# Logistic Regression Model for Business Failures Prediction of Technology Industry in Thailand

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# Logistic Regression Model for Business Failures Prediction of Technology Industry in Thailand

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## Abstract

*Since the large number of parties involved in corporate failure or 'business failure', the avoidance of failure has always been an important issue in the field of corporate finance and business management.*

*In this paper, the model was developed to predict business failure in Thailand particular in technology industry by using four variables from Altman's model and adding one variable to the model. Descriptive statistics, correlation, and independent T-test are used for testing to see the characteristics of each variable on both failed and non-failed companies. The model was developed by using the stepwise logistic regression. Samples were developed by using financial information from private limited companies based on technology industry in Bangkok. The result from this empirical study can conclude that financial ratios are useful analytical techniques for forecasting financial health of companies in technology industry. The result of independent T-test has pointed out sales to total assets ratio is the only significant independent variable indicating significant differences between failed and non-failed group. The Nagelkerke $R^2$ indicated 42.4% of the variation in the outcome variable. The predictability accuracy of the model is 77.8% which is under 95% confidence level.*

## 1. Introduction

The basic objective of financial statements is to provide information useful for making economic decisions. Financial ratios are a popular tool for users who are owner, shareholders, creditors, investors, government and other users to evaluate the financial condition and performance of a company by computing a set of key financial ratios from financial statements. Besides, they also help the auditors' judgment in an ability of a company to continue operations to follow a going concern concept.

The purpose of this paper is to develop a model for prediction of business failure in technology industry of Thailand. In this research, the model was developed by using four variables from Altman's model which are working capital to total assets ratio, retained earnings to total assets ratio, earnings before interest and taxes to total assets ratio, and sale to total assets ratio with the net income (loss) to total assets ratio used as indicators on financial status of companies.

## 2. Research methodology

### 2.1. Research framework

The financial status of a business firm can be produced information to creditors, investors, stockholders and others for making decision. There are many researchers have been used financial information for predicting financial health of companies. The literature of Edward I. Altman developed the popular model called Z-score for a predictor of business failure. Therefore, the model would serve to reduce such losses by providing warning to these interested parties and that model predicts business failure to assess financial status as early as possible. Hence, this study tends to focus on modified Altman's model to develop the business failure prediction which is suitable for Bangkok based companies in technology industry. By doing this, we illustrate the framework of the study as in Fig. 1.

Altman (1968) model uses as predictors five accrual-based ratios which are classified into five standard categories including liquidity, profitability, leverage, solvency and activity. Altman's model is

called Z-score model that consists of five variables. However, in this study, since a limited company does not issue stock to public, one ratio which is Market Value Equity/Book Value of Total Liabilities (MVE/TL) cannot be computed because it lacks of Market Value Equity data. As a result, we modified Altman's model by maintaining the four previous ratios and adding one new ratio to the model which is Net income (loss)/Amount of Shares.

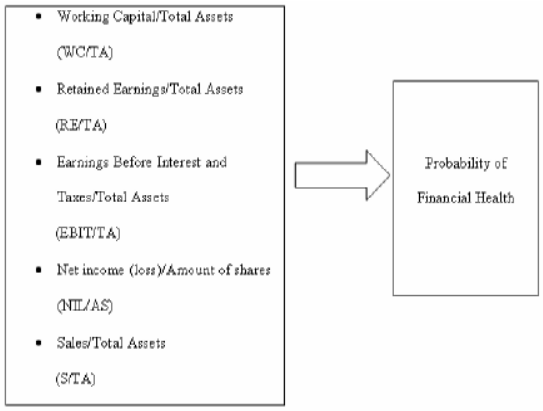


**Figure 1**. Research framework

Dependent variable is predicted in the form of the probability of failure and valued between 0 and 1. That is either 1 for a healthy firm and 0 for a failed firm. In computation processes if an estimated probability value of a firm equals to $\geq 0.5$, the firm will be classified as a healthy firm and otherwise as a failed firm.

## 2.2. Research hypotheses

The equation related to the financial model is shown below:

$$\text{Prob}(0,1) = \text{fn}(WC/TA,\ RE/TA,\ EBIT/TA,\ NIL/AS,\ S/TA) \quad (1)$$

Independent T-test is applied for testing the significance of those variables as warning signs of financial health. Based on literature review, following hypotheses are developed:

$H_{01}$: There is no difference between the means of the ratio in each group to the spread of the ratios within each group.

$H_{a1}$: There is difference between the means of the ratio in each group to the spread of the ratios within each group.

Then, there are twelve hypotheses as in (2):

$$H_0 = \mu_1 \neq \mu_2 \qquad H_a = \mu_1 \neq \mu_2 \quad (2)$$

That $\mu_1$ is the means of the coefficient (ß) of variables, WC/TA, RE/TA, EBIT/TA, NIL/AS, S/TA of failure group. $\mu_2$ is the means of the coefficient (ß) of variables, WC/TA, RE/TA, EBIT/TA, NIL/AS, S/TA of non-failure group.

## 2.3. Method used

Descriptive statistics, correlation, and independent T-test are used for testing to see the characteristics of each variable both failed and non-failed companies. Stepwise logistic regression is the method used to develop the model which derived the variables from modified Altman's model. Samples are developed by using financial information from private limited companies based on Bangkok in technology industry. Logistic regression produces all predictions, residuals, influence statistics, and goodness-of-fit tests using data at the individual case level.

## 2.4. Operation of the independent and dependent variables

The independent variables of five ratios were measured in ratio scale. The dependent variable was measured between 0 and 1, which was assigned to failure companies for 0 and healthy companies for 1. Binomial (or binary) logistic regression is a form of regression which is suitable to predict the business failure in technology industry. The operational definition of independent and dependent variables are explained in Table I.

## 2.5. Respondents and sampling procedure

The target of the sample group is the failed and non-failed of limited companies based on Bangkok in technology industry. In Thailand, a limited company has to be registered at the Department of Business Development that is an authorized department of Ministry of Commerce. Each limited company has to register in one of the 9 major divisions according to its type and business objective as shown in Table II.

According to Table II, the majority of limited companies are under the major division sixth. As a result, we selected this group as a sample. The sample was separated in more details as shown in Fig. 2. As indicated in Fig. 2, the dissolved companies come under the sub category code 61504 whose registered capitals are more than $125,000. The sample is limited

to the year of 2001. Financial year of selected companies are same. There were 33 companies from the common year 2001 and selected 12 companies out of 33 as failed firms (dissolved companies). As a result, the respondent rate is 36%. The non-failed firms were selected the same amount from the same period and same criteria.

**TABLE I**

OPERATION OF THE INDEPENDENT AND DEPENDENT VARIABLES

| Conceptual Definition | Operational Definition | Expectation | Scale |
|---|---|---|---|
| Working capital/ Total assets (WC/TA) | A measure of the net liquid assets of the form relative to the total capitalization. | Relationship with probability of failure | Ratio |
| Retained earnings/ Total assets (RE/TA) | A measure if cumulative profitability over its total assets. | Relationship with probability of failure | Ratio |
| Earning before interest and taxes/ Total assets (EBIT/TA) | A measure of the true productivity of the firm's assets | Relationship with probability of failure | Ratio |
| Net income(loss) / Amount of Shares (NIL/AS) | A measure of the income or loss per share | Relationship with probability of failure | Ratio |
| Sales/ Total sales (S/TA) | A measure of the firm's asset utilization | Relationship with probability of failure | Ratio |
| Probability of Financial Health | An estimated probability of financial health | Relationship with WC/TA, RE/TA, EBIT/TA, NIL/AS, S/TA | $P_i$ is between 0 and 1 |

**TABLE II**

TYPES OF BUSINESS ACTIVITIES IN THAILAND

| Major Division | Description | No. of limited company from 1912-2005 |
|---|---|---|
| 1 | Agriculture, Hunting, Forestry and Fishing | 833 |
| 2 | Mining and Quarrying | 354 |
| 3 | Manufacturing | 17,329 |
| 4 | Electricity Gas and Water | 93 |
| 5 | Construction | 13,347 |
| 6 | Wholesale, Retail Trade, Restaurants and Hotels | 66,326 |
| 7 | Transport, Storage, and Communication | 7,834 |
| 8 | Financing, Insurance, Real Estate, and Business Service | 37,580 |
| 9 | Community Social and Personal Service | 10,582 |

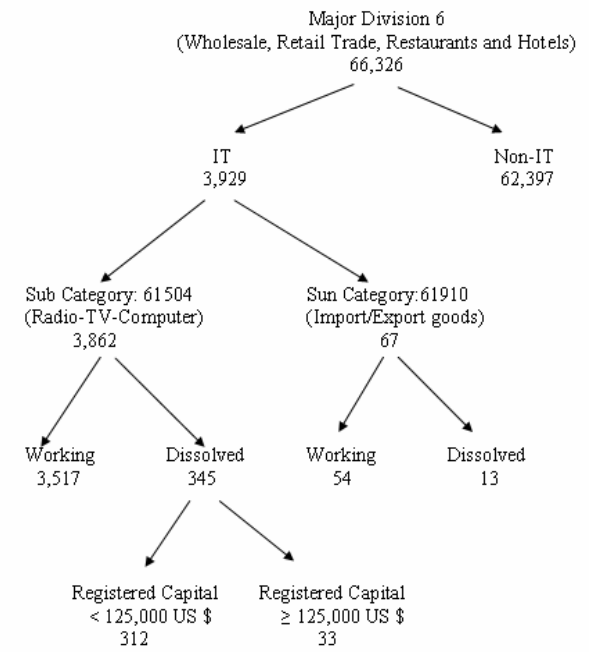


**Figure 2.** Procedure of sample selection

## 2.6. Research instruments

In this study, published financial information which have been obtained from Department of Business Development of Ministry of Commerce are used for computation of each company financial position. There are four ratios contributed by Altman (1983). For analysis purposes, one ratio as Net income(loss)/Amount of Shares was added. The stepwise logistic regression is used to develop all models. The overall quality of logistic regression model is tested through goodness of fit tests and significant levels. The model is developed by using significant variables. The t-test in logistic regression method is used to test hypotheses.

## 2.7. Collection of data

Each of the selected failed firms is matched with non-failed firms in the same industry, location, group size, and financial year. The data have obtained from secondary reliable source from Department of Business Development of Ministry of Commerce.

# 3. Data Presentation

## 3.1. Descriptive statistics and correlation

The relationship between dependent variable and independent variable were measured by correlation test before developing the model. The descriptive statistics and result of correlation test present in Table III. The variables were defined as follows:

$X_1$ = working capital/total assets
$X_2$ = retained earnings/total assets
$X_3$ = earnings before interest and taxes/total assets
$X_4$ = net income (loss)/amount of shares
$X_5$ = sales/total assets

**TABLE III**

DESCRIPTIVE STATISTIC AND CORRELATION

| **Non-failed companies** | | | | | | | |
|---|---|---|---|---|---|---|---|
| Variables | Mean | s.d. | n | $X_1$ | $X_2$ | $X_3$ | $X_4$ |
| $X_1$ | 0.303 | 0.367 | 12 | | | | |
| $X_2$ | 0.039 | 0.187 | 12 | -0.128 | | | |
| $X_3$ | -0.021 | 0.127 | 12 | -0.526 | 0.683* | | |
| $X_4$ | -5.793 | 23.176 | 12 | -0.399 | 0.633* | 0.895** | |
| $X_5$ | 2.585 | 2.104 | 12 | -0.650* | 0.021 | 0.199 | 0.137 |
| **Failed companies** | | | | | | | |
| Variables | Mean | s.d. | n | $X_1$ | $X_2$ | $X_3$ | $X_4$ |
| $X_1$ | -37.966 | 129.642 | 12 | | | | |
| $X_2$ | -0.741 | 1.928 | 12 | 0.965** | | | |
| $X_3$ | 1.024 | 4.551 | 12 | -0.987** | -0.919** | | |
| $X_4$ | -21.144 | 44.055 | 12 | -0.146 | -0.032 | 0.225 | |
| $X_5$ | 0.735 | 1.110 | 12 | 0.214 | 0.205 | -0.216 | -0.358 |

* correlation is significant at the 0.05 level (2-tailed)

** correlation is significant at the 0.01 level (2-tailed)

The characteristics between failed and non-failed companies were different. There are four out of five mean values of failed companies were less than those values of non-failed companies. Only one ratio $X_3$ of failed companies had the mean value more than non-failed companies. Moreover, the correlation of the ratios between failed and non-failed companies were different. In the non-failed group, $X_3$ and $X_4$ variables were highly significant more than $X_2$ and $X_3$, $X_2$ and $X_4$, and $X_1$ and $X_5$ variables. Nonetheless, in failed group, $X_1$, $X_2$ and $X_3$ were highly significant. Most ratios of failed companies had fluctuation data more than non-failed companies. Only $X_5$ ratio of non-failed companies had fluctuation data more than failed companies as shown in Fig. 3.

## 3.2. Hypotheses testing

Independent T-test of each financial ratio was applied for testing the significance of each independent variable. The result showed that the mean of individual ratio of failed group were smaller than the non-failed groups. However, only sales to total assets ($X_5$) was the only significant independent variable among them. This indicates significant differences in this variable between failed and non-failed groups.

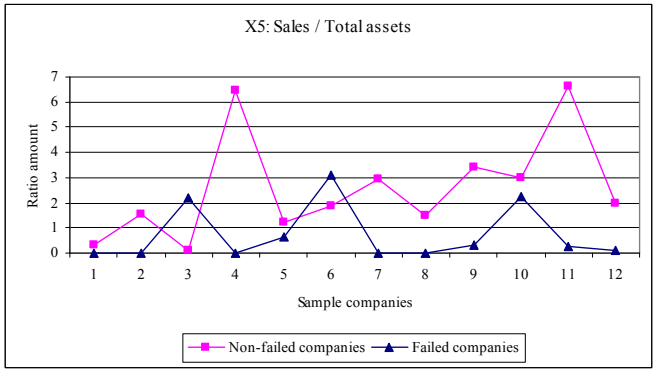


**Figure 3.** $X_5$ ratio of failed and non-failed companies

## 3.3. Model interpretation

Third part of this study is to determine and test validity of the model based on the five variables. Variables considered the importance of predicting financial health, including working capital to total assets ($X_1$), retained earning to total assets ($X_2$), earning before interest and taxes to total assets ($X_3$), net income (loss) to amount of shares ($X_4$), and sales to total sales ($X_5$). The coefficients were developed from the stepwise logistic regression model. The equation for the probability of financial health can be expressed as in (3) which Z value derives from (4):

$$\text{Probability (Financial Health)} = 1/(1+e^{-Z}) \quad (3)$$

$$Z = -0.373 + 0.701(X_1) - 0.508(X_2) + 1.641(X_3) + 0.011(X_4) + 0.595(X_5) \quad (4)$$

where $X_1$ = working capital/total assets
$X_2$ = retained earnings/total assets
$X_3$= EBIT/total assets
$X_4$ = net income (loss)/amount of shares
$X_5$ = sales/total assets

With this stepwise logistic regression model, the Nagelkerke $R^2$ shows 42.4% of the variation in the outcome variable. The result of Hosmer and Lemeshow's Goodness of Fit test shows that the chi-square is 18.948 with 7 degrees of freedom and the observed significance level for the chi-square value is

0.008 implying that the model's estimates fit the data at an acceptable level. The classification table IV shows that the model correctly predicted 77.8% of the financial health overall with the 95% confidence level.

**TABLE IV**

CLASSIFICATION TABLE

| Observed | | | Predicted | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Selected Cases | | | Unselected Cases | | |
| | | | Dissolved-Healthy | | % correct | Dissolved-Healthy | | % correct |
| | | | 0 | 1 | | 0 | 1 | |
| Step 1 | Dissolved-Healthy | 0 | 6 | 2 | 75.0 | 3 | 1 | 75.0 |
| | | 1 | 2 | 8 | 80.0 | 0 | 2 | 100.0 |
| | Overall Percentage | | | | 77.8 | | | 83.3 |

## 4. Conclusion

This empirical finding will provide warning signs to both the internal and external users of financial statements in planning, controlling, and decision-making. The warning signs and stepwise logistic regression model have the ability to assist management for predicting corporate problems early enough to avoid financial difficulties. Moreover, the evidence from analysis of warning signs and the model can signal going concern problems early before eventually enters bankruptcy.

Financial analysts could improve the development of this model since there are limitations associated that affected the ability of warning signs on financial status and predictive ability. For example, the failed firms selected in this study were dissolved not bankruptcy. To improve the significance and predictive ability of the model, it is suggested to select failed firms as bankruptcy. The reason is that dissolved companies may need to stop doing business without financial problem while as bankruptcy companies have to stop doing business because of financial problem. Moreover, since financial information in this paper is limited to only income statement and balance sheet, this leads to the limited number of ratios in the model. One way to improve the model is to add more ratios so that the predictability will be more accurate. It would be suggested that other statements such as statement of owner's equity and statement of cash flow should be put into consideration. Lastly, besides the important financial ratios that measure the internal state of the firm, the existing macroeconomic conditions need to be included to help properly model the external environment of the firm.

In the past, corporate failure prediction has been based on traditional methods of financial ratio analysis with multivariate discriminant analysis (MDA). This paper is limited to logistic regression. However, there are methods can be applied for further company failure prediction. For example, neural networks [K. D. Gunawardana, 2002] would be applied to predict corporate failure. Artificial Neural Networks (ANN) are an attempt to imitate the human reasoning and have been used in various applications of financial modeling that can be an effective forecasting alternative when compared to traditional techniques.

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