

See discussions, stats, and author profiles for this publication at: <https://www.researchgate.net/publication/256030566>

# Business Bankruptcy Prediction Models: A Significant Study of the Altman's Z-Score Model

Article in SSRN Electronic Journal · August 2012

DOI: 10.2139/ssrn.2128475

CITATIONS

26

READS

3,328

1 author:



[Sanobar Anjum](#)

University of Toronto

8 PUBLICATIONS 29 CITATIONS

[SEE PROFILE](#)

Some of the authors of this publication are also working on these related projects:



Altman's Model [View project](#)



University of Calgary [View project](#)

## **Business bankruptcy prediction models: A significant study of the Altman's Z-score model**

Sanobar anjum

Research Scholar – Rayalaseema University, Kurnool, India, Instructor- Prince Muhammad University, Dhahran, KSA  
sanjum@pmu.edu.sa

### **ABSTRACT**

Businesses are enterprises which produce goods or render services for profit motive. To be able to predict the financial soundness of a business has led to many research works. Financial ratios are a key indicator of financial soundness of a business. Financial ratios are a tool to determine the operational & financial efficiency of business undertakings. There exist a large number of ratios propounded by various authors. Altman developed a z-score model using ratios as its foundation. With the help of the Z- Score model, Altman could predict financial efficiency /Bankruptcy up to 2-3 years in advance. The following research paper describes in detail the studies carried out by Altman to predict business bankruptcy. Altman made regular changes to achieve the perfect equation which could predict bankruptcy. The following research paper summarises the research of Altman that have being made to develop the Altman Z score model. It can be safely said that Altman's Z score Model can be applied to modern economy to predict distress and bankruptcy one, two & three years in advance.

**Keywords:** Business Failure, Bankruptcy, Altman's Z-Score Model, Financial Ratios.

### **1 Introduction**

Business is any undertaking working towards profit objective. Predicting if a Business will do well or go bankrupt, before they actually do has led to propagation of various theories. It is fascinating for researchers to predict in advance if a business will be able to meet its obligation or will dissolve. Business failure has led to many studies of bankruptcy prediction. Business failure as discussed by some leading authors is discussed below. Fitzpatrick (1932) identified five stages leading to business failure. They are (1) incubation (2) financial embarrassment, (3) financial insolvency, (4) total insolvency, and (5) confirmed insolvency. Incubation is when the company's financials are just developing. Financial embarrassment is when management becomes aware of the firm's distressed condition. Financial insolvency occurs when the firm is unable to acquire the necessary funds to meet its obligations. Total insolvency occurs when the liabilities exceed the physical assets. Finally, confirmed insolvency occurs when legal steps are taken to protect the firm's creditors or liquidation occurs. (Poston, Harmon, & Gramlich, 1994)

Karels and Prakash (1987) mentioned that a diverse set of definitions has emerged to explain business failure. The set includes negative net-worth, non- payments of creditors, bond defaults, inability to pay debts, over drawn bank accounts, omission of preferred dividends, receivership, etc. Aharony, Jones, and swary (1980) describe business failure as an indication of resources misallocation that is undesirable from a social point of view.

The term business failure, used by Dun and Bradstreet, describes various unsatisfactory business conditions. Business failure includes businesses that cease operation following assignment or bankruptcy. Secondly, it includes those that cease with loss to creditors after such actions as execution, foreclosure, or attachment. Third, it includes those that voluntarily withdraw or leave unpaid obligations. Fourth, it includes those that have been involved in court actions such as receivership, reorganization, or arrangement. Finally it adds those that voluntarily compromise with creditors (Altman, 1993)

Table 1 shows the summary of significant researchers and their models for predicting bankruptcy or business failure. This table is only indicative of the significant researches and is not an exhaustive list of all that have researched this field of study.

**Table 1:** Bankruptcy prediction models and authors

Type of Model	Author	Date
Univariate	Fitzpatrick	1932
	Merwin	1942
	Walter	1957
	Beaver	1966
Multiple Discriminant Analysis	Altman	1968
	Edmister	1972
	Deakin	1972
	Blum	1974
	Moyer	1977
	Altman, Halderman, & Naarayanan	1977
	Altman	1983
	Booth	1983
	Rose & Giroux	1984
	Casey & Bartczak	1985
	Lawrence & Bear	1986
	Poston, Harmon, & Gramlich	1994
	Grice & Ingram	2001

There are three other significant types of Bankruptcy prediction models, after Univariate & Multiple Discriminant Analysis. They are Logit & Probit Analysis, Recursive Partitioning Algorithm, and Neural Networks etc. These have not been discussed in detail nor have seminal works in this area been mentioned. Major work has been done under multiple discriminant analysis. Altman's 1968 original Z-score has evolved from the failings of the univariate analysis to being used with more modern methods such as neural networks.

Almost all of the bankruptcy prediction models used in Table 1 use a paired- sample technique. One sample group contains (the measure of study) the companies that will have failed while the other sample contains healthy companies. Both samples use the same variable. Different ratio's, statistical modeling approaches, and sampling techniques make comparing the various models very difficult. Many of the studies have concentrated on specific industries, such as Altman's (1968) and Zavgren (1985) use only large manufacturing firms, while McGurr (1996) and Rance (1999) used retail firms. Nonetheless, most bankruptcy prediction models have been constructed using only large publicly held

business because the financial information is more readily available as compared to small private firms.

The purpose of this journal paper is to review the related literature pertaining to business failure, often called bankruptcy prediction. The research paper is further divided along the following major section: (1) Development of Altman's Z-score Model;

(2) Comparison of Bankruptcy Models; and lastly

(3) Summary

## **2. Development of Altman's Z score Model**

In 1968, Edward Altman published what has become the best known predictor of bankruptcy. This predictor is a statistical model that combines five financial ratios to produce a product called a Z-score. The model has proven to be a dependable instrument in forecasting failure in a diverse mix of business entities. Dr. Altman's original model is calculated as:

$$Z = 0.012X_1 + 0.014X_2 + 0.033X_3 + 0.006X_4 + 0.999X$$

Working capital/total assets ( $X_1$ ) is a measure of liquid assets in relation to the firm's size.

The difference between current assets and current liabilities represents working capital. The current assets of a firm include cash on hand, accounts receivable, and inventories; the latter two assets are considered current, if cash conversion is expected within an operating cycle of a business. Current liabilities consist of the firm's financial obligations—short-term debt and accounts payable—which will be met during the operating cycle. A positive working capital indicates a firm's ability to pay its bills. A business entity with a negative working capital will experience difficulty meeting its obligations. Altman's research finds this ratio to be more helpful than other liquidity ratios, such as the current ratio or the quick ratio. (Altman, 2000; Chuvakhin & Germania, 2003)

Retained earnings/total assets ( $X_2$ ) represent a measure of cumulative profitability reflecting the firm's age as well as its earning power. A history of profitable operations and reduced debt is signified by firms that retain earnings or reinvest operational profits. Low retained earnings may indicate a poor business year or reduced longevity for the firm. According to Dun and Bradstreet, 50% of businesses fail within the first five years of operation (Altman, 2000, 2002). A measure of an organization's operating efficiency separated from any leverage effects is a true depiction of asset production. Represented as earnings before interest and taxes/total assets ( $X_3$ ), this ratio estimates that cash supply available for allocation to creditors, the government, and shareholders. Altman (2000) classifies the ratio as a superior measure of profitability that is better than cash flow.

Altman (2000, 2002) defines the market value of equity, or market capitalization, as a summation of both preferred and common stock or market value of equity/book value of total debt ( $X_4$ ). The stock market, the primary estimator of a firm's worth, suggests that price changes may foreshadow pending problems if a firm's liabilities exceed its assets. Altman believes this ratio is a more effective financial distress predictor than net worth/total debt (book values).

The next ratio, sales/total assets ( $X_5$ ) signifies a standard turnover measure that unfortunately varies from one industry to another. Yet, the ratio is an indicator of a firm's efficient use of assets to create sales (Chuvakhin & Gertmenian, 2003). Altman (2000) has defined this as ".....one measure of management's capacity in dealing with competitive conditions" (p.22). Finally, Eidleman (1995) explains the applicability of the previously discussed ratios. Specifically, Eidleman states "Each of these ratios is multiplied by a predetermined weight factor, and the results are added together. The final number—the z-score—will yield a number between -4 and +8. Scores that add to a z-score < 1.81 have a high probability of bankruptcy, while scores > 2.67 represent financial soundness. The gray area or zone of ignorance exists when firms have z-scores between 1.81 and 2.67 (Eidleman, 1995, pg.3-5).

Altman's pioneer study is based on a sample of 66 publicly traded, manufacturing firms. Thirty-three of the firms had filed for bankruptcy and all had assets over \$1 million. His model correctly predicts financial failure for 95% of the firms, one year prior to their demise. Accuracy decreases to 72% two years out and to 52% three years prior to insolvency (Altman, 1968). Type I errors, those that predict a bankruptcy that does not occur, are shown for 6% of the firms analyzed. Type II errors also were shown for 6% of the firms analyzed. Type II errors predict a solvent firm that files bankruptcy (Altman, 1993).

In 1983, Altman developed a revised Z-score model for privately held firms. "Credit analysis, private placement dealers, accounting auditors, and firms themselves are concerned that the original model is only applicable to publicly traded entities (since  $X_4$  requires stock price data)" (Altman, 1993, p.202). The revised Z-scores substitute the book value of equity for the market value in  $X_4$ . The new Z-score model ratios are listed below:

- $X_1$  = Working capital/total assets
  - $X_2$  = Retained earnings/total assets
  - $X_3$  = EBIT/total assets
  - $X_4$  = N.W. (book value)/total liabilities
  - $X_5$  = Sales/total assets
- A change in the weight factor is also calculated.

The revised Z-score formula follows

$$Z = 0.717(X_1) + 0.847(X_2) + 3.107(X_3) + 0.420(X_4) + 0.998(X_5)$$

Cut off scores are also adjusted so that scores of < 1.23 indicate bankrupt firms and scores of > 2.90 are indicators of non bankrupt firms. Firms with scores between 1.23 and 2.90 are determined to exist in the grey area or zone of ignorance (Altman, 1993). Altman's new sample produces similar results as the original Z-score model, indicating 90.9% accuracy in bankruptcy forecasting at least one year prior to actual failure. Firms with scores over 2.90 have a 97% chance of continuing operations with financial health (Altman, 1993).

Altman does not view his original model nor his revised Zeta model as perfect, citing four issues: (a) subjectiveness in the weightings, (b) an element of ambiguity within the model, (c) the univariate approach, and (d) some misleading ratios (Schaeffer, 2000). He further feels that the fifth ratio (sales/total assets) does not represent a difference between failed and non-failed firms and does not reflect any variations from industry to industry. In addition, the model is unable to accurately forecast financial difficulties for non-manufacturing firms and non-publicly operated forms. As the market value of equity is based on stock prices, the

fourth ratio is difficult to establish in non-public firms (Schaeffer, 2000). In 1993, Altman's continued research produced a further revised model, one that eliminates variables  $X_5$ , sales/total assets. Eliminating sales/totals assets minimizes "the potential industry effect which is more likely to take place when such an industry sensitive variable as asset turnover is included" (Altman, 1993, p.204). The revised Z-score model uses  $X_4 = \text{N.W. (Book value)}/\text{total liabilities}$  to maintain its applicability to privately owned firms. The first three variables are unchanged; however, the weight factor is again recalculated. Hence the revised Z-score model is represented as

$$Z = 6.56(X_1) + 3.26(X_2) + 6.72(X_3) + 1.05(X_4)$$

where cut off scores reflect

Bankrupt firms < 1.10

Non bankrupt firms > 2.60

Grey area = 1.10-2.60

Results of Altman's newest revised Z-score model exhibit a 90.9% success rate in predicting bankruptcy one year prior to firm's demise and a 97% accuracy rate for identifying non bankrupt firms with continuing economic solvency (Altman, 1993). Table 2 illustrates Altman's bankruptcy models (Rance, 1999, p.8)

**Table 2: Altman's Z-Score Models**

Coefficients Variables	Original Model (1968)	Revised Model (1983)	Revised Four Model (1993)
$X_1$	1.21	0.717	6.56
$X_2$	1.41	0.847	3.26
$X_3$	3.30	3.107	6.62
$X_4$	0.60	0.42	1.05
$X_5$	0.999	0.998	N/A
Cutoff scores	<1.81	<1.23	>1.10
Bankrupt firms	>2.67	>2.90	>2.60
Non Bankrupt Firms			
Grey Area	1.81-2.67	1.23-2.90	1.10-2.60
Classification Results			
Actual Bankrupt	94%	90.9%	90.9%
False Bankrupt	6%	9.1%	9.1%
Actual Bankrupt	97%	97%	97.0%
False Bankrupt	3%	3%	

Altman cautions that his model has limitations in its applicability to different business entities with the same prediction accuracy. First, 20 years of studies encompass a diverse assortment

of manufacturing firms that vary in size. Second, his model does not always have the same accuracy across these businesses. Even though Altman's bankruptcy prediction model is the most popular analytical tool utilized by investors, auditors, and stakeholders, Altman advises not to use his formula to the exclusion of other analytical techniques (Altman, 1993).

In Conclusion, Altman's revised Z-score model is one of the most effective Multiple Discriminant Analysis, which has been researched throughout the last 40 years. Altman's Model has been used in various industries to predict bankruptcy. Researchers have used Altman's Z score model in the service industry, manufacturing industry, publically listed companies, and banks alike to predict if the business will have a downfall. All the 3 revision of Altman equation has been used by different authors in their studies, with constructive predictability. It can be safely said that Altman's Z score Model can be applied to modern economy to predict distress and bankruptcy one, two & three years in advance.

The next kinds of bankruptcy prediction model are Logit & Probit Analysis. There have been varied amount of research done under this bankruptcy model. This model is followed by research done under the Recursive Partitioning Algorithm, followed by the latest neural networks. The journal article concludes by comparing the different bankruptcy prediction model followed by a Summary for this chapter.

### **3. Comparison of Bankruptcy Models**

Several bankruptcy prediction models have been used in the past century. Univariate analysis progressed to Multiple Discriminant Analysis. Logit/Probit analysis came next. Recursive Partitioning Algorithm followed. Finally, Neural Networks is the latest bankruptcy prediction model. Beaver (1966) is the first to recognize that not all the ratios predict equally. Since this time, researchers have been constantly determining the key predictive variables in their study. Rose et al. (1984) added that single-ratio predictor tests could be misleading. Altman (1968) uses multiple discriminant analysis to fix this problem. Altman concluded that his model predicted well for one year (94%) and somewhat for two years (72%). Edmister (1972) added that small companies predicted almost as well at 93%. This is significant because all of the past studies dealt with larger corporation. Lau (1987) using Logit analysis had better predictability for three years. The three years are 96%, 92%, and 90%, respectively. McKee et al. (2000) using recursive partitioning algorithm had a predictive accuracy of up to 97%. All of the neural networks had lower predictive accuracy than the models already mentioned. Collins and green (1982) compared several bankruptcy models. The authors used multiple discriminant analysis offered the least richness of the results. However, multiple discriminant analysis and linear probability produce uniformly good results. The logit model appears to be more consistent with the theory of financial distress. Altman, Marco, and Varetto (1994) also compared several bankruptcy methods. The author used linear discriminant analysis and neural networks. They concluded that discriminant analysis was better than the neural networks trained in their experiments. It is possible to learn what the most important variables are for explanation purposes, which is not possible with neural networks that have illogical behavior patten

### **4. Conclusion**

This research paper summaries significant studies in the bankruptcy prediction area and provides a comparison of the different models which are commonly used. The studies

selected show that various financial information can be useful in predicting business failure. One common theme throughout has been that a consensus has not been forthcoming as to which variables are most effective in predicting bankruptcy and the time period prior to failure. Most of the bankruptcy studies have used multiple discriminant analysis (MDA) statistical techniques to develop models and have included large and small firms, as well as private & publicly held firms. Dr Altman's model has been well researched and many pioneering studies have been done under his z-score yardstick. The significant changes done on the Altman equation has improved the predictability of bankruptcy. The chapter started with an explanation of Business bankruptcy, or what does it mean for a business to become bankrupt. This discussion was followed by the various types of bankruptcy prediction model as applicable in today's economic scenarios. There are majorly five different types of bankruptcy prediction model. Multiple discriminant analysis is the crux of this research paper. Dr Altman's model is discussed in detail describing the changes occurring to the equation so as to reach a perfect prediction model.

## **5. References**

1. Fitzpatrick, P.J. (1932), A comparison of ratios of successful industrial enterprises with those of failed companies, *Certified Public Accountant*, pp 598-605, 656-662, &721-731.
2. Poston, K.W., Harmon, W.K., Gramlich, J.D. (1994), A test of financial ratios as predictors of turnaround versus failure among financially distressed firms. *Journal of Applied Business Research*, 10, pp 41-51.
3. Karels, G.V., & Prakash, A.J. (1987), Multivariate normality and forecasting of business bankruptcy. *Journal of Business Finance and Accounting*, 14, pp 573-593.
4. Aharony J., Jones C.P., & Swary, I. (1980). An Analysis of risk and return characteristics of corporate bankruptcy using capital market data. *Journal of Finance*, 35, pp 1001-1016.
5. Altman, E. (2000), Predicting financial distress of companies: Revisiting the Z-score and Zeta Model, available at <http://www.pages.stern.nyu.edu/~ealtman/>, accessed during May 2012.
6. Chuvakhin, N. Gertmenian, L.(2003), Predicting bankruptcy in the WorldCom age. *Graziadio Business Report*, 6(1), available at <http://gbr.pepperdine.edu/031/print/bankruptcy.html>, accessed during May 2012.
7. Eidleman, G. (1995), Z-scores- a guide to failure prediction. *The CPA Journal*, 12(9), pp 52-53.
8. Altman, E. (1968), Financial ratios, discriminant analysis and the prediction of corporate bankruptcy. *The Journal of finance*, 23(4), pp 598-608.
9. Altman, E. (1993), *Corporate financial distress and bankruptcy*. (3rd ed.). New York: John Wiley & Sons, Inc.



10. Schaeffer, M. (2000), International affairs. Business Credit available at <http://www.Highbeam.com/library/doc3.asp?> accessed during May 2012
11. Rance, R.(1999), The application of Altman's revised four-variable Z-score bankruptcy prediction model for retail firms and the influence of asset size and sales growth on their future. Unpublished doctoral dissertation, Nova Southeastern University, Fort Lauderdale, FL.
12. Beaver, W.H (1966), Financial Ratios as predictors of failure. Journal of Accounting Research, 4, pp 71-111.
13. Rose, P.S., & Giroux, G. A. (1984). Predicting corporate bankruptcy: an analytical and empirical evaluation. Review of Business and Economic Research, 19(2), pp 1-12.
14. Altman, E.I. (1968), Financial ratios, discriminant analysis and the prediction of corporate bankruptcy, The Journal of Finance, 23, pp 589-609.
15. Edmister, R.O, (1972), An empirical test of financial ratio analysis for small business failure prediction. Journal of Financial and Quantitative Analysis, 7, pp 1477-1493.
16. Lau, A.H. (1987), A five state financial distress prediction model. Journal of Accounting Research, 25, pp 127-138.
17. McKee, T.E, &Greenstein, M. (2000), Predicting bankruptcy using recursive partitioning and a realistically proportioned data set. Journal of Forecasting, 19(3), pp 219-230.
18. Collins, R.A., & Green, R.D. (1982). Statistical methods for bankruptcy prediction. Journal OF Economics and business, 34, pp 349-354.
19. Altman, E.I., Marco, G., & Varetto, F. (1994). Corporate distress diagnosis: Comparisons using linear discriminant analysis and neural networks (the Italian experience). Journal of banking and Finance, 18, pp 505-529.