The Ability to Predict Firms’ Bankruptcy Using Financial Ratios

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Abstract: Financial status and performance are analyzed in order to discover the strong and weak points of past activities and to make decisions about future activities. Investors always want to predict the possibility of a firm’s bankruptcy in order to avoid the risks of losing their principal and interest capital. Therefore they try to find methods for assessing firms’ financial bankruptcy and one of these methods is to use financial models for bankruptcy prediction. The statistical population of this research includes all the companies accepted in Tehran Stock Exchange of which 44 companies were chosen as sample and the data of their financial statements in a 7-year period between 2003 and 2010 was collected. In order to examine research hypothesis and to compute the financial ratios of sample companies, the companies’ 7-year average data was entered into Excel spreadsheet software, and then, the independent variables related to the Philosophov and Ohlson models were determined. In order to reject or approve the hypotheses in Ohlson model, logit regression has been used, where in hypothesis 1, the model has been able to predict bankruptcy and in hypothesis 2, there has been a significant relationship between financial ratios and the ability to predict bankruptcy. In order to approve the hypotheses in Philosophov model, cumulative frequency diagrams have been used.

Key words: Bankruptcy, Bankruptcy Prediction, Financial Ratios, Bankruptcy Prediction Models, Ohlson Model, Philosophov Model.

INTRODUCTION

With the advancement of science and technology, humans’ economic relations have become much more complicated. Economy and trade entered a new phase, where small institutions turned into huge stock and multinational companies, leading to development and expansion of financial and monetary markets and thousands of people around the world started investing on companies’ stocks. This rapid growth and evolution of economic relations led to intense competition in trade, industry, and investment arenas. Thus, a quick and proper reaction against the very unsteady conditions of the market as an institution plays an important role.

Using financial ratios is a tool for investors to assess companies as well as a tool for managing an enterprise in order to assess the status quo and predict future status of the enterprise. In fact, financial ratios evaluate the relationship between two or more variables or in other words, are obtained through dividing some items of financial statements by some other, and can be used to determine some concepts such as the ability to meet short-term and long-term obligations, company’s efficiency and profitability and etc.

Discovering company’s operational and financial difficulties is a notion that goes hand in hand with financial ratios. In 1930, official investigations into reasons of economic failure initiated and researches showed that financial ratios of bankrupt (unsuccessful) companies don’t have desirable status in comparison with the ratios of successful companies and analyzing financial ratios can be helpful in predicting bankruptcy. “By combining these ratios, researchers managed to present multivariate models for bankruptcy prediction which are actually of the most successful academic products and decision-making tools (Haroonkalani, 2004)”.

Bankruptcy prediction models are tools for estimating future status of companies. Investors and creditors have a strong tendency for firms’ bankruptcy prediction, for in case of bankruptcy, they will be inflicted with so many costs. These models have their own specific weak and strong points (Rostami, 2003).

Nowadays, rapid technological advancement and extensive environmental changes have increasingly accelerated economy and the increasing competition of institutions has limited profitability and has increased the possibility of bankruptcy. Proprietors, managers, investors, commercial associates, and creditors are, just like governmental firms, interested in assessing the financial status of a company and its susceptibility of bankruptcy. Thus, financial decision-making has become more strategic than before.
In financial decision-makings for a firm, we need the proper scientific and real index of each firm. One of the appropriate indices for such an objective is accurate assessment of the possibility of firms’ bankruptcy. Using financial ratios is one of the tools for analyzing financial problems and researchers have been able to combine these ratios to offer multivariate models for bankruptcy prediction. Bankruptcy prediction models are of the techniques and tools for predicting future status of firms which estimate the possibility of bankruptcy by combining a group of financial ratios.

A model for bankruptcy prediction is limited to establishing a relationship between bankruptcy and some financial ratios. There are ratios that can be computed using data from firms’ annual reports. One of the financial signs of bankruptcy is unfavorable basic financial ratios. In fact, each ratio has some prediction ability; thus, imminent bankruptcy reveals almost every dimension of a firm’s financial status. Therefore, in this research which is an applied research, we try to apply Philosophov and Ohlson models to the economic conditions of Iran.

According to the theoretical bases presented in this research, as well as the rest of the observations, research hypotheses are as follows:

1. Philosophov and Ohlson models are appropriate tools for firms’ bankruptcy prediction
2. There is a significant relationship between financial ratios and bankruptcy prediction of firms accepted in Tehran Stock Exchange using Philosophov and Ohlson models

Research Literature:
The first research on the subject of bankruptcy prediction was done in 1990 by Thomas F. Woodlock. He performed a classic analysis of Railroad Industry and presented the results of his research in an article titled “The Percentage of Operating Costs to Retained Profit Margin”. In 1911, Lawrence Chamberlain, in an article titled “The Principles of Bond Investment”, used the ratios obtained by Woodlock and created performance ratios (Rasulzadeh, 2002).

At the time of America’s financial crisis (1930’s), two American researchers, Winakor and Smith, studied the records of 183 firms that faced financial disturbance and calculated 21 ratios of the various numbers in their financial statements for the past ten years and concluded that the most precise and trustworthy ratio whose unfavorable trend can signify bankruptcy is Working Capital to Total Assets ratio. Naturally, financial crisis necessitated when this ratio that represents liquidity preferences is taken into consideration.

Subsequently, another researcher named FitzPatrick compared 13 financial statement ratios of 20 bankrupt firms and 19 profitable and successful firms during a 5-year period and concluded that all ratios somehow indicated financial distress of bankrupt firms. However, the best ratios that can predict irregularities are Return on Capital and of Investor’s Equity Net Worth to Total Debt ratio. In the next decade in 1942, an analyst named Merwin chose 939 firms and examined their financial status in a 10-year period and concluded that in order to predict a firm’s bankruptcy four or five years before failure and bankruptcy, we can use three ratios that make prediction feasible. These three ratios are Current Ratio, Net Working Capital to Total Assets and Capital to Total Debt ratio. In all the firms that faced bankruptcy, the foresaid ratios had been significantly defected long before failure and collapse (Akbari and Alimadad) (Alikhani, 2007).

In 1968, Edward Altman presented a model for bankruptcy prediction in the article “Financial Ratios, Discriminant Analysis and the Prediction of Corporate Bankruptcy” which is known as Altman Z-score. In this model, he has used five ratios: Working Capital to Total Assets ratio, Earnings before Interest and Taxes to Total Assets ratio, Sales to Total Assets ratio, Retained Earnings to Total Assets ratio, and Market Value of Equity to Book Value of Total Liabilities ratio. In the following years he presented corrected models (Altman 1968).

Ohlson’s Model:
Ohlson (1980) was the first to apply multidimensional logistic regression for creating a bankruptcy prediction model in order to avoid some difficulties related to multiple discriminant analysis. Ohlson used 105 bankrupt and non-bankrupt firms as test sample. He used all of the bankrupt and non-bankrupt firms as test sample; all bankrupt firms were being traded in stock markets and he obtained the required data from K-10 financial statements. His objective was to use 9 variables to present three models that can predict firm’s bankruptcy three years before it occurred. The logistic regression model was as follows:

\[ Y_1 = \frac{1}{32.407X_1 + 6/03X_2.1/43X_3 + /0757X_4 1/72X_5 / . 52X_6 2/37X_7 1/83X_8 + /285X_9} \]
Where $X_1$ is the logarithm of Total Assets to price index of Gross National Product, $X_2$ is Total Debt to Total Assets, $X_3$ is Working Capital to Total Assets, $X_4$ is Current Liability to Assets, $X_5$ is a dummy variable that is 1 if Total Debt is greater than or equal to total assets and 0 otherwise, $X_6$ is a dummy variable that equals 1 if the net profit of the recent two years is negative and equals 0 otherwise, $X_7$ is Net Profit to Total Assets, $X_8$ is Operation Cash Flow to Total Debt, and $X_9$ is changes in net profit as

$$(CHNI = NI_{T-1} - NI_{T-2}) / 2|NI_T| + |NI_{T-1}|$$

Model sorting precision for years 1 to 3 is 85.1%, 87.6%, and 82.6% respectively (Ohlson, 1980).

Philosophov Model:

In 2002, Leonid and Vladimir Philosophov, in a research titled “An Attempt at a Combined Prediction of the Bankruptcy Event and Time Interval of Its Occurrence”, examined the problem of firms’ bankruptcy with a simultaneous assessment of the time interval within which the bankruptcy must occur. Then, by comparative statistical analysis, they extracted financial changes indices and identified 4 relatively dependent factors that had considerable potential for bankruptcy prediction. Two of these characterize the quantity and quality of corporate debt, while the other two characterize the ability to pay the debt, which are Interest to Total Assets ratio, Current Liabilities to Total Assets ratio, Earnings before Interest and Taxes to Total Assets ratio, and Retained Earnings to Total Assets ratio. Current liabilities increase during one or two years before bankruptcy because a large portion of long-term liabilities reach maturity.

If time interval is taken into account in bankruptcy prediction, we will consider the prognostic problem as a multi-alternative problem of Statistical Decision Theory. The synthesized prognostic rules involve calculation of posterior probabilities of firm bankruptcy within the first, second, and third year. A correct formulation for bankruptcy prognosis problem must show the time interval in which bankruptcy will occur. We can predict bankruptcy in a certain time interval by relating major events. By correctly assessing the time left to bankruptcy, algorithms that process prediction factors independently, efficiently predict bankruptcy in case the time interval is less than 1 year or more than 5 years. The goal of prognostic factors in this research is to correctly compute the final possibility of bankruptcy. Data collected from 24 firms that faced bankruptcy during 1980 to 1988 was used as main empirical material for choosing prediction factors, the structure of prediction algorithm, and assessment of their capabilities. Profit and loss statements, firms’ balance sheets, and information about the date of sensing the possibility of bankruptcy were collected. Data includes 7 balance sheets and annual income statements for each firm. The last pair is one year before the date of sensing the possibility of bankruptcy. The optimal rules for prognosis are those that predict firm’s bankruptcy within the next one, two, or three years. The efficiency of the variants of prognostic rules developed in this research were assessed and showed that in comparable conditions they are more efficient than Altman’s familiar Z-score rule and tested logistic rules (Alikhani, 2007).

Research Methodology:

The method used in this research is exploratory of correlation type using historical data which includes firms accepted in Tehran Stock Exchange during the years 2003 to 2010.

Hypotheses Test:

In Ohlson model, logistic (logit) regression analysis has been used in order to analyze the data. After collecting the data, we used Excel software to compute the prognostic ratios. Then, these ratios entered the analysis process. Statistical analysis was performed using SPSS software. The analysis process was as follows: the data related to one year before the bankruptcy of bankrupt firms entered the analysis with the data related to year 2010 of healthy firms; the data related to two years before the bankruptcy with the data related to year 2009 of healthy firms, and the data related to three years before the bankruptcy with the data related to year 2008 separately entered the analysis.

One Year Before Bankruptcy:

44 firms were surveyed in this research none of which had any missing data; thus, all 44 firms were included in the analysis. The dependent variable in this research is bankruptcy or non-bankruptcy which is shown with 0 and 1. Logistic regression has been fitted to the data. After applying backward stepwise method, in the first step, net profit to total assets variable with improvement on chi-square approximation equal to -0.021, in the second step, firm size index with improvement on chi-square approximation equal to -0.010 and likewise, in the third and fourth step profit variability ratio in the last two years and operation cash flow to total debt were respectively obtained from the equation.
Therefore, it was shown that among the examined bankruptcy prediction variables, only these four variables have prediction ability. Since the significance level of the model (SIG=0) is less than confidence level (\( \alpha = 0.05 \)), null hypothesis for the first year before bankruptcy is rejected and our main hypothesis (hypothesis 1) is approved. In other words, the examined financial ratios can predict bankruptcy using logit model.

The following table shows independent variables’ coefficients in the logistic model. It shows that the \((X_1), (X_2), (X_4), \) and \((X_6)\) variables stay in the model, that is, their coefficients have a significant difference from zero (at 0.1 level). Test of significance is done using Wald statistic which is similar to Student’s t-test. The last column of the table includes coefficients’ odds ratio that is used in logistics to interpret coefficients and is obtained from exponentiated by regression coefficient. This model shows that financial ratios have a significant relationship with bankruptcy or non-bankruptcy.

<table>
<thead>
<tr>
<th>Table 3-4: Coefficients of the Logit Model. Variables in the Equation.</th>
</tr>
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<tbody>
<tr>
<td>(B)</td>
</tr>
<tr>
<td>---</td>
</tr>
<tr>
<td>X1</td>
</tr>
<tr>
<td>X2</td>
</tr>
<tr>
<td>X4</td>
</tr>
<tr>
<td>X6</td>
</tr>
</tbody>
</table>

The above table shows the variables present in the equation. These variables are Working Capital to Total Assets ratio (\(X_1\)), Current Liability to Total Debt (\(X_2\)), Total Debt to Total Assets (\(X_4\)) and Total Assets to Total Debt ratio (\(X_6\)). The negative coefficient of total debt to total assets ratio shows a decrease in possibilities of staying healthy, or in other words, an increase in bankruptcy possibility of this ratio, that is, a 1% increase of this variable increases the chances of a firm’s bankruptcyup to 3 times. Moreover, the positive coefficient of working capital to total capital ratio signifies an increase in staying healthier the increase of this ratio, that is, a 1% increase of this variable increases the chances of firm’s staying healthy up to 4.5 times. According to the formula of logistic regression equation, the final equation is

\[
\ln\left(\frac{P}{1-P}\right) = 6.1^{wc}_{/TA} + 3.9^{CL}_{/CA} - 5.7^{TL}_{/TA} + 2.20^{ENEG}
\]

Where \(P\) is the ratio of bankrupt firms to the total number of firms.

Using the above equation, we can predict the possibility of a firm’s bankruptcy. For instance, if we replace the variables of the above model respectively with 0.1, 1.1, and 0, the possibility of a firm’s bankruptcy equals 0.23. While if the last variable is 1, the possibility increases to 0.73. The cutoffpoint is assumed to be 0.5. If a firm’s \(P\) (L) is calculated lower than 0.5, it is expected that the firm will be liable to article 141 of Business Law. It must be noted that the 0.5 point shows a state in which the cost of type I and II errors are assumed to be equal, while we know that the cost of type I error is much higher than that of type II error.

Model Summary:

<p>| Table 4-4: |
|---|---|---|---|</p>
<table>
<thead>
<tr>
<th>Step</th>
<th>-2 Log likelihood</th>
<th>Cox &amp;Snell R Square</th>
<th>Nagelkerke R Square</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>48.465</td>
<td>0.207</td>
<td>0.276</td>
</tr>
</tbody>
</table>

The above table includes goodness-of-fit data and model’s R square. Cox & Snell R square is about 0.2 and Nagelkerke R square is about 0.28, which is not too high, but for nonlinear regressions, this is not irregular. Therefore, this model is appropriate for bankruptcy prediction.

Second and Third Year Before Bankruptcy:

We analyzed the second and third year data, like the first year, using SPSS software and extracted the following formula:

\[
\ln\left(\frac{P}{1-P}\right) = 16.21^{NA}_{/TA} - 1.96^{CHIN} - 1.63^{GDP}
\]

where \(P\) is bankrupt firms to total firms ratio.
The final formula of the model which is related to the third year is as follows:

\[
\ln\left(\frac{P}{1-P}\right) = 1.3 \frac{CL}{CA} + 11.57 \frac{NA}{TA} - 1.8GDP
\]

Variables with significant coefficients have stayed in the model and have made the model generally significant.

We can use the above equation to predict the possibility of a firm’s bankruptcy.

In Philosophov model for bankruptcy prediction of a firm, cumulative frequency diagrams were used seven years before bankruptcy occurs. In order to draw these diagrams, first, the missing data of each variable for seven years before firms’ bankruptcy during the years 2003 to 2010 were identified and omitted, in order to have firms with intact and analyzable data. Then, we obtained the cumulative odds of each variable in each year. For obtaining these odds, we sorted the data and attributed \(1/n\) to the least possibility, \(2/n\) to the second least possibility and so on and 1 was attributed to the biggest data. Odds obtained through this method formed the Y axis of the diagram and the X axis showed the different variables of the model during seven years. Thus, each diagram shows the values of these four variables separately in seven years and in order to specify the line related to each year, the number of that year is printed on the line. These operations were done using S-Plus 6.2 software.

Results of Hypothesis Test:
A. Results of Ohlson’s Research:
Hypothesis 1:

The following table shows that models have high audit ability and we can be hopeful of a prediction with fewest errors. The true audit abilities for different cutoffs of different three-year models are mostly higher than 70% that appears to be optimum and satisfactory. In comparing the three models for three different years we can say that considering the prediction precision of the model of different years according to cutoff points, the evident result shows that the first year model and third year model have an almost similar precision which is more than that of the second year model.

<table>
<thead>
<tr>
<th>First Year</th>
<th>Second Year</th>
<th>Third Year</th>
<th>Cutoff Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Successful</td>
<td>UnsUCCESSFUL</td>
<td>Total Precision</td>
<td>Successful</td>
</tr>
<tr>
<td>52</td>
<td>84</td>
<td>73</td>
<td>60</td>
</tr>
<tr>
<td>64</td>
<td>84</td>
<td>73</td>
<td>68</td>
</tr>
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<td>88</td>
<td>74</td>
<td>82</td>
<td>80</td>
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<td>96</td>
<td>42</td>
<td>73</td>
<td>96</td>
</tr>
<tr>
<td>96</td>
<td>37</td>
<td>71</td>
<td>96</td>
</tr>
</tbody>
</table>

Hypothesis 2:

Financial ratios used in this research have high prediction ability; in the first year, Working Capital to Total Assets, Current Liabilities to Current Assets, Total Liabilities to Total Assets, and Comparison of Total Assets and Total Liabilities ratios had the highest prediction ability equal to 82%; in the second year, Net Profit to Total Assets ratio, Net Profit Variability to Total Assets ratio, and firm size index had 70% prediction ability, and in the third year, Net Profit to Total Assets ratio, Current Liabilities to Current Assets ratio and firm size index had 82% prediction ability.
B. Philosophov’s Research Results:

Hypothesis 1:

In Philosophov model, cumulative frequency diagrams were used for firms’ bankruptcy prediction. If the two bankruptcy factors (Current Liabilities to Total Assets and Interest to Total Assets ratios) increase in a firm, in the related cumulative diagrams, the firm stays in the upper right side, and conversely, if the other two bankruptcy factors (Retained Profit to Total Assets and Profit before Interest and Tax to Total Assets ratios) decrease in a firm, in the related cumulative diagrams, the firm stays in the lower left side and in this case, the firm gets close to bankruptcy. If the two bankruptcy factors (Current Liabilities to Total Assets and Interest to Total Assets ratios) decrease in a firm, in the related cumulative diagrams, the firm stays in the lower left side, and conversely, if the other two bankruptcy factors (Retained Profit to Total Assets and Profit before Interest and Tax to Total Assets ratios) increase in a firm, in the related cumulative diagrams, the firm stays in the upper right side and in this case, the firm is no longer bound to bankruptcy and stays healthy (non-bankrupt).

Hypothesis 2:

Generally in Philosophov model, bankruptcy factors (current liabilities, interest, retained profit, and profit before interest and tax) signal firm’s bankruptcy one or two years before it occurs.

Fig. 1: Current Liabilities to Total Assets Ratio.

Sample’s Cumulative Distribution, Current Liabilities to Total Assets Ratio:

The more firm approaches bankruptcy, the more this factor increases. Bankruptcy factor signals the separation of firms one or two years before bankruptcy. (Numbers beside the curves indicate the years before bankruptcy)

Fig. 2: Retained Profit to Total Assets Ratio.
Sample’s Cumulative Distribution, Retained Profit to Total Assets Ratio:
The more firm approaches bankruptcy, the more this factor increases. Bankruptcy factor signals the separation of firms one or two years before bankruptcy. (Numbers beside the curves indicate the years before bankruptcy).

Fig. 3: Interest to Total Assets Ratio.

Sample’s Cumulative Distribution, Interest to Total Assets Ratio:
The more firm approaches bankruptcy, the more this factor increases. Bankruptcy factor signals the separation of firms one or two years before bankruptcy. (Numbers beside the curves indicate the years before bankruptcy).

Fig. 4: Profit before Interest and Tax to Total Assets Ratio.

Sample’s Cumulative Distribution, Profit Before Interest and Tax to Total Assets Ratio:
The more firm approaches bankruptcy, the more this factor decreases. Bankruptcy factor signals the separation of firms one or two years before bankruptcy. (Numbers beside the curves indicate the years before bankruptcy).

Conclusion:
Hypothesis 1:
Because of its importance, bankruptcy prediction has, in recent years, become the center of attention of accounting, financial management, and economics researchers. The present research is an attempt to test important bankruptcy prediction models. The result is that Ohlson model can predict firms’ bankruptcy with a high precision up to three years before bankruptcy occurs. Also Philosophov model can predict firms’ bankruptcy up to seven years before bankruptcy occurs.
Hypothesis 2:

In this research, we cannot disregard the effect of the chosen variables. The chosen variables in this model are exactly those that Ohlson and Philosophov used in their models. In Ohlson model, in the first year before bankruptcy, Working Capital to Total Assets, Current Liabilities to Current Assets, Total Debt to Total Assets, and the Comparison of Total Assets and Total Liabilities ratios have 82% prediction ability; in the second year, Net Profit to Total Assets ratio, Net Profit Variability to Total Assets ratio, and firm size index had 70% prediction ability, and in the third year, Net Profit to Total Assets ratio, Current Liabilities to Current Assets ratio and firm size index had 82% prediction ability. In Philosophov model, the more the firm approaches bankruptcy, the more factors of Retained Profit to Total Assets and Profit before Interest and Tax to Total Assets ratios decrease and Current Liabilities to Total Assets and Interest to Total Assets ratios increase.

We have to consider the special economic and legal conditions when choosing the variables. Bankruptcy has a liquidity concept in the economic setting which Ohlson presented in his model. In other words, in such a setting, if a highly profitable firm fails to pay its debt by the time of its maturity, it is considered as bankrupt. It is evident that variables or financial ratios that assess the liquidity status of a firm can suggest the occurrence of bankruptcy more efficiently.

However, in this research, bankruptcy has a profitability concept. In other words, if the retained loss of a firm is more than half of its recorded capital, it is considered as bankrupt. Such a firm might have an almost favorable liquidity, but it is still considered bankrupt. Thus, in such a concept, profitability ratios can probably predict bankruptcy more efficiently. The results of this research approve this theory.

REFERENCES


