



An evaluation of Altman's Z-score using cash flow ratio to predict corporate failure amid the recent financial crisis: Evidence from the UK



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ABSTRACT

This paper investigates the extension of the Z-score model in predicting the health of UK companies; using discriminant analysis, and performance ratios to test which ratios are statistically significant in predicting the health of UK companies from 2000 to 2013. The purpose of this study is to contribute towards Altman's (1968) original Z-score model by adding a new variable. We found that, cash flow when combined with the original Z-score variable is highly significant in predicting the health of UK companies. A J-UK model was developed to test the health of UK companies. When compared to the Z-score model, the predictive power of the model was 82.9%, which is consistent with Taffler's (1982) UK model. Furthermore, to test the predictive power of the model before, during and after the financial crisis period; results show that J-UK model had higher accuracy to predict the health of UK companies than the Z-score UK model. Thus, the extension of Altman's Z score model leads to better results and assists users such as researchers, managers, regulators and other practitioners to manage their risk profile more effectively.

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1. Introduction

The prediction of companies operating in financial difficulties has been a particular subject of interest for many academics, scholars, businesses and the government. Financial ratio analysis technique has dominated such studies. These studies could be traced in the 1930's (Fitzpatrick, 1932). Before the development of quantitative measures of assessing the creditworthiness of company performance, these studies concluded that failing firms display significantly different measurement of financial ratios (Altman, 1968, 590).

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In addition, recent studies have employed different techniques to estimate bankruptcy. Theoretically, Beaver (1966) initiated financial ratios that were basically univariate in nature. However, other studies argued that, the univariate approach employed a single ratio, which had individual signs of impending problems that might lead to misinterpretation and, less importantly potentially confusing (Altman, 1968, 591). The shortcomings of the above studies acted as a spring-board for recent studies to detect which ratios are most significant in predicting the health of companies? After a careful consideration of the research problem and purpose of this study, multiple discriminate analysis (MDA) was chosen as the appropriate statistical technique.

2. Literature review

The literature on bankruptcy prediction dates back to the 1930's with initial studies regarding the use of ratio analysis techniques to predict future bankruptcy studies right up to the mid-1960's focusing on univariate technique (Bellovary et al., 2007). Research on predicting bankruptcy has been of significant interest in accounting, banking and finance, including practitioners for the last four decades (Agarwal and Taffler, 2007, p. 286). Bankruptcy models generally provide measures of financial distress and are regularly employed by scholars to examine the financial health of companies (Grice and Dugan, 2001). In addition, the multivariate technique for failure prediction was first published in 1968 by Altman, Edward, which remains very popular in the literature today.

Before the beginning of quantitative analysis of company performance, one would examine early failure predictable models as in the 1930s in understanding the failure of companies. Several empirical approaches have been employed in bankruptcy prediction models, since the pioneer studies of financial models such as Fitzpatrick (1932) compared 13 financial ratios of both failed and successful firms whereby 19 of each firm status were compared. His result shows that, a majority of successful company cases displayed favourable ratios while the failed firms experienced unfavourable ratios when compared with standard trend ratios. Fitzpatrick concluded that Net Worth to Debt and Net Profit to Net Worth. In addition, he reported that less significance should be placed on current and quick ratios for firms having long-term liabilities. On the other hand, Merwin as cited in Bellovary et al. (2007) published a study on small manufacturers. His results show that, when comparing successful and failing firms, the failing firm displays several signs of weakness early as four to five years before failure. He identifies Net Working Capital to Total Assets. This is consistent with Altman (1968); Beaver (1966); Altman (1968); Ohlson (1980) and Taffler (1982). Statistical methods have been applied in corporate prediction studies of both non-bankrupt and bankrupt firms. Predicting bankruptcy using multivariate discriminant analysis has been generally employed, for instance Altman (1968); Taffler (1982); Ohlson (1980) with logit analysis. This approach requires classification of paired sample (failed and non-failed companies) using financial ratios.

2.1. Early bankruptcy prediction studies

One of the early works in the area of using ratio analysis to predict bankruptcy was performed by Beaver in 1966 (Altman, 1993, p. 181; Drapeau et al., 2004). Beaver (1966) employed univariate statistical techniques to distinguish between healthy and failing companies (Back et al., 1996). William Beaver (1966) introduced a univariate approach to classify into two major groups by employing some financial ratios. These ratios were employed on a basis of cutoff scores between individual ratios to minimize misclassification. Furthermore, Beaver (1966) divided financial statement data of companies into years before failure and examines the predictive ability of the financial ratios concerned. He assumed that a single variable or the ratio (cash flow to debt ratio) can be used in predicting the health of companies. Beaver (1966) found that a number of indicators could discriminate between matched samples of both failed and non-failed firms for as long as five years before actual failure. Nevertheless, Beaver's univariate technique is considered less effective in predicting the health of companies (Altman, 1968). More so, Dimitras et al. (1996), argues that a variety of factors can describe the financial status of a company; therefore a single ratio may not provide enough information for complete analysis. In line with this claim, Altman (1968) questioned the application of univariate approach and introduced the multivariate analysis.

Despite the above criticism, the univariate approach employed by Beaver (1966) led the way in developing discriminant analysis, which was later expanded by other studies on corporate failure (Agarwal and Taffler, 2007). The following paragraph examines this approach. Altman (1968) model has been considered by most researchers, practitioners and managers as an effective tool to predict the health of companies.

Additionally, Altman original Z-score model has proven to be quite accurate over the last twenty decades and remains an established tool for assessing the health of companies. Recently, this evidence is confirmed by Al Zaabi and Obaid Saif (2011) who employed Emerging Markets (EM) Z-score model to predict failure and to measure the financial performance of major Islamic banks in the UAE context. They found that Z-score model is a suitable model to measure Islamic banks' performance and the factors used in computing Z-score can be considered to give precious instrumental indicators. Their findings are consistent with Lugovskaya (2010); Gutzeit and Yozzo (2011a); Li and Rahgozar (2012); Li et al. (2013); Bhandari and Iyer (2013); Goswami et al. (2014); and Mizan and Hossain (2014).

The MDA approach used a paired sample between failed firms matched with non-failed sample by employing financial ratios. The result shows that financial ratio analysis is a useful tool to predict failure five years before the event. Generally, these studies concluded that ratios such as profitability, liquidity, and solvency existed as the most significant indicators. However, the selection and order of importance of these ratios are not clear since almost every study cited a different ratio to measure the health of companies (Altman, 1968).

Table 1
F-test summary Table 1.

Altman ratios	F	Sig.
X1	44.166	.000
X2	6.287	.012
X3	.724	.395
X4	4.668	.031
X5	3.723	.054

From the literature on predicting failure in companies, a handful of previous studies widely employed accounting ratio-based on Z-score modelling as a substitute for default risk or failure (for example, Altman et al., 1977; Dichev, 1998; Griffin and Lemmon, 2002; Agarwal and Taffler, 2007). However, to the author's own knowledge, hardly of these previous studies has extended the original Z-score model in the case of UK general companies. This paper contributes to the emerging body of literature in accounting and finance by extending the original Z-score model developed by Altman in 1968. This is done by adding a new variable (Cash flow) to predict the health of UK general companies. The following section presents the hypotheses of the study, methodology and statistical techniques employed to support our hypothesis.

2.2. Hypotheses

H₁. There is a difference in the predictive ability of the J-UK model and Altman's UK model.

H₀. There is no difference in the predictive ability of the J-UK model and Altman's UK model.

H₂. There is a significant relationship between the original Z-score variables and the additional variables.

H₀. There is no significant relationship existing between the original Z-score variables and the additional variables.

H₃. J-UK model has the ability to predict failure before, during and after the crisis than the Altman UK model.

H₀. There is no predictive power between J-UK model and Altman's UK model before, during and after the crisis.

3. Research methodology

Secondary data were obtained from Bloomberg database. This database is suitable since it fulfils the requirement of the data approach and clearly distinguishes between different types of UK companies. We included a total number of 1000 UK companies in which successful companies are of 2013 and 90 failed companies listed anytime over a period of 13 years (2000–2013). The reason for this selection is because it provides a wide range of time to generate enough data for the research. The financial data of these companies are classified under two distinct groups, namely, failed and non-failed companies. This approach is justified since it fulfils our empirical modelling of Altman (1968). Again, the selection of variables (ratios) is justified by their occurrence in the literature and their significance in predicting failure from the study of Altman (1968). However, due the limitation of data, the calculations of some ratios were not possible for all companies. For this rationale, they were excluded from the final sample. Key variables (ratios) from part of Altman's Z-score model were considered, for instance, there was a need to consider data items that are used to calculate the formulae $Z = XT1 + XT2 + XT3 + XT4 + XT5$. This made it possible to identify companies that were in different categories of the Z-score, i.e. successful, failed and grey area companies. The following results were arrived at.

Table 2
F-test summary for J-UK model.

Ratios	Wilks' lambda	F	Sig.
J1	.987	73.223	.000
J2	.993	40.600	.000
J3	.994	31.149	.000
J4	.999	3.187	.074
J5	.997	14.807	.000
J6 (cash flow)	1.000	.230	.631

Table 3

Wilks' lambda for Altman UK model.

Test of function(s)	Wilks' lambda	Chi-square	Sig.
1	.995	54.517	.000

Table 4

Wilks' lambda for J-UK model.

Test of function(s)	Wilks' lambda	Chi-square	Sig.
1	.983	93.240	.000

4. Empirical results

This section starts by pre-testing the individual ratios of Altman original Z-score model. Later on, the study includes a sixth ratio, therefore, extending the Z-score model to a J-UK model and finally performs some validation tests on the J-UK model.

4.1. Pre-modelling or univariate analysis

Adhering to the testing sequence of Altman (1968), the first test would be to test for the discriminating ability of the ratios on an individual basis. This is done by performing an analysis of variance (ANOVA) F-test. The F-test allows for a test of the equality of variances. After testing the ability of individual ratios of the original Z-score model in UK companies using F-test, our result shows that there is an extremely significant difference between the groups for variables X1, X2, X4 and X5, while variable X3 does not show a significant difference between these groups. This analysis can be seen in Table 1.

Whereby:

- X1 = Working capital/total assets
- X2 = Retained earnings/total assets
- X3 = Earnings before interest and tax (EBIT)/total assets
- X4 = Market value equity/total liabilities
- X5 = Sales/total assets

As can be observed from Table 1, the results of Altman's original ratios indicate that, X1, X2, X4 and X5 are statistically significant at a 5% confidence interval, whereas ratio X3, with a p-value of 0.395 is not significant at a 10% confidence level. These results indicate that, there is a significant difference between the two groups. Therefore, the original Z-score model identified Sales/TA (X5) as "not significant" in this context. In contrast, when applied to UK companies, we observed that EBIT (X3) was "less significant" in UK companies. Furthermore, based on the values from Table 1, the null hypothesis of equal means is rejected at a 5% significance level for the variables X1, X2, X4 and X5, whereas the null is not rejected for X3.

From the above analysis, Z-score variables can be improved upon by adding new variables to test the ability of ratios to predict the financial health of UK companies. After conducting the F-test by including a sixth variable-cash flow (J6), our results show that, the additional ratios affect the Altman's original ratios and make it more significant at 10% confidence level, while the market value of equity/total liabilities (J4) is significant at .074 which is more than 0.5 p-values. In the individual test, J6 is not at all significant due to the limitation in data for failed companies. However, cash flow (J6) has a positive impact on the other five ratios of Altman's original Z-score variables. The result of the F-test is presented in the following Table 2.

Table 5

Predictive power of Altman UK model.

Classification results ^a					
		Failed–not failed	Predicted group membership		Total
			Failed	Not Failed	
Original	Count	Failed	473	307	780
		Not failed	4723	5537	10,260
	%	Failed	60.6	39.4	100.0
		Not failed	46.0	54.0	100.0

^a 54.4% of original grouped cases correctly classified.

Table 6

Predictive power of J-UK model.

Classification results ^a					
			Predicted group membership		Total
			Failed	Not failed	
Original	Count	Failed	71	77	148
		Not failed	864	4476	5340
	%	Failed	48.0	52.0	100.0
		Not failed	16.2	83.8	100.0

^a 82.9% of original grouped cases correctly classified.

4.2. Discriminant analysis

As already mentioned in [Research methodology](#) section, one useful method in arriving to both significant and explanatory results is the multiple discriminate analyses. After performing the essential steps in the Statistical Package for Social Science ([Field, 2009](#)), the below presented equation reflects the model for the UK companies.

After performing all necessary steps, the following equation reflects the final J UK model.

$$ZJ = 1.484J1 + 0.043J2 + 0.390J3 + 0.004J4 + -.424J5 + 0.75J6$$

Where,

J1 = Working capital/total asset

J2 = Retained earnings/total assets

J3 = Earnings before interest and tax (EBIT)/total assets

J4 = Market value equity/total liabilities

J5 = Sales/total assets

J6 = Cash Flow from operations/total liabilities

After obtaining both F-test results, the overall significance of the discriminant model is further discussed. One frequent test statistics used in the multivariate analysis of variance is the Wilks' lambda, and it is a measure of the class centres separation as well as of the proportion of variance. If a small proportion of the variance is explained by the independent variable, then it can be advocated that there is no effect of the grouping variable (in this case the financial ratios) and the groups (in this case bankrupt and non-bankrupt) have no different mean values ([Klecka, 1980](#)). Furthermore, Wilks' lambda can be regarded as a multivariate generalization of the univariate F-distribution. The SPSS output for an MDA analysis already gives a summary output table for Wilks' lambda, which is presented below:

The value of Wilks' lambda is all the time a number between 0 and 1. Furthermore, the lower the value, the higher the model's ability to discriminate, thus more separation between the groups. The first column in the table shows the value of Wilks' lambda, which in this case is 0.995. This number represents the proportion of the total variability that is left unexplained ([Klecka, 1980](#)). Even though, at the first glance, this might seem a rather large number, it still shows that there is an effect of the grouping variable and that the groups have different mean values. Furthermore, it must be interpreted together the chi-square test with its corresponding degrees of freedom. Given the p-value of the chi-square test of 0.000, it can be concluded that the discriminant model is highly significant at a 5% significance level of the original variables of [Altman \(1968\)](#). Furthermore, after including cash flow as a sixth variable to the other ratios, we found out that the values of Wilks' lambda are .983 which is lower than .995 of the original [Altman \(1968\)](#) variables. This implies that $.983 < .995$, therefore .983 has a higher ability to discriminate between groups failed and non-failed ([Tables 3 and 4](#)). The following presents an analysis of the additional variable.

The final analysis is to test the predictive power of [Altman's \(1968\)](#) variables with UK companies, compared with J-UK model. Companies are classified between failed and non-failed groups. This can be seen from the following [Table 5](#).

From the above results in [Table 5](#), the percentage of correctly classified firms is 54.4%. Furthermore, the percentage of correctly classified failed companies is 60.6%, while the percentage of correctly classified non-failed companies is 54.0. When compared with the J UK model, we observed that the percentage of correctly classified firms is 82.9%. This can be seen in the following [Table 6](#) below:

In addition, we applied DA for the J UK model and Altman UK model before, during and after the recent financial crisis to see the predictive power for each period. This study found that there is a significant difference of the predictive power of both

models. J-UK model had a higher accuracy (64.1%) to predict the health of UK companies better than Altman's UK model (51.5%) before the crisis (2000–2006).

(See Table A, A1 in Appendix: Altman UK model before crisis classification results).

Moreover, when both models are computed during the crisis (i.e. 2007–2008), the study observed a more interesting result, J-UK model still performed well (79.2%) than Altman's UK model (67.4%).

(See Table B, B1 in Appendix: Altman UK model during crisis classification results).

Besides, after the crisis (2009–2013), our results show that J-UK model outperformed Altman's UK model by 81.2% as against 71.5%.

(See Table C, C1 in Appendix: Altman UK model after crisis classification results).

Overall, an average of 11.37% of J-UK model is observed accurate to Altman's UK model. Therefore, this study concludes that, J-UK model is more accurate in predicting failed and non-failed general UK companies before, during and after the financial crisis. This result is consistent with those of [Teti et al. \(2013\)](#) who found a significant decrease in the discriminant score during the crisis in relation to the effects of the financial crisis in the medium, rather than short term. Similar findings on the effect of the crisis on the performance of financial ratios can be seen from [Fahlenbrach et al. \(2012\)](#) and [Dietrich and Wanzenried \(2011\)](#).

However, the Type I error significantly increased for J-UK model. This result is related to [Gutzeit and Yozzo \(2011a\)](#) who examined the performance of the Z-score model amid the Great Recession and noted that a high Type I error rate is achieved at the cost of high Type II error rate, while Type II accuracy can be improved by accepting more Type I accuracy rate.

Appendix A

Table A

Altman UK model before crisis classification results.

		Failed–not failed	Predicted group membership		Total
			Failed	Not failed	
Original	Count	Failed	384	296	680
		Not failed	1934	1988	3922
	%	Failed	56.5	43.5	100.0
		Not failed	49.3	50.7	100.0

51.5% of original grouped cases correctly classified.

Table A1

J-UK model before crisis classification results.

		Failed-not failed	Predicted group membership		Total
			Failed	Not failed	
Original	Count	Failed	22	8	30
		Not failed	153	266	419
	%	Failed	73.3	26.7	100.0
		Not failed	36.5	63.5	100.0

64.1% of original grouped cases correctly classified.

Table B

Altman UK model during crisis classification results.

Classification results ^a					
		Failed–not failed	Predicted group membership		Total
			Failed	Not failed	
Original	Count	Failed	87	61	148
		Not failed	572	1221	1793
	%	Failed	58.8	41.2	100.0
		Not failed	31.9	68.1	100.0

^a 67.4% of original grouped cases correctly classified.

Table B1

J-UK model during crisis classification results.

Classification results ^a					
		Failed-not failed	Predicted group membership		Total
			Failed	Not failed	
Original	Count	Failed	28	40	68
		Not failed	226	985	1211
	%	Failed	41.2	58.8	100.0
		Not failed	18.7	81.3	100.0

^a 79.2% of original grouped cases correctly classified.**Table C**

Altman UK model after crisis classification results.

		Failed-not failed	Predicted group membership		Total
			Failed	Not failed	
Original	Count	Failed	66	81	147
		Not failed	1256	3290	4546
	%	Failed	44.9	55.1	100.0
		Not failed	27.6	72.4	100.0

71.5% of original grouped cases correctly classified.

Table C1

J-UK model after crisis classification results.

			Predicted group membership		
			Failed	Not failed	Total
Original	Count	Failed	40	73	113
		Not failed	646	3064	3710
	%	Failed	35.4	64.6	100.0
		Not failed	17.4	82.6	100.0

81.2% of original grouped cases correctly classified.

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