Reverse Stress Testing:
Challenges & Benefits

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Reverse Stress Testing: Introduction & Agenda

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» Reverse stress testing is a hot topic around the world
» 700+ registrations from Europe, North and Latin America, the Middle East, Africa and Asia
Today’s Agenda

• Types of Stress Testing
• Reverse Stress Testing: Definition and Key Purpose
• Quantitative Approach to Reverse Stress Testing
• Qualitative and Hybrid Approaches to Reverse Stress Testing
• Understanding Key Risks to the Global Economy
Stress Testing
### Types of Stress Tests

**Single Factor / Sensitivity Analysis**
- Assess effect of a large move in one risk factor
- E.g. Increase of PD by 10% or LGD to 80%
- Easily understood, established and simple to apply
- Not capturing dependencies

**Multi Factor / Scenario Analysis**
- Historical Scenarios (e.g. recession early 90s)
- Hypothetical Scenarios or hybrid forms
- Capture dependencies among risk factors

**Reverse stress testing**
- Scenario that would make a business model unviable
- For firms to better understand vulnerabilities
- Allow for better capital planning
Reverse Stress Testing

Definition:
Process of identifying the point at which a financial institution’s business model becomes unviable and then identifying scenarios and circumstances that might cause this to occur.

Idea:
Reverse engineering of the risk management process
Think beyond capital/losses/liquidity: reputation, concentration, loss of confidence

Purpose:
- Overcome disaster myopia an improves contingency planning
- To be added as a key Risk Management tool
Quantitative Reverse Stress Testing
What the Regulator says

 “We are proposing to introduce a ‘reverse-stress test’ requirement, which would apply to banks, building societies, CRD investment firms and insurers, and would require firms to consider the scenarios most likely to cause their current business model to become unviable”

 “A key objective of the reverse stress testing is to overcome disaster myopia and the possibility that a false sense of security might arise from regular stress testing in which institutions identify manageable impacts”

 “Our aim is to ensure that firms more fully explore ‘Tail Risks’ which, if they were to crystallize, would cause counterparties and investors to lose confidence in them, so that a firm is more aware of its business model vulnerabilities when making strategic business decisions, when contingency planning, and when considering its risk management arrangements”

Financial Service Authority CP 08/24, PS 09/20 and GL32
Reverse Stress Testing – Identifying Unmanageable Impacts

- What losses lead to dropping below a minimum capital ratio $X$ and what events and business lines could cause these losses?
- When a financial institution should be recapitalized under a given (macro) scenario?
- What risk factors drive the losses and their connections with portfolio’s performance (e.g. insolvency, bankruptcy…etc.)?
- What are the hidden vulnerabilities of my business model?
- Is there any relationship between the Stress Testing and the Reverse Stress Testing outcomes? Reconciliation?

Moody’s Analytics can “reverse engineer” via the RiskFrontier™ Trial-by-Trial capability which specific factors could cause the business model to become unviable: hidden vulnerabilities and unmanageable impacts that are not detected in the stress testing analysis.
The Portfolio Loss Distribution

Capital Zone: Capital required to cover and protect the shareholder from potential economic losses (unexpected negative changes in economic value) within a given confidence level, over a given time horizon.

Expected loss

High probability of average loss

Unexpected loss

0

Economic Capital

Loss

Probability of loss

Very low probability of extreme loss

A
1 in 1000

Aa
1 in 2000

Aaa
1 in 5000

Extreme
tail
event
Reverse Stress Testing vs. Stress Testing – “The Big Picture”

Stress Testing

- Input: Macro Economic Variables & Scenarios
- Output: Macro Economic Variables & Scenarios
- Detected Variables & Manageable Impacts
- Overlapped & Common Variables

Moody’s Analytics GCorr Factors (124)

Reverse Stress Testing

- Input: Target Capital or Tail Loss
- Output: Losses & Capital
- Financial Institutions Own Factors or Models

Hidden Vulnerabilities & Unmanageable Impacts
Detected Variables & Manageable Impacts
Reverse Stress Testing with RiskFrontier™ – Modeling Steps

Stage 1: Definition of the appropriate loss level or some other measure of interest on the balance sheet of the financial institution (e.g. capital ratios)

Stage 2: RiskFrontier™ Trial-by-Trial outputs the exact “states-of-the-world” or factor draws that had the most impact on the portfolio Tail Region

Stage 3: Once the most reactive factors have been identified from step 2 for each “state-of-the-world” scenario then an analysis is performed to measure the impact of these factors in the portfolio

Stage 4: Factors from step 3 are ranked and mapped to macroeconomic variables according to the combinations for a given target loss/capital in the portfolio

Stage 5: Macroeconomic variables from step 4 are mapped to macroeconomic variables thus identifying hidden vulnerabilities and overlapping effects
Reverse Stress Testing with RiskFrontier™ – Step-by-Step

1. Using the RiskFrontier™ Trial-by-Trial capability – given a target loss $\zeta$ – we are able to identify and quantify in $\$ \text{ terms}$ different shock impacts in the Tail Region for each macro scenario.
Reverse Stress Testing with RiskFrontier™ – Step-by-Step

2. RiskFrontier™ overlapping Analysis reveals hidden vulnerabilities & macro variables in the portfolio and firm’s stress testing analysis

<table>
<thead>
<tr>
<th>Overlapping Analysis &amp; Hidden Variables</th>
<th>Reverse Stress Testing Factors Contribution Analysis (Target Capital $\zeta = 10$ bps)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Global Factors</td>
</tr>
<tr>
<td>Stress Testing Macro Variables</td>
<td></td>
</tr>
<tr>
<td>US Unemployment Rate</td>
<td></td>
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<tr>
<td>VIX Index</td>
<td></td>
</tr>
<tr>
<td>HP Single Family Home Price</td>
<td></td>
</tr>
<tr>
<td>SP500 Index</td>
<td></td>
</tr>
<tr>
<td>Portfolio Sensitivity to Shocks</td>
<td>55%</td>
</tr>
</tbody>
</table>
Reverse Stress Testing with RiskFrontier™ – Step-by-Step

3. Strategic Decision Making Analysis: Factors and Macro scenarios that will make the business and/or portfolio unviable (e.g. M&A, macro shock…)

Boxplot of Portfolio 10bps Tail — Factor realizations

Tail Risk Analysis

Capital Millions

Tail Exposure
Reverse Stress Testing with RiskFrontier™ – Step-by-Step

4. Moody’s Analytics Reverse Stress Testing Reports help senior management to put in place capital contingency plans and to develop the firm’s risk appetite, business strategy and risk limits.

<table>
<thead>
<tr>
<th>Share of Portfolio Exposure</th>
<th>Share of Portfolio Capital</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduce Limits</td>
<td>Increase Limits</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th></th>
<th>Amount</th>
<th>As a Proportion of MTM Exposure</th>
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<tbody>
<tr>
<td>No. of Exposures</td>
<td>1006</td>
<td></td>
</tr>
<tr>
<td>No. of Expired Exposures</td>
<td>68</td>
<td></td>
</tr>
<tr>
<td>No. of Counterparties</td>
<td>599</td>
<td></td>
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<tr>
<td>No. of Exposures Excl.</td>
<td>68</td>
<td></td>
</tr>
<tr>
<td>Commitments</td>
<td>616,363,700,000</td>
<td></td>
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<tr>
<td>Book Exposure</td>
<td>616,363,700,000</td>
<td></td>
</tr>
<tr>
<td>MTM Exposure</td>
<td>658,247,528,290</td>
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</tr>
<tr>
<td>Total Spread Revenue</td>
<td>11,354,725,842</td>
<td>168.3 bp</td>
</tr>
<tr>
<td>Expected Loss</td>
<td>5,157,629,337</td>
<td>78.2 bp</td>
</tr>
<tr>
<td>Expected Spread Revenue</td>
<td>5,482,896,805</td>
<td>90.1 bp</td>
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<tr>
<td>Unexpected Loss</td>
<td>12,402,335,833</td>
<td>188.2 bp</td>
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<tr>
<td>Capital</td>
<td>53,425,219,811</td>
<td>810.4 bp</td>
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<tr>
<td>Expected Shortfall</td>
<td>83,770,278,501</td>
<td>967.3 bp</td>
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<tr>
<td>Sharpe Ratio</td>
<td>47.35 %</td>
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<tr>
<td>RORAC</td>
<td>18.39 %</td>
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<tr>
<td>Vasicek Ratio</td>
<td>11.11 %</td>
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</table>
Reverse Stress Testing: Mathematical Challenges

The math behind reverse engineering of risk modeling

- **Macro & Capital Market Scenarios**
- **Risk Parameters & Correlation:** Credit, Market, Liquidity, Organizational Risks
- **Outputs:** Loss Distribution, Capital Requirements, Liquidity, etc.

But $z_1 \rightarrow \{y_1, y_2, \ldots, y_s\} \rightarrow \{x_1, x_2, \ldots, x_{n+m}\}$ opens the door to **multiplicity**

$LGD = f(PD)$
Reverse Stress Testing: Mathematical Challenges

The math behind reverse engineering of risk modeling

From PD, LGD, Correlation and other Risk Parameters to Consistent Macro and Capital Market Scenarios:

Multiplicity is still an issue!
Identification problems to be dealt with.
Reducing the dimension of the Macro Scenarios (factor analysis) could match the two dimensions
Squeeze Box Approach to Stress Testing

Consider year-on-year log-returns of 4 major indices at monthly frequency:

DJEuroStoxx 50, FTSE 100, S&P 500, SPTSX60 (Jan 01 – Sep 10)
Squeeze Box Approach to Stress Testing

Return correlation is strong and growing…

<table>
<thead>
<tr>
<th></th>
<th>DJEuro Stoxx 50</th>
<th>FTSE 100</th>
<th>S&amp;P 500</th>
<th>SPTSX 60</th>
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<tr>
<td><strong>2001-2010</strong></td>
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<tr>
<td>DJEuro Stoxx 50</td>
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<td>FTSE 100</td>
<td>0.98</td>
<td>1</td>
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<tr>
<td>S&amp;P 500</td>
<td>0.94</td>
<td>0.95</td>
<td>1</td>
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<tr>
<td>SPTSX 60</td>
<td>0.91</td>
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<td>0.93</td>
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<tr>
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Squeeze Box Approach to Stress Testing

How to capture this communality?

**Principal components** (PC) analysis

- From our 4x4 correlation matrix we extract 4 eigenvalues
- To each eigenvector corresponds an eigenvector
- Eigenvectors, which are orthogonal by construction, capture non-overlapping pieces of information
- Starting from eigenvalues and eigenvectors we can build PC scores and PC loadings

What do we want to achieve?

- A single PC capturing most of the covariance across the 4 stock indices: a **Global Equity Factor**
Squeeze Box Approach to Stress Testing

The PC 1, or GEF, captures most of the variance in equity returns.
**Squeeze Box Approach to Stress Testing**

1. **Model the GEF** conditional on different macroeconomic scenarios
2. **Link GEF with Risk Parameters**: PD, LGD, Correlations, etc
3. **Condition our original stock indices on the GEF forecasts**
   to get predictions across alternative scenarios.
Squeeze Box Approach to Stress Testing

We can use the same approach for forecasting CDS spreads for, e.g., global non-financial corporates for Moody’s rating buckets (Aaa, Aa, A, Baa, Ba, B, Caa).

Source: Moody’s Analytics, Capital Market Research Group
Squeeze Box Approach to Stress Testing

We now call PC1 **Global Credit Factor**

% of explained variance

[Graph showing the percentage of explained variance for PC1, PC2, PC3, PC4, PC5, PC6, and PC7 over time.]
Squeeze Box Approach to Stress Testing

Hence, we can model the GCF conditional on different macro scenarios.

Condition GCF on Alternative Macro Scenarios

Condition Aaa Aa A Baa Ba B Caa on GCF

Link to Risk Parameters
Squeeze Box Approach to Stress Testing

Challenge to model pure macroeconomic series:

- **MONETARY CYCLE**
  - Inflation

- **CREDIT CYCLE**
  - Rates

- **REAL BUSINESS CYCLE**
  - Econ Activity

% of explained variance

- PC1: 35%
- PC2: 30%
- PC3: 20%
Qualitative and Hybrid Reverse Stress Testing
Qualitative Approach to Reverse Stress Testing

Beyond standard macroeconomic and financial stressed scenarios: Reputation, Concentration, Loss of Confidence, Organizational Risks

**Purpose:**
- Think through and write down contingency plans for such events
- Get Senior Management involved
- Smaller institutions can concentrate more on qualitative analysis rather than reverse engineering the risk models

**Difficulties:**
How to define these events?
Likelihoods?
Hybrid Approach to Reverse Stress Testing

Stress on Business Model → Qualitative Analysis: Key Risks → Potential Scenarios

Calculate Losses, Capital and Liquidity ← Implement scenarios into Risk Management Tools ← Time Series of Macro & Financial Series

Qualitative Reverse Stress Testing
Quantitative Standard Stress Testing
Today’s Key Risks to the Global Economy
Top Global Economic Threats
Based on expected value of global economic loss

» European Sovereign Debt and Banking Crisis
» Deflationary Trap in U.S.
» Global Protectionism and Currency Wars
» Chinese Hard Landing
» Crashing Commodity Price Bubble
» Runaway Global Inflation
» Terrorist Attack
» U.S. Fiscal Crisis and $ Crash
Europe’s Sovereign Problems Boil Over

Spread between 10-year sovereign and German bunds, bp

Sources: Bloomberg, Moody’s Analytics
Deflationary Forces Overwhelm U.S. Economy

% change year ago

Sources: BLS, Moody’s Analytics
Currency War Intensifies

9/09 – 9/10

% Change in Real Effective Exchange Rate

Change in International Reserves as a % of GDP

Sources: Bloomberg, Moody’s Analytics
Concluding Remarks

• Reverse Stress Testing represents a challenge to risk management traditional thinking.

• Pushes management to think about multiple business risks, beyond capital, liquidity and losses.

• Its application and practical advantages yet to be tested. Is it here to stay?

• Started in the UK and other European countries; if successful it could expand to the global economy.

• Combination of quantitative and qualitative analysis to be expected
Q&A Session
Thank you!