From Basel to Balance Sheet: How Banks Stay Safe

Kent Economics Society Workshop

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Outline

From Basel to Banks — What this series is about

- Explore how banks manage risk and maintain stability within the **Basel** regulatory framework.
- Bridge **macroeconomic theory** with **quantitative financial practice**.
- Connect regulation, risk modelling, and the **bank balance sheet**.
- Each module builds toward an **integrated stress testing** session that simulates real-world resilience scenarios.

Purpose of this Introduction

Goal

Outline the **conceptual** and **quantitative** foundations for the workshop series and set expectations for subsequent sessions.

- Define the scope and learning arc of the series.
- Motivate why **capital**, **risk**, and **supervision** matter for banks and the economy.
- Preview the modelling activities you will implement in **Excel** and **Python**.

Who is this for?

- Students and practitioners in **quantitative finance**, **risk management**, **data science**, and **economics**.
- Anyone aiming to **translate theory into applied, industry-aligned analysis**.
- Participants comfortable with **hands-on** computation and visualization.

How the series flows

- Introduce ⇒ **Capital Adequacy & Basel** ⇒ core risk modules:
  - **Credit risk**: PD, LGD, EAD; portfolio loss and correlation.
  - **Market risk**: VaR/ES; historical vs. parametric; backtesting.
  - **Liquidity risk**: LCR/NSFR; maturity ladder; run-off shocks.
  - **Operational & Model risk**: scenarios, heatmaps, governance.
- Finish with **Integrated Stress Testing**: re-compute CET1 & leverage under combined shocks.

What you will take away

- See how risk types interconnect on a **bank balance sheet**.
- **Quantify** capital requirements under the Basel framework.
- Build and visualize **stress tests** that mirror supervisory logic.
- Think like regulators, model like analysts, and reason like economists.

Why Capital Matters

- Banks face unexpected losses from credit, market, and liquidity shocks.
- **Capital** acts as a financial buffer that protects depositors, creditors, and the wider system.
- Regulators require minimum capital levels to ensure **solvency**, **confidence**, and **continuity** of banking operations.
- This module introduces how capital requirements are structured under the Basel framework.

The Basel Regulatory Evolution

- **Basel I** (1988): Simple credit-risk rules, standardised risk weights.
- **Basel II** (2004): Internal Ratings Based (IRB) models; inclusion of operational risk.
- **Basel III** (2010–2023): Stronger capital definitions, liquidity standards (LCR/NSFR), leverage ratio.
- **Basel IV** (Basel III Revisions): Standardised approach overhaul, output floors, model constraints.

Purpose: Improve global financial stability by strengthening resilience and limiting model risk.

The Three Pillars of Basel

Pillar 1

- Minimum capital requirements
- Credit, market, operational risk
- CET1 / RWA ratios

Pillar 2

- Supervisory review process
- Internal capital adequacy (ICAAP)
- Governance, model validation

Pillar 3

- Market discipline
- Transparency & disclosures
- Public reporting of risk

Constructing a Simplified Balance Sheet

- We build a stylised bank balance sheet to calculate:
  - **Common Equity Tier 1 (CET1)** capital
  - **Risk-Weighted Assets (RWA)**
  - **Leverage Ratio Exposure**
- These components determine the bank's **capital adequacy**.

Core Formula

$$\text{CET1 Ratio} = \frac{\text{CET1 Capital}}{\text{Risk-Weighted Assets}}$$

Capital Buffers and Stress Conditions

- Beyond minimum requirements, banks must hold:
  - **Capital Conservation Buffer (CCB)**
  - **Countercyclical Buffer (CCyB)**
  - **Systemic Risk Buffers** (G-SIB/O-SII)
- Under stress scenarios, asset values fall and RWA increases.
- The workshop shows how these combined effects push CET1 ratios toward regulatory thresholds.

What is Credit Risk?

- Credit risk is the danger that a borrower fails to meet contractual obligations.
- It is the largest component of a bank's total risk profile and the key driver of regulatory capital.
- Basel's Internal Ratings Based (IRB) framework quantifies credit risk through:
  - **Probability of Default (PD)**
  - **Loss Given Default (LGD)**
  - **Exposure at Default (EAD)**
- These parameters feed into models that determine expected and unexpected loss.

Core IRB Concepts

Expected Loss (EL)

$$\text{EL} = PD \times LGD \times EAD$$

Unexpected Loss (UL)

Capital is held for **UL**, which arises from extreme or correlated default events.

$$\text{UL} = f(PD, LGD, EAD, \rho, \text{confidence level})$$

- IRB places strong emphasis on **default correlation** (ρ), which increases during downturns.
- Higher correlation increases capital requirements non-linearly.

Portfolio Structure for the Exercise

- We model a simplified loan portfolio with:
  - N borrowers
  - Individual PDs, LGDs, and EADs
  - A shared systematic factor representing macroeconomic conditions
- The portfolio loss distribution is generated by simulating:
  - Borrower defaults
  - Losses conditional on default
  - The effect of correlation between borrowers

Monte Carlo Simulation Framework

- We estimate the full loss distribution using a Monte Carlo simulation:
  1. Draw a systematic risk factor $Z \sim N(0, 1)$
  2. For each borrower, draw an idiosyncratic shock ϵ_i
  3. Determine default when the latent variable falls below a PD threshold:

$$\sqrt{\rho}Z + \sqrt{1-\rho}\epsilon_i < \Phi^{-1}(PD_i)$$

  4. Compute portfolio loss:

$$L = \sum_i \text{Default}_i \times LGD_i \times EAD_i$$

- Running thousands of simulations yields a distribution used to estimate:
  - Value-at-Risk of credit losses
  - Unexpected loss capital
  - Stress outcomes under downturn conditions

Incorporating Macroeconomic Stress Multipliers

- Stress scenarios increase PD, LGD, and correlation:

$$\begin{aligned} PD_{\text{stress}} &= PD \times m_{PD} \\ LGD_{\text{stress}} &= LGD \times m_{LGD} \\ \rho_{\text{stress}} &= \rho + \Delta\rho \end{aligned}$$

- These adjustments mimic recessionary conditions.
- The workshop shows how losses escalate when:
    - corporate defaults become clustered
    - recovery rates shrink
    - exposures migrate to worse credit grades

Outputs from the Credit Risk Module

- Loss distribution under:
  - Base conditions
  - Stress conditions
- Expected and Unexpected Loss metrics
- Credit Value-at-Risk (Credit VaR)
- Capital charge for unexpected loss
- Sensitivity of losses to PD, LGD, and correlation

What is Market Risk?

- Market risk arises from changes in interest rates, equity prices, FX rates, credit spreads, and commodity prices.
- It affects a bank's trading book, treasury operations, and hedging activities.
- Basel requires banks to hold capital against large **unexpected market movements**.
- This module introduces how Value-at-Risk (VaR) and Expected Shortfall (ES) quantify those risks.

Why VaR and ES?

Value-at-Risk (VaR)

The maximum loss over a given time horizon at a specified confidence level:

$$\text{VaR}_\alpha = \inf\{l : P(L > l) \leq 1 - \alpha\}$$

Expected Shortfall (ES)

The average loss given that the VaR threshold has been breached:

$$\text{ES}_\alpha = E[L \mid L > \text{VaR}_\alpha]$$

- Basel's **FRTB** replaces VaR with ES for capital because ES captures **tail risk**.
- VaR alone can underestimate tail behaviour in volatile markets.

Approaches to VaR Estimation

1. **Historical Simulation**
   - Use actual historical returns.
   - No assumptions about distributions.
   - Captures real market behaviour and non-normality.
2. **Parametric (Variance–Covariance)**
   - Assume returns follow a distribution (often Normal).
   - VaR computed using mean and standard deviation:

$$\text{VaR} = \mu + z_\alpha \sigma$$

   - Fast and transparent, but may underestimate fat tails.

Portfolio-Level Market Risk

- Market risk is driven by:
  - **Volatility** of asset returns
  - **Correlation** between asset classes
  - **Position sizes and sensitivities**
- For a multi-asset portfolio:

$$\sigma_p = \sqrt{w^\top \Sigma w}$$

- VaR and ES are computed from the distribution of portfolio returns.
- Correlations spike during crises — increasing capital needs.

Backtesting VaR Models

- Backtesting compares predicted VaR to actual realised losses.
- A **VaR breach** occurs when:

$$L_t > \text{VaR}_t$$

- Regulators track the number of breaches in a "traffic light" framework:
  - **Green**: Model performs well (few breaches)
  - **Yellow**: Model uncertain, capital multiplier increases
  - **Red**: Model unreliable, punitive capital add-ons
- Backtesting is required under Basel's market risk rules.

Link to Basel's FRTB

- The **Fundamental Review of the Trading Book (FRTB)** modernises market risk regulation.
- Key features:
  - Replace VaR with **Expected Shortfall**
  - Introduce **liquidity horizons** for different asset classes
  - Align trading book vs. banking book boundary
  - Constrain internal models through **modellability tests**
- The module explains how these reforms increase capital during periods of extreme market stress.

Simulation Exercise Overview

- Using Python, we estimate VaR and ES via:
    - Historical simulation
    - Parametric (Normal) methods
    - Stress-volatility adjustments
- We then compare:
    - Loss distribution tail thickness
    - 95% vs 99% VaR and ES
    - Performance under stressed volatility regimes
- Students will observe how tail behaviour drives capital under Basel.

What is Liquidity Risk?

- Liquidity risk arises when a bank cannot meet its obligations as they fall due.
- Solvent banks can still fail if they cannot convert assets to cash quickly enough.
- Key drivers:
  - Sudden deposit withdrawals
  - Market disruptions and funding freezes
  - Maturity mismatches between assets and liabilities
- Basel III introduced quantitative liquidity standards to ensure short- and long-term resilience.

Basel III Liquidity Standards

Two mandatory liquidity ratios:

- **Liquidity Coverage Ratio (LCR)**

$$\text{LCR} = \frac{\text{High-Quality Liquid Assets (HQLA)}}{\text{Net Cash Outflows (30 days)}} \geq 100\%$$

- **Net Stable Funding Ratio (NSFR)**

$$\text{NSFR} = \frac{\text{Available Stable Funding}}{\text{Required Stable Funding}} \geq 100\%$$

- LCR ensures short-term survival during a severe 30-day stress scenario.
- NSFR promotes structural funding stability over a 1-year horizon.

High-Quality Liquid Assets (HQLA)

- Only certain assets count toward LCR:
  - Level 1: Cash, central bank reserves, sovereign bonds (no haircut)
  - Level 2A: High-grade corporates and covered bonds (15% haircut)
  - Level 2B: Equities, lower-grade bonds (25–50% haircut)
- Assets must remain liquid even under stress conditions.
- Haircuts reflect market liquidity deterioration during crises.

Cash Flow Maturity Ladder

- A key liquidity tool: compare cash inflows vs. outflows across time buckets.
- Typical buckets: 0–7 days, 7–30 days, 1–3 months, 3–6 months, etc.
- Components:
  - Contractual inflows (loan repayments, maturing securities)
  - Contractual outflows (deposits, debt maturities, margin calls)
  - Behavioural adjustments (run-off rates, prepayment assumptions)
- Students construct a simplified maturity ladder to assess liquidity gaps.

Stress Scenario: Deposit Run

- Liquidity stress often begins with a sudden loss of confidence.
- Basel prescribes run-off rates for different categories of deposits:
  - Retail insured: 3–5%
  - Retail uninsured: 10%
  - SME deposits: 10–40%
  - Financial corporates: up to 100%
- In the workshop:
  - Students shock deposit outflows
  - Recalculate net cash outflows
  - Evaluate whether HQLA meets the LCR requirement

Simulating a Liquidity Shock

- Liquidity crises escalate rapidly:
  1. Increase deposit run-off rates
  2. Apply haircuts to liquid asset valuations
  3. Accelerate derivative margin calls
  4. Block access to wholesale funding markets
- Students simulate a 30-day liquidity shock and observe:
  - HQLA depletion
  - Cash-flow imbalances
  - Rapid deterioration of LCR

NSFR: Long-Term Funding Stability

- NSFR ensures funding resilience under normal and stressed conditions.

Key Concepts

- **Available Stable Funding (ASF)**: Equity, long-term liabilities, stable deposits.
- **Required Stable Funding (RSF)**: Illiquid or long-maturity assets.
- RSF weights reflect the difficulty of monetising assets quickly.

- A bank with excessive short-term funding will fail the NSFR.
- Workshop participants build a simplified NSFR calculation.

What is Operational Risk?

- Operational risk arises from failures of:
  - Systems (IT outages, cyber-attacks)
  - Processes (errors, control failures)
  - People (fraud, misconduct, misreporting)
  - External events (disasters, regulatory changes)
- Basel defines it as losses resulting from inadequate or failed internal processes, people, systems, or external events.
- Operational events can be low frequency but extremely high severity.

Categories of Operational Risk

- **Internal Fraud**
- **External Fraud**
- **Employment Practices & Workplace Safety**
- **Clients, Products & Business Practices**
- **Damage to Physical Assets**
- **Business Disruption & System Failures**
- **Execution, Delivery & Process Management**

Simple Quantitative Framework

- We introduce a scenario-based capital model:

$$\text{OpRisk Capital} = \mu_{\text{loss}} + z_\alpha \sigma_{\text{loss}}$$

- Losses are modelled using:
  - Frequency distribution (Poisson or Negative Binomial)
  - Severity distribution (Lognormal or Pareto)
- Monte Carlo simulation produces the aggregate annual loss distribution.

Model Risk: Risks of the Models Themselves

- Model risk arises from:
  - Incorrect model specification
  - Wrong assumptions (normality, independence, linearity)
  - Bad or insufficient data
  - Incorrect implementation (code errors)
  - Misuse by analysts
- Regulators require a full **Model Risk Management Framework (MRMF)** including:
  - Independent validation
  - Documentation standards
  - Backtesting & benchmarking
  - Model approval committees

Building a Risk Heatmap

- Students generate a heatmap of:
  - **Impact** (Severity)
  - **Likelihood** (Frequency)
- Events are mapped across:
  - Low / Medium / High likelihood
  - Low / Medium / High impact
- This identifies priority risks requiring governance escalation.

Model Validation Concepts

- Key validation components:
  - Assumption testing
  - Data quality review
  - Code review and challenge
  - Sensitivity and stress testing
  - Benchmarking against alternative models
- Linking to Basel:
  - IRB validation (credit models)
  - Market risk modellability tests (FRTB)
  - Liquidity model backtesting

Why Integrated Stress Testing?

- Capital adequacy depends on interactions between credit, market, and liquidity risks.
- Real crises involve simultaneous shocks, not isolated risk events.
- Regulators (BoE, ECB, Fed) use integrated stress tests to assess:
  - Solvency under severe macroeconomic paths
  - Resilience of capital buffers
  - Funding stability and market liquidity
- This module teaches how to combine these risk types into a unified solvency view.

Structure of a Supervisory Stress Test

Typical components include:

1. **Macroeconomic Scenario**: GDP, unemployment, interest rates, inflation.
2. **Credit Shock**: PD increases, LGD rises, correlations spike.
3. **Market Shock**: Equity crash, yield curve shifts, volatility spike.
4. **Liquidity Shock**: Deposit run-offs, higher funding costs.
5. **Balance Sheet Projection**: Losses, provisions, RWA migration.
6. **Capital Ratio Recalculation**: CET1, leverage, liquidity metrics.

Capital Adequacy Metrics Revisited

- After stress shocks, capital is recalculated using:

$$\text{CET1 Ratio} = \frac{\text{CET1 Capital}}{\text{Risk-Weighted Assets}}$$
$$\text{Leverage Ratio} = \frac{\text{Tier 1 Capital}}{\text{Total Exposure}}$$
$$\text{LCR/NSFR} \quad \text{to assess liquidity position}$$

- Stress testing observes how far capital ratios fall below:
  - Minimum requirements
  - Capital conservation buffer
  - G-SIB / O-SII buffers

Integrated Loss Impact

- Aggregate losses come from:
  - **Credit losses**: higher PD, LGD, EAD migration
  - **Market losses**: trading book valuation drop
  - **Liquidity losses**: increased funding costs, fire-sale haircuts
- Total stress impact:

$$\text{Total Loss} = L_{\text{credit}} + L_{\text{market}} + L_{\text{liquidity}}$$

- CET1 after losses:

$$\text{CET1}^{\text{post}} = \text{CET1}^{\text{pre}} - \text{Total Loss}$$

Stress Testing Dashboard Concept

- Students develop a small dashboard showing:
    - Credit loss distribution
    - Market VaR/ES shock
    - Liquidity gap from maturity ladder
    - CET1 and leverage ratios pre- and post-stress
- The dashboard summarises overall resilience under the integrated scenario.

References

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