Corporate Credit Scoring Models

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Problems With Traditional Financial Ratio Analysis

1 Univariate Technique

  1-at-a-time

2 No "Bottom Line"

3 Subjective Weightings

4 Ambiguous

5 Misleading

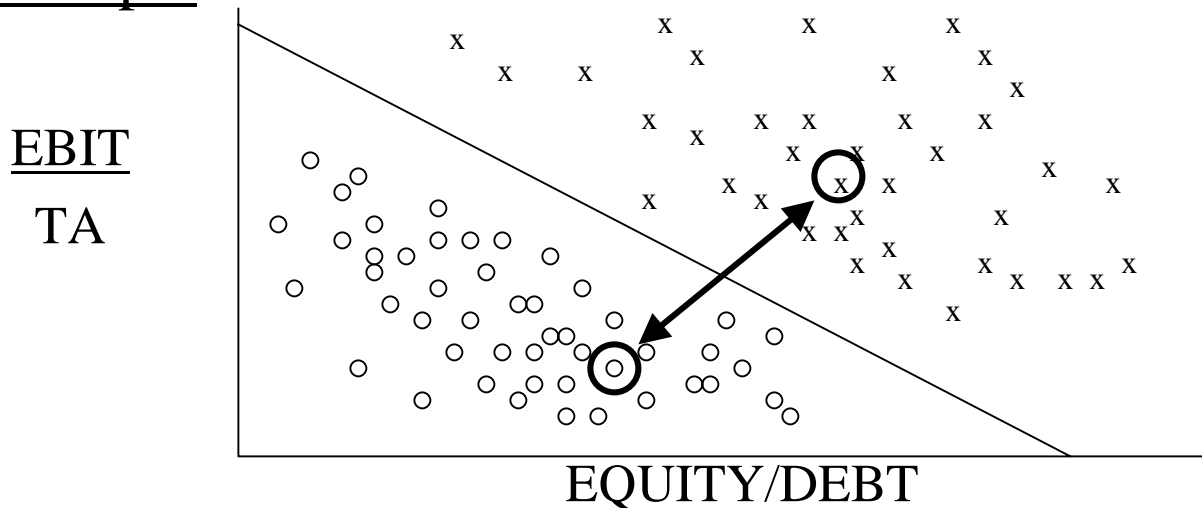# Forecasting Distress With Discriminant Analysis

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

EBIT / TA

EQUITY/DEBT

"Z" Score Component Definitions

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

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

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

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

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

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

Zones of Discrimination:
Original Z - Score Model

$$Z > 2.99 - \text{``Safe'' Zone}$$

$$1.8 < Z < 2.99 - \text{``Grey'' Zone}$$

$$Z < 1.80 - \text{``Distress'' Zone}$$

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%	-	-	-	-

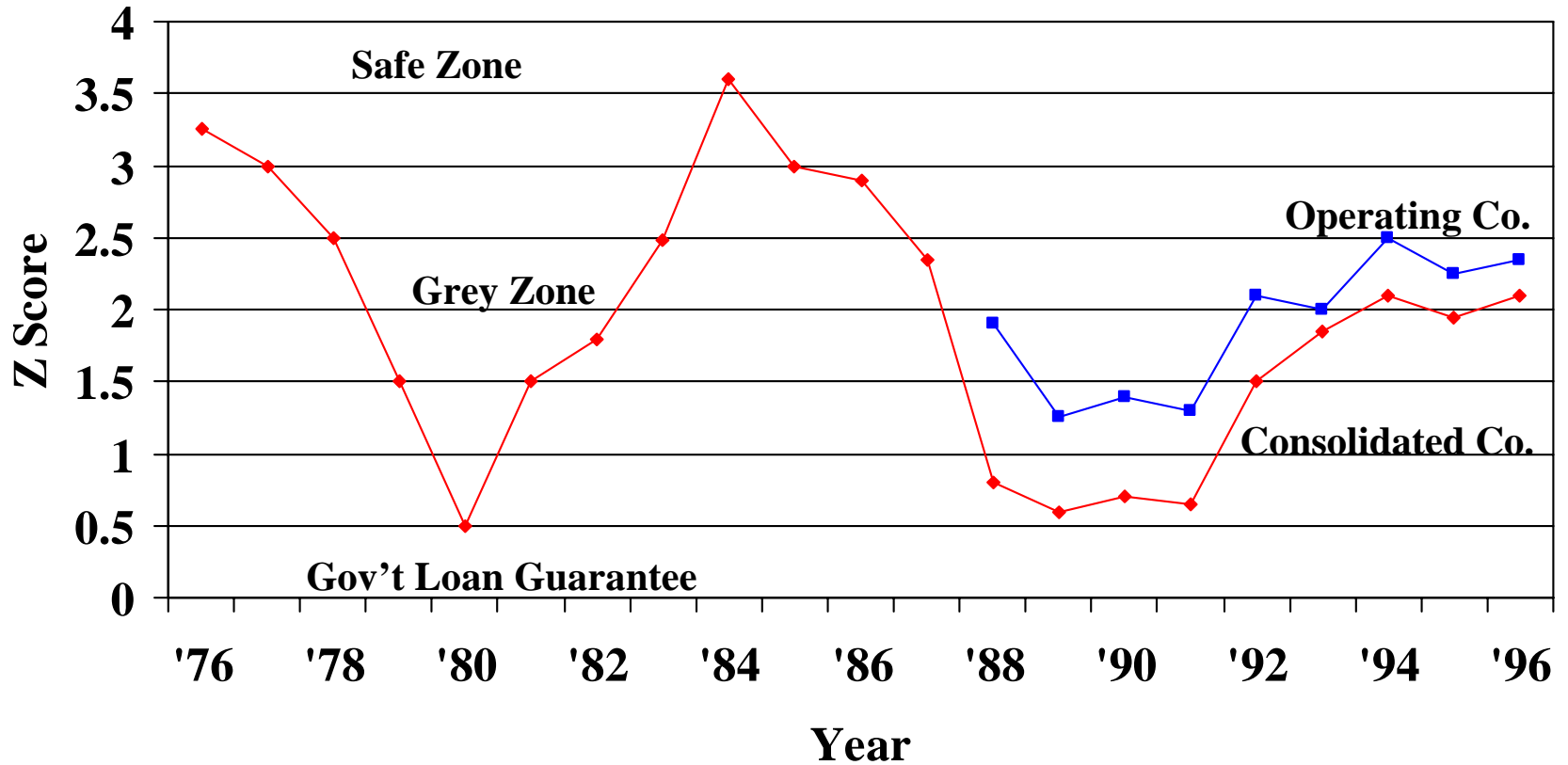*Using 2.67 as cutoff score (1.81 cutoff accuracy in parenthesis)
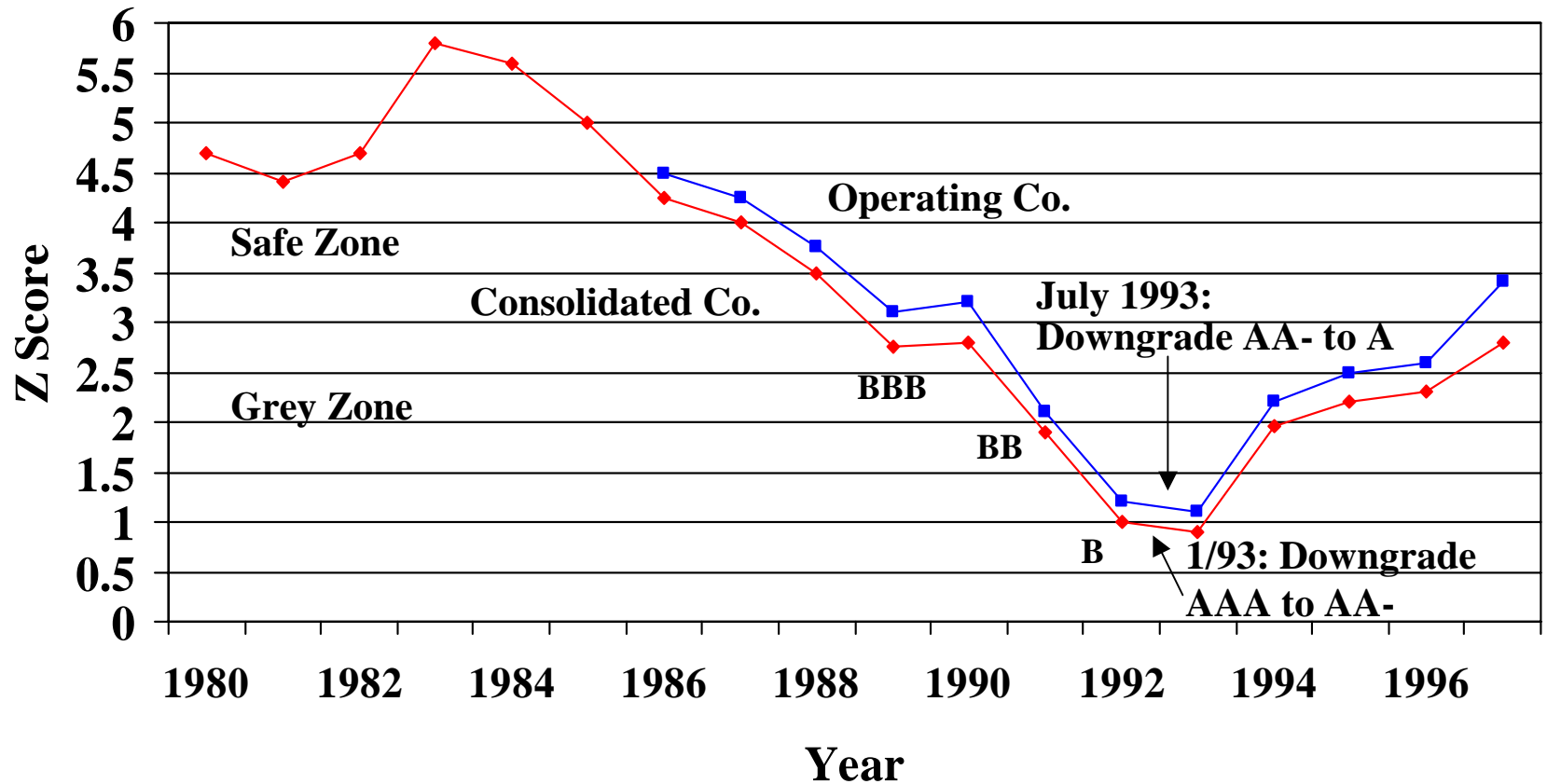
Z Score Trend - LTV Corp.

8
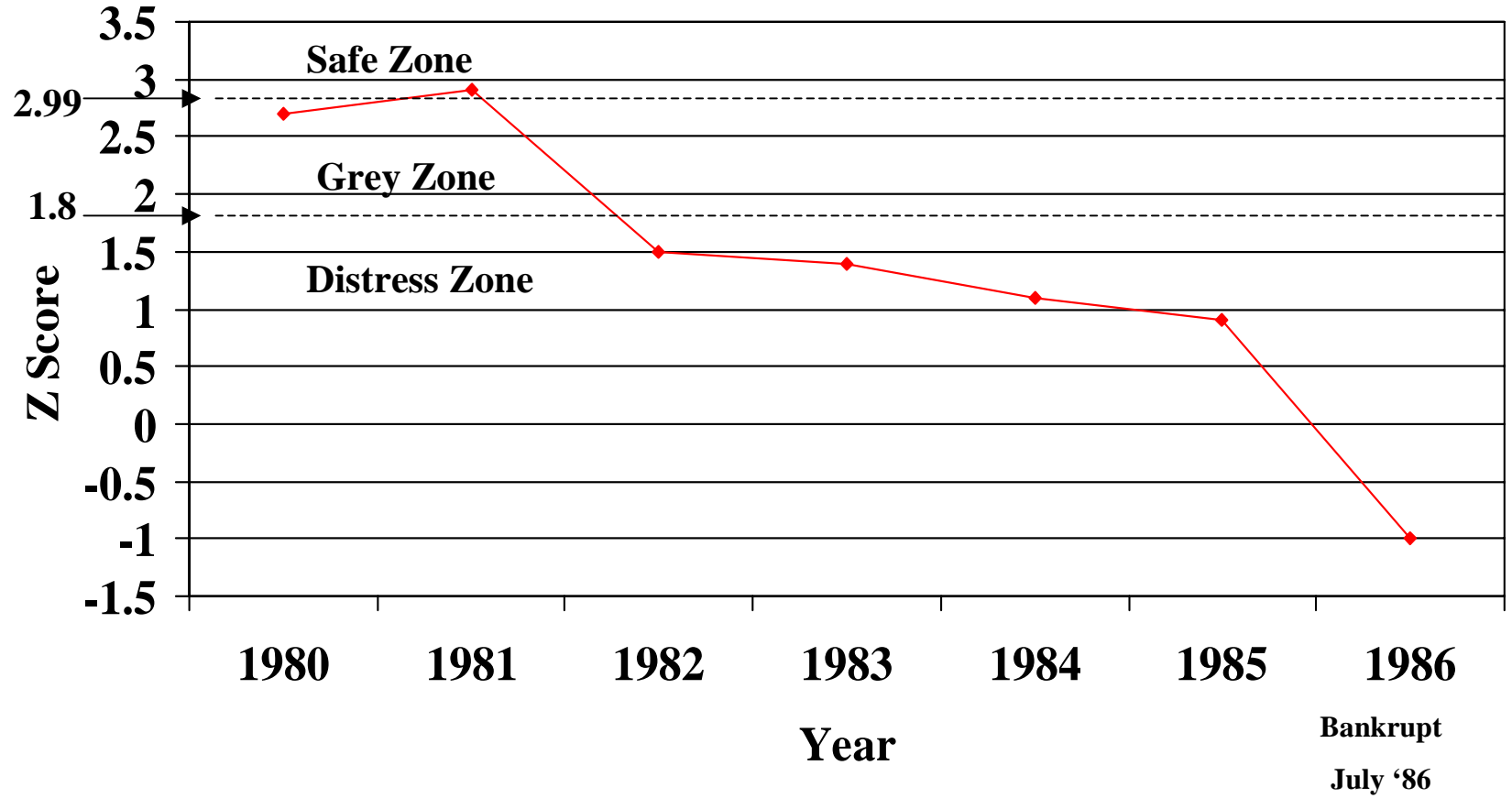
International Harvester (Navistar)
Z Score (1974 - June 1996)
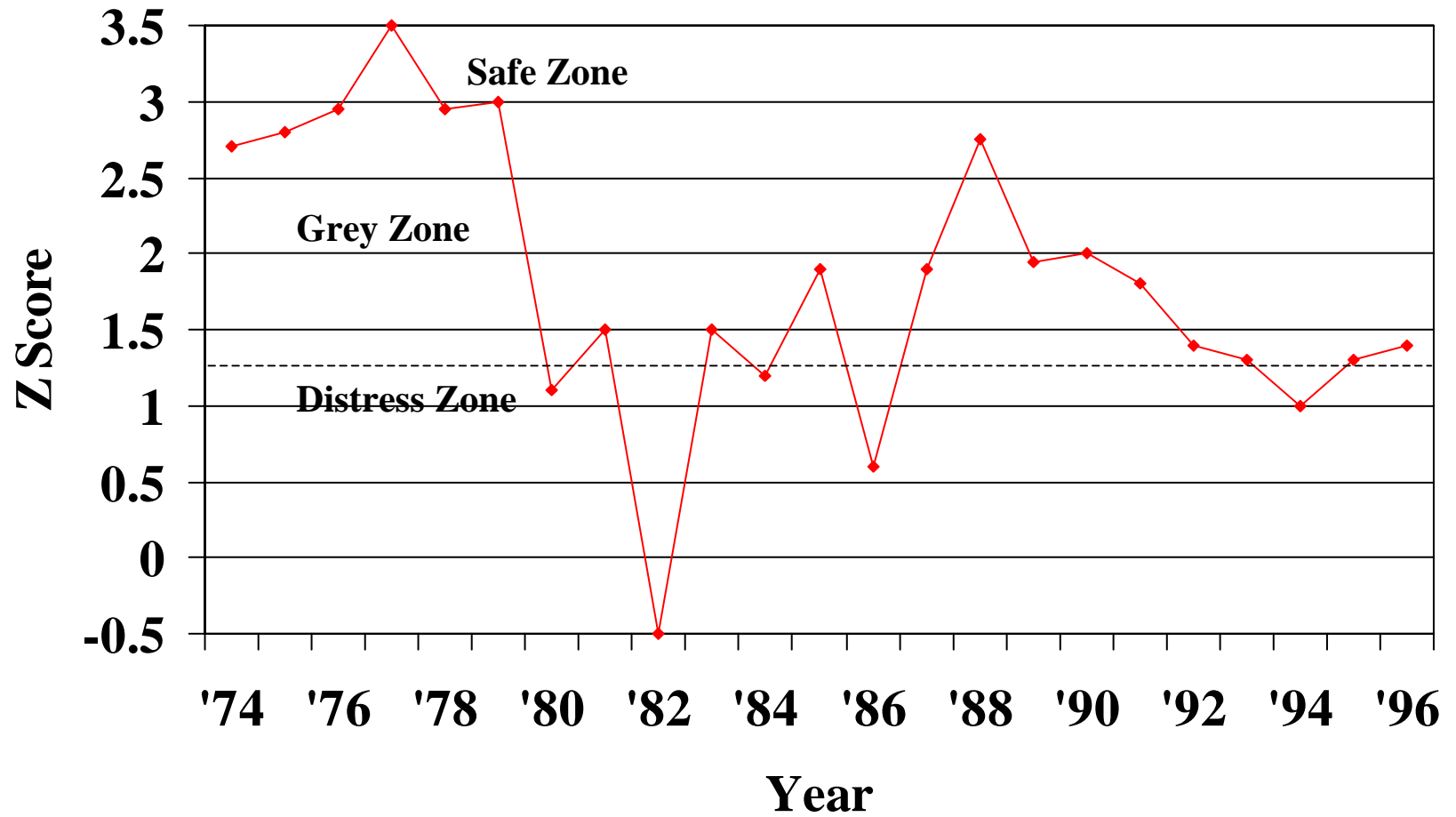
Chrysler Corporation
## Z Score (1976 - June 1996)

IBM Corporation
Z Score (1980 - June 1997)

Average Z-Score by S&P Bond Rating
S&P 500: 1992 - 1995 *

	Num. Of Firms	1995 Avg.	1995 Std. Dev.	1994 Avg.	1994 Std. Dev.	1993 Avg.	1993 Std. Dev.	1992 Avg.	1992 Std. Dev.
AAA	11	5.020	1.603	4.376	1.380	4.506	1.499	5.263	2.194
AA	46	4.296	1.911	4.047	1.832	4.032	1.893	4.226	2.088
A	131	3.613	2.259	3.472	2.007	3.607	2.180	3.923	3.255
BBB	107	2.776	1.493	2.701	1.580	2.839	1.741	2.601	1.535
BB	30	2.449	1.623	2.276	1.694	2.185	1.626	2.102	1.544
* B	80	1.673	1.234	1.876	1.517	1.964	1.716	1.962	2.333

Xerox Credit Quality: Z Score Analysis 1998-2000
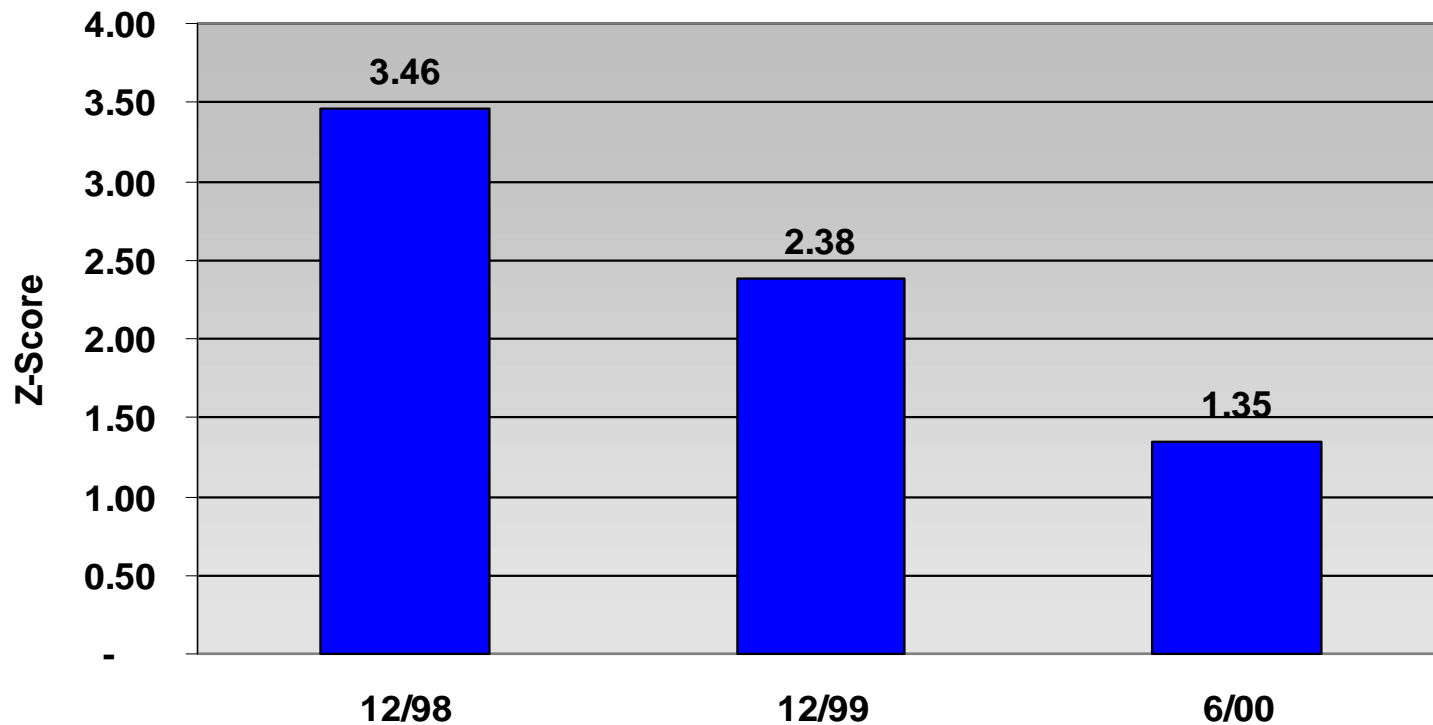
Bond Rating Equivalents:

12/98 A
12/99 BB
06/00 B

Actual Rating (S&P):

12/98 A
12/99 A
06/00 A
12/00 BBB-

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Z' Score
Private Firm Model

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

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

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

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

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

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

$Z' > 2.90$ - "Safe" Zone

$1.23 < Z' < 2.90$ - "Grey" Zone

$Z' < 1.23$ - "Distress" Zone

Z'' Score Model for Manufacturers, Non-Manufacturer Industrials, & Emerging Market Credits

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

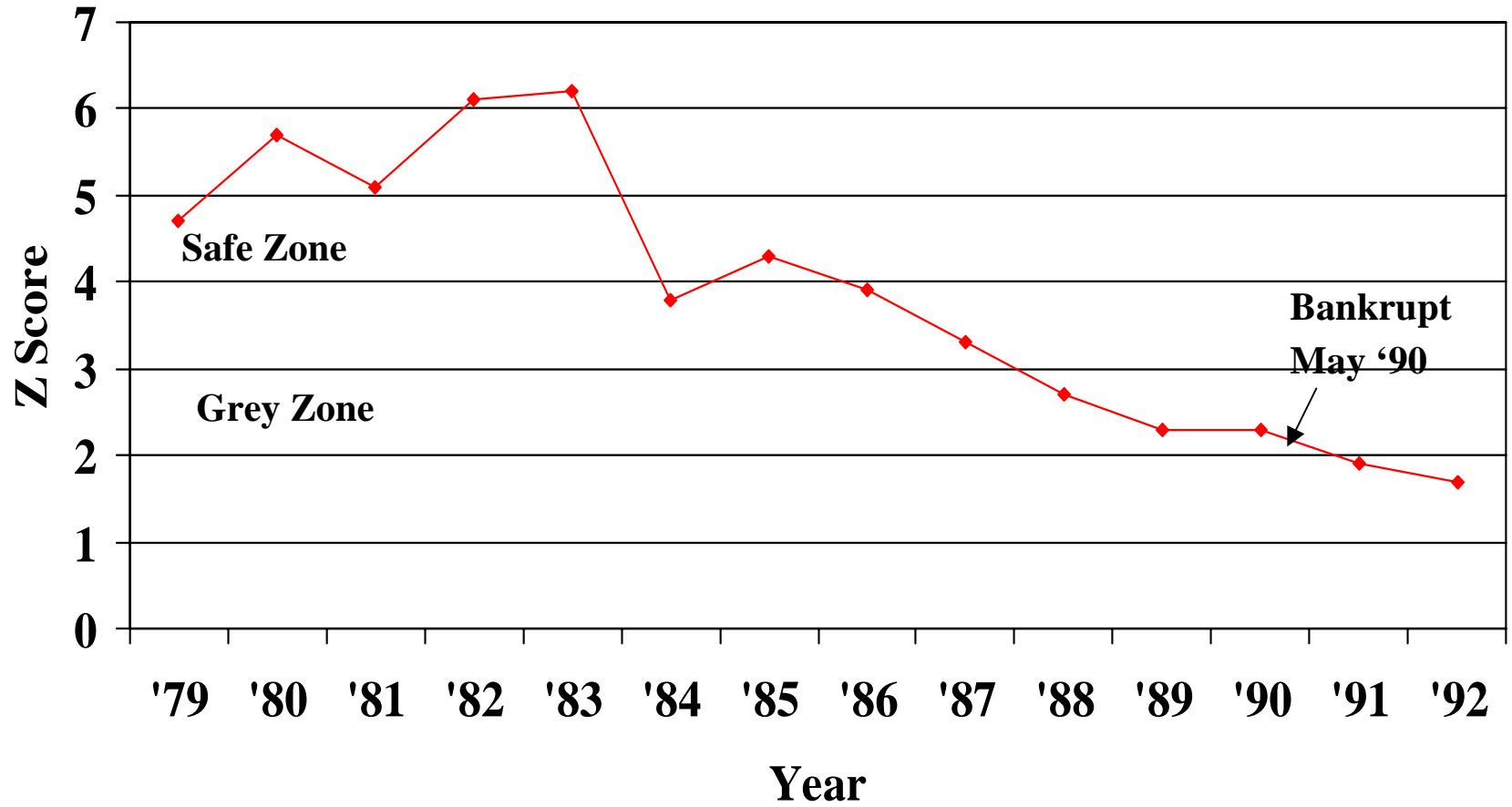$X_1 = \dfrac{\text{Current Assets - Current Liabilities}}{\text{Total Assets}}$

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

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

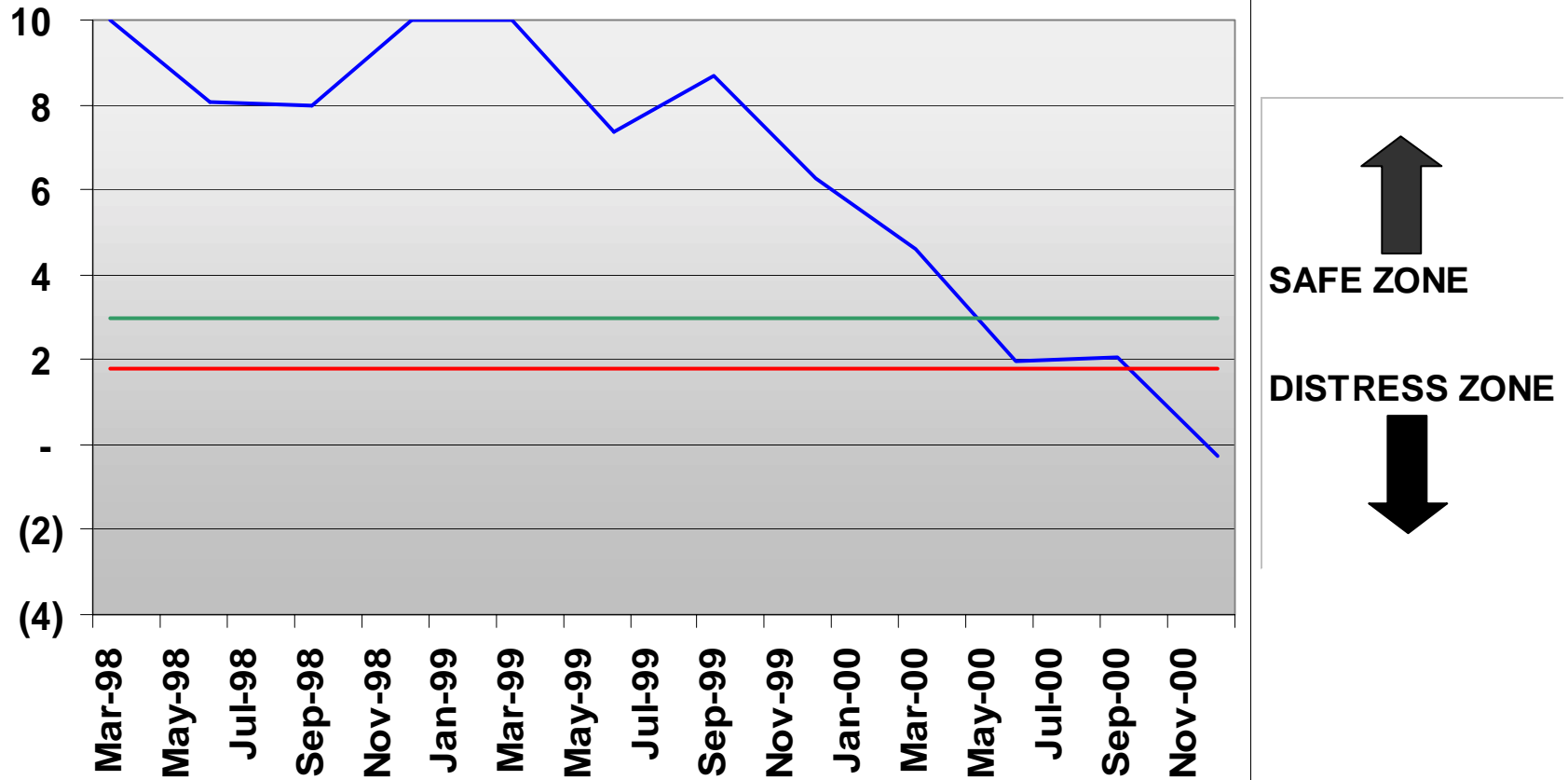$X_4 = \dfrac{\text{Book Value of Equity}}{\text{Total Liabilities}}$

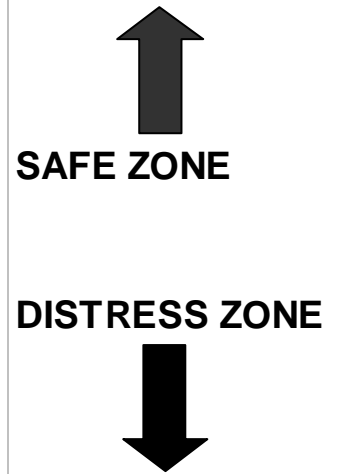| |
|---|
| Z'' > 2.60 - "Safe" Zone |
| 1.1 < Z'' < 2.60 - "Grey" Zone |
| Z '' < 1.1 - "Distress" Zone |

Circle K - Z Score (1979 - 1992)

**Amazon.com Z-Scores 1998-2000
Five Variable Model With Market Value Equity (X4)**

SAFE ZONE

DISTRESS ZONE

Amazon.com Z-Scores 1997-2000
Four Variable Model With Book Value Equity (X4)

SAFE ZONE

DISTRESS ZONE
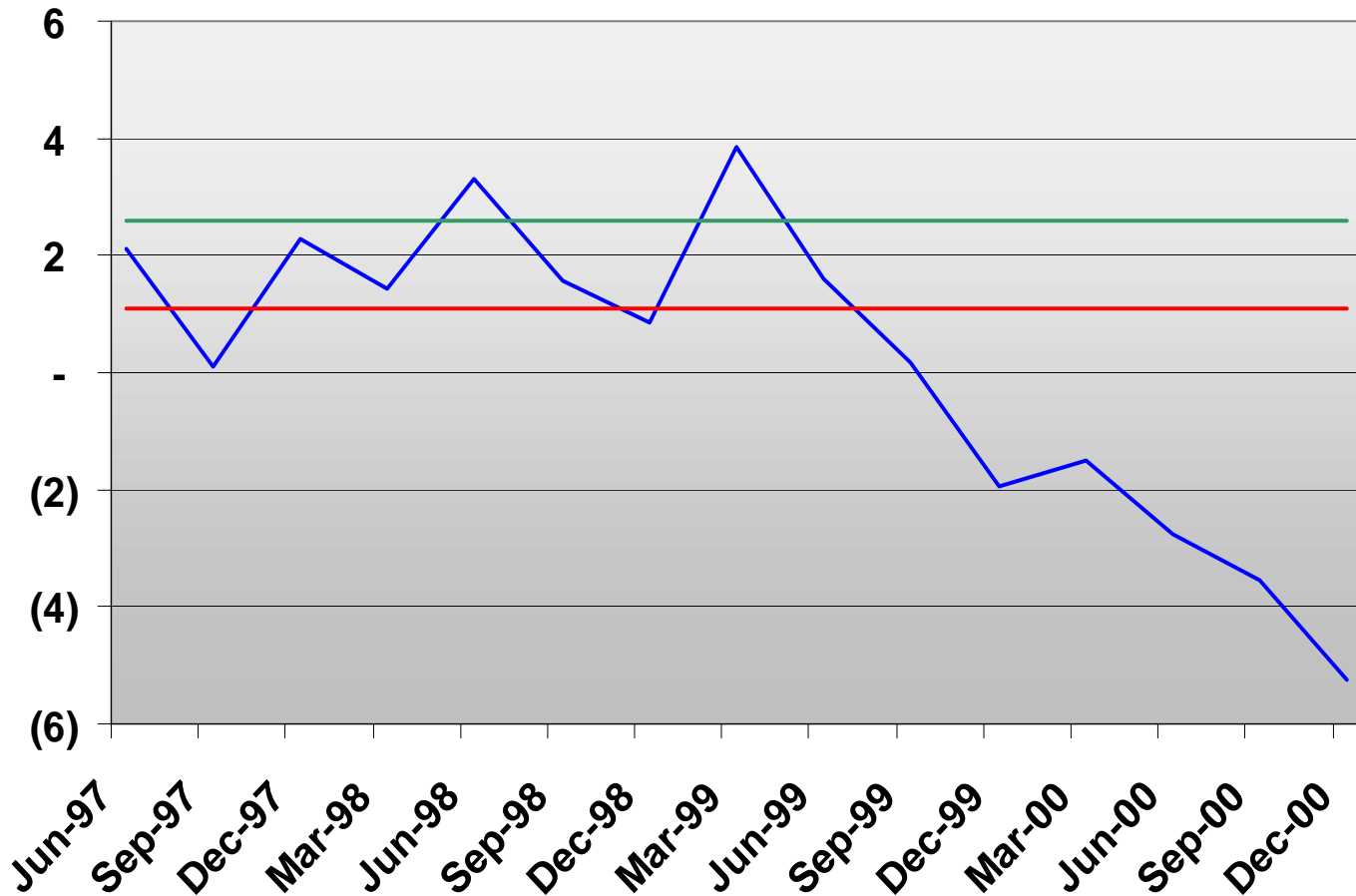
DAF Corporation Z Scores
(Dutch Company Bankruptcy 1993)
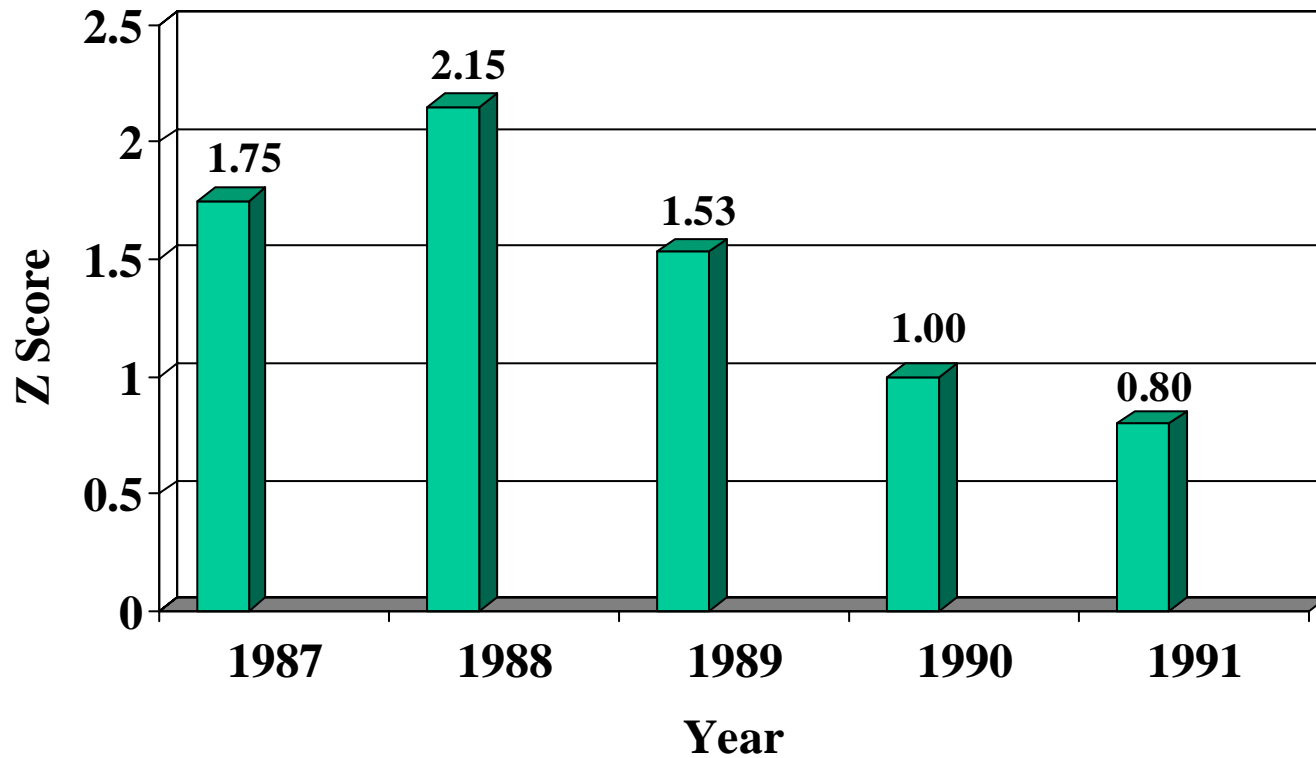
Average Z-Scores: US Industrial Firms 1975-1999
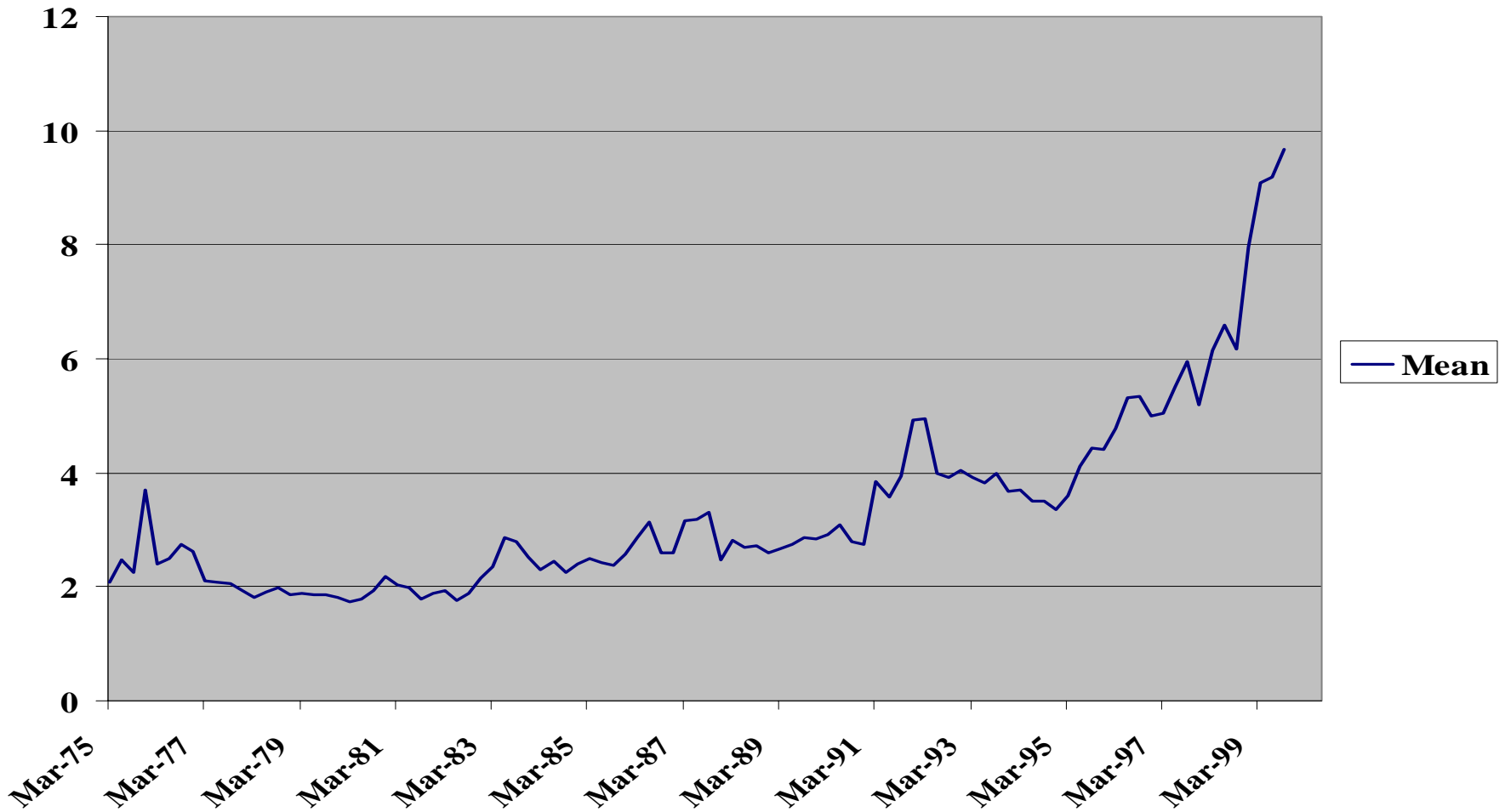
Argenti (A Score System)

Defects

In Management

 Weight

8 - Chief Executive is an autocrat

4 - He is also the chairman

2 - Passive Board - an autocrat assures this

2 - Unbalanced Board - too many engineers or too many finance types

1 - Poor management depth

In Accountancy

3 - No budgets or budgetary controls

3 - No cash flow plans, or not updated

3 - No costing system. Cost and contribution of each product unknown

15 - Poor response to change, old fashioned product, obsolete factory, out-of-date marketing

Total Defects 42   Pass 10

Argenti (A Score System)

Weight

_____ 5 - Financial signs, such as Z Score

4 - Creative accounting. Chief executive is the first to see signs of failure, and in an attempt to hide it from creditors and the banks, accounts are 'glossed over' by overvaluing stocks, using lower depreciation, etc.

3 - Non-financial signs, such as untidy offices, frozen salaries, chief executive 'ill', high staff turnover, low morale, rumors

1 - "Terminal signs"

Total Symptoms   13

Total Possible Score   100   Pass   25

Total Score	Prognosis
0-10	No Worry (High Pass)
0-25	Pass
10-18	Cause for Anxiety (Pass)
18-35	Grey Zone - Warning Sign
>35	Company "At Risk"

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KMV MODEL

KMV Credit Monitor Model

- Provides a quantitative assessment of the credit risk of publicly traded companies

- The model is theoretically rather than empirically based

- It is built around the market's valuation of a firm's creditworthiness

- The model can be applied to the universe of publicly-traded companies

- The universe consists of thousands of companies in the U.S.

- By contrast, only approximately 2000 companies have publicly-traded debt that is rated by the rating agencies. Even then, bond price data is often difficult to get.

The *Market's* Valuation of Debt

- The stock market's perception of the value of a firm's equity are readily conveyed in a traded company's stock price

- The information contained in the firm's stock price and balance sheet can be *translated* into an implied risk of default through two relationships:

  - The relationship between the market value of a firm's equity and the market value of its assets.

  - The relationship between the volatility of a firm's assets and the volatility of a firm's equity.

KMV Credit Monitor Output

- A quantitative estimate of the *default probability* called the expected default frequency (EDF).

- EDFs are calibrated to measure the probability of a borrower defaulting within one year.

- EDFs are reported in percentages ranging from 0 to 20.

KMV Model - Empirical Result

STEP 1 -   Model <u>Estimates</u> Market Value and Volatility of Firm's Assets

STEP 2 -   Then calculates the Distance-to-Default (# of Standard
            Deviations)

            Distance-to-Default is a Type of Asset/Liability Coverage Ratio

STEP 3 -   Distance-to-Default of a Firm is Mapped Against a Database of
            Empirical Frequencies of Similar Distance-to-Default Companies
            to Obtain <u>Expected</u> <u>Default</u> <u>Frequency</u> (EDF) for a Firm

Estimation of Market Value
And Volatility of Firm's Assets

• Asset Values are Based on Underlying Value of Firm, Independent of Firm's Liabilities.

• Asset Volatility Calculated as the Annualized Standard Deviation of Percentage Changes in the Market Value of Assets.

• Equity Market Value and its Volatility, as Well as the Liability Structure, are Used as Proxies for the Asset's Value and Volatility.

• Option Theory of Assets Used to Value Assets Since MV of Debt is Not Known. If Debt MV is Known, then A=E+D (MV). But, MV Assets are Calculated by Knowing Only the MV Equity and PV of Liabilities.

Estimation of Market Value
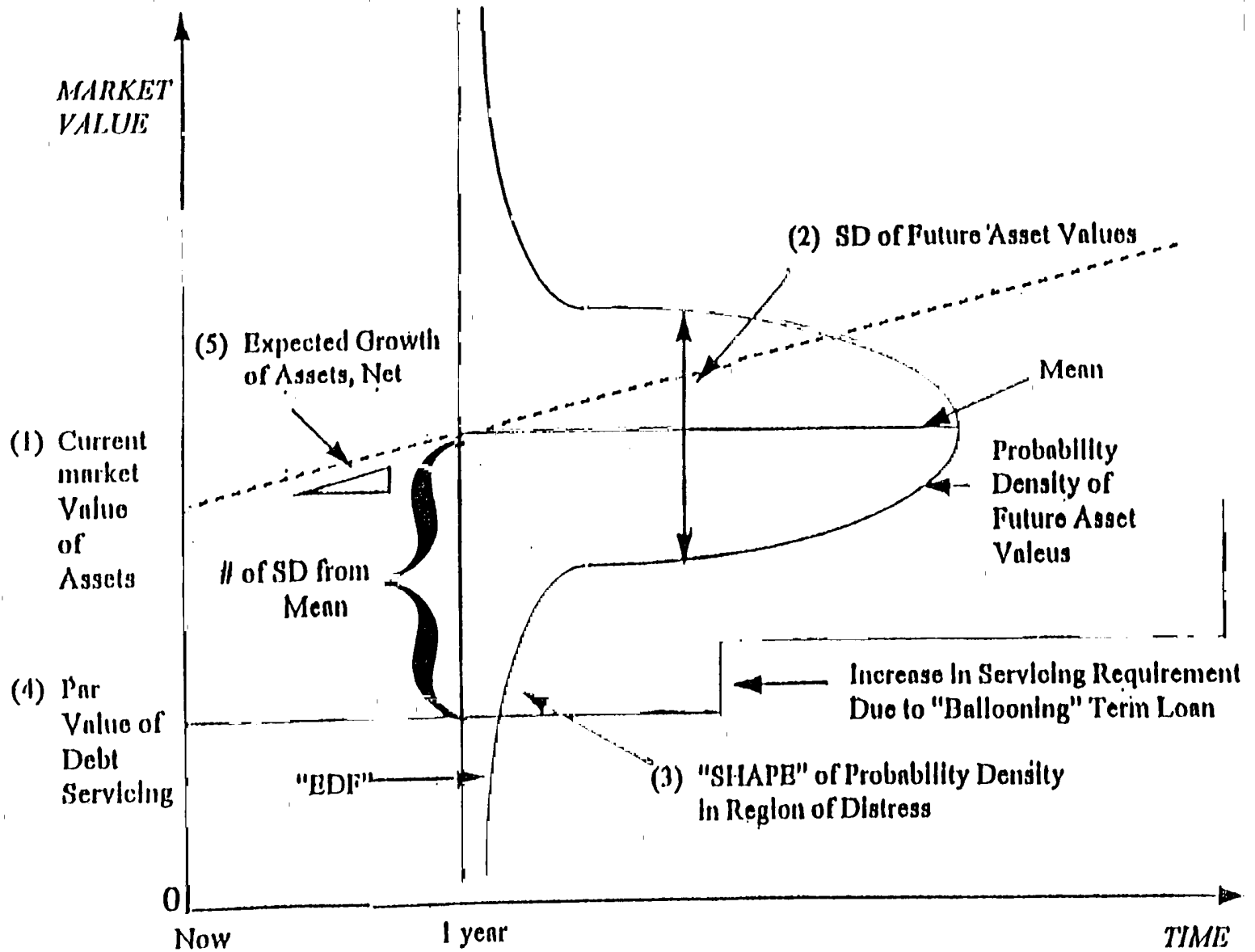## And Volatility of Firm's Assets
(continued)

• KMV Assumes that All Short Term Debt and 50% of Long Term Liabilities Are Used to Calculate the Default Point (Was 25% of LTD).

• When MV Assets < Payable Liabilities then Firm Defaults. Firm Cannot Sell Off Assets or Raise Additional Capital Because All Existing Assets are Fully Encumbered.

KMV Strengths

- Can be applied to any publicly-traded company

- Responsive to changing conditions, (EDF updated quarterly)

- Based on stock market data which is timely and contains a forward looking view

- Strong theoretical underpinnings (versus ad-hoc models)

KMV Weaknesses

- Difficult to diagnose a theoretical EDF (what is the distribution of asset return outcomes)

- Problems in applying model to private companies and thinly-traded companies

- Results sensitive to stock *market* movements (does the stock-market over-react to news?)

- Ad-hoc definition of anticipated liabilities (ie. 50% of long-term debt)

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

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KMV'S Expected Default Frequency (EDF)

Based on empirical observation of the Historical Frequency of the Number of Firms that Defaulted With Asset Values (Equity + Debt) Exceeding Face Value of Debt Service By a Certain Number of Standard (Std.) Deviations at one year prior to default.

For Example:

|		
Current Market Value of Assets	=	$ 910
Expected One Year Growth in Assets	=	10%
Expected One Year Asset Value	=	$1,000
Standard Deviation	=	$ 150
Par Value of Debt Service in One Year	=	$ 700
Therefore:		
# Std. Deviations from Debt Service	=	2

Expected Default Frequency (EDF)

$$EDF = \frac{\text{Number of Firms that Defaulted With Asset Values 2 Std. Deviations from Debt Service}}{\text{Total Population of Firms With 2 Std. Deviations from Debt Service}}$$

$$eg. = \frac{50 \text{ Defaults}}{1,000 \text{ Population}} = .05 = EDF$$

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Comparing Z-Score and KMV-EDF Bond Rating Equivalents

IBM Corporation
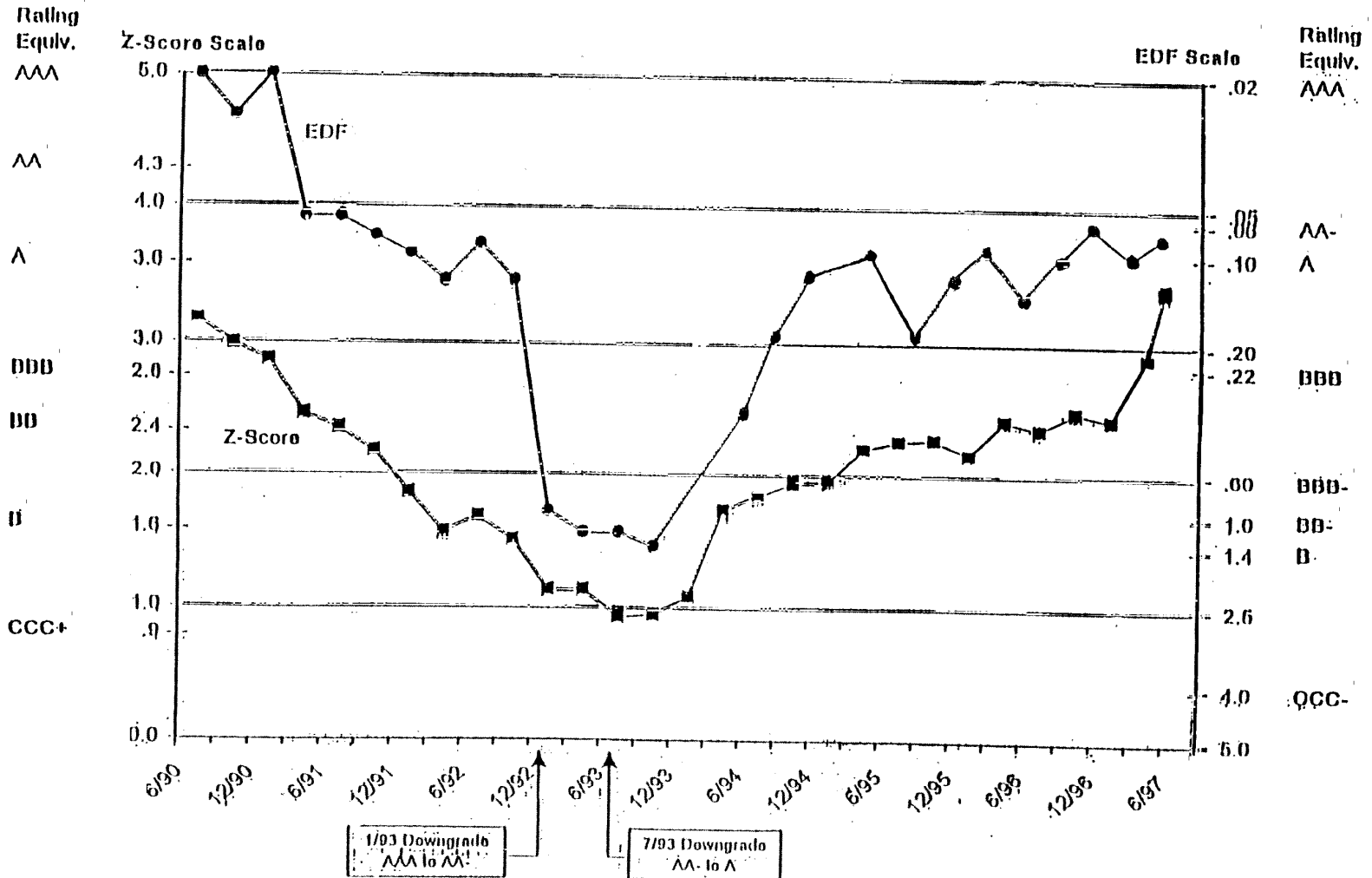
Diversification Based on Stock-Market Correlations (KMV)

• Uses Contingent Claims Approach based on the level and volatility of common stock prices to assess the value of the equity and its potential distribution. Compare that distribution of equity values plus the level of debt (total assets) to the anticipated debt level in the future in order to attain the probability of default (assets < liabilities). Losses based on expected recoveries.

• Assess the correlation of each loan's expected return based on correlations of stock prices and the unexpected losses from different combination of Loans.

• Observes the possible Sharpe Ratios (expected return spread / unexpected loss) on various combinations of loans with differential investments (weight) in each loan.

• Stipulates the official frontier portfolio.