

Application of the Z -Score Model with Consideration of Total Assets Volatility in Predicting Corporate Financial Failures from 2000-2010

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This study re-examines the accuracy of the original Z-score model in predicting corporate failures in the U.S. from 2000-2010. It also explores whether asset volatility substantiates the Z-score in predicting bankruptcies. The results show that the original Z-score model is valuable in predicting corporate financial stress for both manufacturing and non-manufacturing firms. It also finds total asset volatility might be a missing variable from the original model when predicting financial distress of manufacturing firms. Other results imply that stakeholders would further benefit from observing a company's financial status for a period longer than one or two years.

INTRODUCTION

The recent financial crisis has pushed the U.S. economy into its most severe recession since the Great Depression. Many U.S. companies have filed for bankruptcy in recent years. Company failures negatively affect stakeholders including stockholders, creditors, customers, suppliers, and employees. If stakeholders know that a bankruptcy may occur in the next year or two, they will be better prepared to protect their own interests.

Beaver (1966) and Altman (1968) developed the “Z-score” to predict the financial failures of companies. To test the accuracy of the model, Altman calculated the Z-score for groups of bankrupt and non-bankrupt firms. He found that about 95% of the bankrupt firms were correctly classified as bankrupt and roughly 80% of non-bankrupt firms were correctly classified as such.

The original Z-score model has drawn several statistical objections over the years because of its use of unadjusted accounting data, data from relatively small firms, and old data. Despite such concerns, the original Z-score model is the best-known and most widely used financial distress test. The Z - score measures how closely a firm resembles other firms that have filed for bankruptcy. It is a measure of corporate financial distress or economic bankruptcy.

The primary objective of our study is to re-examine the accuracy of the original Z-score in predicting corporate failures in the U.S. from 2000-2010. We examined the Z-score of the public companies using financial data from one, two, and averages of three and five years prior to filing for bankruptcy. The results would show which year(s) and/or averages of the Z-score is a superior predictor of financial failure

in helping stakeholders to determine when they should begin tracking financial performances of companies.

A study by Hillegeist et al (2004) has indicated that Altman's model is deficient and fails to include a measure of asset volatility. Consideration of such volatility is important because it measures the probabilities that the value of a firm's assets decline to an extent that it is unable to pay its debts. To address this deficiency, we explore whether asset volatility corroborates with Z - score in predicting bankruptcies.

The remainder of this paper includes a review of the related literature, methodology and predicted results, and conclusions and implications of the study.

RELATED LITERATURE

Using a univariate, discriminate analysis, Beaver (1966) was able to predict business distress. Altman (1968) extended Beaver's approach and developed a model that combines five ratios to derive a "Z-score." The developed model, which outperformed Beaver's approach in bankruptcy prediction, especially for manufacturing companies, is:

$$Z = 1.2X_1 + 1.4X_2 + 3.3X_3 + 0.6X_4 + .999X_5$$

Where,

X_1 = Working Capital / Total Assets

X_2 = Retained Earnings / Total Assets

X_3 = Earnings Before Interest and Taxes / Total Assets

X_4 = Market Value of Equity / Total Liabilities

X_5 = Sales/ Total Assets

Altman's original model predicts that firms with Z-scores above 3 are unlikely to file for bankruptcy. Firms with Z - scores below 1.81 are likely to fail. Z-scores between 3 and 1.81 are considered "grey" area.

Numerous studies have documented evidence of the effectiveness of Altman's Z - score in predicting corporate financial distress (e.g., more recently, Wang & Campbell 2010, Lugovskaya 2010, Gerantonis, et. al 2009, Xu & Zhang 2009). However, Altman's model is not without criticisms. Gharghori et al. (2006) and Hillegeist et al. (2004) argue that the Altman's model comprises different measures of accounting variables that are derived from the financial statements. By nature, the financial statements are backward looking and may not provide predictive value for an entity's future. The same critics also argue the financial statements are prepared with a going concern assumption, in other words, companies are assumed not to file bankruptcy. These characteristics are inconsistent with the forward-looking measure and thus limit the effectiveness of Altman's model and any other accounting-based models in predicting corporate failure.

According to Hillegeist et al. (2004), another deficiency of Altman's model is its failure to include a measure of asset volatility. Such volatility is important because it measures the probabilities that the value of a firm's assets decline to an extent that it is unable to pay its debts. In addition, Begley et. al (1996) indicate that the Altman's Z-score model provides a more accurate prediction for U.S. companies in certain periods than others. Likewise, Grice and Ingram (2001) find that the Z-score performs better with manufacturing companies than with companies in other industries.

In evaluating the performance of different default-risk models, Gharghori et al. (2006) find the option-based models outperform the accounting ratio models. Similarly, Black-Scholes-Merton option-pricing model is found to be superior to accounting-based measures in bankruptcy prediction (Hillegeist et al. 2004). However, there is evidence that a hybrid approach, which combines a market-based model and an accounting-based model (e.g. Altman's), provides better bankruptcy prediction than either model

alone. A market-based model is found to be significant in predicting default of companies with high credit risk, while the accounting-based model is significant in default prediction of those with low credit risk. Thus based on a company's credit risk, the prediction accuracy can be improved by placing more (less) emphasis on the market-based model while reducing (increasing) the emphasis on the accounting-based model (Li & Miu 2010). This is consistent with the finding of Das (2009) that a model incorporates both accounting-based information and market-based information outperforms either model. A hybrid model appears to be also useful in predicting the bankruptcy of Japanese listed companies (Xu and Zhang 2009).

METHODOLOGY

Our sample consists of all publicly traded companies that filed for Chapter 11 and Chapter 7 bankruptcies in the U.S. between 2000 and 2010. Data was obtained from two sources: COMPUSTAT and BankruptcyData.com. There were 294 companies in COMPUSTAT and 118 in BankruptcyData.com filing for Chapter 11 and Chapter 7 bankruptcies; respectively. We extracted the Z - score for all 412 firms from the COMPUSTAT and eliminated firms with incomplete or missing Z-scores. The final sample contained 252 firms.

To check the accuracy of Z-score in predicting financial stress, we employed one, two and averages of three and five years Z-scores prior to each firm filing for bankruptcy. The analysis of these Z-scores identifies which one is a superior predictor of financial failure.

The original Z-score model was developed to predict bankruptcy of the publicly held manufacturing companies. To re-examine whether Z-score predictions differ among different industries, the sample was divided into manufacturing and non-manufacturing companies. For each group, we calculated the average Z-score and compared the prediction outcomes. To study the strength of the Z-score predictions under different economic conditions, we investigated the accuracy of bankruptcy predictions each year.

To address the failure of the Altman's model to include a measure of asset volatility, we calculated a coefficient of variation for each firm to measure its total asset volatility. We anticipate firms with high coefficients of variations to have a Z-score closer to bankruptcy level

PREDICTION RESULTS

Table 1 Panel A presents the aggregated Z-score prediction results for all companies filing for bankruptcy during 2000-2010. To see if the prediction outcomes differ among different industries, Panels B and C show Z-score predictions for manufacturing and non-manufacturing firms. Furthermore, Table 2 includes Z-score predictions for companies filing either for Chapter 11 or for Chapter 7 bankruptcies (The complete prediction results appear on Appendices A and B).

The data reported in Table 1 Panel A are one, two, and averages of three and five year Z-score predictions prior to filing for bankruptcies. They disclose accurate (a), inaccurate (i), and gray area (g) predictions of failures. The results reveal that out of 252 firms, the number and percentage of accurate bankruptcy predictions applying one and two-year z-scores are 156 (61.90%) and 171 (67.86%); respectively, while accurate prediction by averages of three and five-year are 178 (70.63%), and 194 (76.98%). These estimates imply that observations of financial performances over a longer period (i.e., 5-year) could lead to better predictions of financial distress than a shorter period like one or two years.

Consistent with the results from Panel A, the estimated Z-score data in Table 1 Panels B and C for manufacturing and non-manufacturing firms show the average five-year Z-score provides a superior prediction of company failures than the other Z-scores in the table. In addition, the Z-score predictions for non-manufacturing firms are as valid as those for manufacturing firms. The average three and five-year Z-scores provide nearly equal accurate bankruptcy prediction rates for manufacturing and non-manufacturing firms (70.33%, 70.81% and 75.82, 77.64%). Except for the two year prediction for manufacturing firms, the one and two year prediction rates are noticeably lower than those for averages of three and five years.

TABLE 1
SUMMARY Z-SCORE PREDICTIONS OF COMPANIES FILING CHAPTER 11
AND CHAPTER 7 BANKRUPTCIES DURING 2000-2010

Panel A								
<u>Z - Score Predictions All Firms</u>								
<u>Year</u>	<u>Firms</u>	<u>Prior 1st yr</u>		<u>Prior 2nd yr</u>		<u>Ave 3-yr</u>		<u>Ave 5-yr</u>
2000	252	156-a	61.90%	171-a	67.86%	178-a	70.63%	194-a 76.98%
-2010		51-i	20.24%	48-i	19.05%	46-i	18.25%	36-i 14.29%
		45-g	17.86%	33-g	13.09%	28-g	11.12%	22-g 8.73%
Panel B								
<u>Z - Score Predictions Manufacturing Firms</u>								
<u>Year</u>	<u>Firms</u>	<u>Prior 1st yr</u>		<u>Prior 2nd yr</u>		<u>Ave 3-yr</u>		<u>Ave 5-yr</u>
2000	91	59-a	64.84%	64-a	70.33%	64-a	70.33%	69-a 75.82%
-2010		15-i	16.48%	11-i	12.09%	14-i	15.39%	12-i 13.19%
		17-g	18.68%	16-g	17.58%	13-g	14.28%	10-g 10.99%
Panel C								
<u>Z - Score Predictions Non-Manufacturing</u>								
<u>Year</u>	<u>Firms</u>	<u>Prior 1st yr</u>		<u>Prior 2nd yr</u>		<u>Ave 3-yr</u>		<u>Ave 5-yr</u>
2000	161	97-a	60.25%	107-a	66.46%	114-a	70.81%	125-a 77.64%
-2010		36-i	22.36%	37-i	22.98%	32-i	19.87%	24-i 14.91%
		28-g	17.39%	17-g	10.56%	15-g	9.32%	12-g 7.45%

Note: "a" represents accurate bankruptcy prediction, "i" denotes inaccurate prediction and "g" is "grey" zone of Z - score prediction. Complete prediction results appear on Appendices A and B.

Table 2 presents Chapter 11 and Chapter 7 Z- score bankruptcy predictions during 2000-2010. As shown in Panel A, for the 219 firms filing for Chapter 11, the average five-year Z-score accurate bankruptcy prediction rate is 77% which is the highest among Z-score accuracy prediction rates reported in the table. Furthermore, inaccurate prediction rates are also lower for average 5-year Z-score than those for others.

TABLE 2
SUMMARY Z-SCORE PREDICTIONS OF COMPANIES FILING CHAPTER 11
AND/OR CHAPTER 7 BANKRUPTCIES DURING 2000-2010

Panel A								
<u>Z - Score Predictions Chapter 11</u>								
<u>Year</u>	<u>Firms</u>	<u>Prior 1st yr</u>		<u>Prior 2nd yr</u>		<u>Ave 3-yr</u>		<u>Ave 5-yr</u>
2000	219	136-a	62.10%	148-a	67.58%	158-a	72.15%	169-a 77.17%
-2010		41-i	18.72%	42-i	19.18%	37-i	16.90%	31-i 14.15%
		42-g	19.18%	29-g	13.24%	24-g	10.95%	19-g 8.68%
Panel B								
<u>Z - Score Predictions Chapter 7</u>								
<u>Year</u>	<u>Firms</u>	<u>Prior 1st yr</u>		<u>Prior 2nd yr</u>		<u>Ave 3-yr</u>		<u>Ave 5-yr</u>
2000	33	20-a	60.61%	23-a	69.70%	20-a	60.61%	25-a 75.76%
-2010		10-i	30.30%	6-i	18.18%	9-i	27.27%	5-i 15.15%
		3-g	9.09%	4-g	12.12%	4-g	12.12%	3-g 9.09%

Note: "a" represents accurate bankruptcy prediction, "i" denotes inaccurate prediction and "g" is "grey" zone of Z - score prediction. Complete prediction results appear in Appendices A & B

As shown under Panel B in Table 2, for the 33 firms filing for Chapter 7, the average five-year Z-score provides the highest accuracy prediction rate (76%) and the lowest inaccurate prediction rate (15%). These results are consistent with those for firms that filed Chapter 11 bankruptcies.

To address asset volatility and corporate bankruptcy, we calculated a coefficient of variations for all firms that the Z-score accurately predicted their failures. We assume that if asset volatility is a missing variable from the Altman's model, the volatility measured by a coefficient of variations and Z-score bankruptcy predictions somehow has to be correlated.

TABLE 3
BANKRUPTCY PREDICTIONS USING THREE AND FIVE-YEAR Z-SCORE, TOTAL ASSET VOLATILITY AND CORRELATIONS FOR MANUFACTURING AND NON-MANUFACTURING COMPANIES FILING FOR CHAPTER 11 DURING 2000-2010

Panel A: Bankruptcy Prediction of Manufacturing Companies							
Year	No.	3-Yr Z	%	CV	5-Yr Z	%	CV
2010	00		----	----	00	----	----
2009	12	8-a	67	0.189	9-a	75	0.315
2008	6	5-a	83	0.680	6-a	100	0.50
2007	3	3-a	83	0.190	3-a	100	0.454
2006	22	19-a	86	0.251	17-a	77	0.430
2005	4	3-a	75	0.114	3-a	75	0.339
2004	2	2-i	----	0.568	2-i	----	0.661
2003	11	6-a	55	0.497	9-a	82	0.470
2002	7	6-a	86	0.270	6-a	86	0.254
2001	2	1-a	50	0.120	1-a	50	0.176
2000	8	5-a	63	0.379	6-a	75	0.390
Correlation:			.08			0.75	
Panel B: Bankruptcy Prediction of Non-Manufacturing Companies							
Year	No.	3-Yr Z	%	CV	5-Yr Z	%	CV
2010	2	2-a	100	0.278	2-a	100	0.354
2009	18	12-a	67	0.305	13-a	72	0.354
2008	11	7-a	64	0.314	9-a	82	0.391
2007	7	3-a	43	0.142	3-a	43	0.337
2006	36	27-a	75	0.382	29-a	80	0.562
2005	9	6-a	67	0.397	6-a	67	0.436
2004	8	6-a	75	0.281	6-a	75	0.360
2003	11	9-a	82	0.192	9-a	82	0.265
2002	13	12-a	93	0.390	12-a	93	0.415
2001	15	11-a	74	0.255	11-a	74	0.245
2000	12	7-a	58	0.335	9-a	75	0.418
Correlation:		0.30			0.11		

Note: "No." is the number of companies whose bankruptcies were accurately predicted applying three and five-year Z-scores. "3-YrZ", "5-YrZ", and % are the numbers and percentages of accurate bankruptcy predictions. CV is the averages of coefficient of variations of total assets of firms whose bankruptcies were accurately predicted each year. Correlation figures show the relationship between percentages of accurate bankruptcy predictions and the total asset risk measured by the CV.

Table 3 includes three and five-year Z-score accurate numbers and percentages predictions of Chapter 11 manufacturing and non-manufacturing firms. It also includes total assets volatility (risk) measured by a coefficient of variations (CV). In addition, correlations between percent of accurate predications and risks (CV) are presented in the table.

As indicated in Table 3 Panel A, the correlation between percentages of accurate bankruptcy predictions using average three-year Z-score and total asset risk is 0.08 for manufacturing firms, while the correlation using average 5-year Z-score is 0.75. Under Panel B, for non-manufacturing firms, the correlations figures are 0.30 and 0.11, respectively. These correlations numbers imply that total asset volatility might be a missing variable when using the average five-year Z-score and the original model to predict bankruptcy for manufacturing firms. However, for non-manufacturing firms, three-year average Z-score and total asset risks have higher correlations.

CONCLUSIONS & IMPLICATIONS

This study examines the accuracy of Z-score in predicting corporate filings for Chapter 11 reorganizations and Chapter 7 liquidations. Although the original Z-score was developed for manufacturing firms, we find it performs equally well in predicting bankruptcy for non-manufacturing companies. We also find that both the 3-year average and the 5-year average Z-scores predict bankruptcy better than one and two year Z-scores prior to bankruptcy years. In almost all cases, the average 5-year Z-score is superior in predicting financial distress over one, two, and average of 3-year Z-scores. In addition, total asset volatility is a more important variable when using the Z-score model to predict bankruptcy for manufacturing firms than for non-manufacturing firms.

Our overall conclusion is that the original Z-score model is still valuable in predicting corporate financial stress for both manufacturing and non-manufacturing firms. The total asset volatility might be a missing variable for the model when predicting financial distress of manufacturing firms. Our findings also imply that stakeholders would benefit further from observing company financial status for a period longer than one or two years.

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APPLENDIX A
ANNUAL ONE AND TWO YEAR Z-SCORE PREDICTION OF MANUFACTURING AND
NON-MANUFACTURING COMPANIES FILING CHAPTER 11 BANKRUPTCY
DURING 2000-2010

<u>Z-Score Prediction</u>						
<u>Year</u>	<u>Manufacturing Companies</u>			<u>Non-Manufacturing Companies</u>		
	<u>No.</u>	<u>Prior 1st yr</u>	<u>Prior 2nd yr</u>	<u>No.</u>	<u>Prior 1st yr</u>	<u>Prior 2nd yr</u>
2010	0	---	---	2	1-a	2-a
		---	---		1-r	---
		---	---		---	---
2009	12	7-a	8-a	18	9-a	13-a
		1-r	2-r	---	5-r	3-r
		4-g	2-g	---	4- g	2-g
2008	6	5-a	4-a	11	6-a	7-a
		1-r	1-r		2-r	3-r
		---	1-g		3-g	1-g
2007	3	3-a	2-a	7	2-a	2-a
		---	---		4-r	5-r
		---	1-g		1-g	---
2006	22	17-a	18-a	36	23-a	23-a
		2-r	2-r		10-r	8-r
		3-g	2-g		3-g	5-g
2005	4	3-a	3-a	9	5-a	5-a
		1-r	1-r		2-r	2-r
		---	---		2-g	2-g
2004	2	2-a	2-a	8	6-a	6-a
		---	---		2-r	2-r
		---	---		---	---
2003	11	5-a	5-a	11	7-a	8-a
		3-r	3-r		2-r	2-r
		3-g	3-g		2-g	1-g
2002	7	5-a	7-a	13	11-a	12-a
		1-r	---		---	1-r
		1-g	---		2-g	---
2001	2	1-a	---	15	8-a	9-a
		---	---		2-r	5-r
		1-g	2-g		5-g	1-g
2000	8	4-a	6-a	12	6-a	6-a
		1-r	---		1-r	2-r
		3-g	2-g		5-g	4-g

Note: No. is the number of companies in each category filing for bankruptcy; a represents accurate prediction, r denotes wrong prediction and g is "grey" zone of Z-score predictions.

APPENDIX B
ANNUAL THREE & FIVE YEAR AVERAGE Z-SCORE PREDICTION OF MANUFACTURING
AND NON-MANUFACTURING COMPANIES FILING CHAPTER 11
BANKRUPTCY DURING 2000-2010

<u>Year</u>	<u>Z-Score Prediction</u>					
	<u>Manufacturing Companies</u>			<u>Non-Manufacturing Companies</u>		
	<u>No.</u>	<u>Ave 3-yr Z</u>	<u>Ave 5-yr Z</u>	<u>No.</u>	<u>Aver 3-yr Z</u>	<u>Ave 5-yr Z</u>
2010	0	---	---	2	2-a	2-a
2009	12	8-a	9-a	18	12-a	13-a
		2-r	2-r		5-r	4-r
		2-g	1-g		1-g	1-g
2008	6	5-a	6-a	11	7-a	9-a
		1-r	---		3-r	2-r
					1-g	---
2007	3	3-a	3-a	7	3-a	3-a
					4-r	4-r
2006	22	19-a	17-a	36	27-a	29-a
		2-r	2-r		6-r	6-r
		1-g	3-g		3-g	1-g
2005	4	3-a	3-a	9	6-a	6-a
		1-r	1-r		2-r	2-r
					1-m	1-g
2004	2	2-r	2-r	8	6-a	6-a
					2-r	1-r
					---	1-g
2003	11	6-a	9-a	11	9-a	9-a
		2-r	1-r		2-r	1-r
		3-g	1-g		---	1-g
2002	7	6-a	6-a	13	12-a	12-a
		1-g	1-g		1-g	1-g
2001	2	1-a	1-a	15	11-a	11-a
		1-g	1-g		1-r	2-r
2000	8	5-a	6-a	12	3-g	2-g
		1-r	---		7-a	9-a
		2-g	2-g		1-r	1-r
					4-g	2-g

Note: No. is the number of companies in each category filing for bankruptcy; a represents accurate prediction, r denotes wrong prediction and g is "grey" zone of Z-score predictions.