Turnaround: Applications of the Z-Score Model in the US and China

The GTI Case

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Corporate Credit Scoring Models and the Bond Rating Equivalence

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)

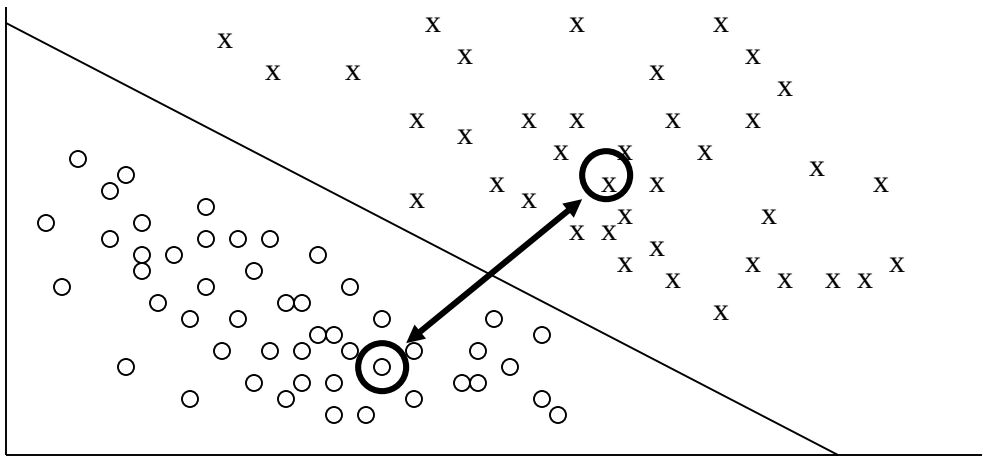
$a_1 \longrightarrow a_n$ = Discriminant Coefficients (Weights)

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

Example

EBIT

TA



"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	$\frac{\text{Sales}}{\text{Total Assets}}$	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

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

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

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

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

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

Zones of Discrimination: Original Z - Score Model

$Z > 2.99$ - "Safe" Zone

$1.8 < Z < 2.99$ - "Grey" Zone

$Z < 1.80$ - "Distress" Zone

Average Z-Score by S&P Bond Rating S&P 500: 1992 - 2005

Rating	2004-2005	1996-2001	1992-1995
AAA	5.31	5.60	4.80
AA	4.99	4.73	4.15
A	4.22	3.74	3.87
BBB	3.37	2.81	2.75
BB	2.27	2.38	2.25
B	1.79	1.80	1.87
B-	1.34	1.31	1.38
CCC+	0.90	0.82	0.89
CCC	0.45	0.33	0.40
D	-0.19	-0.20	0.05

Source: Compustat Database

Estimating Probability of Default and Probability of Loss Given Defaults

- Credit scores on new issues to estimate
- Bond ratings equivalents on new issues and then,
- Utilize mortality rates to estimate annual and cumulative defaults

Marginal and Cumulative Mortality Rate Equation

$$\mathbf{MMR_{(t)}} = \frac{\textit{Total value of defaulting debt in year (t)}}{\textit{total value of the population at the start of the year (t)}}$$

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,

$$CMR_{(t)} = 1 - \prod_{t=1} SR_{(t)},$$

here CMR $_{(t)}$ = Cumulative Mortality Rate in $_{(t)}$,
SR $_{(t)}$ = Survival Rate in $_{(t)}$, 1 - MMR $_{(t)}$

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	--	--	--	--	--	--
Total	1,500	50	100	25	100	200	40

Amount Start of Period								
1,500	-	175	-	1,325	-	340	=	985

	Year 1	Year 2
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

11 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

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

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

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 during 1st half of 75

- 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

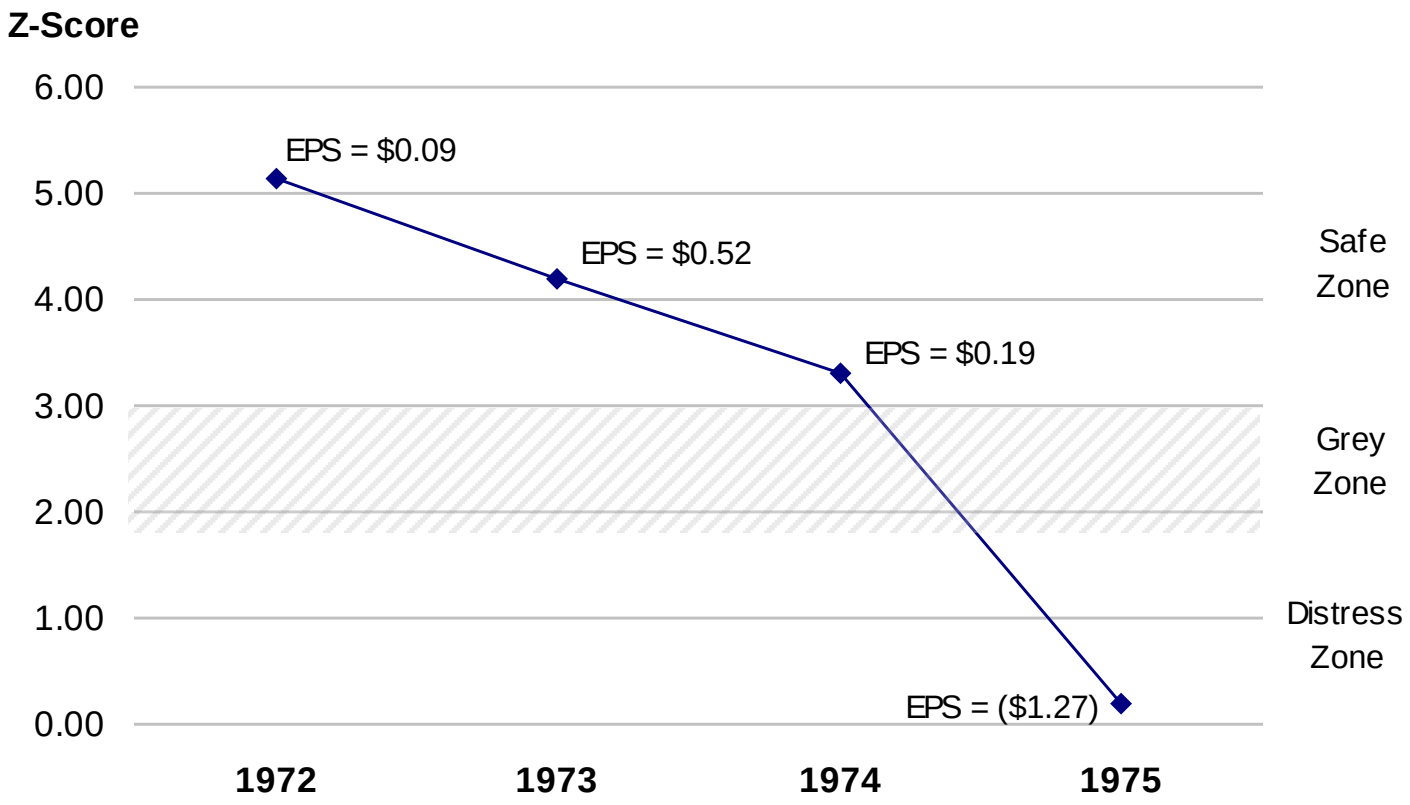
- Condition of GTI in June of 1975
- Management & Control changes
- Definition of Management's Responsibility
- Description of Management tools used
- Caveats for a successful Turnaround

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

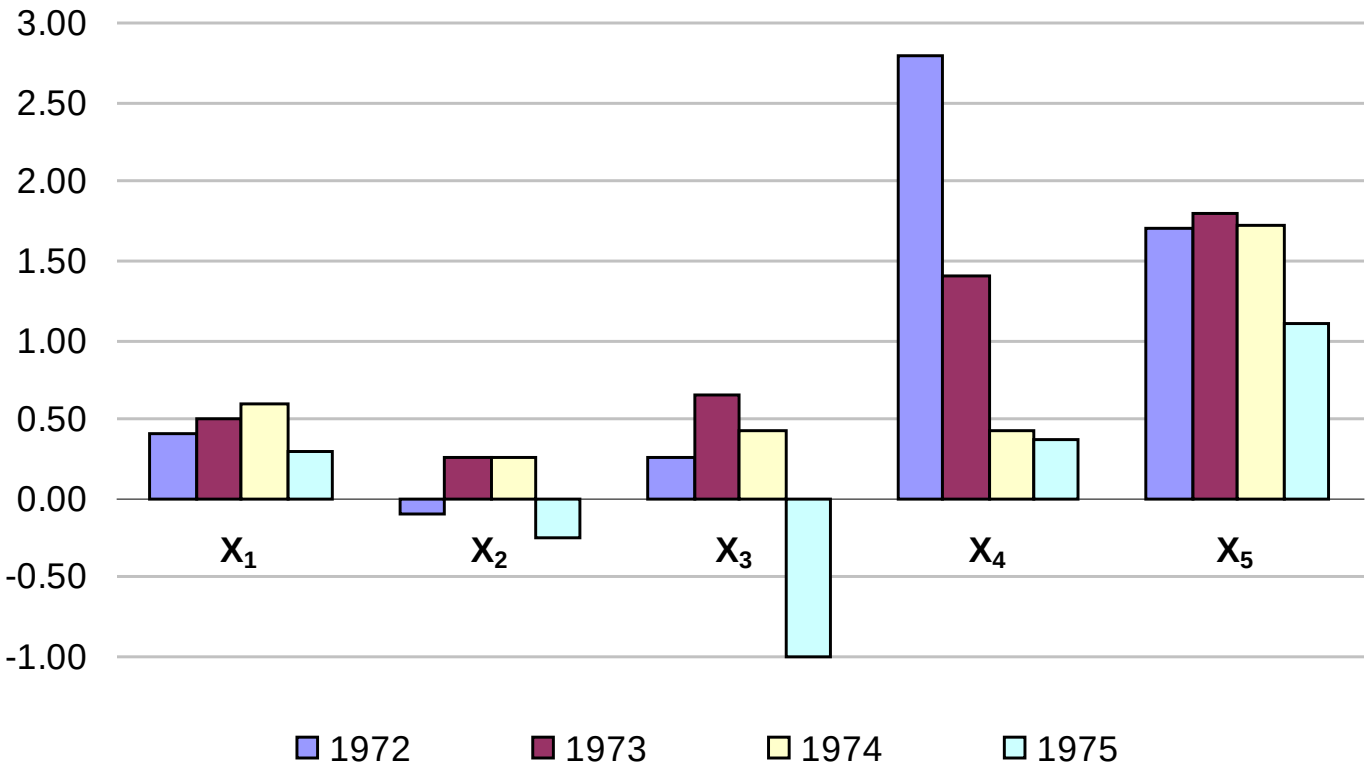
Z-Score Distressed Firm Predictor:

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

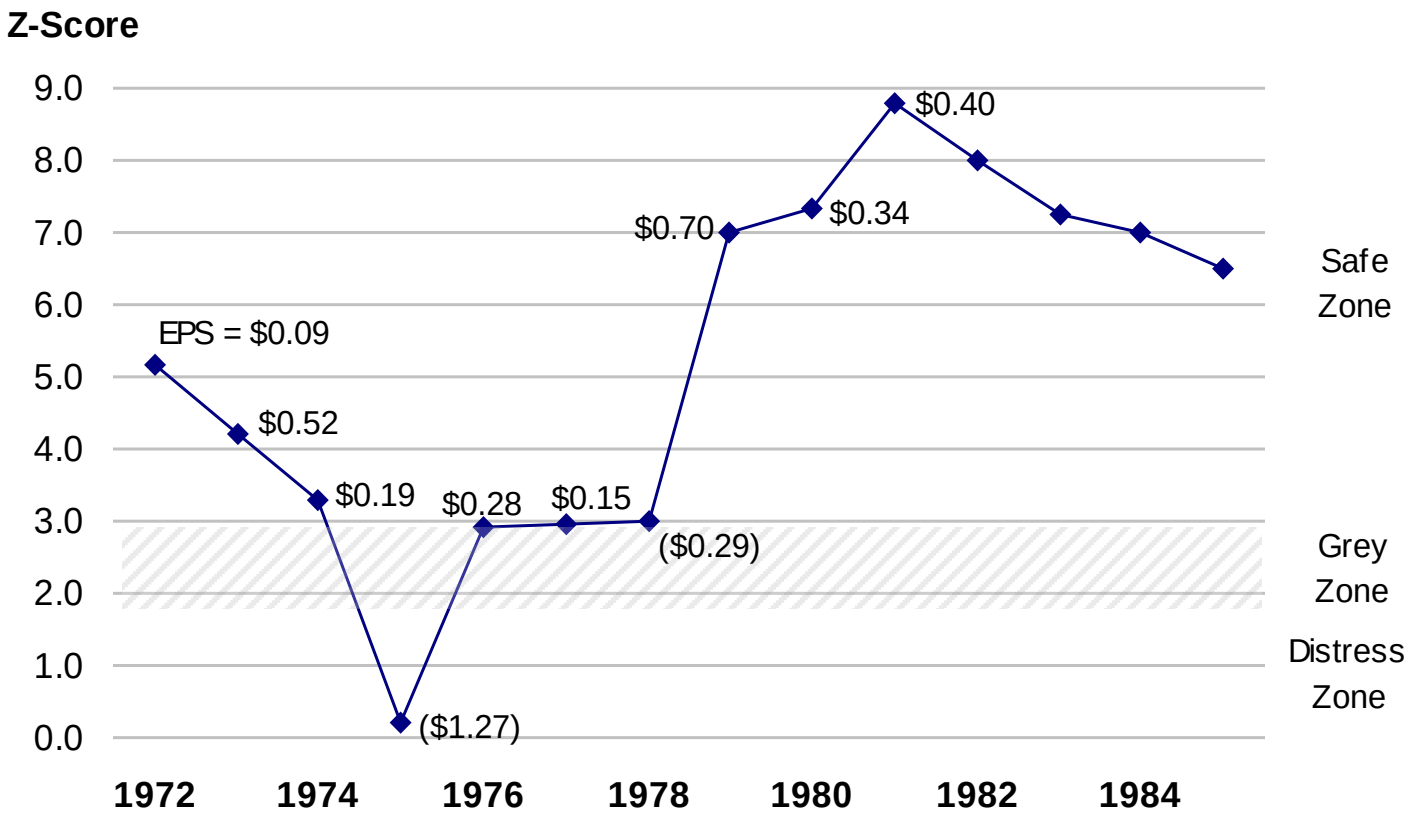
Variable	Definition	Weighting Factor
X_1	$\frac{\text{Working Capital}}{\text{Total Assets}}$	1.2
X_2	$\frac{\text{Retained Earnings}}{\text{Total Assets}}$	1.4
X_3	$\frac{\text{EBIT}}{\text{Total Assets}}$	3.3
X_4	$\frac{\text{Market Value of Equity}}{\text{Book Value of Total Liabilities}}$	0.6
X_5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

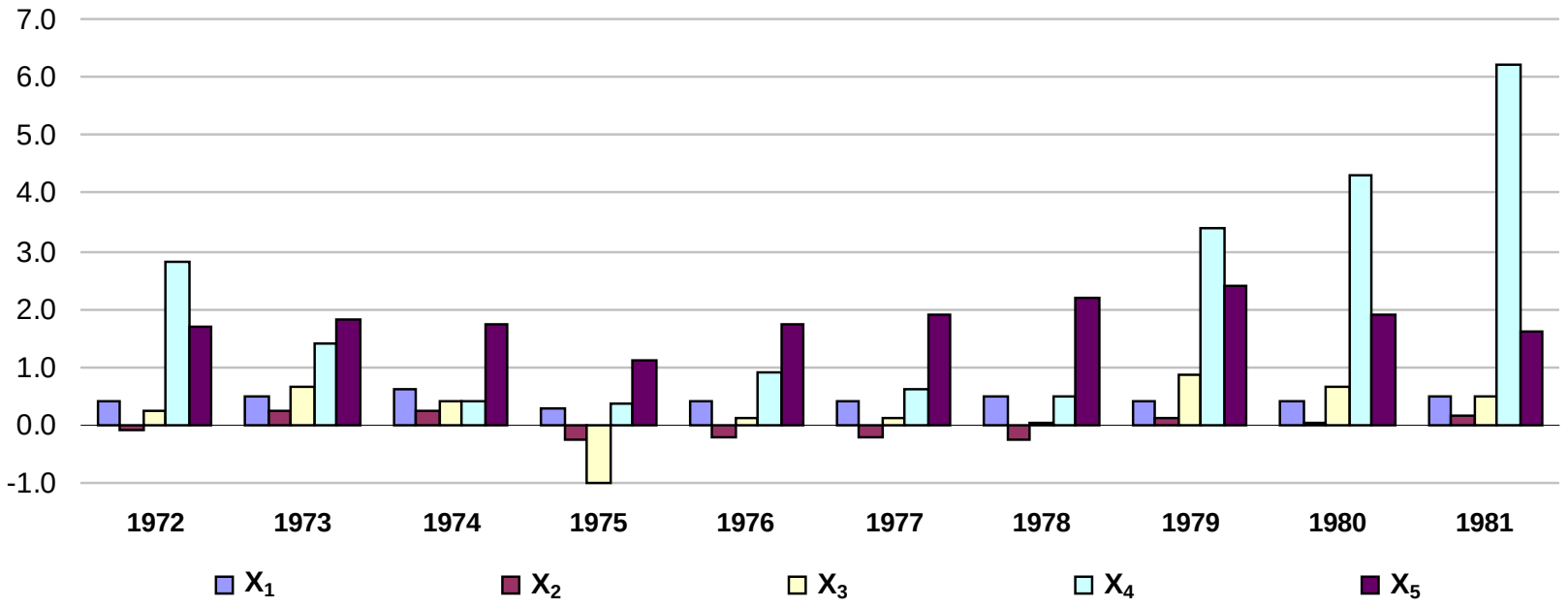
Z-Score Distressed Firm Predictor

Application to GTI Corporation (1972 – 1984)

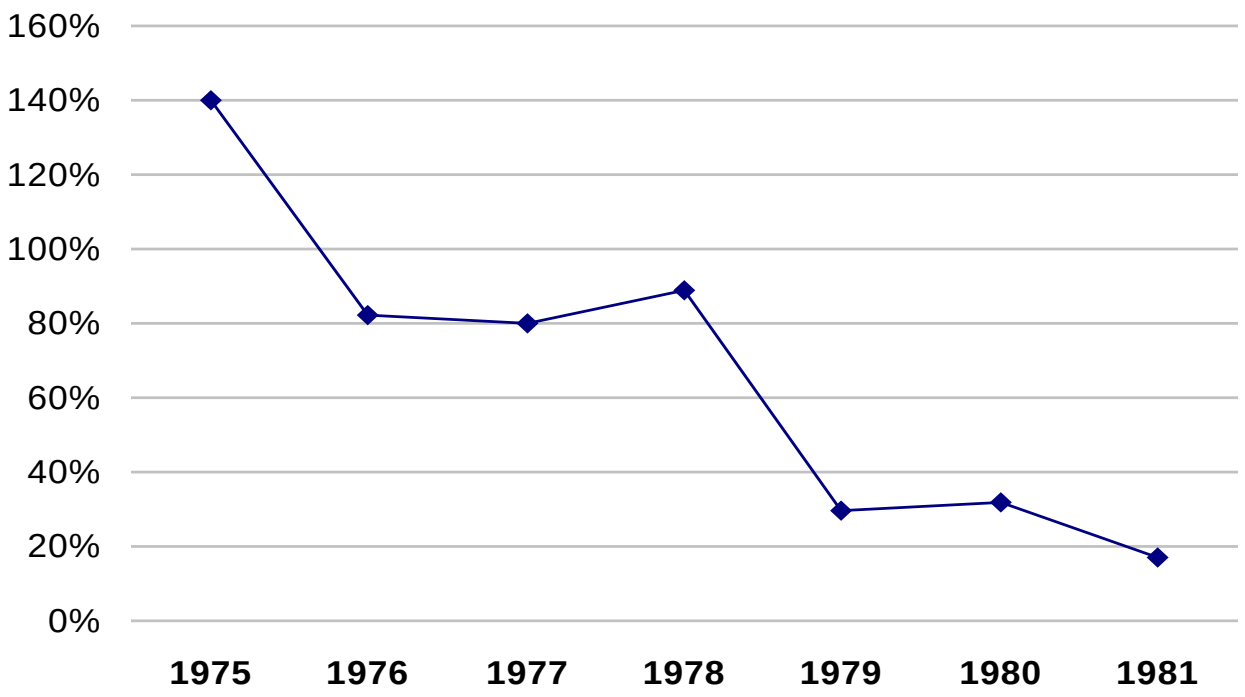


Components of Z-Score Distressed Firm:

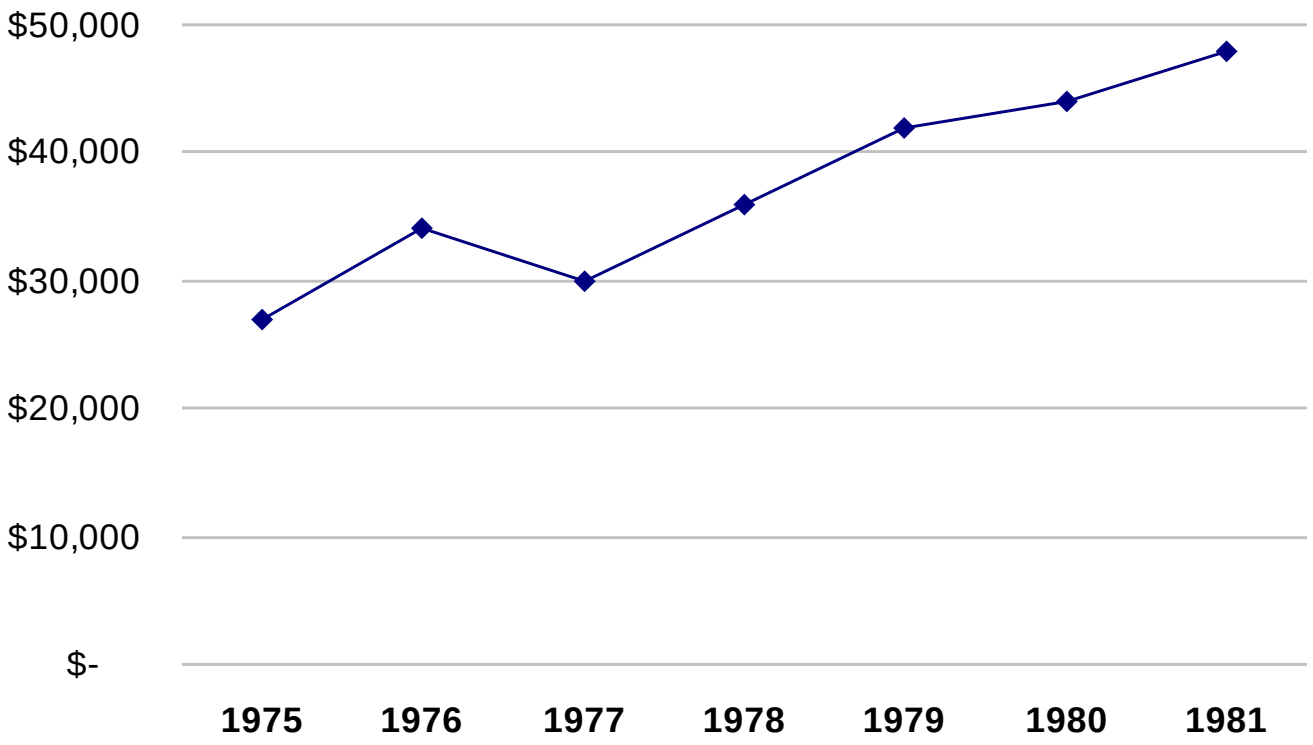
Predictor as Applied to GTI Corporation



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:

	Mean "ST"	Mean "Non-ST"
X_1 = Working Capital / Average Total Assets (ATA) =	• -0.17	0.12
	(F = 5.8)	
X_2 = Retained Earnings / TA =	• -0.33	0.22
	(F = 19.8)	
X_3 = Net Profit / ATA =	• -0.36	0.26
	(F = 139.1)	
X_4 = Total Liabilities / TA =	• 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