

Predictive Analytics: A Review of Bankruptcy Prediction Models

Guruansh Singh¹, Rachit Mahajan²

^{1,2}Student, Guru Nanak Dev University

ABSTRACT

This paper reviews some of the most accurate bankruptcy prediction models. Four bankruptcy prediction models have been examined deeply which are, The Altman Model (1968), The Ohlson Model(1980), The Zmijewski Model(1984) and The Springate Model (1978). The analysis of bankruptcy prediction is based on Methodology(formula) followed by accuracy and finally we have considered some drawbacks . From this particular paper one can easily get an overview and some factual information about the bankruptcy prediction models can be utilised in the suitable situation in the businesses . Overall this paper can make a financial firm implement these predictive models in order to ensure more precision and minimize the biasness

Keywords: Altman, Ohlson, Zmijewski, Springate, Prediction, Bankruptcy.

INTRODUCTION:

Bankruptcy Prediction models have been increasingly prominent globally throughout time as a means of predicting corporate firm failure. These models enables a company to examine its overall performance and helps to predict he financial failure in advance. Distinct models can be used in order to predict bankruptcy according to the scenario.

All the reviewed bankruptcy Prediction Models used the statistical techniques. The Altman Model (1968)and the Springate model uses Multiple discriminant Analysis (MDA).MDA is a Technique which is used to minimize the difference between variables so as to categorize them into broad groups .The Ohlson Model used logistic regression which allowed the evaluation of financial situation by involving Qualitative and discrete variables. Lastly the Zmijewski Model [1983-84] used probit as statistical tool where dependent variable can take only two values for eg:- Bankrupt or Non- Bankrupt .Different Models have their own formulations, Accuracies and suitability, so prior attention must be given before the selection of a particular Model.

Literature Review

THE ALTMAN Z-SCORE MODEL(1968)

The first multivariate Bankruptcy prediction model was developed by E.I Altman (1968) from New York university. The Altman Z-score model was used to calculate the financial soundness of publicly held manufacturing companies using a number of corporate financial indicators from financial statements. Later on with some modifications, respectively Z1 and Z2-score for privately held manufacturing and non-manufacturing companies was introduced.

The classifications of Z-series score are as follows:-

1. For publicly held Manufacturing companies.

$$Z=1.2x_1 + 1.4x_2 + 3.3x_3 + 0.6x_4 + 1.05x_5.$$

2. For privately held Manufacturing companies.

$$Z1=0.717x_1 + 0.872x_2 + 3.107x_3 + 0.420x_4 + 0.998x_5.$$

3. For non-Manufacturing companies.

$$Z2 =6.56x_1 + 3.26x_2 + 6.72x_3 + 1.05x_4 + 3.25$$

Financial ratios used in Altman z-score model.

Credit		Financial ratio	
X1			
X2		Working capital / Total Assets.	
X3		Retained earning / Total Assets	
		Earning before interested and Taxes/ Total assets.	
X4		Market value of Equity / Book value of total liabilities	
X5		Sales / Total Assets.	
S.no	Statistical	formulation	Score category
01	Technique		
	MDA	$Z=1.2x_1 + 1.4x_2 + 3.3x_3 + 0.6x_4 + 1.05x_5.$	<1.81(distress zone) >2.99(safe zone)
	Multiple Discriminant Analysis	$Z1=0.717x_1 + 0.872x_2 + 3.107x_3 + 0.420x_4 + 0.998x_5.$	<1.23(distress zone) >2.9(safe zone)
		$Z2 =6.56x_1 + 3.26x_2 + 6.72x_3 + 1.05x_4 + 3.25$	<1.1(distress zone) >2.6(safe zone)

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Accuracy and implementation of Altman's Model

The Altman Model of bankruptcy prediction is considered one of the most accurate model of prediction like Springate, Ohlson, Zmijewski, Grover's model and many more. The z-score is a multiple discriminant analysis which combines the ratio in the multivariate context. By taking the sample of 66 companies. Altman examined a list of twenty-two possible ratios and choose five numerous ratios. The multi-discriminant function classifies 95% correctness in one year before bankruptcy and 83% two years before bankruptcy. This particular function was applied to a sample of bankruptcy companies three, four and five years before bankruptcy and predicts 48%,29%and36% respectively. Because the power Prediction dropped drastically after the 2nd year, so the Altman concluded that the model could be relied upon to predict bankruptcy for two years earlier only companies with a z-score ≥ 2.675 are not expected to go bankrupt. Altman also introduced grey areas to make classification more accurate. In this case, Altman cannot be recommended for companies with z-score lower than 1.81 are predicted to go bankruptcy and companies with score higher than 2.99 do not go bankrupt. (1) & (2)

Implementation by researchers

Research was conducted in Greece by Mahail Diakomihalis in which He implemented all the three versions of Altman model. Approximately 40 percent of the total businesses in the distress zone were assessed having a z-score below 1.8, while the percentage of Z-score formula was found to be the precise one with an accuracy rate of 88.2 percent in 2007, the Z1 model gained accuracy rate of 83.33 percent and lastly the Z2 model gained the accuracy rate of 80 percent. (3)

- Another research was carried out by a group of researchers on manufacturing company in Indonesia with ALTMAN Z-score model which was able to secured the accuracy rate of 87.8.(4)
- One more research was carried in Lebnon for Classifying manufacturing firm using the Altman model,11 manufacturing enterprises were classified, which were subject to an empirical investigation than span three years from 2009 to 2011 and results showed up that Altman's model is the most accurate model for manufacturing concerns. (5)

The ALTMAN's Model was considered the best model for the manufacturing concerns due to its accuracy in the particular field.

LIMITATIONS

*The Altman Z- score model, primarily focuses on financial ratios derived from historical data which does not consider market conditions, industry trends , managerial skills and the influence of upcoming event are not taken into account ,it was originally created for manufacturing Companies, it may not fully represent some industry specific traits also the Altman Z-Score is susceptible to producing false positive and negative it might mistakenly label financially sound businesses as hazardous or vice versa, producing imprecise estimates of the likelihood of bankruptcy.

OHLSON MODEL (1980)

Ohlson model has been built up on the base of logit regression also referred as logistic regression. It allows the evaluation of financial situation involve qualitative and discrete variable. The basic form of J.A Ohlson

model was constructed in 1980, he was believed to be the first to develop a model using multiple logistic regression and the first who explicitly considered timing issue.

According to Khun thong (1997) Ohlsons model uses a logit model to examine the effect of four basic factors on the probability of bankruptcy:-

- *The Size of firm.
- *Measure of firm’s financial structure
- *Measures of performance.
- *Measure of current liquidity.

FORMULA IS AS FOLLOWED

$$OS_t = -1.32 - 0.407 \log(Tat/GNP) + 6.03 \frac{TL}{TA} - 1.4 \frac{WC^t}{TA_t} + 0.0757 \frac{cct}{CA^t} - 1.72x - 2.37 \frac{NIT}{TA^t} - 1.83 \frac{ffot}{TL^t} + 0.285 Y - \frac{0.521}{|NIT| + |NIT^{-1}|}$$

ABBREVIATIONS

TA	Total assets
GNP	Gross national product (price index level)
TL	Total liabilities
WC	Working capital
CL	Current liabilities
CA	Current assets
X	1 if TL>TA otherwise 0
NI	Net income
FFO	Funds from operations
Y	1 if net loss for the last two years, otherwise 0

OHLSON MODEL

SCORE CATEGORY

OS	>0.38 (BANKRUPT)
OS	=0.38(GREY AREA)
OS	<0.38(NON-BANKRUPT)

Implementation and Accuracy

Usually, money lenders and financial institutions use the o-score to evaluate the credit worthiness of potential borrows using this model they can assess the possibilities of bankruptcy and default threats it assists them in making informed decisions about extending credit loan. This model is also beneficial for the mergers and acquisitions processes as it helps to acquire the results of financial health and stability of the targeted company. It also assists the investors to deduct the soundness of the company in which are investing.

- Research was carried out in Indonesian companies’ market of 2015-2019 on 17 delisting companies the number of samples used in this study were 8 companies by using SPSS version 25. The result should that accuracy of the Altman model is 58.3%, while the Ohlson model is 79.2% at the and it conclude that Ohlson model was the most accurate model in detecting the soundness of the delisting companies. (9)

- Another research was also carried out by Oude Avenhuis and Joren (2013), in this research 15 bankrupt companies and 476 non bankrupt companies were included, using the single statistical technique of logistic regression results were gained, where the Ohlson model was the most accurate model having the accuracy of 93.8%. (10)

LIMITATIONS

The Ohlson model relies on historical financial data, so a sudden change in cash flow or any other financial ratio cannot be recorded. The model assumes linear relationship between variables, which reduces its accuracy. the model also does not consider qualitative aspects such as management quality, legal regulatory changes which impact the bankruptcy. (11)&(8)

SPRINGATE MODEL

SPRINGATE model (1978), developed by Gorgon L.V. Springate was similar to Altman’s Z-score model as he framed his predictive model for the financial distress using MDA (multiple discriminant analysis). In his model, springate selected 4 out of 19 common financial ratios, those were considered best to determine the likelihoods of a firm failing to fulfil its financial obligation. Springate’s step wise model helps predict company’s financial distress, assess the company’s growth potential and consider organisational plan ‘s viability and reasonability while choosing alternative plans by focusing on the on-going events. The way that springate model separates the healthy companies from the failing companies, sets it apart from other models .it emphasizes that the profitability ratio will ascertain the score in the end. (16)(17)(18)&(20).

FORMULA

The spring ate model (1978) formula modifies Altman multi- Discriminant Analysis formula -

$$SS=1.03X1+3.07X2+0.66X3+0.4X4$$

COEFFICIENTS	VARIABLES
X1	Working capital/total assets (liquidity ratio)
X2	EBIT/TOTAL ASSETS (profitability ratio)
X3	EBT/current liabilities (operational efficiency)
X4	Sales /total assets (sales growth)

S score	Category
SS<0.862	Bankrupt
SS>0.862	Non bankrupt

Abbreviation

EBIT – Earning Before Interest and tax

EBT - Earning Before tax

ACCURACY & IMPLEMENTATION

The springate model combines multiple standard financial ratios with varying weights to forecast a company’s likelihood of surviving. The model produces a numerical value to acknowledge the possibility of company’s bankruptcy. The springate model works on a two – level system, i.e, bankrupt and non –

bankrupt. In his own test on 40 manufacturing companies, in Canada using his score model, Springate valued his model to be 92.5% accurate. Over the years, 2 other tests done by scholars using Springate model are as follows- (2)(14)(20)

No. of companies	Average assets of the company	Accuracy obtained
50 companies	2.5 million	88%
24 companies	63.4 million	83%

Springate model is found to be accurate for the financial institution, but it may not be accurate for manufacturing and constructing companies.

1. A study was conducted on Indian stock exchange where Altman z model, Springate model, and Grover model were used to predict the distress level of companies. Springate model accurately predicted the hardship of the companies and it was founded that the.
2. A study on Indonesian banking entities (2019-2021) applied Springate model along with other models, demonstrates the dominance of Springate model in identifying and predicting financial trouble in the Indonesian banking sector.
3. As stated earlier, it may not give accurate result in manufacturing and constructing companies, the same was concluded in research on U S - manufacturing companies 1990-2018 that Springate model lost its forecasting efficiency 3 years before bankruptcy. (6)(12)(13)

LIMITATION

A very distinct limitation in Springate model is it uses EBITDA {EBITDA (Earnings before interest, tax, depreciation and amortization) reduces real expenses that a company actually spends on}. This deceits the business that require a lot of money. (17)

ZMIJEWSKI MODEL

The most widely used model by accounting scholars is the Zmijewski {1984} x- score model. It employs a multivariate logit method of statistical approach to model bankruptcy using financial ratios that gauge the performance, leverage and liquidity of the organization. These ratios were chosen on how well they took over for

a period of 20 years. The model made use of data from 800 non-bankrupts' industrial firms and 40 bankrupts industrial forms between 1972 – 1978. Random sampling was used as the sample selection technique. Mark E. Zmijewski spent more than 2 decades reviewing earlier studies on bankruptcy. Financial ratios from earlier studies conducted between 1972 - 1978 also included 75 samples of bankrupts' companies and 73 samples of non-bankrupt companies were cited in the Zmijewski model. Zmijewski was not the first to use probit analysis in the prediction of bankruptcy but he is the one who created the most well-known and widely used model for bankruptcy prediction, and was the first to construct a general probit model. Zmijewski statistical model shows similarity to Ohlson's logistic regression. (15) (16) & (18)

FORMULA

Zmijewski model (1984) model chose ratios that show the performance, liquidity & leverage of the company. He measured the performance by estimating return on assets (ROA), i.e, a metric used to assess how well a business generates revenue. An organization will be in sound financial position and be less

vulnerable to bankruptcy if it generates higher ROA. A higher ROA suggests that the corporation is in better position to fulfil its commitment to its creditors. (2) & (15)

Model	Formula	Element	Condition
Zmijewski Probit Model	$X \text{ score} = 4.336 - 4.513x_1 + 5.679x_2 + 0.04x_3$	<p>X1 = profit after tax (net income) /total asset.ROA or performance ratio}</p> <p>X2 =total liabilities/ total assets {debt ratio or Leverage.</p> <p>X3= current assets / current liabilities {liquidity or current ratio)</p>	<p>If $x > 0.5$ Company is Bankrupt or prone to bankrupt</p> <p>If $X < 0.5$ Company is free from financial distress</p>

Accuracy and Implementation

A financial distress model is empirically tested using a sample of companies that face financial strain and companies that do not. Zmijewski Model calculates financial strain possibility by making use of ratios chosen more for Theoretical reasons than for practicality. (14)(19) During 1972-1978 each bankrupt company and each non bankrupt company with complete data were randomly given a year to gather the data. As a result, the sample of 1600 businesses avoided bankruptcy, for a total sample size of 1,681 businesses. Zmijewski split these 1,681 sample companies into two random subsets- “the estimation sample, which has 40 bankrupt companies and 800 non-bankrupt companies and “The prediction sample” which has 41 bankrupt companies and 800 non bankrupt companies. Prediction sample are used to compare WESML and unweighted evaluation based on projected probabilities evaluation while the estimation sample is used to choose customer-based alternative estimation sub-estimates. The prediction sample on the others hand, is the same in all estimations and serves as a useful bench mark for comparison. Each sample has a unique composition making it challenging to compare classifications between samples. According to Zmijewski’s Model, businesses are categorized as bankrupt if their likelihood is **more** than 0.5 and as non-bankrupt if their probability is **less** than 0.5. the Zmijewski’s model overall out-of-sample accuracy percentage is 95.29% (2). In 1983 Zmijewski’s tested is model on 96 distressed’ firms and 3880 non-distressed industrial firms. This result on the sample had a high accuracy of 98%on an error of 2% on entire samples.

Zmijewski's model also showed high accuracy in the following samples

- Zmijewski's model was chosen to be most precise one in calculating by bankruptcy in a study conducted by Fatnawati [2017] on Indonesia stock exchange. the sample was on 30 companies [period of 2003 – 2009] listed on stock exchange.
- A study by Aminian [2016] on 35 companies from textile and ceramic and tile companies listed on Tehran stock exchange [period of 2008-2013] stated zmijewski model to be most accurate.
- A study compared accuracy of Altman, Ohlson zmijewski by Avenhuis [2013] on prediction power on Dutch companies for period 2005 – 2012 gave the result

Altman – 80.6 %

Ohlson - 93.8 %

Zmijewski – 95.8% (15)

- Adriami and Sihombing [2021] stated zmijewski's Xscore to be most fruitful in giving accurate results in predicting financial Distress in property & Real Estate. Listed in Indonesian Stock Exchange By 90%. (18)

Limitations

1. The findings indicate that Zmijewski Model is sensitive to time periods i.e the accuracy of the model depleted when applied over time spans different from those used to develop these models. (7)
2. The zmijewski Model can only predict financial distress and not complete Bankruptcy.
3. The coefficients that are used in the Zmijewski model were drafted in 1984, these coefficients may not be able to cope-up with advanced accounting in the modern era.

Conclusion

From the above information, we can easily conclude that all the bankruptcy prediction model has their own repercussions. While using the model for bankruptcy prediction the data which is being used must be free from manipulation because usually the companies maintain multiple set of books, one set of books is maintained to cover tax liability and other may be maintained in order to impress the investors. Another point to be noted is that models usually do not pay attention to cash flow, so an adequate amount of prediction must be added to do so. Models are usually industry specific, however in practice, analysts use models across industries. It is therefore, important to realise that in such cases, the model may not give right result. Many models rely on coefficients, which provide weight to a particular ratio. However, it is important to note that the data on which model is based was collected in 1960's, so adjustment must be made in this regard with the help of financial analyst. Also models are sometimes not able to predict outliers, outliers are companies that have a low probability of default, but if default happens then the impact is very high, therefore a room must be secured for it. While predicting bankruptcy, a single model should not be encouraged, a combination must be used in order to improve the accuracy.

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