

---

# Evolution of bankruptcy prediction models

---

**Dr. Edward Altman**  
*NYU Stern School of Business*

1<sup>st</sup> Annual Edward Altman Lecture Series  
Warsaw School of Economics  
Warsaw, Poland  
April 14, 2016

# Scoring Systems

---

- Qualitative (Subjective)
- Univariate (Accounting/Market Measures)
- Multivariate (Accounting/Market Measures)
  - Discriminant, Logit, Probit Models (Linear, Quadratic)
  - Non-Linear Models (e.g., RPA, NN)
- Discriminant and Logit Models in Use
  - Consumer Models - Fair Isaacs
  - Z-Score (5) - Manufacturing
  - ZETA Score (7) - Industrials
  - Private Firm Models (eg. Risk Calc (Moody' s), Z" Score)
  - EM Score (4) - Emerging Markets, Industrial
  - Other - Bank Specialized Systems

# Scoring Systems

(continued)

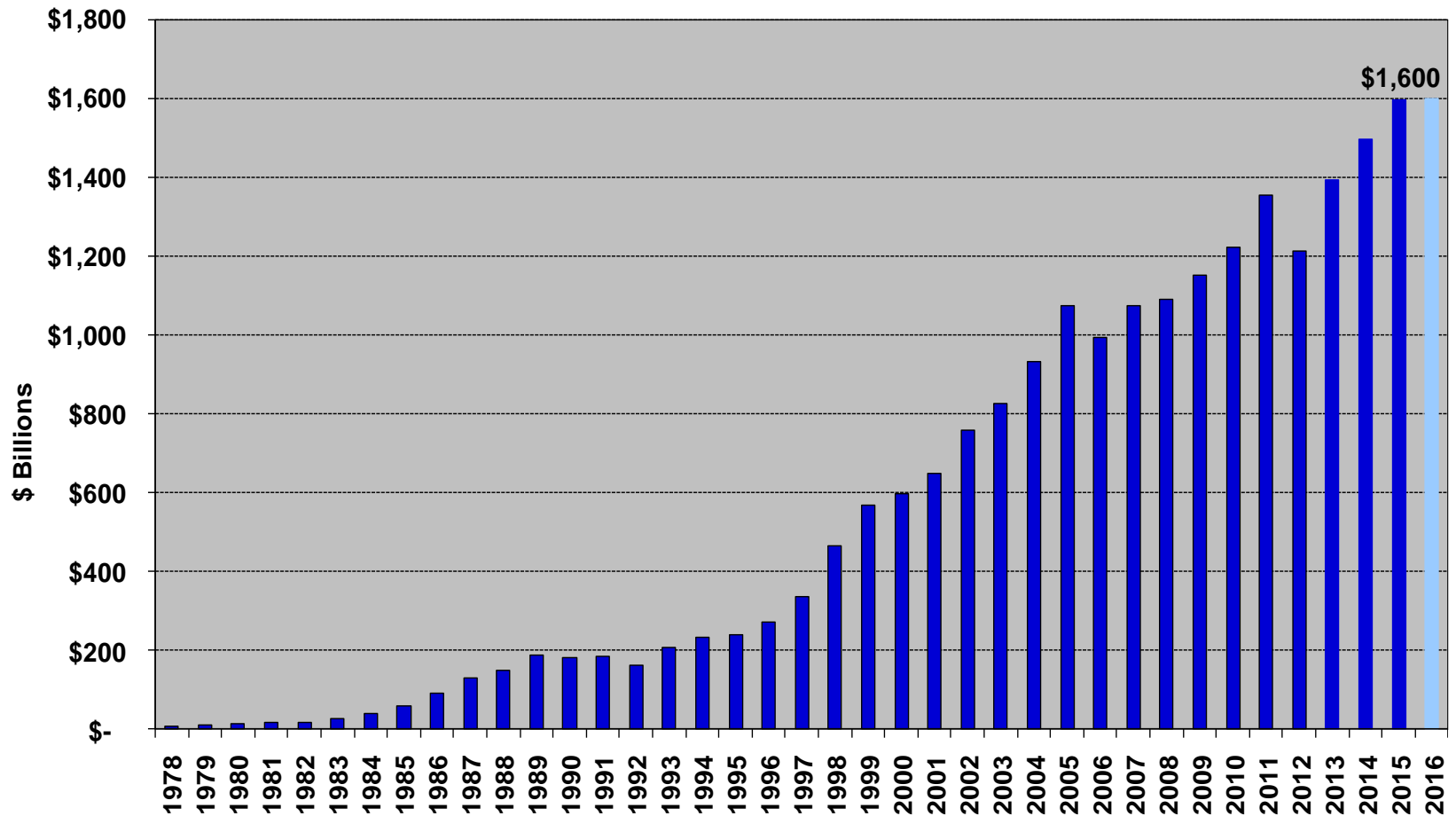
- Artificial Intelligence Systems
  - Expert Systems
  - Neural Networks (eg. Credit Model (S&P), CBI (Italy))
- Option/Contingent Claims Models
  - Risk of Ruin
  - KMV Credit Monitor Model
- Blended Ratio/Market Value Models
  - Moody's *Risk Cal*
  - Bond Score (*Credit Sights*)
  - Z-Score (*Market Value Model*)
- Z-Metrics (MSCI)
  - Blended and Macro Approach

# Major Agencies Bond Rating Categories

<u>Moody's</u>		<u>S&amp;P/Fitch</u>
Aaa	↑	AAA
Aa1		AA+
Aa2		AA
Aa3		AA-
A1		A+
A2		A
A3		A-
Baa1		BBB+
Baa2		BBB
Baa3		BBB-
Ba1	Investment Grade	BB+
Ba2	High Yield ("Junk")	BB
Ba3		BB-
B1	↓	B+
B2		B
B3		B-
Caa1		CCC+
Caa		CCC
Caa3		CCC-
Ca		CC
		C
C		D

# Size of the US High-Yield Bond Market

1978 – 2016 (Mid-year US\$ billions)



Source: NYU Salomon Center estimates using Credit Suisse, S&P and Citi data.

# Key Industrial Financial Ratios

## (U.S. Industrial Long-term Debt)

Medians of Three- Year (2009-2011) Averages	AAA	AA	A	BBB	BB	B	CCC*
EBITDA margin (%)	27.9	27.6	20.4	19.7	17.6	16.6	
Return on Capital (%)	30.6	23.6	20.7	13.2	10.9	7.8	2.7
EBIT Interest Coverage(x)	33.4	14.2	11.6	5.9	3.0	1.3	0.4
EBITDA Interest Coverage (x)	38.1	19.6	15.3	8.2	4.8	2.3	1.1
Funds from Operations/Total Debt (%)	252.6	64.7	52.6	33.7	24.9	11.7	2.5
Free Operating Cash Flow/Total Debt (%)	208.2	51.3	35.7	19.0	11.1	3.9	(3.6)
Disc. Cash Flow/Debt (%)	142.8	32.0	26.1	13.9	8.8	3.1	
Total Debt/EBITDA (x)	0.4	1.2	1.5	2.3	3.2	5.5	8.6
Total Debt/Total Debt + Equity (%)	14.7	29.2	33.8	43.5	52.2	75.2	98.9
No. of Companies	4	14	93	227	260	287	

\* 2005-2007

Source: Standard & Poor's, CreditStats: 2011 Industrial Comparative Ratio Analysis, Long-Term Debt – US (RatingsDirect, August 2012).

# Key Industrial Financial Ratios

## (Europe, Middle East & Africa Industrial Long-term Debt)

Medians of Three- Year (2008-2010) Averages	AA	A	BBB	BB	B
EBITDA margin (%)	24.9	16.6	15.5	17.6	16.3
Return on Capital (%)	20.0	15.3	11.2	9.3	6.7
EBIT Interest Coverage(x)	15.7	7.0	3.9	3.1	1.0
EBITDA Interest Coverage (x)	18.5	9.5	5.7	4.6	2.0
Funds from Operations/Total Debt (%)	83.4	45.7	32.3	22.7	10.5
Free Operating Cash Flow/Total Debt (%)	57.8	23.2	16.0	7.1	1.3
Disc. Cash Flow/Debt (%)	30.5	12.5	8.0	3.4	0.8
Total Debt/EBITDA (x)	0.9	1.6	2.6	3.2	5.8
Total Debt/Total Debt + Equity (%)	25.7	33.8	44.4	51.9	75.8
No. of Companies	8	55	104	58	55

Source: Standard & Poor's, CreditStats: 2010 Adjusted Key US & European Industrial and Utility Financial Ratios (RatingsDirect, August 2011).

# Problems With Traditional Financial Ratio Analysis

---

- 1 Univariate Technique  
1-at-a-time
- 2 No “Bottom Line”
- 3 Subjective Weightings
- 4 Ambiguous
- 5 Misleading



# Forecasting Distress With Discriminant Analysis

## Linear Form

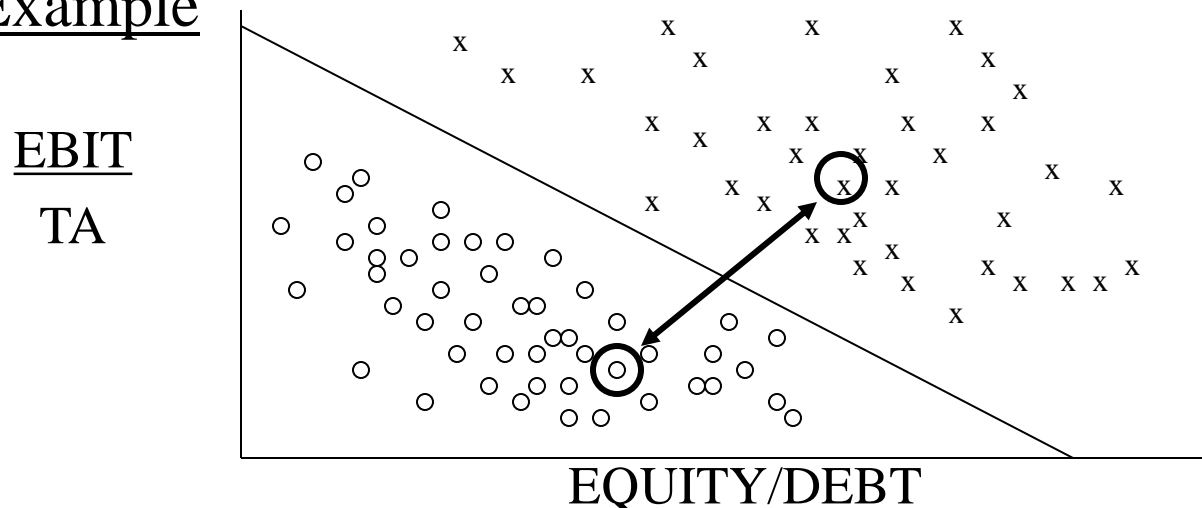
$$Z = a_1x_1 + a_2x_2 + a_3x_3 + \dots + a_nx_n$$

Z = Discriminant Score (Z Score)

$a_1 \rightarrow a_n$  = Discriminant Coefficients (Weights)

$x_1 \rightarrow x_n$  = Discriminant Variables (e.g. Ratios)

## Example



# Z-Score Component Definitions and Weightings

<u>Variable</u>	<u>Definition</u>	<u>Weighting Factor</u>
$X_1$ - - - - -	$\frac{\text{Working Capital}}{\text{Total Assets}}$	1.2
$X_2$ - - - - -	$\frac{\text{Retained Earnings}}{\text{Total Assets}}$	1.4
$X_3$ - - - - -	$\frac{\text{EBIT}}{\text{Total Assets}}$	3.3
$X_4$ - - - - -	$\frac{\text{Market Value of Equity}}{\text{Book Value of Total Liabilities}}$	0.6
$X_5$ - - - - -	$\frac{\text{Sales}}{\text{Total Assets}}$	1.0

# Z Score Bankruptcy Model

$$Z = .012X_1 + .014X_2 + .033X_3 + .006X_4 + .999X_5$$

e.g. 20.0%

$$Z = 1.2X_1 + 1.4X_2 + 3.3X_3 + .6X_4 + .999X_5$$

e.g. 0.20

$$X_1 = \frac{\text{Current Assets} - \text{Current Liabilities}}{\text{Total Assets}}$$

$$X_4 = \frac{\text{Market Value of Equity}}{\text{Total Liabilities}}$$

$$X_2 = \frac{\text{Retained Earnings}}{\text{Total Assets}}$$

$$X_5 = \frac{\text{Sales}}{\text{Total Assets}} \quad (= \# \text{ of Times e.g. 2.0x})$$

$$X_3 = \frac{\text{Earnings Before Interest and Taxes}}{\text{Total Assets}}$$

# Zones of Discrimination: Original Z - Score Model (1968)

**$Z > 2.99$  - “Safe” Zone**

**$1.8 < Z < 2.99$  - “Grey” Zone**

**$Z < 1.80$  - “Distress” Zone**

# Time Series Impact On Corporate Z-Scores

---

- Credit Risk Migration
  - Greater Use of Leverage
  - Impact of HY Bond & LL Markets
  - Global Competition
  - More and Larger Bankruptcies
- Increased Type II Error

# Estimating Probability of Default (PD) and Probability of Loss Given Defaults (LGD)

## Method #1

- Credit scores on new or existing debt
- Bond rating equivalents on new issues (Mortality) or existing issues (Rating Agency Cumulative Defaults)
- Utilizing mortality or cumulative default rates to estimate marginal and cumulative defaults
- Estimating Default Recoveries and Probability of Loss

or

## Method #2

- Credit scores on new or existing debt
- Direct estimation of the probability of default
- Based on PDs, assign a rating

# Median Z-Score by S&P Bond Rating for U.S. Manufacturing Firms: 1992 - 2013

<b>Rating</b>	<b>2013 (No.)</b>	<b>2004-2010</b>	<b>1996-2001</b>	<b>1992-1995</b>
<b>AAA/AA</b>	<b>4.13 (15)</b>	<b>4.18</b>	<b>6.20*</b>	<b>4.80*</b>
<b>A</b>	<b>4.00 (64)</b>	<b>3.71</b>	<b>4.22</b>	<b>3.87</b>
<b>BBB</b>	<b>3.01 (131)</b>	<b>3.26</b>	<b>3.74</b>	<b>2.75</b>
<b>BB</b>	<b>2.69 (119)</b>	<b>2.48</b>	<b>2.81</b>	<b>2.25</b>
<b>B</b>	<b>1.66 (80)</b>	<b>1.74</b>	<b>1.80</b>	<b>1.87</b>
<b>CCC/CC</b>	<b>0.23 (3)</b>	<b>0.46</b>	<b>0.33</b>	<b>0.40</b>
<b>D</b>	<b>0.01 (33)</b>	<b>-0.04</b>	<b>-0.20</b>	<b>0.05</b>

\*AAA Only.

Sources: Compustat Database, mainly S&P 500 firms, compilation by NYU Salomon Center, Stern School of Business.

# Marginal and Cumulative Mortality Rate Actuarial Approach

$$\mathbf{MMR}_{(r,t)} = \frac{\text{total value of defaulting debt from rating } (r) \text{ in year } (t)}{\text{total value of the population at the start of the year } (t)}$$

$\overline{\text{MMR}}$  = Marginal Mortality Rate

One can measure the cumulative mortality rate (CMR) over a specific time period (1,2,..., T years) by subtracting the product of the surviving populations of each of the previous years from one (1.0), that is,

$$\mathbf{CMR}_{(r,t)} = 1 - \prod_{t=1 \rightarrow N} \mathbf{SR}_{(r,t)},$$

$r = \text{AAA} \rightarrow \text{CCC}$

here  $\mathbf{CMR}_{(r,t)}$  = Cumulative Mortality Rate of (r) in (t),

$\mathbf{SR}_{(r,t)}$  = Survival Rate in (r,t) ,  $1 - \mathbf{MMR}_{(r,t)}$



# Mortality Rate Concept (Illustrative Calculation)

## For BB Rated Issues

Security No.	Issued Amount	Year 1 Default	Call	SF	Year 2 Default	Call	SF
1	50	--	--	5	--	--	5
2	50	50	--	--	NE	NE	NE
3	100	--	100	--	NE	NE	NE
4	100	--	--	--	100	--	--
5	150	--	--	--	--	--	15
6	150	--	--	--	--	--	--
7	200	--	--	20	--	--	20
8	200	--	--	--	--	200	--
9	250	--	--	--	--	--	--
10	250	--	--	--	--	--	--
<b>Total</b>	<b>1,500</b>	<b>50</b>	<b>100</b>	<b>25</b>	<b>100</b>	<b>200</b>	<b>40</b>
Amount Start of Period	1,500	-	175	-	1,325	- 340	= 985
		<b>Year 1</b>			<b>Year 2</b>		
Marginal Mortality Rate		50/1,500 = 3.3%			100/1,325 = 7.5%		
Cumulative Rate		3.3%			1 - (SR1 x SR2 ) = CMR2 1 - (96.7% x 92.5%) = 10.55%		

NE = No longer in existence  
SF = Sinking fund

# Mortality Rates by Original Rating

All Rated Corporate Bonds\*  
1971-2015

Years After Issuance

		1	2	3	4	5	6	7	8	9	10
AAA	Marginal	0.00%	0.00%	0.00%	0.00%	0.01%	0.02%	0.01%	0.00%	0.00%	0.00%
	Cumulative	0.00%	0.00%	0.00%	0.00%	0.01%	0.03%	0.04%	0.04%	0.04%	0.04%
AA	Marginal	0.00%	0.00%	0.21%	0.07%	0.02%	0.01%	0.01%	0.01%	0.02%	0.01%
	Cumulative	0.00%	0.00%	0.21%	0.28%	0.30%	0.31%	0.32%	0.33%	0.35%	0.36%
A	Marginal	0.01%	0.03%	0.12%	0.13%	0.10%	0.06%	0.02%	0.25%	0.08%	0.05%
	Cumulative	0.01%	0.04%	0.16%	0.29%	0.39%	0.45%	0.47%	0.72%	0.80%	0.85%
BBB	Marginal	0.33%	2.36%	1.26%	1.00%	0.50%	0.22%	0.26%	0.15%	0.15%	0.34%
	Cumulative	0.33%	2.68%	3.91%	4.87%	5.34%	5.55%	5.80%	5.94%	6.08%	6.40%
BB	Marginal	0.94%	2.02%	3.88%	1.97%	2.34%	1.51%	1.45%	1.12%	1.43%	3.13%
	Cumulative	0.94%	2.94%	6.71%	8.54%	10.68%	12.03%	13.31%	14.28%	15.51%	18.15%
B	Marginal	2.85%	7.72%	7.85%	7.80%	5.70%	4.48%	3.58%	2.08%	1.76%	0.77%
	Cumulative	2.85%	10.35%	17.39%	23.83%	28.17%	31.39%	33.85%	35.22%	36.36%	36.85%
CCC	Marginal	8.13%	12.43%	17.89%	16.32%	4.85%	11.65%	5.44%	4.84%	0.66%	4.28%
	Cumulative	8.13%	19.55%	33.94%	44.72%	47.40%	53.53%	56.06%	58.19%	58.46%	60.24%

\*Rated by S&P at Issuance  
Based on 2,903 issues

Source: Standard & Poor's (New York) and Author's Compilation

# Mortality Losses by Original Rating

All Rated Corporate Bonds\*  
1971-2015

Years After Issuance

		1	2	3	4	5	6	7	8	9	10
AAA	Marginal	0.00%	0.00%	0.00%	0.00%	0.01%	0.01%	0.01%	0.00%	0.00%	0.00%
	Cumulative	0.00%	0.00%	0.00%	0.00%	0.01%	0.02%	0.03%	0.03%	0.03%	0.03%
AA	Marginal	0.00%	0.00%	0.03%	0.03%	0.01%	0.01%	0.00%	0.01%	0.01%	0.01%
	Cumulative	0.00%	0.00%	0.03%	0.06%	0.07%	0.08%	0.08%	0.09%	0.10%	0.11%
A	Marginal	0.00%	0.01%	0.05%	0.06%	0.06%	0.04%	0.02%	0.03%	0.05%	0.03%
	Cumulative	0.00%	0.01%	0.06%	0.12%	0.18%	0.22%	0.24%	0.27%	0.32%	0.35%
BBB	Marginal	0.24%	1.54%	0.76%	0.59%	0.27%	0.14%	0.16%	0.09%	0.09%	0.19%
	Cumulative	0.24%	1.78%	2.52%	3.10%	3.36%	3.49%	3.65%	3.74%	3.82%	4.01%
BB	Marginal	0.56%	1.17%	2.31%	1.12%	1.34%	0.71%	0.79%	0.49%	0.74%	1.10%
	Cumulative	0.56%	1.72%	3.99%	5.07%	6.34%	7.01%	7.74%	8.19%	8.87%	9.87%
B	Marginal	1.91%	5.40%	5.33%	5.22%	3.77%	2.46%	2.33%	1.15%	0.92%	0.54%
	Cumulative	1.91%	7.21%	12.15%	16.74%	19.88%	21.85%	23.67%	24.55%	25.24%	25.64%
CCC	Marginal	5.38%	8.70%	12.52%	11.49%	3.39%	8.62%	2.34%	3.39%	0.41%	2.73%
	Cumulative	5.38%	13.61%	24.43%	33.11%	35.38%	40.95%	42.33%	44.29%	44.51%	46.03%

\*Rated by S&P at Issuance  
Based on 2,481 issues

Source: Standard & Poor's (New York) and Author's Compilation

# Classification & Prediction Accuracy

## Z Score (1968) Failure Model\*

Year Prior To Failure	Original Sample (33)	Holdout Sample (25)	1969-1975 Predictive Sample (86)	1976-1995 Predictive Sample (110)	1997-1999 Predictive Sample (120)
1	94% (88%)	96% (72%)	82% (75%)	85% (78%)	94% (84%)
2	72%	80%	68%	75%	74%
3	48%	-	-	-	-
4	29%	-	-	-	-
5	36%	-	-	-	-

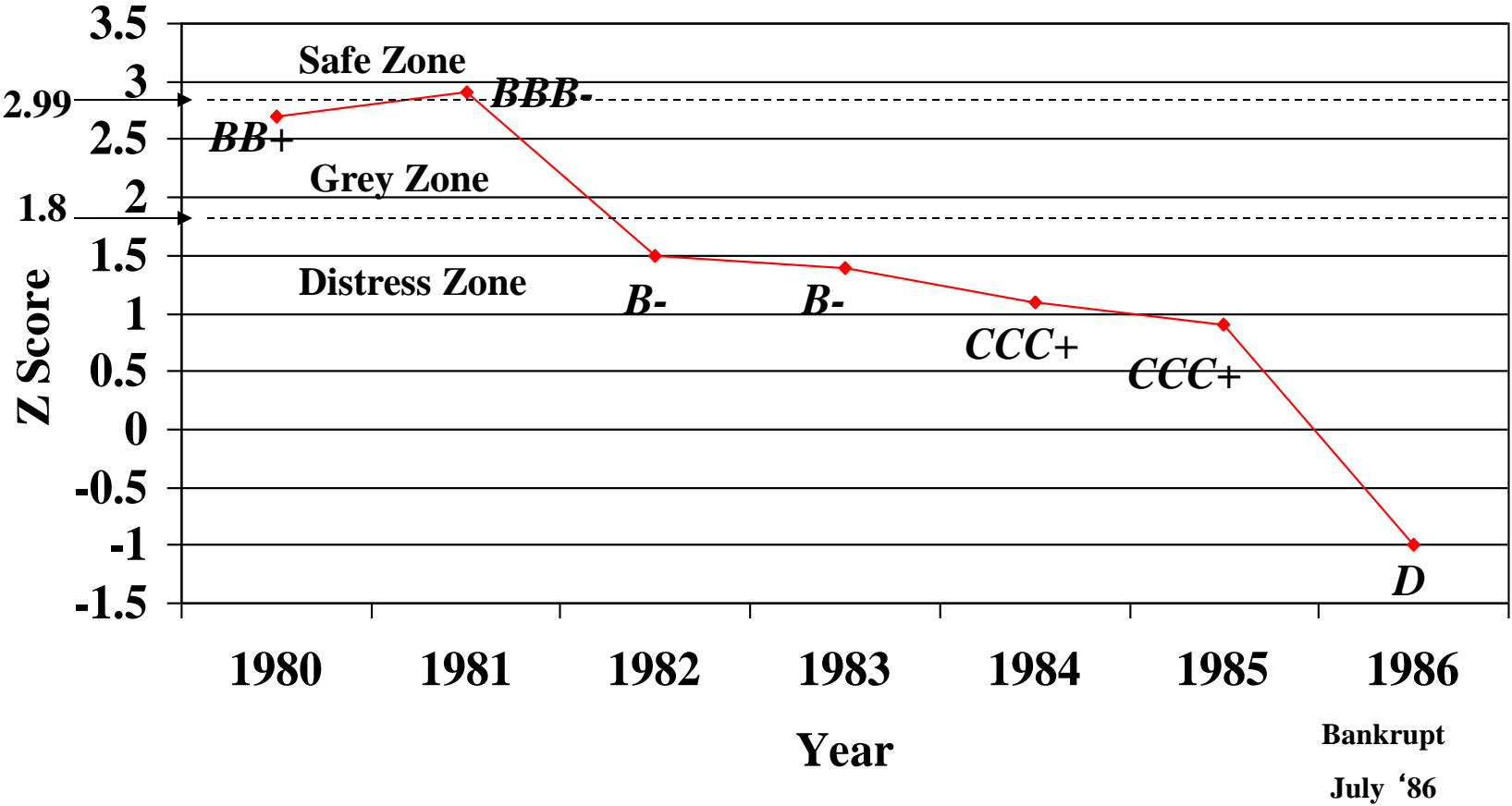
\*Using 2.67 as cutoff score (1.81 cutoff accuracy in parenthesis)

# Where to Find More Information

---

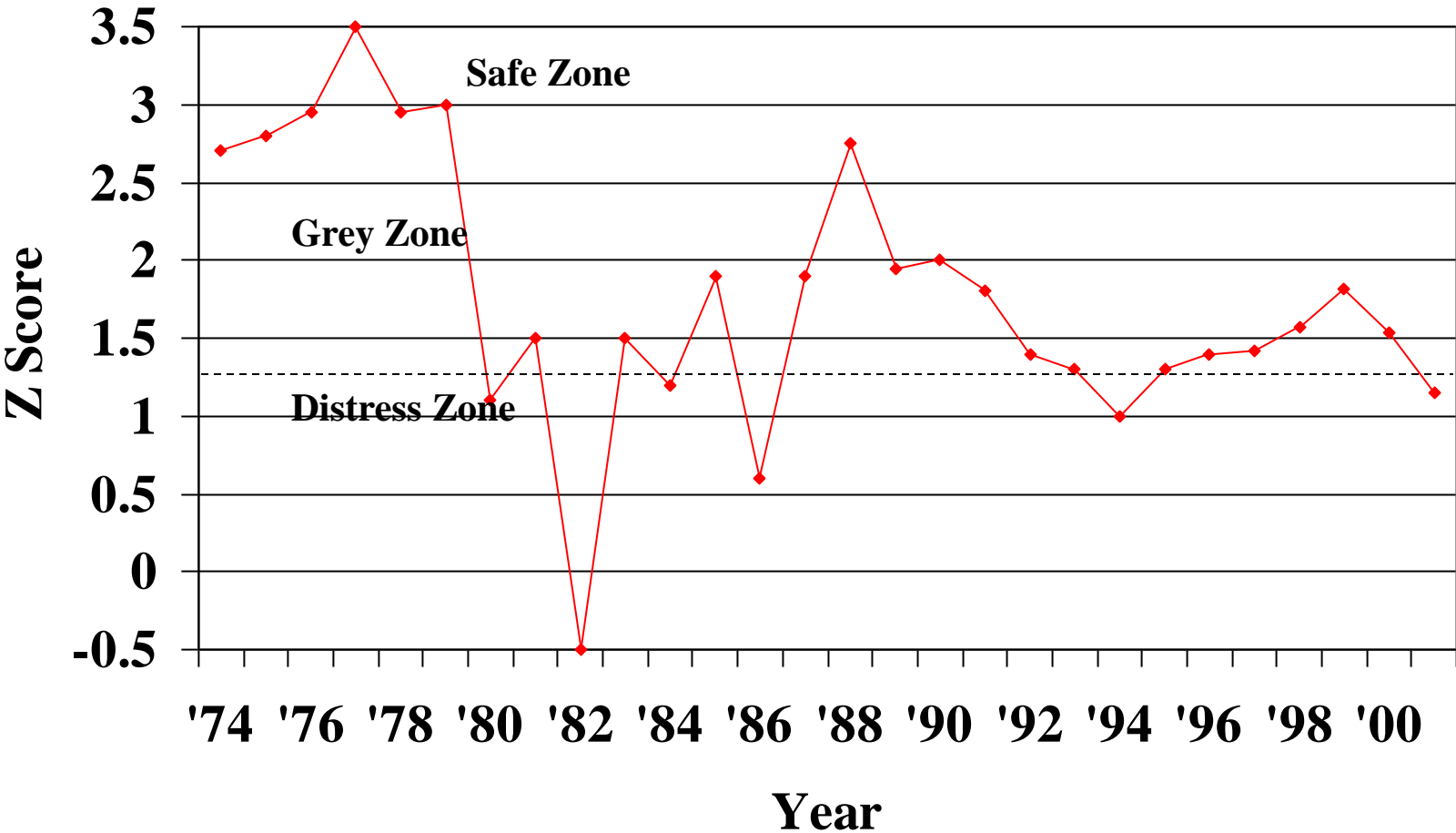
- Web Site – <http://altmanzscoreplus.com>
- E-Mail : [zscore@businesscompassllc.com](mailto:zscore@businesscompassllc.com)
- Telephone: +1 (973) 944-3989

# Z Score Trend - LTV Corp.

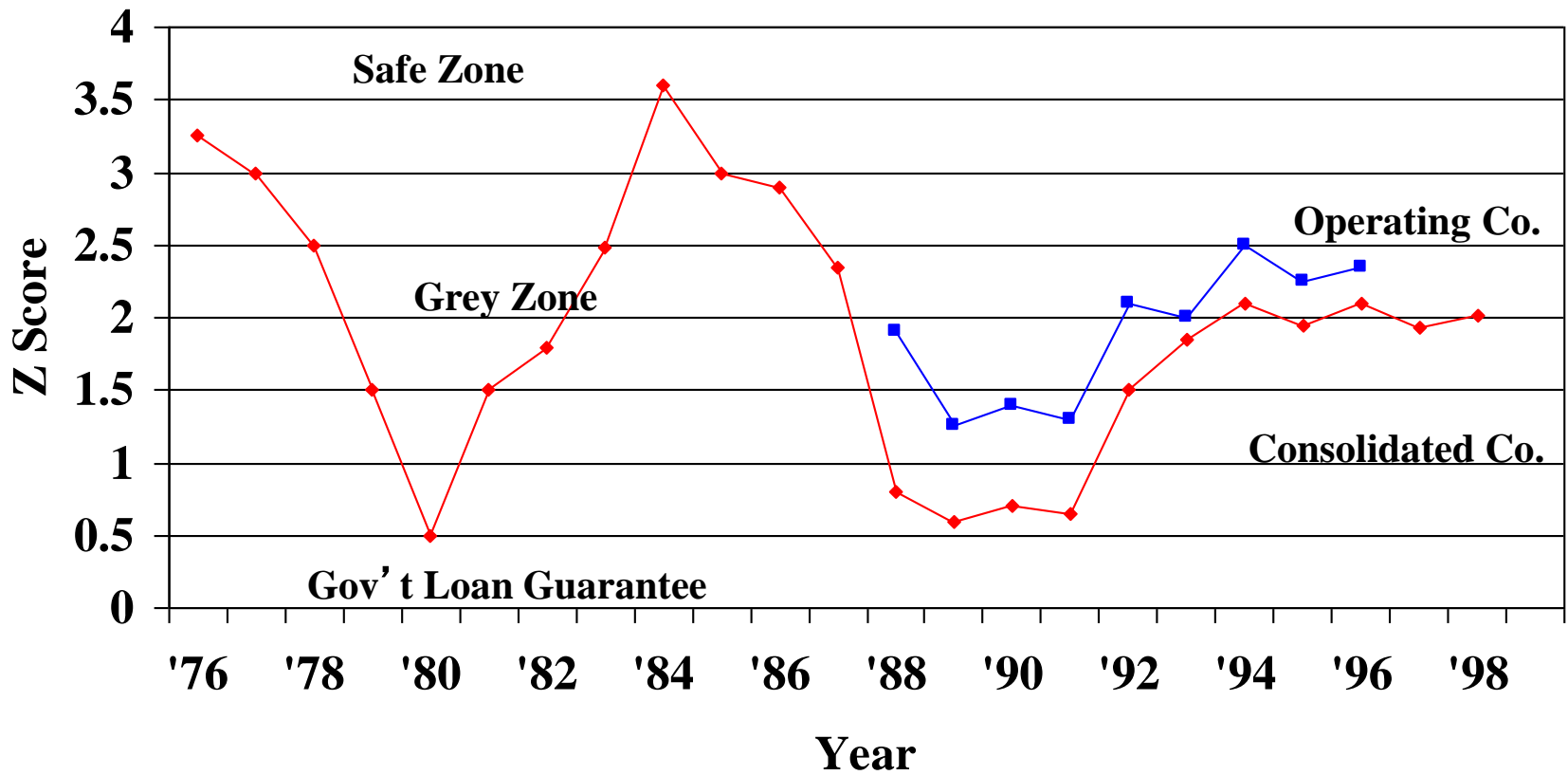


# International Harvester (Navistar)

## Z Score (1974 – 2001)



# Chrysler Corporation Z Score (1976 – 3Q 1998\*)

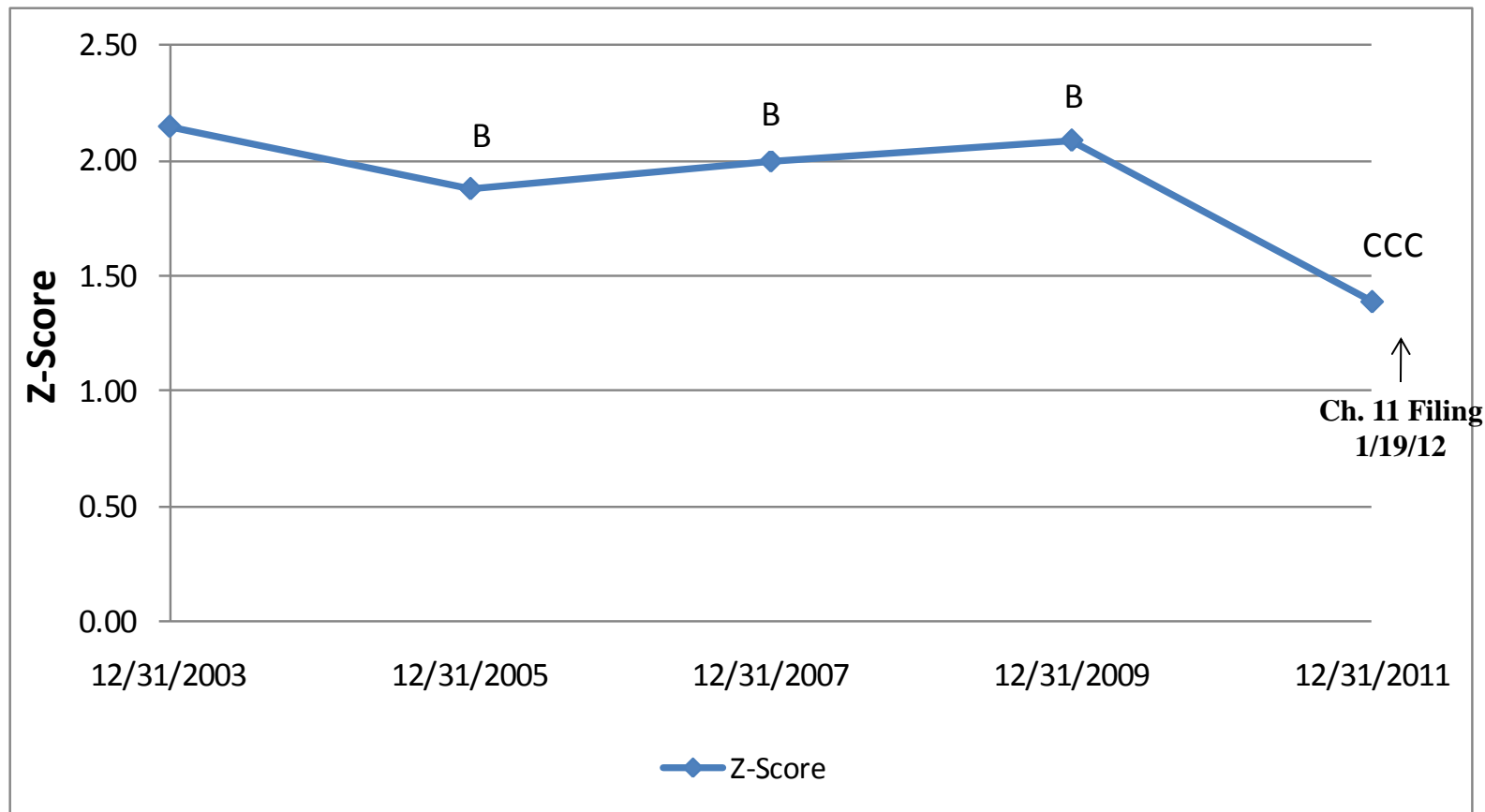


\*Third quarter figures for 1998 are annualized

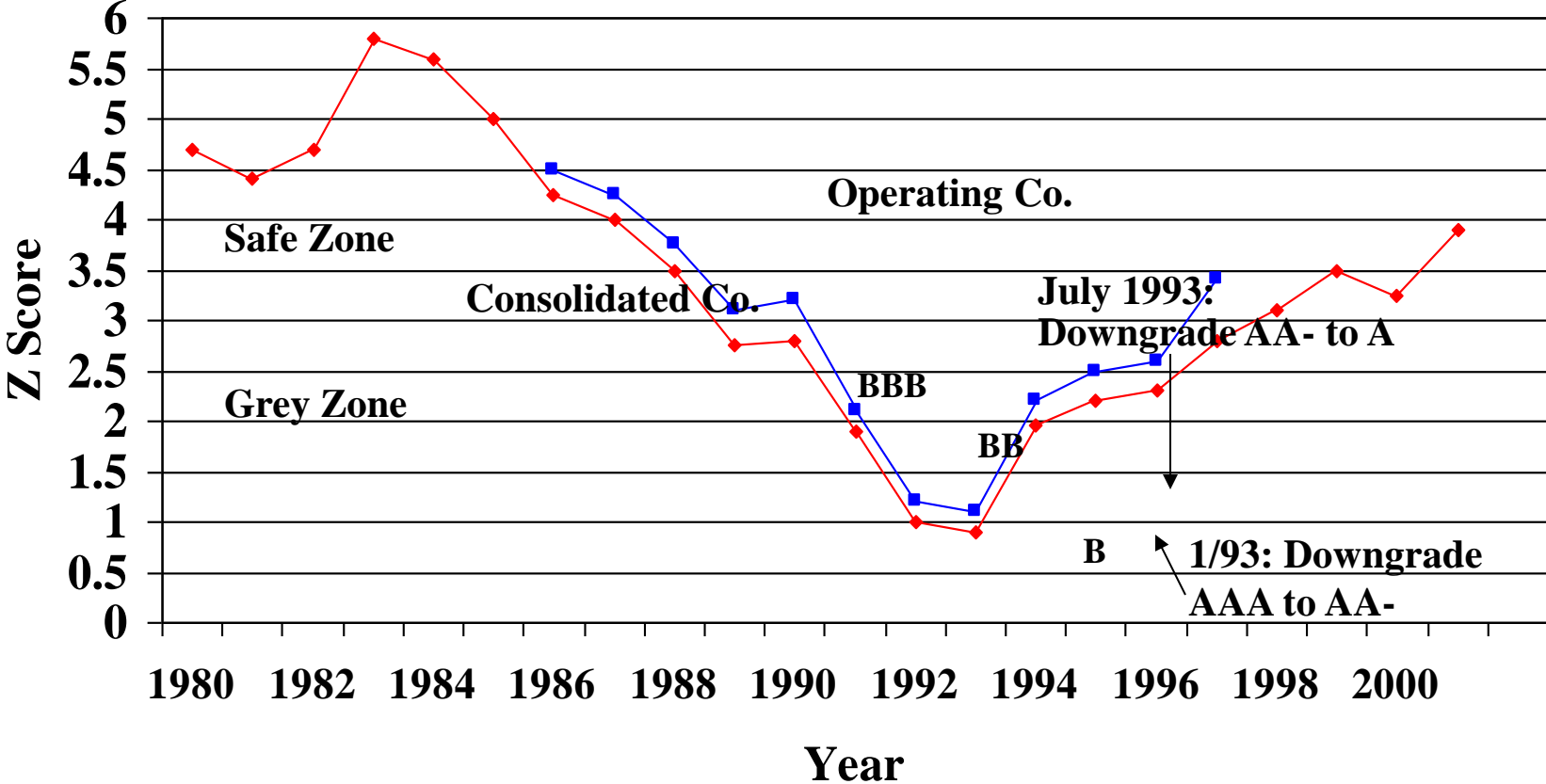


# Eastman Kodak: Z-Score Analysis

## December 2003 – December 2011 (Biennial)



# IBM Corporation Z Score (1980 – 2001)

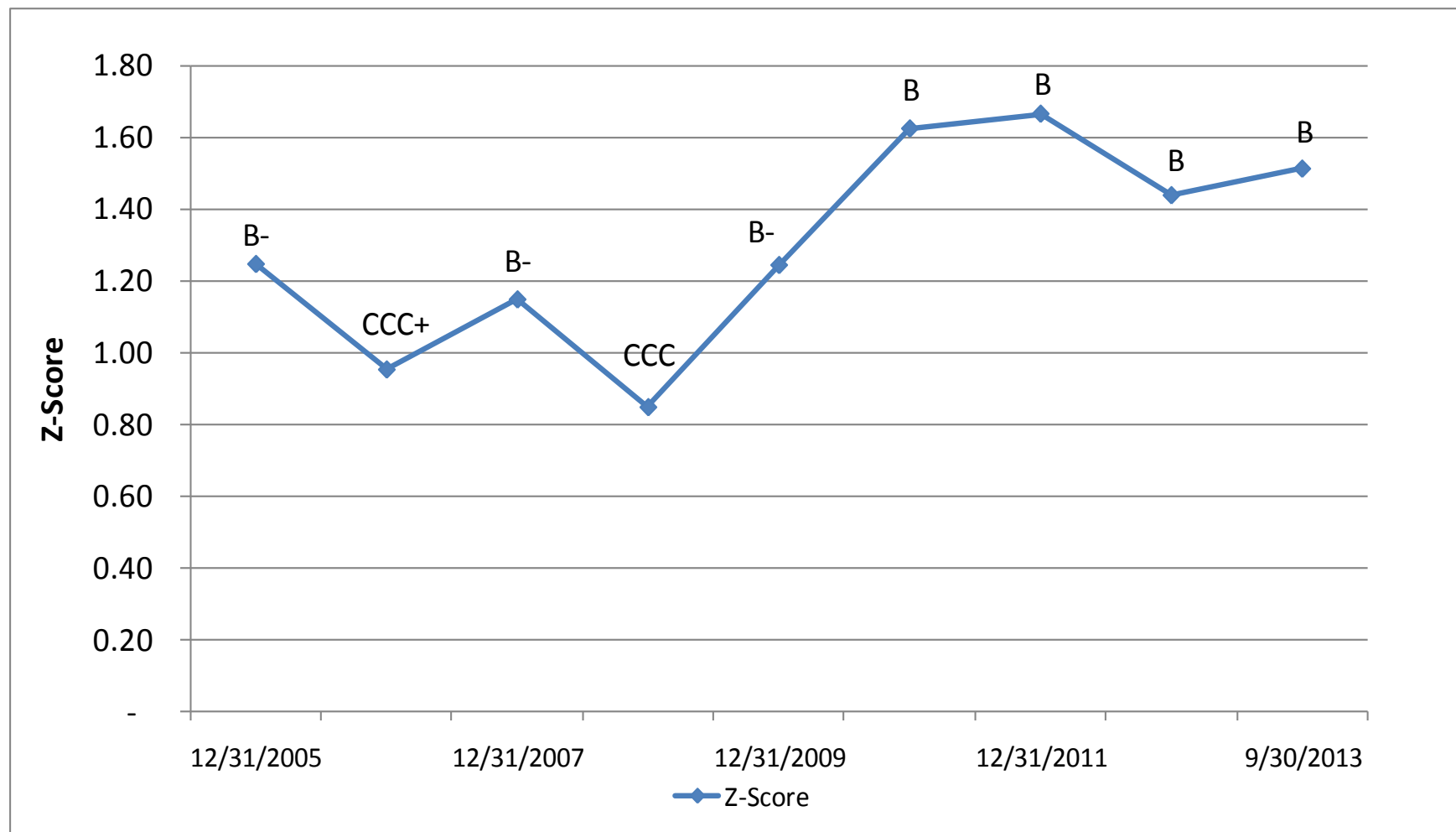


# U.S. Automotive Industry: Z, Z''-Scores and Bond Rating Equivalents (BRE) - Ford & GM: Z and Z''-Score Tracking

	Ford		GM	
	Z-Scores	BRE	Z-Scores	BRE
09/30/13	1.51	B	1.44	B
12/31/12	1.44	B	1.57	B
12/31/11	1.66	B	1.59	B
12/31/10	1.62	B	1.56	B
12/31/09	1.24	B-	0.28	CCC
03/31/09	n/a	n/a	(1.12)	D
12/31/08	0.85	CCC	(0.63)	D
12/31/07	1.15	B-	0.77	CCC+
12/31/06	0.95	CCC+	1.12	B-
12/31/05	1.25	B-	0.96	CCC+
	Z''-Scores	BRE	Z''-Scores	BRE
09/30/13	5.61	BB-	4.56	B+
12/31/12	5.59	BB-	4.54	B+
12/31/11	6.29	BB+	5.04	B+
12/31/10	5.86	BB-	4.60	B+
12/31/09	5.84	BB-	2.72	CCC+
12/31/08	4.71	B+	(3.62)	D
12/31/07	5.82	BB-	1.85	CCC-
12/31/06	5.42	BB-	3.39	B-
12/31/05	5.74	BB-	6.59	BBB+

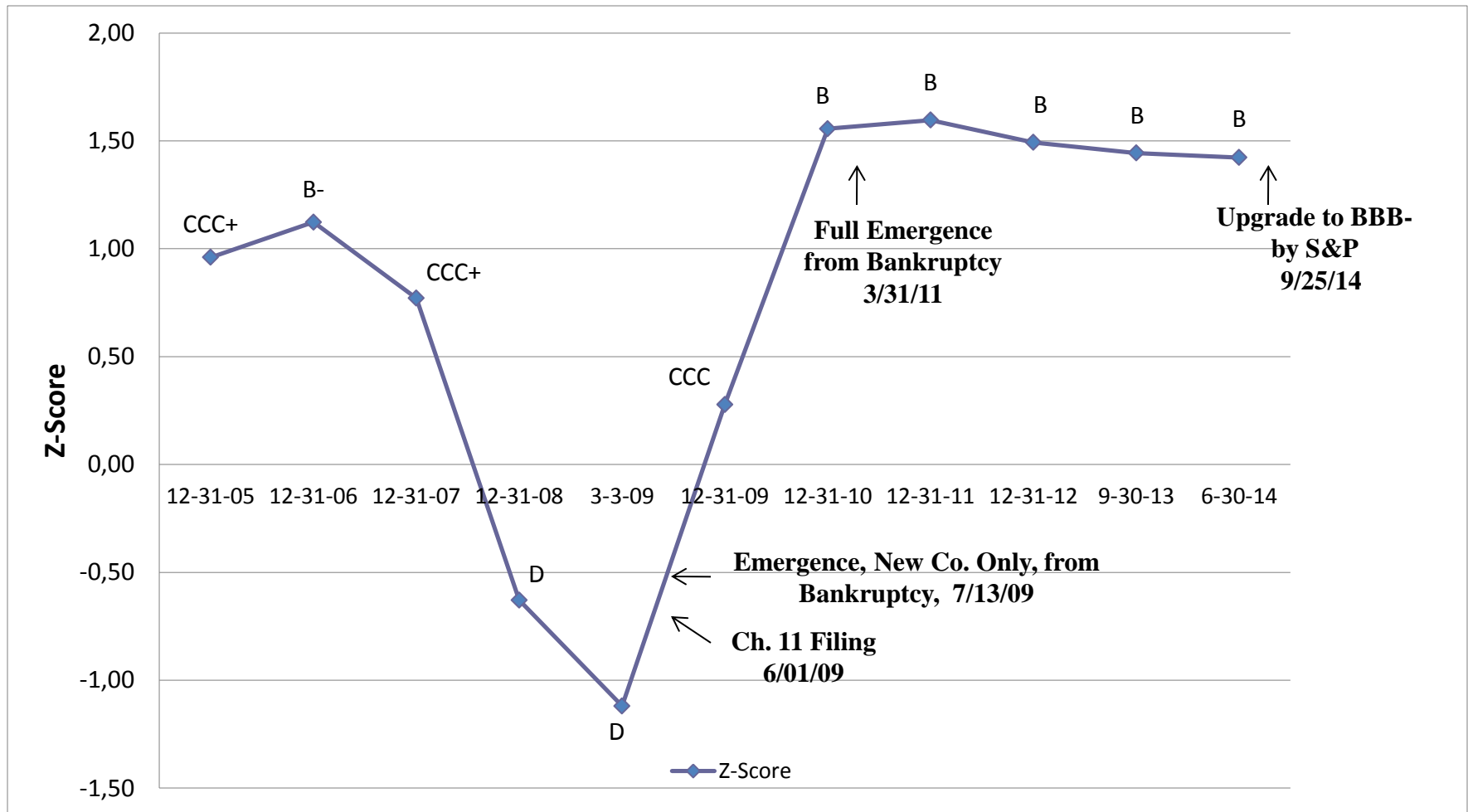
# Z-Score Model Applied to Ford (Consolidated Data): Bond Rating Equivalents and Scores from 2005 – 2013 (9/30)

Z- Score: Ford Motor Co.



# Z-Score Model Applied to GM (Consolidated Data): Bond Rating Equivalents and Scores from 2005 – 2014 (6/30)

Z- Score: General Motors Co.



# Z' Score

## Private Firm Model

$$Z' = .717X_1 + .847X_2 + 3.107X_3 + .420X_4 + .998X_5$$

$$X_1 = \frac{\text{Current Assets} - \text{Current Liabilities}}{\text{Total Assets}}$$

$$X_2 = \frac{\text{Retained Earnings}}{\text{Total Assets}}$$

$$X_3 = \frac{\text{Earnings Before Interest and Taxes}}{\text{Total Assets}}$$

$$X_4 = \frac{\text{Book Value of Equity}}{\text{Total Liabilities}}$$

$$X_5 = \frac{\text{Sales}}{\text{Total Assets}}$$

$Z' > 2.90$  - "Safe" Zone  
 $1.23 < Z' < 2.90$  - "Grey" Zone  
 $Z' < 1.23$  - "Distress" Zone

# Z" Score Model for Manufacturers, Non-Manufacturer Industrials; Developed and Emerging Market Credits

$$Z'' = 3.25 + 6.56X_1 + 3.26X_2 + 6.72X_3 + 1.05X_4$$

$X_1 = \text{Current Assets} - \text{Current Liabilities}$

$\frac{\quad}{\text{Total Assets}}$

$X_2 = \text{Retained Earnings}$

$\frac{\quad}{\text{Total Assets}}$

$X_3 = \text{Earnings Before Interest and Taxes}$

$\frac{\quad}{\text{Total Assets}}$

$X_4 = \text{Book Value of Equity}$

$\frac{\quad}{\text{Total Liabilities}}$

$Z'' > 5.85$  - "Safe" Zone

$4.35 < Z'' < 5.85$  - "Grey" Zone

$Z'' < 4.35$  - "Distress" Zone

---

# **AN EMERGING MARKET CORPORATE MODEL**

---



# An Emerging Market Credit Scoring System

---

- Step 1- Calculate the EM Score and its Bond Rating Equivalent (BRE) compared to the U.S. Bond Market
  
- Step 2 -Adjust (modify) the Bond Rating Equivalent for Forex Revaluation Vulnerability
  - High vulnerability = -1 rating class (3 notches)
  - Neutral vulnerability = -1 notch
  - Low vulnerability = no change
  
- Step 3 -Adjust BRE for Risk of Industry in the Emerging Market vs. Risk of the Industry in the U.S.
  - $\pm$  - 1 or 2 notches

# An Emerging Market Credit Scoring System

---

- Step 4 - Adjustment of BRE for Competitive Position
  - Dominant firm in industry = +1 notch
  - Average firm in industry = no change
  - Poor competitive position = -1 notch
- Step 5 - Special Collateral or Guarantees Impact on BRE
- Step 6 - Assess the yield in the U.S. market on the modified BRE of the emerging Market credit, then add the sovereign yield spread. Finally, compare the resulting required yield with the yield in the market.

# Classification & Prediction Accuracy (Type I) Z”-Score Bankruptcy Model\* (Based on the Original Sample and a Sample of Recent Bankruptcies (2011-2014))

No. of Months Prior to Bankruptcy Filing	Original Sample (33)	Holdout Sample (25)	2011-2014 Predictive Sample (71)
6	94%	96%	93%
18	72%	80%	87%
30	-	-	67%

\*E. Altman and J. Hartzell, “Emerging Market Corporate Bonds – A Scoring System”, Salomon Brothers Corporate Bond Research, May 15, 1995, Summarized in E. Altman and E. Hotchkiss, **Corporate Financial Distress and Bankruptcy**, 3<sup>rd</sup> Edition, John Wiley & Sons, 2006.

# Z''-Score Analysis of A Sample of Recently Bankrupt Publicly Held, Non-financial Companies

(2011-2014)

Z''-Scores and Cutoffs	Z'' (t)*	Z'' (t-1)*	Z'' (t-2)*
Average	(10.95)	1.15	2.65
Median	(1.75)	2.75	3.55
Z'' < 4.35 (Distress Zone)	66/71	62/71	46/69
Type I Accuracy	93.0%	87.0%	66.7%
Z'' > 5.85 (Safe Zone)	1/71	5/71	9/69
Type II Accuracy	98.6%	93.0%	87.0%

\* On average, 5.6 months prior to bankruptcy at (t), 17.6 months at (t-1) and 29.6 months at (t-2).

Source: Altman NYU Salomon Center Bankruptcy Database, Capital I.Q., Altman & Hotchkiss (2006).

# Estimated Prediction Accuracy Levels for Recent Samples of Bankrupt and Non-Bankrupt Firms Based on Various Z"-Score Cutoff Levels

Z"-Score Cutoffs	BRE	Bankruptcy Prediction Accuracy <sup>1</sup>	Type I Error	Non-Bankrupt Prediction Accuracy <sup>2</sup>	Type II Error <sup>2</sup>
< 4.35	B	66/71 (93.0%)	7.0%	65.0%	35.0%
< 3.75	B-	64/71 (90.1%)	9.9%	77.5%	22.5%
< 2.57	CCC	57/71 (80.3%)	19.7%	88.3%	11.7%
< 1.72	CCC-	50/71 (70.4%)	29.6%	92.5%	7.5%
< 0.05	D	42/71 (59.2%)	40.8%	97.2%	2.8%

<sup>1</sup> Based on a sample of 71 Bankrupt, non-financial companies from 2011-2014, using data from the most recent financial statements issued prior to bankruptcy (average of 5.6 months prior).

<sup>2</sup> Based on a sample of 760 high-yield bond issues in 2014. Type II error is estimated by subtracting the expected one-year high-yield bond default rate for 2015 (2.5%) from the total Type II error assuming no defaults.

Source: Z"-Score calculations, Capital I.Q. financials and NYU Salomon Center Bankruptcy Database.

# US Bond Rating Equivalents Based on Z"-Score Model

$$Z'' = 3.25 + 6.56X_1 + 3.26X_2 + 6.72X_3 + 1.05X_4$$

Rating	Median 1996 Z''-Score <sup>a</sup>	Median 2006 Z''-Score <sup>a</sup>	Median 2013 Z''-Score <sup>a</sup>
AAA/AA+	8.15 (8)	7.51 (14)	8.80 (15)
AA/AA-	7.16 (33)	7.78 (20)	8.40 (17)
A+	6.85 (24)	7.76 (26)	8.22 (23)
A	6.65 (42)	7.53 (61)	6.94 (48)
A-	6.40 (38)	7.10 (65)	6.12 (52)
BBB+	6.25 (38)	6.47 (74)	5.80 (70)
BBB	5.85 (59)	6.41 (99)	5.75 (127)
BBB-	5.65 (52)	6.36 (76)	5.70 (96)
BB+	5.25 (34)	6.25 (68)	5.65 (71)
BB	4.95 (25)	6.17 (114)	5.52 (100)
BB-	4.75 (65)	5.65 (173)	5.07 (121)
B+	4.50 (78)	5.05 (164)	4.81 (93)
B	4.15 (115)	4.29 (139)	4.03 (100)
B-	3.75 (95)	3.68 (62)	3.74 (37)
CCC+	3.20 (23)	2.98 (16)	2.84 (13)
CCC	2.50 (10)	2.20 (8)	2.57(3)
CCC-	1.75 (6)	1.62 (-) <sup>b</sup>	1.72 (-) <sup>b</sup>
CC/D	0 (14)	0.84 (120)	0.05 (94) <sup>c</sup>

<sup>a</sup>Sample Size in Parantheses. <sup>b</sup>Interpolated between CCC and CC/D. <sup>c</sup>Based on 94 Chapter 11 bankruptcy filings, 2010-2013.  
Sources: Compustat, Company Filings and S&P.

# Classification & Prediction Accuracy (Type I) Z"-Score Bankruptcy Model\*

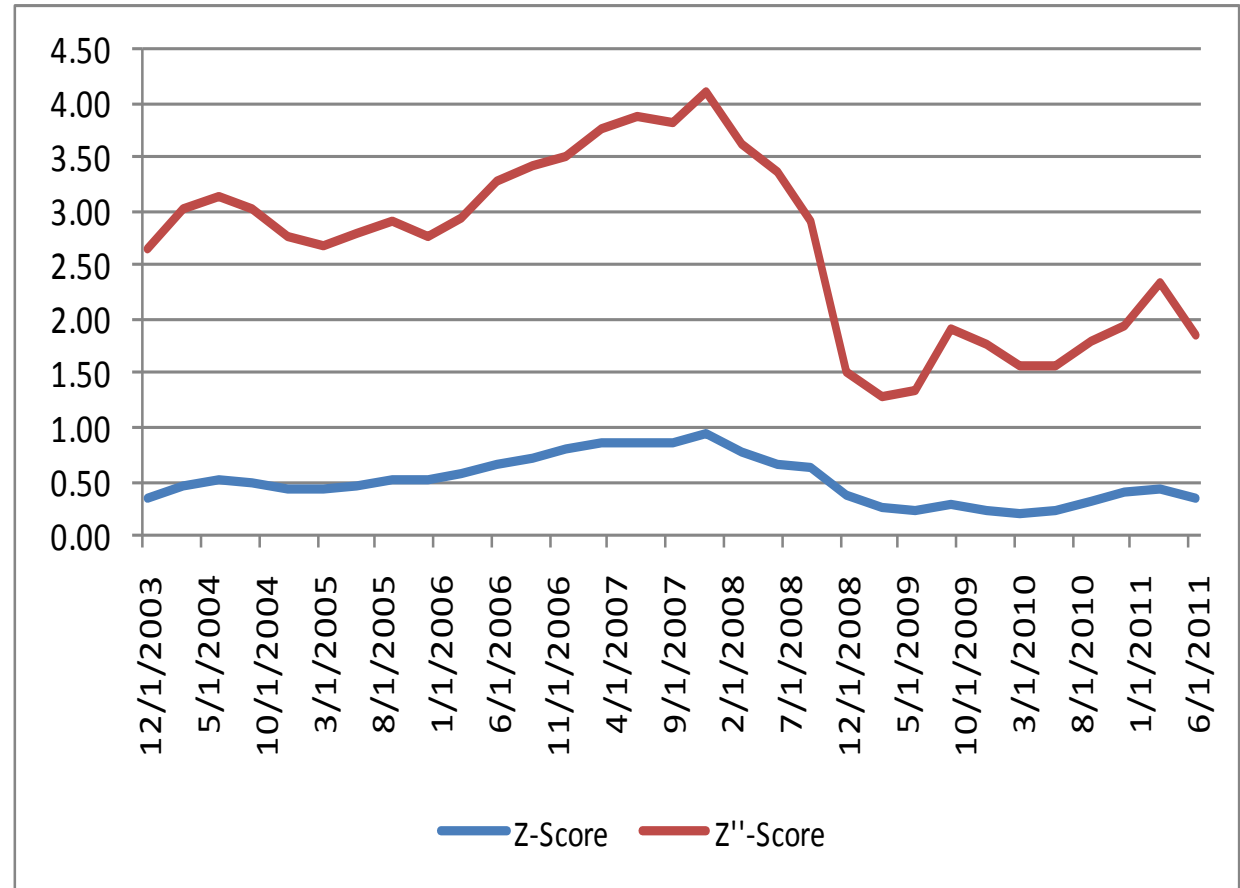
No. of Months Prior to Bankruptcy Filing	Original Sample (33)	Holdout Sample (25)	2011-2014 Predictive Sample (69)
6	94%	96%	93%
18	72%	80%	87%

\*E. Altman and J. Hartzell, "Emerging Market Corporate Bonds – A Scoring System", Salomon Brothers Corporate Bond Research, May 15, 1995, Summarized in E. Altman and E. Hotchkiss, **Corporate Financial Distress and Bankruptcy**, 3<sup>rd</sup> Edition, John Wiley & Sons, 2006.

# American Airlines: Z Score & Z'' Score Analysis

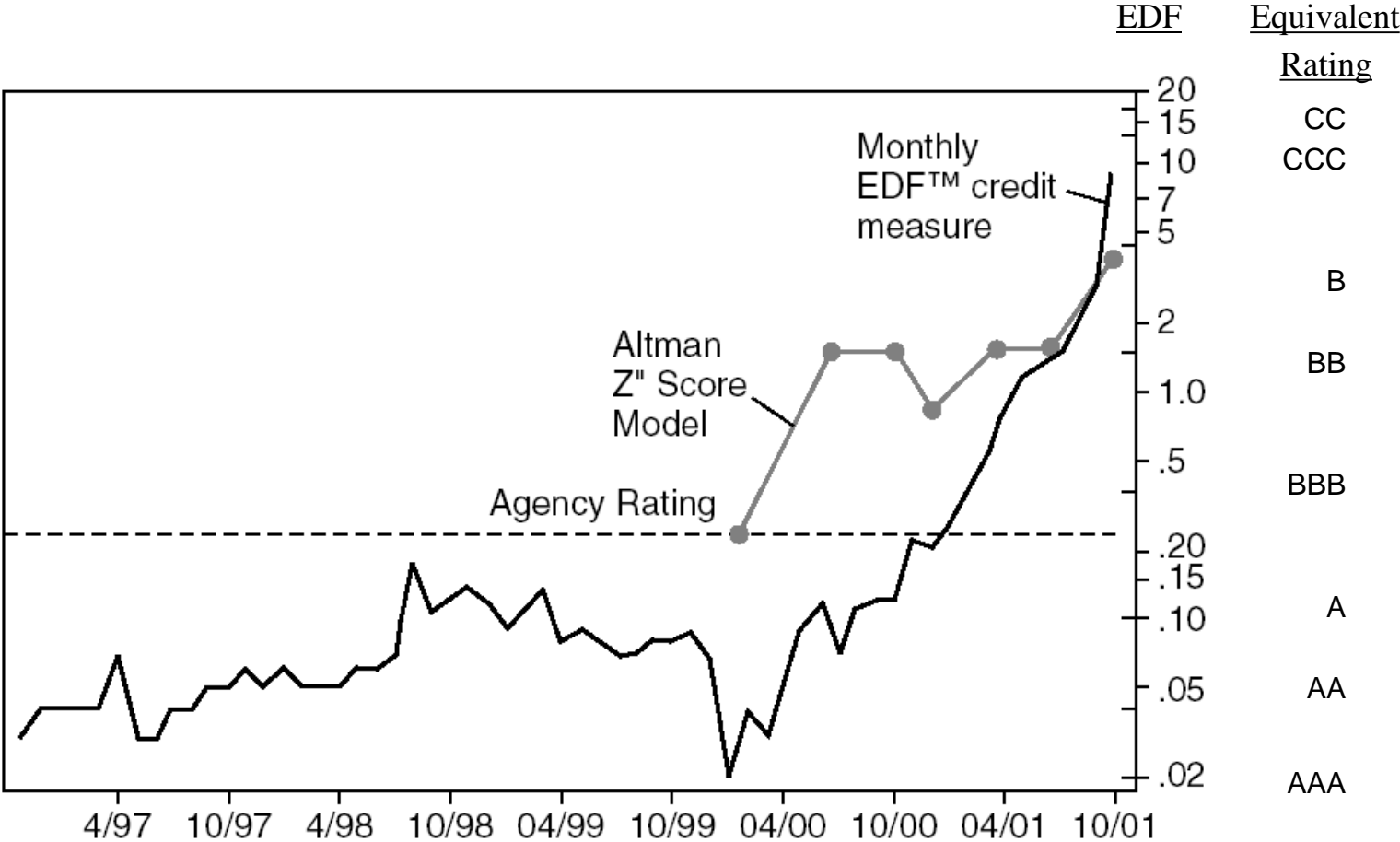
## December 2003 – June 2011

Date	Z-Score	Z''-Score
12/31/03	0.35	2.30
03/31/04	0.46	2.55
06/30/04	0.52	2.63
09/30/04	0.49	2.53
12/31/04	0.44	2.32
03/31/05	0.42	2.25
06/30/05	0.46	2.32
09/30/05	0.51	2.41
12/31/05	0.51	2.27
03/31/06	0.58	2.36
06/30/06	0.66	2.62
09/30/06	0.71	2.70
12/31/06	0.80	2.71
03/31/07	0.86	2.89
06/30/07	0.86	3.02
09/30/07	0.86	2.97
12/31/07	0.94	3.16
03/31/08	0.77	2.86
06/30/08	0.67	2.71
09/30/08	0.63	2.29
12/31/08	0.37	1.16
03/31/09	0.27	1.02
06/30/09	0.24	1.09
09/30/09	0.28	1.64
12/31/09	0.23	1.55
03/31/10	0.19	1.40
06/30/10	0.22	1.36
09/30/10	0.32	1.47
12/31/10	0.40	1.53
03/31/11	0.43	1.91
06/30/11	0.36	1.49



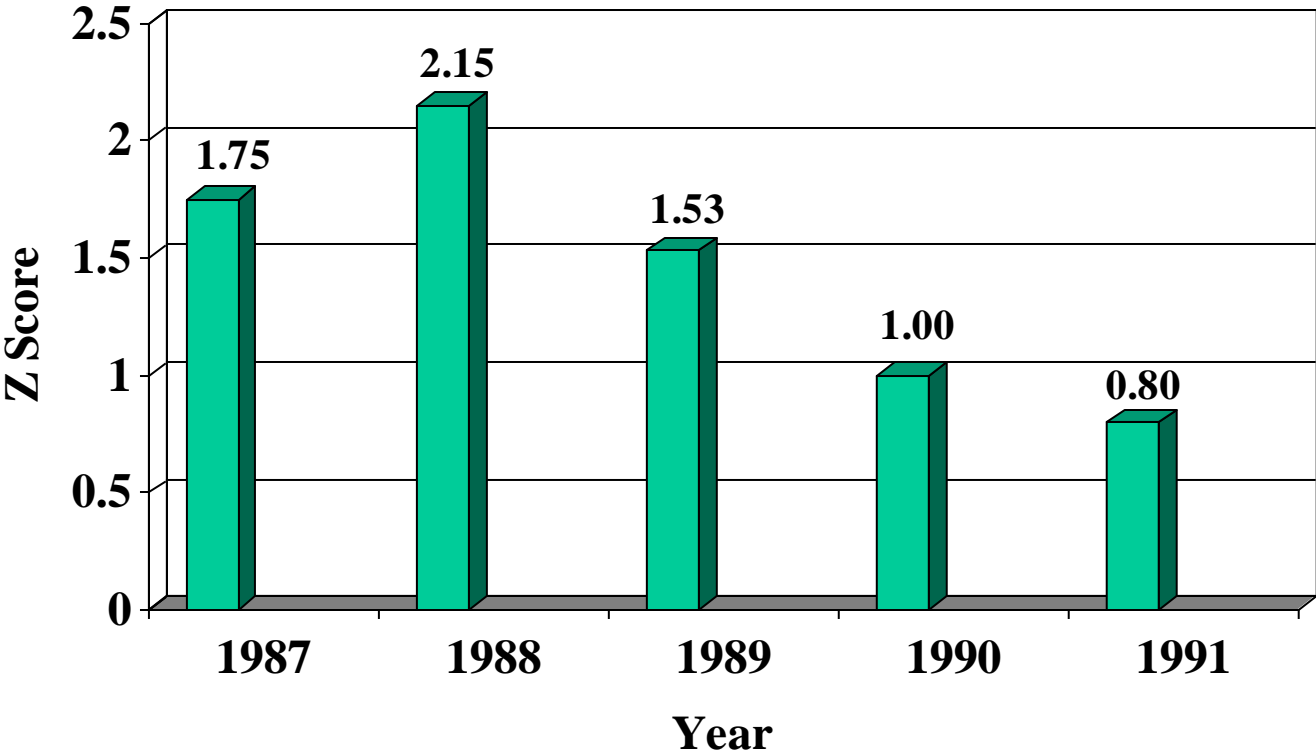


# Enron Credit Risk Measures



Source: A. Saunders and L. Allen, *Credit Risk Measurement*; J. Wiley, 2002

# DAF Corporation Z Scores (Dutch Company Bankruptcy 1993)



# Financial Distress Prediction Applications

- Lenders
- Investors
- Long/Short Investment Strategy on Stocks
- Security Analysts
- Regulators & Gov' t Agencies
- Auditors
- Legal Direction – e.g. “Deepening Insolvency”
- Credit Rating Agencies
- Sovereign Default Risk Assessment
- Advisors
- M&A
- Purchasers, Suppliers
- Accounts Receivable Management
- Researchers
- Chapter 22 Avoidance
- MANAGERS
  - Managing a Financial Turnaround