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# An Empirical Investigation on Bankruptcy Model

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**Abstract**

Bankruptcy is a state of insolvency, where a person or company is not able to repay the amount owed to the creditor. Financial health prediction is a very crucial task for the stakeholder as well as the nation's economy. Corporate economic failure is an ongoing area at present for comparison between five bankruptcy models (Springate, Ohlson, Zmjjewski, Grover, and Altman). The main objective is to identify the best predictive model with the help of a comparative analysis between the models. Descriptive research design is used, which is based on secondary data obtained from publication sources, i.e. the annual report of ten years. The Ohlson model is highly accurate for predicting the bankruptcy category, but gives quite late predictions compared to the Springate and Zmijewski model. This study will have vital inferences for the manager to take a financial decision and the stockholder to choose a model. This paper sheds light on the problem of model choice in empirical bankruptcy prediction of corporates and suggests some directions and future examination.

**Keywords:** Bankruptcy, Altman, Grover, Ohlson, Springate, Zmijewski

**JEL Classification Code:** G33, G21, G17

## Introduction

Bankruptcy means insolvency or financial deficiency, where the company or the person is not able to repay the amount to creditors (Altman & Hotchkiss, Corporate Financial Distress and Bankruptcy, 1993). There are many reasons for financial crisis; however, one of the main reasons is that the amount of organisation debt is higher than its value of existing assets and corporate mismanagement (Ahmed, 2009). The high production cost, financial activities weakness, ineffective sales activities, and managerial failure are several reasons for economic deficiency (Teece, 2014). According to the Union Minister of State for Finance and Corporate Affairs, Anurag Singh Thakur, 149 companies filed for bankruptcy in 2018, 103 in 2019, and another 72 in 2020, making a total of 324 Indian companies which have filed for bankruptcy during the aforesaid three-year period (Writer, 2021). At present, to avoid the risks, it is necessary to predict bankruptcy.

Bankruptcy evaluation for internal and external management will be effectual if they get intimation or specific signs of the insolvency, as the management can then take the necessary steps for further improvement (Karanja, 2019). There is a vast need to predict bankruptcy at an early stage to avoid failure (Altman, 1968). The organisation that shows signs of concern should start anticipating the beginning of the bankruptcy of the company (Mellahi, 2005).

Many different prediction models have been used to predict corporate financial failure (Charitou et al., 2004). Each model has its characteristics, and financial institutes are always looking out for optimum methods to evaluate the creditworthiness of the organisation (Resti, 1997). Bankruptcy prediction is of vital importance to many investors, creditors, borrowing companies, and the government, to determine the time when companies may fail in their operation (Kotsiantis et al., 2005).

The first bankruptcy prediction model was introduced by Altman (1968) and is popularly known as the Altman Z-score (Anjum, 2012). This model has used five ratios to predict whether a company is bankrupt in the grey area or in the healthy area. Later, many other models were introduced for the prediction of bank failure, such as Springate (1978) – this model used four ratios for the prediction of bankruptcy; Ohlson (1980) – this model used nine ratios; Zmijewski (1983), which used three ratios; and Grover (2001), which used four ratios to predict the

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insolvency situation of the company. The selection of these five bankruptcy models is based on the name of the researcher who introduced them.

This paper is an analysis of nine bankrupted or to be bankrupted companies using the five bankruptcy prediction models for a period of the last ten years, from the date of their bankruptcy. The main purpose of this study is to identify the best model for bankruptcy prediction in India and make a comparison between models.

## Review of Literature

### Altman Z-Score Model

Altman's Z-score model is a numerical measurement that is used to predict the chances of a business going bankrupt in the next two years. The model was developed by American finance professor Edward Altman in 1968, as a way to measure the financial stability of companies.

The Z-score model is based on five key financial ratios, and it relies on the information contained in the 10-K report. It increases the model's accuracy when measuring a company and its probability of going bankrupt. The Altman model of Z-score has an accuracy rate of 80%.

Sanesh (2016) evaluated the Altman Z-score of NIFTY 50 companies, apart from the bank and financial companies, and tried to investigate the probability of default due to the financial distress based on the current financial statistics of the company. Another study conducted by Kumari (2013) to predict bankruptcy for MMTC based on the Altman's model of the Z-score concluded that the overall financial health of MMTC is good; it was mentioned as an investor-friendly company. In one more study led by Reddy & Reddy (2013), the Z-score analysis shows the poor financial performance of Chittoor Co-operative Sugars Ltd. and Sri Venkateswara Sugar Factory Ltd. Financial performance was good. Tyagi (2014), in his study, investigated the financial health of the logistics industry in India and found that the Indian logistics industry was healthy. It indicates a positive sign that the Z-score values increase from 2006 to 2010 (2.54 to 3.01) when the Indian economy was hit by the global recession. Al-Rawi, Kiani and Vedd (2008) tried to predict a firm's insolvency. During a study, they remarked that the firm has increased debt and was facing bankruptcy shortly. Gerantonis et al. (2009) checked whether the Z-score model can predict bankruptcies for a period of up to three years ahead. According to their study, the result indicated that the Altman model performed effectively in predicting failure. They remarked that the result can be used by corporate governance for financial planning and decision, by regulatory authorities, and by portfolio managers in portfolio management.

### Springate Model

The Springate model was the first model introduced by Gordon LV in 1978. This model is based on the revolution of the Altman model, which was developed by multiple discriminant analysis. At the initial stage, a total of 19 ratios have been used for the prediction of bankruptcy. However, the final testing of the Springate model included four financial ratios that have been used to determine the company's financial position. This model was applied to 40 companies and test results show that the model has an accuracy rate of 92.5%.

There is much research conducted on the Springate model, which shows the predictive ability of the model. Sajjan (2016) studied at providing a theoretical foundation and compared the results of two models – Zmijewski and Springate. Studies indicated that the Springate model was more efficient than other models in predicting bankruptcy. According to Imanzadeh, Maran-Jouri, & Sepehri (2011) who studied the Zmijewski and Springate model on the Tehran Stock Exchange, the Springate is a more conservative model than the Zmijewski model. Thus, other analysts state that other prediction models are more accurate compared to the Springate model.

### Zmijewski Model

This model uses a ratio measure of performance, leverage, and liquidity applied to companies that are already bankrupt, and predicts if the company can survive. If the Zmijewski model has exceeded predictions of zero, then the company could potentially be bankrupt. Otherwise, if the company has a score of less than zero, then the company is not potentially bankrupt. This model has an accuracy rate of 90%.

This model is also criticised by reviewers such as Timmermans (2014).

## Grover Model

This model was created by restoring or redesigning the model of the Altman Z-score. It takes X1 and X3 of the Altman model and then adds profitability ratios, which are indicated by return on asset (ROA). As a result, the Grover model is the most appropriate predictive model applied to companies in the food and beverage sector. The study shows that the Grover model has the highest degree of accuracy that is equal to 100% (Grover, 2003).

The Grover model is a model developed by restoring the Altman Z-model by Jeffrey S. Grover. According to Primassari (2017), during the development of the model he used the sample according to the Altman Z-score by adding 13 financial ratios. He used a sample of 70 companies with 35 bankrupt and 35 non-bankrupt companies. He considered a data period from 1982 to 1996. Literature review on the Grover model shows the following facts: a study was conducted by Qamruzzaman & Jianguo (Dec. 2016) on the Grameen bank in Bangladesh using the same models. Its study concludes that the G-score provides conflicting predictions. Primassari (2017) found the Grover model to be the least accurate. A majority of the reviews on the Grover model reflect negative views on its predictions. This suggests the need for a revision of this model.

## Ohlson Model

The Ohlson model (1995) made a hit in market-based accounting research, because financial information was considered a value component. This model underlines the traditional belief that the company value is comprised of two main parts: the net value of the investment made in it (book value) and the present value of the period benefits (earnings), which together bring the 'clean surplus' concept of the shareholders' equity value.

According to Begley, Ming and Watts (1996), the study uses secondary data of 20 listed companies of ten years. In the study, the comparison is made between Altman's original model and modified model to that of Ohlson's original and modified models. The author finds that Ohlson's original model displays the strongest overall performance. Another study compared Canadian bankruptcy prediction models formed by Springate (1978), Véronneau (1986), and Altman and Levallee (1980), against the Altman and Ohlson models, using recent data to determine the applicability of the Altman and Ohlson models in the Canadian environment. Results indicate that the models developed by Springate (1978) and Véronneau (1986) yield similar results to the Ohlson (1980) model and require fewer data. Further, findings regarding the Altman and Ohlson models are consistent and suggest that the Ohlson model is superior to the Altman model (Wang & Campbell, 2010). Another research was conducted by Scacun and Voronova (2018), in their research, 21 companies were selected for primary research from one industry – manifesting of metals and metal products and its accuracy is 70.59% and 64.71%, respectively.

# Research Methodology

Based on the reviewed literature, some gaps and limitations were found. Much research was conducted on bankruptcy in the Indian context; however, no such research was done in the last ten years concerning bankruptcy in the Indian scenario. The purpose of this study is to test and evaluate the efficiency and accuracy of five bankruptcy prediction models; the main purpose of this study is to identify the best model for bankruptcy prediction in India and make a comparison between the models.

Data of this study is collected from the financial statement of nine bankrupted or to be bankrupted companies in which bankruptcy occurred. This information and data are collected through the websites of Money Control, the Bombay Stock Exchange, and Stock Screener.

To anticipate the insolvency of the organisations, bank failure expectation models of Ohlson, Altman, Springate, Grover, and Zmijewski are utilised. The extracted information was then placed in the equation of the above-mentioned models. This provides us with a view of the model and whether it was able to predict bankruptcy or not. This study analysed the frequency of correct predictions by the different models, which gave us a clear picture as to which model is the most effective and suited for companies in the Indian context.

The bankrupted companies which were taken under consideration and the time duration of data are shown in Table 1.

**Table 1**

| | |
|---|---|
| Kingfisher Airlines Ltd. | 2004-2013 |
| Reliance Communications | 2009-2018 |
| Prag Bosimi Synthetics | 2009-2018 |
| Cranes Software International | 2009-2018 |
| Prakash Industries | 2009-2018 |
| Dewan Housing Finance Ltd. | 2010-2019 |
| Lanco Infra | 2008-2017 |
| Alok Industries | 2008-2017 |
| Jet Airways | 2010-2019 |

Source: Almeida, 2021.

The formula, description, and score categorisation for each model are presented in Table 2.

**Table 2**

| *Sr. No.* | *Model* | *Equation* | *Description* | *Bases of Discrimination* |
|---|---|---|---|---|
| 1 | Altman Z-Score (1995) | $Z = 6.56X1 + 3.26X2 + 6.72X3 + 1.05X4$ | X1 = Working Capital/Total Asset<br>X2 = Retained Earnings/Total Asset<br>X3 = Earnings before Interest and Taxes/Total Asset<br>X4 = Book Value of (Equity/Total Debt) | ZM > 2.60 = Healthy, ZM = 1.10-2.60 = Grey, ZM < 1.10 = Bankrupt |
| 2 | Springate Model (1978) | $SS = 1.03X1 + 3.07X2 + 0.66X3 + 0.4X4$ | X1 = Working Capital/Total Asset<br>X2 = Net Profit before Interest and Taxes/Total Assets<br>X3 = Net Profit before Taxes/Current Liabilities<br>X4 = Sales/Total Assets | SS > 0.862 = Healthy, SS < 0.862 = Bankrupt |
| 3 | Zmijewski (1983) | $Z = -4.3 - 4.5X1 + 5.7X2 - 0.004X3$ | X1 = ROA (Net Income/Total Assets)<br>X2 = Leverage (Total Liabilities/Total Assets)<br>X3 = Liquidity (Current Assets/Current Liabilities) | ZS < 0= Healthy, ZS > 0 = Bankrupt |
| 4 | Grover (2001) | $G = 1.650X1 + 3.404X2 - 0.016X3 + 0.057$ | X1 = Working Capital/Total Assets<br>X2 = Earnings before Interest and Taxes/Total Assets<br>X3 = ROA = Net Income/Total Assets | GS ≥ 0.01 = Healthy, GS ≤ −0.02 = Bankrupt |
| 5 | Ohlson (1980) | $OS = -1.32 - 0.407X1 + 6.03X2 - 1.43X3 + 0.0757X4 - 2.37X5 - 1.83X6 + 0.285X7 - 1.72X8 - 0.521X9$ | X1 = Log (Total Assets/GNP Index)<br>X2 = Total Liabilities/Total Assets<br>X3 = Working Capital/Total Assets<br>X4 = Current Liabilities/Current Assets<br>X5 = 1 if Total Liabilities > Total Assets; 0 otherwise<br>X6 = Net Income/Total Assets<br>X7 = Cash Flow from Operations/Total Liabilities<br>X8 = 1 if Net Income Negative; 0 otherwise<br>X9 = Change in Net Income | OS < 0.38 = Healthy, OS = 0.38 = Grey Area, OS > 0.38 = Bankrupt |

## Data Analysis and Interpretation

Five bankruptcy models were applied on data of the nine bankrupted or likely to be bankrupted companies mentioned in Table 1.

The five models' formula were applied on the data of nine bankrupted or likely to be bankrupted companies, as shown in Tables 3-11.

**Table 3: Kingfisher Airlines Ltd.**

| | *OS = Ohlson Score* | | *SS = Springate Score* | | *ZS = Zmijewski Score* | | *GS = Grover Score* | | *Altman Z-Score (1995)* | |
|---|---|---|---|---|---|---|---|---|---|---|
| 2004 | 6.1500 | Bankrupt | 0.6884 | Bankrupt | 0.2823 | Bankrupt | 0.5873 | Healthy | 2.4352 | Grey |
| 2005 | 4.3570 | Bankrupt | 0.2852 | Bankrupt | 1.4186 | Bankrupt | 0.1505 | Healthy | 0.7115 | Bankrupt |
| 2006 | 3.7269 | Bankrupt | −0.6585 | Bankrupt | 1.6239 | Bankrupt | −0.8749 | Bankrupt | −1.0381 | Bankrupt |
| 2007 | 3.7450 | Bankrupt | −0.5089 | Bankrupt | 1.2224 | Bankrupt | −0.7087 | Bankrupt | −0.5517 | Bankrupt |
| 2008 | 4.4755 | Bankrupt | −1.3074 | Bankrupt | 1.2427 | Bankrupt | −1.5024 | Bankrupt | −3.2755 | Bankrupt |
| 2009 | 2.8458 | Bankrupt | −1.0924 | Bankrupt | 4.0137 | Bankrupt | −1.5405 | Bankrupt | −5.6319 | Bankrupt |
| 2010 | 4.5436 | Bankrupt | −1.0546 | Bankrupt | 5.1670 | Bankrupt | −1.4455 | Bankrupt | −5.8800 | Bankrupt |
| 2011 | 4.0101 | Bankrupt | −0.7417 | Bankrupt | 3.9970 | Bankrupt | −1.1907 | Bankrupt | −5.2112 | Bankrupt |
| 2012 | 4.2261 | Bankrupt | −1.8570 | Bankrupt | 5.7435 | Bankrupt | −2.4696 | Bankrupt | −9.6003 | Bankrupt |
| 2013 | 28.0813 | Bankrupt | −7.7185 | Bankrupt | 34.4827 | Bankrupt | −9.7918 | Bankrupt | −45.2684 | Bankrupt |

Source: Calculation based on the annual report.

Kingfisher Airlines Ltd.: The Ohlson model is capable to assume bankruptcy since 2004. In 2004, the OS zone value is 6.15, which is greater than its zone value, i.e. 0.38.

The Springate model is giving bankruptcy predictions from 2004. In 2004, the SS zone value is 0.6884, which is less than its zone value, i.e. < 0.862.

The Zmijewski score is giving bankruptcy predictions from 2004. In 2004, the ZS zone value is 0.2823, which is greater than its zone value, i.e. 0.

The Grover score shows that the company is going to be bankrupt in the near future. The Grover score is capable to assume bankruptcy since 2006. In 2006, the GS zone value is −0.8749, which is lower than its zone value, i.e. −0.02.

According to the Altman model, in 2004, the company is in the grey area and from 2005 till 2013 it is showing a high chance of bankruptcy.

**Table 4: Reliance Communications**

| | *OS = Ohlson Score* | | *SS = Springate Score* | | *ZS = Zmijewski Score* | | *GS = Grover Score* | | *Altman Z-Score (1995)* | |
|---|---|---|---|---|---|---|---|---|---|---|
| 2009 | 1.4592 | Bankrupt | 0.3831 | Bankrupt | −2.0448 | Healthy | 0.3178 | Healthy | 2.6449 | Healthy |
| 2010 | 6.5747 | Bankrupt | 0.2834 | Bankrupt | −2.0496 | Healthy | 0.2379 | Healthy | 2.5394 | Grey |
| 2011 | −0.4885 | Healthy | −0.1046 | Bankrupt | −1.6135 | Healthy | −0.1532 | Bankrupt | 0.9993 | Bankrupt |
| 2012 | −0.8284 | Healthy | 0.0510 | Bankrupt | −1.5977 | Healthy | 0.0326 | Healthy | 1.5983 | Grey |
| 2013 | 2.3609 | Bankrupt | 0.0930 | Bankrupt | −1.1283 | Healthy | 0.0464 | Healthy | 1.3205 | Grey |
| 2014 | 2.8179 | Bankrupt | −0.0523 | Bankrupt | −0.9724 | Healthy | −0.0737 | Bankrupt | 0.8761 | Bankrupt |
| 2015 | −2.0758 | Healthy | −0.0347 | Bankrupt | −1.3093 | Healthy | 0.0611 | Healthy | 1.7117 | Grey |
| 2016 | 1.1299 | Bankrupt | −0.1371 | Bankrupt | −0.6925 | Healthy | −0.1291 | Bankrupt | 0.6081 | Bankrupt |
| 2017 | 1.2128 | Bankrupt | −0.1307 | Bankrupt | −0.3510 | Healthy | −0.1901 | Bankrupt | 0.0758 | Bankrupt |
| 2018 | 2.6109 | Bankrupt | −0.0143 | Bankrupt | 1.2410 | Bankrupt | 0.0078 | Grey | 0.4012 | Bankrupt |

Source: Calculation based on the annual report.

Reliance Communications: The Ohlson results are fluctuating from 2009-2010 to 2013-2014 and 2016-2018; it is showing chances of bankruptcy, as the value of the model is greater than 0.38. In 2011-2012, it shows that the company is healthy; and in 2013-2014 chance of bankruptcy. Therefore, this model is not able to give the correct predictions about the company's bankruptcy.

The Springate model is giving bankruptcy predictions from 2009. In 2009, the SS zone value is 0.3831, which is lower than its zone value, i.e. < 0.862.

The Zmijewski score is not giving bankruptcy predictions from 2009. In 2009, the ZS zone value is −2.0448, which is lower than its zone value, i.e. 0. Only in 2018 does it show that there is a chance of bankruptcy. This model is not able to give the correct prediction about the company's bankruptcy.

The Grover score is fluctuating; in 2011, 2014, 2016, and 2017, it is showing chances of bankruptcy, as the value of the model is lower than its zone value, i.e. −0.02. In 2009, 2010, 2012, 2013, and 2015, it shows that the company is healthy. In 2018, chance of bankruptcy. Therefore, this model is not able to give the correct predictions about the company's bankruptcy.

According to the Altman model, in 2012 and 2013, the company is in a grey area, which means some improvement, while from 2016 onwards it is showing a high chance of bankruptcy.

**Table 5: Prag Bosimi Synthetics**

| | *OS = Ohlson Score* | | *SS = Springate Score* | | *ZS = Zmijewski Score* | | *GS = Grover Score* | | *Altman Z-Score (1995)* | |
|---|---|---|---|---|---|---|---|---|---|---|
| 2009 | 3.6137 | Bankrupt | −0.3776 | Bankrupt | 1.2596 | Bankrupt | −0.1960 | Bankrupt | −1.0815 | Bankrupt |
| 2010 | 1.3780 | Bankrupt | −0.4665 | Bankrupt | −2.8542 | Healthy | −0.0920 | Bankrupt | 0.8454 | Bankrupt |
| 2011 | 3.3543 | Bankrupt | −1.1266 | Bankrupt | −1.1691 | Healthy | −0.2201 | Bankrupt | 0.1910 | Bankrupt |
| 2012 | 2.5227 | Bankrupt | −0.7188 | Bankrupt | −1.0676 | Healthy | −0.4691 | Bankrupt | −0.9949 | Bankrupt |
| 2013 | 2.5810 | Bankrupt | −0.4537 | Bankrupt | −0.0496 | Healthy | −0.3964 | Bankrupt | −0.2940 | Bankrupt |
| 2014 | 2.9536 | Bankrupt | −1.2159 | Bankrupt | 0.3423 | Bankrupt | −0.6326 | Bankrupt | −1.1134 | Bankrupt |
| 2015 | 3.6561 | Bankrupt | −0.2078 | Bankrupt | −0.9652 | Healthy | −0.2703 | Bankrupt | 0.3119 | Bankrupt |
| 2016 | 2.5095 | Bankrupt | −0.4795 | Bankrupt | −0.2404 | Healthy | −0.1692 | Bankrupt | 0.3560 | Bankrupt |
| 2017 | 2.7656 | Bankrupt | −0.5310 | Bankrupt | −0.1457 | Healthy | −0.2516 | Bankrupt | −0.1169 | Bankrupt |
| 2018 | 3.5731 | Bankrupt | −0.3946 | Bankrupt | −0.1223 | Healthy | −0.0335 | Bankrupt | 0.5284 | Bankrupt |

Source: Calculation based on the annual report.

Prag Bosimi Synthetics: The Ohlson model is capable to assume bankruptcy since 2009. In 2009, the OS zone value is 3.6137, which is greater than its zone value, i.e. 0.38.

The Springate model is giving bankruptcy predictions from 2009. In 2009, the SS zone value is −0.3776, which is less than its zone value, i.e. < 0.862.

The Zmijewski score is not giving bankruptcy predictions.

The Grover score shows that the company is going to be bankrupt in the near future. The Grover score is capable to assume bankruptcy since 2009. In 2009, the GS zone value is −0.1960, which is lesser than its zone value.

According to the Altman model, in 2009, the company is in bankruptcy; the area is showing a high chance of bankruptcy.

**Table 6: Cranes Software International**

| | *OS = Ohlson Score* | | *SS = Springate Score* | | *ZS = Zmijewski Score* | | *GS = Grover Score* | | *Altman Z-Score (1995)* | |
|---|---|---|---|---|---|---|---|---|---|---|
| 2009 | 3.2402 | Bankrupt | 0.8412 | Bankrupt | −1.3669 | Healthy | 0.7975 | Healthy | 3.7388 | Healthy |
| 2010 | 2.2105 | Bankrupt | −0.8046 | Bankrupt | 0.2654 | Bankrupt | −0.2457 | Bankrupt | 1.1707 | Grey |
| 2011 | 2.9129 | Bankrupt | −0.8277 | Bankrupt | 0.5246 | Bankrupt | −1.0036 | Bankrupt | −2.4518 | Bankrupt |
| 2012 | 4.4948 | Bankrupt | −1.1886 | Bankrupt | 0.2900 | Bankrupt | −1.3674 | Bankrupt | −3.2656 | Bankrupt |
| 2013 | 3.3592 | Bankrupt | −1.6205 | Bankrupt | 2.1843 | Bankrupt | −1.9737 | Bankrupt | −5.7977 | Bankrupt |
| 2014 | 2.7826 | Bankrupt | −1.7883 | Bankrupt | 2.0940 | Bankrupt | −2.2649 | Bankrupt | −6.4008 | Bankrupt |
| 2015 | 3.3460 | Bankrupt | −0.9806 | Bankrupt | 1.9769 | Bankrupt | −1.4140 | Bankrupt | 38.2550 | Healthy |
| 2016 | 2.1442 | Bankrupt | −1.4458 | Bankrupt | 2.5193 | Bankrupt | −2.0285 | Bankrupt | 137.2768 | Healthy |
| 2017 | 4.3993 | Bankrupt | −1.8480 | Bankrupt | 4.7009 | Bankrupt | −2.6574 | Bankrupt | 178.4129 | Healthy |
| 2018 | 5.9517 | Bankrupt | −2.1803 | Bankrupt | 6.8501 | Bankrupt | −3.1822 | Bankrupt | 338.2735 | Healthy |

Source: Calculation based on the annual report.

Cranes Software International: The Ohlson model is capable to assume bankruptcy since 2009. In 2009, the OS zone value is 3.2402, which is greater than its zone value, i.e. 0.38.

The Springate model is giving bankruptcy predictions from 2009. In 2009, the SS zone value is 0.8412, which is less than its zone value, i.e. < 0.862.

The Zmijewski score is giving bankruptcy predictions from 2010. In 2010, the ZS zone value is 0.2654, which is greater than its zone value, i.e. 0.

The Grover score shows that the company is going to be bankrupt in the near future. The Grover score is capable to assume bankruptcy since 2010. In 2010, the GS zone value is −0.2457, which is lesser than its zone value.

According to the Altman model, in 2009 and 2010, the company is in a grey area, which means some improvement, while from 2011-2014, it is showing a high chance of bankruptcy. After 2015, it is indicating a healthy position.

**Table 7: Prakash Industries**

| | *OS = Ohlson Score* | | *SS = Springate Score* | | *ZS = Zmijewski Score* | | *GS = Grover Score* | | *Altman Z-Score (1995)* | |
|---|---|---|---|---|---|---|---|---|---|---|
| 2009 | 2.1863 | Bankrupt | 1.6871 | Healthy | −3.0220 | Healthy | 0.7297 | Healthy | 3.7168 | Healthy |
| 2010 | 2.2300 | Bankrupt | 1.9832 | Healthy | −3.4868 | Healthy | 0.8374 | Healthy | 4.3844 | Healthy |
| 2011 | 2.4032 | Bankrupt | 1.3683 | Healthy | −2.7425 | Healthy | 0.4858 | Healthy | 2.9706 | Healthy |
| 2012 | 2.5646 | Bankrupt | 1.2961 | Healthy | −2.4995 | Healthy | 0.4265 | Healthy | 2.7593 | Healthy |
| 2013 | 2.9051 | Bankrupt | 0.9205 | Healthy | −2.4921 | Healthy | 0.2815 | Healthy | 2.5391 | Grey |
| 2014 | 2.5052 | Bankrupt | 0.8434 | Bankrupt | −2.5163 | Healthy | 0.2638 | Healthy | 2.4737 | Grey |
| 2015 | 11.8259 | Bankrupt | 0.8374 | Bankrupt | −2.2643 | Healthy | 0.2758 | Healthy | 2.4068 | Grey |
| 2016 | 2.2185 | Bankrupt | 0.2721 | Bankrupt | −2.2577 | Healthy | 0.0039 | Grey | 1.8987 | Grey |
| 2017 | 2.1029 | Bankrupt | 0.4090 | Bankrupt | −2.4153 | Healthy | 0.0605 | Healthy | 2.0664 | Grey |
| 2018 | 1.8334 | Bankrupt | 1.1084 | Healthy | −3.0570 | Healthy | 0.3982 | Healthy | 3.1025 | Healthy |

Source: Calculation based on the annual report.

Prakash Industries: The Ohlson's values show the company's bankrupt position from 2009 till 2016. The Springate value is fluctuating; from 2009-2013, and 2015 and 2018, it is showing a healthy chance for the company. In 2009-2013, it shows the company is healthy, while in 2014-2017, it shows the chances of the company going bankrupt. Thus, it is not able to give the correct predictions about the company's bankruptcy.

From 2009-2018, the company is healthy as per the Zmijewski value. The Grover model is not able to predict the bankruptcy of the company, as the values state that the company is healthy throughout the study period, while according to the Altman model, the company is in the grey zone between 2013 and 2017. It was healthy till 2009.

**Table 8: Dewan Housing Finance Ltd.**

| | *OS = Ohlson Score* | | *SS = Springate Score* | | *ZS = Zmijewski Score* | | *GS = Grover Score* | | *Altman Z-Score (1995)* | |
|---|---|---|---|---|---|---|---|---|---|---|
| 2010 | 5.8893 | Bankrupt | 0.2929 | Bankrupt | 0.5716 | Bankrupt | 1.6928 | Healthy | 6.6339 | Healthy |
| 2011 | 4.8593 | Bankrupt | 0.2457 | Bankrupt | 0.7936 | Bankrupt | 0.2124 | Healthy | 0.7846 | Bankrupt |
| 2012 | 4.9076 | Bankrupt | 0.1367 | Bankrupt | 0.7957 | Bankrupt | 0.0478 | Healthy | 0.1356 | Bankrupt |
| 2013 | 4.7478 | Bankrupt | 0.0756 | Bankrupt | 0.8261 | Bankrupt | −0.0343 | Bankrupt | −0.1903 | Bankrupt |
| 2014 | 4.8443 | Bankrupt | 0.0651 | Bankrupt | 0.8792 | Bankrupt | −0.0384 | Bankrupt | −0.2324 | Bankrupt |
| 2015 | 4.7844 | Bankrupt | −0.0153 | Bankrupt | 0.8639 | Bankrupt | −0.1431 | Bankrupt | −0.6403 | Bankrupt |
| 2016 | 4.7766 | Bankrupt | −0.0100 | Bankrupt | 0.9284 | Bankrupt | −0.1212 | Bankrupt | −0.5909 | Bankrupt |
| 2017 | 4.4739 | Bankrupt | 0.1985 | Bankrupt | 0.7597 | Bankrupt | −0.2004 | Bankrupt | 0.7447 | Bankrupt |
| 2018 | 6.8060 | Bankrupt | 0.2731 | Bankrupt | 0.7716 | Bankrupt | −1.6611 | Bankrupt | 0.5462 | Bankrupt |
| 2019 | 2.8429 | Bankrupt | 0.5730 | Bankrupt | 1.0008 | Bankrupt | −0.9419 | Bankrupt | 0.8355 | Bankrupt |

Source: Calculation based on the annual report.

Dewan Housing Finance Ltd.: The Ohlson model is capable to assume bankruptcy since 2010. In 2010, the OS zone value is 5.8893, which is greater than its zone value, i.e. 0.38.

The Springate model is giving bankruptcy predictions from 2010. In 2010, the SS zone value is 0.2929, which is less than its zone value, i.e. < 0.862.

The Zmijewski score is giving bankruptcy predictions from 2009. In 2009, the ZS zone value is 0.5716, which is greater than its zone value, i.e. 0.

The Grover score shows that the company is going to be bankrupt in the near future. The Grover score is capable to assume bankruptcy from 2013 onwards. In 2013, the GS zone value is −0.0343, which is lesser than its zone value, i.e. −0.02.

According to the Altman model, in 2010, the company is in a healthy area, and from 2011 till 2019, it shows a high chance of bankruptcy.

**Table 9: Lanco Infra**

| | *OS = Ohlson Score* | | *SS = Springate Score* | | *ZS = Zmijewski Score* | | *GS = Grover Score* | | *Altman Z-Score (1995)* | |
|---|---|---|---|---|---|---|---|---|---|---|
| 2008 | 3.1691 | Bankrupt | 0.3740 | Bankrupt | −0.8132 | Healthy | 0.2195 | Healthy | 2.6507 | Healthy |
| 2009 | 4.1689 | Bankrupt | 0.7275 | Bankrupt | −0.5788 | Healthy | 0.5277 | Healthy | 2.4795 | Grey |
| 2010 | 3.8986 | Bankrupt | 0.8602 | Bankrupt | −0.7788 | Healthy | 0.6875 | Healthy | 3.0722 | Healthy |
| 2011 | 4.7584 | Bankrupt | 0.2405 | Bankrupt | 0.0744 | Bankrupt | 0.0900 | Healthy | 0.6504 | Bankrupt |
| 2012 | 5.3704 | Bankrupt | 0.2082 | Bankrupt | 0.3268 | Bankrupt | 0.0901 | Healthy | 0.6892 | Bankrupt |
| 2013 | 8.6111 | Bankrupt | 0.1258 | Bankrupt | 0.3485 | Bankrupt | 0.1037 | Healthy | 0.7756 | Bankrupt |
| 2014 | 2.6558 | Bankrupt | −0.1889 | Bankrupt | 0.8266 | Bankrupt | −0.1117 | Bankrupt | 0.1089 | Bankrupt |
| 2015 | 3.5310 | Bankrupt | −0.2174 | Bankrupt | 0.9794 | Bankrupt | −0.1773 | Bankrupt | −0.3508 | Bankrupt |
| 2016 | 3.6410 | Bankrupt | −0.1509 | Bankrupt | 0.9764 | Bankrupt | −0.1627 | Bankrupt | −0.4006 | Bankrupt |
| 2017 | 3.2031 | Bankrupt | −0.3932 | Bankrupt | 1.2917 | Bankrupt | −0.4609 | Bankrupt | −1.5501 | Bankrupt |

Source: Calculation based on the annual report.

Lanco Infra: The Ohlson's model is capable to assume bankruptcy since 2008. In 2008, the OS zone value is 3.1691, which is greater than its zone value, i.e. 0.38.

The Springate model is giving bankruptcy predictions from 2008. In 2008, the SS zone value is 0.3740, which is less than its zone value, i.e. < 0.862.

The Zmijewski score is giving bankruptcy predictions from 2011. In 2011, the ZS zone value is 0.0744, which is greater than its zone value, i.e. 0.

The Grover score shows that the company is going to be bankrupt in the near future. The Grover score is capable to assume bankruptcy from 2014 onwards. In 2014, the GS zone value is −0.1117, which is lower than its zone value, i.e. −0.02.

According to the Altman model, in 2008, the company is in a healthy area; from 2011 till 2017, it is showing a high chance of bankruptcy.

**Table 10: Alok Industries**

| | *OS = Ohlson Score* | | *SS = Springate Score* | | *ZS = Zmijewski Score* | | *GS = Grover Score* | | *Altman Z-Score (1995)* | |
|---|---|---|---|---|---|---|---|---|---|---|
| 2008 | 4.3418 | Bankrupt | 0.7227 | Bankrupt | 0.0202 | Bankrupt | 0.6083 | Healthy | 2.5081 | Grey |
| 2009 | 4.9678 | Bankrupt | 0.7189 | Bankrupt | 0.2400 | Bankrupt | 0.6710 | Healthy | 2.6911 | Healthy |
| 2010 | 4.8668 | Bankrupt | 0.5513 | Bankrupt | 0.2122 | Bankrupt | 0.4307 | Healthy | 1.8065 | Grey |
| 2011 | 4.6412 | Bankrupt | 0.7048 | Bankrupt | 0.0250 | Bankrupt | 0.6234 | Healthy | 2.6615 | Healthy |
| 2012 | 4.3249 | Bankrupt | 0.4753 | Bankrupt | 0.0301 | Bankrupt | 0.3140 | Healthy | 1.3776 | Grey |
| 2013 | 4.6862 | Bankrupt | 0.4917 | Bankrupt | 0.1587 | Bankrupt | 0.3411 | Healthy | 1.4630 | Grey |
| 2014 | 4.4275 | Bankrupt | 0.8343 | Bankrupt | 0.0544 | Bankrupt | 0.5482 | Healthy | 2.0765 | Grey |
| 2015 | 5.7970 | Bankrupt | 0.5953 | Bankrupt | 0.2890 | Bankrupt | 0.4487 | Healthy | 2.0099 | Grey |
| 2016 | 2.4693 | Bankrupt | −0.7235 | Bankrupt | 0.8538 | Bankrupt | −0.5824 | Bankrupt | −0.5953 | Bankrupt |
| 2017 | 3.4199 | Bankrupt | −0.8187 | Bankrupt | 1.3566 | Bankrupt | −0.8613 | Bankrupt | −2.1512 | Bankrupt |

Source: Calculation based on the annual report.

Alok Industries: The Ohlson model is capable to assume bankruptcy since 2008. In 2008, the OS zone value is 4.3418, which is greater than its zone value, i.e. 0.38.

The Springate model is giving bankruptcy predictions from 2008. In 2008, the SS zone value is 0.7227, which is less than its zone value, i.e. < 0.862.

The Zmijewski score is giving bankruptcy predictions from 2008. In 2008, the ZS zone value is 0.0202, which is greater than its zone value, i.e. 0.

The Grover score shows that the company is going to be bankrupt in the near future. The Grover score is capable to assume bankruptcy from 2016 onwards. In 2016, the GS zone value is −0.5824, which is lower than its zone value, i.e. −0.02.

According to the Altman model, in 2008, the company is in a healthy area; from 2016 till 2017, it shows a high chance of bankruptcy.

**Table 11: Jet Airways**

| | *OS = Ohlson Score* | | *SS = Springate Score* | | *ZS = Zmijewski Score* | | *GS = Grover Score* | | *Altman Z-Score (1995)* | |
|---|---|---|---|---|---|---|---|---|---|---|
| 2010 | 2.4114 | Bankrupt | −0.2908 | Bankrupt | 0.6239 | Bankrupt | −0.4152 | Bankrupt | −1.2364 | Bankrupt |
| 2011 | 2.9585 | Bankrupt | −0.1119 | Bankrupt | 0.7198 | Bankrupt | −0.3462 | Bankrupt | −1.3077 | Bankrupt |
| 2012 | 2.9208 | Bankrupt | −0.0845 | Bankrupt | 0.6789 | Bankrupt | −0.4220 | Bankrupt | −1.7295 | Bankrupt |
| 2013 | 2.9751 | Bankrupt | −0.3516 | Bankrupt | 1.3428 | Bankrupt | −0.7168 | Bankrupt | −2.7348 | Bankrupt |
| 2014 | 2.2634 | Bankrupt | −0.2029 | Bankrupt | 1.6192 | Bankrupt | −0.7264 | Bankrupt | −3.0744 | Bankrupt |
| 2015 | 1.8339 | Bankrupt | −0.8088 | Bankrupt | 2.9886 | Bankrupt | −1.3370 | Bankrupt | −4.9169 | Bankrupt |
| 2016 | 3.1808 | Bankrupt | −0.3419 | Bankrupt | 3.0684 | Bankrupt | −0.9621 | Bankrupt | −4.4432 | Bankrupt |
| 2017 | 2.4890 | Bankrupt | 0.1901 | Bankrupt | 2.0193 | Bankrupt | −0.4838 | Bankrupt | −3.1053 | Bankrupt |
| 2018 | 5.7874 | Bankrupt | 0.5492 | Bankrupt | 3.7891 | Bankrupt | −0.3768 | Bankrupt | −4.1980 | Bankrupt |
| 2019 | 3.3041 | Bankrupt | −0.0995 | Bankrupt | 4.9764 | Bankrupt | −1.0929 | Bankrupt | −6.0538 | Bankrupt |

Source: Calculation based on the annual report.

Jet Airways: The Ohlson model is capable to assume bankruptcy since 2010. In 2010, the OS zone value is 2.4114, which is greater than its zone value, i.e. 0.38.

The Springate model is giving bankruptcy predictions from 2010. In 2010, the SS zone value is −0.2908, which is less than its zone value, i.e. < 0.862.

The Zmijewski score is giving bankruptcy predictions from 2010. In 2010, the ZS zone value is 0.6239, which is greater than its zone value, i.e. 0.

The Grover score shows that the company is going to be bankrupt in the near future. The Grover score is capable to assume bankruptcy from 2010 onwards. In 2010, the GS zone value is −0.4152, which is lower than its zone value, i.e. −0.02.

According to the Altman model, from 2010 till 2017, the company is showing a high chance of bankruptcy.

**Table 12: Data and Model Values of Nine Companies over the Last Ten Years**

| | | *Kingfisher Airlines Ltd.* | *Reliance Communi-cations* | *Prag Bosimi Synthetics* | *Cranes Software Inter-national* | *Prakash Industries* | *Dewan Housing Finance Ltd.* | *Lanco Infra* | *Alok Indu-stries* | *Jet Airways* | *Total* |
|---|---|---|---|---|---|---|---|---|---|---|---|
| OS = Ohlson Score | Bankrupt | 10 | 7 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 87 |
| | Healthy | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 |
| | Grey | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SS = Spring-ate Score | Bankrupt | 10 | 10 | 10 | 10 | 4 | 10 | 10 | 10 | 10 | 84 |
| | Healthy | 0 | 0 | 0 | 0 | 6 | 0 | 0 | 0 | 0 | 6 |
| | Grey | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| ZS = Zmijew-ski Score | Bankrupt | 10 | 1 | 2 | 9 | 0 | 10 | 7 | 10 | 10 | 59 |
| | Healthy | 0 | 9 | 8 | 1 | 10 | 0 | 3 | 0 | 0 | 31 |
| | Grey | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | | *Kingfisher Airlines Ltd.* | *Reliance Communi-cations* | *Prag Bosimi Synthetics* | *Cranes Software Inter-national* | *Prakash Industries* | *Dewan Housing Finance Ltd.* | *Lanco Infra* | *Alok Indu-stries* | *Jet Airways* | *Total* |
|---|---|---|---|---|---|---|---|---|---|---|---|
| GS = Grover Score | Bankrupt | 8 | 4 | 10 | 9 | 0 | 7 | 4 | 2 | 10 | 54 |
| | Healthy | 2 | 5 | 0 | 1 | 9 | 3 | 6 | 8 | 0 | 34 |
| | Grey | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 2 |
| Altman Z-Score | Bankrupt | 9 | 5 | 10 | 4 | 0 | 9 | 7 | 2 | 10 | 56 |
| | Healthy | 0 | 1 | 0 | 5 | 5 | 1 | 2 | 2 | 0 | 16 |
| | Grey | 1 | 4 | 0 | 1 | 5 | 0 | 1 | 6 | 0 | 18 |

Source: Calculation based on the annual report.

The Ohlson model is highly accurate for predicting the bankruptcy category, but gives quite late predictions compared to the Springate and Zmijewski model. Grover showed two companies throughout in the healthy zone, while the Altman model is very weak in predicting bankruptcy.

## Limitation and Future Scope of the Study

This study is only limited to five bankruptcy models applied on the data of nine financial companies based on the published data of financial statements of the last ten years from the year of filing for bankruptcy. Further studies can be extended using multiple bankruptcy models, and a large number of companies from different sectors can be taken into consideration.

## Conclusion

This is one of a handful of studies that are focused on the comparison between multiple bankruptcy prediction models to track the financial position of the bankrupted organisation. This study explores the effectiveness of five model positions – Ohlson, Springate, Zmijewski, Grover, and Altman – to analyse the monetary sufficiency of the organisation. The review covers nine bankrupted or liable to be bankrupted organisations, and information of ten years prior to the year they are going for liquidation are taken.

As per the discoveries, the various qualities across the bankruptcy expectation models were just because of various estimations used to anticipate the organisation's insolvency. These findings further imply that the bankruptcy prediction models have different levels of accuracy in predicting the performance of the firms. Further, it is proposed that the organisation be healthy. In addition, according to the Zmijewski, Grover, and Altman models, the odds of the organisation becoming bankrupt are high from 2009 itself.

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