Moody's Analytics / PRMIA Seminar:

17:00 – 17:15  Registration

17:20 – 17:30  PRMIA Greece Welcome

17:30 – 18:00  Stress Testing beyond regulatory challenges
   • Current status of European Central Bank (EZB) and European Banking Authority (EBA) on the regulatory challenges in 2014
   • Stress testing leveraging a correlation approach
   Dr. Christian Thun, Senior Director – Strategic Business Development, Moody’s Analytics

18:00 – 18:30  Main challenges for Stress Testing to remain as a key risk management tool
   • A macroeconomic overview on stress testing
   • Risk modelling 2.0 – Recycling existing risk equations vs. designing stress testing models
   Dr. Juan Licari, Senior Director, Moody’s Analytics

18:30 – 18:45  Questions and Answers

18:45 – 20:00  Cocktail Reception
Stress Testing beyond regulatory challenges
Stress Testing – from a regulatory exercise to a value driver in risk management

Stress Testing is back on the agenda!

Financial Times, 24 Oct 2013

Frankfurter Allgemeine Zeitung, 23 Oct 2013

De Telegraaf, 23 Oct 2013

La Repubblica, 23 Oct 2013

Wall Street Journal, 23 Oct 2013

Le Figaro, 22 Oct 2013
Stress Testing – from a regulatory exercise to a value driver in risk management

Topics for today’s discussion

1. Current status of regulatory discussions and challenges in 2014

2. Stress testing using a correlation model
Stress Testing – from a regulatory exercise to a value driver in risk management

Current schedule of events

- **Sep 12, 2013**
  EU parliament votes to create Single Supervisory Mechanism (SSM)

- **Oct 23, 2013**
  ECB outlines Comprehensive Assessment

- **November 2013**
  ECB will begin the portfolio selection

- **November 2014**
  ECB will supervise >120 banks in Euro zone

- **May 2014**
  Asset Quality Review

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**Comprehensive Assessment**
Three goals of the Comprehensive Assessment (CA)

…The goal of the exercise is therefore to remedy those weaknesses and dispel those uncertainties. In particular, we say in the note that you have in front of you that there are three more specific goals:

i) to foster transparency, i.e. to make sure that correct information is provided on the real situation of the European banks;

ii) to repair balance sheets in the specific cases deemed necessary, i.e. we want to prescribe and indicate the actions that the repair has to consist of; and

iii) as a result of the first two, to foster confidence in the banks among all the major 3 stakeholders (depositors, investors and lenders to the real economy).

Ignazio Angeloni, Director General Financial Stability at ECB, Frankfurt, 23 October 2013

Source: European Central Bank, Press Briefing
Stress Testing – from a regulatory exercise to a value driver in risk management

Key steps of the Comprehensive Assessment (CA)

1. Supervisory Risk Assessment
   Quantitative and qualitative analysis to identify the highest risk exposures of those banks under SSM supervision. It will include risk such as liquidity or leverage of a bank, maturity transformation etc.

2. Asset Quality Review
   Examination of a broad range of portfolios selected on a risk-based approach followed by a data integrity validation, on-site reviews etc.

3. Stress Test
   Stress test in collaboration with EBA based on the work of the stages 1 & 2. The stress test will include banks outside the SSM.
CA – Major Challenges for Regulators & Institutions

- **Accounting and reporting** is a major challenge: Only in mid-October a standardized definition of non-performing loans (NPLs) across Europe was established. So far, reporting of forborne loans has often been woeful in many cases, with no consistency in definitions. Asset quality reviews in Greece, Cyprus and Spain all showed up material misreporting of problem loans.

- **Focus on specific objectives** such as adequate provisioning, the valuation of collateral and the valuation of complex financial instruments and other risky assets.

- **Resources are a constraint** for both institutions & regulators – The CA will affect 128 banks across several European jurisdictions; consulting companies and further third parties will be hired for this exercise.

- Previous asset quality reviews in Greece, Cyprus and Spain found widespread **misreporting of loan quality**, due to loan forbearance and sloppy procedures around collateral management.
Comparability of Non-Performing-Loans

Primary elements

• Principal or interest 90 days or more overdue
• The obligor is unlikely to pay its credit obligations

Secondary elements

• Treatment of restructured or replacement loans
• Consideration of collateral or guarantee when measuring loan quality
• Total loan of only part of loan recorded as non-performing
• Instrument- or obligor-view for downgrade to NPL status

Source: OeNB, Non-Performing Loans in Western Europe, 2013
Asset Quality deteriorated widely across Europe

Source: Moody’s Investors Service, Banking System Outlook: UK, July 2013
Problem asset classes differ by country

Source: Moody’s Investors Service, Banking System Outlooks, as of September 2013
US and European Stress Testing of Banks: Different Outcomes

Median EDF

- **US Financial (Left Axis)**
- **W.Europe Financial (Right Axis)**

- **SCAP : Feb 2009**
- **CEBS Stress Testing 2009**
- **EBA Stress Testing 2011**
- **CCAR II : Nov 2011**
Topics for today’s discussion

1. Current status of regulatory discussions and challenges in 2014

2. Stress testing using a correlation model
The Objective: Relating a Credit Portfolio Model to the States of the Economy

» Moody’s Analytics maintains and updates its global multi-factor correlation model GCorr, used for modeling losses on credit portfolios.

» GCorr Corporate describes correlations among asset returns of borrowers.
  - Asset return – a proxy for a change in credit quality of a borrower.

GCorr Macro model: A model that links systematic credit risk factors from GCorr to macroeconomic variables.
RiskFrontier Framework with the GCorr Macro Model

- **Stress Testing** – from a regulatory exercise to a value driver in risk management

**GCorr Macro Model**

- **Draws of borrower specific credit risk factors**
  - $\phi_{CR1}, \phi_{CR2}, \ldots$

- **Joint distribution with correlation matrix $\Sigma$**

- **Draws of systematic credit risk factors**
  - $\phi_{RSQ}$

- **1-RSQ**

- **Draws of asset returns (credit quality changes)**
  - PD, LGD, EAD, Credit Migration

- **Credit portfolio loss distribution on a horizon**

- **Range of losses given a macroeconomic shock**

- **Scenario for macroeconomic variables (MV) → conditional loss distribution.**

- **Mapping between $\phi_{MV}$ and macroeconomic variables (MV)**

**GCorr Macro Model**
Running RiskFrontier, Including the Simulation, with the GCorr Macro Model

Expanded covariance matrix

<table>
<thead>
<tr>
<th></th>
<th>$r_C$ and $r_I$</th>
<th>$\phi_{MV}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$r_C$</td>
<td>$r_{C}$</td>
<td>$\phi_{MV}$</td>
</tr>
<tr>
<td>$r_I$</td>
<td>$\phi_{MV}$</td>
<td>$r_{I}$</td>
</tr>
</tbody>
</table>

Mapping between standard normal macroeconomic factors $\phi_{MV}$ and macroeconomic variables $MV$.

RiskFrontier Monte Carlo simulation engine

Output of Monte Carlo simulation

<table>
<thead>
<tr>
<th>Trial</th>
<th>Simulated macroeconomic factors</th>
<th>Simulated GCorr systematic credit risk factors</th>
<th>Portfolio Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>$\phi_{MV1}$, $\phi_{MV2}$, ...</td>
<td>$\phi_1$, $\phi_2$, ...</td>
<td>$L_{Trial 1}$</td>
</tr>
<tr>
<td>2</td>
<td>$\phi_{MV1}$, $\phi_{MV2}$, ...</td>
<td>$\phi_1$, $\phi_2$, ...</td>
<td>$L_{Trial 2}$</td>
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<td>...</td>
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Conversion to observable macroeconomic variables $MV_1$, $MV_2$,... using mappings

Losses can account for credit quality deterioration.

Analysis of relationships between portfolio losses and macroeconomic variables across trials
Example: Effect of an Oil Price Drop on the Systematic Factor of the U.S. Oil Industry

» $\phi_{US,Oil}$ = systematic credit risk factor of U.S. “Oil, Gas, and Coal Expl/Prod” industry.

» $\phi_{\Delta OilPrice}$ = standard normal shock representing oil price changes.

» Effect of the negative two standard deviation shock to the oil price: $\phi_{\Delta OilPrice} = -2$?

Unconditional distribution of $\phi_{US,Oil}$

Unconditional distr.

Mean = 0
Std = 1

Corr($\phi_{US,Oil}, \phi_{\Delta OilPrice}$)

$\rho = 41\%$

A mapping links the standard normal macroeconomic shock $\phi_{\Delta OilPrice}$ to observable changes in the oil price, $\Delta OilPrice$.

For example: $\phi_{\Delta OilPrice} = -2 \leftrightarrow \Delta OilPrice = -52\%$ over a quarter.
Effect of an **Oil Price Increase** on the Systematic Factor of the U.S. Oil Industry

- $\phi_{US,\text{Oil}}$ = systematic credit risk factor of U.S. “Oil, Gas, and Coal Expl/Prod” industry.
- $\phi_{\Delta\text{OilPrice}}$ = standard normal shock representing oil price changes.
- Effect of the positive two standard deviation shock to the oil price: $\phi_{\Delta\text{OilPrice}} = 2\sigma$
GCorr Macro Components that Need to be Calibrated…

» Expanded covariance matrix
  - Covariance matrix linking the current GCorr country and industry factors \( r_C \) and \( r_I \) and macroeconomic factors \( \phi_{MV} \).

<table>
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<tr>
<th>( r_C ) and ( r_I )</th>
<th>( \phi_{MV} )</th>
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<tbody>
<tr>
<td>Current GCorr Covariance Matrix</td>
<td>( \phi_{MV} )</td>
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<th>( \phi_{MV} )</th>
<th>( \Delta OilPrice )</th>
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<td>Current GCorr Covariance Matrix</td>
<td>( \phi_{\Delta OilPrice} )</td>
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</table>

- Estimating parameters for these two blocks.

» Mapping between macroeconomic variables MV and standard normal macroeconomic factors \( \phi_{MV} \).

\[ \Delta OilPrice \]

Oil price drops by 52% 

Standard normal distribution \( \phi_{\Delta OilPrice} \)

Two standard deviation shock
Calibration Process

» Calibration of the expanded covariance matrix
  – Data: quarterly macroeconomic data and quarterly returns of GCorr Corporate factors; time range from 1999 Q3 through 2012 Q1 (including the dot-com recession and the financial crisis).
  – Transformations of the macroeconomic data to obtain stationary time series.

» Calibrations of the mappings
  – Data: quarterly stationary macroeconomic time series over time range 1970 – 2012 (a short period does not provide enough observations to appropriately estimate mappings for some variables).
  – Empirical quantile mapping.
Related Research

- **Austrian National Bank** – Nonperforming Loans in Western Europe – A Selective Comparison of Countries and National Definitions (2013)

- **European Central Bank** – ECB SSM Press Briefing, 23 October 2013

- **European Central Bank** – Note Comprehensive Assessment / October 2013 (2013)

- **Moody’s Analytics** – Modeling Credit Correlations Using Macroeconomic Variables (2012)

- **Moody’s Analytics** – Applications of GCorr™ Macro: Risk Integration, Stress Testing, and Reverse Stress Testing (2013)

- **Moody’s Investors Service** – Banking System Outlooks (2012 and 2013)
Main challenges for Stress Testing to remain as a key risk management tool

Dr. Juan Licari
Senior Director
Head of Economic & Consumer Credit Analytics - EMEA
Topics for discussion

1. Scenario Generation
2. Dynamic vs. Static Approach to Stress Testing
3. Partial vs. General Equilibrium
4. Top-down vs. Bottom-up
5. Modelling Methodologies: Stress Testing vs. Forecasting
Stress Testing Challenges: 1 - Scenario Generation

GDP at Market Prices, q/q % change

Unemployment Rate, (%, SA)

Consumer Price Index, y/y % change

Home Price Index - Dwellings, (Index 1997=100, SA)
Stress Testing Challenges: 1- Scenario Generation

Inflation Rate, History & Forecasts, Euro-Zone Level

Inflation Rate Distribution, Euro-Zone Level

Inflation Rate Distribution, Euro-Zone Level
Stress Testing Challenges: 2- Dynamic vs. Static Approach

Historic and predicted default rates (severe scenario), % of balance at origination
Consolidated portfolio, vintages over time

Performance History

Performance of Future Loans

Forecasted Performance of Existing Loans
Stress Testing Challenges: 3- Partial vs. Gral. Equilibrium

Example from the Proposed UK ST Framework

UK Banks’ ST Models

BoE’s SYSTEM-WIDE Models (e.g. RAMSI)

PRA’s ST Models (leveraging FDSF data)
Stress Testing – from a regulatory exercise to a value driver in risk management

Stress Testing Challenges: 3- Partial vs. Gral. Equilibrium

Examples of collateral type for RMBS/ABS deals

RMBS
» Mortgage rate difference from origination
» Unemployment rate
» Employment growth
» Income growth
» House price growth
» Home equity

Auto-Equipment Loan/Lease
» Interest rates
» Unemployment rate
» Commodity/oil prices
» Price index for used cars

Small Business Loans
» Interest rates
» Unemployment rates
» Income growth
» Profits (National Accounts)
» Share market
Stress Testing Challenges: 4- Top-down vs. Bottom-up

**Issue:** Loan level model can miss correlations and feedback effects

» Individual performance depends on other loans

» Difficult to model individuals within a system

Risk models could miss the forest for the trees

– Why not model the forest, model the trees and then make sure the tree model agrees with forest projections?
Stress Testing Challenges: 5- Modelling Methodologies

Figure I: Bi-Modal Nature of Credit Transitions
Bi-Modal Distribution of Baa to Ba Credit Migrations (Bar Chart) vs. a Normal, Symmetric Distribution (Green Solid Line)
Stress Testing Challenges: 5- Modelling Methodologies

**Binary (Probit) Model Downgrade**

- **CaaC to Default**
- **Baa to A**
Stress Testing – from a regulatory exercise to a value driver in risk management

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