ESGs
Testing and validating scenarios

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Agenda

• Using ESGs
  – Purpose
  – Process (providers, groups and business units)
  – Solvency II requirements

• Formulating calibration assumptions
  – Required assumptions
  – Data challenges
  – Potential solutions

• Validating scenario sets
  – Aims
  – Analyses

• Future challenges
Using ESGs
Using ESGs
What do ESGs do?

• Generate many scenarios for future economic variables

• Asset classes:
  – Nominal rates
  – Real rates
  – Inflation
  – Equities
  – Property
  – Credit spreads / default probabilities
  – Alternatives
  – Exchange rates
Using ESGs

Purposes

- Two key types of ESG model:

  - Risk neutral
    - Market-consistent valuation (for reporting)
    - Hedging

  - Real world
    - Risk/return quantification
    - Regulatory/economic capital calculation
    - Investment strategy setting
    - Pricing

(Deflator-based models incorporate features of both types of model)

- Application: Monte Carlo approach especially useful for valuation when liabilities involve non-linear cashflows:
  - Options/guarantees
  - Path-dependence
  - Management actions
Using ESGs
Stochastic modelling for valuation

Liability values found as expected value of discounted projected cashflows:

- Risk-neutral means no arbitrage opportunities:
  - Expected PV of any investment strategy is equal to amount invested today
  - In contrast to real-world simulation, where risk premiums may be used
Using ESGs

Market consistency

- Risk-neutral ESG models are calibrated to market data

- Calculated values of liabilities (which are complex financial contracts) can be thought of as being a “market price”
Using ESGs
Provision of scenarios: a typical process

Data → ESG provider → Group office → Business unit → Data

- Software
- Calibrations
- Assumptions/insights
- Scenario files

• Software?
• Calibrations?
• Scenario files

- Business-unit specific assumptions and file requirements
- Company-specific assumptions and file requirements
Using ESGs
Provision of scenarios - challenges

• For example:
  – Ownership of assumptions
  – Adequate validation/challenge of assumptions
  – Meeting ad-hoc requirements

• Often Business Units do not have access to software / provider contact themselves, perhaps due to:
  – Cost
  – Resource/expertise requirements

• We are seeing reliance on third party providers and/or group centralisation increasing over time
  – For software and resources… but not assumptions!

• For CEE calibrations (e.g. Czech Koruna), lack of market data can make calibration difficult
Using ESGs
Solvency II

Article 126

“The use of a model or data obtained from a third-party shall not be considered to be a justification for exemption from any of the requirements for the internal model set out in Articles 120 to 125.”

- Use test
- Statistical quality standards
- Calibration standards
- Profit & loss attribution
- Validation
- Documentation

As an ESG provider, we find we get many more questions and challenges now than we used to – this is good!
Formulating calibration assumptions
Formulating calibration assumptions
Required assumptions

• Aim wherever possible to calibrate to today’s **market price data**
• Projected behaviour based upon these prices:

Drift
• Linear payoffs – bonds, forward contracts

Volatility, skew, autocorrelation etc.
• Non-linear payoffs - options + other derivatives
Formulating calibration assumptions

Required assumptions

• Ideally:

Nominal rates
  - Initial yield curve
  - Swaption prices/implied vols

Real rates/inflation
  - Initial yield curve
  - Volatility & mean reversion levels

Equities & other indices
  - Option prices/implied vols
  - Forward dividends
  - Dividend volatility & mean reversion

Credit
  - Initial credit spread curves
  - Spread volatility

FX
  - FX option prices/implied vols

+ inter-asset class correlation assumptions!
Formulating calibration assumptions

Data challenges

Ideally, we would calibrate using targets solely sourced from market prices. In practice, many reasons why not possible:

<table>
<thead>
<tr>
<th>Nominal rates</th>
<th>• Swaption prices based on swap rates – inconsistency if using government curve</th>
</tr>
</thead>
<tbody>
<tr>
<td>Real rates</td>
<td>• Few economies issue inflation-linked bonds</td>
</tr>
<tr>
<td></td>
<td>• Derivatives on these bonds are even rarer</td>
</tr>
<tr>
<td>Equities &amp; other indices</td>
<td>• Insurers generally interested in long term implied volatilities – very scarce data</td>
</tr>
<tr>
<td></td>
<td>• For property etc., no liquid derivative markets</td>
</tr>
<tr>
<td>Credit</td>
<td>• Data very fragmented as multiple issuers – some indices do exist for major economies</td>
</tr>
<tr>
<td></td>
<td>• Few derivatives</td>
</tr>
<tr>
<td>Correlations</td>
<td>• Few liquid cross-asset class derivatives</td>
</tr>
</tbody>
</table>
Formulating calibration assumptions
Important features of an assumption-setting approach

The issues described have long existed and many workarounds can be used. In a Solvency II world, these must be well-justified!

- Informed by relevant data
- Limited and well-validated use of expert judgement
- Stability over time
Formulating calibration assumptions

Solutions

1 – Use of historic data

- Common approach for several targets
  - Volatility – property, inflation, credit…
  - Correlations

- Note implied volatility ≠ volatility
  - Bias
  - Observed volatility says nothing about forward-looking term structure, skew

![Graph showing time series of VIX implied volatility and 60D vol with a note of average 3.5% difference]
Formulating calibration assumptions

Solutions

2 – Use of proxy data series

- Asset class may be approximated by a related, more established class for which data exists
- Substitute assumption should be well-validated:
  - Statistically
  - Analysis of underlying drivers

- May seek to make appropriate adjustments to proxy data
Formulating calibration assumptions
Solutions

3 – Third party guidance

• Calibration assumptions are, ultimately, prices of simple financial contracts
  – Request quotes from banks – they are the market makers!
  – Seek assistance from data provider
  – Inspect regulatory returns

• With Solvency II, insurer still required to take ownership of assumptions
Formulating calibration assumptions
Example – Czech/CEE equity

- Only short-term options traded for CECE
  - Would like a full surface

- Could we use a major EUR index like the Eurostoxx or DAX as a proxy?

Historic behaviour:
Formulating calibration assumptions
Example – Czech/CEE equity

Historic volatility:

<table>
<thead>
<tr>
<th></th>
<th>CECE</th>
<th>Eurostoxx 50</th>
<th>DAX</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>27.2%</td>
<td>23.1%</td>
<td>24.44%</td>
</tr>
</tbody>
</table>

Short term ATM implied volatilities:

Unusual downward slope!
Formulating calibration assumptions

Example – Czech/CEE equity

Higher moments:

<table>
<thead>
<tr>
<th></th>
<th>CECE</th>
<th>Eurostoxx 50</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skewness</td>
<td>-0.7</td>
<td>-0.8</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>6.2</td>
<td>5.9</td>
</tr>
</tbody>
</table>
Formulating calibration assumptions

Example – Czech/CEE equity

- Lot of choice as to how incorporate these observations into assumptions
  - But this analysis provides us with evidence to back-up approach

- Approach should be robust – i.e. stable over time
Validating scenario sets
Validating scenario sets

Aims

• Having made a set of scenarios, must adequately validate them

• Seek to verify:
  
  - Arbitrage-freeness
  - Model stability
  - Market consistency / fit to calibration targets
  - Compatibility with cashflow model

• Ideally in as automated and judgement-free way as possible
Validating scenario sets
Analyses – no arbitrage/leakage

Test both raw outputs and more complex (dynamic?) strategies:

- Means of quantifying error:
  - Maximal error
  - Confidence intervals
  - Terminal leakage
Validating scenario sets
Analyses – market consistency

Compare market prices against those found through pricing using scenarios:
Validating scenario sets
Analyses – market consistency

Compare market prices against those found through pricing using scenarios:
Validating scenario sets
Analyses – market consistency

• Monte Carlo prices are an average
  → can use similar pass/fail criteria used for no-arbitrage tests

• Can break down error into two parts:

  1. Fitting error (Targets - Fitted)
  2. Sampling error (Fitted - Generated)

  Market consistency error

• Significance of sampling error best quantified through comparing prices, not vols etc.
Validating scenario sets
Analyses – convergence

• Are we convinced enough simulations have been used?

• In more volatile environments, more scenarios required
Validating scenario sets
Analyses – out of sample testing

• Wish to verify model is not over-fitted, but instead has some predictive power
  – If it doesn’t, ESG is pointless!

Do not always have excess data available, but sometimes we do!

- Bond prices
- Swaption cube points
- Interest rate caps
- Intermediate points on implied vol term structure
Validating scenario sets
Analyses – distributional features

• Out-of-sample contracts most likely to be mispriced if output distributions are “not sensible”

• Extreme distributions may also impact ALM model compatibility

• Additionally, consider changes in distributional statistics over time – are these consistent with changes in calibration assumptions?
Validating scenario sets
Analyses – distributional features

• Out-of-sample contracts most likely to be mispriced if output distributions are “not sensible”

• Extreme distributions may also impact ALM model compatibility

• Additionally, consider changes in distributional statistics over time – are these consistent with changes in calibration assumptions?

• Aside: have seen other European regulators asking firms to test multiple models
Validating scenario sets
Analyses – calibration stability

• For a given model, finding optimal parameter set is a hard problem

1) Test optimisation routine
   – Generate targets from the model
   – Fit to these targets – should be able to achieve exact fit, and ideally same parameters as used to generate targets

2) Test goodness-of-fit over time
   – Fit to historic targets
   – Assess fit in range of market conditions, and stability over time

3) Test parameter stability
   – Make small adjustments to initial guess – should have small impact on outcome
Validating scenario sets
Doing all this analysis

• Some of this is one-off work (validating optimisation routine etc.)

• Model is not particularly firm-specific – provider may be best to validate
  – Firm need only demonstrate evidence and understanding

• If Business Unit is reliant on Group for scenarios, must seek to request sufficient information to calibrate
  – e.g. to accurately price swaption, many outputs required

• Much of regular validation process can be automated
Future challenges
Future challenges
Immediate issues

• ESGs models have reached a mature stage where most calibration targets can be achieved:
  – Initial yield curves
  – Option surfaces
  – Volatility cubes

• Some advances can still be made with regards to credit modelling

• Automation an area of focus as volume of ESG file required increases
  – Quicker delivery
  – Sensitivities
  – Nested stochastic etc.
Future challenges
Longer term

• Emerging standards, including Solvency II and IFRS, continue to emphasize market consistency - generally a good thing.
• Insurance definition is based on classical option pricing theory (replicating portfolios); many assumptions:

Forbidden
• Bid-ask spreads
• Market impact of trades
• Information asymmetries
• Taxes
• Solvency capital requirements and costs of holding these.
• Collateral posting requirements
• Risk of default on derivatives
• Illiquidity premiums or other non-cash-flow valuation effects
• Limitations highlighted post-2008!

Required
• Investment and unlimited borrowing at a single risk free rate.
• Unlimited and infinitely-divisible supply of underlying assets.
• Continuous-time trading (24/7)
• Buying and selling with no impact on the market price.
• Consensus on possible price moves in the underlying asset.
Future challenges
Longer term

• Banks have adopted adjustments to counter weaknesses in theory:

<table>
<thead>
<tr>
<th>Credit valuation adjustment</th>
<th>Allowance for possible default by derivative counterparties</th>
</tr>
</thead>
<tbody>
<tr>
<td>CVA</td>
<td></td>
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</table>

<table>
<thead>
<tr>
<th>Debit valuation adjustment</th>
<th>Reduce stated liabilities with an allowance for own default.</th>
</tr>
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<tbody>
<tr>
<td>DVA</td>
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</table>

<table>
<thead>
<tr>
<th>Funding valuation adjustment</th>
<th>Allowance for funding of derivative position (borrowing over the risk free rate, stock lending, collateral posting).</th>
</tr>
</thead>
<tbody>
<tr>
<td>FVA</td>
<td></td>
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</tbody>
</table>

• These innovations may hit insurers first via IFRS rather than Solvency II
Future challenges
Longer term

• Real-world modelling has itself advanced greatly in recent years due to Solvency II
  – *Diverged* from risk-neutral approach

• Incorporating these “real-world” features into market-consistent modelling will bring these two types of modelling closer together

• Working towards a Grand Unified Model!