ESGs: Spoilt for choice or no alternatives?

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Agenda

1. Why do we need Economic Scenario Generators (ESGs)?
2. Different uses ask for different types of scenario sets
   A. Valuation of (life) insurance liabilities
   B. Measuring risk
   C. Calibration of replicating portfolios
3. Making a good choice
4. Example: Interest Rate Models for risk-neutral valuation
Movements in economic assumptions are often the biggest driver of changes in liability cash flows.

### Input data
- Policy data
- Statutory balance sheet \((t=0)\)
- ...
- Economic scenario

### Cash flow model

- **Statutory P&L / Balance sheet**
- **Dynamic management actions** e.g. bonus crediting
- **Fund-based policyholder benefits and fees**
- **Dynamic policyholder actions** e.g. lapses

### Present value of liability cash flows
Most life insurers need/require complex stochastic models for valuation of their liabilities at reference day.

Input data
- Policy data
- Statutory balance sheet \((t=0)\)
- ...
- Economic scenarios

Cash flow model
- Best estimate (?) liabilities
- Statutory P&L / Balance sheet
- Dynamic management actions e.g. bonus crediting
- Fund-based policyholder benefits and fees
- Dynamic policyholder actions e.g. lapses
ESGs are at the core of stochastic modelling

- An ESG produces forward-looking scenarios for a specified set of risk factors, e.g.:
  - Interest rate term-structures
  - Inflation
  - Index returns, e.g. for equity, real estate, hedge funds, private equity
  - Exchange rates

- Assumption: The possible behaviour of risk factors (and their interaction) can be described sufficiently well by certain stochastic models

- Choice of the stochastic model and a set of parameters determines the range of the scenarios produced by ESG
Monte Carlo simulation is currently the only feasible method to value complex (life) liabilities

- **Idea behind Monte Carlo method:**
  - Generate sample paths for set of risk factors over the modeling period
  - Calculate the discounted cash flows of the sample paths
  - Aggregate the results

- **Key idea & assumptions for valuation:**
  - We start in a risk-neutral setting by calibrating the ESG to available market prices of options and derivatives (this setting is free of arbitrage)
  - Best estimate for the liabilities is calculated as expectation
  - Property of arbitrage-freeness is not affected

- **Alternatives to Monte Carlo method (e.g. Fourier inversion)** not (yet?) feasible for high dimensions
Mathematically, change of numéraire makes no difference

- Prices are calculated relative to a numéraire
- Most common choice: risk-free cash account → risk-neutral scenarios
- Alternative: “real-world” scenarios with deflators

Other examples for valuation purposes:
- Estimation of hedging costs of an insurance guarantee
- Pricing of exotic derivatives
ESGs are used to measure market risk

- Real-world calibration: Risk premiums above risk-free rate to reflect risk aversion of investor e.g. for equity, corporate bonds
- Calibration based on historical observations and expert judgement
- Focus realistic distribution of outcomes, particularly in the tail
- SST: 1-year projection
- Generally, two approaches for calibration:
  - High weight put on recent data
  - Longer timelines

Other example for usage of real world scenarios:
- Impact of hedging strategies on capital requirements
Case study: Implications of the choice of distribution

Starting point: 10y, monthly historical data (SNB); yield curve as of 12.2010

Case 1: Assuming absolute returns multivariate normally distributed

Case 2: Assuming logreturns multivariate normally distributed
ESGs are used for the calibration of replicating portfolios

- Replicating portfolios used as proxy for liabilities for solvency capital calculations
- Particularly good fit in the tail of the distribution is necessary
- Choice of the scenario set used for calibration fairly flexible; no direct dependence from valuation scenario set and risk modelling scenario set
Different uses ask for different types of scenario sets

**Risk neutral scenarios**
- Valuation purposes:
  - Best estimate liabilities and sensitivities
- • Calibration on current market prices (as far as available)
- • Projection time derived from life-time of modelled policies
- • Focus on mean of the distribution

**Calibration scenarios**
- Calibration:
  - Proxy representation of liabilities
- • Particularly good fit in the tail of the distribution is necessary

**Real world scenarios**
- Risk modeling:
  - Market risk
- • Calibration based on historical observations and expert judgement
- • Usually 1-year projection
Agenda

1. Why do we need Economic Scenario Generators (ESGs) ?
2. Different uses ask for different types of scenario sets
3. Making a good choice
   A. What are the key properties?
   B. What decisions are to be taken?
   C. How to check the adequacy of the choice?
4. Example: Interest Rate Models for risk-neutral valuation
ESGs need to fulfil some key properties

- Arbitrage free (for valuation purposes)
- Technically, fit for purpose
  - Accurate, complete and appropriate
  - Theoretical and empirical basis
  - Robust calibration process
- Adequate
  - No more complex than necessary, given the specific purpose and usage (e.g. product portfolio)

Users have to make sure that ESG is not considered as black box: the models need to be understood, including
  - Their limitations
  - The choices that had to be made to set the parameters
  - The reason why they are used (and not others)
The choice of the ESG poses some key challenges

- **Choice of complexity of the model**
  - Trade-off between simplicity and (perceived) accuracy

- **Choice of calibration targets**
  - Limited availability / reliability of market prices
  - Limited relevance of historical data for future predictions

- **Relevance of recent extreme events difficult to assess**
  - How should the probability of a 2008 scenario be estimated within a real-world-distribution?

→ Actuarial judgement essential
Some ideas how the adequacy of the ESG can be assessed

- Standard set of tests
  - Leakage
  - Quality of calibration
  - Convergence test
  - …

- Does the model capture the optionality in your liabilities?
- Can you use the replicating portfolio to validate the ESG?
- Would a change in model (achieving a lower calibration error) make a material difference?

→ In the sequel, we will illustrate the main points to be considered for the case of interest rate models.
1. Why do we need Economic Scenario Generators (ESGs)?
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4. Example: Interest Rate Models for risk-neutral valuation

   A. Required properties
   B. A popular choice: the 1-factor Hull-White model
   C. What are the alternatives?
IR models for risk-neutral valuation

Required properties:
- Arbitrage free
- Can be calibrated to initial term structure

CHF Yield FINMA

- as of 30.12.2011
- as of 29.06.2012
IR models for risk-neutral valuation

Required properties:
- Arbitrage free
- Can be calibrated to initial term structure
- Can be calibrated to initial derivative prices

CHF implied swaption vol as of 30.06.12
Source: Bloomberg
IR models for risk-neutral valuation

Required properties:
- Arbitrage free
- Can be calibrated to initial term structure
- Can be calibrated to initial derivative prices
- Produces sufficiently rich set of yield curve movements

\[
\text{Surplus} \quad \text{Interest rate level}
\]
Possible impact of interest environment on surplus

Guarantees biting; 100% cost for shareholder

Guarantee cost paid by existing risk mitigation buffer

Investment profit shared with policyholders

Surrender option cost increases as interest rates increase

Surplus

Dependent on size of risk mitigation buffer

Dependent on level of surrender guarantees

Guaranteed interest

Interest rate level
A popular choice: the 1-factor Hull-White model

\[ dr(t) = (\theta(t) - \alpha r(t)) \, dt + \sigma \, dW(t) \]

\( \alpha \) and \( \sigma \) positive constants,
\( \theta \) chosen so as to exactly fit the term structure of current interest rates

- Short rate model \((r(t))\)
- \(W\): Brownian motion
- Assumes normal distribution for short rate
- Mean reversion
A popular choice: the 1-factor Hull-White model

Property 1: Admits negative interest rates

Brigo, Mercurio (2007): “The risk-neutral probability of negative rates (...) is almost negligible in practice”.

In fact, current (CHF-) interest rates will lead to a significant number of scenarios assuming negative interest rates.

→ Does your model know how to deal with negative interest rates?
A popular choice: the 1-factor Hull-White model

Property 2:
Robust calibration of swaption prices possible but only for one term/tenor
→ difficult choices to make

But:
Might still be sufficient depending on current level of guarantees / duration of liabilities / ...

Relevant criteria:
Change in calibration does not lead to material differences
A popular choice: the 1-factor Hull-White model

Property 3:
Rates at different maturities are perfectly correlated.
→ Unrealistic distribution of interest rate curves.

But:
Don’t we only care for the mean!?

→ Insurance liabilities contain typically path-depending options. They will be mispriced.
What are the alternatives?

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<thead>
<tr>
<th>1-factor Hull-White</th>
<th>Alternative</th>
<th>Goal</th>
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<tbody>
<tr>
<td>Short rate model</td>
<td>Simultaneous modelling of the full term structure</td>
<td>- Increasing variety of yield curve movements</td>
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<td>- Better fit to market prices</td>
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<td>1-factor</td>
<td>Multi-factor</td>
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<tr>
<td>Normally distributed interest rates</td>
<td>Other distributions e.g. lognormal</td>
<td>- Avoid negative interest rates</td>
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Alternatives that are currently used in the market:
- 2-factor Black Karasinski
- Libor Market Model

→ Key question: What is the impact of a change of the interest rate model?
We are definitely not spoilt for choice – but need to understand the alternatives

- Fixing one problem (locally) usually does not come for free.

- There is a wide range of interest rate models – but none without problems, restricting the choice.

- There is a considerable model risk.

- There is a number of providers, unfortunately not all equally active and innovative.

- There is no “one fits all” – you need to take a choice – and you need to understand it and be able to explain it!
Thank you!

The views expressed in this presentation are those of the presenter.

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