Credit Risk Analysis

Implementation of Credit Granting Decision

- ✓Tied to corporate culture
- ✓What level of risk is acceptable ?
- ✓What type of customer?
  - Consumer
  - Commercial
  - Sovereign

Credit Granting Decision

- Classical Credit Analysis
  - Expert System
  - Relationship Banking
  - Asset-Based Lending
- Automated Processes
  - Credit Scoring Models
  - Bankruptcy Models
  - Bond Rating Services

Classical Credit Analysis

Knowing your cusomer well

- ✓ Character (Reputation)
- ✓ Financial
  - Knowing customer's business / industry
  - Understanding customer's financial statements
  - Ratio analysis
  - Executive management evaluated as well as managers of operations, production etc
  - Purpose of loan evaluated
- ✓ Collateral

Shortcomings of Classic Credit Analysis

Limited in volume and scope of lending by level of personnel

Requires high investment in human resources

Automated Processes

- › Higher volume / broaden horizons
  - › Credit Scoring Models
  - › Bankruptcy Models
  - › Bond Rating Services
- ✓ Attempt to quantify financial (and to some extent personal) characteristics of borrower.
- ✓ Models are of the form:

$$Y = a_0 + a_1X_1 + a_2X_2 \ldots\ldots\ldots\ldots a_nX_n$$

where Y is a predictive score and X's are independant financial variables

Credit Scoring Model
(Small Business Loans)

Characteristics	Lowest	Highest
✓ Years in Business	< 1 yr	> 5 yr
✓ Current Ratio	< 1.0	> 1.8
✓ Debt/Equity	> 2.0	< 1.2
✓ Profitability	Loss	Profit 3 yrs
✓ Financial data acceptable?	Only last interim	Last 3 yrs
✓ Accounts Payable	20+% over 60 days	Cash/discount for 80%

Consumer Loans
Credit Screening

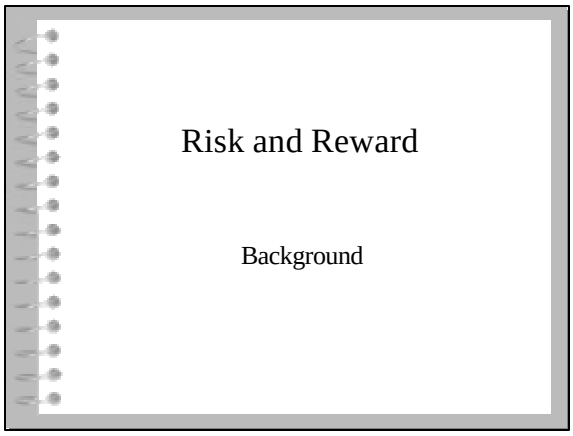
- ✓ Minimum Age (25 years)
- ✓ Maximum debt/salary ratio of 60%
- ✓ At least 2 years on job
- ✓ Type of industry
  - e.g. No show-business people
  - No taxi drivers

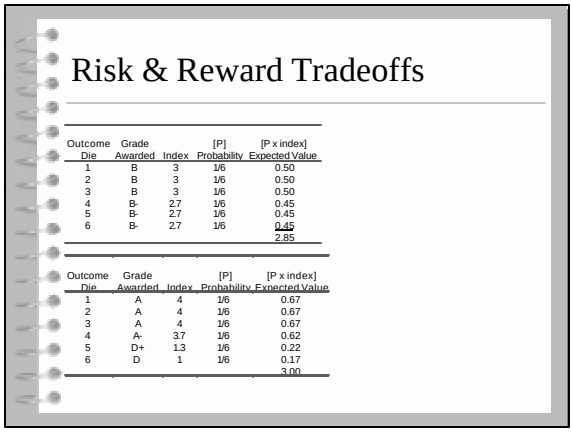
Fail one of screens -- automatically out

Credit Scoring Model
(Consumer Loans)

- ✓ Points awarded for factors such as
  - Number of years at same job
  - Salary level
  - Number of years residing at same location
  - Rent / Own
  - Marital Status
  - Level of Debt
  - Credit history (late payments)
- ✓ Loan granted if points above threshold

Note that certain attributes are financial; others are measures of "character"


Risk and Reward
Background


Risk & Reward Tradeoffs
Outcome Die
Grade Awarded
Index
[P] Probability
[P x index] Expected Value
1 B 3 1/6 0.50
2 B 3 1/6 0.50
3 B 3 1/6 0.50
4 B- 2.7 1/6 0.45
5 B- 2.7 1/6 0.45
6 B- 2.7 1/6 0.45
2.85
Outcome Die
Grade Awarded
Index
[P] Probability
[P x index] Expected Value
1 A 4 1/6 0.67
2 A 4 1/6 0.67
3 A 4 1/6 0.67
4 A- 3.7 1/6 0.62
5 D+ 1.3 1/6 0.22
6 D 1 1/6 0.17
3.00

Risk versus Reward

✓ Which choice do you take?

✓ Higher expected value or less volatility?

What if failure meant below a C (2.0) grade point average?

Choice 1 -- Probability of failure = 0

Choice 2 -- Probability of failure = 1/3

Volatility - measure of risk

Standard Deviation is the most common measure of volatility or risk; it measures the absolute variation or dispersion around the expected or average outcome.

Risk & Reward Tradeoffs

Outcome Die	Grade Awarded	Index	[P] Probability	[P x index] Expected Value	Deviation from Mean	Deviation^2	[P x Deviation^2] Variance
1	B	3	1/6	0.50	0.15	0.02	0.00
2	B	3	1/6	0.50	0.15	0.02	0.00
3	B	3	1/6	0.50	0.15	0.02	0.00
4	B-	2.7	1/6	0.45	-0.15	0.02	0.00
5	B-	2.7	1/6	0.45	-0.15	0.02	0.00
6	B-	2.7	1/6	0.45	-0.15	0.02	0.00
				2.85	0.00		0.02

Mean $\bar{m}$ = 2.85
Variance s^2 = .02
Standard Deviation s = .14

Outcome Die	Grade Awarded	Index	[P] Probability	[P x index] Expected Value	Deviation from Mean	Deviation^2	[P x Deviation^2] Variance
1	A	4	1/6	0.67	1.00	1.00	0.17
2	A	4	1/6	0.67	1.00	1.00	0.17
3	A	4	1/6	0.67	1.00	1.00	0.17
4	A-	3.7	1/6	0.62	0.70	0.49	0.08
5	D+	1.3	1/6	0.22	-1.70	2.89	0.48
6	D	1	1/6	0.17	-2.00	4.00	0.67
				3.00	0.00		1.73

Mean $\bar{m}$ = 3.00
Variance s^2 = 1.73
Standard Deviation s = 1.31

Effects of Diversification

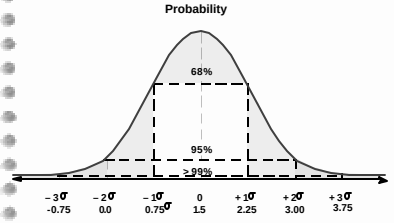
- ✓ Suppose you were taking two courses and choice 2 was given for both courses?
- ✓ You would only fail if die landed on 5 or 6 both times --- probability = 1/3 x 1/3 = 1/9
- ✓ By diversifying you have lowered the risk

Mean μ	= 3.00
Variance s^2	= 0.87
Standard Deviation s	= 0.93

Diversification and Correlations

- ✓ Above calculation only assumes flips of die are independent
- ✓ If they were not independent; effect of diversification would differ as correlation between scores would have to be considered.

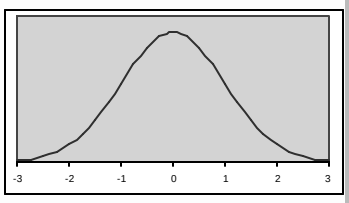
The Normal Distribution



X axis
Top Line: Mean (μ) = 0 and volatility (s) = 1.00
2nd Line: Mean (μ) = 1.5 and volatility (s) = 0.75

The Normal Distribution

σ's from mean	Cumulative Probability
-3	0.1%
-2.5	0.6%
-2.0	2.3%
-1.5	6.7%
-1.0	15.9%
-0.5	30.9%
0	50.0%
0.5	69.1%
1.0	84.1%
1.5	93.3%
2.0	97.7%
2.5	99.4%
3.0	99.9%



A Probabilistic Measure of Liquidity

Emery and Cogger (1982)

Let L = the liquid reserves (e.g., cash) at the beginning of the period
and C = operating cash flow during the period
Therefore cash availability for period = L + C

Insolvency or lack of liquidity is defined as occurring when additional financing is required, i.e. when

$$L + C < 0$$

Assume L = 0.5 and *C* is a random variable with expected value of 1 and volatility as measured by standard deviation of 0.75.
If C is normally distributed, the probability of the above occurring can be found by looking at the normal distribution table for the standardized value

$$-\frac{[L + \mu(C)]}{\sigma(C)} = -\frac{[.5 + 1]}{0.75} = -2$$

where $\mu(C)$ *and* $\sigma(C)$ are the mean and standard deviation of the operating cash flows.

A Probabilistic Measure of Liquidity

- ✓ In our example therefore there is a 2.3% probability of default
- ✓ Clearly, the higher the value of

$$\frac{[L + \mu(C)]}{\sigma(C)}$$

the lower the probability of insolvency.

- ✓ The above can therefore serve as a useful and relevant liquidity ratio as it combines the stock of cash with the flows and the volatility of those flows.

Bankruptcy and Bond Rating Models

Variables Used in Bankruptcy and Bond RatingModels

- ✓ Activity ratios
- ✓ Leverage and Coverage ratios
- ✓ Liquidity ratios
- ✓ Profitability ratios
- ✓ Cash Flow ratios

Univariate Model --Beaver (1966)
Best Predictive Ratio = Cash Flow/Liabilities

Years Prior to Bankruptcy	Overall Correct Classification
1	87%
2	79%
3	77%
4	76%
5	78%

Did this model really do anything?

I can get 95% correct classification if I predict all firms are solvent (nonbankrupt)

Types of Misclassification Errors in Bankruptcy Prediction

,There are two types of misclassification errors:

1. A *type I error* refers to the misclassification of a firm by predicting nonbankruptcy when in reality the firm becomes bankrupt.
2. A *type II error* reflects the misclassification of a solvent firm as bankrupt.

Cost of Type I error > Cost of Type II error

Altman et al., (1977) estimate type I errors to be 35 times as costly as type II errors

Types of Misclassification Errors in Bankruptcy Prediction

	Actual Outcome	
	Bankrupt	*Nonbankrupt*
Predicted Outcome		
Bankrupt	**Correct**	**Error: Type II Cost: Small 0-10%**
Nonbankrupt	**Error: Type I Cost: Large Up to 100%**	**Correct**

Univariate Model --Beaver (1966)
Best Predictive Ratio = Cash Flow/Liabilities

Years Prior to Bankruptcy	Overall Correct Classification	Error Rate Type I	Error Rate Type II
1	87%	22%	5%
2	79%	34%	8%
3	77%	37%	8%
4	76%	47%	3%
5	78%	42%	4%
My model	**95%**	**100%**	**0%**

Altman's Z-score Bankruptcy Prediction Model

Z =	Ratio Category
1.2 x Working Capital / Total Assets	LIQUIDITY
+ 1.4 x Retained Earnings / Total Assets	PROFITABILITY
+ 3.3 x EBIT / Total Assets	PROFITABILITY
+ 0.6 x Market Value of Equity / Book Value of Debt	SOLVENCY
+ 1.0 x Sales / Total Assets	ACTIVITY

Altman's Z-score Bankruptcy Prediction Model

Z Score	Classification
< 1.81	Bankrupt
1.81 - 2.99	Grey area
> 2.99	Nonbankrupt

Performance of Z-score

Classification Errors (%)

	Z-Model	
Years to Bankruptcy	Bankrupt (Type I)	Nonbankrupt (Type II)
1	6	3
2	18	6
3	52	NA
4	71	NA
5	64	NA

Z-score

- ✓ Z-score has held up well over time
- ✓ Lacks theoretical underpinning -- purely empirical model
- ✓ Parameters are public knowledge and model used in many settings as one feature of credit analysis
- ✓ Problem:
  - Designed for publicly traded companies
  - Designed for manufacturing sector
- ✓ Z' and Z" designed to rectify above

For Private Firms $Z' =$	*For Service Sector* $Z'' =$
$0.717 \times \frac{\text{Working Capital}}{\text{Total Assets}}$	$6.56 \times \frac{\text{Working Capital}}{\text{Total Assets}}$
$+ 0.847 \times \frac{\text{Retained Earnings}}{\text{Total Assets}}$	$+ 3.26 \times \frac{\text{Retained Earnings}}{\text{Total Assets}}$
$+ 3.107 \times \frac{\text{EBIT}}{\text{Total Assets}}$	$+ 6.72 \times \frac{\text{EBIT}}{\text{Total Assets}}$
$+ 0.420 \times \frac{\text{Book Value of Equity}}{\text{Book Value of Debt}}$	$+ 1.05 \times \frac{\text{Book Value of Equity}}{\text{Book Value of Debt}}$
$+ 0.998 \times \frac{\text{Sales}}{\text{Total Assets}}$	

Z' score	*Indication*
<1.23	*Bankruptcy*
1.23-2.90	*Gray area*
>2.90	*Nonbankruptcy*

Z" score	*Indication*
<1.10	*Bankruptcy*
1.10-2.60	*Gray area*
>2.60	*Nonbankruptcy*

Commercial Bankruptcy Models

ZETA
KMV Model

The ZETA^{TM} Model (Altman et al)

Only variables disclosed but not formula

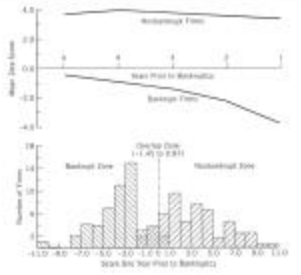
- ✓ Liquidity Ratios
  - Current Ratio
- ✓ Solvency
  - Equity (Market) / Capital
  - Times Interest Earned
- ✓ Profitability
  - ROA
  - Retained Earnings / Assets
- ✓ Other
  - Size (Total Assets)
  - Variability (σ of ROA)
- ✓ Adjusts for OBS liabilities

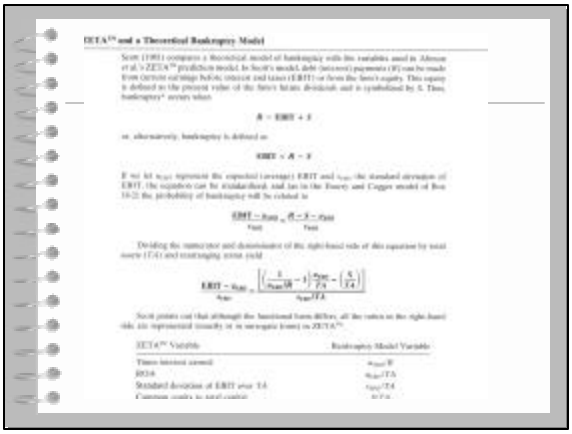
Comparison of Z and ZETA Models

Classification Errors (%)

	Original Z-Model		ZETA^{TM} Model	
Years to Bankruptcy	Bankrupt (Type I)	Nonbankrupt (Type II)	Bankrupt (Type I)	Nonbankrupt (Type II)
1	6	3	4	10
2	18	6	15	7
3	52	NA	25	9
4	71	NA	32	10
5	64	NA	30	18

The ZETA™ Model





K M V Model

KMV Model views bankruptcy as occurring when

Market Value of Assets < Payable Liabilities

Firm cannot sell off assets / raise additional capital as existing assets fully encumbered.

Market Value of Assets < Payable Liabilities

- ✓ Probability or likelihood of bankruptcy is related to value and variance (standard deviation) of assets
- ✓ Problem becomes how to measure these amounts.
- ✓ Solution: A = f(L + E)

Market Value (A) =
f(L + Market value E)

- MV Equity can be readily found from stock price information
- Exact formulation not known but based on option pricing models.
- Standard deviation of MV Assets also derived from Standard deviation of MV Equity

Defining PAYABLE LIABILITIES

- ✓ Payable Liabilities should include debt servicing costs (interest) as well as principal payments currently due (maturing)

- ✓ KMV finds model performs best when

Payable Liabilities =
All Short Term Debt
+ 50% of Long term Debt

Distance -To-Default Ratio (DDR)

MV Assets - Payable Liabilities

s (Assets)

Example:

- **MV Assets: 200 + expected one year growth of 5% = 210**
- **Payable Liabilities = 150**
- **s (Assets) = 30**

DDR = 2

DDR ⟶ EDF (Expected Default Frequency)

Value of DDR compared to database which keeps track of

(1) Total Population of firms with equivalent DDR

(2) Number of firms with equivalent DDR's that defaulted

$$EDF = \frac{\text{Number of firms with equivalent DDR's that defaulted}}{\text{Total Population of firms with equivalent DDR}}$$

KMV - Pros and Cons

Strengths	Weaknesses
✓ Not ad-hoc – based on theoretical-underpinnings	× Sensitive to stock market movements. Market overreactions or bubbles can imply unreasonably high MV Assets
✓ Applicable to all publicly-traded companies	× Not suitable for private (or thinly traded public) companies
✓ Forward-looking as based on stock market data	× Estimation of Payable Debt can cause "jumps" as debt reaches maturity
✓ Responsive to changes in environment	× Ignores off-balance sheet debt (Needs assumption that all companies with similar DDR ratios have similar levels of OBS Debt)

Debt Ratings

Default Risk and Ratings

- ✓ Rating companies
  - – Moody's Investor Service
  - – Standard & Poor's
  - – Duff and Phelps
  - – Fitch
- ✓ Rating Categories
  - – Investment grade
  - – Speculative grade

Bond Credit Ratings

	Standard and Poor's	Moody's
Very High Quality	AAA AA	Aaa Aa
High Quality	A BBB	A Baa
Speculative	BB B	Ba B
Very Poor	CCC CC	Caa C
Default	D	

The Bond Ratings Process

Ratings are sought by companies when they issue new debt. The company pays a fee and the agency issues a rating following an examination of the "creditworthiness" of the company. The agency analyzes the company's operations, personnel, its financial statements, and its *pro forma* projections as well as other relevant financial and nonfinancial information.

The actual ratings process, however, is shrouded in mystery. How each agency arrives at its rating and the criteria used are not disclosed. *The rating agencies go to great lengths to discourage speculation that the rating process is mechanical and based on some mathematical formula.* Rather, they stress that ratings are based on the judgment of their analysts who determine their rating after assimilating quantitative as well as available qualitative data.

Effect of Ratings

- ✓ Level of interest rate tied to rating (see next slide)
- ✓ Additionally,
  - – Bond covenants written into a bond offering are often designed to obtain favorable ratings. As covenants protect creditors by putting restrictions on the equity shareholders, ratings influence the sharing of risk and reward between equity- and debtholders.
  - – Institutional investors are restricted (legally or by internal policy) as to the type of debt they can hold; I.e. the debt must have a minimum rating. Thus, the success or failure of an offering (or whether it is even issued) is often determined by the rating.

Cost of Ratings -- Risk Premium

Bond Yield spread over 30-year Treasury Bond

	1997	1991
AAA	0.28%	0.82%
AA	0.39%	1.13%
A	0.57%	1.61%
BBB	0.83%	2.71%
BB	1.53%	3.92%
B	3.30%	8.93%
C	7.29%	12.95%

Factors Affecting Ratings
Medians of Key Ratios : 1993-1995

	AAA	*AA*	*A*	*BBB*	*BB*	*B*
Pretax Interest Coverage	13.50	9.67	5.76	3.94	2.14	1.51
EBITDA Interest Coverage	17.08	12.80	8.18	6.00	3.49	2.45
Funds from Operations / Total Debt	98.2%	69.1%	45.5%	33.3%	17.7%	11.2%
Free Operating Cashflow/Total Debt	60.0%	26.8%	20.9%	7.2%	1.4%	1.2%
Pretax Return on Permanent Capital	29.3%	21.4%	19.1%	13.9%	12.0%	7.6%
Operating Income/Sales (%)	22.6%	17.8%	15.7%	13.5%	13.5%	12.5%
Long Term Debt/ Capital	13.3%	21.1%	31.6%	42.7%	55.6%	62.2%
Total Debt/Capitalization	25.9%	33.6%	39.7%	47.8%	59.4%	67.4%

Usefulness of Bond Rating Services

- ✓ Bond rating services view themselves as Expert Systems which make use of wide set of data to evaluate creditworthiness
- ✓ Provides service to all creditors who can rely on analysis of rating service.

Bond Ratings Models

Attempt to duplicate bond ratings by use of quantitative models.

Important as

- ✓ Vast majority of firms (including publicly-traded ones) are "unrated"
- ✓ Bond ratings are not timely
- ✓ Firms undergoing significant structural changes (e.g. mergers/acquisitions) need to assess impact on creditworthiness.

Performance of Models

- ✓ **Notwithstanding rating agencies claims, mechanical models have proven to be relatively successful in "duplicating" ratings.**
- ✓ **The models perform quite well; they average anywhere from 60 to 70% accuracy in duplicating the rating arrived at by an agency. Further, when they are in error, it is usually by misclassifying the rating into the immediate adjacent category. <u>When adjacent categories are "allowed," the "success" rate is over 90%.</u>**

Using the Z" model to rate bonds

- ✓ Conceptually the idea is simple
- ✓ Low Z" score signals default
- ✓ High score -- solvency
- ✓ Along continuum should be able to use for gradations of risk -- i.e. bond rating

Bond Rating: Average Z" Score (with intercept)

Z" = 6.56 Working Capital/Total Assets + 3.26 Retained Earnings/Total Assets + 6.72 EBIT/Total Assets + 1.05 Book Value of Equity/Total Liabilities + 3.25

AAA	**8.15**	**BB +**	**5.25**
AA +	**7.60**	**BB**	**4.95**
AA	**7.30**	**BB -**	**4.75**
AA -	**7.00**	**B +**	**4.50**
A +	**6.85**	**B**	**4.15**
A	**6.65**	**B -**	**3.75**
A -	**6.40**	**CCC +**	**3.20**
BBB +	**6.25**	**CCC**	**2.50**
BBB	**5.85**	**CCC -**	**1.75**
BBB -	**5.65**	**D(efault)**	**0**

Enhancement for Emerging Markets

- ✓ Start with basic Z" score which provides equivalent US rating
- ✓ Upgrade/downgrade rating based on
  - currency risk
  - industry risk
  - competitive position
  - Market-to-Book ratio
  - Other
- ✓ Use adjusted rating to assess premium over sovereign "risk-free" rate