

# **Nature of credit risk**

# Credit risk

- The risk that obligors (borrowers, counterparties and debtors) might *default* on their obligations, or having an *impaired ability* to repay them.

How to measure the credit risk?

- At best, we can only make *probabilistic assessments* of the likelihood of default.

# Types of credit risk

- *Default risk*  
Issuer of a bond or the debtor of a loan cannot repay the outstanding debt in full (zero or partial recovery).  
About 1/10 to 1/2 of 1% per year.
- *Downgrade risk*  
Formal credit review by an independent agency on perceived earning capacity.
- *Credit spread risk*  
Increase in the spread over a reference rate, in response to markets' reaction to perceived credit deterioration.

# Issues addressed when dealing with credit risk

- Quantifying aggregate credit risk – losses due to credit events
- Identifying concentration risk – exposure to specific events
- Exploring risk sources – marginal risk added to the portfolio
- Quantifying economic and regulatory capital – buffer for unexpected losses
- Improving risk-return trade-off
- Setting the risk limits

# *Growth of advanced techniques in credit risk management*

- Advances in information techniques and computer systems.
- Dissatisfaction with the BIS and central bank's approach on capital requirement.  
e.g. same 8 percent capital ratio on all private loans

Since 1997, regulators allowed large banks to calculate capital requirements for their trading books using *internal models*.

# Expert System

The *credit decision* is left to a leading officer, relying on her *expertise*, *subjective judgement* and *weighting of certain key factors*.

1. *Character* - reputation of the firm
2. *Capital* - equity distribution of owners
3. *Capacity* - volatility of borrower's earnings
4. *Collateral* - size and priority
5. *Cycle (or economic) conditions* - cycle dependend industries

Difficulties in maintaining *consistency* and *subjectivity*.

# Credit scoring systems

Pre-identify certain key factors that determine the probability of default, and combine or weigh them into a quantitative score.

- can be literally interpreted as a probability of default;
- can be used as a classification system.

# Altman's Z-score model

For commercial loans

$$Z = 1.2X_1 + 1.4X_2 + 3.3X_3 + 0.6X_4 + 1.0X_5$$

$X_1$  = working capital/total assets ratio

$X_2$  = retained earnings/total assets ratio

$X_3$  = earning before interest and taxes/total assets ratio

$X_4$  = market value of equity/book value of total liabilities ratio

$X_5$  = sales/total assets ratio

A loan with Z-score *below* a critical value would be classified as bad.

- The model is *linear* whereas the path to bankruptcy is highly *non-linear*.
- The model is essentially based on historical accounting ratios - cannot pick up a firm whose conditions are rapidly deteriorating.

## Rating at year end (%)

<b>Initial rating</b>	AAA	AA	A	BBB	BB	B	C	default
AAA	<b>91.93%</b>	7.46%	0.48	0.08%	0.04%	0.00%	0.00%	0.00%
AA	0.64%	<b>91.81%</b>	6.76%	0.60%	0.06%	0.12%	0.03%	0.00%
A	0.07%	2.27%	<b>91.68%</b>	5.12%	0.56%	0.25%	0.01%	0.04%
BBB	0.04%	0.27%	5.56%	<b>87.87%</b>	4.83%	1.02%	0.17%	0.24%
BB	0.04%	0.10%	0.61%	7.75%	<b>81.48%</b>	7.90%	1.11%	1.01%
B	0.02%	0.10%	0.28%	0.46%	6.95%	<b>82.80%</b>	3.96%	5.45%
CCC	0.01%	0.19%	0.37%	0.75%	2.43%	12.13%	<b>60.44%</b>	23.69%

*Historical frequency of annual transitions based on S & P observations from 1981 to 1998*

## Some empirical findings on credit migration

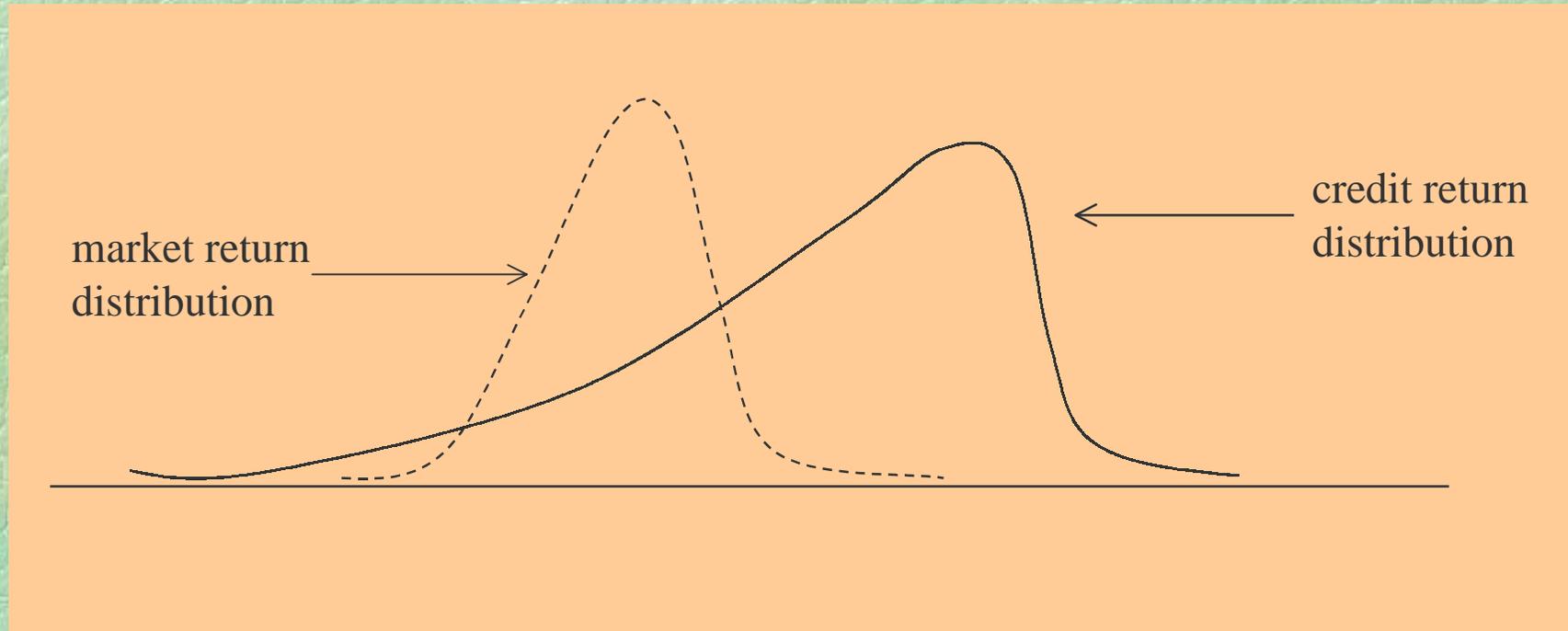
Quotes from Moody's study on the credit histories of over 14,000 US and non-US corporate debt issuers for the year 1920-1996.

- Sudden large changes in credit quality have been very infrequent.
- Higher ratings have been generally less likely than lower ratings to be revised over any time period from one to 15 years.
- When the higher-end investment-grade ratings have changed, they have demonstrated a greater propensity for downward movement than upwards.
- The strength of correlation of credit qualities is determined, in part, by macroeconomic, industrial, geographic factors.

## Difficulties in applying the historical transition matrices

- In spite of large number of observations, some measurements have low statistical significance, particularly the investment grade default frequencies.
- The observations are based on seven major rating categories. Many applications require a finer granularity in credit levels.
- Historical observations do not reflect to the current credit environment.
- Historical observations are primarily based in the U.S. and are inappropriate for emerging markets.
- History only provides an assessment of real probabilities. Pricing models need probabilities which are adjusted for risk (risk neutral) and are consistent with observed prices in the market.

# Distributions of market and credit returns



Market returns are relatively symmetrical.

- Approximated by a normal distribution – only two statistical measures are needed: mean and standard deviation.

The returns to credit risk tend to be skewed since there is limited upside appreciation but subject to large losses on downgrade and default risks.

- Though downgrade and default may have a remote probability of occurring, their ability to produce large losses contributes to the skewed distribution of credit returns, producing large downside tails.

## Market risk

Normal diffusion

Complete markets

Typically symmetric

Daily VAR – real time  
market risk management

Back-testing is easier to be done

Correlation between dimensions

Mature risk management discipline

Historical statistics often available

## Credit risk

Jump event process

Incomplete markets since  
most loans are non-transactable

Asymmetric/Fat Tail

Longer holding period –  
time frame of change is longer

Infrequent events making back  
testing difficult

Correlation between exposures,  
event probabilities and dimensions

Traditional credit analysis

Sketchy historical data with  
lack of depth of database

# Market value of a loan

- loans by and large are not actively transacted
- determined only by comparison for the market prices of financial instruments that are traded

loan yield = riskfree rate + expected loss premium + risk premium

Expected loss premium – account for the actuarial expectation of loss  
– based on the probability of default and the loss given default

Risk-premium – compensation for the non-diversifiable loss risk

The market price for non-diversifiable risk bearing can be determined from the equity and fixed income markets.

# Elements of credit risk analysis

- Exposure
- Default probability
  - chance of default over a given time horizon
- Loss given default
  - recovery process
- Migration risk
  - deterioration of credit quality as reflected by the change in credit rating class
- Default correlations

# Credit Exposure and Credit Risk

## *Credit Exposure*

Amount that stands to be lost upon default and all of the outstanding value is lost.

## *Credit Risk*

Takes into account the likelihood of default and the amount that might be recovered if it did.

- Consider a portfolio of loans to small corporates. Since those loans are generally illiquid, there is *no meaningful market value* for the loan book. The *credit exposure does not change* even when the benchmark interest rates (a market risk) go up.

**Credit loss** (for a credit asset) depends on

1. credit risk exposure;
2. default rate;
3. recovery rate.

A *credit risk model* attempts to estimate the *probability distribution* of each of the above variables as a function of *time horizon*.

\* If they are *independent*, then credit loss is

$$\begin{aligned} & \text{expected credit risk exposure} \times \text{expected default rate} \\ & \times (1 - \text{expected recovery rate}) \end{aligned}$$

# Credit exposure on derivatives

Credit risk fluctuates over time with the variables that determine the value of the underlying contract.

## *Current exposure*

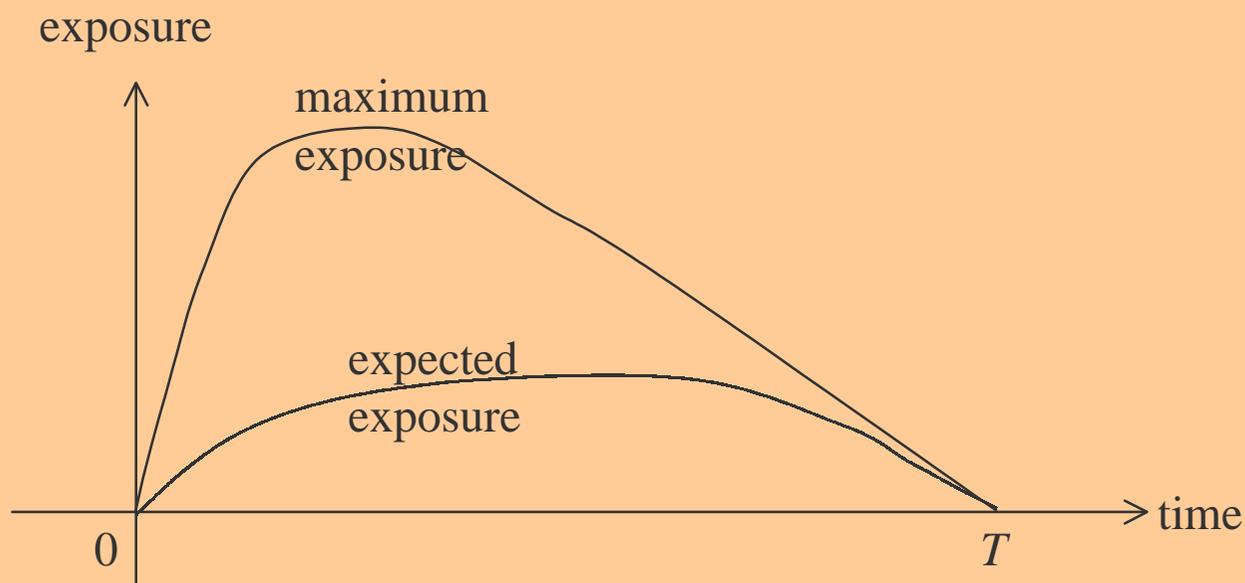
Replacement cost if the counterparty defaults right now or market value of the derivative.

## *Potential exposure*

Estimation of the future replacement cost: *expected exposure* and *maximum exposure*. Calculated using probability analysis.

# Interest rate swap's credit exposure

- Expected exposure at any time during the life of the swap is the mean of all possible probability-weighted *replacement costs*, where the replacement cost is the mark-to-market present value if positive and zero if negative.



The concave shape is the offsetting influence of the *diffusion effect* and *amortization effect*.

- Diffusion effect - the variability phenomenon that the underlying variable diffuses away from the initial value.
- Amortization effect - reduction in the number of years of cash flows that needed to be replaced.

The maximum exposure will depend on the confidence level chosen. If two standard deviations on a one-tail test are used to calculate the maximum exposure, then there is statistically only a 2.5% chance the actual exposure is greater than the calculated maximum exposure.

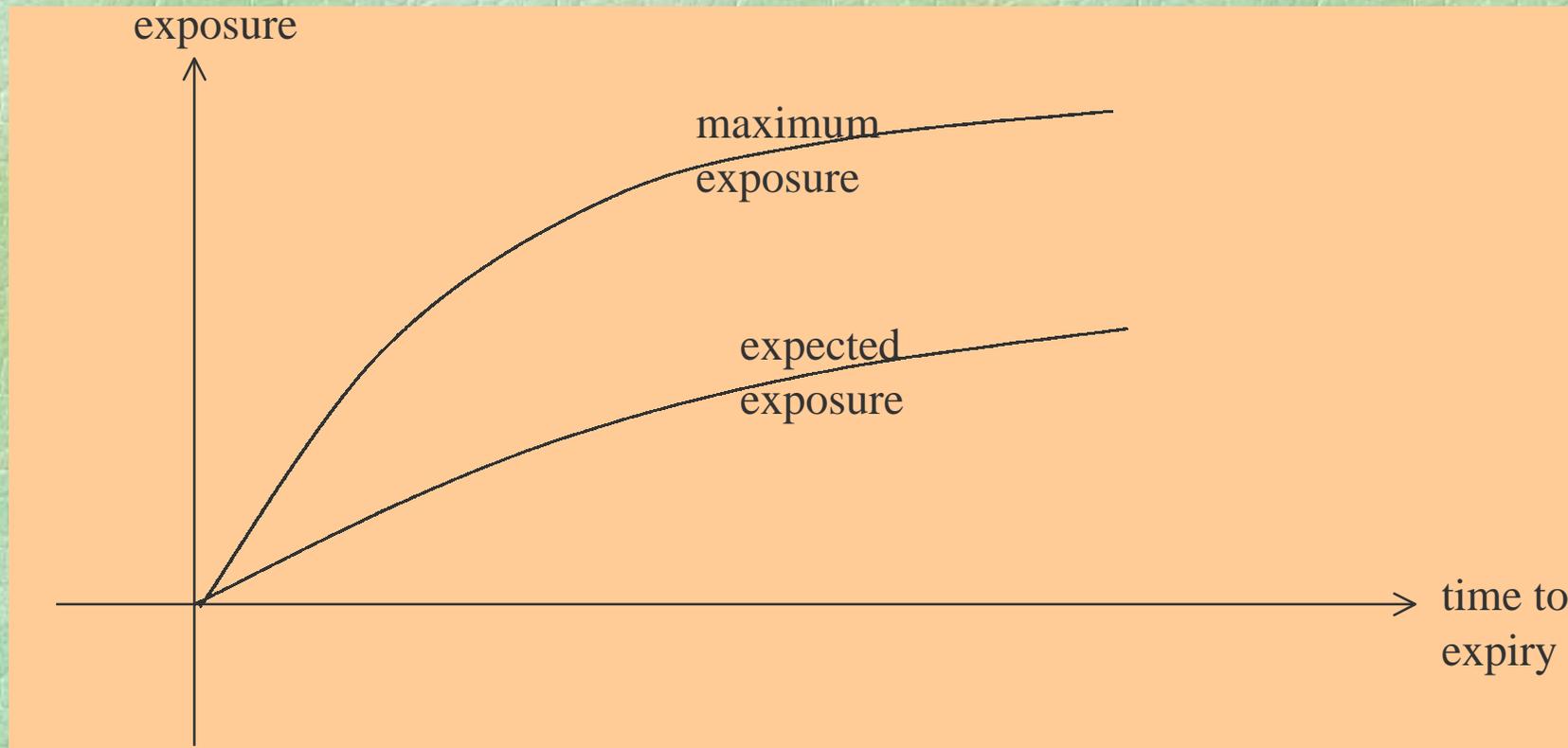
**Counterparty credit criteria  
of General Electric for  
entering into an interest rate  
or currency swap**

	<b>Credit Rating</b>	
	<b>Moody's</b>	<b>Standard &amp; Poor's</b>
<b>Term of transaction</b>		
Between one and five years	Aa3	AA–
Greater than five years	Aaa	AAA
<b>Credit exposure limits</b>		
Up to \$50 million	Aa3	AA–
Up to \$75 million	Aaa	AAA

- Longer time horizon, higher credit rating required.
- Allow higher exposure limit for higher quality counterparty.

# Option's credit exposure

The exposure profile of options tends to be greater than that for swaps since options are characterized by an up-front premium.



- \* The amortization effect is limited to time decay of the option price and is outweighed by the diffusion effect.

## Common methods of obtaining default probabilities

- *Judgmental approach* – agency ratings  
(combined judgment, experience and theory in some undefined manner).
- *Statistical methods* – scoring model
- *Market-implicit default probability models* – KMV model
  - default probability of a firm implied by the value and volatility of its stock price (more timely).