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# Models for Predicting Financial Distress: Z-Score After 50 Years, What Have We Learned?

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June 25, 2018

*Sessions 1 & 2*



# 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)
  - *KMV's* Credit Monitor Model (1993) – Extensions of Merton (1974) Structural Framework

# Scoring Systems

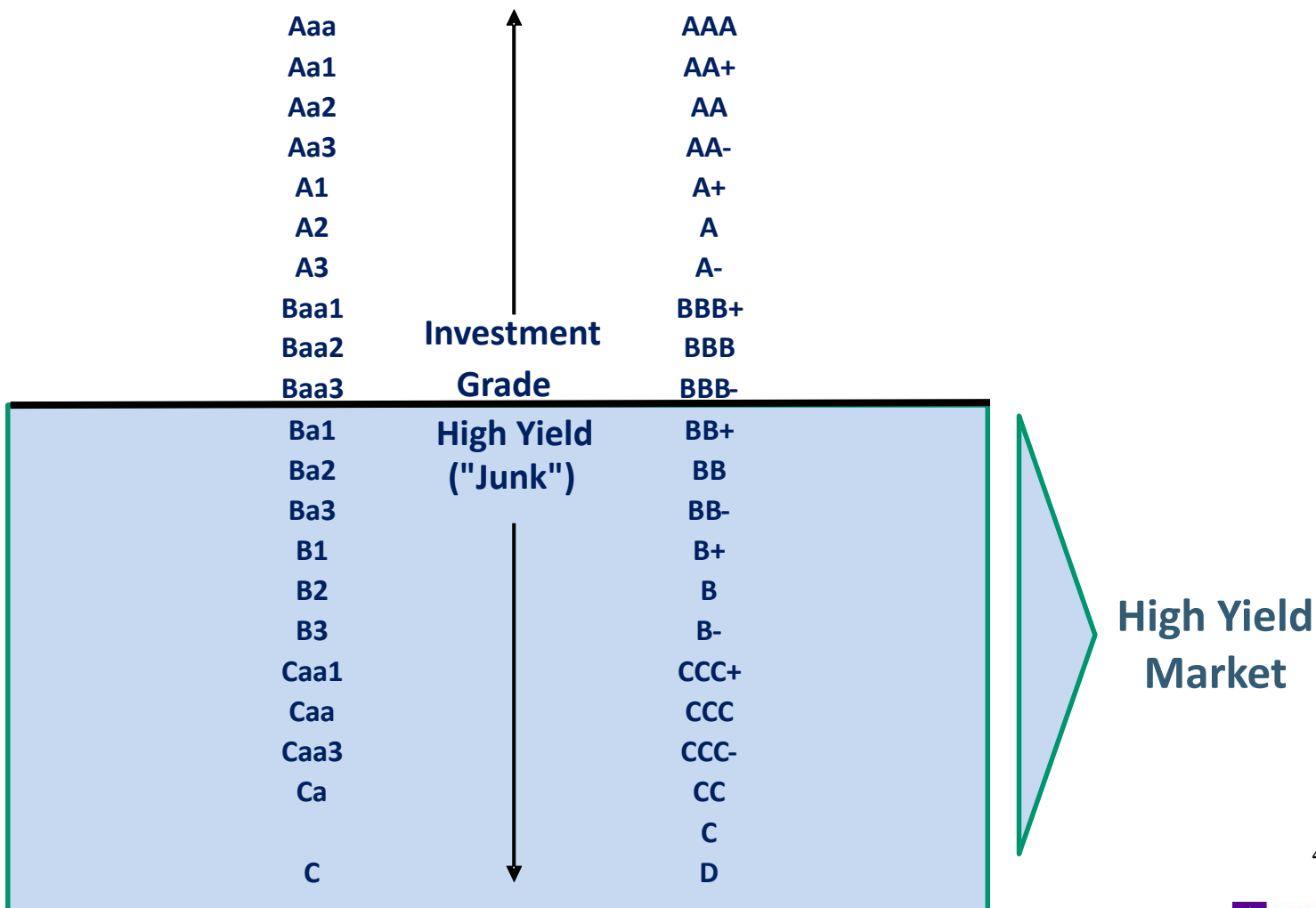
(continued)

- 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

Moody's

S&P/Fitch



# Z-Score (1968) 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

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

<b><math>Z &gt; 2.99</math> - “Safe” Zone</b>
<b><math>1.8 &lt; Z &lt; 2.99</math> - “Grey” Zone</b>
<b><math>Z &lt; 1.80</math> - “Distress” Zone</b>

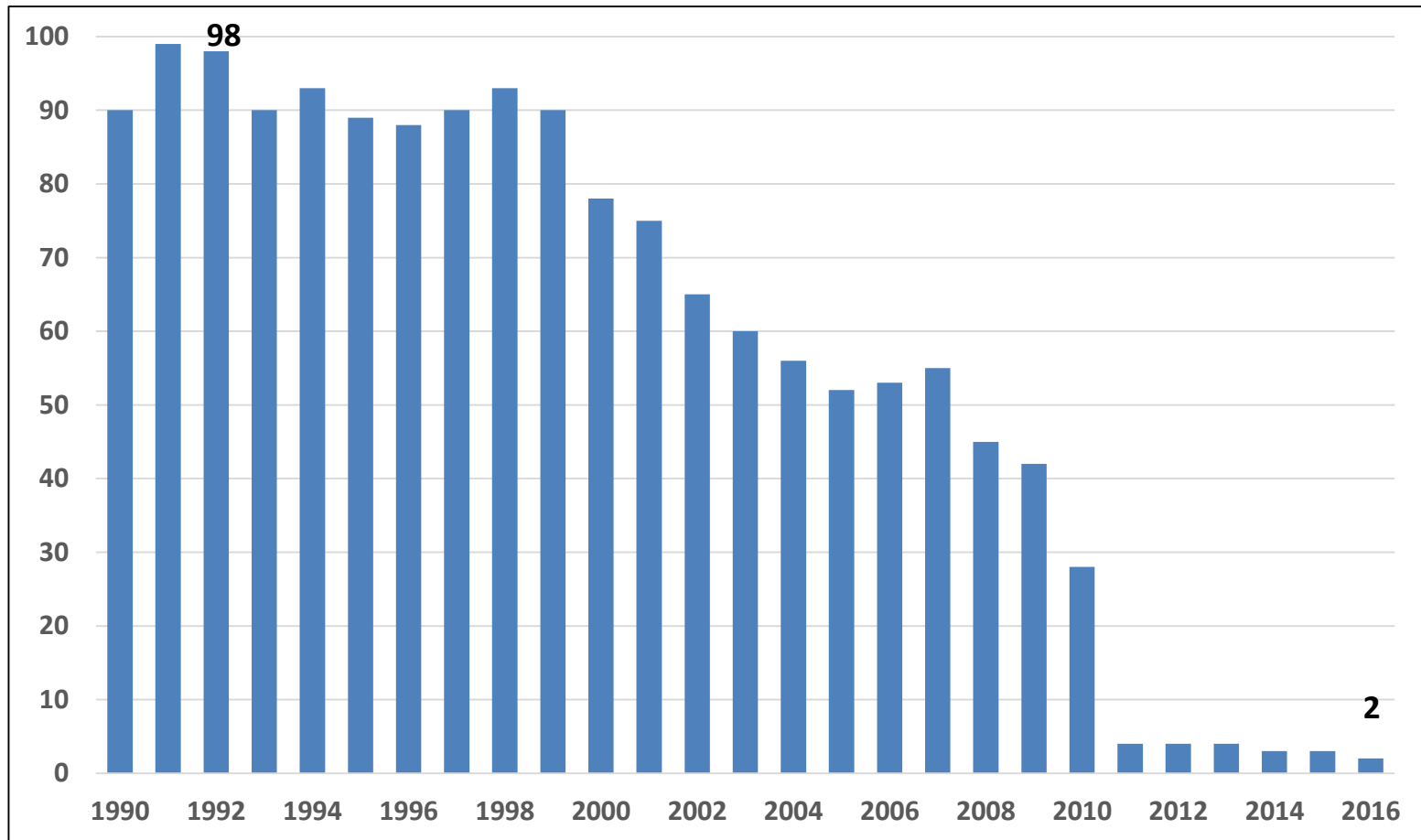
# Time Series Impact On Corporate Z-Scores

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- Credit Risk Migration
  - Greater Use of Leverage
  - Impact of HY Bond & Lev Loan 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

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

\*AAA Only.

<sup>1</sup> From 1/2014-11/2017, <sup>2</sup>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

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

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,

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

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

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 Rates by Original Rating

All Rated Corporate Bonds\*  
1971-2017

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%	0.19%	0.05%	0.02%	0.01%	0.01%	0.01%	0.01%	0.01%
	Cumulative	0.00%	0.00%	0.19%	0.24%	0.26%	0.27%	0.28%	0.29%	0.30%	0.31%
A	Marginal	0.01%	0.03%	0.10%	0.11%	0.08%	0.04%	0.02%	0.23%	0.06%	0.03%
	Cumulative	0.01%	0.04%	0.14%	0.25%	0.33%	0.37%	0.39%	0.62%	0.68%	0.71%
BBB	Marginal	0.31%	2.34%	1.23%	0.97%	0.48%	0.21%	0.24%	0.15%	0.16%	0.32%
	Cumulative	0.31%	2.64%	3.84%	4.77%	5.23%	5.43%	5.66%	5.80%	5.95%	6.25%
BB	Marginal	0.91%	2.03%	3.83%	1.96%	2.40%	1.54%	1.43%	1.08%	1.40%	3.09%
	Cumulative	0.91%	2.92%	6.64%	8.47%	10.67%	12.04%	13.30%	14.24%	15.44%	18.05%
B	Marginal	2.85%	7.65%	7.72%	7.74%	5.72%	4.45%	3.60%	2.04%	1.71%	0.73%
	Cumulative	2.85%	10.28%	17.21%	23.62%	27.99%	31.19%	33.67%	35.02%	36.13%	36.60%
CCC	Marginal	8.09%	12.40%	17.71%	16.22%	4.88%	11.60%	5.39%	4.73%	0.62%	4.23%
	Cumulative	8.09%	19.49%	33.75%	44.49%	47.20%	53.33%	55.84%	57.93%	58.19%	59.96%

\*Rated by S&P at Issuance  
Based on 3,359 issues

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

# Mortality Losses by Original Rating

All Rated Corporate Bonds\*  
1971-2017

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%	0.02%	0.02%	0.01%	0.01%	0.00%	0.01%	0.01%	0.01%
	Cumulative	0.00%	0.00%	0.02%	0.04%	0.05%	0.06%	0.06%	0.07%	0.08%	0.09%
A	Marginal	0.00%	0.01%	0.04%	0.04%	0.05%	0.04%	0.02%	0.01%	0.05%	0.02%
	Cumulative	0.00%	0.01%	0.05%	0.09%	0.14%	0.18%	0.20%	0.21%	0.26%	0.28%
BBB	Marginal	0.22%	1.51%	0.70%	0.57%	0.25%	0.15%	0.09%	0.08%	0.09%	0.17%
	Cumulative	0.22%	1.73%	2.41%	2.97%	3.21%	3.36%	3.45%	3.52%	3.61%	3.77%
BB	Marginal	0.54%	1.16%	2.28%	1.10%	1.37%	0.74%	0.77%	0.47%	0.72%	1.07%
	Cumulative	0.54%	1.69%	3.94%	4.99%	6.29%	6.99%	7.70%	8.14%	8.80%	9.77%
B	Marginal	1.90%	5.36%	5.30%	5.19%	3.77%	2.43%	2.33%	1.11%	0.90%	0.52%
	Cumulative	1.90%	7.16%	12.08%	16.64%	19.78%	21.73%	23.56%	24.41%	25.09%	25.48%
CCC	Marginal	5.35%	8.67%	12.48%	11.43%	3.40%	8.60%	2.30%	3.32%	0.38%	2.69%
	Cumulative	5.35%	13.56%	24.34%	32.99%	35.27%	40.84%	42.20%	44.12%	44.33%	45.83%

\*Rated by S&P at Issuance  
Based on 2,797 issues

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

# Financial Distress (Z-Score) Prediction Applications

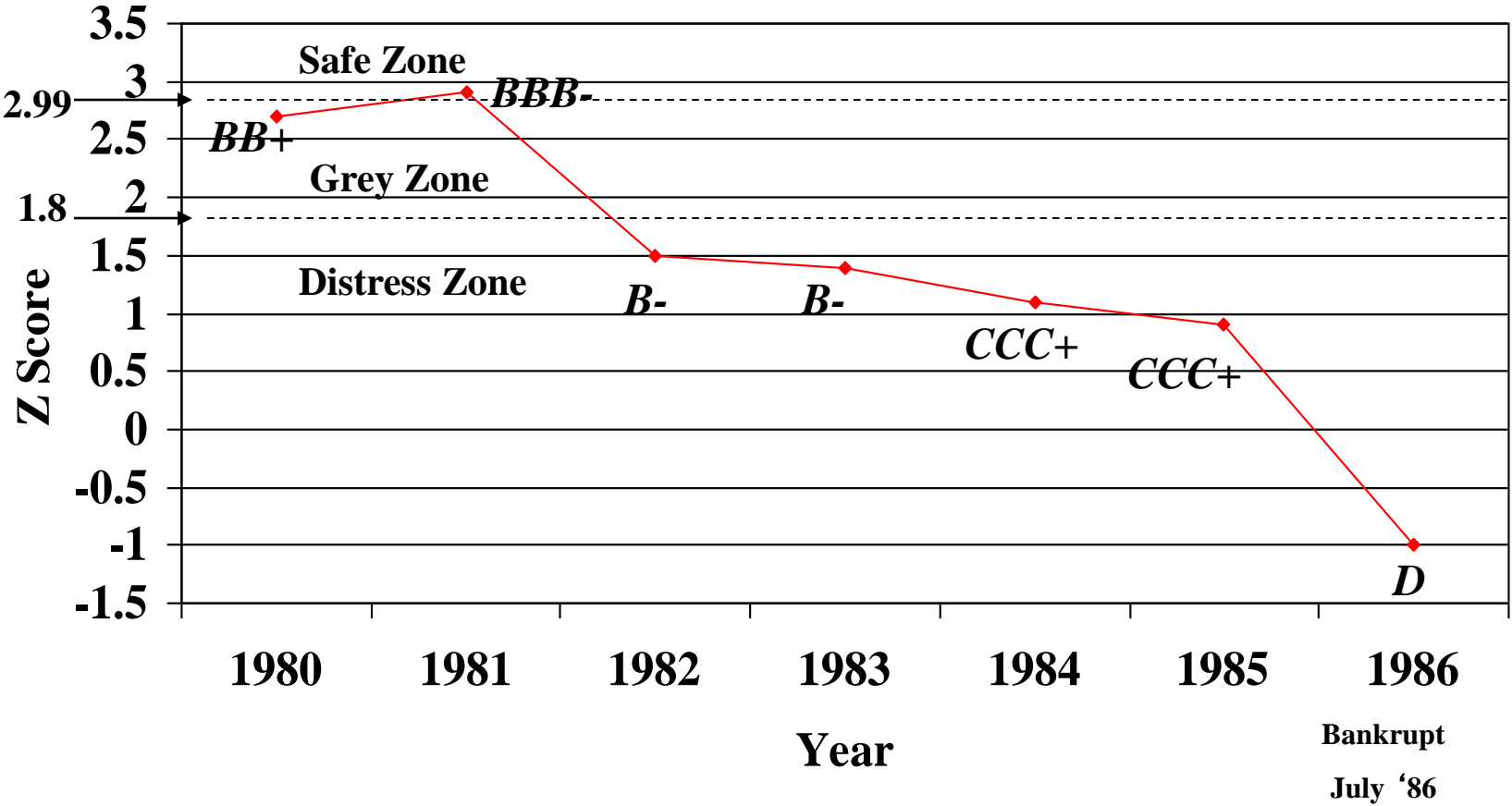
## External (To The Firm) Analytics

- **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)
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- M&A (e.g., Bottom Fishing)

## Internal (To The Firm) & Research Analytics

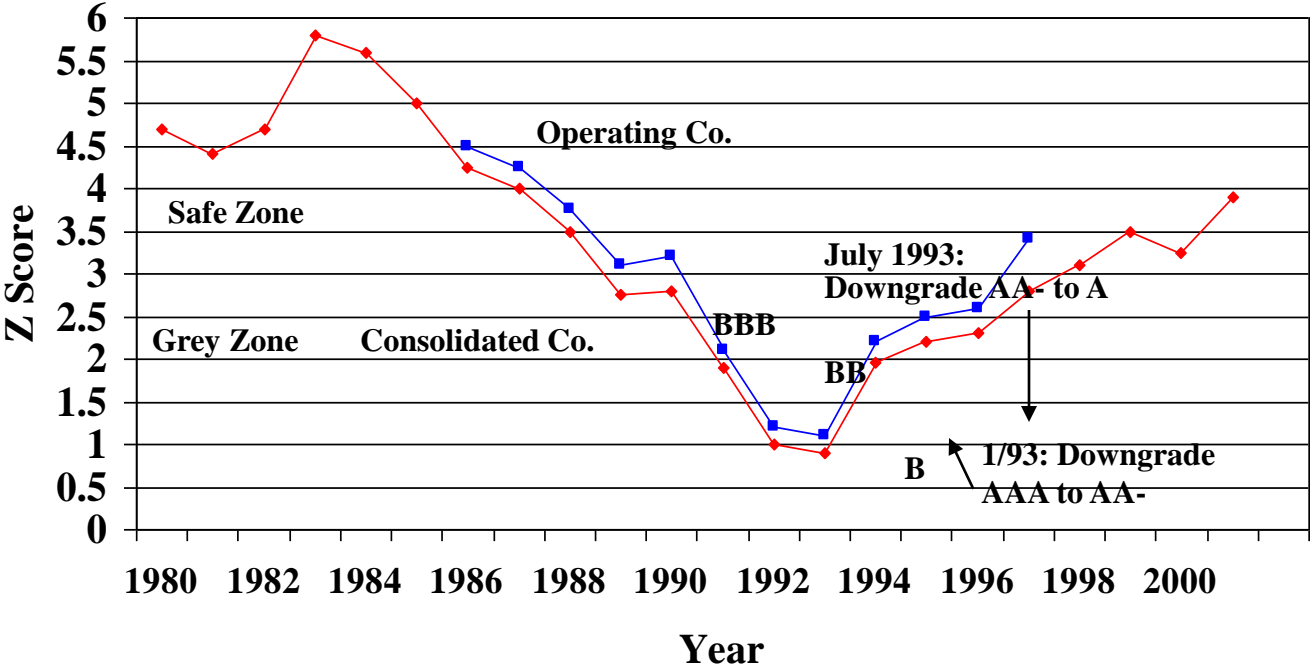
- **To File or Not (e.g., General Motors)**
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- Chapter 22 Assessment
- Managers – Managing a Financial Turnaround

# Z Score Trend - LTV Corp.



# 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+



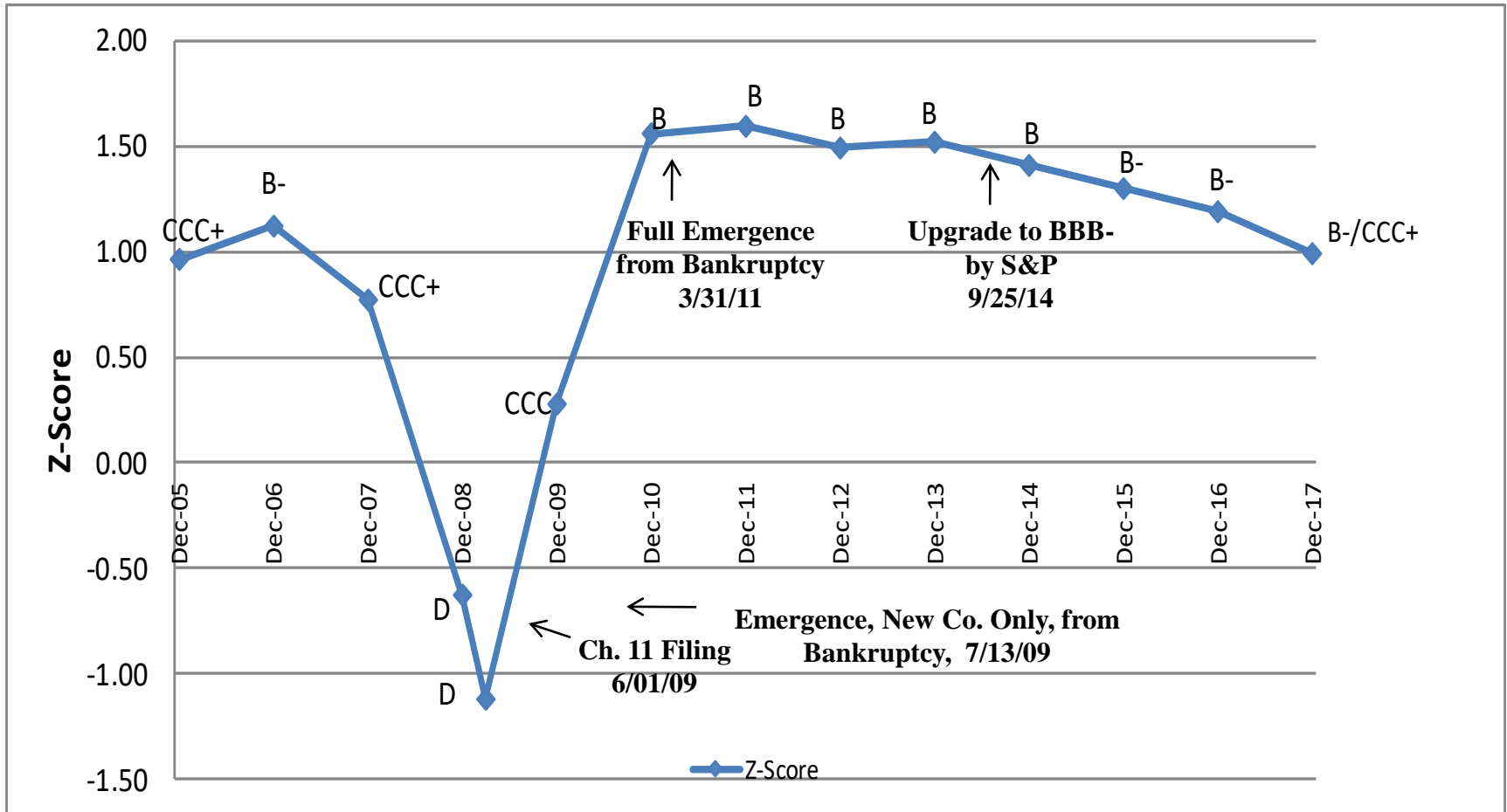
## Z-Score Model Applied to General Motors (Consolidated Data): Bond Rating Equivalents and Scores from 2005 – 2017

	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.



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# **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)**

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# **Italian High-Yield Bond Market**

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**Our Work with U.S. H.Y. Bond Market, Classis Capital,  
Italian Borsa, & Wiserfunding**

**Providing a Credit Market Discipline to the Italian Mini-bond  
Market**

**Models to Assess the Risk & Return Trade-Off for Investors &  
Issuers of Mini-bonds**

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# SME $Z_T$ -Score: Summary of Results

- We segmented the Italian SMEs by industrial sectors and developed four default prediction models for Manufacturing, Services, Retail and Real Estate firms.
- Models have been developed on a representative sample of more than 14,500 SMEs located in the north of Italy and then certified for their relevance at national level.
- Prediction power of the models is significantly high due to the use of informative variables and appropriate techniques applied.
- In addition to the Score, Firms/Analysts/Investors also receive an estimated **Bond Rating Equivalent** and **Probability of Default**.
- The **SME  $Z_T$ -Score** improves the matching of demand and supply in the capital markets between SMEs looking for funding options and investors.

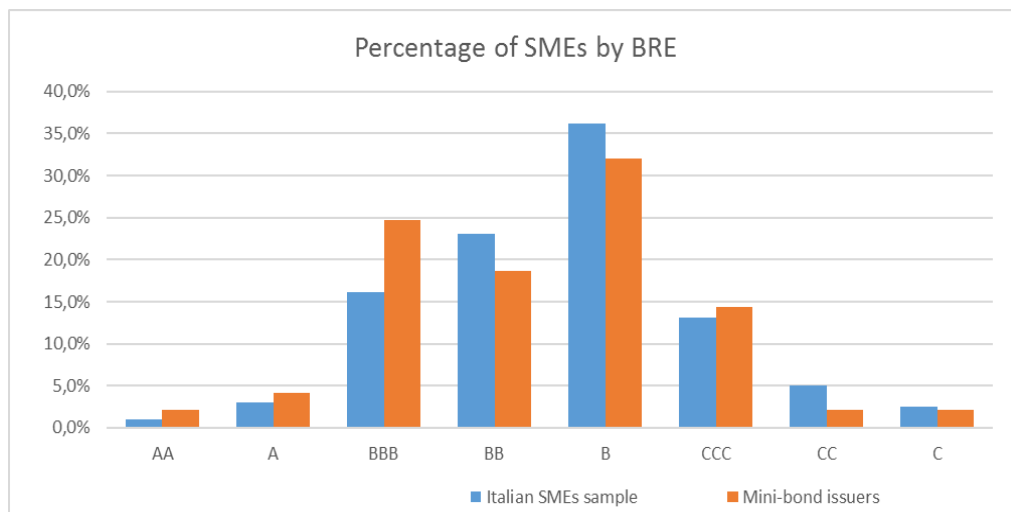
# The Results

	Type I error rate	Type II error rate	1- Average Error Rate	Accuracy ratio
<b>Manufacturing Model</b>	6.92% (8.23%)	26.57% (27.64%)	83.26% (82.07%)	93.08% (92.21%)
<b>Retail Model</b>	16.77% (18.54%)	27.78% (28.89%)	77.73% (76.29%)	83.23% (81.76%)
<b>Services Model</b>	12.05% (14.88%)	24.54% (26.43%)	81.70% (79.35%)	87.94% (84.12%)
<b>Constructions and Real Estate</b>	8.89% (10.12%)	26.02% (28.24%)	82.55% (80.82%)	91.11% (89.86%)

# Risk Profile of Mini-bond issuers (2015)

Bond Rating Equivalent	# SMEs	% SMEs	Avg. Coupon Yield
AA	2	2%	0,057
A	4	4%	0,062
BBB	24	25%	0,065
BB	18	19%	0,055
B	31	32%	0,059
CCC	14	14%	0,065
CC	2	2%	0,030
C	2	2%	0,060

Source: Firms listed on Borsa Italiana Extra MOT, calculations by the authors



Source: Firms listed on Borsa Italiana Extra MOT, calculations by the authors

Applying our SME  $Z_1$ -Score on the mini-bond issuers as of 2015, we find that:

- Risk profile of SMEs doesn't seem to influence the bond pricing;
- Majority of existing mini-bond issuers classified as non-investment grade;
- The risk profile of the mini-bond issuers is better (i.e. less risky) than total SME sample.

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

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

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

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

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

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



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

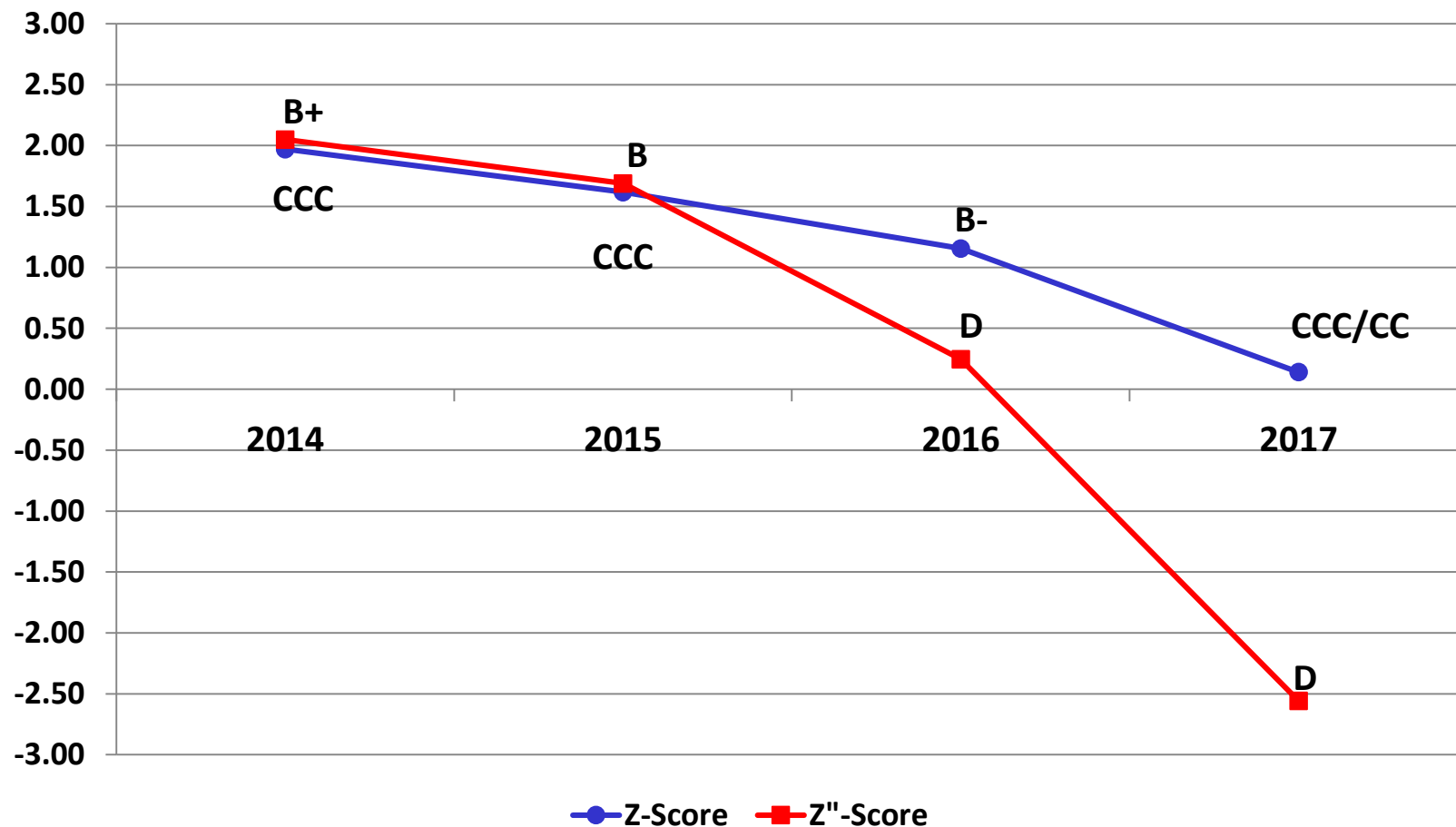
$$Z'' = 3.25 + 6.56X_1 + 3.26X_2 + 6.72X_3 + 1.05X_4$$

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>

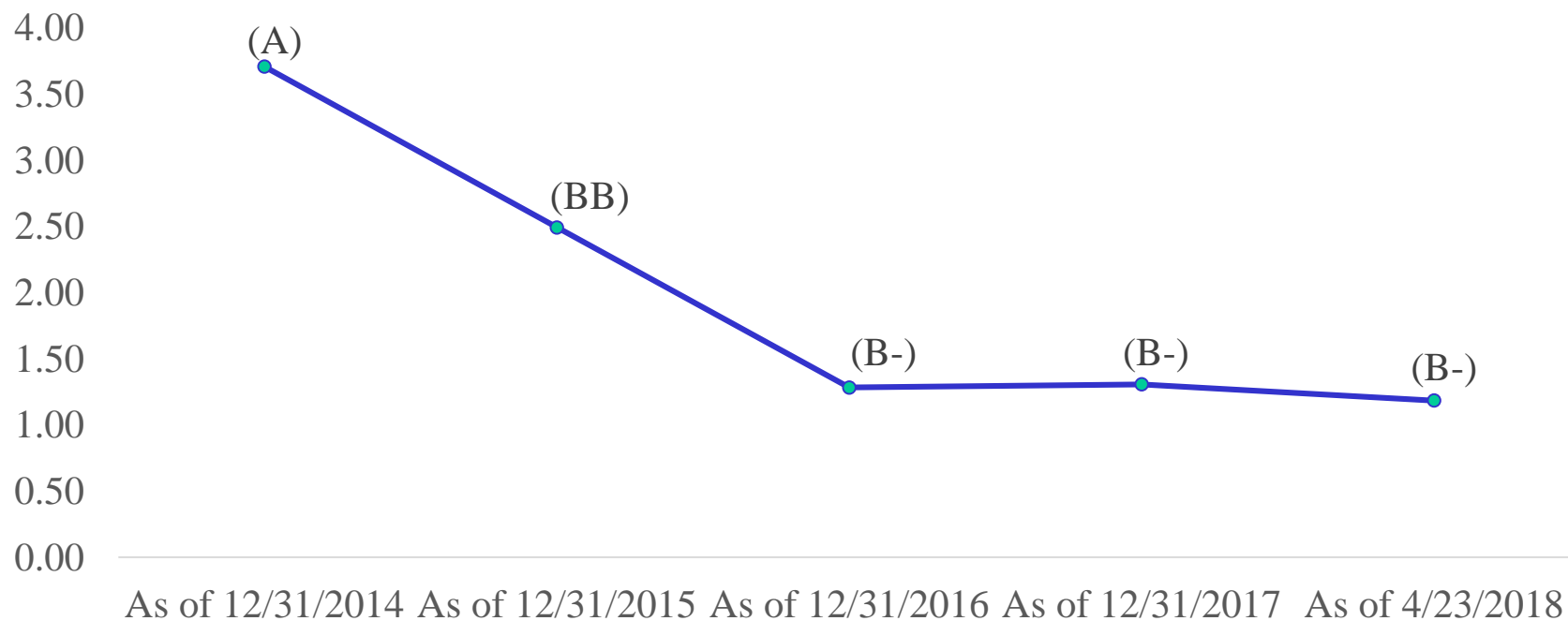
<sup>a</sup>Sample Size in Parantheses. <sup>b</sup>Interpolated between CCC and CC/D. <sup>c</sup>Based on 94 Chapter 11 bankruptcy filings, 2010-2013.  
Sources: Compustat, Company Filings and S&P.

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

Z and Z''- Score: Sears, Roebuck & Co.



# Tesla Z Scores and BREs (2014 – April 2018)



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# **MANAGING A FINANCIAL TURNAROUND: APPLICATIONS OF THE Z-SCORE MODEL**

## **THE GTI CASE**

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# Financial Distress (Z-Score) Prediction Applications

## External (To The Firm) Analytics

- **Lenders (e.g., Pricing, Basel Capital Allocation)**
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## Internal (To The Firm) & Research Analytics

- **To File or Not (e.g., General Motors)**
- **Comparative Risk Profiles Over Time**
- **Industrial Sector Assessment (e.g., Energy)**
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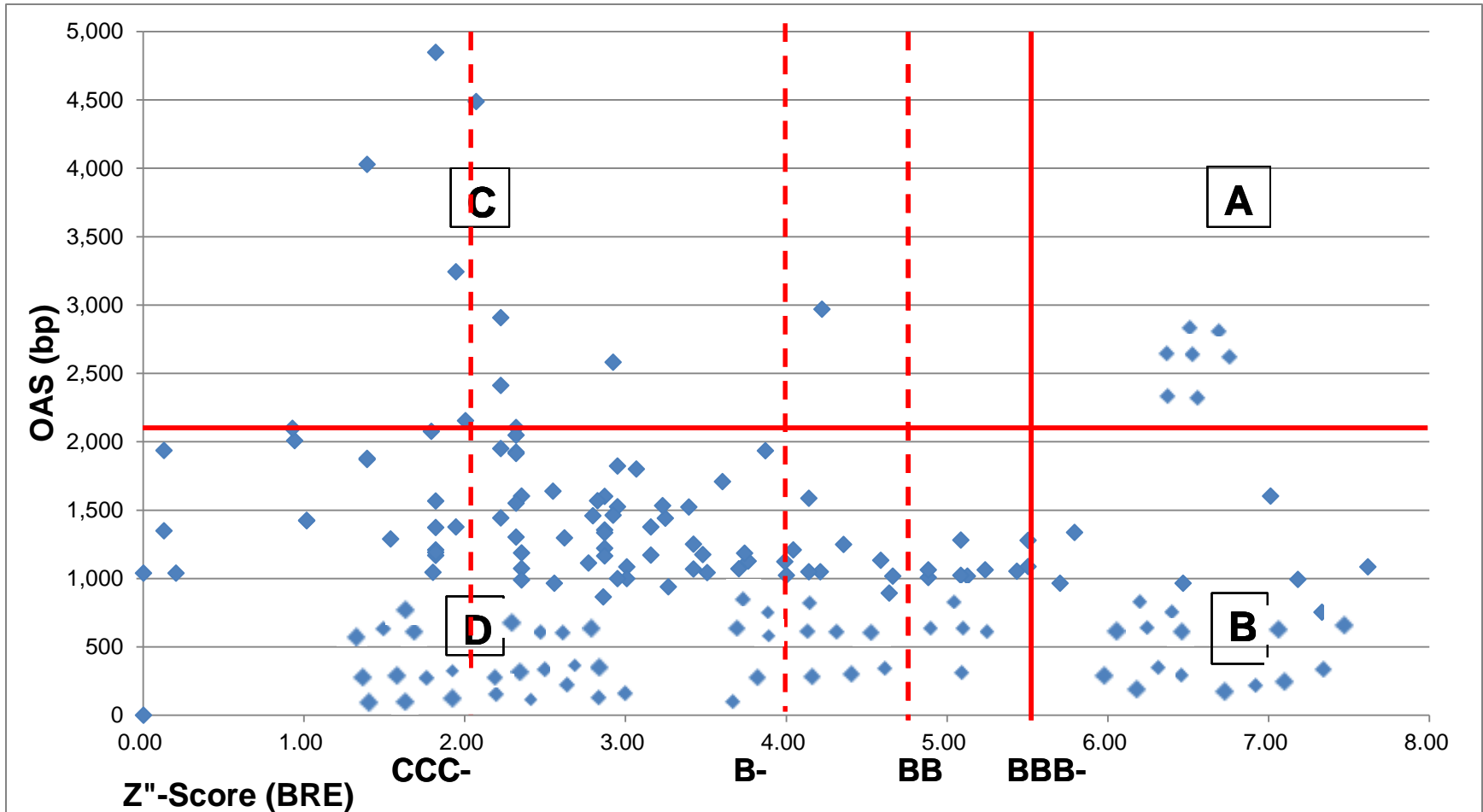
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# QUALITY JUNK STRATEGY

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# 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

# Objectives

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- 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

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- 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

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- 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

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

# Employee Moral & Attitude

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- Internally Competitive
- Angry
- Insecure

# Management's Responsibility

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- “PROTECT and ENHANCE  
the Stockholders Investment in GTI”  
*(Words of the new CEO)*

# Material to be Covered

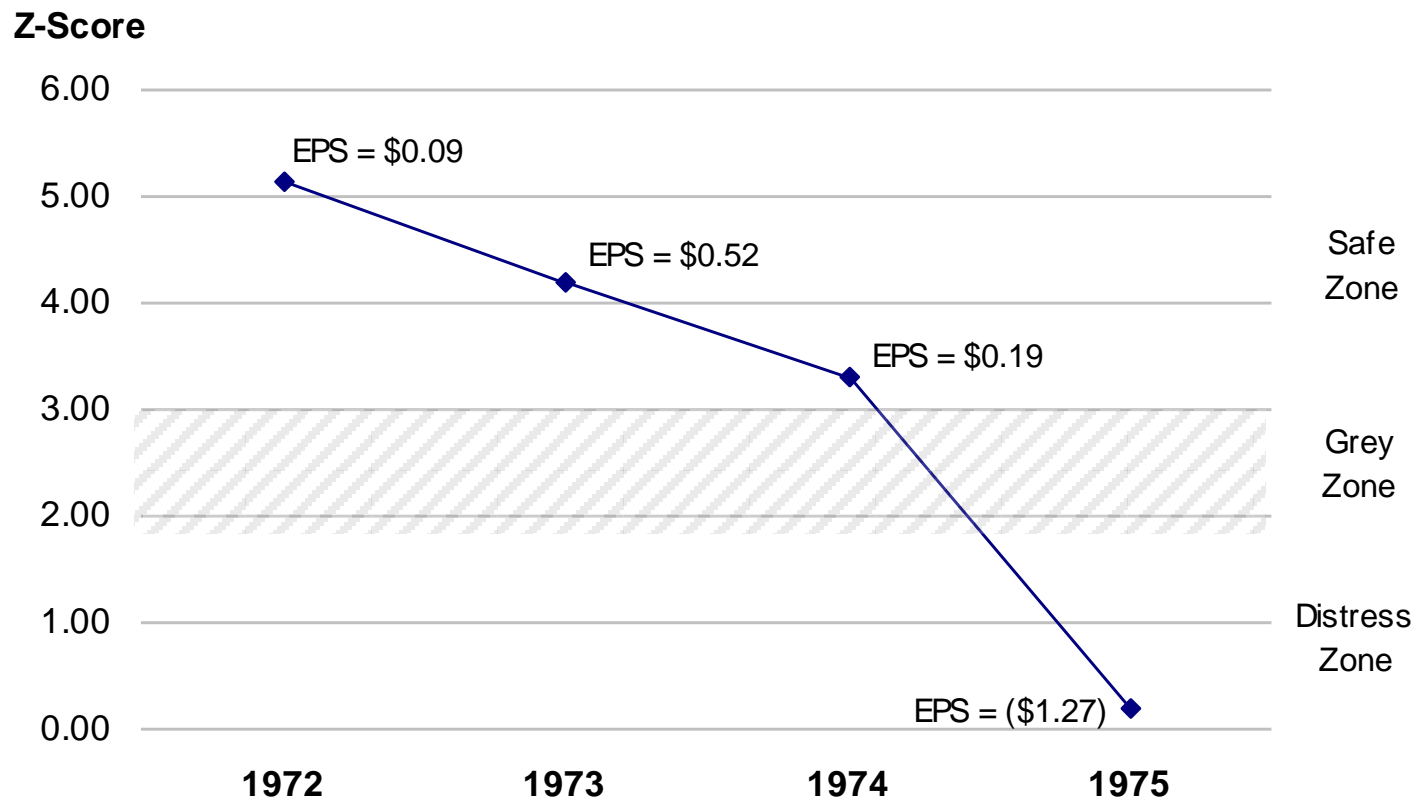
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- Condition of GTI in June of 1975
- Management & Control changes
- Definition of Management's Responsibility
- Description of Management tools used
- Caveats for a successful Turnaround

# Z-Score Component Definitions

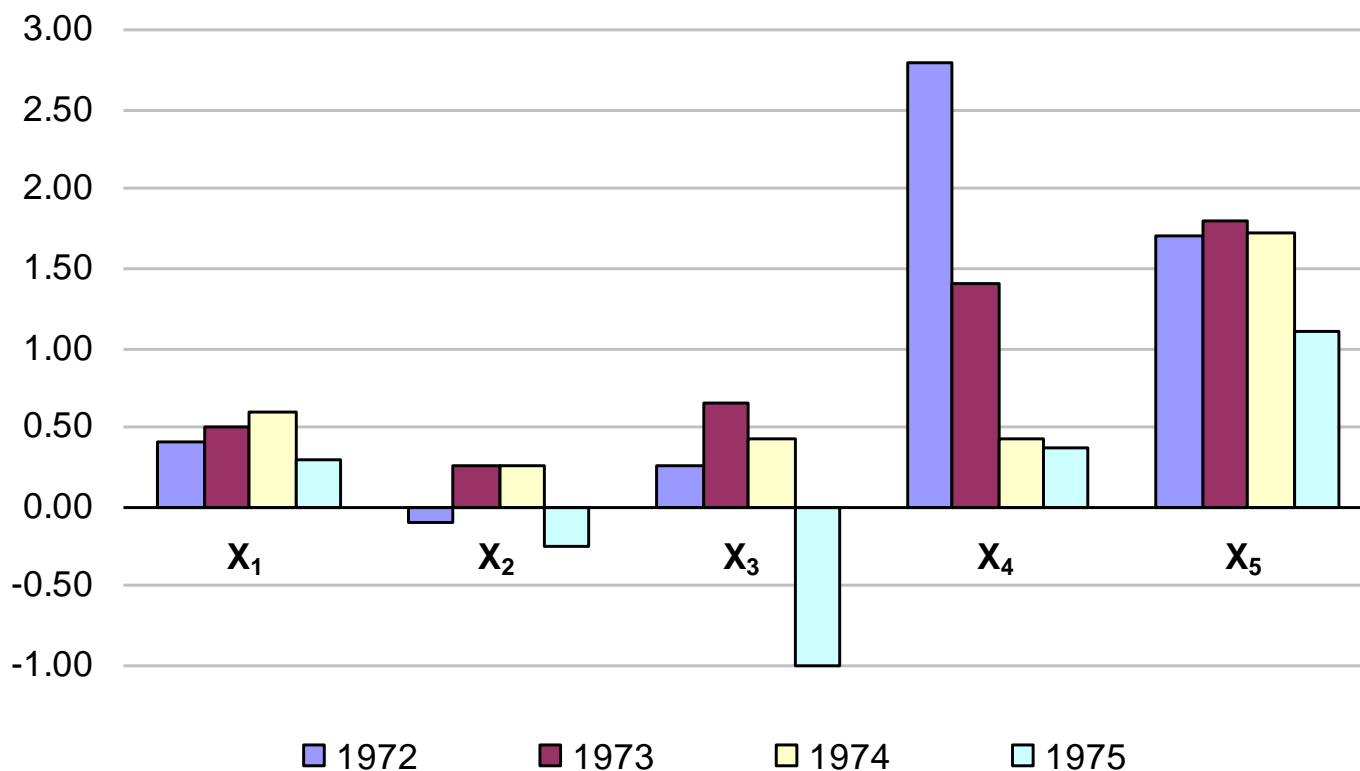
<u>Variable</u>	<u>Definition</u>	<u>Weighting Factor</u>
$X_1$	$\frac{\text{Working Capital}}{\text{Total Assets}}$	1.2
$X_2$	$\frac{\text{Retained Earnings}}{\text{Total Assets}}$	1.4
$X_3$	$\frac{\text{EBIT}}{\text{Total Assets}}$	3.3
$X_4$	$\frac{\text{Market Value of Equity}}{\text{Book Value of Total Liabilities}}$	0.6
$X_5$	$\frac{\text{Sales}}{\text{Total Assets}}$	.999

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

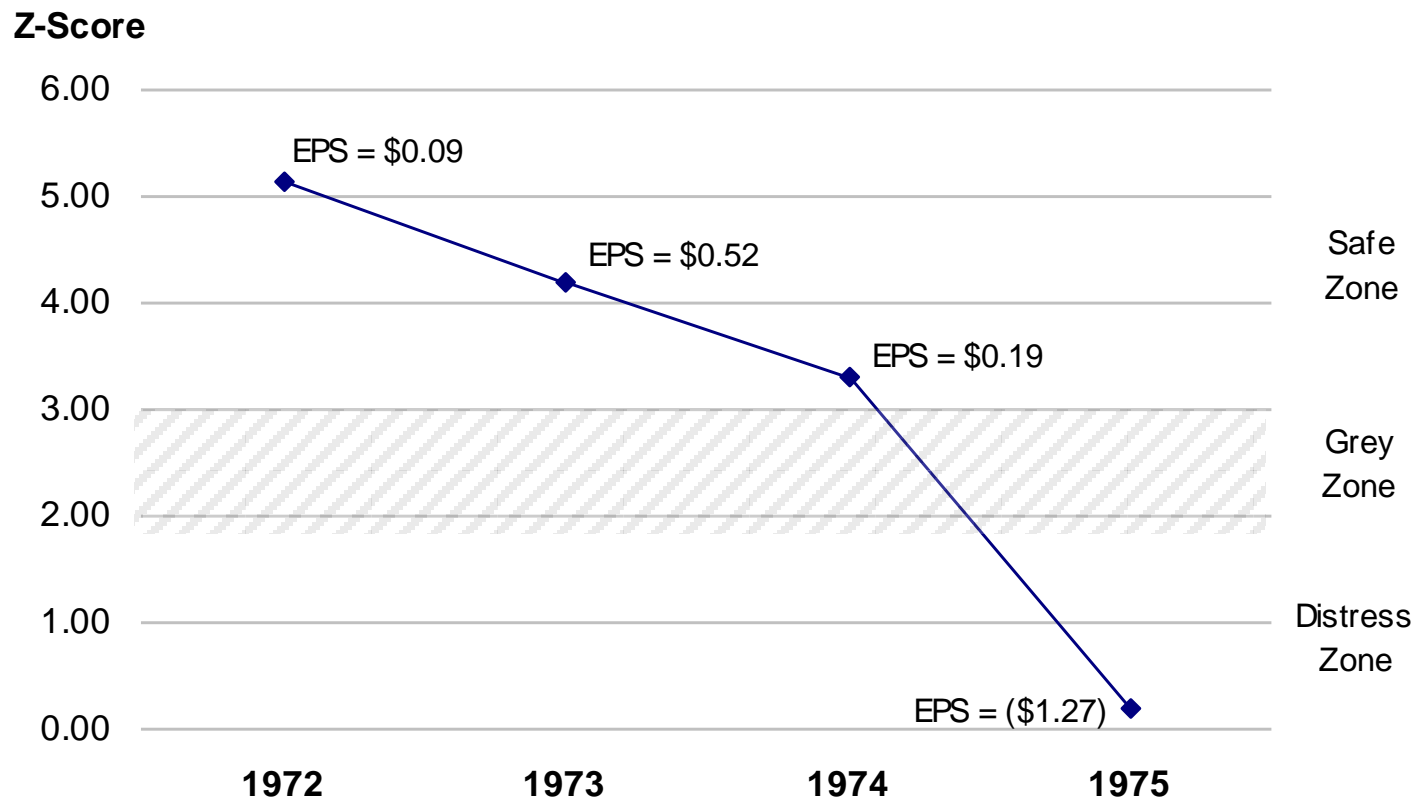




# Components of Z-Score Distressed Firm: Predictor as Applied to GTI Corporation



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



# Management Tools Used

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

# Strategy

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

# 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

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

# Z-Score Component Definitions

<u>Variable</u>	<u>Definition</u>	<u>Weighting Factor</u>
$X_1$	$\frac{\text{Working Capital}}{\text{Total Assets}}$	1.2
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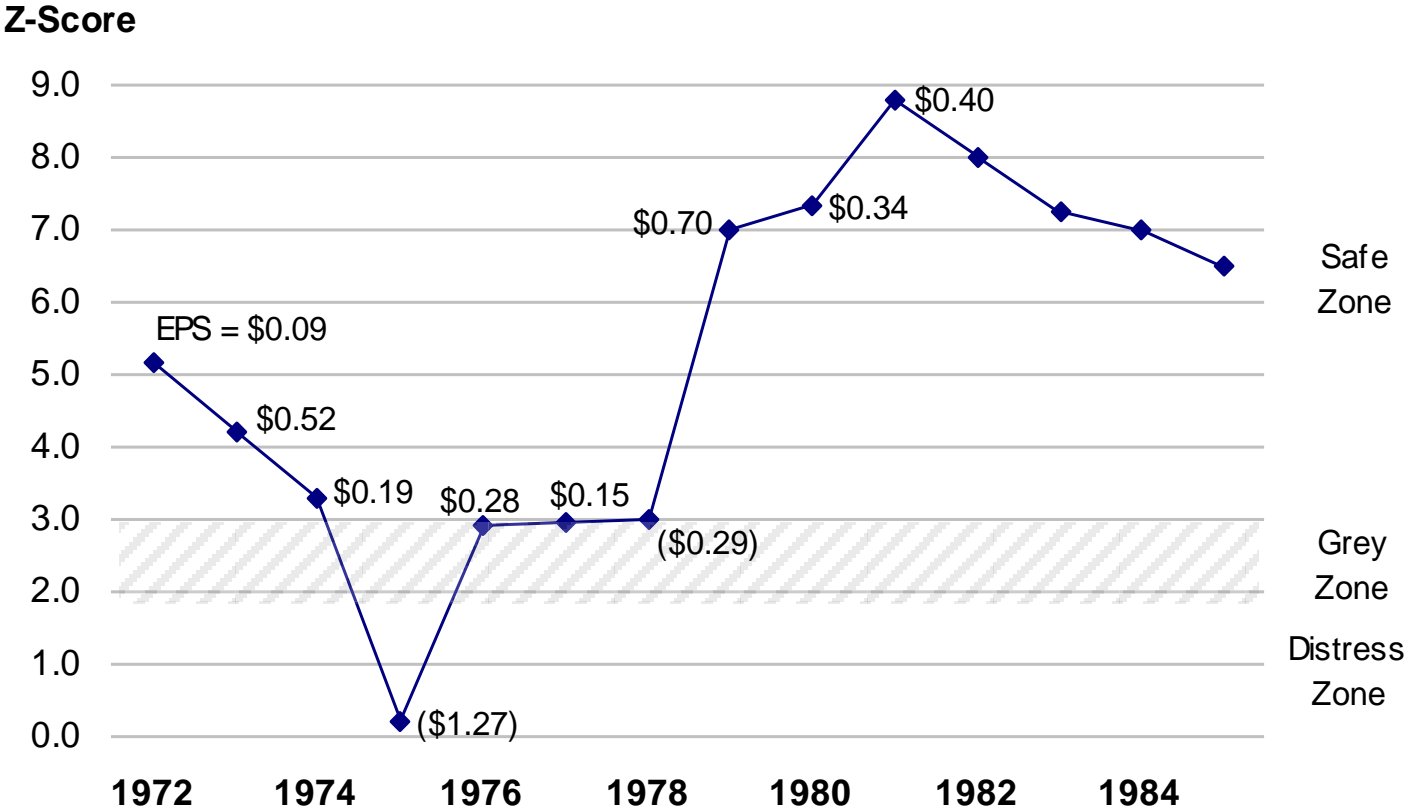
# Managerial & Financial Restructuring Actions and Impact on Z-Score

<u>Strategy</u>	<u>Reason</u>	<u>Impact</u>
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

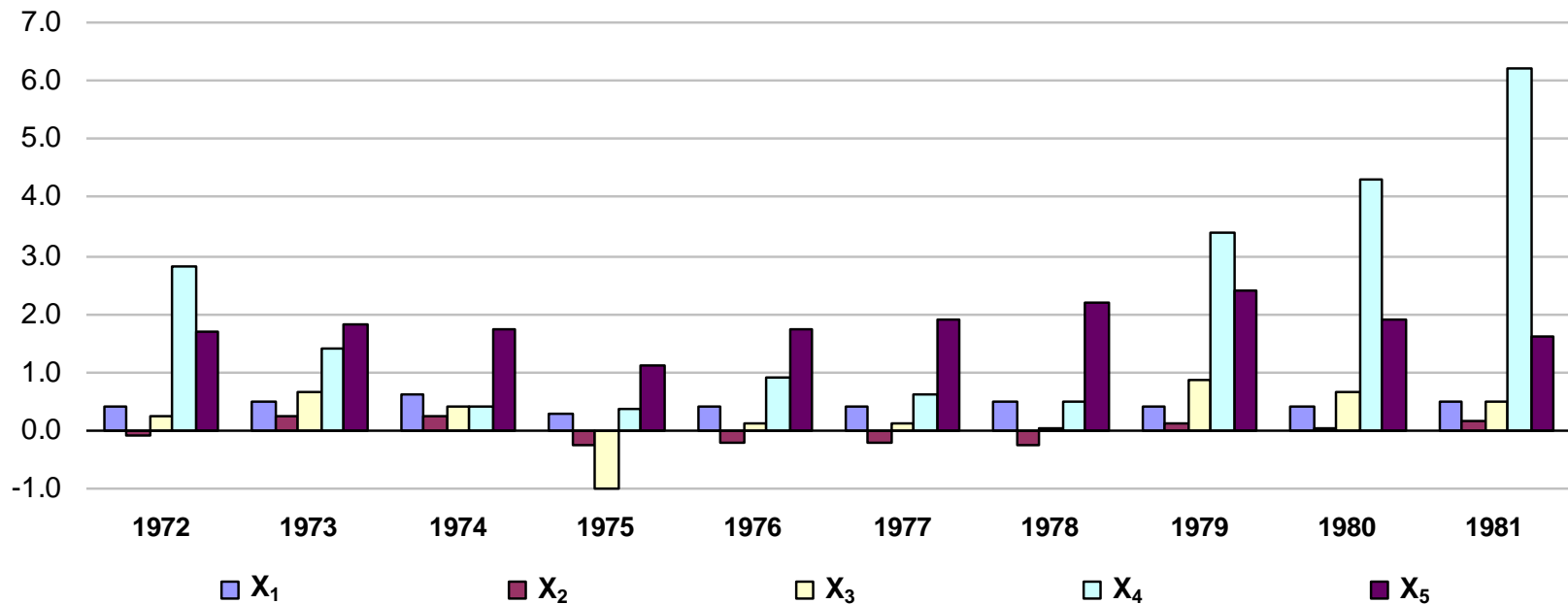


# Z-Score Distressed Firm Predictor

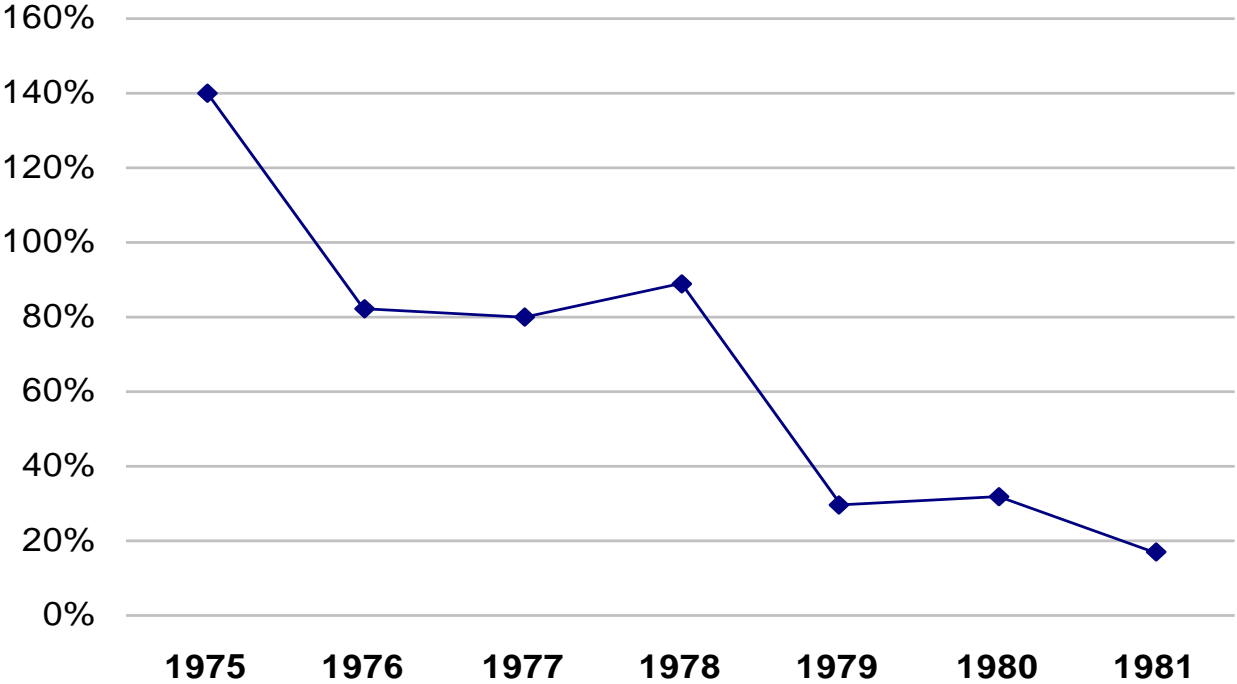
## Application to GTI Corporation (1972 – 1984)



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



# Debt / Equity Ratio



# Sales Dollars / Employee

