AGENDA

• Motivations for firmwide risk analysis
• Firmwide risk capital approaches
  • Top-down approaches
  • Bottom-up approaches
• Firmwide scenario analysis and stress testing
  • Approach
  • SAS examples
  • Combining bottom-up approaches with top-down
• Firmwide regulatory stress scenario approach: CCAR and EBA
  • Bank specific approach
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MOTIVATIONS I - DRIVERS

• **Drivers for firmwide risk analysis**
  - Definition of risk appetite and ICAAP
    - Understand firmwide risk levels and firmwide capital consumption
    - Basel II, Pillar 2: "The bank's board of directors has responsibility for setting the bank's tolerance for risks. It should also ensure that management establishes a framework for assessing the various risks, develops a system to relate risk to the bank's capital level…"
  - Firmwide stress analysis and risk based financial planning
    - Regulatory: EBA in Europe, CCAR in US
  - Effective risk data aggregation and risk reporting to obtain firmwide exposures (bcbs239)

• **Challenges**
  - Risk measurement and organizational silos (systems and people), risk frequencies, …
  - Massive data volumes
MOTIVATIONS II - CONCEPTS

• **Risk capacity**
  - the set of resources (e.g. capital, earnings) available to absorb losses based on current/actual levels

• **Risk exposure**
  - the amount of risk actually being taken
  - Firmwide: loss from all sources, across all businesses, from e.g.: a specified confidence level of a statistical model, or a defined macro-economic/market stress scenario

➢ **Firmwide risk capital model needed**…what are the approaches?
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• **Top-Down correlated aggregation**
  - Based on macroeconomic view and broad "correlations" between risks
  - Benchmark approach for more granular bottom-up approaches
  - ...Typically needed even in bottom-up approaches for risks that cannot be aggregated bottom-up

• **Bottom-Up approaches**
  - Centralized firmwide scenario management / Models for "core" macroeconomic risk factors
    - **Silo**: Application to actual portfolios in silo risk systems (transform back to detailed portfolio risk factors)
    - **Firmwide model**: Approximate silo system portfolios using "core" risk factors
  - Applicable to both firmwide stress testing & firmwide risk levels
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TOP-DOWN APPROACH

Workflow
- Create a risk tree map of the organization
- Source input marginal distributions
- "Fit" dependence parameters (e.g., correlations) and examine co-dependencies visually
- Calculate firmwide risk statistics e.g., VaR
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Same copula to roll-up all risks
**TOP-DOWN APPROACH**

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---

**Mixture of copulas to roll-up all risks**
- Each sub-risk is using its best-fit copula

**Aggregation level**

<table>
<thead>
<tr>
<th>Model</th>
<th>Copula aggregation model</th>
</tr>
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<tbody>
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<td>1</td>
<td>t(50) c(1) c(0.5) c(0.3) f(-1) c(1) c(0.5) c(2) t(50)</td>
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<tr>
<td>2</td>
<td>t(15) c(3) c(2) c(1) f(-3) c(2) c(1.5) c(4) t(10)</td>
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<tr>
<td>3</td>
<td>t(5) c(8) c(5) c(4) f(-8) c(9) c(7) c(10) t(3)</td>
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<tr>
<td>4</td>
<td>t(3) c(15) c(15) c(15) f(-15) c(15) c(15) c(15) t(3)</td>
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**Aggregation results VaR(99%)**

<p>| | | | | | | | | |</p>
<table>
<thead>
<tr>
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<td>4.73</td>
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<td>8.23</td>
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</table>

*Note: BU1: MR, BU1: CR, BU2: CR, BU2: ALM, BU3: INS*
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**BOTTOM-UP: SILO APPROACH**

- **Central definition of firmwide key risks** e.g., market risk, credit risk, net interest margin (earnings) and other risks
- **Joint macroeconomic risk factor scenarios** using a correlated scenario model or single stress scenario
- **Transform back scenarios** to actual detailed “silo” risk systems risk factors
  - Use “satellite” models e.g., factor models, conditional distributions – sometimes referred to as satellite models
- **Apply scenarios in ”silo” risk systems**
BOTTOM-UP: FIRMWIDE RISK MODEL APPROACH

- **Does not use silo systems**...implements portfolio approximation methods for the risks
- **Usually relies on a dimension reduced joint ”core” risk factor scenarios**
- **Key is portfolio approximation techniques..**
  - Market risk: Delta-Gamma, grid pricing and curve fitting
  - Credit risk: Pooled portfolio representations
  - ALM (earnings): Small replicating portfolio and pooled portfolios
### EXAMPLE: ICAAP P/L STRESS TEST

<table>
<thead>
<tr>
<th>ICAAP P&amp;L Stress Test</th>
<th>07/2013-06/2014</th>
<th>07/2014-06/2013</th>
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<tbody>
<tr>
<td><strong>Amounts in EUR mn</strong></td>
<td>Plan</td>
<td>Mild Stress</td>
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<tr>
<td>Net Interest Income</td>
<td>530</td>
<td>534</td>
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<tr>
<td>IRR Risk</td>
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<td>3</td>
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<tr>
<td>Liquidity Risk</td>
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<td>0</td>
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<tr>
<td>Volume/margin impact</td>
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<td>0</td>
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<tr>
<td>NCI</td>
<td>189</td>
<td>155</td>
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<tr>
<td>Gains &amp; losses</td>
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<td>81</td>
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<td>Trading book</td>
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<td>0</td>
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<tr>
<td>IRR Bank book (F/P positions)</td>
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<td>-6</td>
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<tr>
<td>SCA (F/P positions)</td>
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<td>-30</td>
</tr>
<tr>
<td>Credit spread risk (MTM and F/P incl. own issues)</td>
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<td>13</td>
</tr>
<tr>
<td>Funds (F/P book losses)</td>
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<td>6</td>
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<tr>
<td>FX risk B</td>
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<tr>
<td>Other Operating Income</td>
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<tr>
<td>Operating Revenues</td>
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<tr>
<td>Operating Profit</td>
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<td>255</td>
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<td>LLP securities</td>
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<td>65</td>
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<tr>
<td>Bank levy</td>
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<tr>
<td>Taxes, minorities</td>
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<td>1</td>
</tr>
<tr>
<td>Profit after tax &amp; minorities</td>
<td>143</td>
<td>20</td>
</tr>
<tr>
<td>Coupon</td>
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<td>-24</td>
</tr>
<tr>
<td>Profit After Tax and Coupon</td>
<td>119</td>
<td>-4</td>
</tr>
<tr>
<td>Other Comprehensive Income</td>
<td>-89</td>
<td>-146</td>
</tr>
<tr>
<td>Credit Spread Risk (F/P positions)</td>
<td>-89</td>
<td>-106</td>
</tr>
<tr>
<td>IRR AFS positions</td>
<td>29</td>
<td>29</td>
</tr>
<tr>
<td>Total Comprehensive Income</td>
<td>119</td>
<td>-99</td>
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**FIRMWIDE SCENARIO ANALYSIS**

**Statistical Approach**

Allows the aggregation of firm-wide risks using statistical techniques which can then be tied to probabilities / confidence levels

*A large number of potential outcomes and associated losses is simulated, rooted in historically observed market changes*.

**Scenario-based Approach**

More intuitive stress measure which calculates the impact of a scenario on the firm-wide portfolio including the causality chain by which losses would arise if the scenario were to unfold

*Scenarios enable incorporation of forward-looking views*.
FIRMWIDE SCENARIO ANALYSIS

1. **Macroeconomic scenarios**
2. **Satellite models**
3. **Portfolio management intervention**

P/L calculation
Silo or firmwide risk model approach

Aggregation of earnings and loss impacts

Projected financial income statements

- Is capital or liquidity buffer depleted?

- Actual capital + earnings – losses
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EXAMPLE SAS FIRMWIDE RISK APPLICATIONS

- Bank firmwide risk model with 150 core risk factors and 25 firmwide risks
  - Firmwide risk model approach with portfolio approximations

- Mortgage book capital and stressed loss
  - Exact calculation approach – later used as input to the firmwide stress and capital models

- Treasury book earnings stress
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BANK FIRMWIDE RISK MODEL

- 150 core risk factors
  » Each risk factor use mean-reverting Vasicek type process with univariate t-distribution as error term and sampling residual
  » A t-copula is used for the 150 models
BANK FIRMDWIDE RISK MODEL

- Core risk factor models are regularly calibrated and tested
BANK FIRMWIDE RISK MODEL

- Two-step model specification
  1. Specification of the 150 risk models
  2. Specification of copula model
25 firmwide risk portfolios with approximating quadratic portfolio for each risk (KRI)
Model is used to estimate both firmwide capital levels and for firmwide stress (EBA)
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MORTGAGE PORTFOLIO STRESS

- Portfolio risk capital is computed over 9 quarters
MORTGAGE PORTFOLIO STRESS

• The portfolio specific risk factors are linked to core macroeconomic factors used in stress testing and scenario analysis (CCAR)
• The stressed mortgage portfolio results are then aggregated with stress results from other portfolios to achieve a firmwide stress result
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TREASURY PORTFOLIO STRESS

- The portfolio earnings are stressed based on market rates, spreads and behavioral factors.
The different internal and regulatory scenarios are managed.
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COMBINING BOTTOM-UP AND TOP-DOWN

- Firmwide risk measures are usually a combination of bottom-up (scenario based) risk approaches and a top-down risk aggregation approach
- Some risk types and lines of business cannot be integrated bottom-up. For example, a difficulty to specify granular risk factor level dependence
- Largely applicable to non-financial risks e.g., strategic, operational, reputational (event and severity based)
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The success of CCAR stress tests in US has inspired the development of the more recent European EBA stress tests.

Both CCAR and EBA are focusing on **firmwide risk** with contributions from market loss, credit loss, earnings loss etc.

Firmwide (macroeconomic) scenarios are regulatory pre-scribed.

The use of models is critical to the materialization of the high level macroeconomic scenario: macroeconomic shock $\rightarrow$ portfolio shock.

- Models are hence clearly central to both firmwide stress testing and the traditional risk based model charges.

Completing the stress testing process involves both the banks risk experts as well as the banks finance experts.
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BANK SPECIFIC APPROACH

- The stress is multi-horizon

- Not estimating capital sufficiency per se but rather that capital ratios are sufficient under stress (which is more demanding of course)

- Requires stressed estimation of Basel II/III required capital in addition to stressed losses and earnings

\[ R = \frac{Actual \ capital + Earnings - Losses}{Required \ Capital \ under \ stress} \]
For example: Expand balance sheet if earnings minus losses are positive and capital ratio is within limits. Otherwise, use retained earnings to build up capital in next period....
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FINANCIAL SYSTEM IMPACT ANALYSIS

• When central banks perform this stress testing exercise per bank, using their macroeconomic stress testing models, or, by rolling up banks own provided stress test results, they also add financial contagion analysis
  • If a systemically important bank fails to pass the test it can have consequences on other banks through either direct bilateral linkages or more indirectly through financial system confidence effects
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The use of firmwide stress testing - both for regulation and business practice - puts pressure on the *firmwide stress testing process to be formalized* with:

- proper controls,
- overall management of the process,
- transparency, and,
- auditability

Central firmwide risk and *stress testing teams* are becoming the norm.

**Multiple model approaches** are frequently being used:

- Top-down … as simple benchmark model
- Silo approach as "exact" firmwide risk
- Approximating firmwide risk ICAAP and stress test model managed by central team:
  - Model is also used to challenge central banks and other regulatory views
  - Model is validated vs. silo approach
THANK YOU. QUESTIONS?