

# Risk Integrated

## **Risk Measurement and Capital Management**

Basel & Risk Management Workshop

# Contents

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- **Introduction to Risk Integrated**
- **Risk Models for Individual Assets**
- **Portfolio Risk Models for Economic Capital**
  - The Conceptual Framework: Economic Capital
  - Types of Portfolio models
- **Basel II Capital**
  - The Process of creating the New Basel Accord
  - Basel's Capital Rules

# Introduction to Risk Integrated

- **Focus on risk systems for Specialized Lending**
  - Project finance & Commercial Real Estate
- **Provide methodology and technology**
- **Clients**
  - SNDO, Turkish Treasury
  - Anglo Irish (IFSRA), Hypo International, Wüertt Hyp (BaFin)
  - Federal Reserve, Morgan Stanley, World Bank
- **Leadership team**
  - Dr. Chris Marrison: RAF, Princeton, OWC, Capco, FRM
  - Dr. Yusuf Jafry: MIT, Stanford, ESA, WW

# Types of risk models for individual assets

Intuitive scorecards

→ Do not give probabilities

Regressions (Z Scores)

→ Requires significant historical data  
Cannot capture the details of SL deals

Merton (KMV)

→ Requires traded equity information

Static cashflow model

→ Does not give probabilities

Basic Simulation

→ Does not account for correlations

Advanced Simulation

→ Uses all available information  
Carefully correlates inputs  
Includes comprehensive payment cascade

# Economic Capital

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## Contents

- The Conceptual Framework
- Three types of portfolio models

# Definition of Economic Capital

- Capital is held to ensure that a bank is likely to remain solvent, even if it suffers unusually large losses
- Available economic capital:
  - The amount by which the value of all assets *currently* exceeds the value of all liabilities
- Required economic capital:
  - The amount by which the value of all assets *should* exceed the value of all liabilities to ensure that there is a very high *probability* that the assets will still exceed the liabilities in one year's time
- Typically, banks aim to have a high (e.g., 99.9%) probability of remaining solvent

# Two ways of thinking about capital

- 1. Given the random amount of losses we suffer each year, how much could we lose if we are unlucky?**
  - Capital as an unexpected loss percentile
  - Capital = percentile of PDF
  
- 2. How much could we expect to lose in a recession?**
  - Capital as expected loss conditional on “severe” draw of systematic risk factor
  - Uncertainty in LGD and EAD assumed to be idiosyncratic, so
  - Conditional EAD and conditional LGD are equal to their expected values, respectively
  - Capital = conditional default probability x LGD x EAD

# The building blocks of EC

$$\text{Loss} = \text{Default} \times \text{Loss Given Default} \times \text{Exposure at Default}$$

## ■ EAD: Exposure At Default

- Expected gross dollar exposure of the facility upon the obligor's default
- Closely related to LEQ: Loan Equivalent Exposure
- Random in many cases because we do not know drawdown (for a line or commitment) or amortization

## ■ PD: Probability of Default

- Also referred to as Expected Default Frequency (EDF)

## ■ LGD: Loss Given Default

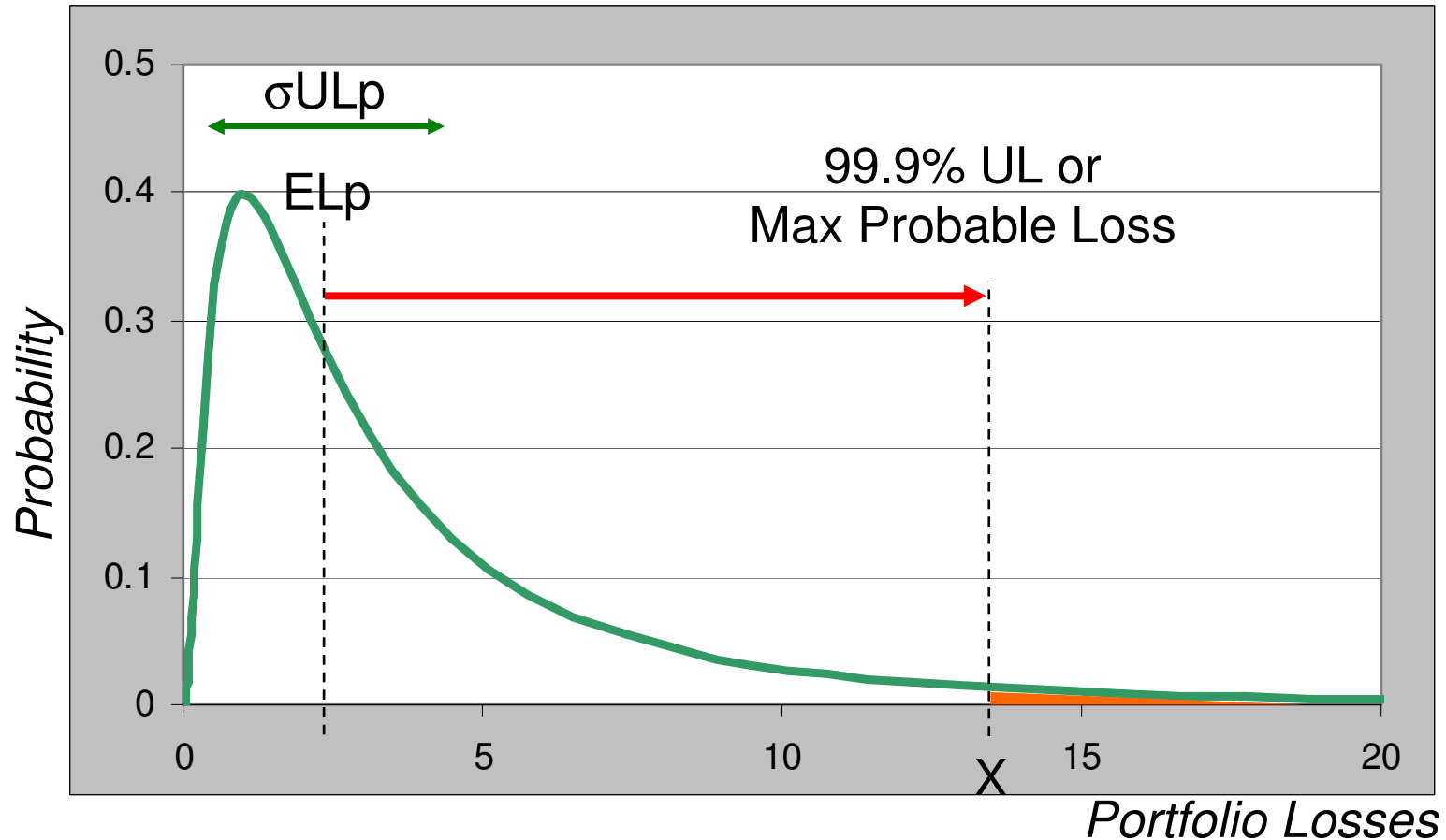
- Also called Loss In the Event of Default (LIED) or Severity
- $\text{LGD} = 1 - \text{Recovery}$

## ■ M: Remaining Maturity

## ■ Rho: Correlation

- Default correlation
- Asset correlation

# Probability Density Function of Portfolio Loss



# Portfolio Loss PDF and Capital

- In general, loss distribution is skewed and “fat-tailed”
- Simple models attribute losses to default only
- More sophisticated models attribute losses to both default *and* changes in credit quality
- Expected Loss (EL) = Mean of distribution
  - EL is *not* the most likely loss outcome (in general)
  - EL is *not* the median (50<sup>th</sup> percentile) of the PDF
- Unexpected Loss (UL) provides a practical approach for quantifying credit risk
  - UL depends on the correlation of losses
  - Intuitively, if losses are highly correlated, then UL moves to the right, so required capital increases

# Bank usage of EC models and RAROC

- **Capital decisions**
  - General provisions, reserves, capital allocation
- **Portfolio allocation decisions**
  - Hotspot identification
- **Pricing and profitability decisions**
  - RAROC: Risk-Adjusted Return On Capital
    - Return based on capital allocated to the business
    - Allocation is based on unexpected loss
    - But fails to account for correlation
  - Boosting high RAROC business lines
  - Loan pricing
    - $\text{Margin} = \text{EL} + H \times \text{Capital} + \text{OpRisk} + \text{OpCost}$

# Key Takeaways from Economic Capital

- **EC is the amount of capital to be held to protect against low probability losses**
- **The building blocks of EC:**
  - PD, LGD, EAD, correlation, (M)
- **The key parameters describing the Credit Loss PDF**
  - EL and UL
  - Capital as percentile of PDF
- **Basel Capital is a stylized version of EC**
  - A single correlation is assumed
  - A single systematic risk factor
  - “Infinite granularity”, no large loans or concentrations
  - No uncertainty in LGD

# The Creation of the New Basel Accord

- The process of creating the new Basel Accord
- The principles behind the Accord
- The structure of the Accord

# What is the Basel Committee?

- **Basel Committee on Banking Supervision was established by the central-bank governors of the G10 countries in 1974**
  - Belgium, Canada, France, Germany, Italy, Japan, Luxemburg, Netherlands, Spain, Sweden, Switzerland, UK, US
- **Meets at the Bank for International Settlements in Basel**
- **Formulates broad guidelines in the expectation that individual authorities will implement them**
- **First major result was the 1988 Capital Accord**
- **Strong interest from non-G10 countries wanting to show the international stature of their banks**

# Motivation for Basel II

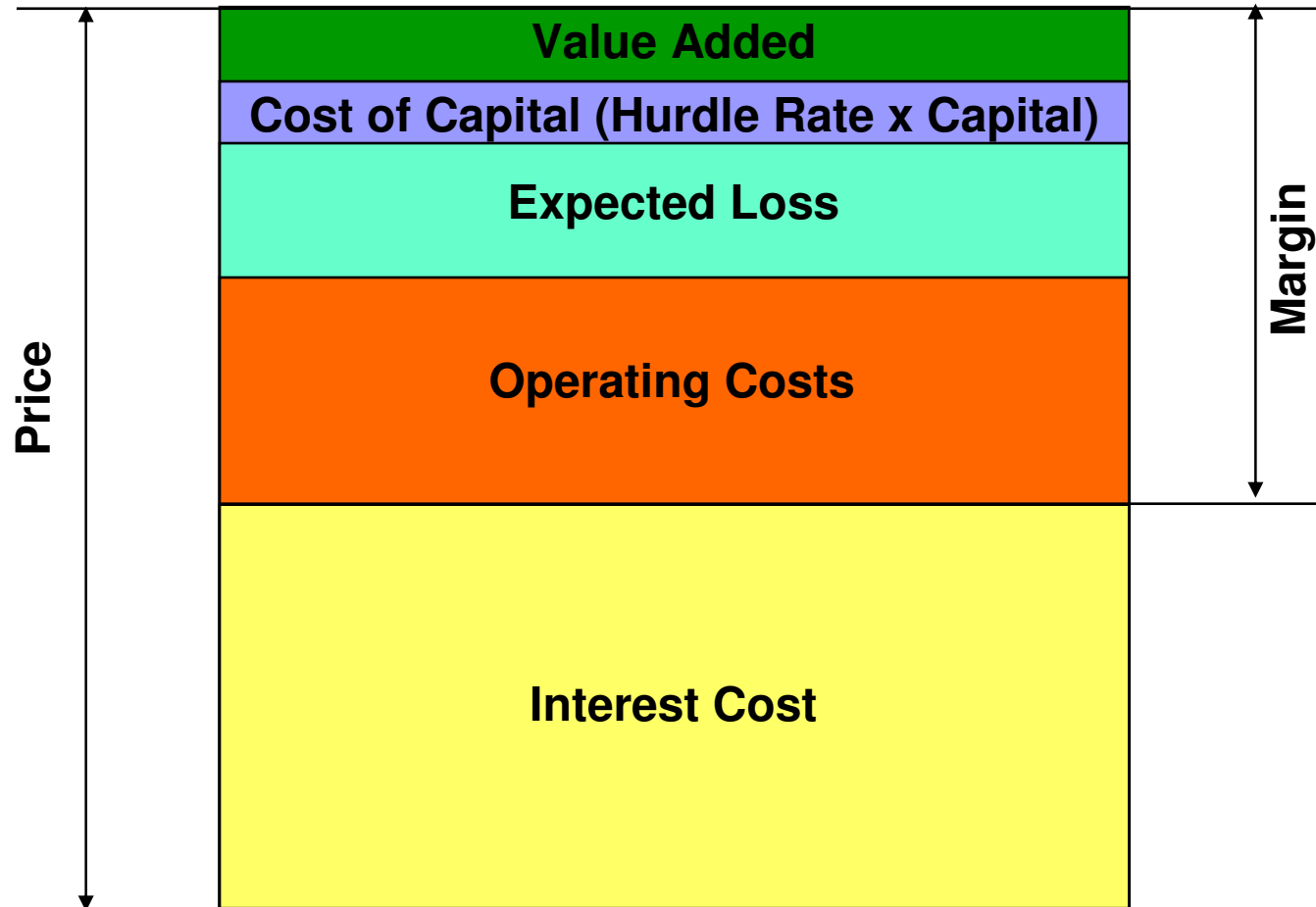
- **Problems with the 1988 Accord due to capital arbitrage opportunities**
  
- **Growth of modern risk management**
  - Value-at-Risk (VaR) for market risk
  - Economic capital and credit portfolio models
  - Models to estimate the profitability of individual deals
  - Models are already changing the market

## Basel II is intensifying existing trends

- Many banks have already adopted risk quantification for good risk management and price discipline
- This can leave the remaining banks exposed to adverse selection
- Basel II will have a large impact on bank operations:
  - Required Capital > Required Pricing
  - Required Capital > Measured Profitability > Bonuses
- Basel II is forcing the pace of model adoption and forcing a link between measured risk and allocated capital

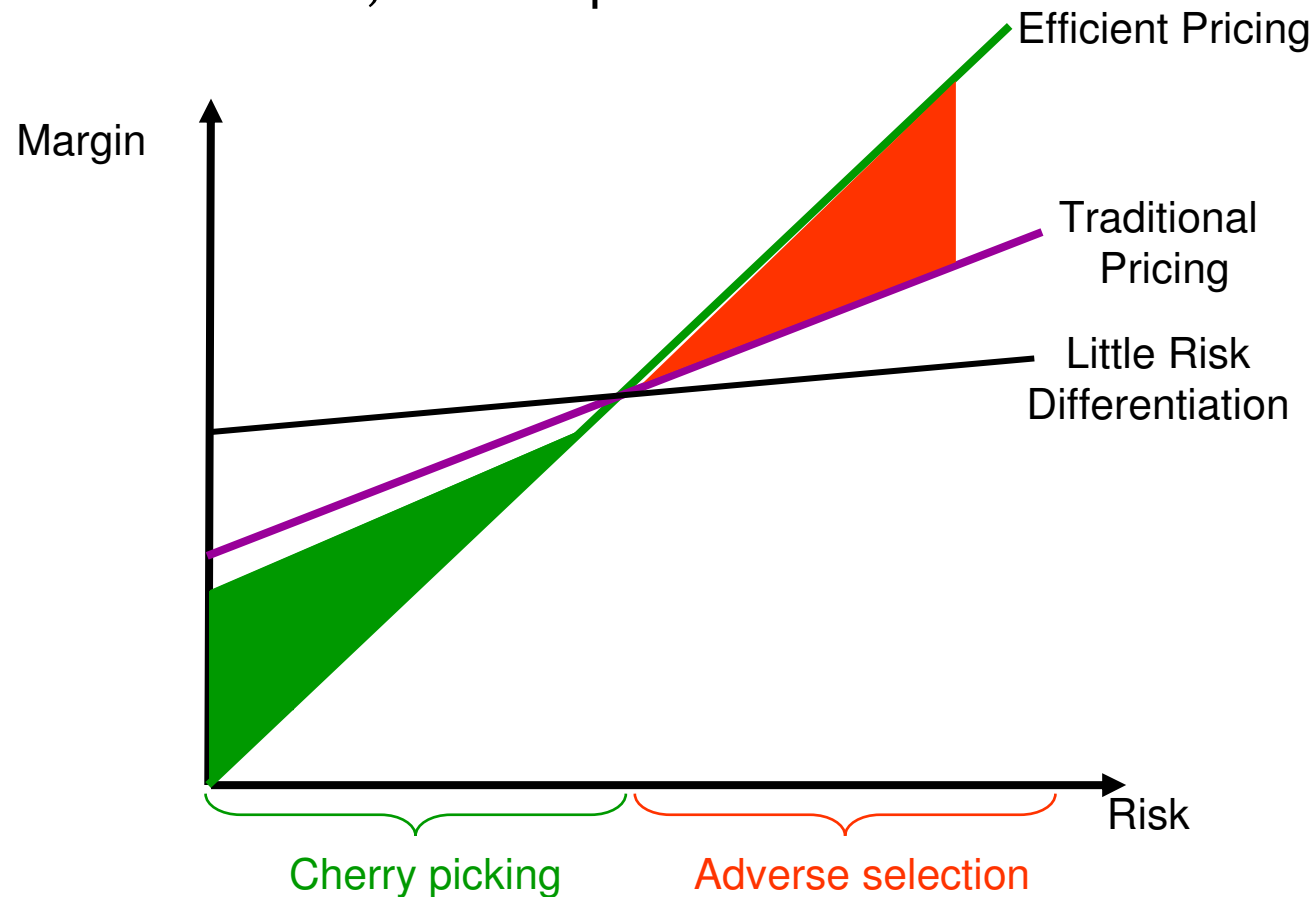
# Banks already use RAROEC models for pricing

## *Loan Pricing by Risk Adjusted Return on Economic Capital*



# Models are creating competitive pressures

- Some banks are using models to cherry-pick the low-risk deals, leaving the risky deals to their competitors
  - First credit cards, now corporates



# The process associated with Basel II

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- **Basel I (1988)**
- **The Market Risk Amendment (1996)**
- **Basel II Guidelines**
- **EU Legislation based on Basel II (CAD3/CRD 2005)**
- **Revision of US Capital Adequacy Regulations (2007 for 2009)**

# Objectives of the New Basel Accord

- Strengthen the international banking system while avoiding competitive inequality
- Encourage improvements in risk management by emphasizing *internal* assessments of capital adequacy and market discipline
- Provide incentives for banks to enhance their risk management capabilities
  - Overall capital levels should be the same
  - Capital under the advanced approaches should be a little less

# Principles in designing the New Accord

- **Develop a measure of capital adequacy that is better suited to the complex activities of large, internationally active banks**
- **Make the measure of capital adequacy more risk-sensitive**
- **Allow the use of best available tools and estimates for risk**
- **Use a consistent framework for all banks**
- **Be capable of adapting to the evolution of markets, products, and risk measurement techniques**
- **Minimize incentives for regulatory capital arbitrage**

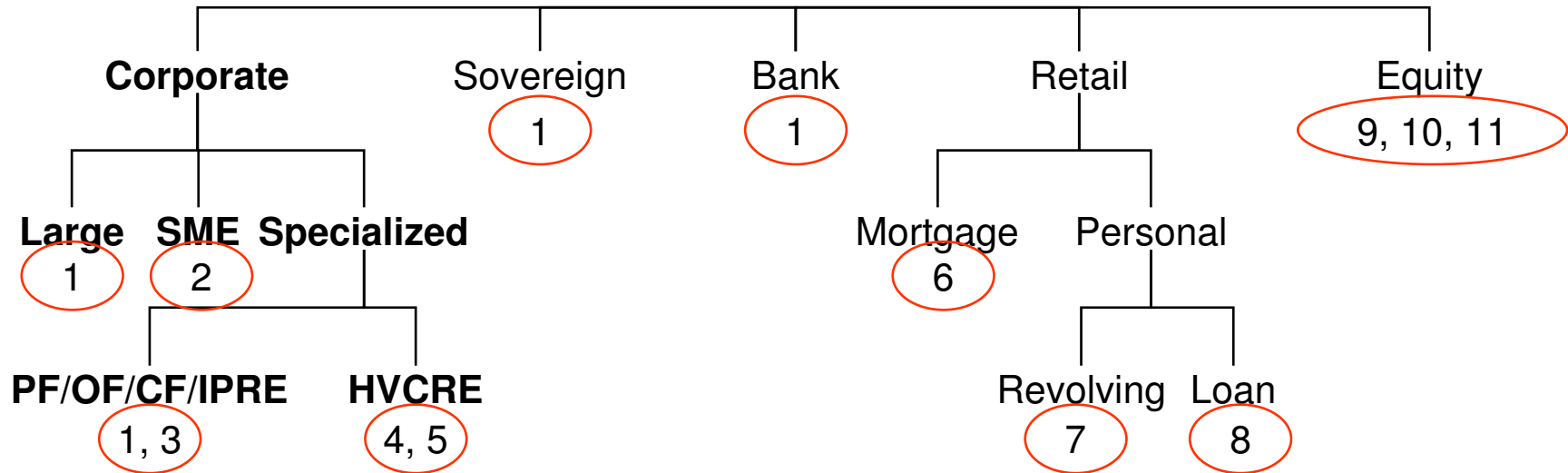
# The scope of Basel II

- **Range of risks (we will focus on credit risk)**
  - Credit risk
  - Operational risk (part of the old 8%)
  - Market Risk Amendment: as in 1996
  - Interest rate risk: “principles” not capital (Pillar 2)
  
- **Range of banks (“internationally active”)**
  - All European (as decided by EU)
  - US Core: \$250 Bn assets or \$10 Bn foreign assets
  - US Opt-in: voluntarily apply the Advanced Approach
  - US General: other banks (Basel I)

# The structure of Basel II

- **Three pillars (we will focus on Pillar 1)**
  - Pillar 1: minimum capital requirements
  - Pillar 2: supervisory review
    - Interest rate risk, credit concentrations
  - Pillar 3: disclosure of information to strengthen market discipline
- **Three approaches (we will focus on Advanced for the US)**
  - Standardized
  - Foundation Internal Ratings Based (IRB)
  - Advanced Internal Ratings Based (IRB)
- **Five Asset Classes (we will focus on corporate)**
  - Corporate
  - Sovereign
  - Bank
  - Retail
  - Equity

# The range of capital calculations



- 1) Formula-1 page 60
- 2) Formula-1, but lower R page 60
- 3) Slotting page 61
- 4) HVCRE slotting page 61
- 5) Formula-1, but higher R page 62
- 6) Formula-2 page 69
- 7) Formula-2, but lower R page 70
- 8) Formula-3 page 70
- 9) Simple weights page 72
- 10) VaR page 73
- 11) Formula-1, 90% LGD page 73

Page Number in Basel's Revised Framework

# Corporate asset classifications

- Large corporates
- SME: small and medium enterprises (< €50M in sales)
- Specialized Lending
  - PF: Project Finance
  - OF: Object Finance
  - CF: Commodities Finance
  - IPRE: Income Producing Real Estate
  - HVCRE: High Volatility Commercial Real Estate

# Our Focus

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- **Capital Amount / Supervisory Review / Market Disclosure**
- **Credit Risk / Operational Risk**
- **Corporate / Sovereign / Bank / Retail / Equity**

# Basel's Capital Rules

## Contents

- The main differences between Basel I and Basel II
- The components of the new capital equation
- The difference that asset type makes to the capital

# Summary of the 1988 Basel Accord

- **Available Capital must be greater than 8% of Risk Weighted Assets (RWA)**
- **Available Capital**
  - Tier 1
    - Share capital
    - Disclosed reserves
  - Tier 2 (no more than 50%)
    - Undisclosed and revaluation reserves
    - Subordinated debt & hybrid debt/equity
    - General provisions
- **Risk Weighted Assets, e.g.,**
  - RWA = 0% for loans to governments
  - RWA = 20% for loans to OECD banks
  - RWA = 50% for residential mortgages
  - RWA = 100% for corporate and retail loans

# Summary of Basel II

- **Available Capital must be greater than 8% of Risk Weighted Assets (RWA)**
- **Available Capital**
  - Mostly the same
  - “general provisions” → “general provisions - EL”
- **Risk Weighted Assets (Pillar 1)**
  - Standardized
  - Foundation IRB (PD, EAD, M, slotting)
  - Advanced IRB (PD, LGD, EAD, M, slotting)
  - Operational Risk

# Review of the building blocks

■ EAD	Exposure at Default	\$
■ PD	Probability of Default (EDF)	%
■ LGD	Loss Given Default (LIED)	%
■ M	Remaining Maturity	1-5 years
■ K	Capital as a % of EAD	%
■ RWA	Assets as if fixed 8% Capital	\$
■ EL	Expected Loss	% or \$
■ UL	Unexpected Loss	% or \$

# The Relationship between Capital and RWA

- Basel I used the concept of Risk Weighted Assets: RWA
- Basel II uses the concept of required capital: K
- The relationship between them is straight-forward
  - $RWA = 12.5 \times K \times EAD$
  - Min Tier 1 and 2 capital = 8% of RWA, or simply  $K \times EAD$

## *Example*

<b>Real Asset:</b>	<b>EAD = \$100</b>
<b>Required Capital:</b>	<b>K = 6%</b>
<b>Risk Weighted Asset:</b>	<b><math>RWA = 12.5 \times 6\% \times \\$100 = \\$75</math></b>
<b>Min Tier 1 &amp; 2 Capital:</b>	<b><math>8\% \times \\$75 = \\$6</math> (same as <math>K \times EAD</math>)</b>

# Risk counted in two parts: EL and UL

## Expected Loss (EL)

- EL affects the calculation of *available* capital

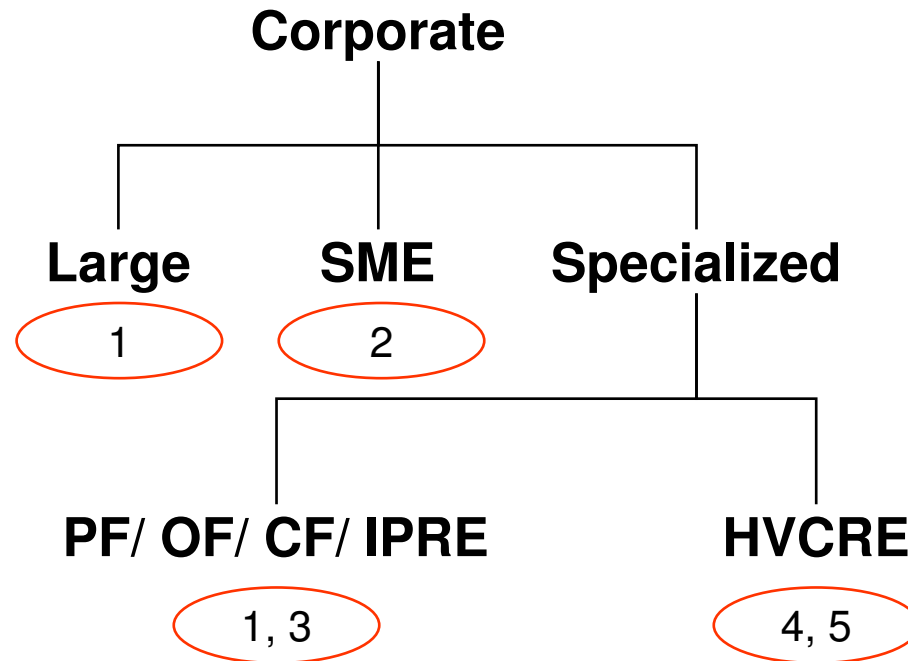
$$\text{Expected Loss} = \text{PD} \times \text{LGD} \times \text{EAD}$$

- Provisions are no longer directly allowed in capital
- If EL is less than provisions
  - difference can be added to Tier 2 (up to 0.6% of RWA)
- If EL is more than provisions
  - difference is subtracted equally from Tier 1 and Tier 2

## Unexpected Loss (UL)

- UL is used to calculate the *required* capital
- UL = the complex formulas for K

# The capital calculations for corporates



- 1) Formula-1 page 60
- 2) Formula-1, but lower R page 60
- 3) Slotting page 61
- 4) HVCRE slotting page 61
- 5) Formula-1, but higher R page 62

# Basel's IRB Approach to Setting a Capital Standard

- Construct capital standard around implicit model where banks estimate EADs, PDs, and LGDs, but where supervisors impose asset correlation assumptions
- Analytical basis
  - Facility's capital requirement depends solely on its characteristics
    - "portfolio invariance"
  - Rules out recognizing differences in diversification across banks
  - Estimate and calibrate for well-diversified portfolio
  - Manage risk concentrations through supervision
- Consequences
  - Capital charges recognize "average" diversification but are still additive
  - Idiosyncratic risk is assumed to be fully diversified
  - LGD and EAD are assumed to be idiosyncratic

# Assumptions in the capital formula

- **Portfolio fully diversified with “infinite granularity”**
  - Very large loans cause extra risk
- **No uncertainty in LGD or EAD**
  - Need to use “stress” cases
- **Normal distribution of a single macro factor & company shock**
  - Shocks may be worse than “Normal”
- **PD, LGD and EAD are estimated correctly**
  - If these factors are undercounted, capital will be undercounted

# The main capital equation for corporates

- The main approach for calculating capital is the formula on page 60 of the *Revised Framework* 1

- It is a multiple of EAD, LGD, “default-tail” and maturity-factor

$$K(\%) = \text{LGD} \times \text{DefaultTail} \times \text{MaturityFactor}$$

$$\text{Capital}(\$) = K \times \text{EAD}$$

i.e.

$$\text{Capital}(\$) = \text{LGD} \times \text{DefaultTail} \times \text{MaturityFactor} \times \text{EAD}$$

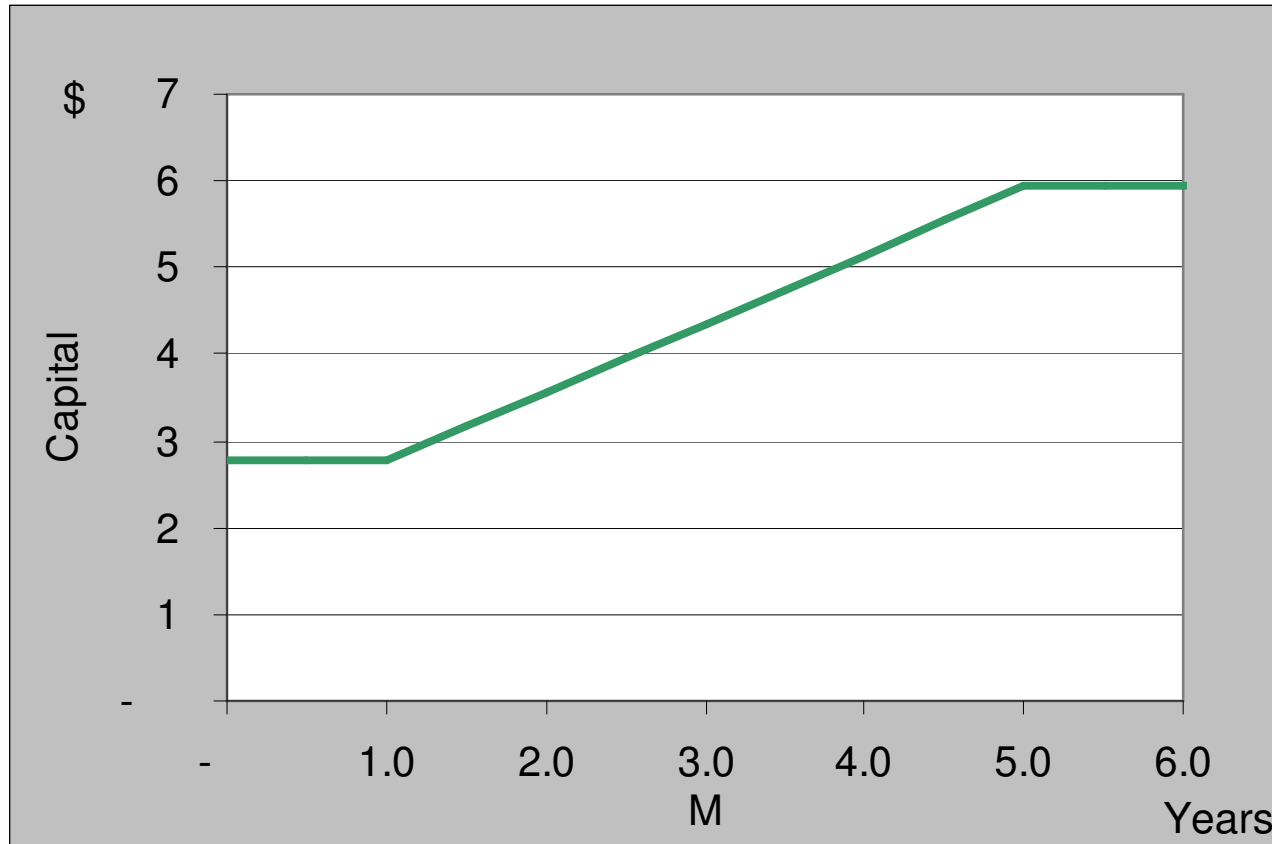
# The maturity factor

- The maturity factor adjusts for the increased risk of longer term loans
- It is based on historical data and depends on PD and M
  - M varies between 1 and 5 years
  - If M = 1, Maturity Factor = 1
  - If M = 5, Maturity Factor = 1.2 for B- and 3.4 for AAA
  - The PD adjustment is called “b”

$$b = (0.11852 - 0.05478 \times \ln(\text{PD}))^2$$

$$\text{MaturityFactor} = \left( \frac{1 + (M - 2.5) \times b}{1 - 1.5 \times b} \right)$$

# The effect of changing maturity



**Base case: PD=0.25%, LGD = 45%, EAD=\$100, M=1, Capital = \$2.77**

# The components of the default tail

- The default tail reflects four components:
  - The Expected Loss
  - The level of the shock
  - The base probability of a default without a shock
  - The correlation of asset values causing loans to default at the same time (R)

$$\text{DefaultTail} = N \left\{ \frac{\overset{\text{Base PD}}{G\{PD\}} + \overset{\text{99.9\% shock}}{G\{0.999\}} \sqrt{R}}{\underset{\text{Correlation}}{\sqrt{1-R}}} \right\} - \underset{\text{For EL}}{PD}$$

- $N\{\}$  and  $G\{\}$  represent the assumed Normal distribution of the shock

# The source of the Capital Formula

- The Default Tail is the proportion of a portfolio of identical assets that is expected to default in a 99.9% economic downturn
- The derivation of the formula starts from a model of a firm's asset values:

$$\text{Firm Value} = A \times \text{Firm Performance} - B \times \text{Macro Conditions}$$

- If Firm Value falls below a threshold, it will default
- The unconditional probability of falling below the threshold is PD
- The conditional probability of falling below the threshold in an economic downturn is given by the default tail formula

# The correlation

- The correlation reflects the extent to which one loan in the portfolio is being affected by the same economic factors as another loan
- The equation is based on historical data and depends on PD
  - If PD = 3bps, R = 24%
  - If PD = 10%, R = 12%

$$R = 0.12 \left[ \frac{1 - e^{-50PD}}{1 - e^{-50}} \right] + 0.24 \left[ 1 - \frac{1 - e^{-50PD}}{1 - e^{-50}} \right]$$

$$R \approx 0.12 + 0.12e^{-50PD}$$

## Detail: Derivation of the Capital Formula

- Firm Value = A x Firm Performance - B x Macro Conditions

$$v = a i - b m, \quad v = \sqrt{1 - \rho^2} i - \rho m, \quad R \equiv \rho^2$$

$$PD(m) = P\{v < \zeta\} = P\left\{\left(\sqrt{1 - R} i - \sqrt{R} m\right) < \zeta\right\}$$

$$PD(m) = P\left\{i < \frac{\zeta + \sqrt{R} m}{\sqrt{1 - R}}\right\} = N\left\{\frac{\zeta + \sqrt{R} m}{\sqrt{1 - R}}\right\}$$

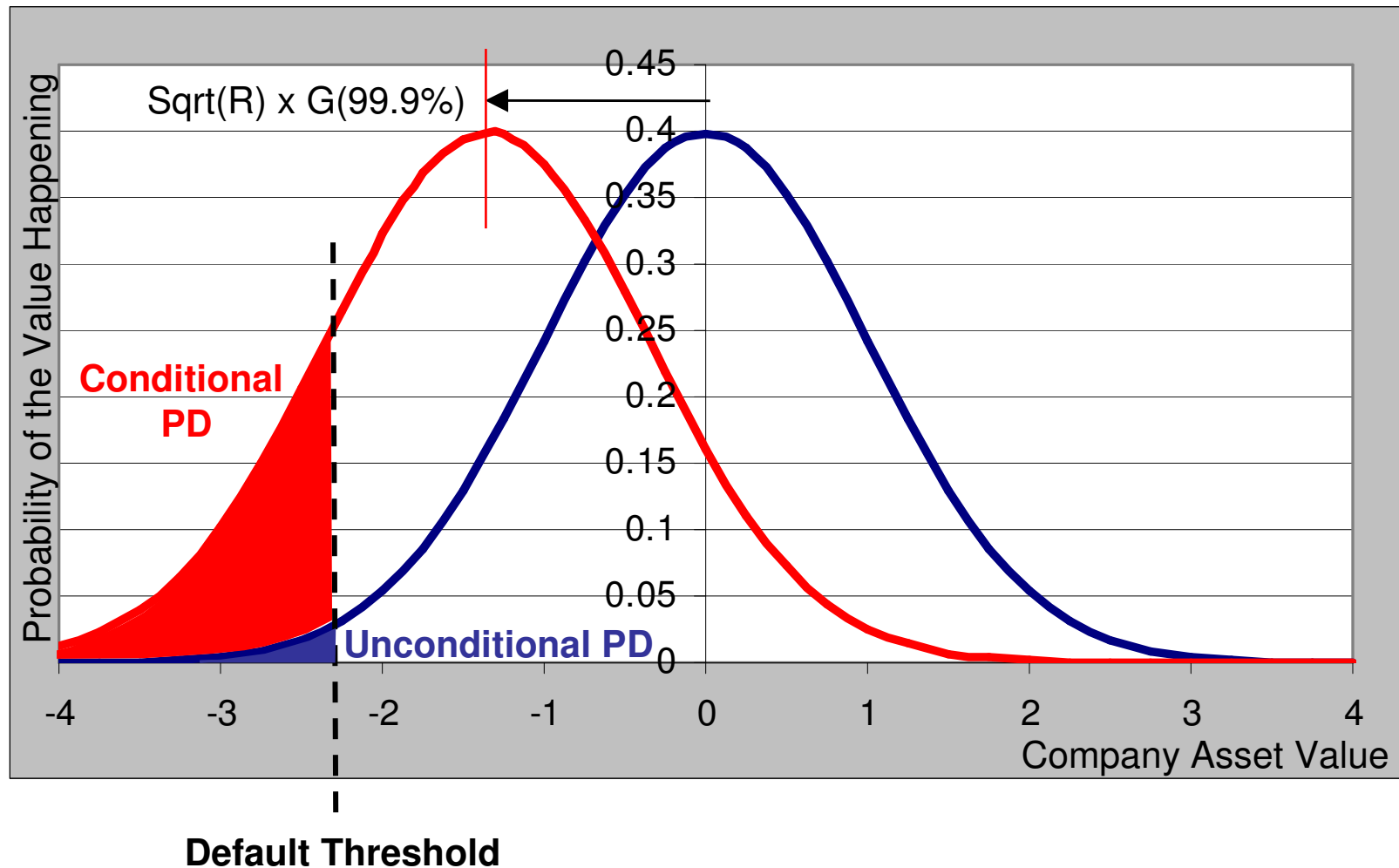
$$\zeta = \text{Level for Unconditional PD} = G\{PD\}$$

$$m = \text{Level for 99.9\% macro shock} = G\{99.9\%\} = 3.1$$

$$PD(99.9) = N\left\{\frac{G\{PD\} + \sqrt{R} G\{99.9\%\}}{\sqrt{1 - R}}\right\}$$

# Detail: The 99.9% economic shock

The 99.9% economic shock shifts the distribution of end of year asset values for the company



## Detail: Components of the default tail if PD = 1%

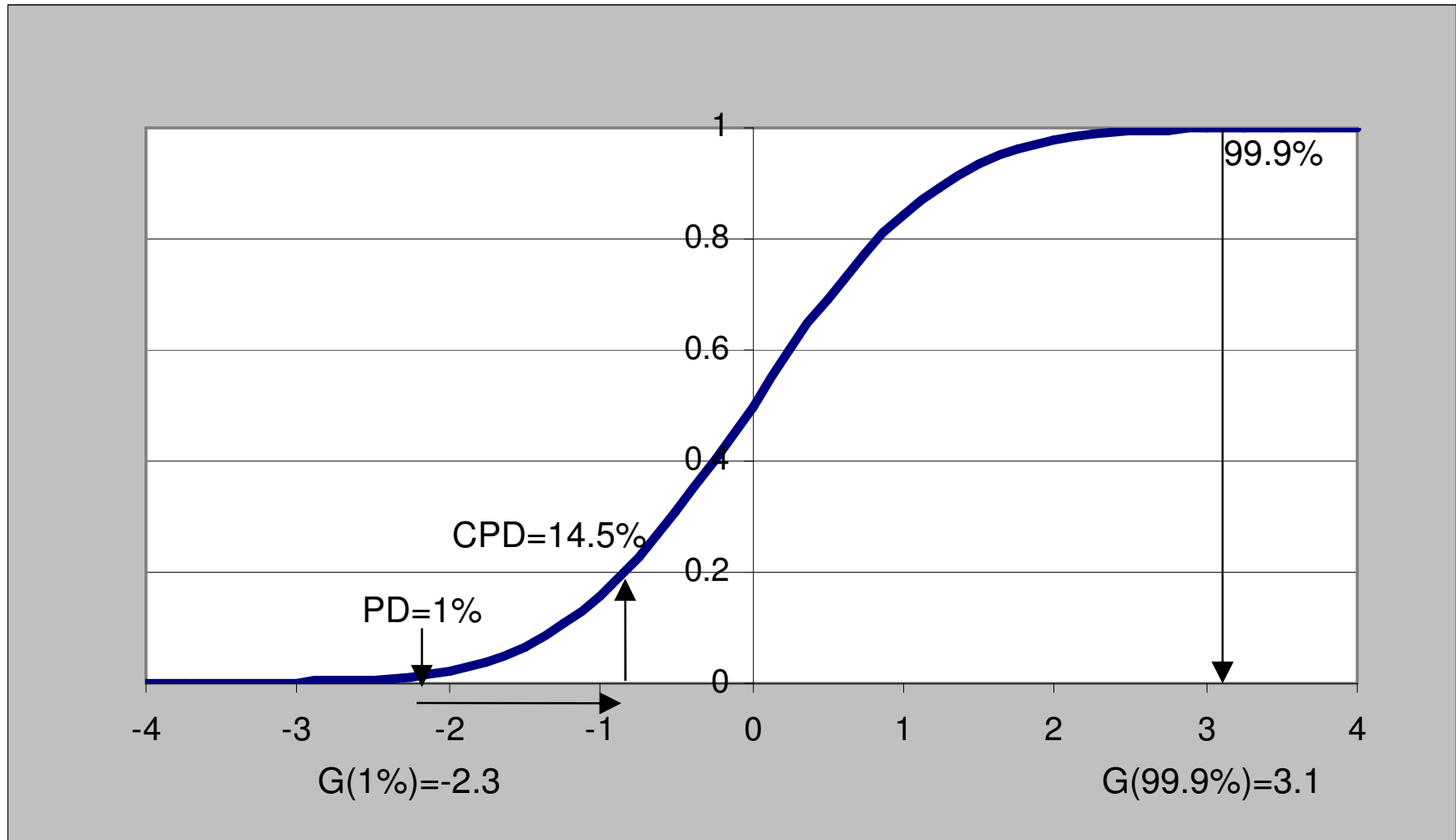
$$\text{DefaultTail} = N \left\{ \frac{G\{PD\} + G\{0.999\} \sqrt{R}}{\sqrt{1-R}} \right\} - PD$$

$$\text{DefaultTail} = N \left\{ \frac{G\{1\%\} + 3.1 \times .43}{0.9} \right\} - 1\%$$

$$\text{DefaultTail} = N \left\{ \frac{-2.3 + 1.4}{0.9} \right\} - 1\%$$

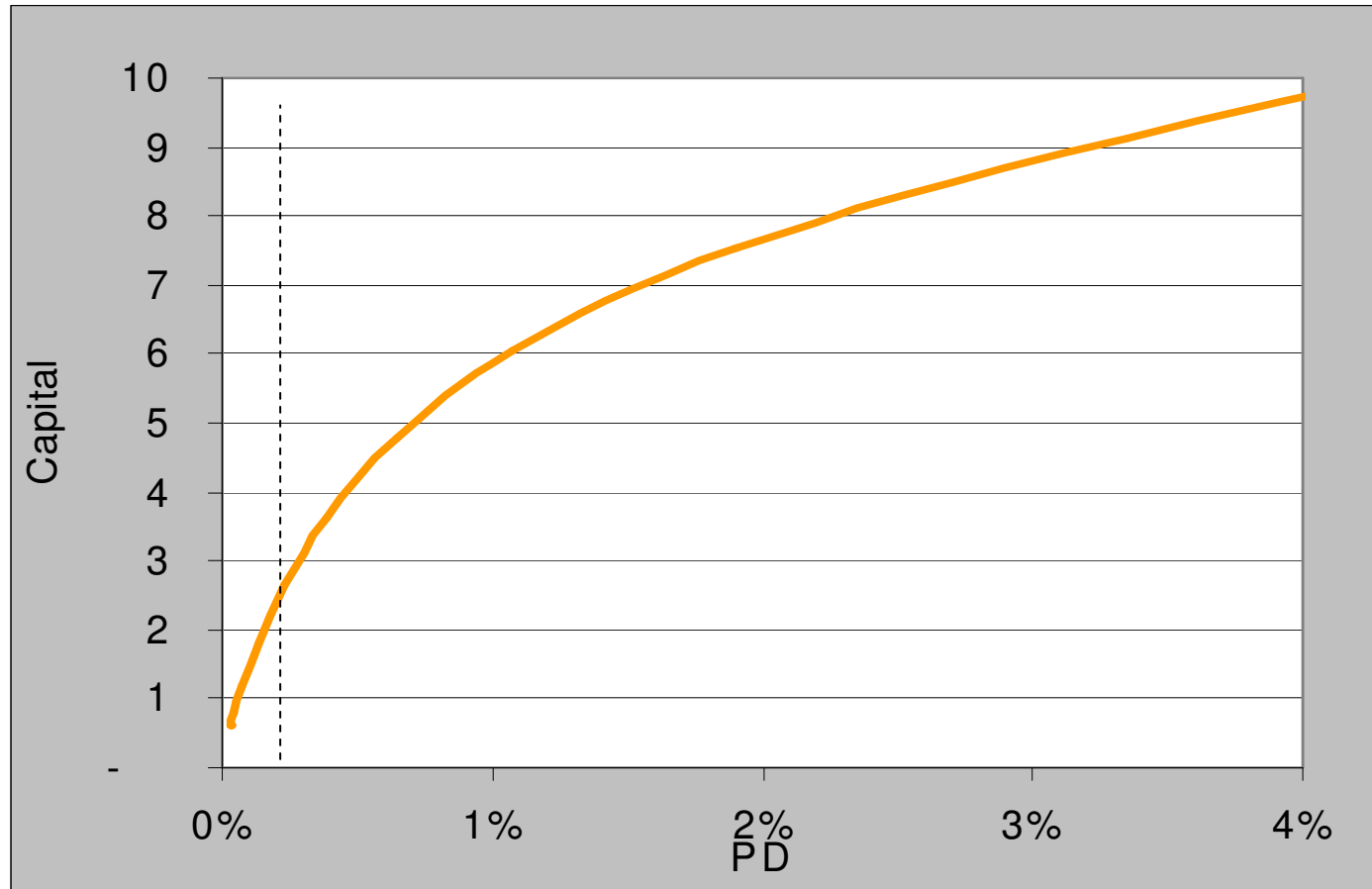
$$\text{DefaultTail} = N\{-1.05\} - 1\% = 14.5\% - 1\%$$

# Detail: Components of the default tail if PD=1%



# The effect of changing Probability of Default

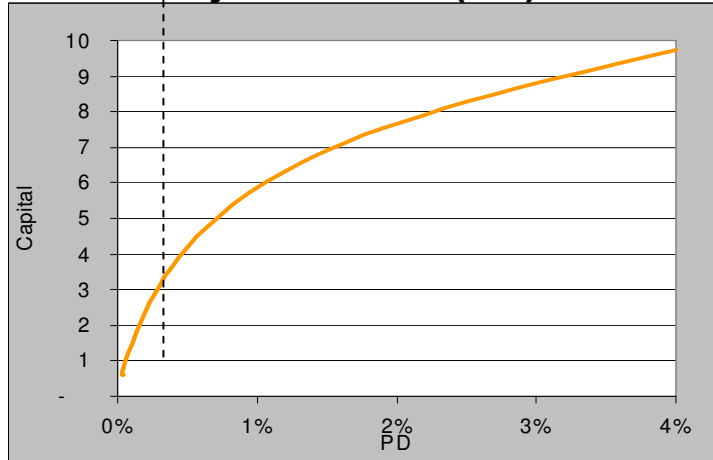
- A “square root” effect: 4 times PD => 1.5 times Capital



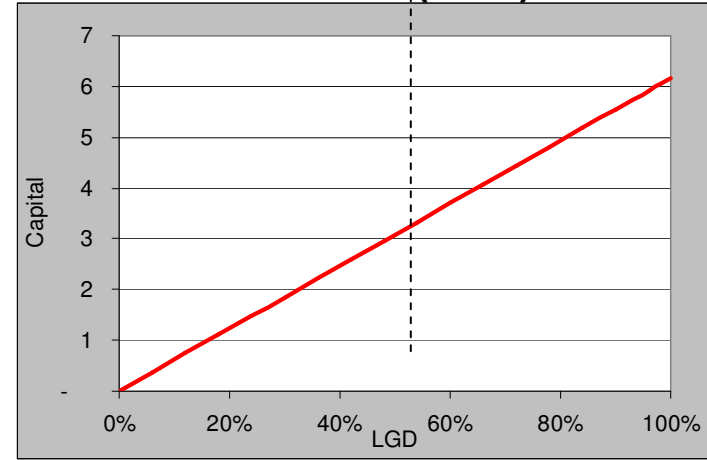
Base case: PD=0.25%, LGD = 45%, EAD=\$100, M=1, Capital = \$2.77

# The effect of changing each parameter

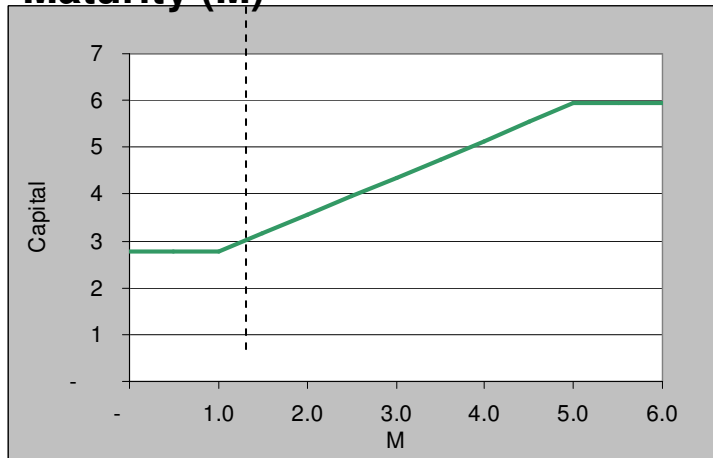
**Probability of Default (PD)**



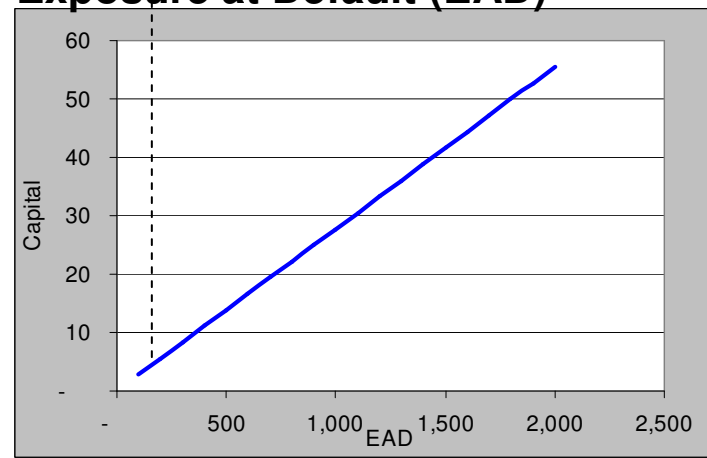
**Loss Given Default (LGD)**



**Maturity (M)**



**Exposure at Default (EAD)**



Base case: PD=0.25%, LGD = 45%, EAD=\$100, M=1, Capital = \$2.77

# The capital equation for corporates

1

$$\text{Capital} = \text{EAD} \times \text{LGD} \times \text{DefaultTail} \times \text{MaturityFactor}$$

$$\text{MaturityFactor} = \left( \frac{1 + (M - 2.5) \times b}{1 - 1.5 \times b} \right)$$

$$b = (0.11852 - 0.05478 \times \ln(\text{PD}))^2$$

$$\text{DefaultTail} = N \left\{ \frac{G\{\text{PD}\} + G\{0.999\} \sqrt{R}}{\sqrt{1 - R}} \right\} - \text{PD}$$

$$R = 0.12 \left[ \frac{1 - e^{-50\text{PD}}}{1 - e^{-50}} \right] + 0.24 \left[ 1 - \frac{1 - e^{-50\text{PD}}}{1 - e^{-50}} \right]$$

# Adjustments for SMEs & HVCRE

- Large Corporate (~ 23%)

$$R = 0.12 \left[ \frac{1 - e^{-50PD}}{1 - e^{-50}} \right] + 0.24 \left[ 1 - \frac{1 - e^{-50PD}}{1 - e^{-50}} \right]$$

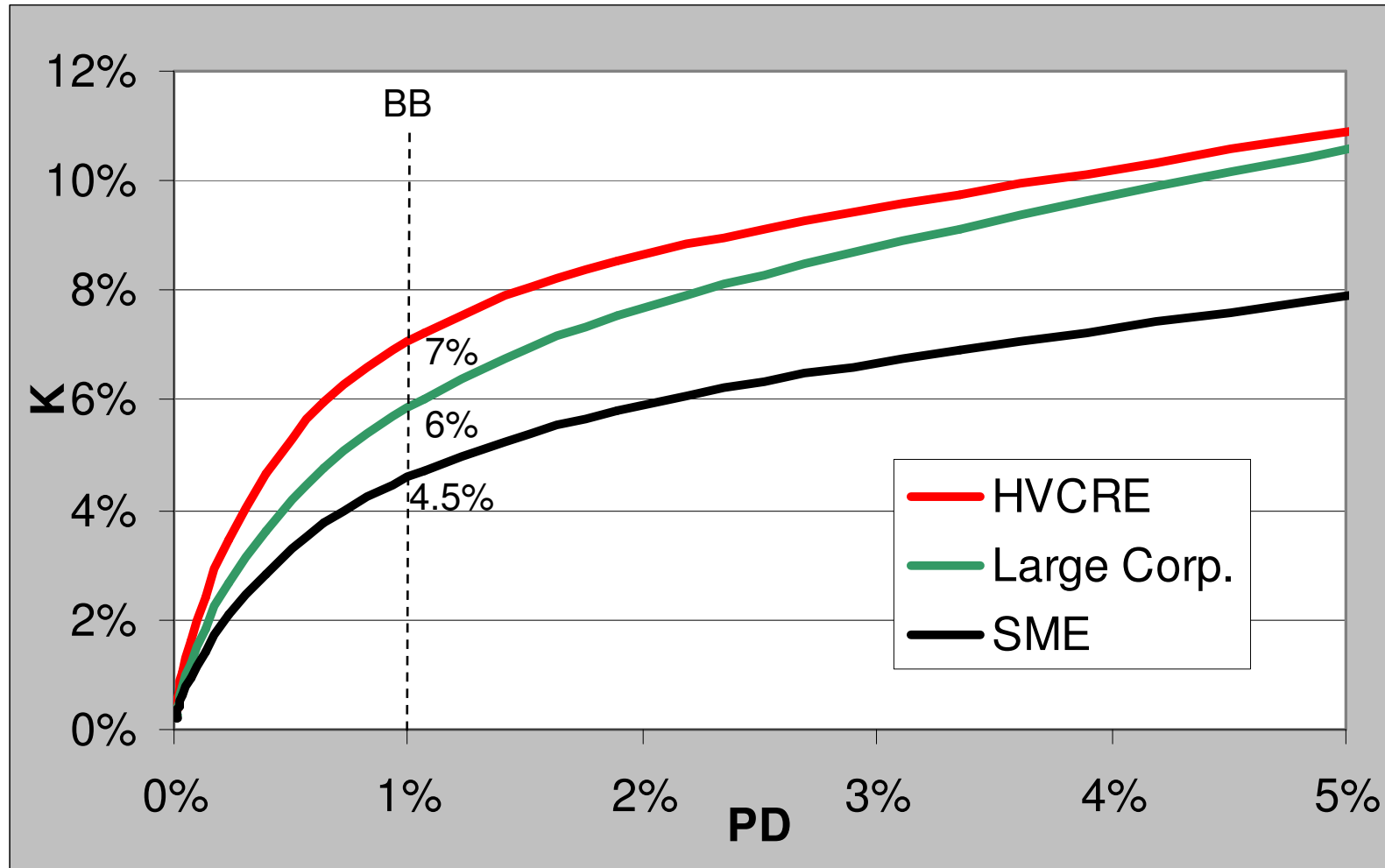
- SME (minus 0 to 4%)

$$R = 0.12 \left[ \frac{1 - e^{-50PD}}{1 - e^{-50}} \right] + 0.24 \left[ 1 - \frac{1 - e^{-50PD}}{1 - e^{-50}} \right] - 0.04 \left[ 1 - \frac{\text{Sales} - 5}{45} \right]$$

- HVCRE (plus ~ 6%)

$$R = 0.12 \left[ \frac{1 - e^{-50PD}}{1 - e^{-50}} \right] + 0.30 \left[ 1 - \frac{1 - e^{-50PD}}{1 - e^{-50}} \right]$$

# Comparison of capital for SME and HVCRE



M=1, LGD = 45%, SME Sales = 5M/yr

# Slotting for specialized lending: Percent

## 3 *PF / OF / CF / IPRE*

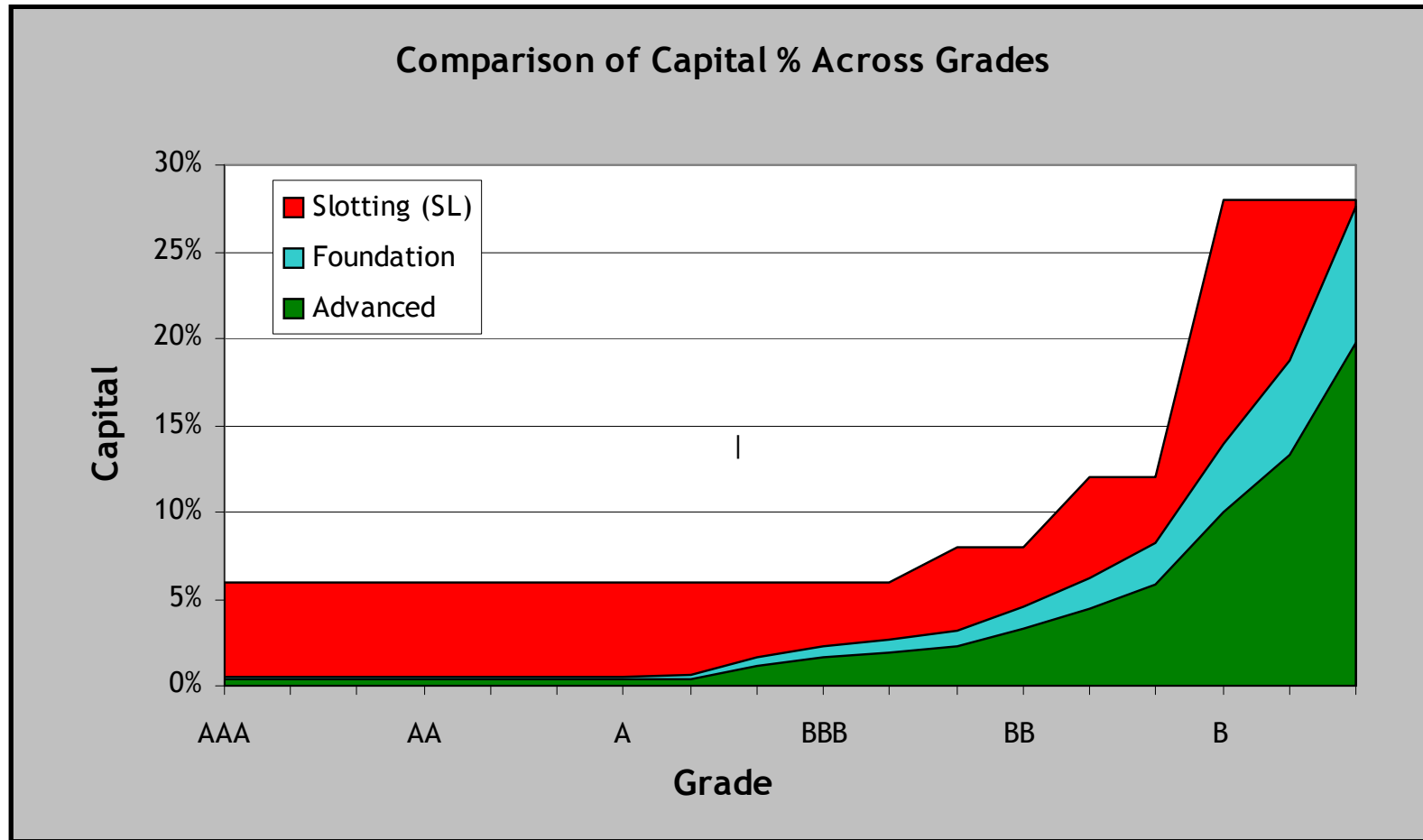
Category	Strong	Good	Satis.	Weak	Default
Rating	AAA to BBB-	BB+ to BB	BB- to B+	B to C-	D
UL K	5.6%	7.2%	9.2%	20%	0%
EL %	0.4%	0.8%	2.8%	8%	50%

## 4 *HVCRE*

Category	Strong	Good	Satis.	Weak	Default
UL K	7.6%	9.6%	11.2%	20%	0%
EL %	0.4%	0.8%	2.8%	8%	50%

# Slotting compared with full IRB

Slotting will be allowed as an Internal Ratings Based (IRB) approach for Specialized Lending



Assuming 35% LGD for Foundation and 25% for Advanced, M=1

# Why is Basel capital not the same as EC?

- **Difference in purpose**
  - Basel capital is intended to be a minimum standard
  - Basel must balance auditability with risk sensitivity
- **Differences in methodology**
  - Scenario analysis vs. loss distribution
  - Treatment of correlation
  - Treatment of LGD uncertainty
  - Treatment of Value uncertainty
- **Different confidence levels**
  - Basel set at 99.9%
  - Institutions may target a different solvency level in their EC

# A capital story that some banks hope to tell

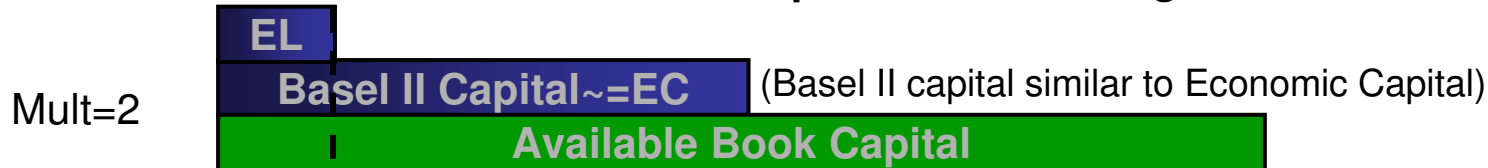
**Initial State: Bank “well” capitalized according to Basel I**



**Initial State: Bank “over” capitalized according to Economic Capital**



**Initial State: Bank “over” capitalized according to Basel II**



**Final State: Reduce available capital to become “well” capitalized under B II**



# Takeaways from Basel capital calculation

- **The basic Tier 1 and 2 capital rules are similar to Basel I**
  - RWA is no longer 8%, but now a formula
  - EL is subtracted from provisions, capital is based on UL
- **The building blocks are PD, LGD, EAD, and M**
  - LGD and M have a strong “linear” influence on capital
  - PD has a “square root” influence
- **Asset class such as SME and HVCRE have different R**
- **The stylized assumptions in the formula create the need to be careful**
  - Risk concentrations
  - Definitions of default
  - Uncertainty in LGD
- **Errors in the estimation of PD and LGD can undercount risk**