DOI: 10.2478/orga-2024-0008

Application of the Altman Model for the Prediction of Financial Distress in the Case of Slovenian Companies

Tatjana DOLINŠEK, Tatjana KOVAČ

Faculty of Commercial and Business Sciences, Slovenia, tatjana.dolinsek@fkpv.si, tanja.kovac@fkpv.si

Background/Purpose: The aim of this paper is to verify the applicability and accuracy of the Altman model in the case of Slovenian companies. The use of the Altman model is hugely popular and widespread among financiers, analysts and other stakeholders who want to determine the creditworthiness of a company's operations and the likelihood of it running into financial difficulties in the coming years.
Methods: The study was conducted on a sample of 66 Slovenian companies, which were divided into two equal groups: bankruptcy and non-bankruptcy companies. Based on accounting data for the last five years, the authors of this paper calculated the Z-Score, which is based on the Multiple Discriminant Analysis (MDA). By calculating the statistical error of the estimate (type I and II), the authors verified the extent (in percentage terms) to which the companies had been correctly classified by the model. The Mann-Whitney U test was used to check whether there was a difference in the average Z-Score between the two groups of companies.
Results: The authors determined that the reliability of the Altman model was 71.21% when tested at the upper bound (the threshold value of the Z-Score was 2.6) and 80.30% when tested at the lower bound (the threshold value of the Z-Score was 1.1). This is similar to other countries, where the reliability was found to be over 70% in most cases. Despite the lower reliability of the model, the Z-Score proved to be an important factor in differentiating between the two groups of companies, as bankruptcy companies had a lower value of this indicator than non-bankruptcy companies.
Conclusion: Based on the results of this study, as well as those of other studies, it can be summarized that the Altman model is a fairly good way for companies to determine the success of their business in a relatively simple and quick way and also to predict the potential risk of their operations in the future. However, since the reliability of the model is not 100%, it is important to be careful when making business predictions and carry out additional in-depth analyses or use other methods.

Keywords: *Financial distress, Altman Z''-Score model, Bankruptcy prediction, Multiple Discriminant Analysis, Slovenia*

1 Introduction

Each company has its own lifespan during which various ups and down occur. Some companies have a tradition dating back more than 100 years, while others cease their business activities after only a few years. In the short term the company aims to maximize current profits, while in the long term it aims to increase the value of the company itself . Some companies operating within a certain period of time are forced to fail to fulfill their obligations or be liquidated, due to financial difficulties (Martini et al., 2024). Reasons for the termination of a company's activities may vary. One of the most common reasons is financial distress, which manifests itself in insolvency and can subsequently lead to bankruptcy. Bankruptcy is a problem that can occur in a company if the company cannot maintain the stability of the company's performance. Bankruptcy

Received: 5th December 2023; Accepted: 24th January 2024

is a condition when a company suffers from insufficient funds to run its business (Yuna et al., 2020). In this case, it is highly important to be able to predict such an event and take appropriate measures in order to mitigate the consequences. The prediction of business distress and creation of a model that could predict financial distress with a sufficient degree of probability started as early as the end of 1930s, when the first research on the topic was carried out, mainly for banks to assess the creditworthiness (Fitzpatrick, 1932). Charles L. Merwin (1942) published a study on the prediction of financial distress, which held primacy in the field until 1966, when Beaver published a new study that was carried out on a sample of 79 companies that had gone bankrupt in the period between 1954-1964 (Beaver, 1966). The focus of this early studies was on the analysis of financial ratios in order to find financial indicators able to predict business failure (Bogdan et al., 2021). All these studies were based on a univariate statistical analysis, as they merely compared the successful companies with the unsuccessful ones. Nevertheless, they were still important, as they provided a good basis for all the subsequent studies, which were based on multivariate bankruptcy prediction methods. The first such study, which was based on discriminant analysis, was published in 1968 by Edvard I. Altman who developed a five-factor model for predicting bankruptcy of manufacturing companies listed on a stock exchange. The model predicted bankruptcy if the Z-Score value was lower than the critical value. The model was later extended by adding two new versions, namely for non-producing and unlisted companies. The Altman model has thus become one of the most recognized models for predicting a company's financial distress and is used by various companies, credit rating agencies, financial analysts and the like (Altman, 1968).

In the 1950s, predicting problems in the operations of companies and the possibilities of forecasting their bankruptcy also became an increasingly pressing issue in Slovenia, specifically in the banking, business and scientific spheres. Slovenia experienced its first bankruptcy at the end of 1990s, when it was still part of the former Yugoslavia. From then on, assessing the creditworthiness and predicting the bankruptcy of a company has not only become important for creditors, but also for owners, suppliers, customers, employees and other shareholders. The study, which Altman et al., (2014) conducted based on 35 countries, also included a sample of companies from Slovenia (n=41). The analysis in this study shows that while a general international model works reasonably well for most countries, with prediction accuracy levels (AUC - Area Under the Curve) of about 75% (72% for Slovenia), and exceptionally well for some (above 90%), the classification accuracy may be considerably improved with country-specific estimation, especially with the use of additional variables (Altman et al., 2014).

The aim of this paper is to test the usefulness of the Altman model for the prediction of bankruptcy of Slovenian companies (n=66), in a similar way to the studies that were carried out in other countries, including Slovakia (Vavrek et al., 2021), Sweden (Charraud & Garcia Saez, 2021), Croatia (Galant & Zenzerović, 2023; Bogdan et al., 2019), Romania (Grosu & Macsim, 2019), Italy (Celli, 2015), Indonesia and Singapore (Muzanni & Yuliana, 2021), Turkey (Cındık & Armutlulu, 2021), Greece (Kokkoris & Anagnostopoulou, 2016) and other. Some authors only conducted studies on a specific industry, e.g. banking (Kokkoris & Anagnostopoulou, 2016), agriculture (Vavrek et al., 2021), pharmaceuticals (Panigrahi, 2019) and coal mining (Mulyati & Ilyasa, 2020), while others were not limited solely to a specific industry but included companies from the entire economy. These are just a few examples; in various countries, hundreds of studies can be found using the model. Some resulted in favor of the validity of the Altman Z-Score model, while others revised the model or offered more state-of-the-art technology-added methods (Cındık & Armutlulu, 2021).

2 Theoretical Background

Financial distress is defined as a condition in which a company had negative net income for several consecutive years (Hofer, 1980; Whitaker, 1999). Hopwood, McKeown & Mutchler (1994) stated that financial distress occurs when negative working capital, operating losses and negative retained earnings occur simultaneously. Despite these two definitions, a financial distress signal can also be seen from a company's financial statement. Brigham and Gapenski (1997) split the definition of financial distress into several types, namely economic failure, business failure, technical insolvency, insolvency in bankruptcy, bankruptcy and legal. Financial distress occurs prior to bankruptcy. Bankruptcy itself is usually defined as a situation in which companies fail or are no longer able to meet their obligations to the debtors because they are experiencing a shortage and insufficiency of funds (Ningsih & Filtri Permatasari, 2018). It is important to understand the difference between insolvency and bankruptcy, because the two terms are often confused. A company can be insolvent without being bankrupt, however, a company cannot be bankrupt without being insolvent. First, insolvency can be defined as the inability of a company to pay its debts in time, to counter this problem a company can borrow money from a bank, which will put the company in economic distress (Charraud & Garcia Saez, 2021).

2.1 Theories Examining Financial Distress

Theories that examine financial distress can be divided into two groups. The first consists of those theories that examine the causes or reasons of financial distress. According to Charraud and Garcia Saez (2021), these are the following: liquidity theory, solvency theory, pecking order theory, profitability theory, cash flow theory and the contagion effect. The second group includes more recent theories on which models that predict a company's bankruptcy are based. According to Aziz and Dar (2004), these are as follows: entropy theory, gambler's ruin theory, cash management theory and credit risk theory. These are discussed in more detail below.

a) Balance Sheet Decomposition Measure (BSDM) / Entropy Theory

One way of identifying a company's financial distress could be a careful look at the changes occurring in its balance sheets. If a company's financial statements reflect significant changes in its balance sheet composition of assets and liabilities over a reasonable period of time, it is more likely that the company is incapable of maintaining a state of equilibrium. Since these changes are likely to become uncontrollable in the future, it is possible to predict financial distress in these companies (Aziz & Dar, 2004).

b) Gambler's Ruin Theory

This probability-based theory, developed by Feller (1968), states that a gambler's capacity to win or lose money depends on chance. The theory assumes that the bettor commences gambling with a positive amount of cash (In the context of a company's financial distress, the company would take the place of a gambler. Like the gambler, we assume that the firm has a certain amount of cash that is constantly entering and existing the firm as it conducts its operations (Francis, 2022).

c) Cash Management Theory

An imbalance between cash inflows and outflows would mean failure of a company's cash management. Persistence of such an imbalance may cause the company financial distress and, hence, failure (Aziz &Dar, 2004). To avoid financial difficulties and subsequent insolvency, business should place a strong emphasis on proper cash management (Francis, 2022).

d) Credit Risk Theory

The credit risk theory is closely related to the Basel I and Basel II[1] Accords, which mostly refer to financial companies. Credit risk is the risk that a borrower/counterparty will default, i.e. fail to repay an amount owed to a bank. Credit risk includes all of the counterparties and reasons for which they may default on their obligations to repay (Aziz & Dar, 2004).

2.2 Models for Predicting Company Bankruptcy

Throughout history, a large number of models for predicting bankruptcy have been developed using various quantitative methodologies, from simple regression modeling to very complex methods (Galant & Zenzerović, 2023). In practice, the Altman model (1968) has been the most widely used, and has also been the basis for other models, such as the Springate model (1978), the Ohlson model (1980), and the Zmijewski model (1984). The main difference between them lies in the methodological approach; while Altman used the MDA (Multiple Discriminant Analysis), Ohlson's model is based on logistic regression and Zmijewski's on probit analysis. In 1991, Peter Kralicek developed a model for German-speaking countries called the Kralicek Quick Test (Kralicek, 1991). Unlike the Altman model, which incorporates static indicators, the Kralicek Quick Test includes both dynamic and static indicators and is most commonly used in Germany, Switzerland and Austria (Šverko et al., 2017). The advantage of using all the above-mentioned models is the ability to quickly and simply assess a company's financial position, while the disadvantage is the limited accuracy of the forecasting assessment.

2.2.1 The First Altman Model (Z')

The original Altman model of 1968 included a sample of 66 American companies, of which 33 (half) went bankrupt, while the other half did not. The chosen companies came from the manufacturing industry, they were medium-sized and listed on the stock exchange in the period 1946-1965 (Altman, 1968). For all the companies, Edvard I. Altman obtained financial statements and calculated 22 financial indicators relating to profitability, indebtedness, liquidity, activity and solvency (Alcalde et al., 2022). By using the MDA, he modelled these 22 indicators into five variables and developed a Z-Score model to predict whether or not a company would go bankrupt. The Z-Score model is a linear analysis, which uses five measures that are objectively weighted and summed up to arrive at an overall score that then becomes the basis for classification of companies into one of the a priori groupings: bankruptcy and non-bankruptcy (Altman, 2013). The model has the following form:

[1] Basel is a set of international banking regulations established by the Basel Committee on Banking Supervision (BCBS). It prescribes minimum capital requirements for financial institutions, with the goal of minimizing credit risk (https://www.investopedia.com/terms/b/basel_i.asp).

$$Z = 1.2\,x_1 + 1.4\,x_2 + 3.3\,x_3 + 0.6\,x_4 + 0.999\,x_5 \quad (1)$$

where:
X1 = Working capital/Total assets
X2 = Retained Earnings/Total assets
X3 = EBIT (Operating income)/Total assets
X4 = Market value of equity/Book value of total liabilities
X5 = Sales/Total assets
Z' = Overall Index

The higher the Z-Score, the lower the risk of a company going bankrupt. Altman developed three zones: the safe zone, the grey zone and the distress zone. The safe zone ($Z > 2.99$) means that the company is in a good financial position and that it is not likely to go bankrupt in the next two years. The grey zone ($1.81 < Z < 2.99$) means that the company has financial difficulties, but the possibility of being saved and going bankrupt is just as great depending on the company's policy decisions. The distress zone ($Z < 1.81$) means that the company is in serious financial difficulties and that there may be a solvency issue or the possibility of bankruptcy of the company in the following two years (Altman, 2013).

2.2.2 The Second Altman Model (Z')

Since this original Altman model was only intended for the manufacturing companies listed on the stock exchange, it was later revised. In 1983, Altman developed a new model (Z'), which was designed for companies not listed on the stock exchange. In light of this, he replaced the market value of the capital with the book value in the numerator of the x4. variable. The other variables remained the same as in the original model. In this revised model, Altman also changed the constants in individual variables and slightly lowered the values of the intervals according to the bankruptcy prediction. This model has the following form (Altman, 1983):

$$Z' = 0.717\,x_1 + 0.847x_2 + 3.107x_3 + 0.420x_4 + 0.998x_5 \quad (2)$$

Due to the change in the discriminant of the function, the intervals for the classification of companies into a relevant zone have also been changed: a value of $Z' > 2.9$ represents the safe zone, values in the range $1.23 < Z' < 2.99$ mean the grey zone and the values of $Z' < 1.23$ fall into the distress zone (Altman, 1983).

2.2.3 The Third Altman Model (Z'')

The third modification of the Altman model originates from 1995 and is called the Emerging Market System (EMS) or the Z'' and can be applied to both manufacturing and non-manufacturing companies (Altman, 2005). Unlike the revised model above (Z'), this model only includes the first four variables. Altman omitted the fifth variable (x5)

$$Z'' = 6.56x_1 + 3.26x_2 + 6.72x_3 + 1.05\,x_4 \quad (3)$$

due to the possible influence of the activity on the value of the dependent variable. He also changed the constants of the variables, which are higher than in the previous two models. The advantage of this model is it is also suitable for companies not listed on the stock exchange and for the companies engaged in non-manufacturing activities. This model was also used in our study and takes the following form:

where:
X1 = Working capital/Total assets
X2 = Retained Earnings/Total assets
X3 = Operating income/Total assets
X4 = Book value of equity/Total liabilities
Z' = Overall Index

In this case, too, the values of the intervals for the classification of companies into zones have lowered because of the changed discriminant function: a $Z'' > 2.6$ value means the safe zone, values in the $1.10 < Z' < 2.60$ range represent grey zone and values of $Z'' < 1.10$ mean the distress zone (Altman, 2005).

3 Methodology

The study was carried out in three steps. First, the authors created a study sample, which was then stratified into two groups – the first stratum included companies that had gone bankrupt or into liquidation in the past (hereinafter referred to as 'bankruptcy companies'), and the second stratum consisted of companies that were still in business (hereinafter referred to as 'non-bankruptcy companies'). A random sampling was carried out within the stratum, whereby each of the two stratums included 33 companies, thus resulting in a total sample of 66 companies. The data were obtained from AJPES[2].

The second step involved obtaining data for every company from its financial statements (balance sheet and profit and loss account) for the last five years of its operations (the five years preceding insolvency proceedings

[2] AJPES manages the Slovenian Business Register as a central public database for all business entities, their subsidiaries and other organization segments located in Slovenia that are engaged in profitable or non-profitable activities (https://www.ajpes.si/?language=english).

for the unsuccessful companies and the last five years of operation for the successful companies), i.e. from 2017 to 2022. The source of the data was the Slovenian credit rating agency BIZI.si, which provides access to financial statements (balance sheet and profit and loss account) for each company for previous periods.

In the third step, the third Altman Z-Score model (Z'') was applied, which is based on MDA. The MDA is a statistical technique used to classify an observation into one of several a priori groupings dependent upon the observation's individual characteristics (Altman, 2013). It is used primarily to classify and/or make predictions for problems where the dependent variable appears in qualitative form, for example, male or female, bankrupt or non-bankrupt. In its most simple form, MDA attempts to derive a linear combination of the characteristics that 'best' discriminate between the groups. If a particular object, for instance, a corporation, has characteristics (financial ratios) that can be quantified for all of the companies in the analysis, the MDA determines a set of discriminant coefficients (Altman, 2013).

The aim of this study was to build a model that best distinguishes between bankruptcy and non-bankruptcy companies on the basis of four independent variables (calculated on the basis of data from financial statements). Using financial statement data for the last five years, the authors first calculated the average value for all four independent variables (x1, x2, x3 in x4), which we then weighted with the suitable factors and calculated the value of the dependent variable Z'' on the basis of equation 3. Based on the value of Z'', the companies were divided into three zones, which show the likelihood that a company would go bankrupt in the future. Figure 1 shows the conceptual model of the research.

The main purpose of the study was to test the usability of the Altman model in the case of Slovenian companies. In doing so, the authors formed the following two hypotheses:

H1: There is a significant difference in the value of the Z''-Score between bankruptcy and non-bankruptcy companies.

The authors predict that bankruptcy companies will have a lower Z''-Score value than non-bankruptcy companies. Our hypothesis is established on the theoretical starting points, which explain the reasons for the bankruptcy and represent the basis for the creation of independent variables in the Altman model. These refer to profitability, indebtedness, liquidity, activity and solvency. Higher values of the independent variables are also associated with a higher Z''-Score value, which could thus distinguish between bankruptcy and non-bankruptcy companies.

H2: The Altman model will correctly classify at least 75% of companies.

The Altman model is relatively simple and allows for a quick assessment of the performance of companies. However, it also has a limitation, which is reflected in the limited reliability of the assessment. This has also been discovered by other authors in the case of other countries: for example, the model proved to be 72% reliable for Croatian companies (Bogdan et al., 2019), 78% for Italian companies (Celli, 2015) and 76% for Turkish companies (Cındık & Armutlulu, 2021).

4 Results

4.1 Sample Description

The sample of companies (n=66) was stratified into two equally sized groups: bankruptcy companies (n=33) and non-bankruptcy companies (n=33). The sample was balanced in terms of both the industry (manufacturing, service and trading companies) and the legal form (public limited companies and private limited companies) of

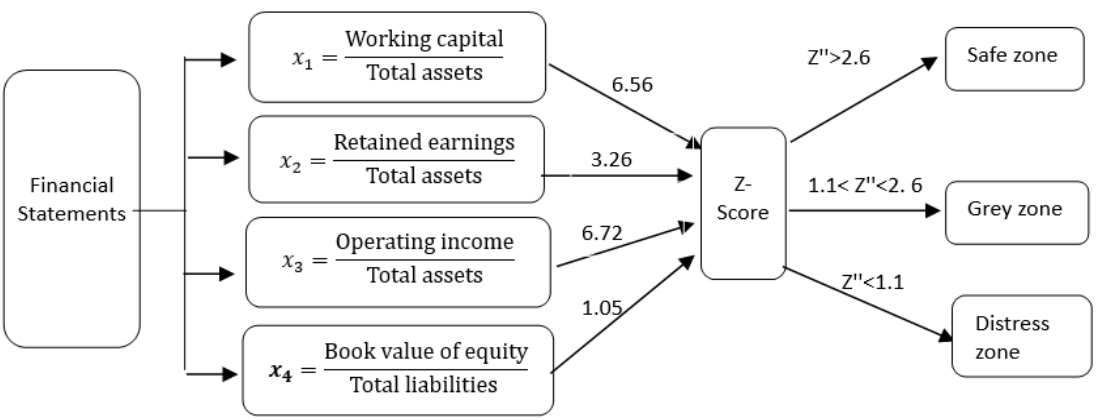

Figure 1: Graphical Representation of the Research Model

both groups of companies, as can be seen in Table 1. Both groups are dominated by service companies (69.7% or 66.7% respectively) and private limited companies (75.8% or 78.8% respectively). There is only a slight difference in the sample structure in terms of the size of companies, with the share of small companies being 63.6% for non-bankruptcy companies and 42.4% for bankruptcy companies.

4.2 Descriptive Statistics of Variables in the Altman Model

Based on the data obtained, the authors of this paper calculated all four variables of the Altman Z'' model and weighted them accordingly. The table below shows the descriptive statistics for the variables (x1 do x4), separately for bankruptcy and non-bankruptcy companies. As can be seen in the table below, the mean value of all four variables is positive for non-bankruptcy companies and negative for bankruptcy companies (with the exception of the x4 variable). This means that the indicators for the successful companies are on average significantly higher and, consequently, reach values higher than 0 compared to the unsuccessful companies, where the average values are lower than 0.

Below, a more detailed commentary has been provided for each variable separately:

a) X1: Working capital/Total assets

This ratio (x1) is the measure of liquidity by comparing net liquid assets with total assets. Working capital is defined as the difference between current assets and current liabilities (Altman, 2013). Its average value is -0.215 (SD = 0.441) for bankruptcy companies and 0.214 (SD = 0.231) for non-bankruptcy companies. The reason behind the negative values is the negative working capital, which means that for bankruptcy companies the current liabilities are higher than the current assets. In contrast, working capital is positive in the case of non-bankruptcy companies, which means that short-term assets are higher than short-term liabilities and this has a positive impact on

Table 1: Discriminant validity

		Companies			
	Bankruptcy (n=33)		Non-bankruptcy (n=33)		
	N	%	N	%	
Industry	Manufacturing	3	9.1%	3	9.1%
	Services	23	69.7%	22	66.7%
	Trade	7	21.2%	8	24.2%
Size	Small	21	63.6%	14	42.4%
	Medium-sized	5	15.2%	12	36.4%
	Large	7	21.2%	7	21.2%
Legal form	Public limited company	8	24.2%	7	21.2%
	Private limited company	25	75.8%	26	78.8%

Table 2: Descriptive Statistics of Independent Variables

Companies		x1	x2	x3	x4
Bankruptcy	Mean	-0.215	-0.216	-0.111	0.119
	Std. deviation	0.441	0.326	0.219	0.285
	Minimum	-1.243	-0.784	-0.792	-0.322
	Maximum	0.590	0.450	0.160	1.058
Non-bankruptcy	Mean	0.124	0.192	0.059	1.176
	Std. deviation	0.231	0.299	0.051	0.771
	Minimum	-0.275	-1.010	-0.012	-0.043
	Maximum	0.648	0.581	0.179	3.826

a company's liquidity. A company with negative working capital is likely to experience problems meeting its short-term obligations because there are simply not enough current assets to cover those obligations (Mcclure, 2022). A Mann-Whitney U test was performed to evaluate whether x1 differed by companies. The results indicated that bankruptcy companies had a significantly lower x1 value of than non-bankruptcy companies (Z = -3.610; p = 0.000).

b) x2: Retained ernings/Total assets

Retained earnings is the account which reports a company's total amount of reinvested earnings and/or losses over its entire life. This ratio measures the amount of reinvested earnings or losses, which reflects the extent of the company's leverage. Companies with low ratios are financing capital expenditure through borrowings rather than through retained earnings. Companies with high ratios suggest a history of profitability and the ability to stand up to a bad year of losses (Mcclure, 2022).

Table 2 shows that the mean value of this indicator for bankruptcy companies is negative (M=-0.216; SD = 0.326), indicating that these companies were loss-making in the past and that this loss exceeded profits made in the previous years. In the case of non-bankruptcy companies, the mean value is positive (M=0.192; SD = 0.299), which suggests that this group of companies generated profit that exceeded any loss. Profits were not shared by the owners, but were instead retained in the company. A Mann-Whitney U test was performed to evaluate whether x2 differed by companies. The results indicated that bankruptcy companies had a significantly lower x2 value than non-bankruptcy companies (Z = -4.931; p = 0.000).

c) X3: EBIT/Total assets

This ratio is a measure of the true productivity of a company's assets, independent of any tax or leverage factors. Since a company's ultimate existence is based on the earning power of its assets, this ratio appears to be particularly appropriate for studies dealing with corporate failure. Furthermore, insolvency, in the sense of bankruptcy occurs when the total liabilities exceed a fair valuation of the company's assets with value determined by the earning power of the assets (Altman, 2013). The ratio is a version of return on assets (ROA), an effective way of assessing a company's ability to squeeze profits from its assets before deducting factors such as interest and tax (Mcclure, 2022). Ratio x3 made the highest contribution to discrimination power in this version of model.

Table 2 shows that the interpretation of this indicator is similar to the previous two. For bankruptcy companies, the mean value is negative (M=-0.111; SD = 0.219), indicating that they are generating negative EBIT (Earnings Before Interests and Taxes) or operating losses. For non-bankruptcy companies, the mean value is positive (M=0.059; SD = 0.051), which suggests that the company generated a positive EBIT or operating profit. A Mann-Whitney U test was performed to evaluate whether x3 differed by companies. The results indicated that bankruptcy companies had a significantly lower x3 value than non-bankruptcy companies (Z = -5.444; p = 0.000).

d) X4: Market value of equity/Book value of total liabilities

This ratio shows how much the company's market value would decline before liabilities exceed assets on the financial statements if a company were to become insolvent. This ratio adds a market value dimension to the model that is not based on pure fundamentals. In other words, a durable market capitalization can be interpreted as the market's confidence in the company's solid financial position (Mcclure, 2022).

Table 2 clearly shows that the mean value of this indicator for bankruptcy companies is 0.119 (SD = 0.285) and 1.176 (SD = 0.771) for non-bankruptcy companies. By using the Mann-Whitney U test, the authors determined that bankruptcy companies had a significantly lower x4 value than non-bankruptcy companies (Z = -6.137; p = 0.000).

4.3 Z''-Score Value

Based on the third Altman model (equation 3), the authors of this paper calculated the Z''-Score separately for both groups of companies, noting that the mean value of the Z''-Score for bankruptcy companies is -2.66 (SD = 4.72) and 3.07 (SD = 2.80) for non-bankruptcy companies. The value of the Z''-Score indicator in half of the bankruptcy companies was less than or equal to -1.95, while the median for non-bankruptcy companies equated to 2.61. The distribution for bankruptcy companies is asymmetric to the left and slightly conical, while it is slightly asymmetric to the right and slightly flattened for non-bankruptcy companies.

Verifying the first hypothesis:

The authors of this paper also wanted to determine whether, when using the first hypothesis, there was a statistically significant difference in the Z''-score value between both groups of companies. First, the Kolmogorov-Smirnov test was used to check how the variable was distributed. It was determined that it was not distributed normally (p = 0.07), hence the non-parametric Mann-Whitney U-test was used to verify the hypothesis. The results indicated that bankruptcy companies had a significantly lower Z''-Score value than non-bankruptcy companies (Z=-4.982; p=0.000). This allows the hypothesis to be confirmed with a 5% risk.

4.4 Classification of Companies into the Corresponding Zones

Based on the discriminant analysis, Altman divided the companies into three groups (zones), as described in the previous chapter:

- Safe Zone Z'' > 2.60
- Grey Zone 1.10 < Z'' < 2.60
- Distress Zone Z'' < 1.10

Similarly, for the purposes of this study, the authors also re-coded the value of the Z-Score into three groups. The data can be seen in the table below. For bankruptcy companies, the share of companies in the distress zone is 81.8%, while it is 9.1% in both the grey and safe zones. In the case of non-bankruptcy companies, the largest share of companies can be found in the safe zone (i.e. 51.5%), followed by those companies in the grey zone (i.e. 27.3%) and the distress zone (i.e. 21.2%).

Table 3: Descriptive Statistics of the Z''-Score Value

	Companies	
	Bankruptcy	Non-bankruptcy
Mean	-2.66	3.07
Median	-1.95	2.62
Std. deviation	4.72	2.80
Variance	22.27	7.85
Minimum	-15.39	-3.68
Maximum	5.49	8.36
Range	20.88	12.04
Kurtosis	0.24	-0.18
Skewness	-0.65	0.09

Table 4: Mann Whitney U Test

Companies	N	Mean Rank	Sum of Ranks
Bankruptcy	33	21.73	717.00
Non-bankruptcy	33	45.27	1,494.00
Total	66		
Mann-Whitney U	156.000		
Wilcox W	717.000		
Z	-4.982		
Asymp. sig. (2-tailed)	0,000		

Table 5: Classification of Companies into Zones

		Companies			
	Bankruptcy (n=33)		Non-bankruptcy (n=33)		
	N	%	N	%	
Altman model	Distress Zone	27	81.8%	7	21.2%
	Grey Zone	3	9.1%	9	27.3%
	Safe Zone	3	9.1%	17	51.5%

4.5 Reliability of the Assessment

The explanatory ability of the Altman model is verified by the calculation of the type I error (α) and type II error (β). The primary error types associated with the Altman's Z-Score model are:

1. Type I Error (False Positive): This occurs when the Z-Score predicts financial distress or bankruptcy for a company that does not actually go bankrupt. The formula for the calculation of a type I error is as follows (Bogdan et al., 2019, pp.38):

$$\text{Type I Error} = 1 - \frac{CCF_{BF}}{n_{BF}} \quad (4)$$

Where:

- CCF BF – Correctly classified companies (bankruptcy companies)
- nBF- Sample size for bankruptcy companies

As is apparent from Table 6, the Altman model was used to classify a total of 33 bankruptcy companies, of which 30 (90.91%) were classified according to the upper bound of the interval (Z'' < 2.6) and 27 (81.81%) according to the lower bound (Z'' < 1.1).

2. Type II Error (False Negative): This occurs when the Z-Score fails to predict financial distress or bankruptcy for a company that does go bankrupt or experiences financial difficulties. In this case, the model incorrectly identifies a company with financial troubles as safe. The formula for the calculation of a type I error is as follows (Bogdan et al., 2019):

Where:

$$\text{Type II Error} = 1 - \frac{CCF_{NBF}}{n_{NBF}} \quad (5)$$

- CCF NBF - Correctly classified companies (non-bankruptcy companies)
- nNBF - Sample size for non-bankruptcy companies

As can be seen in Table 7, out of all 33 non-bankruptcy companies, the Altman model correctly classified 17 companies (51.51%) according to the upper bound of the interval (Z'' > 2.6) and 26 companies (78.78%) according to the lower bound of the interval (Z'' > 1.1).

By combining the data from Tables 6 and 7, it can be observed that, in relation to the threshold of 2.6, 47 companies (71.21%) were correctly classified, while 53 companies (80.31%) were correctly classified in relation to the threshold of 1.1, as shown in Table 8.

Table 6: Classification of Bankruptcy Companies According to the Upper and Lower Bound of the Z''-Score Model

		Correctly classified companies - (Z''<2.6)	Type I Error (Z''> 2.6)	Correctly classified companies (Z''<1.1)	Type I Error (Z''>1.1)	Total
Bankruptcy companies	n	30	3	27	6	33
	%	90.91%	9.09%	81.81%	18.19%	100.00%

Table 7: Classification of Non-bankruptcy Companies According to the Upper and Lower Bound of the Z''-Score Model

		Correctly classified companies (Z''<2.6)	Type II Error (Z''>2.6)	Correctly classified companies (Z''<1.1)	Type II Error (Z''>1.1)	Total
Non-bankruptcy companies	n	17	16	26	7	33
	%	51.51%	48.49%	78.78%	21.22%	100.00%

Table 8: Classification of the Entire Sample According to the Upper and Lower Bound of the Z''-Score Model

		Correctly classified companies	Incorrectly classified companies	Correctly classified companies	Incorrectly classified companies	Total
	Limit value=2.6		Limit value=1.1			
All companies	n	47	19	53	13	66
	%	71.21%	28.79%	80.31%	19.69%	100.00%

Verifying the second hypothesis:

When testing the upper bound (the Z''-Score limit value was 2.6) using the Altman model, it was possible to correctly classify 47 companies (71.21%), while 53 companies (80.30%) were correctly classified when testing the lower bound (the Z''-Score limit value was 1.1). If this estimate were to be generalized according to the population with the estimate of the percentage, it can be estimated with a 5% risk that the model would correctly classify between 60.29% and 82.14% of the companies in the entire population (when estimating the upper limit value of 2.6), or between 70.71% and 89.99% (when estimating the lower limit value of 1.1). As hypothesis H2 assumed that the model would correctly classify at least 75% of companies, the authors can confirm the hypothesis, as the value of 75% falls within both the first and the second interval.

5 Discussion

The Altman model is still one of the most widely used predictive models in the 21st century, and it aims to highlight the differences between bankrupt and healthy companies. This model has been modified several times; its most well-known forms are from 1968, 1983 and 1995 (Vavrek et al., 2021). By November 2023, the study of Altman's model had accumulated 24,836 citations (Google Scholar, October 11, 2023), showing that this pioneering work in the field of corporate failure prediction has spread worldwide. As demonstrated by the results of various studies, the Altman model represents a fairly good way for companies to identify the performance of their business in a relatively simple and quick way, and also to predict the potential risk of that business in the future. Due to the fact that insolvency is a problem that concerns different social actors, such as shareholders, suppliers, financial institutions and workers, it is important to know the predictive capacity of the Altman model in order to make adequate decisions (Fito et al., 2018). This model can provide any owner, investor or lender with an indicative assessment of a company's financial stability. This is all the more important in times of financial crisis or potential recession. Companies need to be vigilant and detect problems in time in their own company or with their business partners.

Using a sample of Slovenian companies (n=66), which included both bankruptcy and non-bankruptcy companies, the aim of this study was discover whether the Altman model is also applicable to Slovenian companies. To this end, the authors set two hypotheses, both of which were confirmed. The first hypothesis was intended to determine how good the model is at estimating the mean value of the Z''-Score between the two groups of companies. It was determined that the Z-Score value was higher in bankruptcy companies than in non-bankruptcy companies. In this respect, the Altman model is useful for a first, more general assessment of a company's performance and could also be used to assess a company's creditworthiness. By using the second hypothesis, the authors wanted to see how reliable the model is at estimating the probability of a company going bankrupt in the future. In order to verify the hypothesis, interval estimation of the type I and II errors were used. This study has shown that the reliability of the model turned out to be 71.21% in the case of the upper bound estimation, and 80.30% in the case of the lower bound estimation. The reliability of the model has also been shown to be between 70% and 80% in studies carried out in other countries (Bogdan et al., 2019; Celli, 2015; Cındık, & Armutlulu, 2021), however, there are also some studies in which the reliability of the model is lower. In this regard, the authors confirmed the second hypothesis, which predicted that the model would have a reliability of more than 70%. However, no foreign studies have confirmed the 100% reliability of the Altman model, which means that it is necessary to be cautious when making predictions about business performance.

As a result of the above, it can be concluded that the Altman model is not the most reliable method for predicting a company's bankruptcy, however, it is certainly very useful and suitable for the first assessment of a company's performance. Therefore, it is preferable to use another method (e.g. the logit model) or a more in-depth analysis in addition to the Altman model in order to complement this assessment. The Altman model is also not suitable for newly-formed businesses, as financial statements from previous periods are required in order to carry out a successful analysis. Hence, this topic has become one of the main concerns of the analysts and they are still having difficulties finding a reliable tool for the risks and threats of failure of the companies (Cındık & Armutlulu, 2021).

This study offers a basic overview of the applicability of the Altman model. However, there are certainly numerous possibilities for further studies, e.g. a study could be done for just one industry (construction, hospitality, tourism, etc.) or the Z-Score could be calculated separately for each year, which would determine whether the Z''-Score is higher in the years running up to bankruptcy than in the previous years. It would also be sensible to revise the Altman model and calculate a separate MDA function in the case of Slovenian companies, or to compare the calculations under this model with other methods (logit) or models, such as the Springate, Ohlson or Zmijewski models. Due to the ever-increasing use of artificial intelligence and machine learning, it would also make sense to verify the methods of determining a company's creditworthiness.

Literature

Alcalde, R., Alonso de Armiño, C., & García, S. (2022). Analysis of the economic sustainability of the supply chain sector by applying the Altman Z-score predictor. *Sustainability*, *14*(2), 851. https://doi.org/10.3390/su14020851

Altman, E. I. (1968). Financial ratios, discriminant analysis and the prediction of corporate bankruptcy. *Journal of Finance*, *23*(4), 589-609. http://dx.doi.org/10.1111/j.1540-6261.1968.tb00843

Altman, E. I. (1983). *Corporate financial distress: a complete guide to predicting, avoiding, and dealing with bankruptcy.* Wiley InterScience.

Altman, E. I. (2005). An emerging market credit scoring system for corporate bonds. *Emerging markets review, 6*(4), 311-323.

Altman, E. I. (2013). Predicting financial distress of companies: revisiting the Z-Score and ZETA® models. In A. R. Bell, C. Brooks, & M. Prokopczuk (Eds.), *handbook of research methods and applications in empirical finance*, Chapter 17 (pp. 428-456). Edward Elgar Publishing.

Altman, E. I., Danovi, A., & Falini, A. (2013). Z-Score models' application to Italian companies subject to extraordinary administration. *Journal of Applied Finance (Formerly Financial Practice and Education*), *23(*1). https://ssrn.com/abstract=2686750

Altman, E.I., Iwanicz-Drozdowska, M., Laitinen, E. K., & Suvas, A. (2014). *Distressed firm and bankruptcy prediction in an international context. A review and empirical analysis of Altman's Z-Score model*. http://dx.doi.org/10.2139/ssrn.2536340

Aziz, M. A., & Dar, H. A. (2004). *Predicting corporate financial distress: whither do we stand?* Loughborough University. https://hdl.handle.net/2134/325

Beaver, W.H. (1966). Financial ratios as predictors of failure. *Journal of Accounting Research, 4*, 71-111. https://doi.org/10.2307/2490171

Bogdan, S., Bareša, S., & Hađina, V. (2019). Testiranje primjenjivosti Altmanovog Z-score modela za predviđanje stečaja u Republici. Notitia. *Journal for ecnomic, business and social issues*, (5), 31-46. https://doi.org/10.32676/n.5.1.4

Bogdan, S., Šikić, L. & Bareša, S. (2021). Predicting bankruptcy based on the full population of croatian companies. *Ekonomski pregled, 72*(5), 643-669. https://doi.org/10.32910/ep.72.5.1

Brigham, F., & Gapenski, L. C. (1997). *Financial management: theory and practice*. The Dryden Press.

Celli, M. (2015). Can Z-Score model predict listed companies' failures in Italy? An empirical test. *International Journal of Business and Management, 10*(3), 57-66. 10.5539/ijbm.v10n3p57

Charraud, J., & Garcia Saez, A. (2021). *Bankruptcy prediction models on Swedish companies*. [Master's thesis Umea Univerity]. https://www.divaportal.org/smash/get/diva2:1572482/FULLTEXT01.pdf

Cındık, Z., & Armutlulu, I. H. (2021). A revision of Altman Z-Score model and a comparative analysis of Turkish companies' financial distress prediction. *National Accounting Review*, *3*(2), 237-255. doi: 10.3934/NAR.2021012

Feller, W. (1968). An Introduction to Probability Theory and Its Applications (3rd ed.). New York: Wiley.

Fito, M. A., Plana-Erta, D., & Llobet, J. (2018). Usefulness of Z scoring models in the early detection of financial problems in bankrupt spanish companies. *Intangible Capital, 14(1*), 162-170. doi:10.3926/ic.1108

Fitzpatrick, F. (1932) A comparison of ratios of successful industrial enterprises with those of failed firm. *Certified Public Accountant*, 6, 727-731.

Francis, S. I. (2022). *Testing applicability of Altman Z model in predicting financial distress of non-financial firms listed at the Nairobi security exchange* (Doctoral dissertation), Nairobi: University of Nairobi.

Galant, A., & Zenzerović, R. (2023). Can corporate social responsibility contribute to bankruptcy prediction? Evidence from Croatia. *Organizacija*, *56*(3), 173- 183. https://doi.org/10.2478/orga-2023-0012

Grosu, V., & Macsim, A. R. (2019). Identifiying the bankruptcy risk of companies with the Alman model. *Ecoforum Journal*, *8*(1). http://www.ecoforumjournal.ro/index.php/eco/article/view/962/578

Hofer, C. W. (1980). Turnaround strategies. *Journal of Business Strategy, 1*(1), 19–31.

Hopwood, W. S., McKeown, J. C., & Mutchler, J. F. (1994). A reexamination of auditor versus model accuracy within the context of the going-concern opinion decision. *Contemporary Accounting Research, 10*(2), 409–431. https://doi.org/10.1111/j.1911-3846.1994.tb00400.x

Kokkoris, I., & Anagnostopoulou, M. (2016). Altman Z-Score bankruptcy analysis in the Greek banking sector. *International Corporate Rescue*, *13*(1), 59-68. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2896391

Kralicek, P. (1991). Grundlagen der Finanzwirtschaft. New Business Line.

Martini, R., Raihana Aksara, R., Rachma Sari, K., Zulkifli, Z., & Hartati, S. (2023). Comparison of financial distress predictions with Altman, Springate, Zmijewski, and Grover Models. *Golden Ratio of Finance Management, 3*(1), 11-21. https://doi.org/10.52970/grfm.v3i1.216

Mcclure, B. (2022). *How to calculate an Altman Z-Score*. https://www.investopedia.com/articles/fundamental/04/021104.asp#toc-altman-z-score-disadvantages

Merwin, C. L. (1942). *Financing Small Corporations in Five Manufacturing Industries, 1926–36*. National Bureau of Economic Research.

Mulyati, S., & Ilyasa, S. (2020). The comparative analysis of Altman Z-Score, Springate, Zmijewski, and internal growth rate model in predicting the financial distress (empirical study on mining companies listed on Indonesia stock exchange 2014-2017). *Kinerja, 24*(1), 82-95. https://doi.org/10.24002/kinerja.v24i1.3231

Ningsih, S., & Filtri Permatasari, F. (2018). Analysis

method of Altman Z Score modifications to predict financial distress on the company go public sub sector of the automotive and components. *International Journal of Economics, Business and Accounting Research (IJEBAR), 2*(3), 36-44. DOI:10.29040/ijebar.v2i3.339

Ohlson, J. (1980). Financial ratios and the probabilistic prediction of bankruptcy. *Journal of Accounting Research, 18*(1), 109-131.

Panigrahi, C. M. A. (2019). Validity of Altman's 'z'score model in predicting financial distress of pharmaceutical companies. *NMIMS journal of economics and public policy, 4*(1), 65-73. https://ssrn.com/abstract=3326312

Springate, G. L. V. (1978). *Predicting the possibility of failure in a Canadian firm: a discriminant analysis*. Simon Fraser University.

Šverko Grdić,Z., Krstinić Nižić, M., & Mamula, M. (2017) Insolvency in the Republic of Croatia. *Economic Research-Ekonomska istraživanja, 30*(1), 1693-1704. DOI: 10.1080/1331677X.2017.1383177

Vavrek, R., Gundová, P., Vozarova, I.K., & Kotulič, R. (2021). Altman model verification using a multi-criteria approach for Slovakian agricultural enterprises. *E & M Ekonomie A Management, 24*, 146-164.

Yuna Winaya, G., Rm, K. M., Ayu, G., Budiasih, N., Dewa, I., & Wiratmaja, N. (2020). Analysis of Altman Z-Score and Zmijewski Bankruptcy Prediction in Telecommunication Sub-Sectors Registered in Indonesia Stock Exchange in 2016-2018. *American Journal of Humanities and Social Sciences Research*, 4(1), 313.

Whitaker, R. (1999). The early stages of financial distress. *Journal of Economics and Finance*. *23*(2), 123-133. https://doi.org/10.1007/BF02745946

Zmijweski, M. E. (1984). Methodological issues related to the estimation of financial distress prediction models. *Journal of Accounting Research, 22*, 59–82. https://doi.org/10.2307/2490859

Tatjana Dolinšek, is an Assistant Professor of Accounting and Statistics at the Faculty of Commercial and Business Sciences. Her research interests include cost, financial and management accounting as well as statistical methods in economics and business. As a quest tutor and Member of the Review and Organisational Board of the Science Conference she also cooperates with the college of Financial Management in RRIF Zagreb. She has participated more than 10 scientific and professional conferences and is the author of 5 papers in scientific and professional journals published in Slovenia and elsewhere. She is currently involved in different research projects.

Tatjana Kovač is an Assistant Professor of Business Informatics at the Faculty of Commercial and Business Sciences. She graduated in the field of Information Systems, got her Master's Degree in Management of Information Systems at the University of Maribor, Faculty of Organisational Science and got her PhD Degree in Pedagogy from the University of Ljubljana, Faculty of Art. Her research interests include expert modelling and decision support systems in the field of decision processes. She is involved in many quality management projects at the Faculty of Commercial and Business Science.

Uporaba Altmanovega modela za napoved finančnega neuspeha na primeru slovenskih podjetij

Izhodišče/Namen: Namen članka je verificirati uporabnost in zanesljivost Altmanovega modela na primeru slovenskih podjetij. Uporaba Altmanovega modela je zelo priljubljena in razširjena tako med finančniki, analitiki in ostalimi interesnimi skupinami, ki želijo ugotoviti boniteto poslovanja podjetja in verjetnost, da bi podjetje v prihodnjih letih zašlo v finančne težave.
Metode: Raziskavo smo naredili na vzorcu 66-ih slovenskih podjetij, ki smo jih razdelili v dve enako veliki skupini: podjetja v stečaju in uspešna podjetja. Na podlagi računovodskih podatkov za obdobje zadnjih petih let smo izračunali s pomočjo Altmanovega modela izračunali vrednost Z'', ki temelji na multipli diskriminanti analizi. Z izračunom napake ocene (tipa I in II) smo preverili v kolikšnem % je model pravilno razvrstil podjetja. Z izračunom Mann-Whitney U testa pa smo preverjali ali obstaja razlika v povprečni višini vrednosti Z'' med obema skupinama podjetij.
Rezultati: Ugotovili smo, da je zanesljivost Altmanovega modela 71,21 % pri testiranju na zgornjo mejo (mejna vrednost Z'' je 2,6) pri testiranju na spodnjo mejo pa 80,30 % (mejna vrednost Z'' je 1,1)., kar je podobno kot v ostalih državah, kjer se je ta zanesljivost v večini primerov izkazala za več kot 70 %. Kljub slabši zanesljivosti modela, pa se je izkazalo, da je vrednost Z'' pomemben dejavnik pri razlikovanju med obema skupinama podjetji, saj so podjetja v stečaju dosegla nižjo vrednost tega kazalnika kot uspešna podjetja.
Zaključek: Na podlagi rezultatov naše raziskave in tudi ostalih raziskav lahko povzamemo, da je je Altmanov model dokaj dober način, da lahko podjetja na razmeroma enostaven in hiter način ugotovijo uspešnost poslovanja podjetja in napovejo tudi morebitno tveganje tega poslovanja v prihodnost. Ker pa njegova zanesljivost ni 100 % moramo biti pri napovedi poslovanja tudi previdni in izvesti še kakšno drugo poglobljeno analizo ali uporabiti kakšno drugo metodo.

Ključne besede: *Finančni neuspeh, Altmanov model, Napoved stečaja, Multipla diskriminanta analiza*