SAS Forum Switzerland 2012

Stress Testing
A Whistle-Stop Tour

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Owen Matthews
Agenda

- Overview
- Modelling
- Implementation
- Q&A
Overview
## Risk Management Regimes

<table>
<thead>
<tr>
<th>P&amp;L distribution</th>
<th>Time Scale</th>
<th>Risk Management</th>
<th>Model Performance</th>
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<tbody>
<tr>
<td></td>
<td>Days</td>
<td><strong>Earnings Volatility</strong></td>
<td>Great</td>
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<td></td>
<td></td>
<td>- Meet risk appetite and risk tolerance for volatility of earnings</td>
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<td></td>
<td>Years</td>
<td><strong>Downgrading Risk</strong></td>
<td>Ok</td>
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<td>- Meet risk appetite and risk tolerance for capital requirements related to a target rating</td>
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<td>“1/250”</td>
<td><strong>Tail Risk</strong></td>
<td>Oh dear...</td>
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<td></td>
<td></td>
<td>- Meet risk regulatory requirements and risk tolerance for capital / solvency requirement</td>
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In crisis events, risk and pricing models have often failed to provide realistic and intuitive results, which has made stress testing a “number one” item on the risk agenda.
Following the wake of the Financial crisis, reviews have identified significant gaps in Banking Stress Test practices

- Lack of **senior management involvement**
- Owned by risk with **few interfaces** to business areas, finance and treasury
- Stress testing results **not embedded into business decision making** and planning processes
- Fragmented and **inconsistent practices** across, and sometimes within, Banking Divisions
- Scenarios constrained by historical data, **very little forward-looking elements**
- Scenarios focused on the impact of singular events, insufficient consideration of **knock-on effects and multi-period implications**
- Stress impact often evaluated by risk type in isolation and only in terms of risk measures, lack of a **comprehensive view** across risk types
- Limited to a Risk view – not integrated with Finance and Treasury aspects

.. resulting in regulatory pressure and enhanced standards on Stress Testing to date
**Stress Testing** focuses on multi-period Core Tier1 projections under a specific economic scenario

### Stress Scenarios
- Internal scenarios required to be **"severe and plausible"**
- Follows a **specific narrative** e.g. Mortgage crisis, Sovereign strain, CRE meltdown, etc.
- Short term financial market shock projection
- Medium term macroeconomic variable projection (3-5 yrs)
- Targets specific bank vulnerabilities

### Available Capital
- Stress P&L: Income, **impairments, losses,** Funding costs, etc.
- Available capital: P&L, provisions, tax, etc.

### Required Capital
- Macro-models translate scenario to risk & finance model parameters
- RWA projection across risk types, e.g. credit banking, credit traded products, market risk, OpRisk

### Capital Adequacy
- CT1
- ECAP
- Total Capital

### Capital Adequacy Ratio
- Collate available capital with required capital profiles
- Project capital adequacy ratio profile for the duration of the scenario

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All projections are linked to a particular scenario, which evolves around a specific narrative
Key components of Capital Ratio Stress
Stressing P&L and required capital

- Integrated Capital Stress: **Scenario-consistent** impact on all capital ratio components

\[
T_1\% = \frac{T_1^{\text{capital}} + \text{Income} - \text{Cost} - \text{Losses} - 0.5 \times (\text{EL} - \text{Provisions})}{\text{RWA}}
\]

- Stress affects all elements in the equation at the same time
Modelling
Focus on the Banking Book
The Key Ingredients

- Realistic but severe scenarios, provided by regulator or internally generated
- Macroeconomic models. For banking book focusing on PD.
- The book is broken down into different sub-portfolios by region or industry type
- Quality of data including initial PDs also need to be looked at!

Data quality is often one of the major hurdles in model building and understanding the portfolio
Stress Testing Scenarios
What are they like?

Stress Testing Scenarios Require

- Possible, but perhaps extreme situations
- A description of all the underlying risk factors, taking interdependencies into account
- Including historical scenarios and “reverse stress testing” scenarios
- A narrative describing primary and secondary effects
- Sufficient detail to permit full revaluation of assets and liabilities

Outcomes should be very sensitive to scenarios, so their definition is a key step in stress testing

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Greek Exit of Eurozone

- Greek debt devalued
- Financial institutions suffer

Double Dip Recession

- GDP falls
- Unemployment rises

Housing Crash

- House prices fall
- Consumer spending drops

Eurozone Breakup

- Exchange rate shocks
- Financial institutions suffer

Most stressed scenarios lead to:
- Fall in GDP
- Rise in unemployment
Scenario Generation
Building the Global Model: Example UK

- **UK module (endogenous)**
  - Model trained on historical patterns, preferably including pronounced stress periods
  - Various design choices have to be considered
    - Short-term (mainly momentum-driven correlation) vs longer-term (macroeconomic theory) relationships
    - Frequency of observations
    - ...

- **additional modules (possibly exogenous)**
Scenario Generation
Applying the Global Model: Example UK

- Example: UK base versus stress forecast
- Example: Greece default scenario evaluation
  - Impulse response to pre-defined shocks on currency and GDP
  - Expert specification of GDP trajectory, all other variables projected by model
Stress Macroeconomic Models:
Standard econometrics but there are quite a few pitfalls to consider

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<thead>
<tr>
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<th>Traditional Econometric Modelling</th>
<th>Stress Macro Modelling</th>
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<tbody>
<tr>
<td>Motivation</td>
<td>▪ Accurate forecasting</td>
<td>▪ Projections for hypothetical scenarios</td>
</tr>
<tr>
<td>Basis</td>
<td>▪ Historical time series data</td>
<td>▪ Limited data</td>
</tr>
<tr>
<td></td>
<td>▪ Representative samples</td>
<td>▪ Data by definition not representative for hypothetical stress scenarios</td>
</tr>
<tr>
<td>Focus</td>
<td>▪ Maximize goodness of fit and prediction accuracy</td>
<td>▪ Provide transparent, intuitive and plausible response to stressed inputs</td>
</tr>
<tr>
<td>Variable Selection</td>
<td>▪ Data-driven out-of-time / out-of-sample performance tests</td>
<td>▪ Stability analysis and rationalisation of assumptions for stress periods</td>
</tr>
<tr>
<td>Validation</td>
<td>▪ Mainly statistical</td>
<td>▪ Stability, intuition, ability to project stressed states</td>
</tr>
<tr>
<td>Modelling Approach</td>
<td>▪ Data driven, simple to sophisticated</td>
<td>▪ Simple</td>
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For stress macromodelling, it is often useful to emphasise intuition and stability over statistical fit
Modelling pitfalls
Example: Goodness of fit vs Stability

**Example**
- As we shift the analysis time window, the parameter value changes.
- Different signs when moving from benign period to stress periods.

**Example**
- Parameter sensitivity changes in stress period.
- Distinctive change in sign and value for benign and stress periods.
Applying Macro-Economic Models to a Banking Book
Bringing the Ingredients Together

- The unstressed PD from the data is uplifted to provide the new stressed PD
- The uplift ratio is given by the output of the macroeconomic model
- Uplifted PDs are used to compute expected losses and RWAs - and hence CT1 ratios

\[ \text{Stressed PD} = \text{Unstressed PD} \times \text{Uplift Ratio} \]

- Stressed PD (Output time)
- Unstressed PD (Reference time)
- Macromodel PD (Output time)
- Macromodel PD (Reference time)

Process exceptions such as STD, sovereigns...

Data processing and cleansing

Long-term rating-based PD from database

Compute EL, RWA, and Evolution of EAD

Stress Engine
# Some Stress Testing Challenges
When things get more complicated

## Data Issues

**Problem:** Internal default data are rarely available.

**Solution:** Use external insolvency rates or CDS spreads. These require calibration to internal PDs.

**Problem:** Identification of key sectors of book is difficult, such as those backed by government agencies.

**Solution:** Merge various databases or make pro-rata assumptions.

## Model Issues

**Problem:** Macroeconomic models may prove oversensitive in times of stress.

**Solution:** Ensure that stressed periods are included in regression. Exclude poorly-behaved variables.

**Problem:** Macroeconomic models may behave in a counterintuitive manner.

**Solution:** Check coefficients of regressions at model-build time.

## Special Sectors

**Problem:** Insufficient data exist to build good macroeconomic models for sovereign bonds.

**Solution:** Use projected haircuts or downgrades.

**Problem:** PDs are missing or inaccurate for standardised exposures.

**Solution:** Scale to similar AIRB exposures.

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Often the challenges are more practical than mathematical.
Implementation
SAS Architecture

Database

- Portfolio Table
- Scenario Table
- Model Table
- Results Table

SAS Enterprise Guide

Code 1: Data Pre-process
- Clean data
- Assign models
- Floors and caps

Code 2: PD Uplifts
- Compute uplifts
- Get new PDs
- Special cases

Code 3: RWAs and losses
- Compute RWAs
- Compute ELs
- Evolve EADs

Code 4: Data Post-process
- FX conversion
- Overrides
- Summarise data

Macro-economic variables

Coefficients for macro-economic models

Deal-by-deal results and summaries
SAS and Stress Testing

<table>
<thead>
<tr>
<th>Advantages of SAS</th>
<th>Lessons Learned</th>
<th>Future Developments</th>
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<tr>
<td>Seamless and rapid database access (SAS/ACCESS)</td>
<td>Break the calculation into steps to avoid unnecessary run time</td>
<td>Consider using Risk Dimensions as an integrated solution</td>
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<tr>
<td>Centrally maintained tables for scenarios and models reduce scope for error</td>
<td>Apply filters first for speed, or last for flexibility</td>
<td>Add new features to the code such as quarterly reporting</td>
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<td>Output readily sliced and diced for reporting and interpretation</td>
<td>Never trust the client’s data</td>
<td>Improve treatment of point-in-time versus through-the-cycle initial PDs</td>
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<td>Pre-written tools reduce coding time (SAS/OR, SAS/IML)</td>
<td>Intermediate tables provide a useful diagnostic information</td>
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Close databases integration and a strong suite of pre-built tools make SAS ideal for this project
Q&A