Financial Risk Management
Lecture 1. Introduction

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*University of Paris-Saclay

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General information

1. **Overview**
The objective of this course is to understand the theoretical and practical aspects of risk management.

2. **Prerequisites**
M1 Finance or equivalent

3. **ECTS**
4

4. **Keywords**
Finance, Risk Management, Applied Mathematics, Statistics

5. **Hours**
Lectures: 36h, Training sessions: 15h, HomeWork: 30h

6. **Evaluation**
There will be a final three-hour exam, which is made up of questions and exercises

7. **Course website**
The objective of the course is twofold:

1. knowing and understanding the financial regulation (banking and others) and the international standards (especially the Basel Accords)
2. being proficient in risk measurement, including the mathematical tools and risk models
## Class schedule

**Course sessions**
- September 11 (6 hours, AM+PM)
- September 18 (6 hours, AM+PM)
- September 25 (6 hours, AM+PM)
- October 2 (6 hours, AM+PM)
- November 20 (6 hours, AM+PM)
- November 27 (6 hours, AM+PM)

**Tutorial sessions**
- October 10 (3 hours, AM)
- October 16 (3 hours, AM)
- November 13 (3 hours, AM)
- December 4 (6 hours, AM+PM)

Class times: Fridays 9:00am-12:00pm, 1:00pm–4:00pm, University of Evry
Agenda

- Lecture 1: Introduction to Financial Risk Management
- Lecture 2: Market Risk
- Lecture 3: Credit Risk
- Lecture 4: Counterparty Credit Risk and Collateral Risk
- Lecture 5: Operational Risk
- Lecture 6: Liquidity Risk
- Lecture 7: Asset Liability Management Risk
- Lecture 8: Model Risk
- Lecture 9: Copulas and Extreme Value Theory
- Lecture 10: Monte Carlo Simulation Methods
- Lecture 11: Stress Testing and Scenario Analysis
- Lecture 12: Credit Scoring Models
Additional materials

- Slides, tutorial exercises and past exams can be downloaded at the following address:
  

- Solutions of exercises can be found in the companion book, which can be downloaded at the following address:

Lecture 1: Introduction to Financial Risk Management
- Lecture 2: Market Risk
- Lecture 3: Credit Risk
- Lecture 4: Counterparty Credit Risk and Collateral Risk
- Lecture 5: Operational Risk
- Lecture 6: Liquidity Risk
- Lecture 7: Asset Liability Management Risk
- Lecture 8: Model Risk
- Lecture 9: Copulas and Extreme Value Theory
- Lecture 10: Monte Carlo Simulation Methods
- Lecture 11: Stress Testing and Scenario Analysis
- Lecture 12: Credit Scoring Models
### Table: Some financial innovations

<table>
<thead>
<tr>
<th>Year</th>
<th>Innovation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1970</td>
<td>Mortgage-backed securities</td>
</tr>
<tr>
<td>1971</td>
<td>Equity index funds</td>
</tr>
<tr>
<td>1972</td>
<td>Foreign currency futures</td>
</tr>
<tr>
<td>1973</td>
<td>Stock options</td>
</tr>
<tr>
<td>1979</td>
<td>Over-the-counter currency options</td>
</tr>
<tr>
<td>1981</td>
<td>Interest rate swaps</td>
</tr>
<tr>
<td>1982</td>
<td>Equity index futures</td>
</tr>
<tr>
<td>1983</td>
<td>Equity index options</td>
</tr>
<tr>
<td></td>
<td>Interest rate caps/floors</td>
</tr>
<tr>
<td></td>
<td>Collateralized mortgage obligations</td>
</tr>
<tr>
<td>1985</td>
<td>Swaptions</td>
</tr>
<tr>
<td></td>
<td>Asset-backed securities</td>
</tr>
<tr>
<td>1987</td>
<td>Path-dependent options (Asian, look-back, etc.)</td>
</tr>
<tr>
<td></td>
<td>Collateralized debt obligations</td>
</tr>
<tr>
<td>1994</td>
<td>Credit default swaps</td>
</tr>
<tr>
<td>2004</td>
<td>Volatility index futures</td>
</tr>
</tbody>
</table>
The development of financial markets

- Organized markets (on-exchange)
- Over-the-counter markets or OTC markets (off-exchange)

<table>
<thead>
<tr>
<th>Contract</th>
<th>Futures</th>
<th>Forward</th>
<th>Option</th>
<th>Swap</th>
</tr>
</thead>
<tbody>
<tr>
<td>On-exchange</td>
<td>✓</td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Off-exchange</td>
<td></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>
The development of financial markets

**Figure:** Notional outstanding amount of exchange-traded derivatives (in $ tn)
### Table: Some financial losses

<table>
<thead>
<tr>
<th>Year</th>
<th>Institution</th>
<th>Loss (USD)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1974</td>
<td>Herstatt Bank</td>
<td>$620 mn</td>
<td>foreign exchange trading</td>
</tr>
<tr>
<td>1994</td>
<td>Metallgesellschaft</td>
<td>$1.3 bn</td>
<td>oil futures</td>
</tr>
<tr>
<td>1994</td>
<td>Orange County</td>
<td>$1.8 bn</td>
<td>reverse repo</td>
</tr>
<tr>
<td>1994</td>
<td>Procter &amp; Gamble</td>
<td>$160 mn</td>
<td>ratchet swap</td>
</tr>
<tr>
<td>1995</td>
<td>Barings Bank</td>
<td>$1.3 bn</td>
<td>stock index futures</td>
</tr>
<tr>
<td>1997</td>
<td>Natwest</td>
<td>$127 mn</td>
<td>swaptions</td>
</tr>
<tr>
<td>1998</td>
<td>LTCM</td>
<td>$4.6 bn</td>
<td>liquidity crisis</td>
</tr>
<tr>
<td>2001</td>
<td>Dexia Bank</td>
<td>$270 mn</td>
<td>corporate bonds</td>
</tr>
<tr>
<td>2006</td>
<td>Amaranth Advisors</td>
<td>$6.5 bn</td>
<td>gas forward contracts</td>
</tr>
<tr>
<td>2007</td>
<td>Morgan Stanley</td>
<td>$9.0 bn</td>
<td>credit derivatives</td>
</tr>
<tr>
<td>2008</td>
<td>Société Générale</td>
<td>$7.2 bn</td>
<td>rogue trading</td>
</tr>
<tr>
<td>2008</td>
<td>Madoff</td>
<td>$65 bn</td>
<td>fraud</td>
</tr>
<tr>
<td>2011</td>
<td>UBS</td>
<td>$2.0 bn</td>
<td>rogue trading</td>
</tr>
<tr>
<td>2012</td>
<td>JPMorgan Chase</td>
<td>$5.8 bn</td>
<td>credit derivatives</td>
</tr>
</tbody>
</table>
Financial crises and systemic risk

Figure: Number of bank defaults in the US
International authorities

1. The Basel Committee on Banking Supervision (BCBS)
2. The International Association of Insurance Supervisors (IAIS)
3. The International Organization of Securities Commissions (IOSCO)
4. The Financial Stability Board (FSB)

Table: The supervision institutions in finance

<table>
<thead>
<tr>
<th></th>
<th>Banks</th>
<th>Insurers</th>
<th>Markets</th>
<th>All sectors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Global</td>
<td>BCBS</td>
<td>IAIS</td>
<td>IOSCO</td>
<td>FSB</td>
</tr>
<tr>
<td>EU</td>
<td>EBA/ECB</td>
<td>EIOPA</td>
<td>ESMA</td>
<td>ESFS</td>
</tr>
<tr>
<td>US</td>
<td>FDIC/FRB</td>
<td>FIO</td>
<td>SEC</td>
<td>FSOC</td>
</tr>
</tbody>
</table>
Banking regulation

1988 Publication of “International Convergence of Capital Measurement and Capital Standards”, which is better known as “The Basel Capital Accord”. This text sets the rules of the Cooke ratio.

1996 Publication of “Amendment to the Capital Accord to incorporate Market Risks”. This text includes the market risk to compute the Cooke ratio.


2019 Publication of “Minimum Capital Requirements for Market Risk”. This is the final version of the Basel III framework for computing the market risk.
Figure: The huge increase of the number of banking supervision standards
Cooke ratio:

\[
\text{Cooke Ratio} = \frac{C}{\text{RWA}}
\]

where \( C \) and \( \text{RWA} \) are the capital and the risk-weighted assets of the bank.

A risk-weighted asset is simply defined as a bank’s asset weighted by its risk score or risk weight (RW):

\[
\text{RWA} = \text{EAD} \cdot \text{RW}
\]

where \( \text{EAD} \) is the exposure at default

\[ \Rightarrow \text{Cooke Ratio} \geq 8\% \text{ (Tier one} \geq 4\%) \]
For categories:

1. \( RW = 0\% \)
   - cash, gold, claims on OECD governments and central banks, claims on governments and central banks outside OECD and denominated in the national currency

2. \( RW = 20\% \)
   - claims on all banks with a residual maturity lower than one year, longer-term claims on OECD incorporated banks, claims on public-sector entities within the OECD

3. \( RW = 50\% \)
   - loans secured on residential property

4. \( RW = 100\% \)
   - others
Computing the RWA

Example

The assets of a bank are composed of $100 mn of US treasury bonds, $100 mn of Brazilian government bonds, $50 mn of residential mortgage, $300 mn of corporate loans and $20 mn of revolving credit loans. The bank liability structure includes $25 mn of common stock and $13 mn of subordinated debt.

We obtain the following results:

<table>
<thead>
<tr>
<th>Asset</th>
<th>EAD</th>
<th>RW</th>
<th>RWA</th>
</tr>
</thead>
<tbody>
<tr>
<td>US treasury bonds</td>
<td>100</td>
<td>0%</td>
<td>0</td>
</tr>
<tr>
<td>Brazilian Gov. bonds</td>
<td>100</td>
<td>100%</td>
<td>100</td>
</tr>
<tr>
<td>Residential mortgage</td>
<td>50</td>
<td>50%</td>
<td>25</td>
</tr>
<tr>
<td>Corporate loans</td>
<td>300</td>
<td>100%</td>
<td>300</td>
</tr>
<tr>
<td>Revolving credit</td>
<td>20</td>
<td>100%</td>
<td>20</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>445</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

and:

\[
\text{Cooke Ratio} = \frac{38}{445} = 8.54% 
\]
Amendment to incorporate market risks

Two approaches:
   - The standardized measurement method (SMM)
   - The internal model-based approach\(^1\) (IMA)

⇒ external weights vs internal model (99% value-at-risk for a holding period of 10 trading days)

\(^1\)The use of the internal model-based approach is subject to the approval of the national supervisor.
Value-at-risk (VaR)

Figure: Probability distribution of the portfolio loss
The Cooke ratio becomes:

\[
\frac{C_{\text{Bank}}}{\text{RWA} + 12.5 \times \kappa_{\text{MR}}} \geq 8\%
\]

We deduce that:

\[
C_{\text{Bank}} \geq \left(8\% \times \text{RWA} + \kappa_{\text{MR}}\right) \frac{\kappa_{\text{CR}}}{\kappa_{\text{CR}}}
\]

meaning that \(8\% \times \text{RWA}\) can be interpreted as the credit risk capital requirement \(\kappa_{\text{CR}}\), which can be compared to the market risk capital charge \(\kappa_{\text{MR}}\).
### Basel II

**Table:** The three pillars of the Basel II framework

<table>
<thead>
<tr>
<th>Pillar 1</th>
<th>Pillar 2</th>
<th>Pillar 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum Capital Requirements</td>
<td>Supervisory Review Process</td>
<td>Market Discipline</td>
</tr>
<tr>
<td>Credit risk</td>
<td>Review &amp; reporting Capital above Pillar 1</td>
<td></td>
</tr>
<tr>
<td>Market risk</td>
<td>Supervisory monitoring</td>
<td></td>
</tr>
<tr>
<td>Operational risk</td>
<td>Capital structure</td>
<td></td>
</tr>
</tbody>
</table>

- Thierry Roncalli
- Financial Risk Management (Lecture 1)
The new Accord consists of three pillars:

1. the first pillar corresponds to *minimum capital requirements*, that is, how to compute the capital charge for credit risk, market risk and operational risk;

2. the second pillar describes the *supervisory review process*; it explains the role of the supervisor and gives the guidelines to compute additional capital charges for specific risks, which are not covered by the first pillar;

3. the *market discipline* establishes the third pillar and details the disclosure of required information regarding the capital structure and the risk exposures of the bank.
Credit risk
- The standardized approach (SA)
- The internal ratings-based approach (IRB)
  - Foundation IRB (FIRB or IRB-F)
  - Advanced IRB (AIRB ou IRB-A)

Market risk
- The standardized measurement method (SMM)
- The internal model-based approach (IMA)

Operational risk
- The Basic Indicator Approach (BIA)
- The Standardized Approach (TSA)
- Advanced Measurement Approaches (AMA)
Figure: Minimum capital requirements in the Basel II framework
2008 Global Financial Crisis ⇒ measures to strengthen the rules governing trading book capital, particularly the market risk associated to securitization and credit-related products:

1. the incremental risk charge (IRC), which is an additional capital charge to capture default risk and migration risk for unsecuritized credit products
2. the stressed value-at-risk requirement (SVaR), which is intended to capture stressed market conditions
3. the comprehensive risk measure (CRM), which is an estimate of risk in the credit correlation trading portfolio (CDS baskets, CDO products, etc.)
4. new standardized charges on securitization exposures, which are not covered by CRM
In December 2010, the Basel Committee published a new regulatory framework in order to enhance risk management, increase the stability of the financial markets and improve the banking industry’s ability to absorb macro-economic shocks.

The Basel III (2010) framework consists of micro-prudential and macro-prudential regulation measures concerning:

- a new definition of the risk-based capital
- the introduction of a leverage ratio
- the management of the liquidity risk

Basel III also includes (2013-2019):

- Revision of MR, CR, CCR, CVA and OR standards
- Interest Rate Risk in the Banking Book (IRRBB)
### Table: Basel III capital requirements

<table>
<thead>
<tr>
<th></th>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>CET1</td>
<td>3.5%</td>
<td>4.0%</td>
<td></td>
<td>4.5%</td>
<td></td>
<td></td>
<td>4.5%</td>
</tr>
<tr>
<td>CB</td>
<td></td>
<td></td>
<td></td>
<td>0.625%</td>
<td>1.25%</td>
<td>1.875%</td>
<td>2.5%</td>
</tr>
<tr>
<td>CET1 + CB</td>
<td>3.5%</td>
<td>4.0%</td>
<td>4.5%</td>
<td>5.125%</td>
<td>5.75%</td>
<td>6.375%</td>
<td>7.0%</td>
</tr>
<tr>
<td>Tier 1 Total</td>
<td>4.5%</td>
<td>5.5%</td>
<td></td>
<td>6.0%</td>
<td></td>
<td></td>
<td>6.0%</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td>8.0%</td>
<td></td>
<td></td>
<td>8.0%</td>
</tr>
<tr>
<td>Total + CB</td>
<td></td>
<td></td>
<td></td>
<td>8.0%</td>
<td>8.625%</td>
<td>9.25%</td>
<td>9.875%</td>
</tr>
<tr>
<td>CCB</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0% – 2.5%</td>
</tr>
</tbody>
</table>

- CET1: Common Equity Tier 1
- AT1: Additional Tier 1
- T1: Tier 1
- T2: Tier 2
- CB: Capital Conservation Buffer
- CCB: Countercyclical Conservation Buffer (macro-prudential measure)
• Credit Valuation Adjustment (CVA)

• Leverage ratio (macro-prudential measure) to prevent the build-up of excessive on- and off-balance sheet:

\[
\text{Leverage ratio} = \frac{\text{Tier 1 capital}}{\text{Total exposures}} \geq 3\%
\]

where the total exposures is the sum of on-balance sheet exposures, derivative exposures and some adjustments concerning off-balance sheet items
Liquidity Coverage Ratio (LCR)
The objective of the LCR is to promote short-term resilience of the bank’s liquidity risk profile:

\[
\text{LCR} = \frac{\text{HQLA}}{\text{Total net cash outflows}} \geq 100\%
\]

where HQLA is the stock of high quality liquid assets and the denominator is the total net cash outflows over the next 30 calendar days.

Net Stable Funding Ratio (NSFR)
NSFR is designed in order to promote long-term resilience of the bank’s liquidity profile:

\[
\text{NSFR} = \frac{\text{Available amount of stable funding}}{\text{Required amount of stable funding}} \geq 100\%
\]

ASF and RSF are calculated for the next year.
Basel III also includes new standards (the Basel IV package):

- **Credit Risk**: revision to SA and IRB approaches
- **Market Risk**: SMM is replaced by SA-TB, IMA is revisited, VaR is replaced by ES (expected shortfall), etc.
- **CVA $\Rightarrow$ SA-CVA and BA-CVA**
- **Operational Risk**: BIA, TSA and AMA are replaced by SMA (Standardized Measurement Approach)
- **Introduction of capital floors** (with respect to SA)
Insurance regulation

Figure: Solvency I capital requirement
Insurance regulation

Figure: Solvency II capital requirement
Insurance regulation

Risk components:

1. Underwriting risk (non-life, life, health, etc.)
2. Market risk,
3. Default risk
4. Counterparty credit risk

In the case of the standard formula method, the SCR of the insurer is equal to:

$$\text{SCR} = \sqrt{\sum_{i,j}^{m} \rho_{i,j} \cdot \text{SCR}_i \cdot \text{SCR}_j + \text{SCR}_{OR}}$$

where $\text{SCR}_i$ is the SCR of the risk module $i$, $\text{SCR}_{OR}$ is the SCR associated to the operational risk and $\rho_{i,j}$ is the correlation factor between risk modules $i$ and $j$. 
The solvency ratio is then defined as:

\[
\text{Solvency Ratio} = \frac{C}{\text{SCR}}
\]

where \( C \) is the capital. This solvency ratio must be larger than 33% for tier 1 and 100% for the total own funds.
The need for risk management

Financial regulation

Market regulation

Europe

- 2007: MiFID (Markets in Financial Instruments Directive)
- 2012: EMIR (European Market Infrastructure Regulation)
- 2014: MiFID2, MiFIR (Regulation in Markets in Financial Instruments) and PRIIPS (Packaged Retail and Insurance-based Investment Products)

US

- Securities and Exchange Commission (SEC)
- Commodity Futures Trading Commission (CFTC)
- 2010: Dodd-Frank Wall Street Reform and Consumer Protection Act
- Financial Stability Oversight Council (FSOC)
Systemic risk

- 2009: Creation of the Financial Stability Board (FSB)
- Systemically Important Financial Institutions (SIFIs)
- A SIFI can be global (G-SIFI) or domestic (D-SIFI)
- Three categories:
  1. G-SIBs correspond to global systemically important banks
  2. G-SIIs designate global systemically important insurers
  3. The third category corresponds to non-bank non-insurer global systemically important financial institutions (or NBNI G-SIFIs)