fintegral
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SAS Forum Switzerland 2012

Stress Testing

A Whistle-Stop Tour

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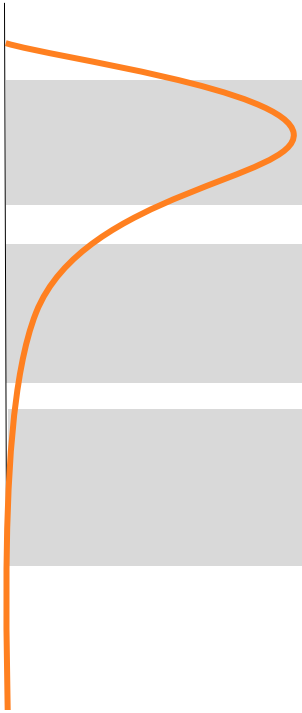
Agenda

- Overview
- Modelling
- Implementation
- Q&A

Overview

Risk Management Regimes

P&L distribution	Time Scale	Risk Management	Model Performance
	Days	**Earnings Volatility** ▪ Meet risk appetite and risk tolerance for volatility of earnings	Great
	Years	**Downgrading Risk** ▪ Meet risk appetite and risk tolerance for capital requirements related to a target rating	Ok
	"1/250"	**Tail Risk** ▪ Meet risk regulatory requirements and risk tolerance for capital / solvency requirement	Oh dear…

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

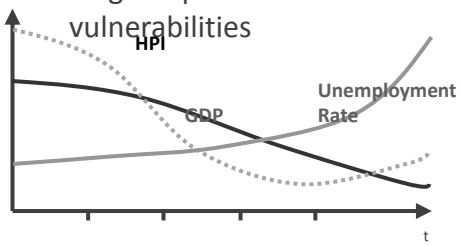
- Lack of **senior management involvement**
- Owned by risk with **few interfaces** to business areas, finance and treasury
- Stress testing results **not embedded into business decision making** and planning processes
- Fragmented and **inconsistent practices** across, and sometimes within, Banking 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

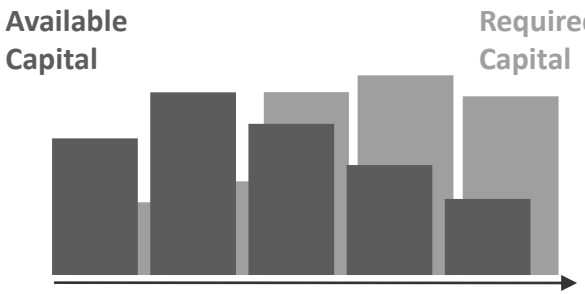
- Stress P&L: Income, **impairments**, **losses**, Funding costs, etc.
- Available capital: P&L, provisions, tax, etc.

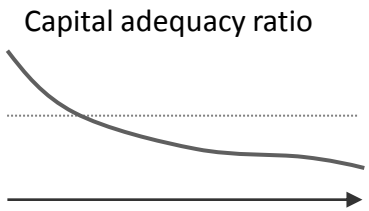
Required Capital

- 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

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





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

- Interest Income
- Fees
- Trading
- Other Non-II

- Funding Cost
- Change in expenses
- ...

- Impairments
- Write Downs
- ...

$$T1\ \% = \frac{T1_{Capital} + Income - Cost\ - Losses - 0.5 * (EL - Provisions)}{RWA}$$

- Credit Risk BB
- CCR
- MR
- ...

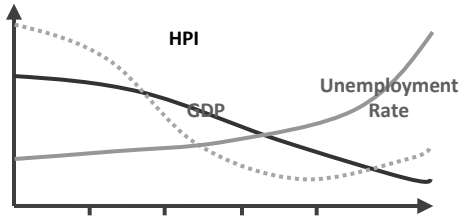
Stress affects all elements in the equation at the same time

Modelling

Focus on the Banking Book

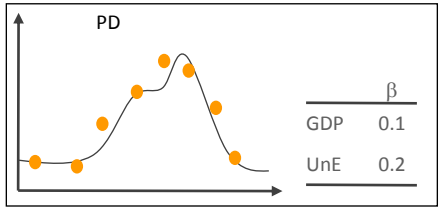
The Key Ingredients

Scenario



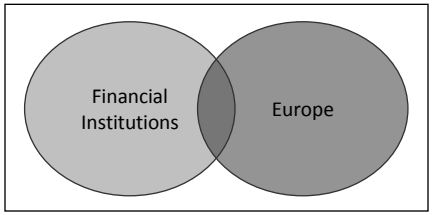
- Realistic but sever scenarios, provided by regulator or internally generated

Macroeconomic Model



- Macroeconomic models. For banking book focussing on PD.

Portfolio Data



- 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

Series of possible "states of the world"

Variables linked via correlations and expert judgment

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:

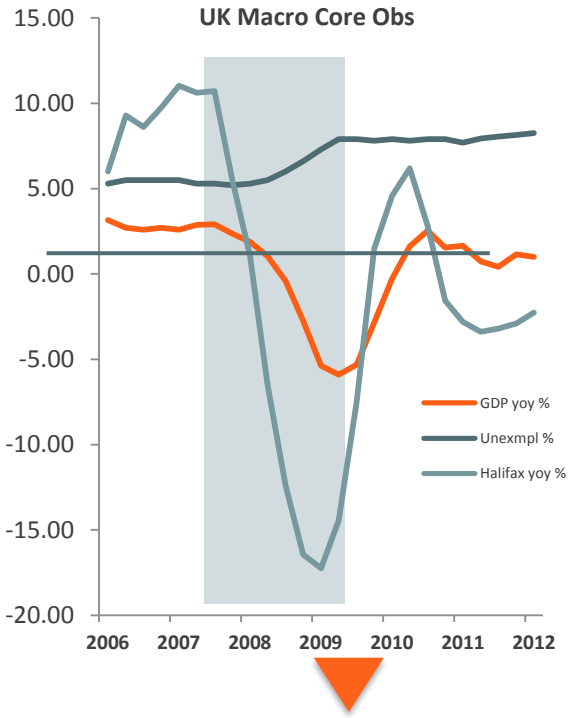
- Fall in GDP
- Rise in unemployment

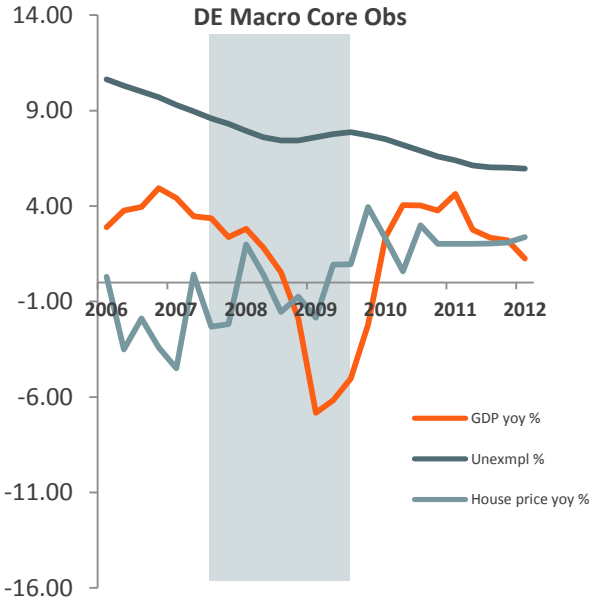
Outcomes should be very sensitive to scenarios, so their definition is a key step in stress testing

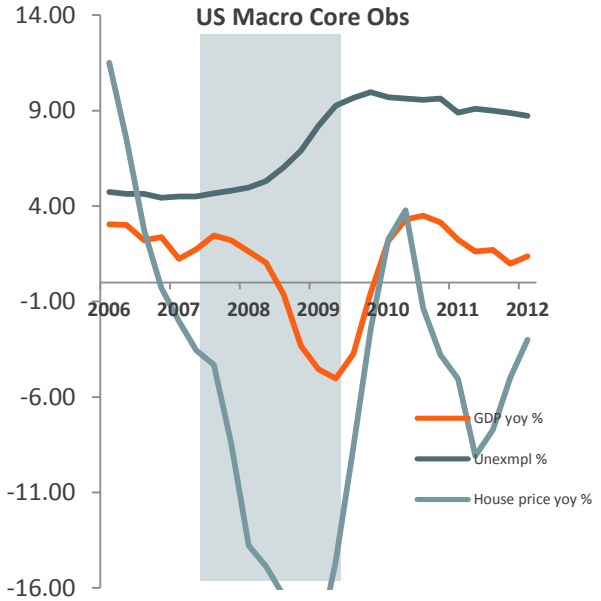
Scenario Generation

Building the Global Model: Example UK

EXAMPLE







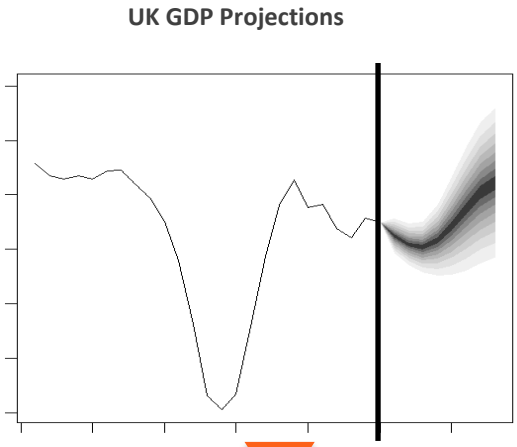
UK module (endogenous)

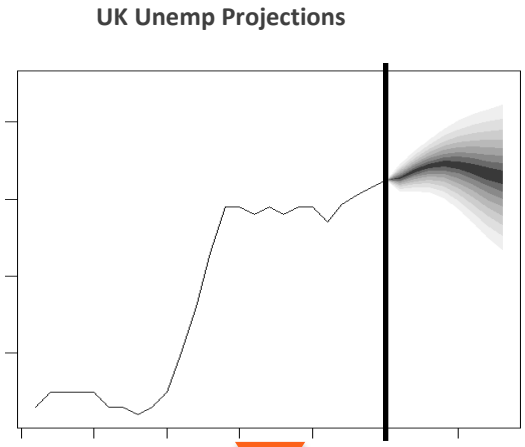
additional modules (possibly exogenous)

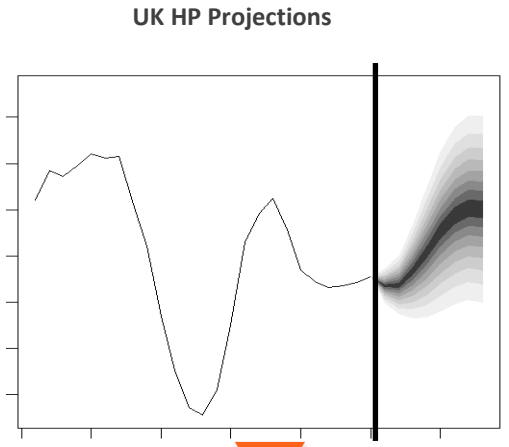
- Model trained on historical patterns, preferably including pronounced stress periods
- Various design choices have to be considered
  - Short-term (mainly momentum-driven correlation) vs longer-term (macoeconomic theory) relationships
  - Frequency of observations
  - ...

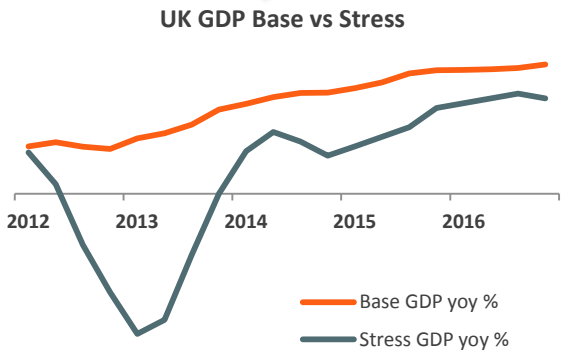
Scenario Generation

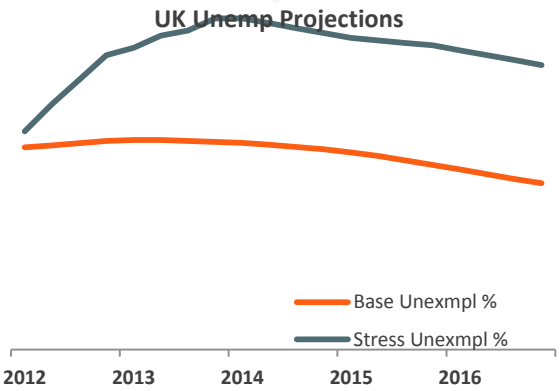
Applying the Global Model: Example UK

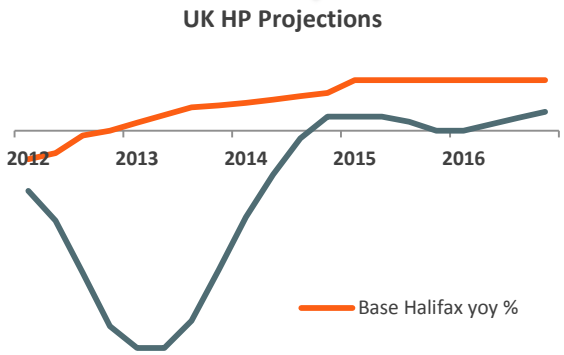












- Example: UK base versus stress forecast
- Example: Greece default scenario evaluation
  - Impulse response to pre-defined shocks on currency and GDP
  - Expert specification of GDP trajectory, all other variables projected by model

Stress Macroeconomic Models:

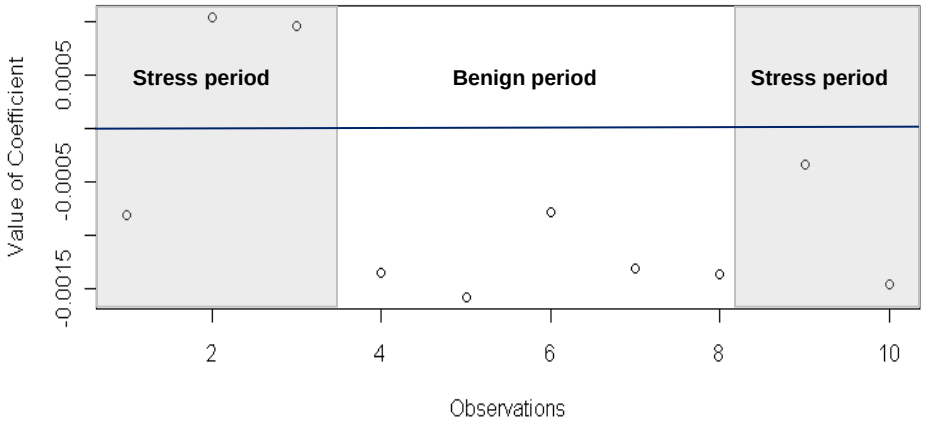
Standard econometrics but there are quite a few pitfalls to consider

	Traditional Econometric Modelling	Stress Macro Modelling
Motivation	▪ Accurate forecasting	▪ Projections for hypothetical scenarios
Basis	▪ Historical time series data ▪ Representative samples	▪ Limited data ▪ Data by definition not representative for hypothetical stress scenarios
Focus	▪ Maximize goodness of fit and prediction accuracy	▪ Provide transparent, intuitive and plausible response to stressed inputs
Variable Selection	▪ Data-driven out-of-time / out-of-sample performance tests	▪ Stability analysis and rationalisation of assumptions for stress periods
Validation	▪ Mainly statistical	▪ Stability, intuition, ability to project stressed states
Modelling Approach	▪ Data driven, simple to sophisticated	▪ Simple

For stress macromodelling, it is often useful to emphasise intuition and stability over statistical fit

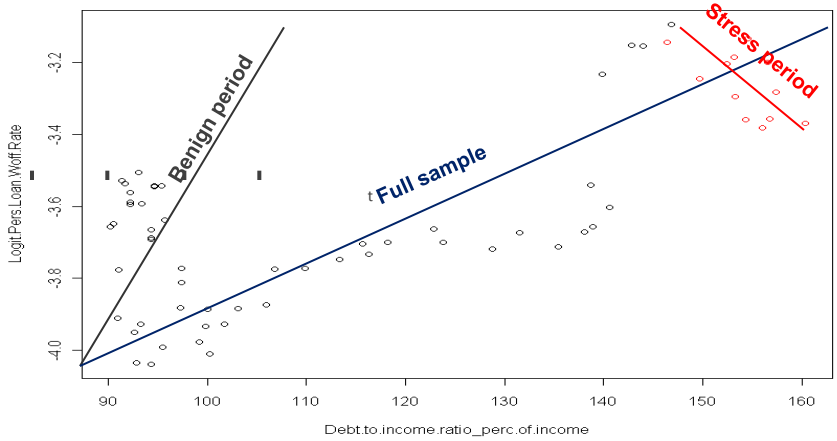
Modelling pitfalls

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

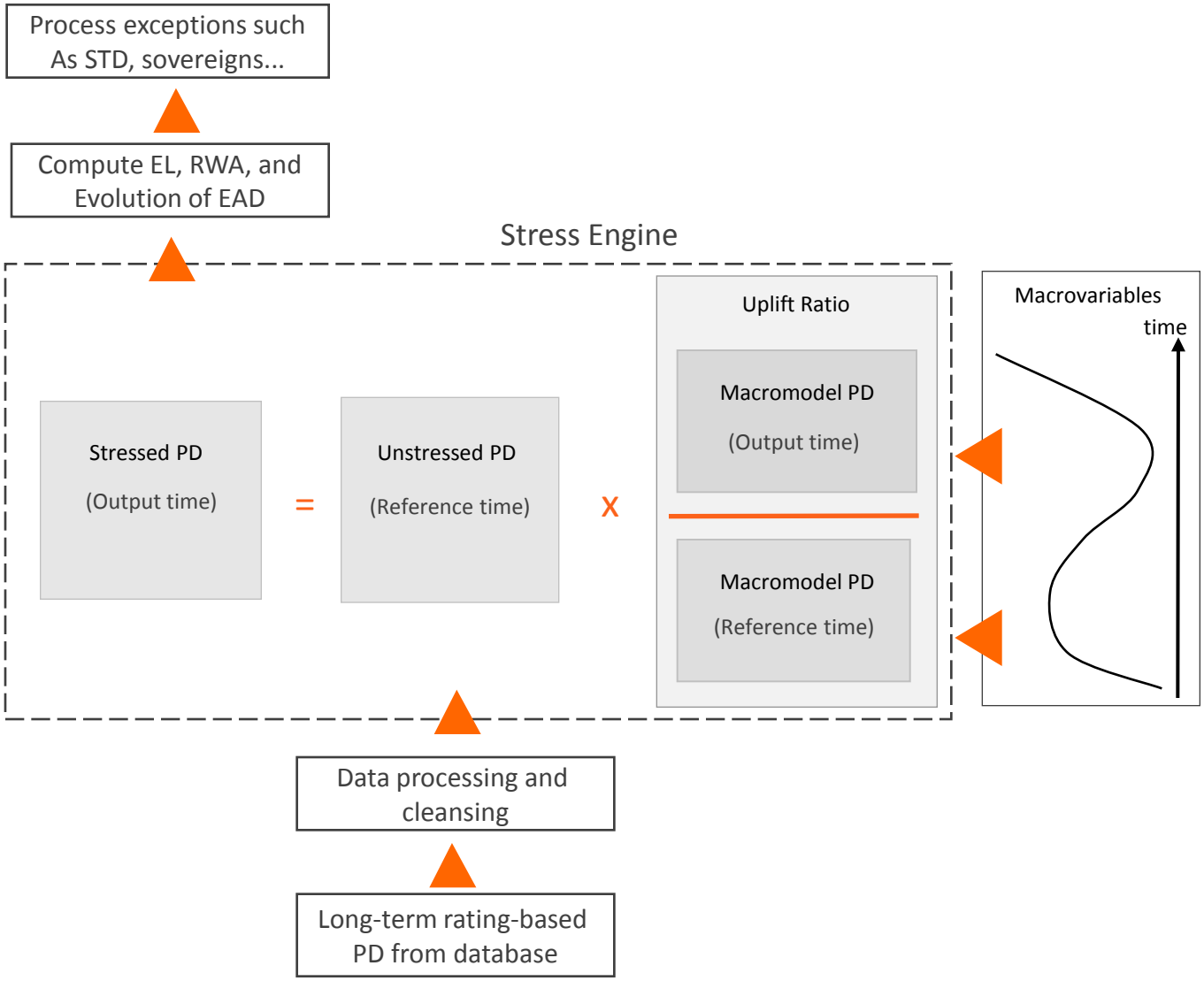


Example

- 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

Some Stress Testing Challenges

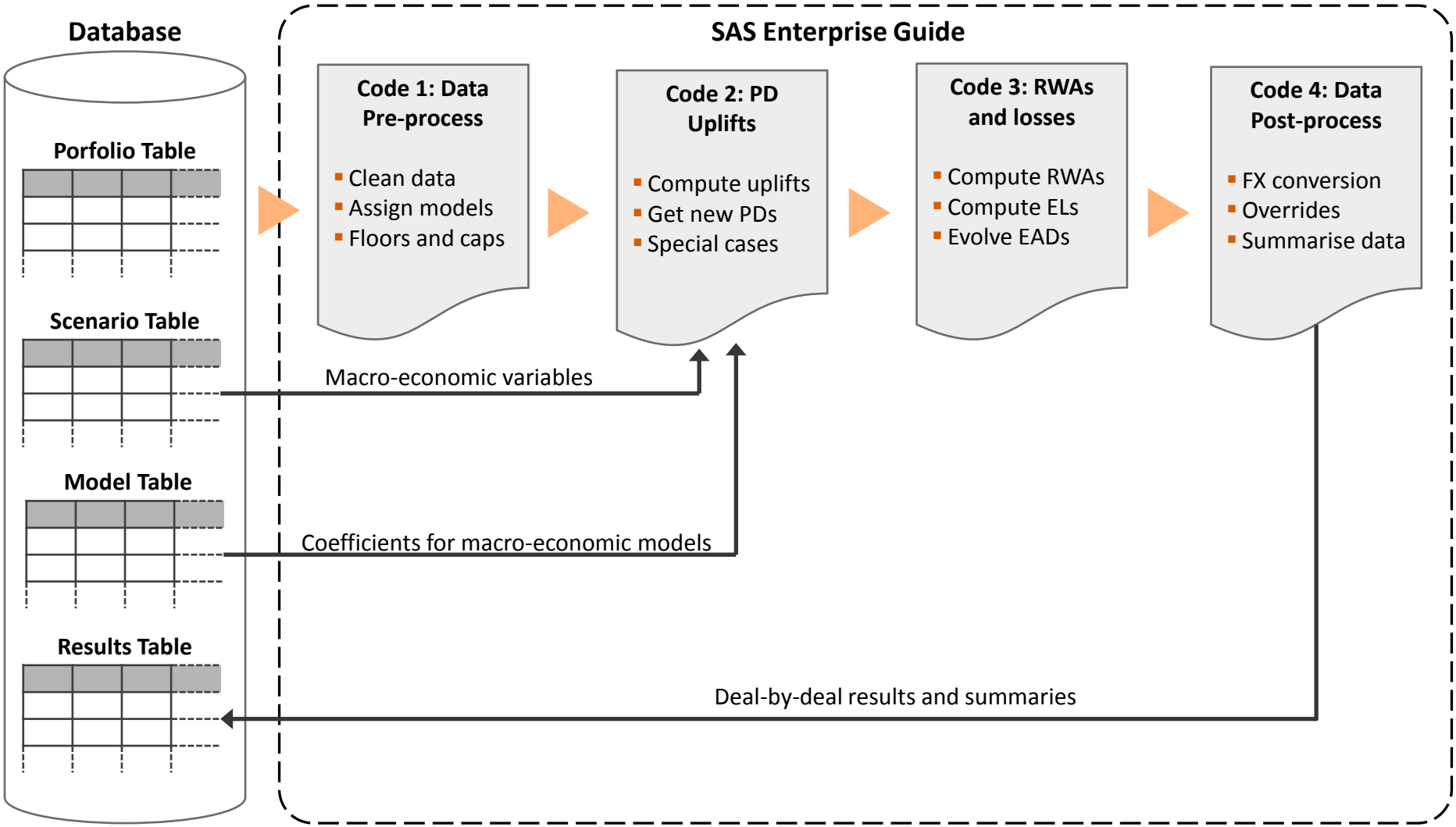
When things get more complicated

Data Issues	Model Issues	Special Sectors
Problem: Internal default data are rarely available. **Solution:** Use external insolvency rates or CDS spreads. These require calibration to internal PDs.	**Problem:** Macroeconomic models may prove oversensitive in times of stress **Solution:** Ensure that stressed periods are included in regression. Exclude poorly-behaved variables	**Problem:** Insufficient data exist to build good macroeconomic models for sovereign bonds **Solution:** Use projected haircuts or downgrades
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	**Problem:** Macroeconomic models may behave in a counterintuitive manner **Solution:** Check coefficients of regressions at model-build time	**Problem:** PDs are missing or inaccurate for standardised exposures **Solution:** Scale to similar AIRB exposures

Often the challenges are more practical than mathematical

Implementation

SAS Architecture



SAS and Stress Testing

Advantages of SAS

- Seamless and rapid database access (SAS/ACCESS)
- Centrally maintained tables for scenarios and models reduce scope for error
- Output readily sliced and diced for reporting and interpretation
- Pre-written tools reduce coding time (SAS/OR, SAS/IML)

Lessons Learned

- Break the calculation into steps to avoid unnecessary run time
- Apply filters first for speed, or last for flexibility
- Never trust the client's data
- Intermediate tables provide a useful diagnostic information

Future Developments

- Consider using Risk Dimensions as an integrated solution
- Add new features to the code such as quarterly reporting
- Improve treatment of point-in-time versus through-the-cycle initial PDs

Close databases integration and a strong suite of pre-built tools make SAS ideal for this project

Q&A

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