Prediction of Corporate Bankruptcy from 2008 Through 2011

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This study examines the prediction of corporate failures in the U.S. during 2008-2011. Three prediction models are examined: Altman's original Z-Score model, a re-estimated Z-Score model and a re-estimated model with an added variable. Through a series of discriminate analyses, the model with only one ratio "Market value of equity/Total liabilities" appears to have the highest bankruptcy predicting power. This lends support to the assertion of the superiority of market-based models in bankruptcy prediction to accounting-based models. Contrary to a popular criticism of the Z-Score model, total asset variability does not appear to be a significant factor for bankruptcy prediction. In addition, all models tend to have high type II error of mis-predicting a solvent firm as bankrupt.

INTRODUCTION

The 2008 financial crisis has pushed the U.S. economy into its most severe recession since the Great Depression. The financial failures of many companies have had a devastating impact on world economy. Company failures negatively affect stakeholders. Prediction of corporate bankruptcy is an important aspect for the protection of the stakeholders' interests.

Altman (1968) developed the "Z-Score" model to predict the financial failures of U.S. manufacturing firms. The 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 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. There is evidence that the Z-Score coefficients should be re-estimated for the prediction of corporate distress involving different time periods or different industries (Grice & Ingram 2001).

The primary objective of this study is to test the accuracy of corporate failures prediction in the U.S. from 2008-2011using three models: Altman's original model, a re-estimated model and a re-estimated model with an added variable. Z-Scores of the publicly held companies from these models are examined using financial data from one and two years prior to bankruptcy. The results would show which version of a model is superior in bankruptcy prediction.

The remainder of this paper includes the following sections. Literature review is followed by methodology and study results. Conclusions and implications are in the last section.

RELATED LITERATURE REVIEW

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

The critical value from the model is 2.675. Firms with Z-Scores above 2.675 are unlikely to file for bankruptcy. Firms with Z - Scores below 2.675 are likely to fail.

Numerous studies have documented evidence of the effectiveness of Altman's Z - Score in predicting corporate financial distress (e.g., more recently, Li & Rahgozar (2012), Satish & Janakiram (2011), Al Zaabi (2011), Gutzeit & Yozzo (2011), 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. Only one (X_4 = Market Value of Equity / Total Liabilities) of the five variables in Altman's original model is market-based and "forward looking" (Gutzeit & Yozzo 2011). These characteristics limit the effectiveness of Altman's model and any other accounting-based models in predicting corporate failure. The results of this research will provide support for the superiority of the market-based models.

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 that 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

Despite the various techniques for bankruptcy predictions, Altman's Z-Score model remains to be the most extensively used and researched method. This study, therefore, focuses on Altman's model. In addition, this study follows the first three of four steps in the development of bankruptcy prediction models identified by Altman et al. (1981): 1. Analyze bankrupt and solvent firms to identify most dissimilar financial characteristics between the groups before bankruptcy, 2. Reclassify the original sample using the financial characteristics, and 3. Test the model's predictive ability in a holdout sample. Altman's 4th step in bankruptcy prediction models is to use the model to predict future bankruptcies.

The sample in this research consists of all publicly traded companies that filed for Chapter 11 and Chapter 7 bankruptcies in the U.S. between 2008 and first quarter of 2011. Those companies were identified from two sources: COMPUSTAT and BankruptcyData.com. There were 106 companies and 66 companies that filed for Chapter 11 and Chapter 7 bankruptcies; respectively. Data were extracted for all 172 companies from COMPUSTAT and firms with incomplete or missing data were eliminated. The final sample size is 70.

A matched pair process is used in the study. For each bankrupt firm, a solvent firm in the same industry and of the closest asset size in the bankruptcy year was identified. For each bankrupt and matching solvent firms, the financial data were collected from COMPUSTAT one and two years prior to bankruptcy. A random sample of 20 out of the 70 bankrupt firms and their matched solvent firms were selected to test the accuracy of each model (prediction group). The remaining 50 bankrupt firms and their solvent counterparts were used as the "estimation group".

To examine Altman's original Z-Score model in predicting financial stress, the Z scores from one and two years prior to bankruptcy years were obtained from COMPUSTAT for each bankrupt and its matched solvent firm (Altman's original model). In response to the issue of whether Z-Score model should be revised for bankruptcy prediction involving both manufacturing and non-manufacturing firms in different time periods, Altman original model's coefficients were re-estimated using the estimation group (re-estimated model) and then tested for accuracy using the prediction group. In addition, to address the failure of the Altman's model to include a measure of asset volatility, a new variable was added (X_6) to the re-estimated model. The new variable is calculated as "(total assets one year prior to bankruptcy – total assets two years prior to bankruptcy)/ total assets two years prior to bankruptcy". A series of discriminate analyses were performed, including step-wise method, for the re-estimated model and the re-estimated model with the add variable.

STUDY RESULTS

Descriptive Statistics of Variables

F tests using data from one and two years prior to bankruptcy are performed to test the individual variables' discriminating powers. Table 1 shows that, except for the results using prior 2nd prediction group data, variable X_4 is the only one that is significant at 0.05 level using all other years' group data. For the same years, X_4 has the highest F statistics than other variables do. These indicate a significant difference between bankrupt and solvent groups in X_4 (Market Value of Equity / Total Liabilities). Surprisingly, contrary to prior expectations, all tests results indicate no significant difference in X_6 , an indicator of asset variability.

TABLE 1
VARIABLE MEANS & TEST OF SIGNIFICANCE

Prior 1st Year Estimation Group Variables	Bankrupt Group Mean	Solvent Group Mean	F Ratio
X_1	-1.0956	-0.0693	3.961*
X_2	-5.9347	-80.8748	0.949
X_3	-0.3975	-0.6163	0.344
X_4	0.8081	13.9844	5.607*
X_5	1.1163	1.1242	0.002
X_6	-0.1639	0.0307	3.525
Prior 1st Year Prediction Group Variables			
X_1	-30.9939	-6.0538	0.665
X_2	-291.4793	-56.3940	0.757
X_3	-1.4376	-2.4579	0.166
X_4	0.6761	8.3267	4.485*
X_5	1.1512	1.0008	0.131
X_6	-0.1781	-0.1170	0.230
Prior 2nd Year Estimation Group Variables			
X_1	-0.0068	-0.0277	0.007
X_2	-1.9856	-3.2856	0.580
X_3	-0.1222	-0.1881	0.148
X_4	1.6830	11.0384	7.066*
X_5	1.1382	0.9810	0.444
X_6	0.1630	0.2454	0.300
Prior 2nd Year Prediction Group Variables			
X_1	-42.8049	-0.0448	1.025
X_2	-289.8170	-61.1858	0.650
X_3	-2.5652	-0.4325	1.850
X_4	2.7843	9.4255	1.744
X_5	0.9342	1.4153	1.524
X_6	0.3344	0.1212	0.394

*Significant at 0.05 level

PREDICTION RESULTS

Altman's Original Model

Table 2 depicts the accuracy of Altman's original model in predicting bankruptcy for 2008 through 2011. Z scores are gathered from COMPUSTAT. Consistent with prior research, Altman's original model performs well in predicting bankrupt firms, with accuracy rates ranging from 80% to 94% and with better prediction from one year prior to bankruptcy. The model, however, tends to mis-predict solvent firms as bankrupt with types II error ranging from 46% to 56%.

TABLE 2
SUMMARY Z – SCORE BANKRUPTCY PREDICTIONS
USING ALTMAN'S ORIGINAL MODEL

One Year Prior To Bankruptcy	Predicted Group Membership Bankrupt	Solvent	Total	Accuracy Rate	Type I Error	Type II Error
Actual Group Membership						
Estimation Group						
Bankrupt	47	3	50	94%	6%	
Solvent	28	22	50	44%		56%
Prediction Group						
Bankrupt	18	2	20	90%	10%	
Solvent	11	9	20	45%		55%

2nd Year Prior To Bankruptcy	Predicted Group Membership Bankrupt	Solvent	Total	Accuracy Rate	Type I Error	Type II Error
Actual Group Membership						
Estimation Group						
Bankrupt	40	10	50	80%	20%	
Solvent	23	27	50	54%		46%
Prediction Group						
Bankrupt	17	3	20	85%	15%	
Solvent	10	10	20	50%		50%

Re-Estimated Model

Altman's model coefficients were re-estimated using estimation group and then tested for accuracy using the prediction group. Using the estimation group data from one year prior to bankruptcy, the discriminate analysis produced the following model: $Z = 0.340X_1 - 0.002X_2 + 0.003X_3 + 0.022X_4 + 0.027X_5 - 0.075$.

As depicted in Table 3, the results are mixed. The re-estimated model accurately predicts 70% of bankrupt firms for one year prior to bankruptcy, with accuracy of 100% using the prediction group data. The same model produced 72% accuracy rate for classifying solvent firms. This is higher than the prediction results produced by Altman's original model. However, when using prediction group data, the accuracy rate dropped to 35%. Using data from two years prior to bankruptcy, the re-estimated model correctly predicted 92% of bankrupt firms and 75% using the prediction group data. Similar to Altman's original model results, the prediction power for solvent firms is less than ideal with type II error of 68% and 55% for estimation and prediction groups, respectively.

TABLE 3
SUMMARY Z – SCORE BANKRUPTCY PREDICTIONS
USING RE-ESTIMATED MODEL

One Year Prior To Bankruptcy	Predicted Group Membership Bankrupt	Solvent	Total	Accuracy Rate	Type I Error	Type II Error
Actual Group Membership						
Estimation Group						
Bankrupt	35	15	50	70%	30%	
Solvent	14	36	50	72%		28%
Prediction Group						
Bankrupt	20	0	20	100%	0	
Solvent	13	7	20	35%		65%

2nd Year Prior To Bankruptcy	Predicted Group Membership Bankrupt	Solvent	Total	Accuracy Rate	Type I Error	Type II Error
Actual Group Membership						
Estimation Group						
Bankrupt	46	4	50	92%	8%	
Solvent	34	16	50	32%		68%
Prediction Group						
Bankrupt	15	5	20	75%	25%	
Solvent	11	9	20	45%		55%

X_4 (Re-Estimated Step-Wise) Model

A multiple discriminate step-wise technique is applied to the re-estimated model which includes variables X_1 through X_5. The results (Table 4) is a model which contains only one variable X_4 (Market Value of Equity / Total Liabilities). Using the estimation group data from one year prior to bankruptcy, the model obtained is: $Z = 0.036X_4 - 0.266$. The critical value is 0 for this model. Firms with a Z score below 0 are predicted to be bankrupt. Those with a Z score above 0 are predicted to be solvent. The model derived from data two years prior to bankrupt is similar to the one with data from prior 1st year with the same critical value: $Z = 0.057X_4 - 0.361$.

The model predicts bankruptcy firms remarkably well with accuracy rate of 96% (94%) and 100% (90%) for estimation and prediction groups, respectively for one year prior to bankruptcy (two years prior to bankruptcy). These results are superior to those produced by Altman's original model and the re-estimated model. However, the model, like the two previous models, falls short on classifying solvent firms as such, with high type II errors ranging from 68% to 80% for the both years.

TABLE 4
SUMMARY Z – SCORE BANKRUPTCY PREDICTIONS
USING X_4 (RE-ESTIMATED STEP-WISE) MODEL

One Year Prior To Bankruptcy	Predicted Group Membership Bankrupt	Solvent	Total	Accuracy Rate	Type I Error	Type II Error
Actual Group Membership						
Estimation Group						
Bankrupt	48	2	50	96%	4%	
Solvent	37	13	50	26%		74%
Prediction Group						
Bankrupt	20	0	20	100%	0	
Solvent	14	6	20	30%		70%

2nd Year Prior To Bankruptcy	Predicted Group Membership Bankrupt	Solvent	Total	Accuracy Rate	Type I Error	Type II Error
Actual Group Membership						
Estimation Group						
Bankrupt	47	3	50	94%	6%	
Solvent	34	16	50	32%		68%
Prediction Group						
Bankrupt	18	2	20	90%	10%	
Solvent	16	4	20	20%		80%

Re-Estimated With X_6 Model

To address the issues of asset variability on bankruptcy prediction, a new variable (X_6 = "(total assets one year prior to bankruptcy – total assets two years prior to bankruptcy)/ total assets two years prior to bankruptcy" was added to the re-estimated model. The model obtained is: $Z = 0.301X_1 - 0.001X_2 - 0.109X_3 + 0.019X_4 - 0.048X_5 + 0.881X_6 + 0.031$.

As indicated in Table 5, the new variable X_6, surprisingly, does not appear to add bankruptcy prediction value to the model. Using estimation group data, the accuracy rates for the prediction of bankrupt firms are 78% and 86%, and 95% and 60% with the prediction group. Similar to the other models, this model has high type II error ranging from 36% to 66%.

TABLE 5
SUMMARY Z – SCORE BANKRUPTCY PREDICTIONS
USING RE-ESTIMATED WITH X_6 MODEL

One Year Prior To Bankruptcy	Predicted Group Membership Bankrupt	Solvent	Total	Accuracy Rate	Type I Error	Type II Error
Actual Group Membership						
Estimation Group						
Bankrupt	39	11	50	78%	22%	
Solvent	18	32	50	64%		36%
Prediction Group						
Bankrupt	19	1	20	95%	5%	
Solvent	12	8	20	40%		60%

2^{nd} Year Prior To Bankruptcy	Predicted Group Membership Bankrupt	Solvent	Total	Accuracy Rate	Type I Error	Type II Error
Actual Group Membership						
Estimation Group						
Bankrupt	43	7	50	86%	14%	
Solvent	33	17	50	34%		66%
Prediction Group						
Bankrupt	12	8	20	60%	40%	
Solvent	9	11	20	55%		45%

X_4 & X_6 Model

A discriminate analysis step-wise approach produced a model with two significant variables: $Z = 0.029X_4 + 1.297X_6 - 0.13$. As disclosed in Table 6, the model performs well in predicting bankrupt firms with accuracy rate of ranging from 85% to 100% from one and two years prior to bankruptcy. However, these results are not as good as the model with X_4 only. With estimation group data from two year prior to bankruptcy, X_4 is the only significant ratio in the model. This appears to solidify the bankruptcy prediction power of a model consisting of only the ratio X_4. Consistent with the results from the last model, X_6, the measure for asset variability in this study, does not appear to increase a model's bankruptcy prediction power.

TABLE 6
SUMMARY Z – SCORE BANKRUPTCY PREDICTIONS
USING X_4 & X_6 MODEL

One Year Prior To Bankruptcy	Predicted Group Membership Bankrupt	Solvent	Total	Accuracy Rate	Type I Error	Type II Error
Actual Group Membership						
Estimation Group						
Bankrupt	46	4	50	92%	8%	
Solvent	26	24	50	48%		52%
Prediction Group						
Bankrupt	20	0	20	100%	0	
Solvent	14	6	20	30%		70%

2nd Year Prior To Bankruptcy	Predicted Group Membership Bankrupt	Solvent	Total	Accuracy Rate	Type I Error	Type II Error
Actual Group Membership						
Estimation Group						
Bankrupt*	47	3	50	94%	6%	
Solvent	34	16	50	32%		68%
Prediction Group						
Bankrupt	17	3	20	85%	15%	
Solvent	14	6	20	30%		70%

* X4 is the only variable from the Step-wise procedure

CONCLUSIONS & IMPLICATIONS

This study examines the accuracy of various Z-Score models in predicting corporate bankruptcy from 2008 through 2011. Although the original Z-Score model was developed for manufacturing firms, it performs equally well in predicting bankruptcy for non-manufacturing companies. The model with only one variable "Market value of equity/Total liabilities" appears to have the highest bankruptcy predicting power. This finding lends support for the assertion from prior research on the superior prediction power of market-value based models. Contrary to a popular criticism on Z-Score model, total asset variability does not appear to be a significant factor for bankruptcy prediction. On the other hand, there's evidence that asset volatility is a significant factor for the bankruptcy prediction of manufacturing firms (Li & Rahgozar 2011). In this study, the change in total assets from one year to 2 years prior to bankruptcy serves as the proxy for asset volatility. Future research could focus on this area by using other proxies for asset volatility. In addition, all models tend to have high type II error of mis-predicting a solvent firm as bankrupt. There appears to be a need for developing a model for the prediction of solvent firms.

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