Predictive Ability of Financial Ratio to Corporate Bankruptcy: An Empirical Analysis

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Abstract—Business failure is the most serious financial dilemma and attracted high attention from market participants[4].Based on the research that is widely explored by related experts and scholars and according to the sample of US failed firms and non-failed firms in 2009 and 2019 selected from the dataset of WRDS, this paper uses financial ratios from the public financial statements of listed companies to conduct a study on the prediction of the probability of company bankruptcy.The analysis shows that some financial ratios, such as the ratios of shareholder equity to total liabilities and net income to total assets, have better predictive capabilities, and that the ratio of sales to total assets may not be an important indicator of predicting corporate insolvency.

Keywords- financial ratios; bankruptcy prediction; prediction models

1 INTRODUCTION

The global economy is growing faster and faster, and business bankruptcy prediction in business management has gradually become a very valuable research field[5]. Many scholars in this field believe that key financial ratios in financial statements provide valuable information that can be applied to bankruptcy prediction models [6].

This study uses financial ratio analysis as a research method for predicting corporate insolvency, based on financial data from financial statements published by insolvent firms prior to the declaration of insolvency and from financial statements published by non-insolvent firms during the same period, to test insolvent firms against non-insolvent firms. The paper is divided into five sections. The next section describes the analytical methodology used in this paper in using financial ratios for corporate bankruptcy prediction; the third section describes the sources of the data; and the fourth section analyzes the predictive power of financial ratios. The final section draws conclusions and provides further discussion.

2 METHODOLOGY

Financial ratios can effectively measure a firm's profitability, debt position, and liquidity [7]. In this paper, we will first describe how financial ratios measure the probability of a firm's insolvency, then conduct univariate analysis, and then combine univariate analysis with

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multivariate models in order to assess the predictive power of financial ratios. Finally, the results of these tests are analyzed and discussed.

Based on the potential relevance of the study and the popularity shown in many literatures, six representative financial ratios that can be used to assess the profitability, efficiency, liquidity and solvency of the selected firms were selected for this paper (Table 1).

TABLE 1 THE SIX RATIOS SELECTED IN THIS STUDY

	Descriptions	**Initials**	**Measure**
1.	Working Capitai / Total Assets	WCTA	Liquidity
2.	Earnings before Interest and Taxes / Total Assets	EBITTA	Profitability
3.	Stockholders'Equity / Total Debt	SEQTD	Liquidity
4.	Sale / Total Assets	STA	Efficiency
5.	Net Income / Total Assets	NITA	Profitability
6.	Total Debt / Total Assets	TDTA	Solvency

3 DATA COLLECTION

Data collection and selection are described in detail in this chapter.

3.1Selection of Failed Firms and Non-failed Firms

The first step was to select a sample of US failed firms in 2009, which was obtained from WRDS (Wharton Research Data Services), and the basic financial data for these companies are provided by the dataset of Compustat North America fundamentals Annual.The General Industry Classification (GIND) uses a six-digit number to represent the industry category of each company. Of the sample are 42 failed companies operating in 20 industries.

In this study, non-bankrupt enterprises with similar assets in the same industry as the bankrupt enterprises were selected, and these enterprises were similar to those in the sample. The total asset sizes of the firms were obtained from the most recent financial statements available prior to the bankruptcy date. The matched sample approach is based on Beaver's suggestion that equal financial ratio values in different industries may represent different bankruptcy probabilities, and therefore industry factors and firm asset size should be integrated into the ratio analysis [3]. The names and data of the unbankrupt firms were taken from the entire Compustat of WRDS, and the matching unbankrupt firms were selected and their number determined in proportion to the frequency of the industries represented by the bankrupt firms.

3.2Collection of Financial Statement Data

Financial statement data for both bankrupt and nonbankrupt companies were obtained from the North America fundamentals Annual of WRDS and were selected for the year prior to their bankruptcy, i.e., 2008 and later, because they include the most recent financial statement information available prior to the company's bankruptcy date [1]. Table 2 presents the number of failed firms and non-failed firms collected, 42 and 360 firms contained, respectively.

TABLE 2 THE NUMBER OF FAILED CORPORATIONS AND NON-FAILED CORPORATIONS

	failed		Total
Year	0	1	
2008	180	24	204
2009	180	18	198
Total	360	42	402

* 0: Non-failed firms 1: Failed firms

4 RESULTS AND ANALYSIS

The section presents the results and evaluation of the forecast performance of the selected accounting ratios. Data analysis was carried out by the STATA.

4.1Mean Values

Table 3 displays the mean value of six ratios, excluding outlier values, which can have a problematic effect on the analysis results).

TABLE 3 THE MEAN VALUE OF RATIOS

Variable	Obs	Mean	Std.Dev.	Min	Max
wcta	267	.1534006	.1775101	-.1848799	.4825049
ebitta	394	.0383481	.0640772	-.0894604	.1701667
seqtd	402	.6322814	.997449	-.2213406	3.675126
sta	402	.6715688	.5624992	.0497991	1.752377
nita	402	-.0257695	.1057143	-.3317555	.1091054
tdta	402	.7552031	.2709944	.2118482	1.270623

4.2Univariate Analysis

Table 4 shows that some hypotheses can serve as the basis for the predictions with average value.

TABLE 4 PREDICTION OF THE MEAN VALUE FOR FAILED AND NON-FAILED FIRMS

Ratio	Prediction: Non-failed > failed
Working Capitai / Total Assets	Yes
Earnings before Interest and Taxes / Total Assets	Yes
Stockholders'Equity / Total Debt	Yes
Sale / Total Assets	Yes
Net Income / Total Assets	Yes
Total Debt / Total Assets	No

4.2.1T-test of The Difference in Means between bankrupt and non-bankrupt enterprises

To clarify whether the average value of each ratio varies considerably between the two groups, it is necessary to conduct a t-test on the difference of group means for all companies on the selected variables one year before failure: wcta, ebitta, seqtd, sta, nita, tdta. The results were presented in Table 5. Variance of holding inequality. Assuming variances are unequal.

Table 5 Summarized Results of T-test

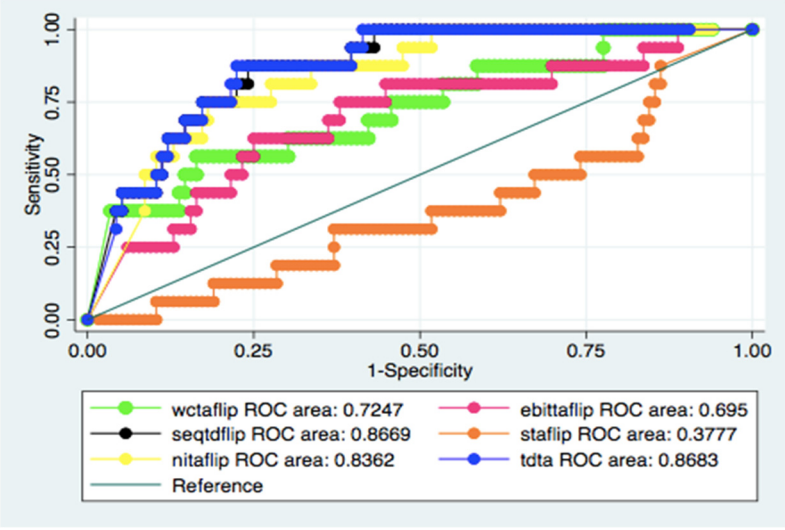
Variable	P-value
wcta	0.0022
ebitta	0.0064
seqtd	0.0000
sta	0.8561
nita	0.0001
tdta	1.0000

The t-test results had confirmed that wcta, ebitta, seqtd, sta, nita can distinguish between the two categories with a p-value of 0.0022, 0.0064, 0, 0.8561 and 0.0001, where approximately 99%, 99%, 100%, 14%, 100% of probability the mean value of these variables for the non-bankrupt group is higher than that for the bankruptcy group in 2008. It also can be seen that tdta can distinguish the two groups as a perfect indicator at the p-value level of 1.0000 and that sta may not be a key predictor to differentiate the two categories.

4.2.2ROC Curves

In this study, the ROC curve was selected to measure the ability of each ratio to make predictions [8]. The area under the curve represents the accuracy and the accuracy is expressed as a percentage. A value of 100% means a perfect ratio for predicting failed firms, with both specificity and sensitivity of 1, while a value of 50% means that the ratio has no predictive power for both failed and non-failed firms [8].

The results of ROC curve for the six ratios are performed in Graph 1 and Table 6.



Graph 1 ROC — Six Ratios

TABLE 6 NUMERICAL RESULTS IN ROC CURVE

	Obs	ROC Area	Std. Err.	—Asymptotic Normal— [95% conf. Interval]	
wctaflip	132	0.7247	0.0728	0.58189	0.86746
ebittaflip	132	0.6950	0.0745	0.54902	0.84106
seqtdflip	132	0.8669	0.0388	0.79096	0.94287
staflip	132	0.3777	0.0747	0.23121	0.52418
nitaflip	132	0.8362	0.0450	0.74798	0.92443
tdta	132	0.8683	0.0379	0.79393	0.94260

Ho: area(wctaflip) = area(ebittaflip) = area(seqtdflip) = area(staflip) = area(nitaflip) = area(tdta)
chi2(5) = 33.04 Prob>chi2 = 0.0000

From the area under the ROC curve, it can be found that the lowest accuracy of the ratio is sales to total assets, which has a value of 37.77%, indicating that the ratio may not be an inappropriate indicator in corporation bankruptcy forecast. The ratios of total liabilities to total assets and shareholder equity to total debts are better than other ratios, with a value of 86.83% and 86.69%, respectively .The forecast capacity of net profit to total assets is better than that of working capital to total assets, while that of EBIT to total assets is a weaker, varying significantly only at the 14% level from 50%.

4.3Multivariate Analysis

4.3.1Correlation Coefficient of selected Variables

To examine whether these ratios have interactional factors to each other in determining bankruptcy forecast, STATA can be used to examine the correlation issues. Table 7 displays the correlation coefficients for the six ratios.

TABLE 7 CORRELATION COEFFICIENTS OF RATIOS

	failed	wcta	ebitta	seqtd	sta	nita	tdta
failed	1.0000						
wcta	-0.2687	1.0000					
ebitta	-0.2095	0.0991	1.0000				
seqtd	-0.2885	0.6052	0.1424	1.0000			
sta	0.1514	0.0888	0.0682	-0.2518	1.0000		
nita	-0.4273	0.2114	0.6499	0.3292	-0.0956	1.0000	
tdta	0.4296	-0.5773	-0.1932	-0.8681	0.2405	-0.4404	1.0000

The coefficients of tdta and seqtd have a higher correlation compared to other variables. The contribution of other four ratios to the likelihood functions are independently and significantly. In general, these variables are critical in the analysis of predictive relationships.

4.3.2Multivariate Logit Model

Through the logit model, the data for 2008 (the year before failure) can be further certified, as shown in Table 8.

TABLE 8 MODEL OF MULTIVARIATE LOGIT

Logistic regression — Number of obs = 132; LR chi2(6) = 37.44; Prob > chi2 = 0.0000; Log likelihood = -30.031102; Pseudo R2 = 0.3840

failed	coef.	Std. Err.	z	p>|z|	[95% conf.	Interval]
wcta	-2.578947	2.110735	-1.22	0.222	-6.715911	1.558017
ebitta	-1.499128	5.26685	-0.28	0.776	-11.82196	8.823709
seqtd	-5.105951	6.135307	-0.83	0.405	-17.13093	6.919031
sta	.4468398	.6672945	0.67	0.503	-.8610334	1.754713
nita	-5.441871	2.526705	-2.15	0.031	-10.39412	-.4896209
tdta	-2.372868	6.982964	-0.34	0.734	-16.05923	11.31349
_cons	.269058	7.269191	0.04	0.970	-13.97829	14.51641

Note: 11 failures and 0 successes completely determined.

. lroc

Logistic model for failed

Number of observations = 132

area under ROC curve = 0.9111

It shows a large area (AUC) under the curve. Similar to the results of the univariate analysis, sta cannot be a useful indicator in corporate bankruptcy forecast. However, tdta performed in the opposite direction as expected. As the company grows, the impact on the probability of failure is expected to increase as well. The reason for this is that when there is a positive change in corporate income, companies typically raise external capital to reduce business risk, and the main source of this external funding is borrowing or increasing debt.

4.4The Analysis on The Dataset of 2019

To determine whether accounting ratios can predict corporate failure more effectively on the latest database, the data of 2019 can be employed to evaluate their predictive ability and compared with the above results.

Through the same approach utilised in the DATA section, the samples of failed corporations in 2019 and the matched non-failed corporations can be established.

Table 9 shows that the final list of bankrupt and non-bankrupt companies comprised 16 and 88, respectively. And the analysis for the mean value of six ratios can be seen in Table 10.

TABLE 9 THE NUMBER OF FAILED FIRMS AND NON-FAILED FIRMS

year	failed 0	1	Total
2017	0	1	1
2018	88	15	103
Total	88	16	104

* 0: Non-failed firms 1: Failed firms

TABLE 10 THE MEAN OF RATIOS

Variable	Obs	Mean	Std.Dev.	Min	Max
wcta	91	.0200946	.21903	-.5651505	.3965563
ebitta	104	.0397619	.0888602	-.1582253	.2038835
seqtd	104	1.167126	1.694143	-.1775351	6.50158
sta	104	.5246568	.4970006	.0416324	1.827365
nita	104	-.0185565	.12661	-.4121397	.1443852
tdta	104	.6292615	.2947172	.1170175	1.215857

4.4.1Univariate Analysis

4.4.1.1T-test

All the examinations one year before failure (2018) were analysed using the same method, and the summarized results is presented in Table 11

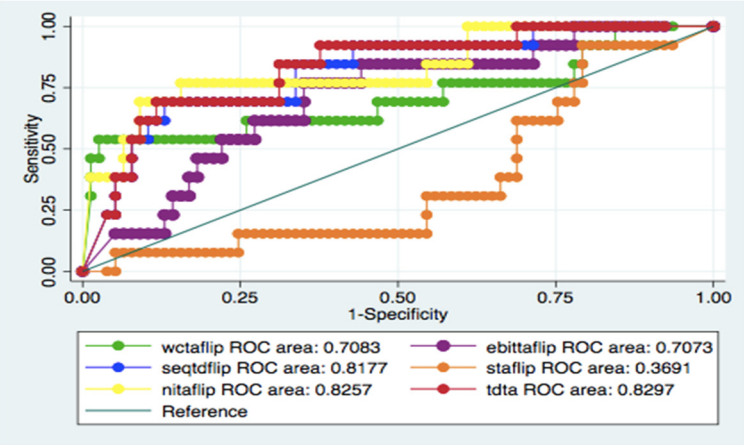
TABLE 11 SUMMARIZED RESULTS OF T-TEST

Variable	P-value
wcta	0.0050
ebitta	0.0069
seqtd	0.0000
sta	0.7504
nita	0.0011
tdta	1.0000

The result is consistent with the analysis of bankrupt companies in 2009, where sta cannot serve as an essential ratio in distinguishing the two categories. In this test, Ebitta has a lower predictive capacity than other ratios.

4.4.1.2Multiple-Ratio ROC Curve

Combining six ratios, the multiple-ratio ROC curves can measure the accuracy of thses variables, as shown in Graph 2.



Graph 2 ROC Curve — Multiple Ratio

In terms of predictive ability, the results of analysis did not differ significantly from that of on the data in 2008. Sta remains the weakest, and the three ratios (tdta, seqtd and nita) outperform other variables. The ratios of wcta and ebitta have similar predictive capabilities in the test.

4.4.2 Multivariate Analysis

4.4.2.1Correlation Coefficient of Variables

Do the same examination as that on the data in 2008 to check the correlation problems between each variable. The analysis is shown in table 12.

TABLE 12 CORRELATION COEFFICIENT OF VARIABLES

	failed	wcta	ebitta	seqtd	sta	nita	tdta
failed	1.0000						
wcta	-0.4547	1.0000					
ebitta	-0.2371	-0.0220	1.0000				
seqtd	-0.2504	0.3878	-0.1576	1.0000			
sta	-0.0755	0.0651	0.3095	-0.1420	1.0000		
nita	-0.5218	0.0828	0.7189	0.1148	0.0335	1.0000	
tdta	0.4321	-0.4197	0.0578	-0.7921	0.1891	-0.2982	1.0000

The coefficients of seqtd and tdta shows a relatively high correlation as compared to other variables. Moreover, nita and ebitta also indicate high correlations.

4.4.2.2 Multivariate Logit Model

The logit model was conducted on the data of 2018 — the year closest to failure. Table 13 shows the result.

TABLE 13 RESULTS OF MULTIVARIATE LOGIT MODEL

Logistic regression — Number of obs = 90; LR chi2(6) = 41.31; Prob > chi2 = 0.0000; Log likelihood = -16.508215; Pseudo R2 = 0.5558

failed	coef.	Std. Err.	z	p>|z|	[95% conf.	Interval]
wcta	-5.839977	2.010196	-2.91	0.004	-9.779888	-1.900066
ebitta	3.854293	8.048541	0.48	0.632	-11.92056	19.62914
seqtd	-.024384	1.037908	-0.02	0.981	-2.058646	2.009878
sta	-.286891	1.182483	-0.24	0.808	-2.604516	2.030734
nita	-12.80188	5.044729	-2.54	0.011	-22.68937	-2.914392
tdta	2.536431	2.86729	0.88	0.376	-3.083353	8.156216
_cons	-4.951411	2.761339	-1.79	0.073	-10.36354	.4607139

. lroc

Logistic model for failed

Number of observations = 90

area under ROC curve = 0.9381

Although the area under the curve (AUC) is high in 0.9381, the analysis demonstrates a different result from that of 2008. Sta, nita, tdta, wcta and seqtd are all functioning in the right direction, while ebitta shows the opposite direction that the probability of bankruptcy is increasing as the business expands. The reason might be that failure companies have high earnings, but huge debt may lead to the risk of bankruptcy, as extensive interests on the debt would have a devastating impact on the net profit.

5 CONCLUSION

In summary, model analyses testing the bankruptcy predictive power of six financial ratios selected based on data from bankrupt firms in 2009 and 2019 suggest that, to some extent, key financial ratios can effectively predict the likelihood of a firm's bankruptcy. Although both univariate and multivariate analyses indicated that the ratio of sales to total assets was not a valid predictor of firm insolvency, the ratios of net income to total assets and shareholders' equity to total debt performed well in terms of predictive ability. It was also shown that the performance results of the ratio of working capital to total assets showed to be more stable than the other two ratios in the test. However, when comparing insolvent firms with non-insolvent firms, the same financial ratios show some differences in predictive accuracy, and not all financial ratios have positive results for predicting firm insolvency. This is primarily due to the inherent flaws of financial ratios, such as the fact that they reflect past performance but do not reflect other important aspects of the firm, such as corporate governance, resource allocation, operational management, and macroeconomic conditions [7]. Accounting ratios are

fundamentally flawed in predicting future events because they are historical in nature and are based on the going concern assumption [2]. As a result, while accounting ratio analysis provides useful information in most cases, additional research in conjunction with other aspects of the firm is required, and the performance of various research models must be systematically compared.

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