

# An Application of Intellectual Capital on Financial Distress Models by Using Neural Network

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## Abstract

As the era of knowledge economy is prevalent in U.S. during 1992, knowledge economy plays an important role around the world. The value and competition of the traditional companies accounted on tangible assets. However, in the era of knowledge economy, the value and continuing operation of the companies accounted on intangible assets. It is not sufficient in estimating the value of a company only by financial ratios (Bublita and Ettredge, 1989; Chauvin and Hirschey, 1993; Bontis et al., 2000). The previous researches found there is a close relationship between the intangible assets and the value of a firm. In this paper, a set of financial ratios, corporate governance variables and intellectual capital indicators will be investigated in a financial distress prediction by employing the Logit model and neural network model. The conclusion in this paper is that the prediction of the financial distress models is more accurate for one year prior to failure. The financial distress can be accurately predicted up to 89.2% or 91.53 with the accuracy diminishing after the first year. The finding is the same with that in previous literature. The profitability of a firm is the most important factor in the earlier stage. The firm with a poor profitability may have a financial distress in the short run. However, in the long run, the operation administration (such as account receivable) and the intellectual capital (such as patent and R&D expenditure) have a significant impact on the financial situation of a firm.

**Keywords:** Financial Distress, Intellectual Capital, Logit Model, Neural Network Model.

## 1. Introduction

Only a set of financial ratios was investigated in the financial distress in the earlier studies, such as Beaver (1966) estimated a univariate financial distress model. Altman (1968) analyzed the financial distress problem of a firm by employing a multiple discriminant analysis. , Martin (1977) and Ohlson(1980) investigated the profitability of a company under Logit model. The application of a financial distress models includes static univariate analysis, multivariate discriminant analysis, Logit model, Probit model and neural network, and dynamic Merton model, CUSUM and so on.

Since the false financial statement of Enron Corporation in 2001 and so did Xerox Corporation in 2002, corporate governance has become a crucial factor in the financial distress models. Belkaoui and Pavlik(1992) investigated the relationship between a company value and the degree of diversification, the degree of non-diversification, the ownership concentration of shareholders and stock holding composition of manager. However, in the era of knowledge economy, intellectual capital is discussed broadly. Schendel and Patton (1978) noted when the more a firm invests in development and research, the more the market share is.

Lev and Sougiannis(1996) found that the ratio of market value to book value isn't significant in high technology industry. These studies showed how intellectual capital influences the value of company. Therefore, financial ratios, corporate governance variables and intellectual capital will be discussed in this paper.

According to previous researches adopting the intellectual capital in financial distress models, it measures human capital as the schooling of employees, average working year per employee and average wage per employee, customer capital with related party transaction ,structural capital with turnover of auditor, financial forecast changes, average employment cost and equipment per employee.

However, Sullivan (2000) noted human capital can't be exchanged and can't be owned by interest groups. Previous researchers found that schooling of employees isn't significant, so the firm may emphasize the working experience and skills instead of schooling of employees. Therefore, in this paper, a set of financial ratios, corporate governance information and intellectual capital indicators will be investigated in distress prediction. The productivity per employee (average sales per employee) and profitability (average earning per employee) are the proxy variables of human capital in this paper. Despite intellectual capital has important impact on the future value and cash flow of firms; it is little introduced into the financial distress model. In this study, we intend to employ the intellectual capital in the financial model to see whether it improve the predictability of the model.

## 2. Methodology and Results

### 2.1 Methodology

The sample firms were announced financial distress level (level D) seasonally by Taiwan Economic Journal. The sample period is from January 1 2003 to December 30, 2005; and there are 31 listed OTC financial distress firms and 31 non-bankrupt firms within the same industry and with the same size. Total sample are 62 firms and 248 observations of 4-season a year. In this study, a set of financial ratios, corporate governance variables and intellectual capital indicators are employed to investigate the financial distress under both Logit model and neural network model. The two models are described as follows:

(1) Logit model transfers from Logistic function, the probability of the event is between 0 and 1. Let the probability of the event be

$$P(y_i = 1 | x_i) = p_i$$

$$y_i = 1, \text{ as } y_i^* > 0$$

$$y_i = 0, \text{ as otherwise.}$$

where the continuous variable  $y_i^*$  is the probability of the financial distress of a firm  $i$ . and  $x_i$  denote the explanatory variables of the financial ratios, corporate governance and intellectual capital, then we transfers it to get Logistic Model below

$$p_i = \frac{1}{1 + e^{-(\alpha + \beta x_i)}} = \frac{e^{\alpha + \beta x_i}}{1 + e^{\alpha + \beta x_i}}$$

The natural log probability of the event and the non-event is

$$y_i^* = \ln\left(\frac{p_i}{1 - p_i}\right) = \alpha + \beta x_i.$$

(2) Neural network is an artificial intellectual system by simulating thoughts of human beings, to find the relationship between input and output through the process of learning the cases. Backpropagation neural network is one of respective and general adapted models. There are five steps to train Backpropagation neural network : the first step is to take input into the input layer, the second step is to calculate the output of network, the third step is calculating the error between the training output and the real output, the forth step is adjusting the weight of the network, the final step is repeating steps one to four.

### 2.2 Results

The firm will default and have a financial distress when it bears too heavy debts and the profitability can't balance its debts. The ratio of net sales to average account receivable measures managerial ability of a firm. A firm won't use cash efficiently if it has too many bad accounts. Empirically, we show the ratios of total debts to total assets and net sales to average account receivable are significant in Logit models through one year, two years and three years prior to the failure of a company. After adding the variables of the intellectual capital, we found average earning per employee is significant in the Logit models through one year, two years and three years prior to failure. The profitability which the employees create for the firm is very important. Moreover, once a set of intellectual capital indicators introduced into the model through all of them, the predictability of the financial distress model is improved about 2.82%-6.54%,

As to that in the neural network analysis, the predictability is also improved about 0.32%-6.43% as a set of intellectual capital indicators introduced. It is obvious that the profitability of financial ratios and intellectual capital indicators are crucial variables in the financial distress models.

As shown in Table 1, as to the proxy variables of the intellectual capital, the predictability of the financial distress model in previous studies is 83.33% one year prior to failure while two years and three years

Table1 Comparing with the previous study

|                | Prior to one year | Prior to two years | Prior to three years |
|----------------|-------------------|--------------------|----------------------|
| Logit Model    | 89.92%            | 84.68%             | 84.32%               |
| Neural Network | 91.53%            | 87.90%             | 79.78%               |
| Previous Study | 83.33%            | na                 | Na                   |

prior to failure are not investigated in them. Comparing to that in this paper, the prediction is lower 8.2%, it may confirm that the intellectual capital indicators in this paper are more suitable than the previous research. The measure of human capital should focus on the profitability which the employee creates for a firm rather than the schooling and average working year per employee. According to Bublita and Ettredge (1989), R&D capital can increase the value of firm. The increase in value of a firm can improve the profitability of a firm and then decrease the probability of financial distress. Thus, R&D capital is not considered in the prediction model will misestimate the value of a firm.

### 3. Conclusions

In the era of knowledge economy, the value and continuing operation of the companies accounted on intangible assets. It is not sufficient in estimating the value of a company only by financial ratios (Bublita and Ettredge, 1989; Chauvin and Hirschey, 1993; Bontis et al., 2000). This study intend to set up a financial distress model by introducing intellectual capital indexes into a set of financial ratios and corporate governance variables under Logit model and neural network model. The prediction of the financial distress models is extreme accurate for one year prior to failure. The financial distress can be accurately predicted up to one year prior to the actual financial distress with the accuracy diminishing after the first year. The finding is the same with that in the previous literatures.

The introduction of a set of financial ratios, corporate variables and intellectual capital indexes into the financial distress model under both Logit Model and neural network can improve the predictability of the model. The

significant intellectual capital index is operation profit per employee for one year, two years and three years prior to failure, so the profitability has a great influence in the financial distress models. The difference of prediction is approximately 2% among Logit model and neural network model, so there is not significantly different between them. The profitability of the firm is an important factor in the earlier stage. A firm with a poor profitability may have a financial distress in the short run. However, in the long run, the operation administration (such as account receivable) and the intellectual capital (such as patent and research & develop expenditure) have a significant influence on the financial situation of the firm.

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