X40 | Gross Margin/Number of employees* | bill. Yen | 83 | 93 | 2.1961 |
| X41 | Selling and administrative expense/ Number of employees* | mill. Yen | 81 | 92 | 1.4868 |
| X42 | Operating income/Number of employees* | mill. Yen | 79 | 92 | -3.5941*** |
| X43 | Tangible assets*/Number of employees* | mill. Yen | 64 | 75 | 0.1217 |
| X44 | Current assets*/Current liabilities* | % | 96 | 94 | 0.8669*** |
| X45 | (Note receivable + accounts receivable)*/(Note payable + accounts payable)* | % | 79 | 87 | -3.6659*** |
| X46 | Cash* x 365/Sales | day | 85 | 91 | -0.0569*** |
| X47 | Quick assets*/(Selling and administrative expense/365) | day | 77 | 89 | 4.1256 |
| X48 | Cash*/(Selling and administrative expense/365) | day | 75 | 81 | 2.4518 |
| X49 | (Current assets + fixed assets)*/Equity* | % | 92 | 73 | 6.0121 |
| X50 | Equity*/Liabilities and shareholders equity* | % | 92 | 94 | -9.0807 |
| X51 | (Short term borrowings + long term borrowings + corporate bond + note receivable discounted)*/Liabilities and equity + note receivable discounted* | % | 98 | 98 | 5.5479 |
| X52 | Fixed assets*/Equity* | % | 85 | 69 | 1.2565 |
| X53 | Fixed assets*/Fixed liabilities and equity* | % | 92 | 93 | -3.3950*** |
| X54 | (Tangible assets at end of peirod - tangible assets at beginning of peirod)/Tangible assets at beginning of period | % | 27 | 70 | 2.9670 |
| X55 | Operating income + interest income/ interest and discount expense | times | 71 | 23 | -2.3259 |
| X56 | (Current liabilities and fixed liabilities)* x 12/Sales | month | 92 | 88 | 2.3295 |

| | Valiable | unit | W:Normal (%)** | | T-value |
|---|---|---|---|---|---|
| No. | Name | | Failed | Nonfailed | |
| X57 | Current liabilities* x 12/Sales | month | 92 | 88 | 3.3856*** |
| X58 | Short term borrowings* x12/Sales | month | 81 | 80 | 0.9872*** |
| X59 | Equity* x 12/Sales | month | 88 | 92 | -7.3663 |
| X60 | Fixed liabilites* x 12/Sales | month | 83 | 81 | 0.6141*** |
| X61 | (Corporate bond + long term borrowings)* x 12/Sales | month | 83 | 80 | 1.2250*** |

Notation:

* average amount during the period

** trimmed off each 20 data from each end of ordered data.

*** in case of the level of *F*-value is more than 5%.

## Appendix B The Result of Linear, Quadratic and other non-parametric Analysis one year prior to Bankruptcy of Japanese Listed Firms

| Name of Firms | Year of Bankruptcy | X2 | X10 | X24 | X36 | Linear | Quad-ratic | Normal Kernel |
|---|---|---|---|---|---|---|---|---|
| Toyo Tanshi Co., Ltd. | 1986.4 | 4.718 | -7.610 | 6.834 | 2.835 | 67.62 | 61.46 | 84.23 |
| Ohto Co., Ltd. | 1986.5 | 17.132 | 40.267 | 10.648 | 2.358 | 86.83 | 99.66 | 76.49 |
| Kokko Steel Works Co., Ltd. | 1986.8 | -30.564 | -10.333 | 5.883 | 2.857 | 98.27 | 0.01 | 100.00 |
| Lek Inc. | 1992.5 | 14.907 | 13.897 | 6.718 | 2.662 | 49.50 | 33.35 | 43.72 |
| Daichibo Co., LTd. | 1992.10 | -15.031 | -15.351 | 7.302 | 2.772 | 94.55 | 17.71 | 99.98 |
| Nikkatsu Co., Ltd. | 1993.7 | -4.220 | -8.731 | 7.089 | 1.824 | 78.70 | 45.49 | 84.21 |
| Koyo Machinery Co., Ltd. | 1993.12 | 8.739 | 7.216 | 6.307 | 5.024 | 80.46 | 89.02 | 87.55 |
| Oriental Photo Industrial | 1995.5 | 0.676 | -4.370 | 4.446 | 1.267 | 36.92 | 20.10 | 14.36 |
| Ga-jo-en Kanko KK | 1997.1 | -102.891 | 9.732 | 3.768 | 0.293 | 99.99 | 00.00 | 00.00 |
| Kyotaru Co., Ltd. | 1997.1 | 3.594 | -3.447 | 4.408 | 0.423 | 22.50 | 18.57 | 44.13 |
| Yaohan Japan Corporation | 1997.9 | -5.451 | -10.141 | 2.768 | 1.012 | 29.80 | 6.47 | 19.51 |

Notation: Linear and Quadratic: Discriminant Analysis with 50% cut-off point

Normal Kernel: diameter r = 0.4

**Table I Correlation coefficient between X2 and X50**

| | | Pearson | Spearman |
|---|---|---|---|
| Bankrupt | All Data | 0.96 | 0.72 |
| Without outliers | | 0.77 | 0.71 |
| Non-bankrupt | All Data | 0.89 | 0.85 |
| Without outliers | | 0.80 | 0.84 |

**Table II Selected variables of the final stage**

| | Stepwise | | Tree Based Model |
|---|---|---|---|
| Order | Valuables | *F*-Value | Variables |
| 1 | X2 | 0.0001 | X2 |
| 2 | X24 | 0.0001 | X24 |
| 3 | X36 | 0.0001 | X36 |
| 4 | X10 | 0001 | X10 |
| 5 | X5 | 0.0001 | X4 |
| 6 | X26 | 0.0001 | X13 |
| 7 | X13 | 0.0001 | X38 |
| 8 | X3 | 0.0052 | X5 |
| 9 | X14 | 0.0293 | X17 |
| 10 | X33 | 0.0600 | X14 |
| 11 | X38 | 0.0791 | X33 |

**Table III Correlation of the selected four variables (bankrupt group)**

| | | X2 | X10 | X27 | X40 |
|---|---|---|---|---|---|
| | | Pearson Correlation | | | |
| X2 | S | | 0.00860 | -.00434 | 0.00287 |
| | p | | 0.8221 | 0.9097 | 0.9402 |
| X10 | e | 0.00049 | | -.003549 | -.03653 |
| | a | 0.9898 | | 0.3533 | 0.3402 |
| X27 | r | 0.04334 | -.09644 | | -.02678 |
| | m | 0.2569 | 0.0115 | | 0.4844 |
| X40 | a | -.09892 | -.08409 | 0.01684 | . |
| | n | 0.0096 | 0.0279 | 0.6601 | |

**Table IV Correlation of the selected four variable (non-bankrupt group)**

| | | X2 | X10 | X27 | X40 |
|---|---|---|---|---|---|
| | | Pearson Correlation | | | |
| X2 | S | | 0.14389 | -.00452 | -.04012 |
| | p | | 0.0126 | 0.9379 | 0.4888 |
| X10 | e | 0.12944 | | -.01568 | -.11612 |
| | a | 0.0250 | | 0.7868 | 0.0445 |
| X27 | r | -.06368 | -.05915 | | 0.07547 |
| | m | 0.2716 | 0.3072 | | 0.1924 |
| X40 | a | -.02519 | -.11837 | -.02978 | . |
| | n | 0.6638 | 0.0405 | 0.6074 | |

**Table V Comparison of discriminant power (misclassification)**

| Set of variables | Bankrupt | Non-bankruptcy | Total |
|---|---|---|---|
| This study | 16.84% | 15.07% | 15.96% |
| Altman Model | 22.63% | 32.88% | 27.75% |
| Toda Model | 19.47% | 34.25% | 26.86% |

**Table VI Classification by Industry and Size**

unit of size: 10,000yen

| Capital Size / Industry | 3,000 | 3,000-5,000 | 5,000-10,000 | 10,000- | Total |
|---|---|---|---|---|---|
| Manufacturing | 74 | 128 | 74 | 68 | 344 |
| Wholesale & Retail | 122 | 158 | 112 | 65 | 457 |
| Others | 41 | 56 | 44 | 44 | 185 |
| Total | 237 | 342 | 230 | 177 | 986 |

**Table VII Discriminant Analysis for mean value of each industry**

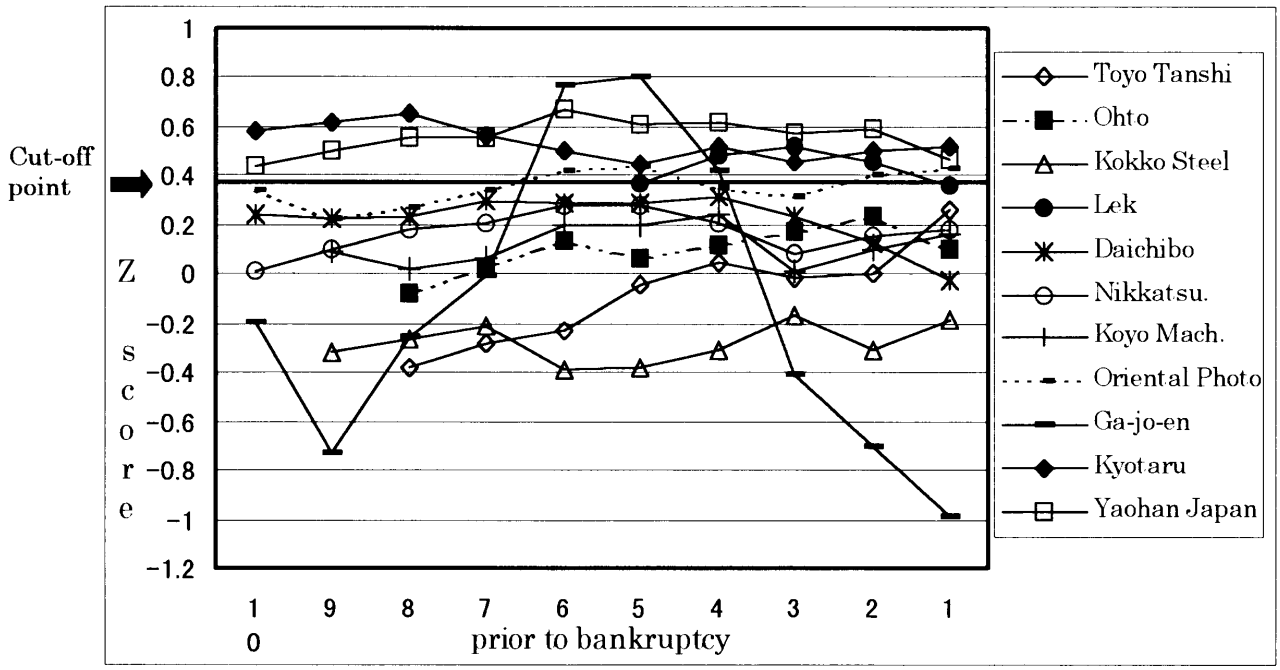
| Industry | Bankrupt | Non-bankrupt |
|---|---|---|
| Manufacturer | 96.0% | 80.7% |
| Wholesale & Retail | 99.0% | 83.6% |
| Others | 97.0% | 48.8% |

**Table VIII Discriminant Analysis for mean value of each capital group**

| Capital size(\10,000) | Bankrupt | Non-bankrupt |
|---|---|---|
| 3,000 | 98.6% | 66.8% |
| 3,000-5,000 | 95.2% | 74.0% |
| 5,000-10,000 | 92.0% | 77.6% |
| 10,000 | 99.9% | 77.4% |

**Table IX The variables impacted upon industry and size**

| Rank | Industry | Size |
|---|---|---|
| 1 | Selling and administrative expense/Number of employees | Working capital / total assets |
| 2 | Operating expense / Sales | Current assets x 12 / sales |
| 3 | (Note receivable + note receivable discounted) x 12 / Sales | Equity x 12 / Sales |
| 4 | Equity x 12/Sales | Note payable x 12/Sales |
| 5 | Liabilities and shareholders equity x12 / Sales | (Operating income + interest and discount expense) / Liabilities and shareholders equity |
| 6 | Tangible fixed assets x 12 / Sales | Gross Margin/Number of employees |




Graph I The Transition of Z score of Eleven Japanese Bankrupt Firms