Economic Scenario Generators

A regulator’s perspective

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Bahnhofskolloquium

12. November 2012
FINMA has observed:

- Calibrating the interest rate model of choice has become increasingly difficult:
  - High implied volatilities, undulating surface
  - Extremely low nominal interest rates, even negative
- Documentation of the ESG as part of the internal model is usually very limited
  - Choice of particular model is not explained
  - Limitations of the chosen model are not discussed

→ The model risk is considerable.
• Why do we need Economic Scenario Generators (ESGs)?
• What are the key properties an ESG should fulfil?
• How can you assess the adequacy of your model choice?
Different uses ask for different types of scenario sets

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- Arbitrage-free
- Calibration on current market prices (as far as available)
- Focus on mean of the distribution
- Projection time derived from life-time of modelled policies
- Usually 1-year projection
- Particularly good fit in the tail of the distribution is necessary
- Calibration based on historical observations and expert judgement
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
Most life insurers require complex stochastic models for valuation of their liabilities at reference day.

Input data
- Policy data
- Statutory balance sheet ($t=0$)
- ...
- Risk-neutral economic scenario set

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

Best estimate liabilities
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 modelling period.
  – Calculate the (discounted) cash flows of the sample paths.
  – Aggregate the results.

• Key idea & assumptions for market consistent valuation:
  → We start in a risk-neutral setting by calibrating the ESG to market prices of options and derivatives from deep and liquid markets. (This setting is free of arbitrage.)
  → Best estimate for the liabilities is calculated as expectation.
  → Property of arbitrage-freeness is not affected.
  → Economically coherent.
Valuation of life liabilities: Survey of Swiss companies

• All companies with materially sized business allowing for policyholder participation are expected to model stochastically

• Number of risk factors varies
  – between 3 (nominal interest rate / inflation / equity index)
  – and ~15 (multi-economy / various indices / credit spread)

• Two providers dominate the market, hence the choice of models limited
  – for nominal interest rate: Hull-White / 2Factor-Black-Karasinski / LMM(+)
The choice of the ESG poses some key challenges

- Choice of modelled risk factors
- Choice of ESG-provider

- 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

→ Actuarial judgement essential that cannot be fully externalised
→ All decisions need to be documented
ESGs need to fulfil some key properties

- Arbitrage free (for valuation purposes)
- Technically, fit for purpose
  - Theoretical basis
  - Data used is accurate, complete and appropriate
  - Robust calibration process

• Adequate:
  “No more complex than necessary, given the specific purpose and usage (e.g. product portfolio)”
(Parsimonious principle)
The complexity of the ESG should be adequate to the complexity of the valuation model.

- **“Too simple”**
  - Big calibration error
  - Optionality in the liabilities not captured
  - Model only working for a certain range of interest rates / volatilities

- **“Just right”**

- **“Too complex”**
  - Extremely difficult calibration
  - “pseudo-accuracy”
  - ESG as black box
Required properties for IR-models for risk-neutral valuation (1/5)

• Arbitrage free

Relevant criteria:

• Martingale test:
  all asset classes achieve the same average return

• Leakage test:
  starting market value of assets (MVA) should be equal to the present value of all future cash flows plus the present value of the residual MVA
Required properties for IR-models for risk-neutral valuation (2/5)

- Can be calibrated to initial term structure

Relevant criteria:
Initial bond prices are perfectly matched.
Required properties for IR-models for risk-neutral valuation (3/5)

• Can be calibrated to initial derivative prices

Relevant criteria:

• Clear acceptance criteria
• Robust calibration process

CHF implied swaption vol as of 30.06.12
Source: Bloomberg

Imp Vol in % -- Assumptions used for SST 2012
Required properties for IR-models for risk-neutral valuation (3/5)

- Can be calibrated to initial derivative prices

**Relevant criteria:**

- Clear acceptance criteria
- Robust calibration process
- Well chosen calibration targets

EUR implied swaption vol as of 30.06.12
Source: Bloomberg
Required properties for IR-models for risk-neutral valuation (4/5)

- Produces sufficiently rich set of yield curve movements

Relevant criteria:
- TVOG not underestimated by choice of interest rate model
  (e.g. path-dependencies likely to be mispriced by 1-factor model)
Required properties for IR-models for risk-neutral valuation (5/5)

- Theoretically sound, numerically stable

- Valuation model and ESG have to be seen as “package”
  - “Sensible” interpretation of extreme scenarios
  - Ability to price options & guarantees by ESG must be sufficient for the options & guarantees intrinsic to the liabilities
  - A bad valuation model cannot be saved by a good ESG
  - Dependency on particular ESG should be minimized

Relevant criteria:
Confirmation by Appointed Actuary
FINMA’s attempt at testing the adequacy of the interest rate model

- **Test 1:** What are the relevant market prices to calibrate to?
  - Using a simplified replicating portfolio approach: asset universe restricted to swaps and (liquid) swaptions
  - “Weights” assigned to swaptions indication for “relevance”

- **Challenges:**
  - Big fitting error expected
  - Results dependent on scenario set used
  - Solution might not be very robust; high offsetting positions
  - Big effort

- **However,**
  - RP not used for (re-) valuations, so quality of fit not so much of an issue
  - Should be run with IR that can fit IR-vol surface well
  - Interested in an indication of region to calibrate to
  - Particularly suitable for companies already using an RP-approach
FINMAs attempt at testing the adequacy of the interest rate model

• Test 2: What impact has a change of the interest rate model?

• Challenges:
  – Change of IR-model not without implications on asset model
  – Impact might not be attributable to a specific characteristic

• However,
  – Use for both valuations simplified asset model (e.g. following Brownian motion)
  – Change IR-model only gradually
    – 1-factor to 2-factor, keeping distribution
    – normal vs. lognormal, keeping # of factors
    – consistent calibration approach, using results of test 1
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