USEFULNESS OF MULTI-CRITERIA TAXONOMY IN CORPORATE BANKRUPTCY PREDICTION – THE POLISH EXPERIENCE

Jacek Welc – Elzbieta Sobczak

Abstract

One of the essential elements of company's economic and financial evaluation is ratio analysis. It includes computation and interpretation of multiple bankruptcy risk ratios. When applying accounting ratios in a credit risk evaluation analysts typically either compute and interpret several individual ratios (a univariate approach) or apply some pre-estimated parametric multi-variable econometric tools, such as the Altman model or discriminant function. The problem with the first approach is that it does not take into account the inter-relationships between the individual ratios. The latter approach, in turn, calls for statistical models, whose parameters may not be stable in time and in space. In this paper we empirically examine the usefulness of the alternative approach, that is simple taxonomic ranking, in corporate bankruptcy risk quantification (on the basis of data from the Polish stock market). We found that this simple non-parametric multivariate method outperforms all other tested approaches (including logit model) in discriminating between bankrupt and healthy firms.

Key words: credit risk analysis, bankruptcy prediction, taxonomy, ratio analysis

JEL Code: G11, C21

Introduction

One of the elements of company's evaluation is ratio analysis. It includes computation of bankruptcy risk metrics. There are multiple such measures, including ratios of profitability, indebtedness, liquidity, and debt coverage. When applying accounting ratios in credit risk evaluation analysts typically either compute and interpret several individual ratios (in isolation from each other) or apply some pre-estimated parametric multi-variable econometric tools, such as the Altman model. The problem with the first approach is that it does not take into account the inter-relationships between the individual ratios. The latter approach, in turn, calls for the pre-estimated statistical models, whose parameters may not be stable in time and in space.

One of the alternative approaches to evaluate corporate credit risk, by means of a set of accounting ratios, is based on a statistical multi-criteria analysis (taxonomy). Under this approach, several accounting ratios are first classified into stimulants, destimulants and nominants. Then, on the ground of the selected set of ratios the synthetic non-parametrical index of credit risk is calculated. Based on the obtained values of such a synthetic bankruptcy risk index the companies may be classified as either "healthy" (solvent) or "hazardous" (i.e. burdened with an increased risk of a financial failure).

In our paper we empirically examine the usefulness of a simple taxonomy-based approach to corporate bankruptcy risk quantification, on the basis of data from the Polish stock market. The study is based on a sample of 100 companies, in which case a bankruptcy filing was announced in a period between the beginning of 2009 and the end of 2016. This sample of bankrupt firms is compared to the counter-sample of companies in which case no any bankruptcy filing occurred. Our research is based on several financial statement ratios, which individually show statistically significant relationships with credit risk. To our knowledge, this is the first paper addressing the usefulness of non-parametrical taxonomy methods in multi-variable bankruptcy risk quantification, in the case of the Central European capital markets.

The remainder of the paper is organized as follows. In the next section we discuss relevant literature and theoretical foundations. Next the data and methodology used in the study are described. Then the section that presents the empirical results follows. The paper closes with concluding comments.

1 Theoretical foundations and literature review

Accounting ratios, computed on the ground of data reported in corporate financial statements, constitute one of the main tools in a credit risk evaluation. The main part of such an evaluation is the analysis of a company's liquidity, indebtedness, profitability and debt-coverage ratios.

Liquidity measures the adequacy of a firm's cash resources to meet its near-term cash obligations (Fridson, Alvarez, 2002), while solvency (indebtedness) analysis examines the firm's capital structure, including the mix of its financing sources and the ability of the firm to satisfy its longer-term debt and investment obligations (Beaver *et al.*, 2005). Liquidity and indebtedness ratios are complementary (rather than competitive) to each other, but may differ in terms of relative usefulness in various circumstances. For example, liquidity is more informative of credit risk for firms with high levels of short-term assets and liabilities (e.g. in inventory-intensive industries), since the operations and cash flows of those firms tend to be

driven by short-term accounts (Demerjian, 2007). In contrast, total indebtedness may be more relevant in capital-intensive industries, where fixed (long-term) assets play a major role.

The empirical studies found that liquidity and indebtedness ratios, despite their simplicity, appear statistically significant in huge majority of statistical models for bankruptcy prediction (Charalambous *et al.*, 2000). However, typically the credit risk of a given company is not evaluated on the basis of liquidity and indebtedness ratios only. Instead, additional measures, such as profitability and debt-coverage or interest-coverage ratios (intended to quantify the extent to which company's debt repayments and interest charges may be services by the profits or cash flows it generates), are taken into consideration (Ganguin, Bilardello, 2005).

Multiple empirical studies confirmed that the various ratios of firm's profitability, liquidity, solvency and debt coverage are powerful predictors of corporate financial failures (Beaver, 1966; Deakin, 1972; Altman, 1968; Altman *et al*. 1977; Ohlson, 1980; Zmijewski, 1984; Mossman *et al.*, 1998; Zhang *et al.*, 1999; Shumway, 2001; Chava, Jarrow, 2004; Beaver *et al.*, 2005; Altman, Sabato, 2007). However, the order of importance of individual ratios is unclear, because almost every study cites a different ratio as the most effective indicator of impending problems. Thus, even though the individual ratios themselves may be informative about the risk of a company's failure, the rigorous credit risk analysis is typically based on a set of ratios (rather than the individual metrics). Consequently, the issue of choosing a methodology of multivariate analysis of credit risk arises (e.g. full-blown econometric modeling or some simpler non-parametric taxonomy).

2 Methodology

In this paper the usefulness of a simple taxonomic procedure for multi-criteria credit risk analysis is tested. To this end, the accuracy of that taxonomic (non-parametric) procedure in discriminating between bankrupt and non-bankrupt firms is evaluated and compared to much simpler univariate approaches (based on individual credit risk ratios) as well as to more sophisticated parametrical multivariate approach (a logit model of bankruptcy probability). The following individual credit risk ratios have been investigated:

1. EBITDA PROFITABILITY = (operating profit + depreciation and amortization in a year) / total assets at the end of the year,
2. INDEBTEDNESS = total liabilities and provisions at the end of the year / total assets at the end of the year,

3. CURRENT LIQUIDITY = total current assets at the end of the year / total current liabilities at the end of the year,
4. EBITDA COVERAGE = (operating profit + depreciation and amortization in a year) / current liabilities at the end of the year.

The ratios of EBITDA profitability, current liquidity and EBITDA coverage are stimulants (i.e. the higher their values, the lower the bankruptcy risk), while the indebtedness ratio may be considered a destimulant (i.e. the higher the indebtedness, the higher the credit risk).

Our research was based on the data from a period between the beginning of 2009 and the end of 2016. Within this timeframe, as many as 100 Polish public firms (listed on the Warsaw Stock Exchange) faced at least one bankruptcy filing. The companies included in that sample, labelled further as "bankrupt firms", form the primary sub-sample. To enable a statistical analysis, this sample has been extended by adding 100 randomly selected firms, in which case no any bankruptcy filing was announced in the same period (this sub-sample is further denoted as "healthy firms" or "non-bankrupt firms"). All the accounting numbers used in this study have been collected from primary sources, that is from annual reports issued by the companies included in the sample.

According to our analysis (not presented here), no any industry seems to dominate in the sample, although two businesses (construction and IT) make up about 30% of the investigated bankruptcy filings. It seems therefore that the sample of corporate failures, included in this study, may be considered representative of a broad spectrum of diverse Polish companies. In contrast, a time-series distribution shows that two years of economic slowdown (2012-2013) seem to be slightly over-represented, while other periods, particularly those featured by fast growth of Polish economy, seem to be under-represented. However, it seems logical, because bankruptcy rates tend to rise / fall when macroeconomic conditions deteriorate / improve.

One-period-ahead bankruptcy prediction horizon has been investigated. To make sure that only data which were publicly available on the bankruptcy filing date are taken into account, for bankruptcy filings announced between the beginning of April and the end of December of *t*-th year (i.e. when annual financial statements for the preceding year have already been published), data from annual reports for *t-1* period have been used. In contrast, for bankruptcy filings announced between the beginning of January and the end of March of *t*-th year, data from annual reports for *t-2* period have been used (as the most recent annual financial information available).

To evaluate and compare the usefulness of individual ratios (listed above) in discriminating between bankrupt and healthy firms, the following procedure has been applied (separately for each of the four ratios):

1. All 200 companies (100 bankrupt and 100 non-bankrupt) were sorted in order of either decreasing values (in case of stimulants) or increasing values (in case of destimulants) of a given ratio.
2. The whole sample was divided into two subsamples (100 firms with the most positive value of a given ratio and 100 firms with the most negative value of a given ratio).
3. Within each of the two subsamples the percentage share of bankrupt companies was computed.
4. The difference (in percentage points) in bankruptcy rate between both subsamples was computed.

To evaluate the usefulness of multivariable approaches, two alternative statistical tools (a non-parametrical taxonomy and a parametrical logit model) have been tested. In the case of the first of those two approaches, the following simple taxonomical (non-parametrical) procedure has been followed:

1. On the ground of each of the four individual ratios (separately) every company in the sample has been ranked, in the way that the company with the most positive value of a given ratio has been given a rank of 200, while the company with the most negative value of a given ratio has been given a rank of 1.
2. For each company its average rank (arithmetic mean of four rank values, obtained for four individual ratios) has been computed.
3. Further three steps were the same as above for individual ratios (with the average rank, instead of a value of the individual ratio, being a sorting criteria.

The last tool evaluated (a parametrical one) was a logit model of a bankruptcy probability, where the following procedure has been applied:

1. On the ground of our sample of 100 bankrupt and 100 non-bankrupt firms a linear logit model was estimated, with those of the four individual ratios used as explanatory variables which turned out to be statistically significant on 5% significance level.
2. For each company its fitted bankruptcy probability (from the obtained logit model) has been estimated.
3. Further three steps were the same as above for individual ratios (with the fitted bankruptcy probability, instead of the value of the ratio, being a sorting criteria).

Finally, all six credit risk evaluation approaches (i.e. four individual ratios and two multivariate statistical tools) have been compared in terms of the precision with which they discriminate between bankrupt and non-bankrupt firms.

3 Results

Table 1 presents the matrix of correlations between pairs of all four individual investigated ratios. Table 2, in turn, discloses the differences between median values of all four ratios within both sub-samples (bankrupt and non-bankrupt firms).

Tab. 1: Correlations between four individual credit risk ratios.

Numbers of ratios	(1)	(2)	(3)	(4)
EBITDA profitability (1)	1,00			
Indebtedness (2)	-0,31	1,00		
Current liquidity (3)	0,15	-0,23	1,00	
EBITDA coverage (4)	0,64	-0,16	0,28	1,00

Source: annual reports of companies in the sample, author's work

Tab. 2: Median values of individual credit risk ratios.

Ratio	Median for:		Wilcoxon Rank-Sum test statistic
	Bankrupt firms	Non-bankrupt firms	
EBITDA profitability	0,3%	10,8%	7,07
Indebtedness	68,6%	44,8%	6,82
Current liquidity	0,98	1,71	6,12
EBITDA coverage	0,9%	41,2%	7,92

Source: annual reports of companies in the sample, author's work

As might be seen in Table 1, the investigated credit risk metrics seem not to be strongly correlated between each other. In case of only one pair of ratios the absolute value of correlation coefficient exceeds 0,50. For the remaining pairs the absolute value of correlation does not exceed 0,31. Accordingly, the investigated ratios seem not to duplicate the economic content of each other. From Table 2, in turn, it may be concluded that in the case of all four ratios there are evident differences between bankrupt and non-bankrupt firms. As expected, healthy firms (when compared to failed ones) tend to have higher profitability, liquidity and debt coverage, but lower indebtedness. For every ratio the absolute value of Wilcoxon Rank-Sum test statistic

exceeds its critical value of 1,96 by high margin, which confirms that the differences in medians (between bankrupt and non-bankrupt firms) are statistically significant in all four cases.

Table 3 presents percentages of bankrupt firms within two sub-samples, formed on the ground of the four individual ratios as well as two multivariate statistical tools (i.e. non-parametric ranking taxonomy and linear logit model for bankruptcy prediction).

Tab. 3: Bankruptcy rates within sub-samples of firms formed on the ground of four individual ratios as well as two multivariate statistical methods.

Credit risk measurement approach	Percentage of bankrupt firms		Difference in percentage points
	100 firms with the most positive value	100 firms with the most negative value	
EBITDA profitability	29	71	**42**
Indebtedness	31	69	**38**
Current liquidity	30	70	**40**
EBITDA coverage	24	76	**52**
Taxonomic ranking	22	78	**56**
Logit model	24	76	**52**

Source: annual reports of companies in the sample, author's work

As might be seen, all six approaches to discriminating between bankrupt and non-bankrupt firms are able to split the whole sample (of 200 firms) into two sub-samples which differ significantly in terms of the share of the failed firms. Among univariate approaches, EBITDA coverage ratio clearly outperforms the others. However, even though the remaining three univariate approaches are individually much less informative (than EBITDA coverage) in identifying bankrupt firms, they do contribute positively when combined into a four-variable taxonomy, which outperforms all other approaches (including logit model). This confirms that all four credit risk ratios should be applied and interpreted in relation to each other (instead of separately). Finally, our findings do not support the supremacy of a parametric approach (logit model of bankruptcy probability) over a simple taxonomic ranking in discriminating between failing and healthy firms.

Conclusion

In this paper we evaluated and compared the usefulness of four individual accounting ratios as well as two multivariate statistical tools in discriminating between bankrupt and non-bankrupt

companies, on the basis of data from the Polish stock market. Our study is based on a sample of 100 firms, in which case a bankruptcy filing was announced in a period between the beginning of 2009 and the end of 2016. This sample of bankrupt firms is compared to the counter-sample of companies in which case no any bankruptcy filing occurred.

We found that in the case of all four individual ratios there are evident differences between bankrupt and non-bankrupt firms, with healthy firms having (on average) higher profitability, liquidity and debt coverage, but lower indebtedness. Among individual ratios, EBITDA coverage clearly outperforms the other three. However, a simple taxonomic ranking, which includes all four individual ratios, outperforms all other tested approaches in discriminating between bankrupt and healthy firms. Last but not least, our findings do not support the supremacy of a logit model (which is a more sophisticated econometric approach, requiring estimates of structural parameters) over a simple taxonomic ranking in identifying failed businesses.

However, our study has relevant limitations. First of all, the period covered by our study is pretty short and includes only few economic and stock market cycles (which means that any single year could significantly impact the final findings). Moreover, during the years under investigation Polish economy did not experience any single year of a recession. This means that our findings about the relative usefulness of the six tested approaches can be somewhat biased.. Regrettably, refining our research to adjust for the above shortcomings is not currently viable, owing to the data availability limitations.

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Contact

Jacek Welc
Wroclaw University of Economics
ul. Nowowiejska 3, 58-500 Jelenia Gora, Poland
jacek.welc@ue.wroc.pl

Elzbieta Sobczak
Wroclaw University of Economics
ul. Nowowiejska 3, 58-500 Jelenia Gora, Poland
elzbieta.sobczak@ue.wroc.pl