Managing Contribution Risk in a Funded Public Defined Benefit Plan: Impact of CVaR Cost Constraints

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Introduction

• Governments face rising costs of underfunded civil servant DB pensions
• Appropriate funding & investment strategy may offer solution

• We propose alternative funding and investment strategies that …
  ✓ minimize expected pension costs
  ✓ control for cash shortfall risks
  ✓ control for contribution rate risk
  ✓ mitigate burden of future generations
  ✓ integrate ALM approach & CVaR risk metrics
Our Approach

• In general, DB plan sponsors face trade-off between contribution rate and solvency risk

• Optimal contribution- & investment strategy traditionally derived by minimizing combined “cost” criterion (e.g. Haberman & Sung (1994,1995), Ngwira & Gerrard (2007), Owadally & Haberman (2004))

• Governments might live with underfunding but not with contribution rate risk and in particular worst-case cost risk

• => We seek to minimize contribution rate risk while controlling for worst-case cost risks.
German Civil Servants Pensions

• Financing: Tax-sponsored, non-contributory, (mostly) unfunded DB plan, some states start funding and invest mostly in (own) govt. bonds

• Benefits:
  - Based on service years and final salary (~1.8% p.a., max. 72% of final pay after 40 years).
  - Not in national Social Security; not portable

• Regular retirement age: Rising to 67

• Dataset: >100,000 active Hessian Civil Servants
Modeling Future Liabilities

- 50-year projection horizon for new DB accruals for current active civil servants and new hires.
  - No real wage growth
  - Replacement hiring
  - Deriving specific mortality tables

- Discount future pension benefits at fixed real rate (3% p.a.), representing government’s cost of financing (“economic valuation”)

- Past pension claims excluded in the model
Finding Regular Contribution Rate

• Deterministic contribution rate of salary per year can be derived as:

\[
\text{Regular Contribution Rate} = \frac{\text{PV Future Pension Liabilities}}{\text{PV Future Salary Payments}}
\]

\[
\text{Regular Contribution Rate} = \frac{20.8 \text{ € bn}}{111.5 \text{ € bn}} = 18.7\%
\]
Modeling Assets

- Investment Universe: Equity, Bonds
- Stochastic asset model: returns (after inflation) follow restricted vector-autoregression
- Parameters based on German market indices

<table>
<thead>
<tr>
<th></th>
<th>Mean (%)</th>
<th>Volatility (%)</th>
<th>Correlations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stocks</td>
<td>6.6</td>
<td>20.7</td>
<td>Stocks 1</td>
</tr>
<tr>
<td>Bonds</td>
<td>4.8</td>
<td>6.7%</td>
<td>Bonds 1</td>
</tr>
</tbody>
</table>
Financing Rules

• Regular Contributions (RC): Constant fraction of current payroll (level to be determined endogenously)

• Funding Deviations recovered by annuity payments over pre-specified spread period (base case: 20 years)
  – Funding Ratio<100%: Supplementary Contributions (SC) => $C_t > RC$
  – Funding Ratio>100%: Withdrawals (W) => $C_t < RC$
Plan Managers’ Objective Function

• Choose combination of (constant) normal contribution rate and asset allocation that minimizes contribution rate volatility:

\[
\min_{CR, x} E \left( \sum_t \left( \frac{C_t}{\text{Salary Payments}_t} - CR \right)^2 \right)
\]

• s.t. the Conditional Value at Risk Constraint:

\[
CVaR_{1\%} \left( TPC = \sum_t \frac{RC_t + SC_t (1 + \xi_1) - W_t (1 - \xi_2)}{(1 + r)^t} \right) \leq c \left( = 20.8 \text{ €bn} \right)
\]

\begin{align*}
x & : \quad \text{Portfolio weights} \quad \xi_i & : \quad \text{Penalty Factor SC (20\%)} \\
RC_t & : \quad \text{Regular Contributions} \quad \xi_2 & : \quad \text{Penalty Factor Withdrawals (20\%)} \\
SC_t & : \quad \text{Supplementary Contributions} \quad r & : \quad \text{Discount Rate (3\%)} \\
W_t & : \quad \text{Withdrawals}
\end{align*}
Optimal Contribution & Asset Allocation

Equity weight (in %)

Normal contribution rate (in %)

CVaR costs

Contribution variation

Equity weight (in %)
Contribution Rates over Time

![Graph showing contribution rates over time with expectation and 95% quantile lines.](image)
Conclusions

• German civil servant pensions substantially underfunded.

• Risky investments proposed to reduce funded DB pension costs.

• We offer interesting approach to determine funding and investment strategies, explicitly accounting for fund manager’s intertemporal risk budget.

• Doing so:
  üFunding combined with optimized investment strategy may substantially reduce pension costs.
  üWorst-Case Risks can be well controlled.
  üPure bond investment strategy sub-optimal.
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Back-up
Age Distribution – Total Workforce

The chart shows the age distribution of the total workforce, with the number of employees on the y-axis and age on the x-axis. The distribution peaks around the age of 48. The number of employees decreases as age increases, with a notable drop after 60 years old.
Age Distribution – „Höherer Dienst“
## Current Civil Servants Workforce

<table>
<thead>
<tr>
<th>Total Workforce</th>
<th>Avg. Age</th>
<th>Avg. Salary (EUR)</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salary Groups</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Level 1</td>
<td>47.7</td>
<td>46,000</td>
<td>28,946</td>
</tr>
<tr>
<td>Level 2</td>
<td>45.6</td>
<td>38,000</td>
<td>63,843</td>
</tr>
<tr>
<td>Level 3</td>
<td>40.3</td>
<td>31,000</td>
<td>11,609</td>
</tr>
<tr>
<td>Level 4</td>
<td>43.7</td>
<td>26,000</td>
<td>503</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Avg. Age</th>
<th>Avg. Salary (EUR)</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>44.7</td>
<td>39,000</td>
<td>104,919</td>
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</tbody>
</table>
## Asset Allocation & Costs

<table>
<thead>
<tr>
<th>Spread period (in years)</th>
<th>1</th>
<th>10</th>
<th>20</th>
<th>50</th>
<th>∞</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal contributions (in %)</td>
<td>23.0</td>
<td>13.0</td>
<td>13.4</td>
<td>13.9</td>
<td>14.1</td>
</tr>
<tr>
<td>Equity weight (in %)</td>
<td>45.0</td>
<td>42.2</td>
<td>40.9</td>
<td>39.9</td>
<td>39.4</td>
</tr>
<tr>
<td>Bond weight (in %)</td>
<td>55.0</td>
<td>57.8</td>
<td>59.1</td>
<td>60.1</td>
<td>60.6</td>
</tr>
<tr>
<td>Contribution rate volatility p.a. (in %)</td>
<td>3.24</td>
<td>1.38</td>
<td>1.25</td>
<td>1.14</td>
<td>1.09</td>
</tr>
<tr>
<td>1%-CVaR pension costs (in € bn)</td>
<td>20.8</td>
<td>20.8</td>
<td>20.8</td>
<td>20.8</td>
<td>20.8</td>
</tr>
<tr>
<td>Expected pension costs (in € bn)</td>
<td>-0.62</td>
<td>2.74</td>
<td>3.20</td>
<td>3.29</td>
<td>3.31</td>
</tr>
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