MEASURING FINANCIAL DISTRESS AND PREDICTING CORPORATE BANKRUPTCY: AN INDEX APPROACH

Qunfeng LIAO*, Seyed MEHDIAN**

Abstract: In this paper, we follow Anderson et al. (2009) and suggest a simple approach to employ a set of financial ratios as inputs to estimate an aggregate bankruptcy index (ABI). This index is a within sample measure, ranges between 0 and 1, and ranks the firms on the basis of their relative financial distress. ABI can be used to predict the propensity of financial failure and corporate bankruptcy. For the purpose of comparison and assessment of the robustness of this index, we estimate Z-score by multivariate discriminant analysis, using the same set of financial ratios to compare the predictive accuracy of two approaches. We find that, to some extent, ABI can predict the bankruptcy of the firms more accurately than Z-score. The empirical results of the paper suggest that ABI has relatively robust predictive power and, therefore, can be applied together with other, based on parametric and non-parametric models to predict corporate bankruptcy.

Keywords: corporate bankruptcy prediction, financial distress, aggregate bankruptcy index

JEL Classification: G33, M41

1. INTRODUCTION

During the last six decades and following the seminal papers by Beaver (1968) and Altman (1968), a voluminous body of literature has been developed in finance and accounting to measure financial distress and to predict the bankruptcy of the firm (i.e., Altman, 1968; Beaver, 1968; Altman, 1973; Altman et al., 1977; Jones, 1987; Altman et al., 1994; Mensah, 1984; Scott, 1981; Zmijewski, 1984;

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Hillegeist et al., 2004; Jones and Hensher, 2004; Beaver and McNichols, 2005; Altman and Branch, 2015; see also Bellovary et al., 2007 for a review of studies on the topic). In a notable portion of these studies, the authors utilize, in general, parametric-based and/or non-parametric-based methodologies.

In his seminal work, Altman (1968), developed a multivariate discriminant analysis (MDA) to analytically enhance the quality of financial ratios analysis to predict corporate bankruptcy. We label this approach and any statistical variations derived from it as parametric (e.g., MDA: Altman, 1968, 1973; conditional logit analysis: Ohlson, 1980; logit model and mixed logit model: Johnson and Melicher, 1994; probit Model: Lennox, 1999; hazard model: Shumway, 2001; mixed logit model: Jones and Hensher, 2004; market-based and accounting-based: Agarwal and Taffler, 2008; logistic regression: Premachandra et al., 2009; hybrid bankruptcy prediction model: Li and Miu, 2010; multi-period logistic model: Topaloğlu, 2012; dynamic logit models: Hwang et al., 2013; option-pricing theory: Charitou et al, 2013). Later, Altman and other researchers revised the original MDA model to incorporate more financial ratios, to introduce other statistical techniques to capture random fluctuation in the data set, and to consider the cost of misclassification of firms as bankrupt and non-bankrupt (Kida, 1998; Wu et al., 2010).

While parametric-based bankruptcy prediction models have been extensively employed to quantify the financial position of the firm, these models are subject to several drawbacks. First, the estimated discriminant coefficients are mostly treated as constant without considering the time varying characteristics of the industry under study. Second, as noted by Edmister (1972), the estimation of discriminant function is usually exposed to potential multicollinearity problems, since financial ratios derived from financial statements are likely to be collinear. Although a selection procedure can be utilized to reduce multicollinearity, this procedure may disregard some relevant ratios, which may cause the misspecification of the model. Third, multiple discriminant analysis is a parametric approach by nature, where the variables utilized are assumed to be normally distributed as they must satisfy several statistical requirements (Ohlson, 1980); this is rather a restrictive assumption. Some studies, in fact, find that financial ratios exhibit non-normality in distribution (Bedingfield et al., 1985). Finally, multivariate discriminant analysis
does not offer the possibility for sensitivity analysis, which can be regarded as an appropriate managerial and selection tool.

Recently, several researchers have attempted to use data envelopment analysis (DEA), artificial neural networks (ANN), and market-based contingent claims models as alternative methodologies to measure and quantify a firm’s financial distress to predict bankruptcy (Back et al., 1996; Zhang, 1999; Cielen et al., 2004; Hillegeist et al., 2004; Premachandra et al., 2009; Sueyoshi and Goto, 2009; Jackson and Wood, 2013). We label these methodologies as non-parametric, employing contingent claim model to gauge the probability of financial failure; there are no functional forms and implied normality assumptions imposed on the structure and the distribution of the financial variables utilized. However, the non-parametric approaches are also exposed to shortcomings of their own. For instance, DEA (non-parametric) is not a stochastic approach; therefore, tests of the statistical significance of coefficients are not possible. Additionally, DEA does not provide possibility to isolate shocks, measurement errors, or random fluctuations in data in the estimation procedure. Accordingly, performance measures may be affected by the presence of outliers.

The purpose of the present paper is to introduce and offer a simple and straightforward methodology through which an aggregate bankruptcy index (ABI) is estimated to evaluate the financial position and measure the financial distress of firms using financial ratios. Additionally, this methodology may offer an alternative method for predicting bankruptcy. There are multiple advantages to this approach. First, it avoids the restrictive normality assumption. Second, the multicollinearity among the financial ratios can be avoided because this approach is non-parametric and no coefficient is estimated. Third, sensitivity analysis is feasible in the framework of this technique, which is a potential shortcoming associated with the parametric approach. Finally, no functional form is imposed on data set. Furthermore, this approach is not exposed to limitations related to non-parametric technique, and results are not contaminated by random fluctuations and the presence of outliers in data.

Following Anderson et al. (2009) we use financial ratios as inputs to estimate ABI, which provides a possibility to rank firms based on their relative financial position in the sample. The index is then used to predict the probability of bankruptcy in the firms included in the sample. The empirical results of the study,
in general, suggest that ABI is an appropriate measure to rank the firms according to their level of financial performance and, to some extent, predict bankruptcy more accurately when compared to Z-score. Specifically, our results of ABI4 show that the prediction accuracy one-year prior to bankruptcy is 93 % and 76 % for bankrupt firms and non-bankrupt firms, respectively. Similar to the results of ABI4, the prediction accuracy of ABI5 is 90 % and 76 % for bankrupt sample and non-bankrupt sample one-year before the bankruptcy date. The prediction accuracy of both ABI4 and ABI5 is higher than that of Z-score, which accurately predict bankruptcy and non-bankruptcy at 88 % and 45 %, respectively, one-year prior to bankruptcy. Therefore, ABI greatly improves the prediction accuracy over Z-score, especially for non-bankrupt firms. We also investigate the correlation between ABI and Z-score. The results show that the correlation coefficient between ABI and Z-core is 0.75, which is positive and significant at 1 %, suggesting that ABI measures the same underlying financial positions for companies as Z-score.

The remainder of the paper is organized as follows. Section 2 describes the data set and methodology of the study. Section 3 presents the empirical results and discusses the findings. Section 4 provides the summary and conclusions.

2. DATA AND METHODOLOGY

2.1 Data

We collect the data of bankrupt and non-bankrupt firms from Compustat database. Bankrupt firms are identified as bankrupt if they filed for Chapter 11 in a certain year. The year of bankruptcy varies across the firms. The bankrupt sample contains firms from 1987 through 2013, with non-missing values for all of the variables used to estimate ABIs. A five-year period prior to the date that firm files for bankruptcy is saved as a test period.

In order to form a control sample containing non-bankrupt firms, we match non-bankrupt firms one-to-one with bankrupt firms in the same year and the same 3-digit SIC industry with the closest total assets. In the matching procedure, we limit the “difference in the size” to be less than or equal to 20 %, where the difference in size is calculated as the absolute value of the difference of total assets between bankrupt and non-bankrupt as a percentage of total assets of the bankrupt
firms. Following this process, we form our sample, which consists of 42 bankrupt firms and 42 matching non-bankrupt firms with complete data.

In order to calculate our measure of bankruptcy, we utilize five variables as follows:

\[
\begin{align*}
    WCTA & = \frac{\text{working capital}}{\text{total assets}}, \\
    RETA & = \frac{\text{Retained earnings}}{\text{total assets}}, \\
    EBTA & = \frac{\text{Earnings before interest and taxes}}{\text{total assets}}, \\
    MVCE & = \frac{\text{Market value of equity}}{\text{book value of total debt}}, \text{ and} \\
    SATA & = \frac{\text{Sales}}{\text{total assets}}.
\end{align*}
\]

We employ the same financial ratios used in the Z-score developed by Altman (1968) in order to facilitate the process of comparison.

### 2.2 Methodology

As mentioned above, the methodology of the study involves estimation of an aggregate bankruptcy index. We follow an approach developed and proposed by Anderson et al. (2009), which ranks firms based on their relative financial position, using financial ratios as inputs. This index is established on the financial ratios that are derived from financial statements of the firms. In order to develop the index, we rank individual financial ratios (WCTA, RETA, EBTA, MVCE, and SATA) into deciles with the least distressed firms taking a value of 10, and the most distressed firms taking a value of 1. The five rankings are then summed up and scaled by a factor of 50 to obtain an aggregate bankruptcy index (ABI5). We drop SATA to estimate another aggregate bankruptcy index (ABI4) by employing four ratios to check for the robustness and sensitivity of estimated ABI with respect to number of ratios employed.¹

This index is within a sample measure that ranks firms based on their financial position, and is calculated over time to discriminate between bankrupt firms and non-bankrupt firms. The estimated ABI ranges between 0 and 1, i.e., ABI

¹ We chose to drop SATA because there is no statistically significant difference of SATA between bankrupt and non-bankrupt firms.
The higher the ABI for a given firm, the lower the financial distress and the probability of bankruptcy of that firm.

3. Empirical Results

The descriptive statistics for financial ratios used in the estimation of the ABI are presented in Table 1, panel A. As it can be seen, the means of all ratios are higher for non-bankrupt firms compared to bankrupt firms, except for SATA. Additionally, as the table shows, the volatility of financial ratios of bankrupt firms is higher compared to non-bankrupt firms, except for MVCE. Considering the ratios are not generally normally distributed, we perform non-parametric Kruskal-Wallis mean and the Mann-Whitney median tests to statistically test the differences of mean and median of financial ratios between the two groups. As the statistics in Table 1 panel B suggest, the mean and median of financial ratios of non-bankrupt firms are statistically significantly higher than those of bankrupt firms, except in the case SATA.

Panel A of Table 2 shows the descriptive statistics of estimated ABI4, ABI5, and Altman Z-scores for bankrupt and non-bankrupt firms. We use five ratios as initially used by Altman (1968) to estimate Altman’s Z-scores and ABI5 for the purpose of comparing the two measures with each other. From Table 2 panel A, we find that the estimated Z-scores and ABIs for non-bankrupt firms, on average, are higher than those for non-bankrupt firms. The Z-scores are, on average, below the 1.8 threshold for bankrupt firms and above the 3.0 limit for non-bankrupt firms. While the results in panel A of Table 2 indicate all ABIs and Z-scores are higher for non-bankrupt firms compared to bankrupt firms, we further perform two non-parametric tests (Kruskal-Wallis and Mann-Whitney) to check whether the differences are statistically significant. The results of these tests are reported in Table 2 panel B. According to these tests, the means of the Z-score and ABIs are statistically significantly higher for non-bankrupt firms relative to bankrupt firms.

Table 3 reports the mean, median, and standard deviation of the three bankruptcy measures (ABI4, ABI5, and Z-score) during a period of five years prior to date of bankruptcy for bankrupt and non-bankrupt firms. The means of ABI4 and ABI5 suggest a trend of steady deterioration of the indices over the five years prior to the bankruptcy for the bankrupt firms. The situation is reversed in the case of non-bankrupt firms where both ABI4 and ABI5 exhibit an upward trend during
the same period. Furthermore, we observe the same declining trend for the mean of Z-score in the case of bankrupt firms as the time approaches the date of bankruptcy. Note that the means of Z-scores for non-bankrupt firms do not reveal any trend in the course of the same five-year period.

Table 4 presents the classification matrix based on ABI4 during the period of one to five years prior to the date of bankruptcy for bankrupt and non-bankrupt firms. There are 5 panels (A to E) in Table 4, and each panel (such as panel A) contains two sub-tables. The first sub-table (on the left) of panel A reports the “predicted group” i.e., the number of bankrupt and non-bankrupt firms as predicted and classified by ABI4. For instance, five years prior to the date of bankruptcy, ABI4 classifies 17 firms correctly as bankrupt but misclassifies 14 firms, which go bankrupt as non-bankrupt (Type I error). The second row of this sub-table shows the classification of non-bankrupt firms as bankrupt or non-bankrupt. We find that 9 non-bankrupt firms are misclassified as bankrupt and 13 non-bankrupt firms are correctly classified as non-bankrupt five years prior to the date of bankruptcy.

The second sub-table of panel A (on the right) presents the results of the first sub-table (on the left) in percentages. According to this sub-table, fifty-five percent of bankrupt firms are correctly classified as bankrupt and forty-five percent of them are misclassified as non-bankrupt. In the bankruptcy prediction literature, this misclassification is termed as Type I error. On the other hand, 41% of the non-bankrupt firms are misclassified as bankrupt. This type of misclassification is defined as Type II error. Panels B, C, D, and E have the same structures as panel A, with a one-year incremental towards the date of bankruptcy. As we observe, in general, the percentage of misclassification of the bankrupt and non-bankrupt firms declines and the level of classification accuracy rises as the date of bankruptcy nears. However, the relative costs of prediction errors and credit risks have not been measured, therefore, these findings should be interpreted cautiously. Table 5 reports the classification matrix of the bankrupt and non-bankrupt firms over the five-year period prior to the date of bankruptcy based on ABI5. We employ five financial ratios (the same ratios used by Altman, 1968) to estimate ABI5. Similar to Table 4, Table 5 includes 5 panels (A to E) and each panel has two sub-tables. The first sub-table (on the left) of panel A reports the number of bankrupt and non-bankrupt firms as classified by ABI5. According to the results, ABI5 predicts 16 firms accurately as bankrupt but it misclassifies 15 bankrupt firms as non-bankrupt
(Type I error). The second row of this sub-table indicates that 11 non-bankrupt firms are wrongly classified as bankrupt and the same number of non-bankrupt firms is correctly classified as non-bankrupt five years prior to the date of bankruptcy. The sub-table (on the right) of panel A of Table 5 shows that 52% percent of bankrupt firms and 50% of non-bankrupt firms are accurately classified. However, 48% percent of bankrupt firms are incorrectly grouped as non-bankrupt firms (Type I error), and 50% percent of the non-bankrupt firms are misclassified as bankrupt (Type II error).

Panels B, C, D, and E are organized as panel A with a one-year increment towards the date of bankruptcy. As in the case of ABI4, the percentage of misclassification of the bankrupt and non-bankrupt firms decreases and the classification accuracy improves as the date of bankruptcy comes near. We can interpret this result as Type I and Type II errors steadily decrease over time.

In order to compare ABI5 with Z-score, we estimate Altman (1968) Z-scores for bankrupt and non-bankrupt firms for our sample. The classification results over the five-year period prior to the date of bankruptcy are reported in Table 6. This table is organized in the same way as Tables 4 and 5. We choose ABI5 because it is based on the same five financial ratios used in Altman’s (1968) model.

Table 6 contains 5 panels (A to E). Each panel has two sub-tables similar to the format of Tables 4 and 5. The first sub-table (on the left) of panel A reports the number of bankrupt and non-bankrupt firms as classified by Z-score five years before the bankruptcy occurs. The results reveal that Z-score appropriately classifies 15 firms as bankrupt but it misclassifies 16 bankrupt firms as non-bankrupt (Type I error). According to the second row of this sub-table, 14 non-bankrupt firms are incorrectly classified as bankrupt and 8 non-bankrupt firms are accurately classified as non-bankrupt.

The second sub-table (on the right) of panel A suggests that 48% of bankrupt and 36% of non-bankrupt firms are correctly classified. However, we find that 52% of bankrupt firms are falsely classified as non-bankrupt firms (Type I error). In addition, according to Z-score, 64% of the non-bankrupt firms are inaccurately classified as bankrupt (Type II error). Panels B, C, D, and E of Table 6 are organized the same way as panel A with a one-year increment towards the date of bankruptcy. Considering the prediction based on Z-score as a whole, we see that
the percentage of correct classification increases over time during the five-year period prior to the date of bankruptcy.

As is the case of ABI5, the numbers of Type I and Type II errors decline steadily overtime as the date of bankruptcy approaches. Moreover, the Type II error of ABI5 is lower than that of Z-score, indicating that ABI5 is less likely to classify non-bankrupt firms as bankrupt. Even though the Type I error predicted by ABI5 is higher than error predicted by Z-score three to four years before bankruptcy date, it becomes smaller one to two years prior to the date of bankruptcy. This implies that ABI5 has a lower propensity to misclassify bankrupt firms as the date of bankruptcy approaches.

There are several possible practical financial applications of our empirical findings. First, the portfolio managers and institutional investors can utilize ABI in process of security selections and investment decisions because the measure provides valuable information concerning the financial health of the firms under consideration. Second, the loan officers at financial institutions and analysts at bond rating agencies can apply ABI when they determine credit scores, default risk, bond ratings, and credit worthiness of the companies and the borrowers. Third, the ABI can also be used along with Altman’s z-score to evaluate financial positions of both publicly and privately held companies in manufacturing and nonmanufacturing sectors.

4. SUMMARY AND CONCLUSIONS

This paper employs an approach proposed by Anderson et al. (2009) to estimate an aggregate bankruptcy index (ABI) as an alternative to parametric and non-parametric models to measure financial distress and to predict corporate bankruptcy. The index is a within sample estimate that ranges between 0 and 1. We can use this index to rank firms according to their relative financial distress and to predict the propensity of bankruptcy. The findings of this study provide evidence to indicate that ABI has reasonably robust predictive power and can be a compliment to the other parametric and non-parametric models to predict corporate bankruptcy.

We estimate multivariate discriminant analysis to obtain Z-core using the same set of financial ratios in order to compare the predictive accuracy between ABI and Z-score. The results indicate that ABI could predict the likelihood of bankruptcy reasonably more correctly compared to Z-score.
While more research is necessary to assess the applicability of ABI, we believe that this index can potentially be employed together with other financial stress indicators by credit officers for credit scoring, by investors for investment decisions, by auditors for risk assessment, and by financial managers for financial planning.

**REFERENCES**


### APPENDIX

**Table 1. Descriptive Statistics for Variables Used in Analysis**

<table>
<thead>
<tr>
<th>Variable</th>
<th>N</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Min.</th>
<th>Q1</th>
<th>Median</th>
<th>Q3</th>
<th>Max.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bankrupt firms</strong></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>working capital (WCTA)</td>
<td>42</td>
<td>-0.573</td>
<td>1.518</td>
<td>-8.570</td>
<td>-0.568</td>
<td>-0.086</td>
<td>0.077</td>
<td>0.485</td>
</tr>
<tr>
<td>Retained earnings total assets (RETA)</td>
<td>42</td>
<td>-4.397</td>
<td>9.591</td>
<td>-39.218</td>
<td>-1.912</td>
<td>-0.803</td>
<td>-0.313</td>
<td>0.420</td>
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<tr>
<td>Earnings before interest and taxes (EBTA)</td>
<td>42</td>
<td>-0.426</td>
<td>0.885</td>
<td>-4.668</td>
<td>-0.510</td>
<td>-0.114</td>
<td>0.009</td>
<td>0.257</td>
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<td>Market value of equity book value of total debt (MVCE)</td>
<td>42</td>
<td>0.790</td>
<td>2.342</td>
<td>0.001</td>
<td>0.028</td>
<td>0.071</td>
<td>0.373</td>
<td>13.259</td>
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<tr>
<td>book value of total debt Sales (SATA)</td>
<td>42</td>
<td>1.386</td>
<td>1.163</td>
<td>0.011</td>
<td>0.575</td>
<td>1.313</td>
<td>1.744</td>
<td>5.507</td>
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<td><strong>Non-bankrupt firms</strong></td>
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<tr>
<td>working capital total assets (WCTA)</td>
<td>42</td>
<td>0.205</td>
<td>0.276</td>
<td>-0.194</td>
<td>0.056</td>
<td>0.140</td>
<td>0.311</td>
<td>0.919</td>
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<tr>
<td>Retained earnings total assets (RETA)</td>
<td>42</td>
<td>-0.843</td>
<td>2.205</td>
<td>-8.323</td>
<td>-0.330</td>
<td>-0.006</td>
<td>0.223</td>
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<td>Earnings before interest and taxes (EBTA)</td>
<td>42</td>
<td>-0.027</td>
<td>0.274</td>
<td>-0.952</td>
<td>-0.063</td>
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<td>0.094</td>
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<td>7.029</td>
<td>11.363</td>
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<td>7.601</td>
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<td>book value of total debt Sales (SATA)</td>
<td>42</td>
<td>1.067</td>
<td>1.099</td>
<td>0.000</td>
<td>0.261</td>
<td>0.985</td>
<td>1.449</td>
<td>5.678</td>
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Table 1-continued
Panel B: Tests between Bankrupt and Non-bankrupt Firms

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<th>Variable</th>
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<td>p-value</td>
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<td>Earnings before interest and taxes total assets (EBTA)</td>
<td>15.144</td>
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<td>Market value of equity/book value of total debt (MVCE)</td>
<td>42.183</td>
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<td>Sales/book value of total debt (SATA)</td>
<td>2.423</td>
<td>0.1196</td>
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Panel A presents descriptive statistics for variables used in calculating ABIs and Z-scores. The bankrupt sample contains firms in Compustat from 1987-2013 with non-missing values for all variables used to calculate bankruptcy measures. The non-bankrupt firms are matched with bankrupt firms in the same year and the same 3-digit SIC industry with closest total asset (within 20%). Panel B shows the Kruskal-Wallis mean test and the Mann-Whitney median test.
Table 2. Descriptive Statistics for Aggregate Bankruptcy Indices (ABIs) and Z-score

Panel A: Descriptive Statistics of ABIs and Z-score

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<th>Std. Dev.</th>
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<tr>
<td>Aggregate bankruptcy index4 (ABI4)</td>
<td>42</td>
<td>0.275</td>
<td>0.131</td>
<td>0.100</td>
<td>0.175</td>
<td>0.250</td>
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<td>Aggregate bankruptcy index5 (ABI5)</td>
<td>42</td>
<td>0.352</td>
<td>0.113</td>
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<tr>
<td>Altman Z-score</td>
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<td>Aggregate bankruptcy index4 (ABI4)</td>
<td>42</td>
<td>0.589</td>
<td>0.172</td>
<td>0.200</td>
<td>0.500</td>
<td>0.625</td>
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<td>0.579</td>
<td>0.147</td>
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<td>4.262</td>
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<td>7.461</td>
<td>27.132</td>
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Panel B: Tests between Bankrupt and Non-bankrupt Firms

<table>
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<td>Chi-Square</td>
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<td>Altman Z-score</td>
<td>28.812</td>
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Panel A presents descriptive statistics for ABIs and Z-score. Panel B shows the Kruskal-Wallis mean test and the Mann-Whitney median test.
<table>
<thead>
<tr>
<th>Variable</th>
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<th>Measure</th>
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<td>Aggregate Bankruptcy</td>
<td>Bankruptcy</td>
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</tr>
<tr>
<td>Index4 (ABI4)</td>
<td></td>
<td>Median</td>
<td>0.475</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Std. Dev.</td>
<td>0.167</td>
</tr>
<tr>
<td></td>
<td>Non-bankruptcy</td>
<td>Mean</td>
<td>0.540</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Median</td>
<td>0.563</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Std. Dev.</td>
<td>0.202</td>
</tr>
<tr>
<td>Aggregate Bankruptcy</td>
<td>Bankruptcy</td>
<td>Mean</td>
<td>0.497</td>
</tr>
<tr>
<td>index5 (ABI5)</td>
<td></td>
<td>Median</td>
<td>0.480</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Std. Dev.</td>
<td>0.141</td>
</tr>
<tr>
<td></td>
<td>Non-bankruptcy</td>
<td>Mean</td>
<td>0.534</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Median</td>
<td>0.520</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Std. Dev.</td>
<td>0.178</td>
</tr>
<tr>
<td>Altman Z-score</td>
<td>Bankruptcy</td>
<td>Mean</td>
<td>3.638</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Median</td>
<td>1.878</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Std. Dev.</td>
<td>6.403</td>
</tr>
<tr>
<td></td>
<td>Non-bankruptcy</td>
<td>Mean</td>
<td>1.823</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Median</td>
<td>1.890</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Std. Dev.</td>
<td>5.819</td>
</tr>
</tbody>
</table>

This table presents the mean, median, and standard deviation for ABIs and Z-scores during the period of 1-5 years prior to bankruptcy.
Table 4. Classification Results Using Aggregate Bankruptcy Index 4 (ABI4)

Panel A: 5 Year Prior to Bankruptcy

<table>
<thead>
<tr>
<th>Actual Group membership</th>
<th>Predicted group</th>
<th>% correct</th>
<th>% error</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bankrupt</td>
<td>Bankrupt</td>
<td>17</td>
<td></td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>Non-bankrupt</td>
<td>14</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bankrupt</td>
<td>Type I</td>
<td>55</td>
<td>45</td>
<td>31</td>
</tr>
<tr>
<td></td>
<td>Type II</td>
<td>59</td>
<td>41</td>
<td>22</td>
</tr>
</tbody>
</table>

Panel B: 4 Year Prior to Bankruptcy

<table>
<thead>
<tr>
<th>Actual Group membership</th>
<th>Predicted group</th>
<th>% correct</th>
<th>% error</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bankrupt</td>
<td>Bankrupt</td>
<td>24</td>
<td></td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>Non-bankrupt</td>
<td>11</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bankrupt</td>
<td>Type I</td>
<td>69</td>
<td>31</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td>Type II</td>
<td>60</td>
<td>40</td>
<td>25</td>
</tr>
</tbody>
</table>

Panel C: 3 Year Prior to Bankruptcy

<table>
<thead>
<tr>
<th>Actual Group membership</th>
<th>Predicted group</th>
<th>% correct</th>
<th>% error</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bankrupt</td>
<td>Bankrupt</td>
<td>32</td>
<td></td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>Non-bankrupt</td>
<td>7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bankrupt</td>
<td>Type I</td>
<td>82</td>
<td>18</td>
<td>39</td>
</tr>
<tr>
<td></td>
<td>Type II</td>
<td>59</td>
<td>41</td>
<td>29</td>
</tr>
</tbody>
</table>

Panel D: 2 Year Prior to Bankruptcy

<table>
<thead>
<tr>
<th>Actual Group membership</th>
<th>Predicted group</th>
<th>% correct</th>
<th>% error</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bankrupt</td>
<td>Bankrupt</td>
<td>32</td>
<td></td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Non-bankrupt</td>
<td>9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bankrupt</td>
<td>Type I</td>
<td>78</td>
<td>22</td>
<td>41</td>
</tr>
<tr>
<td></td>
<td>Type II</td>
<td>77</td>
<td>23</td>
<td>35</td>
</tr>
</tbody>
</table>

Panel E: 1 Year Prior to Bankruptcy

<table>
<thead>
<tr>
<th>Actual Group membership</th>
<th>Predicted group</th>
<th>% correct</th>
<th>% error</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bankrupt</td>
<td>Bankrupt</td>
<td>39</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Non-bankrupt</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bankrupt</td>
<td>Type I</td>
<td>93</td>
<td>7</td>
<td>42</td>
</tr>
<tr>
<td></td>
<td>Type II</td>
<td>76</td>
<td>24</td>
<td>42</td>
</tr>
</tbody>
</table>

This table presents the classification matrix based on ABI4 in the period of 1-5 years prior to bankruptcy.

Table 5. Classification Results Using Aggregate Bankruptcy Index 5 (ABI5)

Panel A: 5 Year Prior to Bankruptcy

<table>
<thead>
<tr>
<th>Actual Group membership</th>
<th>Predicted group</th>
<th>% correct</th>
<th>% error</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bankrupt</td>
<td>Bankrupt</td>
<td>16</td>
<td></td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>Non-bankrupt</td>
<td>11</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bankrupt</td>
<td>Type I</td>
<td>52</td>
<td>48</td>
<td>31</td>
</tr>
<tr>
<td></td>
<td>Type II</td>
<td>50</td>
<td>50</td>
<td>22</td>
</tr>
</tbody>
</table>
### Panel B: 4 Year Prior to Bankruptcy

<table>
<thead>
<tr>
<th>Actual Group membership</th>
<th>Predicted group</th>
<th>% correct</th>
<th>% error</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bankrupt</td>
<td>Bankruptcy</td>
<td>18</td>
<td>17</td>
<td>Type I 51</td>
</tr>
<tr>
<td></td>
<td>Non-bankrupt</td>
<td>8</td>
<td>17</td>
<td>Type II 68</td>
</tr>
</tbody>
</table>

### Panel C: 3 Year Prior to Bankruptcy

<table>
<thead>
<tr>
<th>Actual Group membership</th>
<th>Predicted group</th>
<th>% correct</th>
<th>% error</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bankrupt</td>
<td>Bankruptcy</td>
<td>29</td>
<td>11</td>
<td>Type I 73</td>
</tr>
<tr>
<td></td>
<td>Non-bankrupt</td>
<td>11</td>
<td>18</td>
<td>Type II 62</td>
</tr>
</tbody>
</table>

### Panel D: 2 Year Prior to Bankruptcy

<table>
<thead>
<tr>
<th>Actual Group membership</th>
<th>Predicted group</th>
<th>% correct</th>
<th>% error</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bankrupt</td>
<td>Bankruptcy</td>
<td>36</td>
<td>5</td>
<td>Type I 88</td>
</tr>
<tr>
<td></td>
<td>Non-bankrupt</td>
<td>9</td>
<td>26</td>
<td>Type II 74</td>
</tr>
</tbody>
</table>

### Panel E: 1 Year Prior to Bankruptcy

<table>
<thead>
<tr>
<th>Actual Group membership</th>
<th>% correct</th>
<th>% error</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bankrupt</td>
<td>38</td>
<td>4</td>
<td>Type I 90</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>32</td>
<td>Type II 76</td>
</tr>
</tbody>
</table>

This table presents the classification matrix based on ABI5 in the period of 1-5 years prior to bankruptcy.

### Table 6. Classification Results Using Altman Z-score

#### Panel A: 5 Year Prior to Bankruptcy

<table>
<thead>
<tr>
<th>Actual Group membership</th>
<th>Predicted group</th>
<th>% correct</th>
<th>% error</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bankrupt</td>
<td>Bankruptcy</td>
<td>15</td>
<td>16</td>
<td>Type I 48</td>
</tr>
<tr>
<td></td>
<td>Non-bankrupt</td>
<td>14</td>
<td>8</td>
<td>Type II 36</td>
</tr>
</tbody>
</table>

#### Panel B: 4 Year Prior to Bankruptcy

<table>
<thead>
<tr>
<th>Actual Group membership</th>
<th>Predicted group</th>
<th>% correct</th>
<th>% error</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bankrupt</td>
<td>Bankruptcy</td>
<td>23</td>
<td>12</td>
<td>Type I 66</td>
</tr>
<tr>
<td></td>
<td>Non-bankrupt</td>
<td>15</td>
<td>10</td>
<td>Type II 40</td>
</tr>
</tbody>
</table>

#### Panel C: 3 Year Prior to Bankruptcy

This table presents the classification matrix based on ABI5 in the period of 1-5 years prior to bankruptcy.
This table presents the classification matrix based on Altman Z-score in the period of 1-5 years prior to bankruptcy.