The Evolution & Applications of the Altman Z-Score Family of Models

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Washington D.C.
June 26, 2019

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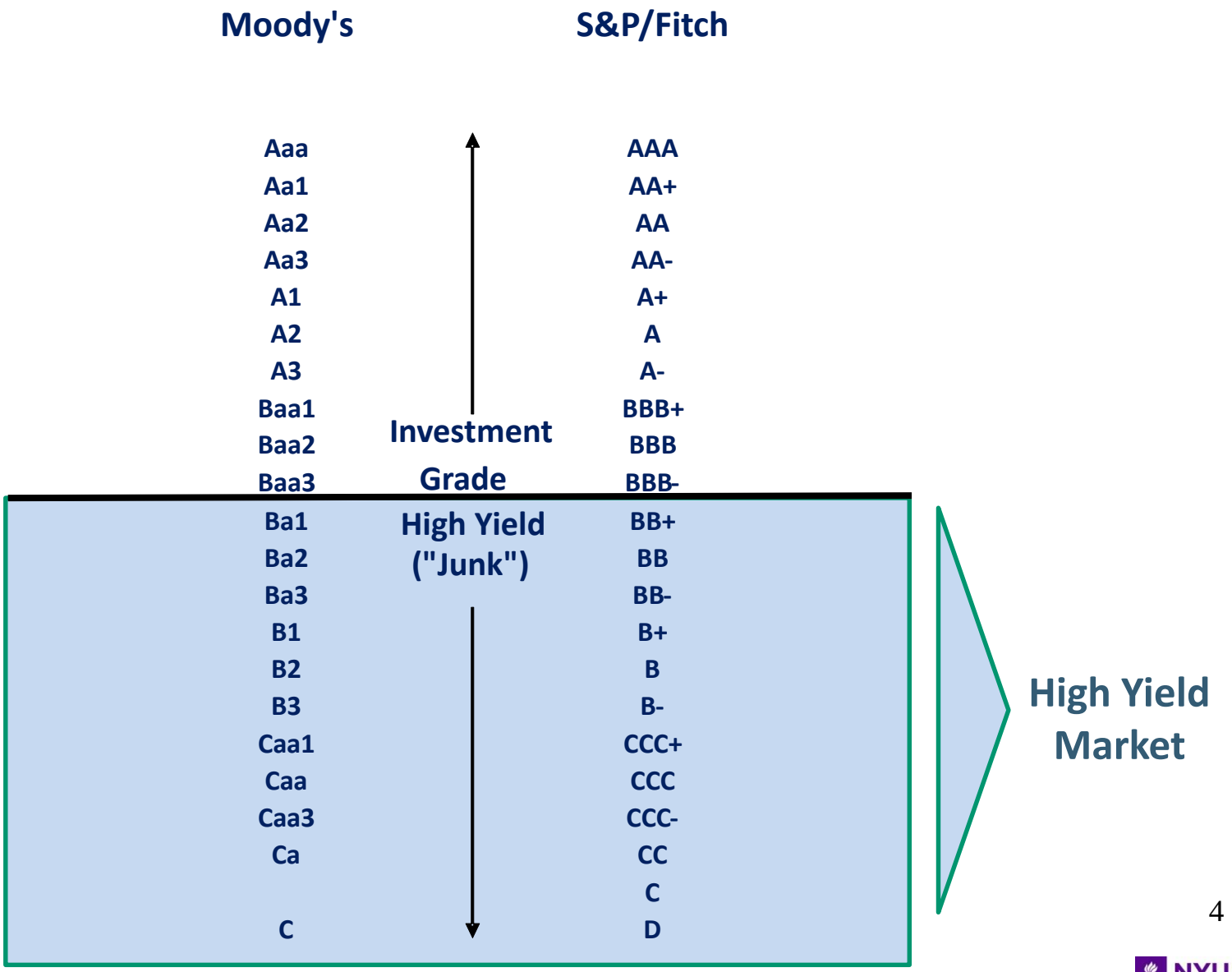
Scoring Systems

- Qualitative (Subjective) – 1800s
- Univariate (Accounting/Market Measures)
  - Rating Agency (e.g. *Moody's* (1909), *S&P Global Ratings* (1916) and Corporate (e.g., *DuPont*) Systems (early 1900s)
- Multivariate (Accounting/Market Measures) – 1968 (Z-Score) → Present
  - Discriminant, Logit, Probit Models (Linear, Quadratic)
  - Non-Linear and "Black-Box" Models (e.g., Recursive Partitioning, Neural Networks, 1990s), Machine Learning , Hybrid
- Discriminant and Logit Models in Use for
  - Consumer Models - *Fair Isaacs* (FICO Scores)
  - Manufacturing Firms (1968) – Z-Scores
  - Extensions and Innovations for Specific Industries and Countries (1970s – Present)
  - ZETA Score – Industrials (1977)
  - Private Firm Models (e.g., Z'-Score (1983), Z"-Score (1995))
  - EM Score – Emerging Markets (1995)
  - Bank Specialized Systems (1990s)
  - SMEs (e.g. Edmister (1972), Altman & Sabato (2007) & *Wiserfunding* (2016))
- Option/Contingent Claims Models (1970s – Present)
  - Risk of Ruin (Wilcox, 1973)
  - *KMVs* Credit Monitor Model (1993) – Extensions of Merton (1974) Structural Framework

Scoring Systems
(continued)

- Artificial Intelligence Systems (1990s – Present)
  - Expert Systems
  - Neural Networks
  - Machine Learning
- Blended Ratio/Market Value/Macro/Governance/Invoice Data Models
  - Altman Z-Score (*Fundamental Ratios and Market Values)* – 1968
  - Bond Score (*Credit Sights*, 2000; RiskCalc *Moody's*, 2000)
  - Hazard (Shumway), 2001)
  - *Kamakura's* Reduced Form, Term Structure Model (2002)
  - Z-Metrics (Altman, et al, *Risk Metrics*©, 2010)
- Re-introduction of Qualitative Factors/FinTech
  - Stand-alone Metrics, e.g., Invoices, Payment History
  - Multiple Factors – Data Mining (Big Data Payments, Governance, time spent on individual firm reports [e.g., *CreditRiskMonitor's* revised FRISK Scores, 2017], etc.)

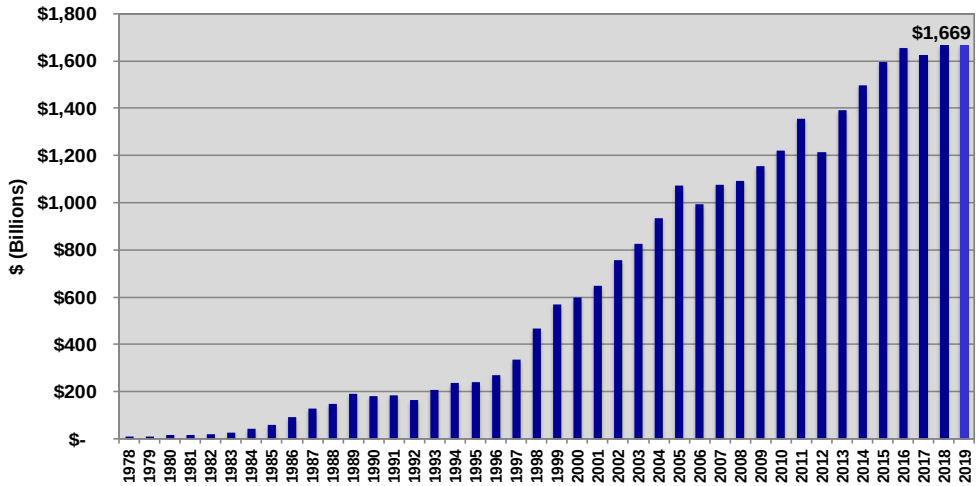
Major Agencies Bond Rating Categories



Size Of High-Yield Bond Market

US Market

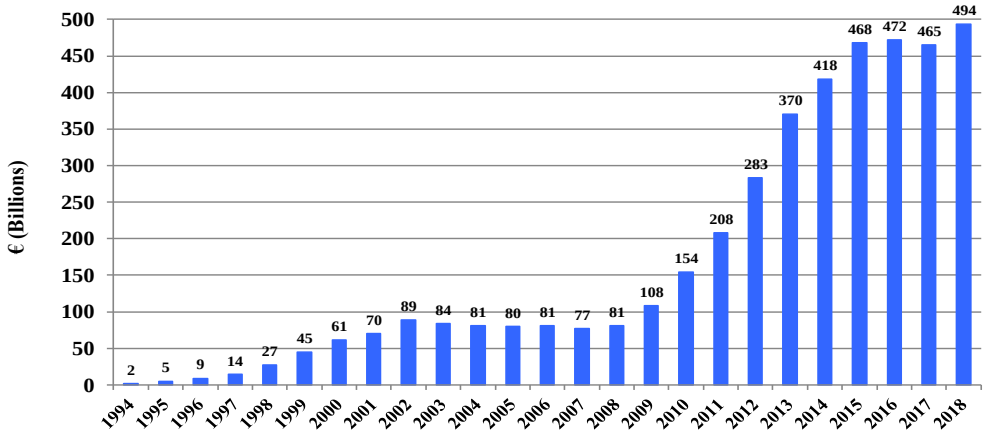
1978 – 2019 *(Mid-year US$ billions)*



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

Western Europe Market

1994 – 2018*



Source: Credit Suisse

*Includes non-investment grade straight corporate debt of issuers with assets located in or revenues derived from Western Europe, or the bond is denominated in a Western European currency. Floating-rate and convertible bonds and preferred stock are not included.

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

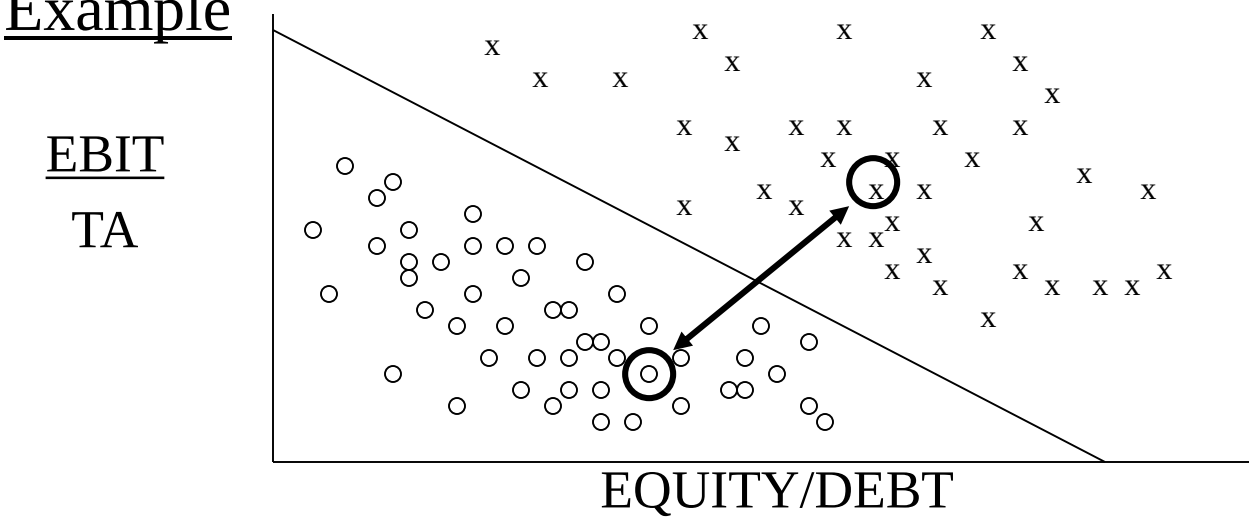
$Z = a_1x_1 + a_2x_2 + a_3x_3 + \ldots\ldots + a_nx_n$

Z = Discriminant Score (Z Score)

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

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

Example



Z-Score Component Definitions and Weightings

Variable	Definition	Weighting Factor
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

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

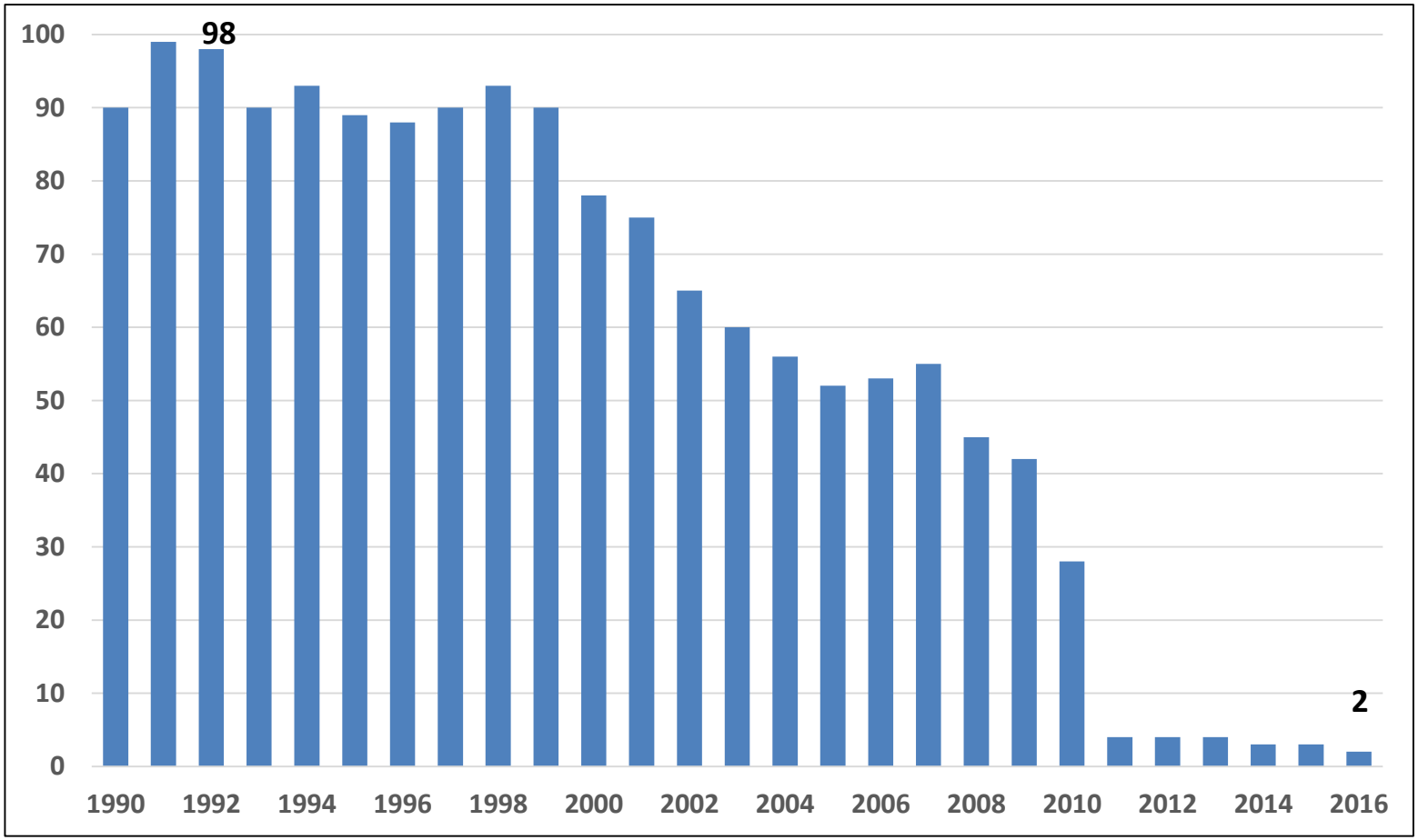
Time Series Impact On Corporate Z-Scores

- Credit Risk Migration
  - Greater Use of Leverage
  - Impact of HY Bond & LL Markets
  - Global Competition
  - More and Larger Bankruptcies
  - Near Extinction of U.S. AAA Firms

- Increased Type II Error

The Near Extinction of the U.S. AAA Rated Company

Number of AAA Rated Groups in the U.S.



Sources: Standard & Poor's, Estimated from Platt, E., "Triple A Quality Fades as Companies Embrace Debt", *Financial Times*, May 24, 2016.

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 - 2017

Rating	2017 (No.)	2013 (No.)	2004-2010	1996-2001	1992-1995
AAA/AA	4.20 (14)	4.13 (15)	4.18	6.20*	4.80*
A	3.85 (55)	4.00 (64)	3.71	4.22	3.87
BBB	3.10 (137)	3.01 (131)	3.26	3.74	2.75
BB	2.45 (173)	2.69 (119)	2.48	2.81	2.25
B	1.65 (94)	1.66 (80)	1.74	1.80	1.87
CCC/CC	0.73 (4)	0.23 (3)	0.46	0.33	0.40
D	-0.10 (6)[1]	0.01 (33)[2]	-0.04	-0.20	0.05

*AAA Only.
[1] From 1/2014-11/2017, [2]From 1/2011-12/2013.

Sources: S&P Global Market Intelligence's *Compustat* Database, mainly S&P 500 firms, compilation by NYU Salomon Center, Stern School of Business.

Marginal and Cumulative Mortality Rate Actuarial Approach

$$\mathbf{MMR_{(r,t)}} \quad \frac{\textit{total value of defaulting debt from rating (r) in year (t)}}{\textit{total value of the population at the start of the year (t)}}$$

$\overline{M}$MR = 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,

$$\boldsymbol{CMR}_{(r,t)} = 1 - \Pi\, SR_{(r,t)}\ ,$$
$$t = 1 \rightarrow N$$
$$r = AAA \rightarrow CCC$$

here $CMR_{(r,t)}$ = Cumulative Mortality Rate of (r) in (t),

$SR_{(r,t)}$ = Survival Rate in $_{(r,t)}$, 1 - $MMR_{(r,t)}$

Mortality Rates by Original Rating

All Rated Corporate Bonds*
1971-2018

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%	0.18%	0.05%	0.02%	0.01%	0.03%	0.04%	0.03%	0.04%
	Cumulative	0.00%	0.00%	0.18%	0.23%	0.25%	0.26%	0.29%	0.33%	0.36%	0.40%
A	Marginal	0.01%	0.02%	0.09%	0.10%	0.07%	0.04%	0.02%	0.22%	0.05%	0.03%
	Cumulative	0.01%	0.03%	0.12%	0.22%	0.29%	0.33%	0.35%	0.57%	0.62%	0.65%
BBB	Marginal	0.29%	2.26%	1.20%	0.95%	0.46%	0.20%	0.21%	0.15%	0.15%	0.31%
	Cumulative	0.29%	2.54%	3.71%	4.63%	5.07%	5.26%	5.46%	5.60%	5.74%	6.03%
BB	Marginal	0.89%	2.01%	3.79%	1.95%	2.38%	1.52%	1.41%	1.07%	1.38%	3.07%
	Cumulative	0.89%	2.88%	6.56%	8.38%	10.57%	11.92%	13.17%	14.10%	15.28%	17.88%
B	Marginal	2.84%	7.62%	7.71%	7.73%	5.71%	4.44%	3.58%	2.03%	1.70%	0.71%
	Cumulative	2.84%	10.24%	17.16%	23.57%	27.93%	31.13%	33.60%	34.94%	36.05%	36.50%
CCC	Marginal	8.05%	12.36%	17.66%	16.21%	4.87%	11.58%	5.38%	4.76%	0.61%	4.21%
	Cumulative	8.05%	19.42%	33.65%	44.40%	47.11%	53.23%	55.75%	57.86%	58.11%	59.88%

*Rated by S&P at Issuance
Based on 3,454 issues

Source: S&P Global Ratings and Author's Compilation

Mortality Losses by Original Rating

All Rated Corporate Bonds*
1971-2018

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%	0.01%	0.02%	0.01%	0.01%	0.00%	0.01%	0.01%	0.01%
	Cumulative	0.00%	0.00%	0.01%	0.03%	0.04%	0.05%	0.05%	0.06%	0.07%	0.08%
A	Marginal	0.00%	0.01%	0.03%	0.03%	0.04%	0.04%	0.02%	0.01%	0.04%	0.02%
	Cumulative	0.00%	0.01%	0.04%	0.07%	0.11%	0.15%	0.17%	0.18%	0.22%	0.24%
BBB	Marginal	0.20%	1.47%	0.68%	0.56%	0.24%	0.14%	0.07%	0.08%	0.08%	0.16%
	Cumulative	0.20%	1.67%	2.34%	2.88%	3.12%	3.25%	3.32%	3.40%	3.47%	3.63%
BB	Marginal	0.53%	1.14%	2.26%	1.09%	1.35%	0.74%	0.79%	0.49%	0.70%	1.05%
	Cumulative	0.53%	1.66%	3.89%	4.93%	6.22%	6.91%	7.65%	8.10%	8.74%	9.70%
B	Marginal	1.88%	5.33%	5.30%	5.18%	3.76%	2.41%	2.33%	1.12%	0.88%	0.50%
	Cumulative	1.88%	7.11%	12.03%	16.59%	19.73%	21.66%	23.49%	24.34%	25.01%	25.38%
CCC	Marginal	5.33%	8.65%	12.45%	11.43%	3.39%	8.58%	2.28%	3.30%	0.37%	2.66%
	Cumulative	5.33%	13.52%	24.29%	32.94%	35.21%	40.77%	42.12%	44.03%	44.24%	45.72%

*Rated by S&P at Issuance
Based on 2,894 issues

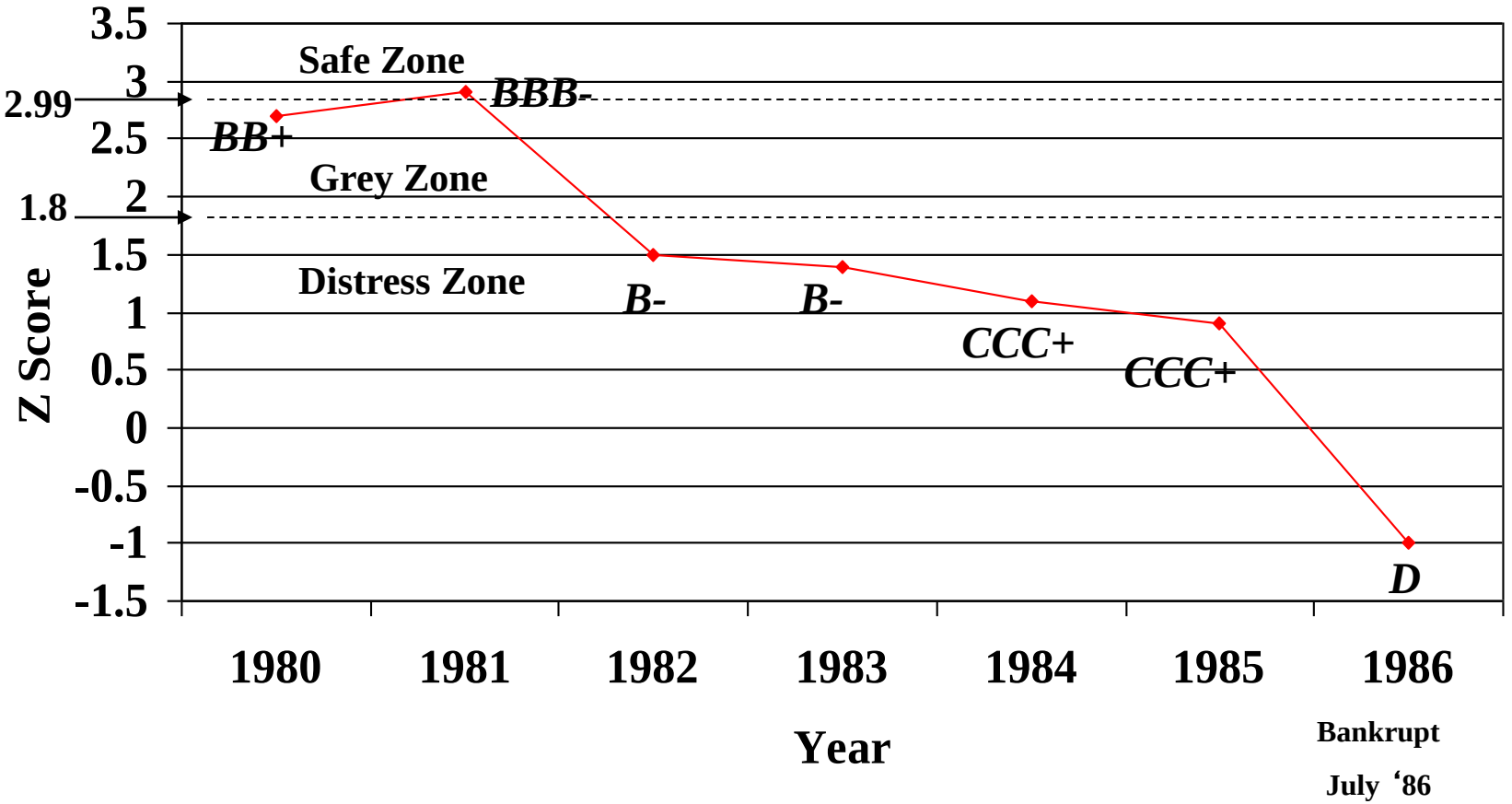
Source: S&P Global Ratings and Author's Compilation

Classification & Prediction Accuracy
Z Score (1968) Failure Model*

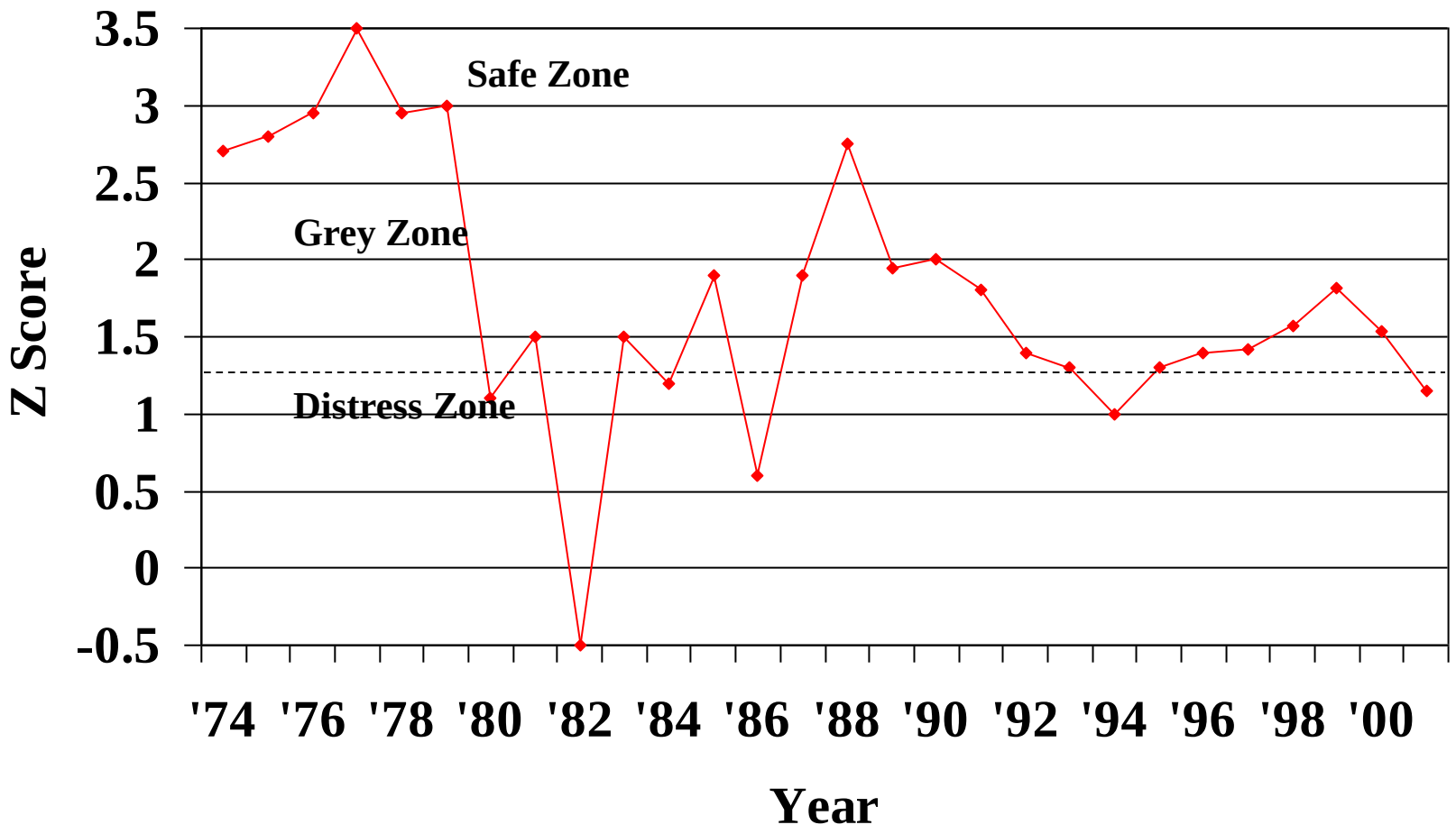
Year Prior To Failure	Original Sample (33)	Holdout Sample (25)	1969-1975 Predictive Sample (86)	1976-1995 Predictive Sample (110)	1997-1999 Predictive Sample (120)
1	94% (88%)	96% (72%)	82% (75%)	85% (78%)	94% (84%)
2	72%	80%	68%	75%	74%
3	48%	-	-	-	-
4	29%	-	-	-	-
5	36%	-	-	-	-

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

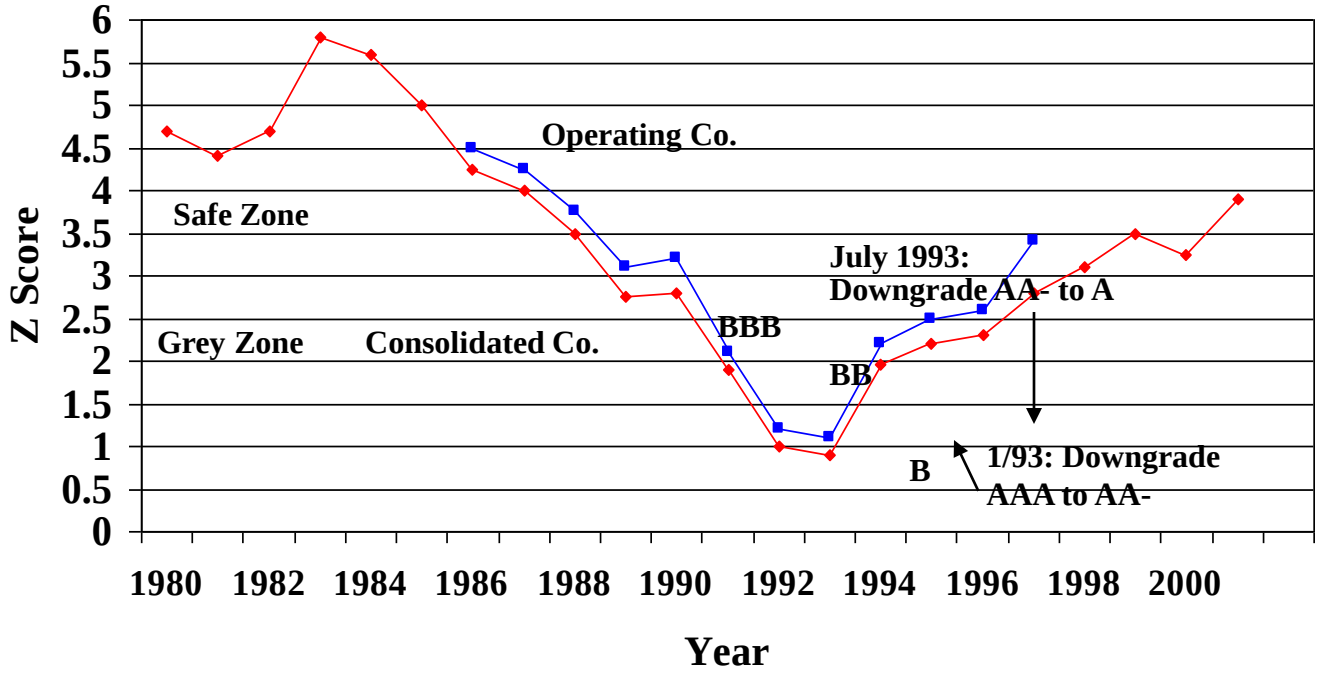
Z Score Trend - LTV Corp.



International Harvester (Navistar)
Z Score (1974 – 2001)



IBM Corporation
Z Score (1980 – 2001, update 2015-2017)



Recent Z-Scores & BREs			
Year -End	Z-Score	BRE	Actual S&P Rating
2015	3.63	A-	
2016	3.58	A-	
2017	3.27	BBB+	A+

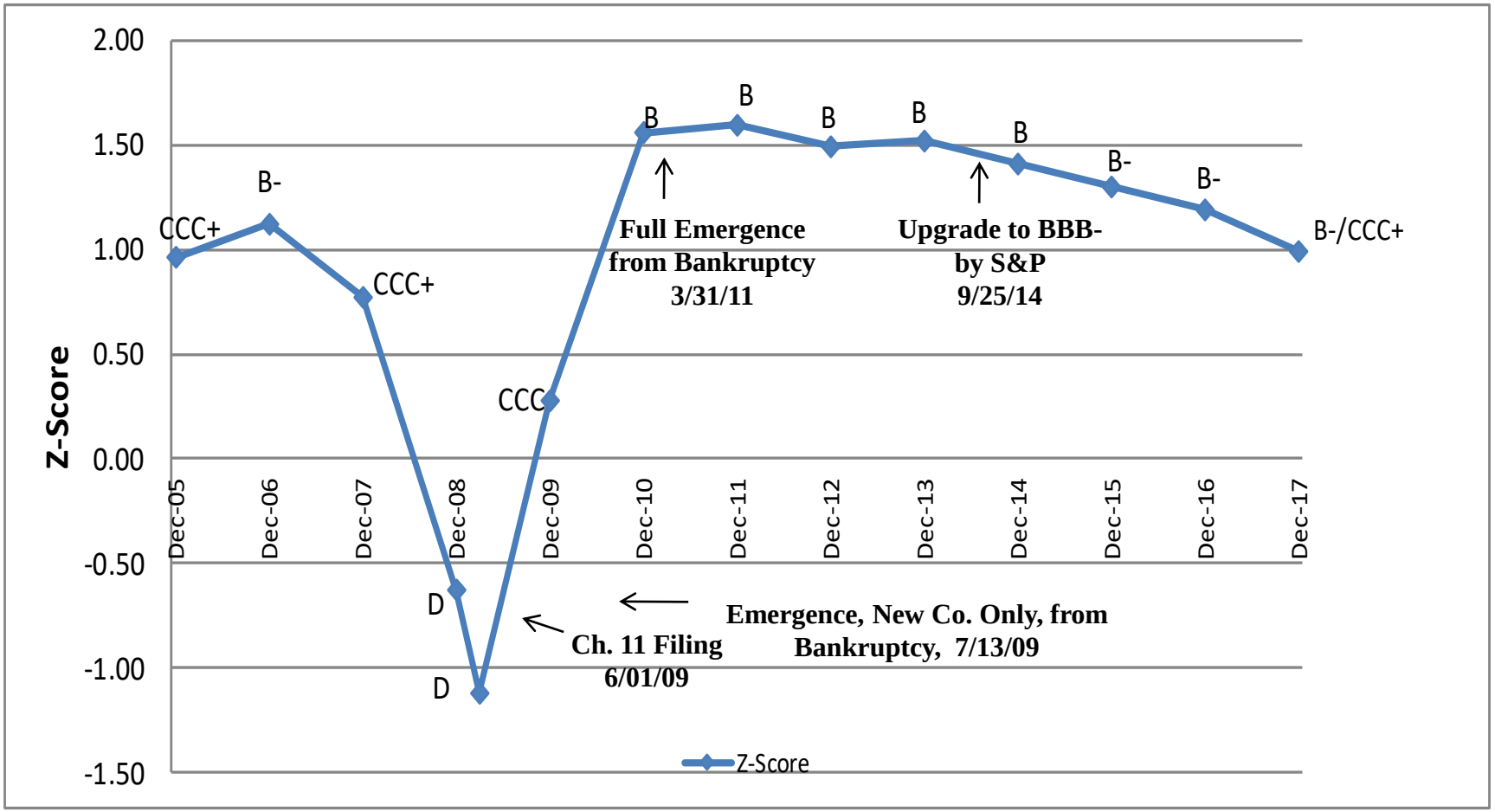
Z-Score Model Applied to General Motors (Consolidated Data): Bond Rating Equivalents and Scores from 2005 – 2017

	Z-Scores	BRE
12/31/17	0.99	B-/CCC+
12/31/16	1.19	B-
12/31/15	1.30	B-
12/31/14	1.41	B
12/31/13	1.52	B
12/31/12	1.49	B
12/31/11	1.59	B
12/31/10	1.56	B
12/31/09	0.28	CCC
03/31/09	(1.12)	D
12/31/08	(0.63)	D
12/31/07	0.77	CCC+
12/31/06	1.12	B-
12/31/05	0.96	CCC+

Note: Consolidated Annual Results. Data Source: S&P Global Market Intelligence's S&P Capital IQ platform, Bloomberg., Edgar

Z-Score Model Applied to GM (Consolidated Data): Bond Rating Equivalents and Scores from 2005 – 2017

Z- Score: General Motors Co.



Applying the Z Score Models to Recent Energy & Mining Company Bankruptcies

2015-9/15/2017

BREs	Z-Score				Z''-Score			
	t-1*		t-2**		t-1*		t-2**	
	#	%	#	%	#	%	#	%
A								
BBB+								
BBB								
BBB-								
BB+							1	2%
BB							0	0%
BB-							3	5%
B+					1	2%	1	2%
B			2	6%	3	5%	13	24%
B-					3	5%	6	11%
CCC+					1	2%	8	15%
CCC	5	16%	12	39%	2	4%	8	15%
CCC-					4	7%	9	16%
D	26	84%	17	55%	41	75%	6	11%
Total	**31**	**100%**	**31**	**100%**	**55**	**100%**	**55**	**100%**

* One or Two Quarters before Filing
** Five or Six Quarters before Filing

Source: S&P Capital IQ

Z-Score: Actual Data for Energy & Mining Companies

2015-9/15/2017

Company	Date	Z-Score		BRE	
		t-1 *	t-2 **	t-1 *	t-2 **
Cal Dive International, Inc.	3/3/2015	(0.48)	0.61	D	CCC/CC
Dune Energy, Inc.	3/8/2015	(0.62)	0.12	D	D
BPZ Resources, Inc.	3/9/2015	(2.97)	(0.71)	D	D
Quicksilver Resources, Inc.	3/17/2015	(3.09)	(0.84)	D	D
Xinergy Ltd.	4/6/2015	(2.27)	(2.05)	D	D
American Eagle Energy Corp.	5/8/2015	(1.65)	0.86	D	CCC/CC
Molycorp., Inc.	6/25/2015	(0.79)	0.00	D	D
Sabine Oil & Gas Corp.	7/15/2015	(2.70)	(0.65)	D	D
Walter Energy, Inc.	7/15/2015	(7.78)	0.10	D	D
Alpha Natural Resources, Inc.	8/3/2015	(0.89)	(0.17)	D	D
Miller Energy Resources, Inc.	10/1/2015	(8.41)	0.69	D	CCC/CC
Offshore Group Investment Ltd.	12/3/2015	0.41	0.50	CCC/CC	CCC/CC
Cubic Energy, Inc.	12/11/2015	(0.88)	(1.64)	D	D
Paragon Offshore, LLC	2/14/2016	0.23	0.75	CCC/CC	CCC/CC
Emerald Oil, Inc.	3/22/2016	(2.50)	0.01	D	D
Southcross Holdings, L.P.	3/27/2016	0.64	1.27	CCC/CC	B
Energy XXI Ltd.	4/14/2016	(7.96)	0.16	D	CCC/CC
SunEdison, Inc.	4/21/2016	(0.01)	0.22	D	CCC/CC
Ultra Petroleum Corp.	4/29/2016	(8.46)	1.02	D	B
Midstates Petroleum Co., Inc.	4/30/2016	(7.23)	0.52	D	CCC/CC
Breitburn Energy Partners LP	5/15/2016	0.24	0.61	CCC/CC	CCC/CC
Warren Resources, Inc.	6/2/2016	(13.49)	(0.29)	D	D
Triangle USA Petroleum Corp.	6/29/2016	(2.71)	0.71	D	CCC/CC
Halcón Resources Corp.	7/27/2016	(3.34)	(0.12)	D	D
Bonanza Creek Energy, Inc.	1/4/2017	(2.08)	(2.64)	D	D
Memorial Production Partners LP	1/16/2017	(1.33)	(0.58)	D	D
Forbes Energy Services Ltd.	1/22/2017	(2.33)	0.08	D	D
Vanguard Natural Resources, LLC	2/1/2017	(2.68)	(1.79)	D	D
Nuverra Environmental Solutions, Inc.	5/1/2017	(8.84)	(5.24)	D	D
Gulfmark Offshore, Inc.	5/17/2017	(0.52)	0.58	D	CCC/CC
Seadrill Ltd.	9/12/2017	0.58	0.27	CCC/CC	CCC/CC

* One or Two Quarters before Filing, ** Five or Six Quarters before Filing
Source: S&P Capital IQ

Z”-Score: Actual Data for Energy & Mining Companies

2015

Company	Date	Z''-Score		BRE	
		t-1 *	t-2 **	t-1 *	t-2 **
Cal Dive International, Inc.	3/3/2015	(0.48)	3.28	D	CCC+
Dune Energy, Inc.	3/8/2015	1.08	3.16	CCC-	CCC+
BPZ Resources, Inc.	3/9/2015	(6.38)	0.88	D	CCC-
Allied Nevada Gold Corp.	3/10/2015	(0.47)	5.65	D	BB+
Quicksilver Resources, Inc.	3/17/2015	(10.87)	0.30	D	CCC-
Venoco, Inc.	3/18/2015	4.07	1.84	B	CCC-
Xinergy Ltd.	4/6/2015	(3.62)	(1.89)	D	D
American Eagle Energy Corp.	5/8/2015	(4.55)	4.25	D	B
Saratoga Resources, Inc.	6/18/2015	(23.78)	3.06	D	CCC+
Molycorp., Inc.	6/25/2015	1.79	3.23	CCC-	CCC+
Sabine Oil & Gas Corp.	7/15/2015	(8.58)	0.94	D	CCC-
Walter Energy, Inc.	7/15/2015	(20.20)	3.09	D	CCC+
Alpha Natural Resources, Inc.	8/3/2015	(0.25)	2.69	D	CCC
Hercules Offshore, Inc.	8/13/2015	(3.50)	3.21	D	CCC+
Samson Resources Corp.	9/16/2015	(4.90)	2.28	D	CCC
Miller Energy Resources, Inc.	10/1/2015	(18.53)	4.40	D	B
RAAM Global Energy Co.	10/26/2015	(1.61)	3.95	D	B
Offshore Group Investment Ltd.	12/3/2015	3.90	3.98	B	B
Energy & Exploration Partners, Inc.	12/7/2015	3.75	3.36	B-	B-
Cubic Energy, Inc.	12/11/2015	(2.37)	(3.24)	D	D
Magnum Hunter Resources Corp.	12/15/2015	(6.34)	1.00	D	CCC-
Swift Energy Co.	12/31/2015	(12.04)	3.91	D	B

* One or Two Quarters before Filing, ** Five or Six Quarters before Filing

Source: S&P Capital IQ

Z”-Score: Actual Data for Energy & Mining Companies

2016

Company	Date	Z''-Score		BRE	
		t-1 *	t-2 **	t-1 *	t-2 **
Arch Coal, Inc.	1/11/2016	(8.76)	3.66	D	B-
Paragon Offshore, LLC	2/14/2016	3.50	3.60	B-	B-
Emerald Oil, Inc.	3/22/2016	(5.96)	3.00	D	CCC+
Southcross Holdings, L.P.	3/27/2016	4.24	4.14	B	B
Peabody Energy Corp.	4/13/2016	(0.54)	3.91	D	B
Energy XXI Ltd.	4/14/2016	(26.02)	3.49	D	B-
Goodrich Petroleum Corp.	4/15/2016	(124.59)	(4.95)	D	D
SunEdison, Inc.	4/21/2016	3.04	2.56	CCC+	CCC
Ultra Petroleum Corp.	4/29/2016	(33.33)	3.85	D	B-
Midstates Petroleum Co., Inc.	4/30/2016	(25.60)	3.99	D	B
Chaparral Energy, Inc.	5/9/2016	(8.47)	5.27	D	BB-
Linn Energy, LLC	5/11/2016	(3.51)	4.23	D	B
Penn Virginia Corp.	5/12/2016	(30.63)	1.02	D	CCC-
Breitburn Energy Partners LP	5/15/2016	3.88	4.94	B-	BB-
Sandridge Energy, Inc.	5/16/2016	(15.02)	1.88	D	CCC-
Warren Resources, Inc.	6/2/2016	(42.00)	2.19	D	CCC
Hercules Offshore, Inc.	6/5/2016	2.18	1.76	CCC	CCC-
Seventy Seven Energy, Inc.	6/7/2016	2.68	4.26	CCC	B
Triangle USA Petroleum Corp.	6/29/2016	(7.21)	3.77	D	B-
C&J Energy Services Ltd.	7/20/2016	(5.89)	4.84	D	B+
Atlas Resource Partners LP	7/26/2016	(6.86)	3.89	D	B
Halcón Resources Corp.	7/27/2016	(9.59)	2.31	D	CCC
Key Energy Services, Inc.	10/24/2016	(8.30)	2.39	D	CCC
Basic Energy Services, Inc.	10/25/2016	(6.01)	2.68	D	CCC
Stone Energy Corp.	12/14/2016	(4.06)	1.06	D	CCC-

* One or Two Quarters before Filing, ** Five or Six Quarters before Filing

Source: S&P Capital IQ

Z”-Score: Actual Data for Energy & Mining Companies

2017 (9/15)

Company	Date	Z''-Score		BRE	
		t-1 *	t-2 **	t-1 *	t-2 **
Bonanza Creek Energy, Inc.	1/4/2017	(5.14)	(2.94)	D	D
Memorial Production Partners LP	1/16/2017	(3.00)	2.38	D	CCC
Forbes Energy Services Ltd.	1/22/2017	(6.12)	2.97	D	CCC+
Vanguard Natural Resources, LLC	2/1/2017	(8.67)	(0.78)	D	D
Nuverra Environmental Solutions, Inc.	5/1/2017	(24.13)	(14.26)	D	D
Gulfmark Offshore, Inc.	5/17/2017	0.51	5.00	CCC-	BB-
CGG Holding (U.S.), Inc.	6/14/2017	0.16	4.13	CCC-	B
Seadrill Ltd.	9/12/2017	4.63	4.07	B+	B

* One or Two Quarters before Filing, ** Five or Six Quarters before Filing

Source: S&P Capital IQ

Additional Altman Z-Score Models:

Private Firm Model (1968)

Non-U.S., Emerging Markets Models for Non Financial Industrial Firms (1995)

e.g. Latin America (1977, 1995), China (2010), etc.

Sovereign Risk Bottom-Up Model (2011)

SME Models for the U.S. (2007) & Europe

e.g. Italian Minibonds (2016), U.K. (2017), Spain (2018)

An Example of A European SME Model

The Italian SME & Mini-Bond Markets

Our Work with the U.S. H.Y. Bond Market and SMEs Globally (WiserFunding Ltd.)

Italy - Classis Capital, Italian Borsa, Wiserfunding and Minibond Advising, Issuance and Trading

Providing a Credit Market Discipline (Credit Culture) to the Italian Mini-bond Market and SMEs Globally

Z' Score
Private Firm Model

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

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

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

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

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

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

Z" Score Model for Manufacturers, Non-Manufacturer Industrials; Developed and Emerging Market Credits (1995)

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

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

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

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

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

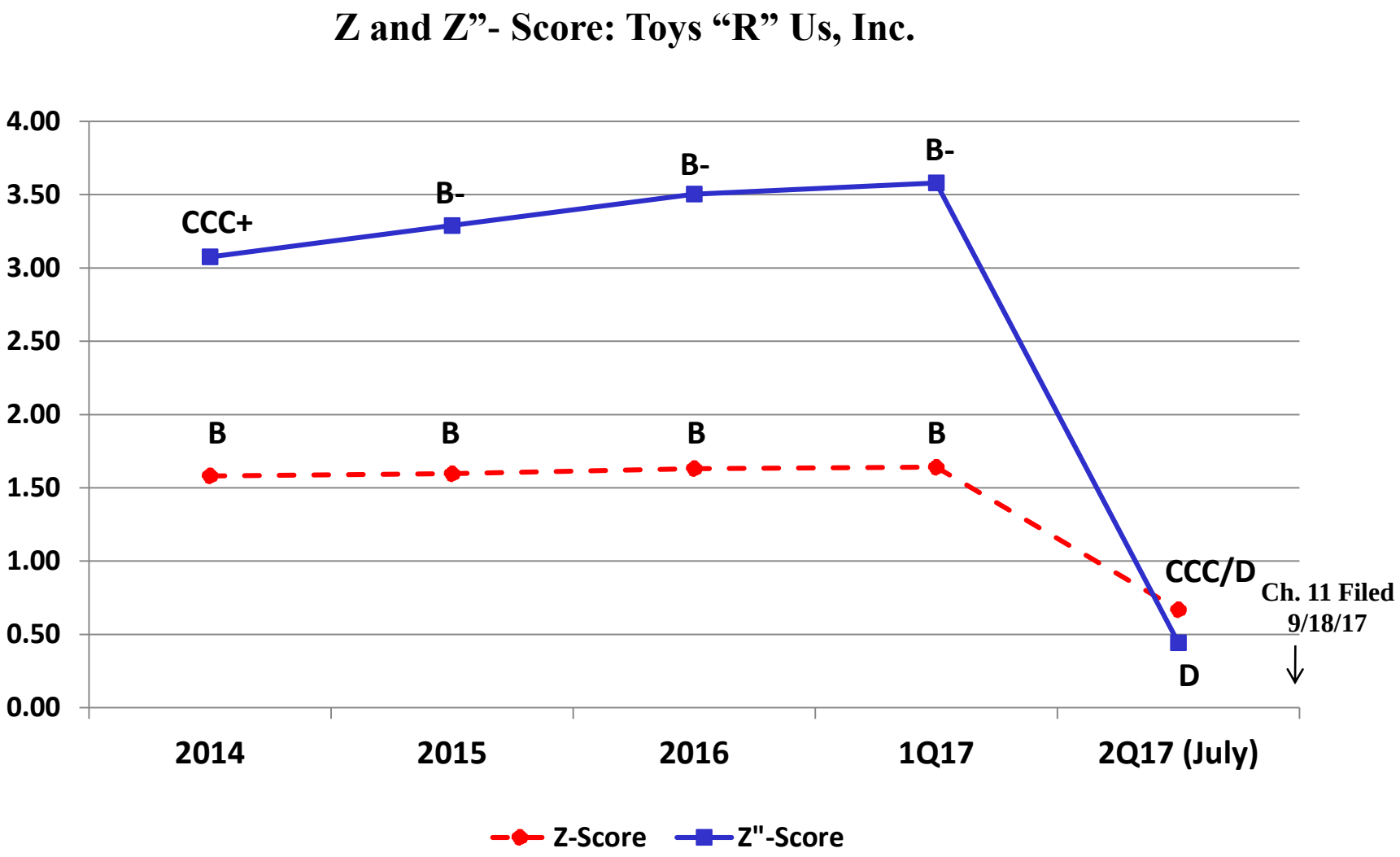
US Bond Rating Equivalents Based on Z”-Score Model

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

Rating	Median 1996 Z”-Score[a]	Median 2006 Z”-Score[a]	Median 2013 Z”-Score[a]
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 (-)[b]	1.72 (-)[b]
CC/D	0 (14)	0.84 (120)	0.05 (94)[c]

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

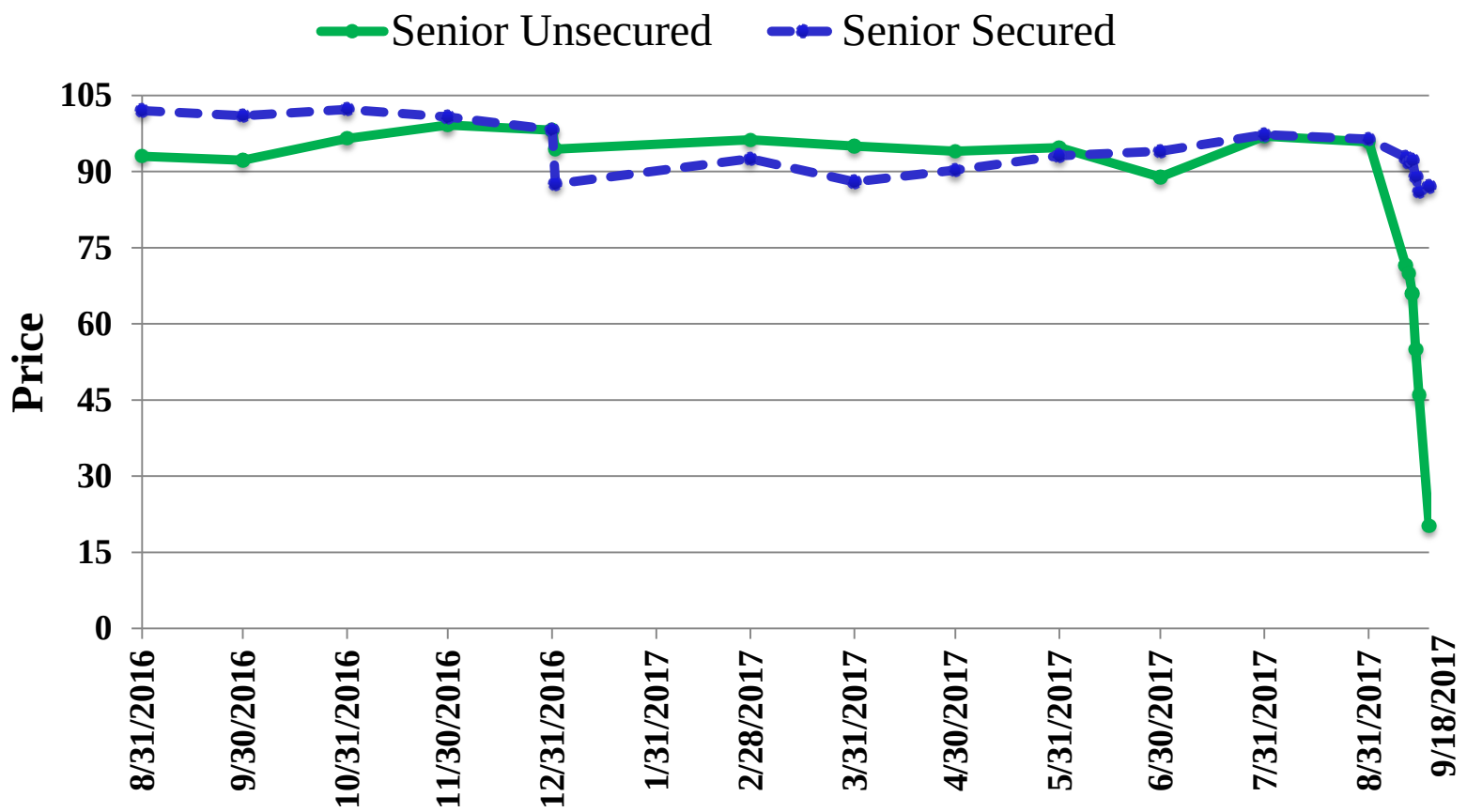
Z and Z”-Score Models Applied to Toys “R” Us, Inc.: Bond Rating Equivalents and Scores from 2014 – 2Q17



Source: E. Altman, NYU Salomon Center

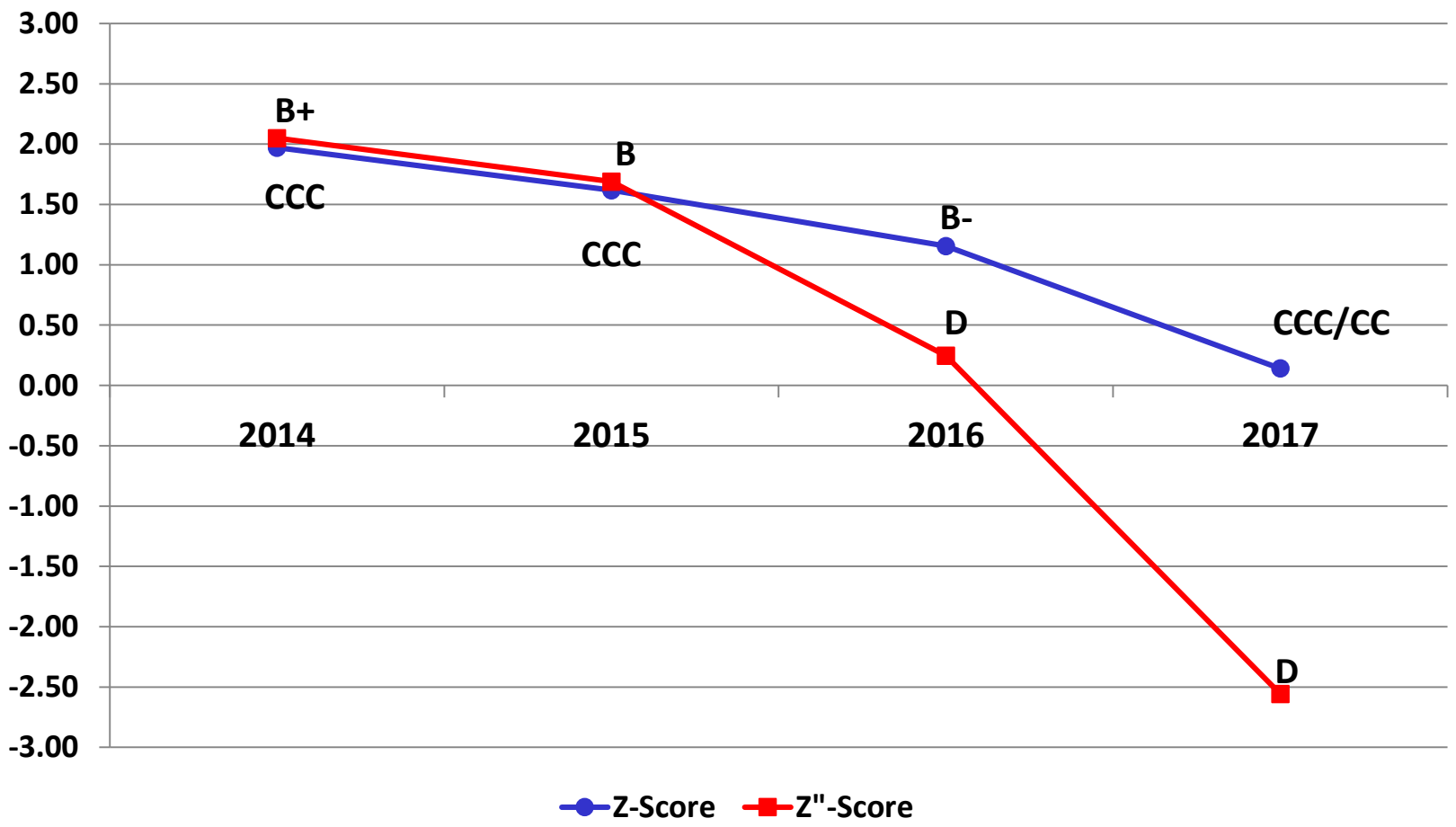
Toys "R" Us, Inc.: Bond Pricing Prior to Default*

August 31, 2016 – September 18, 2017



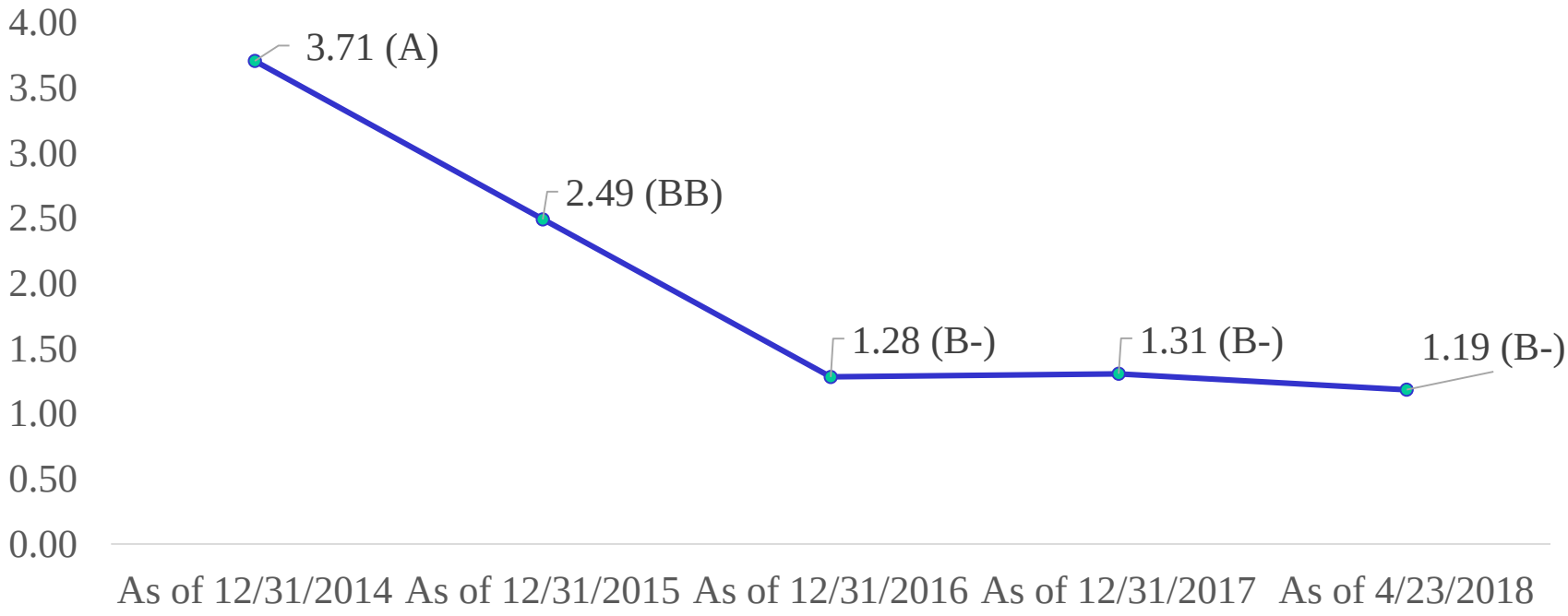
*Prices are at month-end from 8/31/16-8/31/17, then daily from 9/11/17-9/18/17.

Z and Z”-Score Models Applied to Sears, Roebuck & Co.: Bond Rating Equivalents and Scores from 2014 – 2017



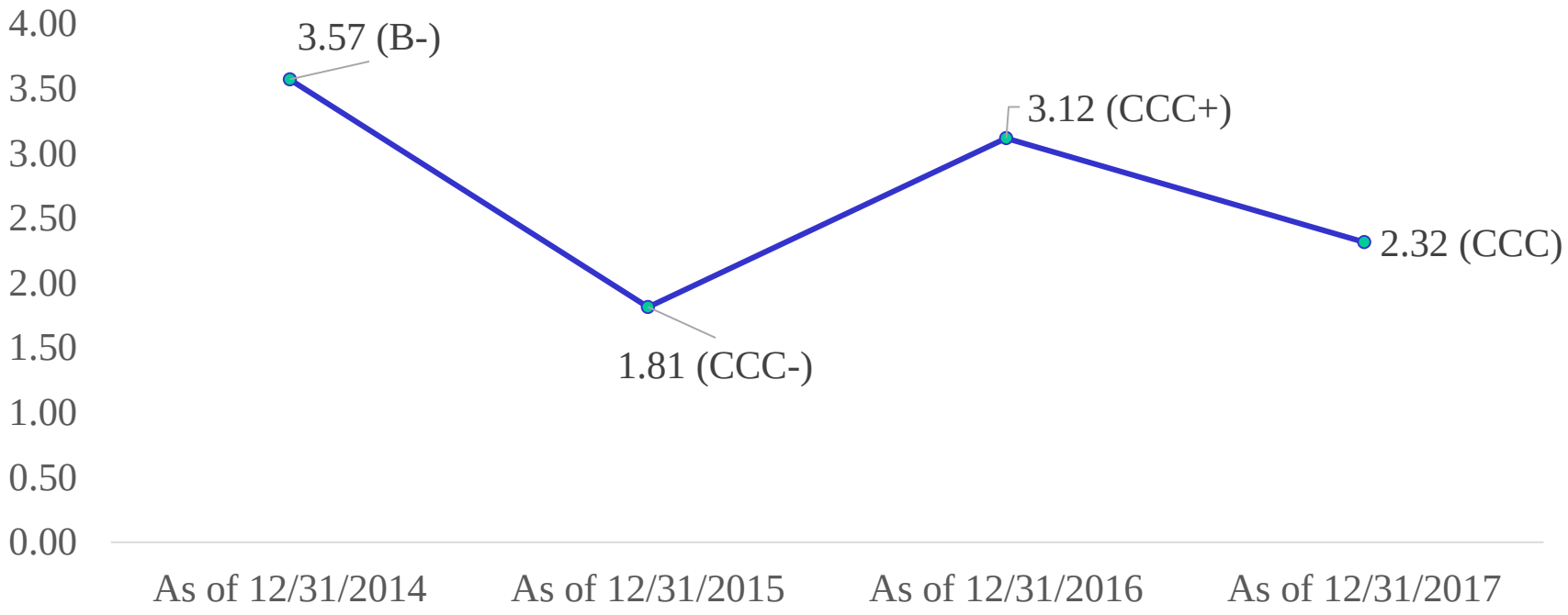
Source: E. Altman, NYU Salomon Center

Tesla Z Scores and BREs (2014 – April 2018)



Source: E. Altman, NYU Salomon Center

Tesla Z" Scores and BREs (2014 – 2017)



Source: E. Altman, NYU Salomon Center

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**, 3rd Edition, John Wiley & Sons, 2006.

Comparative Health of High-Yield Firms (2007 vs. 2017)

Comparing Financial Strength of High-Yield Bond Issuers in 2007& 2012/2014/2017

Number of Firms		
	Z-Score	Z”-Score
2007	294	378
2012	396	486
2014	577	741
2017	529	583

Year	Average Z-Score/ (BRE)*	Median Z-Score/ (BRE)*	Average Z”-Score/ (BRE)*	Median Z”-Score/ (BRE)*
2007	1.95 (B+)	1.84 (B+)	4.68 (B+)	4.82 (B+)
2012	1.76 (B)	1.73 (B)	4.54 (B)	4.63 (B)
2014	2.03 (B+)	1.85 (B+)	4.66 (B+)	4.74 (B+)
2017	2.08 (B+)	1.98 (B+)	5.08 (BB-)	5.09 (BB-)

*Bond Rating Equivalent

Source: Authors’ calculations, data from Altman and Hotchkiss (2006) and S&P Global Market Intelligence’s S&P *Capital IQ platform/Compustat database.*

Equity (Market Value)/Total Liabilities Ratios
(H.Y. Companies, 2007-2016)

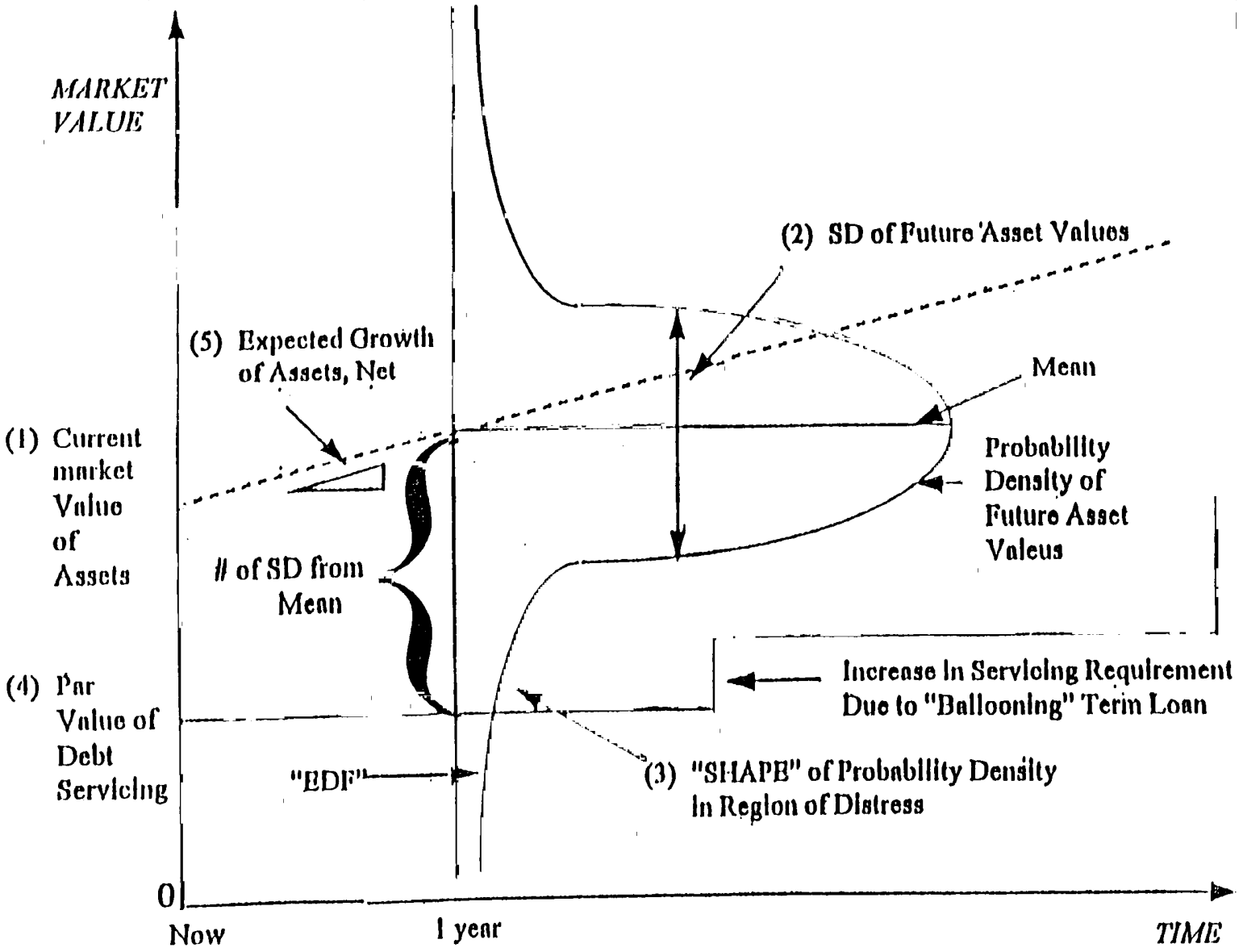
	Average Market Equity/Total Liabilities* (# Firms)
2007	**1.28 (373)**
2008	**0.60 (329)**
2009	**0.98 (322)**
2010	**1.04 (395)**
2011	**0.92 (408)**
2012	**0.95 (481)**
2013	**1.30 (518)**
2014	**1.15 (484)**
2015	**0.97 (427)**
2016	**1.07 (426)**

*X_4 in Z-Score Model
Source: S&P *Capital IQ* & E. Altman, NYU Salomon Center.

AN EMERGING MARKET CORPORATE MODEL: A MODIFIED Z”-SCORE MODEL

CAN WE PREDICT CHAPTER-22?

KMV MODEL


MARKET VALUE
(2) SD of Future Asset Values
(5) Expected Growth of Assets, Net
Mean
(1) Current market Value of Assets
Probability Density of Future Asset Values
# of SD from Mean
(4) Par Value of Debt Servicing
Increase in Servicing Requirement Due to "Ballooning" Term Loan
"EDF"
(3) "SHAPE" of Probability Density in Region of Distress
0
Now
1 year
TIME

MANAGING A FINANCIAL TURNAROUND: APPLICATIONS OF THE Z-SCORE MODEL IN THE US AND CHINA

THE GTI CASE

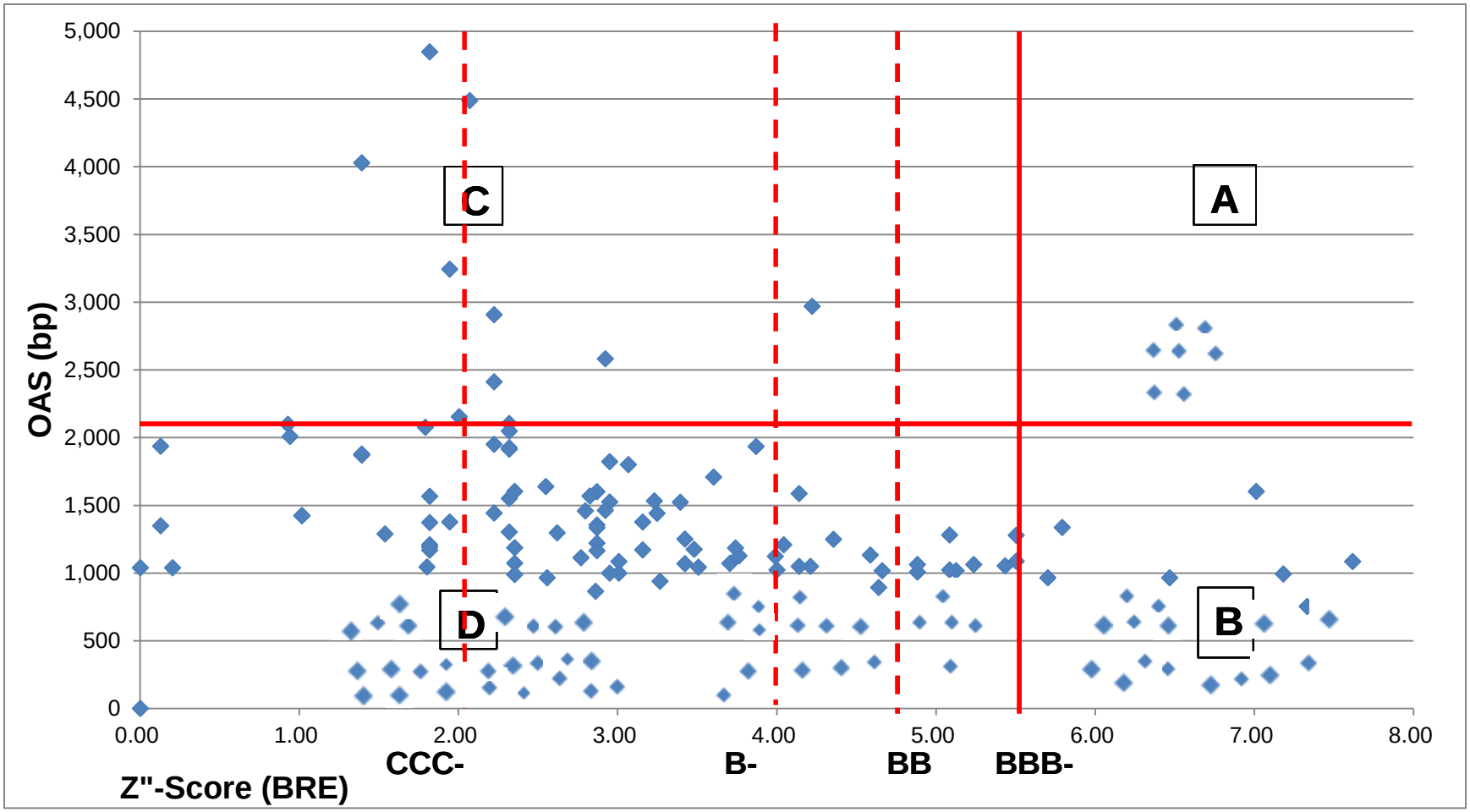
Financial Distress (Z-Score) Prediction Applications

External (To The Firm) Analytics	Internal (To The Firm) & Research Analytics
• **Lenders (e.g., Pricing, Basel Capital Allocation)** • Bond Investors (e.g., Quality Junk Portfolio • Long/Short Investment Strategy on Stocks (e.g. Baskets of Strong Balance Sheet Companies & Indexes, e.g. STOXX, Goldman, Nomura) • Security Analysts & Rating Agencies • Regulators & Government Agencies • Auditors (Audit Risk Model) – Going Concern • Advisors (e.g., Assessing Client's Health) • M&A (e.g., Bottom Fishing)	• **To File or Not (e.g., General Motors)** • **Comparative Risk Profiles Over Time** • **Industrial Sector Assessment (e.g., Energy)** • Sovereign Default Risk Assessment • Purchasers, Suppliers Assessment • Accounts Receivables Management • Researchers – Scholarly Studies • Chapter 22 Assessment • Managers – Managing a Financial Turnaround

QUALITY JUNK STRATEGY

Return/Risk Tradeoffs – Distressed & High-Yield Bonds

As of December 31, 2012



$Z'' = 3.25 + 6.56X1 + 3.26X2 + 6.72X3 + 1.05X4$

X1 = CA – CL / TA; X2 = RE / TA; X3 = EBIT / TA; X4 = BVE / TL

A = Very High Return **/** Low Risk
B = High Return **/** Low Risk
C = Very High Return **/** High Risk
D = High Return **/** High Risk

JUNK QUALITY STRATEGY
OR
SHORT HIGH-YIELD STRATEGY

MANAGING A FINANCIAL TURNAROUND: THE GTI CASE

CAVEATS FOR A SUCCESSFUL TURNAROUND

Objectives

- To demonstrate that specific management tools which work are available in crisis situations
- To illustrate that predictive models can be turned “inside out” and used as internal management tools to, in effect, reverse their predictions
- To illustrate an interactive, as opposed to a passive, approach to financial decision making

Physical Facilities & Financial Situation

- 7 Manufacturing facilities (California to New York)
- 3 Offices locations (California to Germany)
- American Stock Exchange Listed Company
- Incorporated in late 1960's
- Successful IPO through early 1970's

Financial Changes at GTI

- Working Capital decreased by $6 million
- Retained Earnings decreased by $2 million
- A $2 million loss incurred
- Net Worth decreased from $6,207 to $4,370
- Market Value of Equity decreased by 50%
- Sales decreased by 50%

Ethical Consideration

- Pressure led to “Corner Cutting”
- Returns not reported
- Bad inventory (and too much of it)
- Questionable Deferrals and Reserves levels

Employee Moral & Attitude

- Internally Competitive
- Angry
- Insecure

Management's Responsibility

- "PROTECT and ENHANCE
  the Stockholders Investment in GTI"
  (Words of the new CEO)

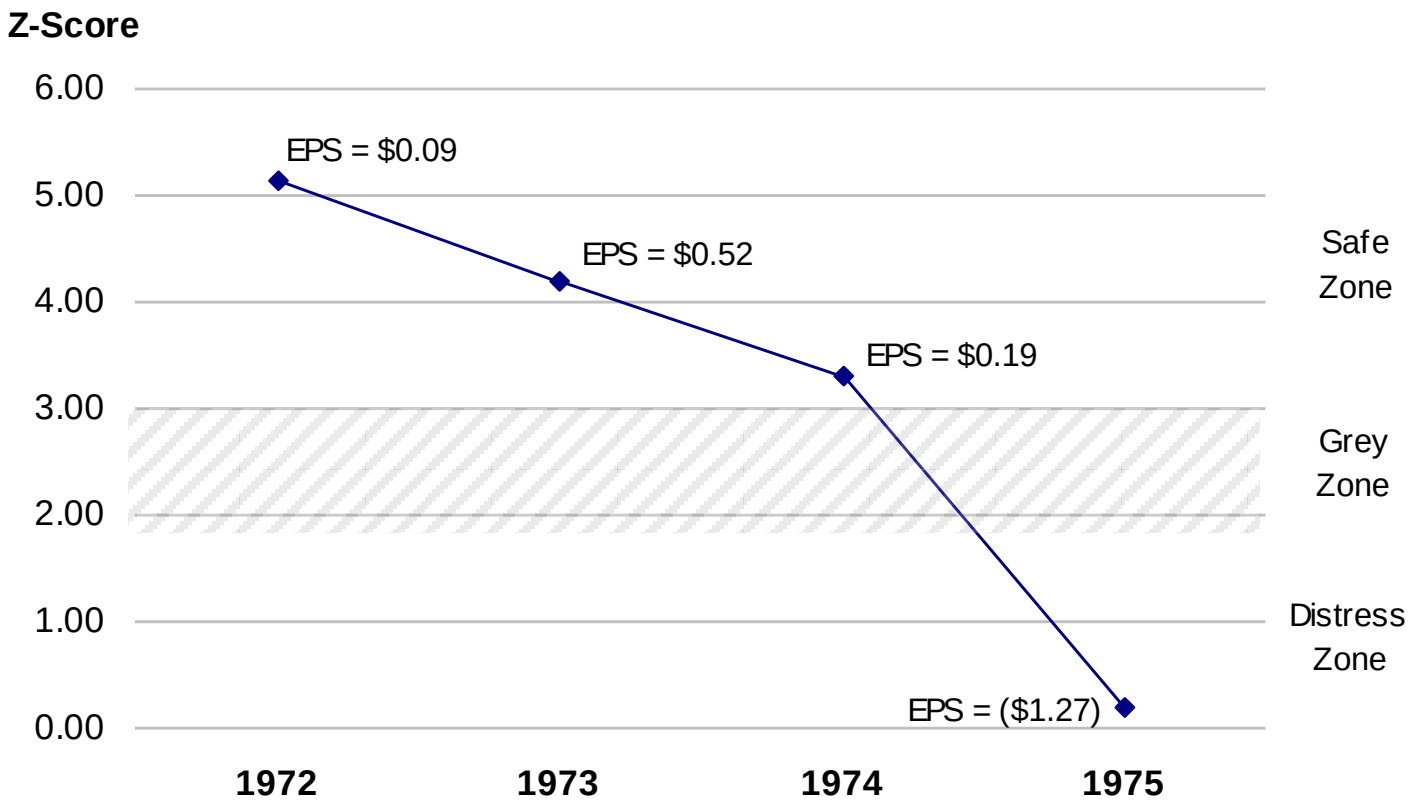
Material to be Covered

- Condition of GTI in June of 1975
- Management & Control changes
- Definition of Management's Responsibility
- Description of Management tools used
- Caveats for a successful Turnaround

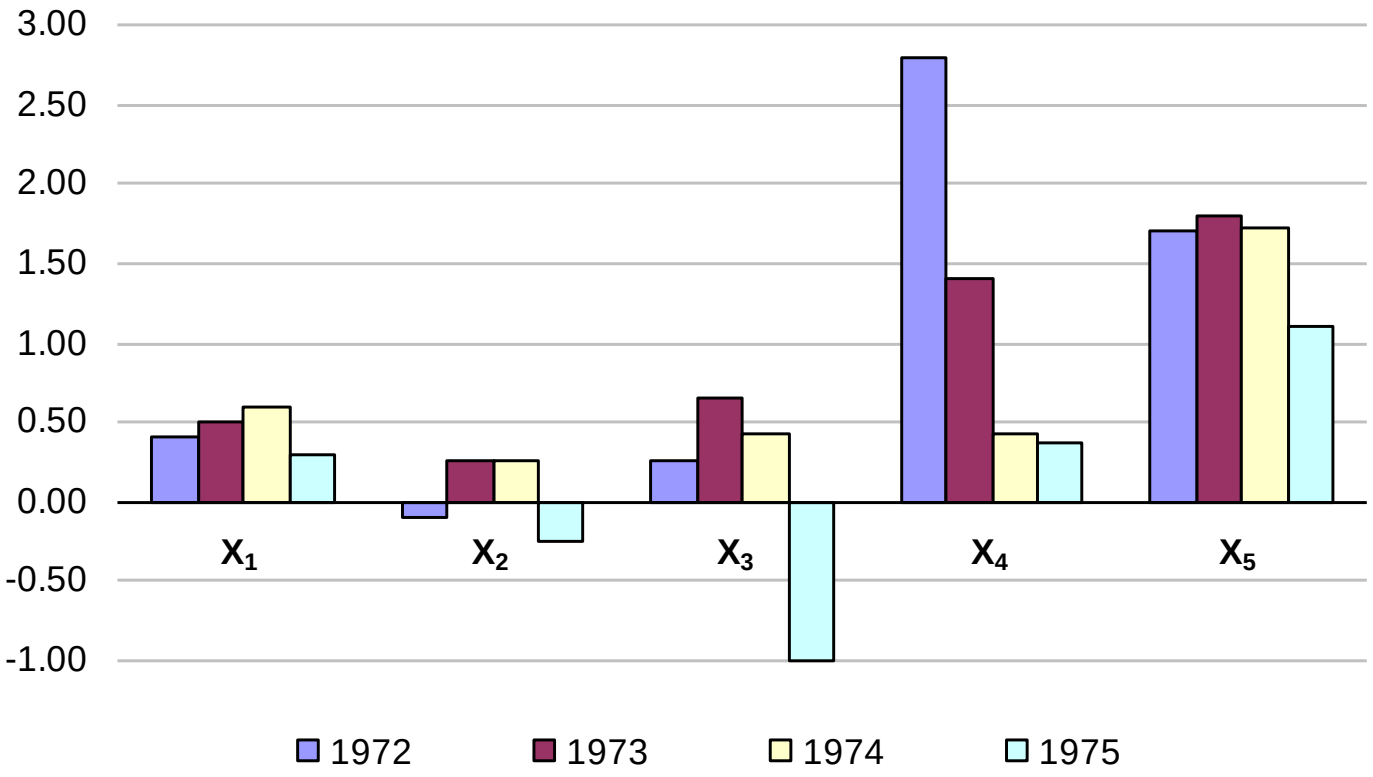
Z-Score Component Definitions

Variable	Definition	Weighting Factor
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	$\frac{\text{Sales}}{\text{Total Assets}}$	.999

Z-Score Distressed Firm Predictor: Application to GTI Corporation (1972 – 1975)



Components of Z-Score Distressed Firm: Predictor as Applied to GTI Corporation



Management Tools Used

- Altman's Distressed Firm Predictor (Z-Score)
- Function / Location Matrix
- Financial Statements
- Planning Systems
- Trend Charts

Strategy

- **Strategy #1**: Reduce Personnel & Eliminate Capital Spending
- **Reason**: Reverse Cash drain
- **Tool**: Source and Application of Funds
- **Timing**: Immediate

Strategy

- **Strategy #2**: Consolidate Locations
- **Reason**: Reduce Management Costs
- **Tool**: Function Location Matrix
- **Timing**: Short and Long Term Planning

Function / Location Matrix

	Pennsylvania	Indiana	New York	California	West Germany	
Operations	$1	$1	$1	$1	$1	$5
Marketing	$1	$1	$1	$1	$1	$5
Engineering	$1	$1	$1	$1	$1	$5
Finance	$1	$1	$1	$1	$1	$5
	$4	$4	$4	$4	$4	$20

Key Actions - 1975

- Immediate Reduction of Personnel
- Stop Capital Spending
- Consolidate Profitable Product Lines

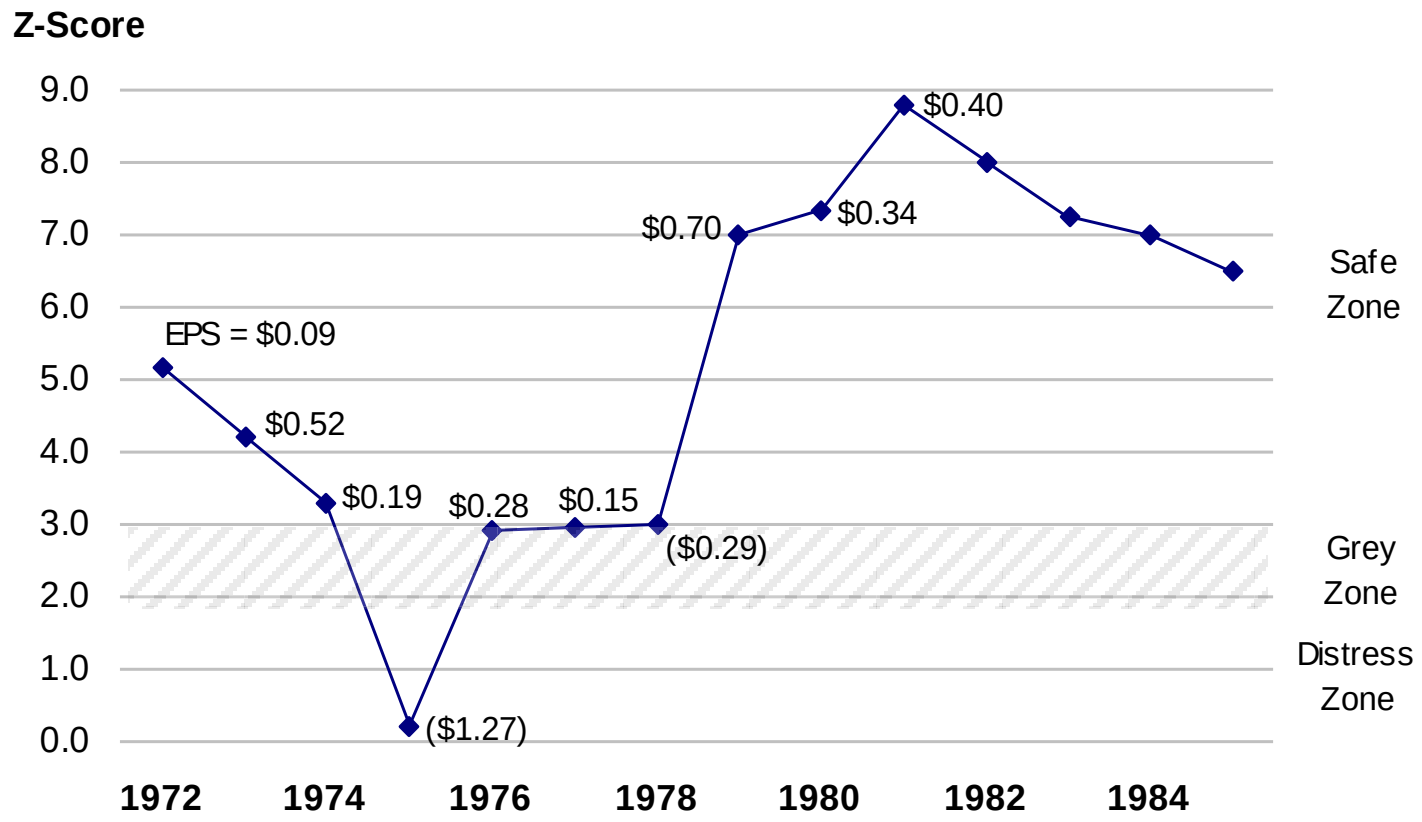
Z-Score Component Definitions

Variable	Definition	Weighting Factor
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	$\frac{\text{Sales}}{\text{Total Assets}}$	.999

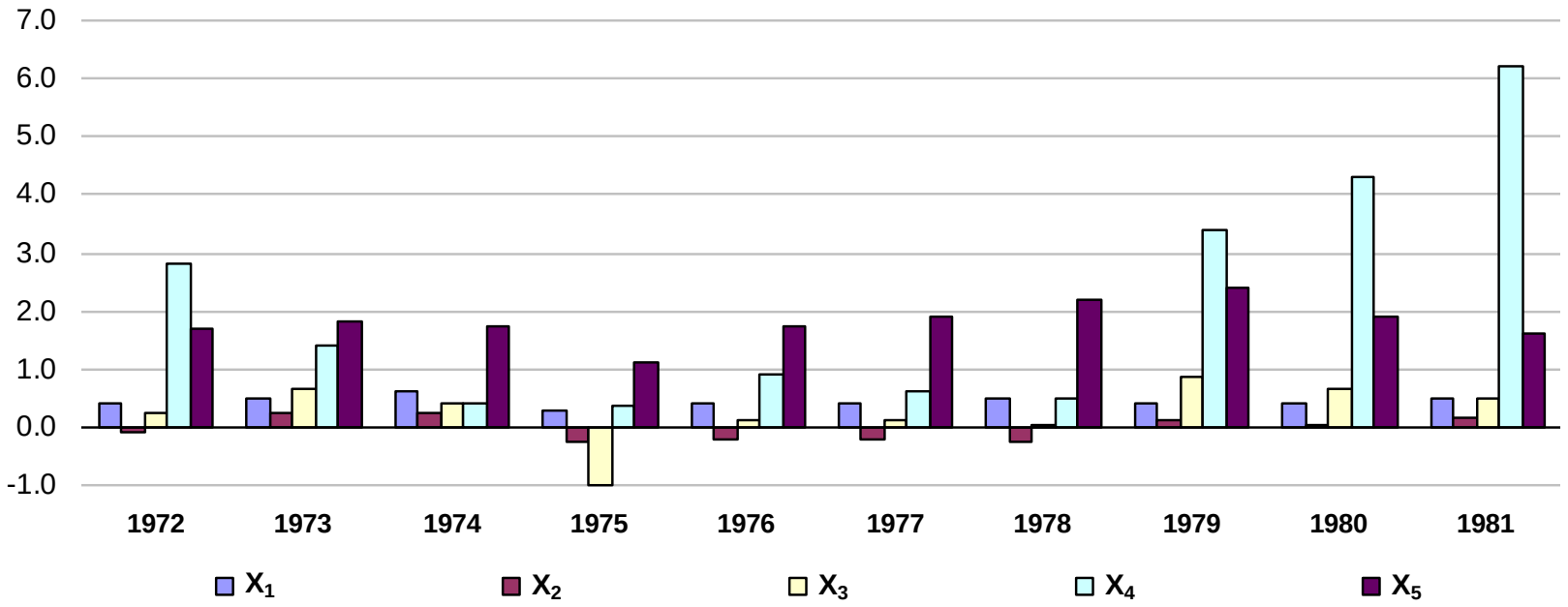
Managerial & Financial Restructuring Actions and Impact on Z-Score

Strategy	Reason	Impact
Consolidated Locations	Eliminate Underutilized Assets	Z-Score
Drop Losing Product Lines	Eliminate Unprofitable Underutilized Assets	Z-Score
Reduce Debt Using Funds Received from Sale of Assets	Reduce Liabilities and Total Assets	Z-Score

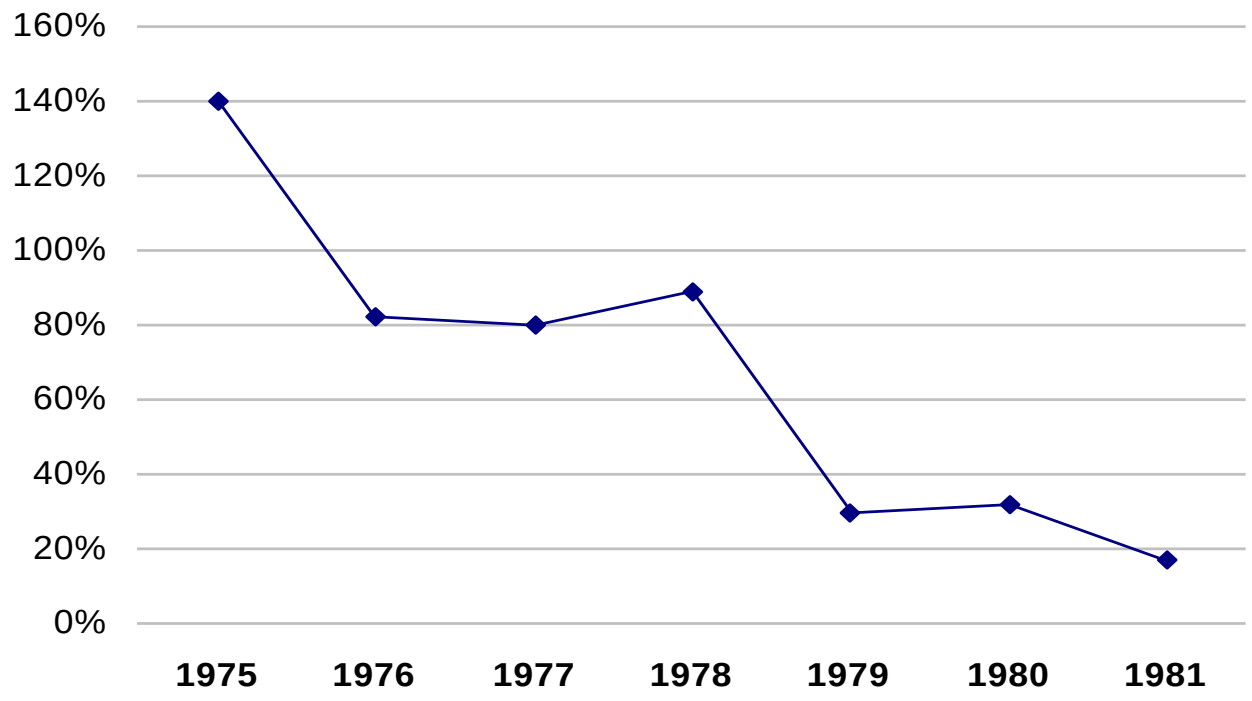
Z-Score Distressed Firm Predictor
Application to GTI Corporation (1972 – 1984)



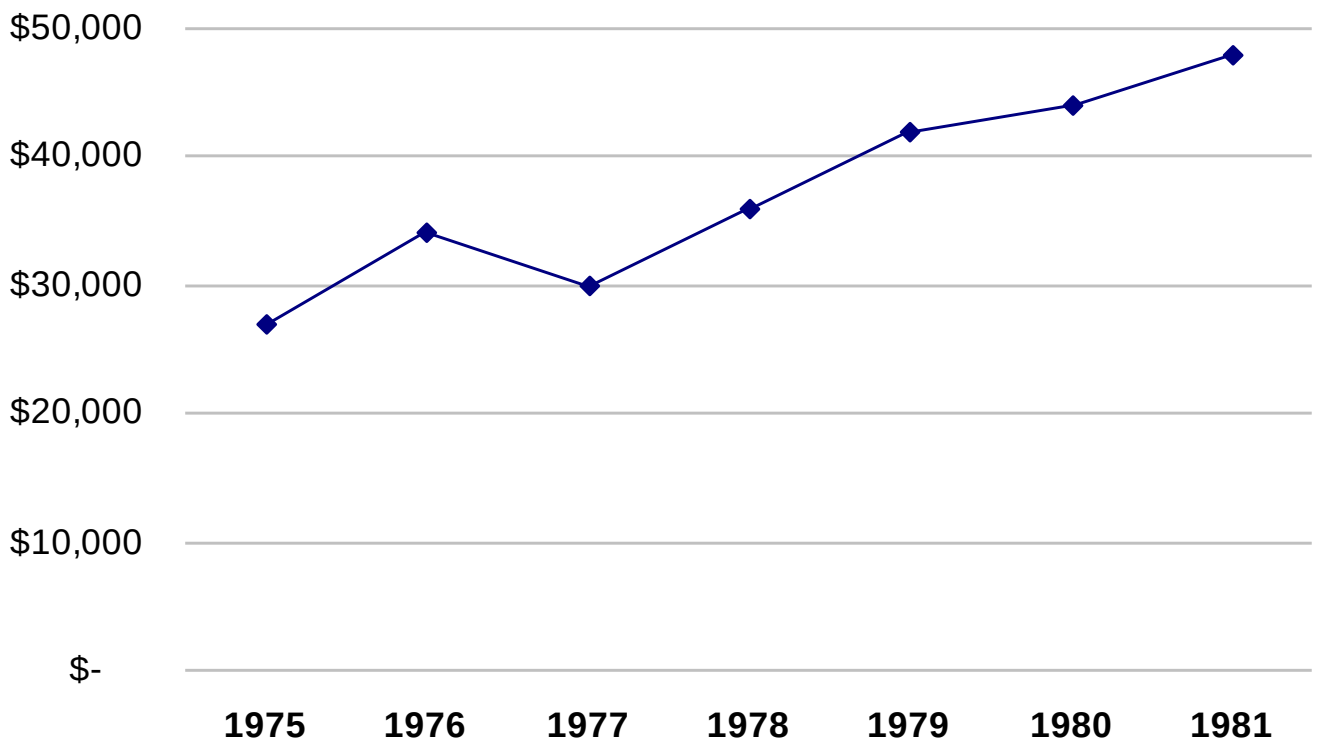
Components of Z-Score Distressed Firm: Predictor as Applied to GTI Corporation



Debt / Equity Ratio



Sales Dollars / Employee



Distress Prediction Model For Chinese Companies

Z_{China} Model for Chinese Companies

Model Development and Test Results

- **Training Sample**: **30** "ST" (Special Treatment Distressed Companies) based on two consecutive years of negative earnings or NAV below par value listed on Sheuzhen or Shanghai Stock Exchanges (1998,1999).
  30 "Non – ST" listed companies (Healthy)
  60

- **Holdout (Test) Sample**: **21** "ST" Companies (1998,1999)
  39 "Non – ST" Companies (Randomly Selected)
  60

- **Variable Selection**: 15 Financial Ratios from one year before "ST," including Profitability, Solvency, Liquidity and Asset Management Measures. Based on their acceptance in China as well as from several prior distress prediction models outside of China.

Based on a study, "Corporate Financial Distress Diagnosis in China," L. Zhang, J. Yen and E. Altman, Summer 2007.

Model for Distress Prediction in China

$$Z_c = 0.517 - 0.388\ (X_1) + 1.158\ (X_2) + 9.320\ (X_3) – 0.460\ (X_4)$$

Where:

X_1 = Working Capital / Average Total Assets (ATA) =

X_2 = Retained Earnings / TA =

X_3 = Net Profit / ATA =

X_4 = Total Liabilities / TA =

	Mean "ST"	Mean "Non-ST"
•	-0.17	0.12
	(F = 5.8)	
•	-0.33	0.22
	(F = 19.8)	
•	-0.36	0.26
	(F = 139.1)	
•	0.75	0.42
	(F = 42.4)	

Classification Accuracy

Training Sample

Actual Classification		*Predicted Classification*	
		Distressed	Non-Distressed
Distressed ("ST")	30	30 (100%)	0
Non-Distressed	0	0	30 (100%)

Accuracy Over Time

Years Prior to "ST"	Accuracy Level
1	100%
2	87%
3	70%
4	60%
5	22%

Holdout Sample Accuracy

		Predictive Accuracy	
	# of Firms	(0.5) Cutoff	(0.3) Cutoff
Distressed	21	21	19
		(100%)	(90%)
Non-Distressed	39	34	39
		(87%)	(100%)

Rating Distribution of Listed Chinese Companies

Rating Level	Z_c–Score Interval	Percentage Each Year 1998	1999	2000	2001	2002	2003	2004	2005
AAA	≥ 1. 8	6.3%	4.3	2.3	0.9	1.0	1.2	2.8	2.5
AA	1.3 – 1.8	17.5	11.0	9.2	5.9	4.2	5.8	5.4	5.7
A	0.9 – 1.3	31.6	31.3	27.6	18.5	15.3	14.8	15.1	12.4
BBB	0.5 – 0.9	24.7	29.3	37.8	40.2	39.6	36.3	34.4	31.8
BB	0.0 – 0.5	10.7	16.1	15.2	22.4	25.6	28.8	28.2	28.8
B	-1.0 – 0.0	4.9	5.0	4.6	7.3	8.1	1.5	6.8	9.4
C	-2.0 – - 1.00	2.7	1.6	1.6	2.6	2.8	1.0	2.6	3.7
D	Z_c < -2.0	1.6	1.6	1.7	2.2	3.5	10.6	4.6	5.8

Credit Ratings of "ST" Companies Announced in 2002

Rating Level	2002 (#)	2002 (%)	2001 (%)	2000 (%)	1999 (%)	1998 (%)
AAA	0	0	0	3.6	3.5	7.1
AA	0	0	0	3.6	7.1	7.1
A	0	0	0	10.7	3.6	10.7
BBB	1	3.6	0	14.3	21.4	28.6
BB	6	21.4	14.3	14.3	39.3	21.4
B	8	28.6	25.0	46.4	17.9	10.7
C	5	17.9	28.6	3.6	7.1	10.7
D	8	28.6	32.1	3.6	0.0	3.6

Total 28 Companies