Corporate Credit Scoring Models

Dr. Edward I. Altman
Stern School of Business
New York University
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

\[ Z = a_1 x_1 + a_2 x_2 + a_3 x_3 + \ldots + a_n x_n \]

\( Z \) = 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

<table>
<thead>
<tr>
<th>Variable</th>
<th>Definition</th>
<th>Weighting Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>$X_1$</td>
<td>Working Capital</td>
<td>1.2</td>
</tr>
<tr>
<td></td>
<td>Total Assets</td>
<td></td>
</tr>
<tr>
<td>$X_2$</td>
<td>Retained Earnings</td>
<td>1.4</td>
</tr>
<tr>
<td></td>
<td>Total Assets</td>
<td></td>
</tr>
<tr>
<td>$X_3$</td>
<td>EBIT</td>
<td>3.3</td>
</tr>
<tr>
<td></td>
<td>Total Assets</td>
<td></td>
</tr>
<tr>
<td>$X_4$</td>
<td>Market Value of Equity</td>
<td>0.6</td>
</tr>
<tr>
<td></td>
<td>Book Value of Total Liabilities</td>
<td></td>
</tr>
<tr>
<td>$X_5$</td>
<td>Sales</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>Total Assets</td>
<td></td>
</tr>
</tbody>
</table>
**Z Score**

**Bankruptcy Model**

\[ Z = 0.012X_1 + 0.014X_2 + 0.033X_3 + 0.006X_4 + 0.999X_5 \]

e.g. 20.0%

\[ Z = 1.2X_1 + 1.4X_2 + 3.3X_3 + 0.6X_4 + 0.999X_5 \]

e.g. 0.20

\[ X_1 = \frac{\text{Current Assets} - \text{Current Liabilities}}{\text{Total Assets}} \]
\[ X_2 = \frac{\text{Retained Earnings}}{\text{Total Assets}} \]
\[ X_3 = \frac{\text{Earnings Before Interest and Taxes}}{\text{Total Assets}} \]
\[ X_4 = \frac{\text{Market Value of Equity}}{\text{Total Liabilities}} \]
\[ X_5 = \frac{\text{Sales}}{\text{Total Assets}} (= \# \text{ of Times e.g. 2.0x}) \]
Zones of Discrimination:
Original Z - Score Model

$Z > 2.99$ - “Safe” Zone

$1.8 < Z < 2.99$ - “Grey” Zone

$Z < 1.80$ - “Distress” Zone
### Classification & Prediction Accuracy

**Z Score (1968) Failure Model**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>94% (88%)</td>
<td>96% (72%)</td>
<td>82% (75%)</td>
<td>85% (78%)</td>
<td>94% (84%)</td>
</tr>
<tr>
<td>2</td>
<td>72%</td>
<td>80%</td>
<td>68%</td>
<td>75%</td>
<td>74%</td>
</tr>
<tr>
<td>3</td>
<td>48%</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>4</td>
<td>29%</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>5</td>
<td>36%</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

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

-1.5 -1 -0.5 0 0.5 1 1.5 2 2.5 3 3.5

Year

Year

Safe Zone

Grey Zone

Distress Zone


Bankrupt
July ‘86
International Harvester (Navistar)
Z Score (1974 - June 1996)

Year

Z Score

Safe Zone
Grey Zone
Distress Zone
IBM Corporation
Z Score (1980 - June 1997)

[IBM Corporation Z Score chart showing trends in Z Score from 1980 to 1997, with key events such as July 1993: Downgrade AA- to A and 1/93: Downgrade AAA to AA-.]

- **Safe Zone**
- **Consolidated Co.**
- **Grey Zone**
  - BBB
  - BB
  - B

Key Events:
- July 1993: Downgrade AA- to A
- 1/93: Downgrade AAA to AA-
## Average Z-Score by S&P Bond Rating

### S&P 500: 1992 - 1995 *

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>AAA</td>
<td>11</td>
<td>5.020</td>
<td>1.603</td>
<td>4.376</td>
<td>1.380</td>
</tr>
<tr>
<td>AA</td>
<td>46</td>
<td>4.296</td>
<td>1.911</td>
<td>4.047</td>
<td>1.832</td>
</tr>
<tr>
<td>BBB</td>
<td>107</td>
<td>2.776</td>
<td>1.493</td>
<td>2.701</td>
<td>1.580</td>
</tr>
<tr>
<td>BB</td>
<td>30</td>
<td>2.449</td>
<td>1.623</td>
<td>2.276</td>
<td>1.694</td>
</tr>
<tr>
<td>* B</td>
<td>80</td>
<td>1.673</td>
<td>1.234</td>
<td>1.876</td>
<td>1.517</td>
</tr>
</tbody>
</table>
Xerox Credit Quality: Z Score Analysis 1998-2000

Bond Rating Equivalents: Actual Rating (S&P):
12/98  A        12/98  A
12/99  BB       12/99  A
06/00  B        06/00  A
12/00  BBB-
Z’ Score
Private Firm Model

\[ Z' = 0.717X_1 + 0.847X_2 + 3.107X_3 + 0.420X_4 + 0.998X_5 \]

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

\[ X_2 = \frac{\text{Retained Earnings}}{\text{Total Assets}} \]

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

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

\[ X_5 = \frac{\text{Sales}}{\text{Total Assets}} \]

- \( Z' > 2.90 \) - “Safe” Zone
- \( 1.23 < Z' < 2.90 \) - “Grey” Zone
- \( Z' < 1.23 \) - “Distress” Zone
$Z'' = 6.56X_1 + 3.26X_2 + 6.72X_3 + 1.05X_4$

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

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

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

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

$Z'' > 2.60$ - “Safe” Zone

$1.1 < Z'' < 2.60$ - “Grey” Zone

$Z'' < 1.1$ - “Distress” Zone
Circle K - Z Score (1979 - 1992)

- **Safe Zone**
- **Grey Zone**
- **Bankrupt May '90**

Year:
- '79
- '80
- '81
- '82
- '83
- '84
- '85
- '86
- '87
- '88
- '89
- '90
- '91
- '92

Z Score:
- 0
- 1
- 2
- 3
- 4
- 5
- 6
- 7
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)
DAF Corporation Z Scores
(Dutch Company Bankruptcy 1993)
Average Z-Scores: US Industrial Firms
1975-1999
Argenti (A Score System)

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)

<table>
<thead>
<tr>
<th>Symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight</td>
</tr>
<tr>
<td>5 - Financial signs, such as Z Score</td>
</tr>
<tr>
<td>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.</td>
</tr>
<tr>
<td>3 - Non-financial signs, such as untidy offices, frozen salaries, chief executive ‘ill’, high staff turnover, low morale, rumors</td>
</tr>
<tr>
<td>1 - “Terminal signs”</td>
</tr>
</tbody>
</table>

| Total Symptoms | 13 |
| Total Possible Score | 100 | Pass | 25 |

<table>
<thead>
<tr>
<th>Total Score</th>
<th>Prognosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-10</td>
<td>No Worry (High Pass)</td>
</tr>
<tr>
<td>0-25</td>
<td>Pass</td>
</tr>
<tr>
<td>10-18</td>
<td>Cause for Anxiety (Pass)</td>
</tr>
<tr>
<td>18-35</td>
<td>Grey Zone - Warning Sign</td>
</tr>
<tr>
<td>&gt;35</td>
<td>Company “At Risk”</td>
</tr>
</tbody>
</table>
KMY 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 Estimates 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 Expected Default Frequency (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)
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:

\[
\# \text{ Std. Deviations from Debt Service} = 2
\]

Expected Default Frequency (EDF)

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

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