Evaluating the Solvency Capital Requirement of Interest Rate Risk in Solvency II

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Overview

1. Introduction

2. Alternative method to derive the required capital

3. Case study: Evaluating interest rate risk in the standard formula

4. Conclusions
Main Question

- **Observation:** One of the most important risks an insurer can face in Solvency II is interest rate risk.

- **Main Question:** Does the methodology as prescribed in the standard formula of Solvency II provide a good measure for the interest rate risk an insurer is facing?

- **Why is it of importance:**
  1. Managing interest rate risk in the insurer’s portfolio
  2. Insurers can opt for a (partial) internal model to determine their SCR instead of using the standard formula.
Conclusions

- We address **three simplifications** in the standard formula of Solvency II
  1. Only **near-parallel shocks** are taken into account
  2. The **Ultimate Forward Rate (UFR)** is **not taken into account** in the shocks
  3. The risk margin is **not taken into account** when measuring interest rate risk

- The **underlying cash flow pattern** determines the impact
  1. If **premium** is material the **shape of the yield curve** is an important aspect
  2. In case of **guarantees** after the last liquid point the **use of the UFR** has a material impact
  3. If the risk margin is a **material part** of the technical provision, leaving out the impact of the change in risk margin from the analysis is a **serious drawback**
Interest rate risk in the standard formula

- Yield curve in the standard formula:
  - Maturities **up to the last liquid point** are based on market data
  - For maturities **beyond the last liquid point** Smith-Wilson extrapolation is used
  - The yield curve converges to an **ultimate forward rate (4.2% for the Euro yield curve)**
Interest rate risk in the standard formula

1. Only **near-parallel shocks** are taken into account in the standard formula.

2. For maturities beyond the last liquid point, the shocks are assumed to be constant.

Yield curve & extrapolated stress scenario's

- **Blue line**: Yield curve
- **Red dashed line**: Upward stress scenario
- **Green dashed line**: Downward stress scenario

![Graph showing yield curve and stress scenarios](image)
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Alternative method to derive the required capital

1. Simulate a set of possible spot rates over a one year time horizon up to the last liquid point

2. Construct the term structure of interest rates for all maturities up to the last liquid point using a cubic Hermite spline

3. Extrapolate the term structures after the last liquid point using the Smith-Wilson technique

4. For each simulation revalue all assets and liabilities, including the risk margin, to derive the distribution of the change in net asset value and the required capital for interest rate risk
1 & 2: Term structure up to the last liquid point

- The method used should provide enough flexibility to construct realistic term structure shapes

1. A set of spot rates is simulated
2. The simulated set of spot rates is interpolated using a Cubic Hermite spline
   - Ensures continuous curves
   - Ensures relatively smooth curves
   - Relatively easy to implement and efficient method

![Simulated set of spot rates](image1)

![Cubic Hermite spline interpolation](image2)
3: Extrapolate the term structure

- Extrapolate the constructed term structure **beyond the last liquid point**
  - The **Smith-Wilson extrapolation technique** is used
  - Consistent with the yield curve used in the standard formula

- The term structure is now constructed for all maturities
  - The method is able to construct **realistic term structure shapes**
  - The method is able to provide a **good fit** with the standard formula

![Yield curves up to the last liquid point](image1)

![Yield curves extrapolated](image2)
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Case study: Evaluating interest rate risk

- For each simulated scenario the required capital is calculated
  - The required capital is equal to the **negative change in net asset value** due to the one-year scenario

- The required capitals of the alternative method and the standard formula are compared
- Insurance products have different specifications

<table>
<thead>
<tr>
<th>Premium payments</th>
<th>No premium payments</th>
</tr>
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<tbody>
<tr>
<td><strong>Short term</strong></td>
<td></td>
</tr>
<tr>
<td>Term insurance</td>
<td>Short term immediate annuity</td>
</tr>
<tr>
<td><strong>Long term</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Whole life insurance</strong></td>
<td>Long term immediate annuity</td>
</tr>
</tbody>
</table>

- Different specifications result in different cash flow patterns
- Recall that the underlying cash flow pattern is important
Case study: Evaluating interest rate risk

- The first step is to calibrate the alternative method to the standard formula.
  - A set of 5 spot rates is simulated. The mean and variance of these rates are calibrated on the standard formula upper- and lower 99.5 percentiles

- The alternative method provides a **good fit** with the standard formula. This is of importance for a fair comparison with the standard formula

- 100,000 scenarios are now **simulated using the alternative method**

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**Monte Carlo estimates using cubic Hermite splines**

<table>
<thead>
<tr>
<th>Maturity (years)</th>
<th>Spot rate (%)</th>
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</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>2</td>
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<tr>
<td>10</td>
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<td>25</td>
<td>6</td>
</tr>
<tr>
<td>30</td>
<td>6</td>
</tr>
</tbody>
</table>

- Monte Carlo 99.5 up
- Monte Carlo 99.5 down
- Standard formula upward stress scenario
Case study: Whole life insurance

- **Correlation** and **Smith-Wilson extrapolation** have a big impact on a whole life insurance.
  
  1. The correlation structure imposed causes the scenario to be **non-parallel for the first 30 years**. More specific: the curve is decreasing between maturities of 15 and 30 years.
  2. The use of the Smith-Wilson technique beyond maturities of 30 years causes the scenario to be **more severe between maturities of 30 and 60 years**.

![Yield curve, Standard formula downward shock and simulated scenario and cash flow pattern]

- **1: Non-parallel shape**
- **2: Smith-Wilson**
Case study: Risk margin

- The risk margin corresponding to a long-term immediate annuity is revalued using the simulations from the alternative method.

- The distribution below shows that the risk margin is dependent on the interest rate.

![Distribution of the risk margin](image)

Risk margin as a percentage of the present value of Best Estimate liabilities.
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Conclusions

- In general, the simplifications can become a serious drawback
  1. If **premium income** is **material** the shape of the yield curve is an important aspect
  2. In case of **guarantees after the last liquid point**, the UFR has a material impact
  3. If the **risk margin is a material part of the technical provision**, excluding this from the required capital is a serious drawback

- The alternative method is not only useful for determining required capital but is also vital in **understanding the dependency of interest rates to the valuation of the portfolio**.