An Economic Capital study of
the Pension Protection Fund and
UK’s Defined Benefit Pension Sector

Pradip Tapadar
University of Kent

Actuarial Teachers and Researchers Conference (2014) – University of Edinburgh

December 2, 2014
Agenda

1. Introduction
2. Economic capital
3. Stochastic model
4. Model assumptions
5. Results
6. Conclusions
Agenda

1. Introduction
   - Background

2. Economic capital

3. Stochastic model

4. Model assumptions

5. Results

6. Conclusions
Background

Regulatory developments

- Basel 2/3.
- Solvency 2.
- Pensions Regulations.

Pensions: Developments in the UK

- Private pension membership: 46% (1997) to 32% (2012).
- DB scheme membership: 34% (1997) to 8% (2012).

Questions:

1. Impact of capital requirements on individual DB pension schemes.
2. Role of the PPF for the risk management of the entire sector.
Agenda

1. Introduction

2. Economic capital
   - Formulation
   - Eligible schemes
   - PPF

3. Stochastic model

4. Model assumptions

5. Results

6. Conclusions
Economic Capital Formulation

**Economic capital** is the excess of assets over liabilities in respect of accrued benefits required to ensure that assets exceed liabilities on all future valuation dates over a specified time horizon with a prescribed high probability.

**Notations:**

- $X_t$: Net cash flow of the scheme;
- $L_t$: Value of s179 liability of the scheme;
- $I_{s,t}$: Accumulation factor;
- $D_{s,t}$: Discount factor.

**Building blocks**

- $P_t = L_{t-1}I_{(t-1),t} - X_t - L_t$: Profit vector, with $P_0 = -X_0 - L_0$.
- $R_t = \sum_{s=0}^{t} P_s I_{s,t}$: Accumulated retained profits until time $t$.
- $V_t = \sum_{s=t+1}^{T} P_s D_{t,s}$: Present value of future profits at time $t$. 
Eligible Scheme Cashflow and Capital Requirement

Capital requirement: $C_t = \max \left[ - \min_{s=t}^{T} V_s D_{t,s}, 0 \right].$

Economic capital requirement: $\rho(C_t) = \text{VaR}(C_t, p = 0.995).$
PPF Cashflow and Capital Requirement

Capital requirement: \( C_t = \max \left[ - \min_{s=t}^T R_s D_{t,s}, 0 \right]. \)

Economic capital requirement: \( \rho(C_t) = \text{VaR}(C_t, p = 0.995). \)
Agenda

1. Introduction
2. Economic capital
3. Stochastic model
   - Economic variables
   - Longevity
4. Model assumptions
5. Results
6. Conclusions
The individual economic random variables, $Z_{it}$s, are modelled as:

$$Z_{it} = \mu_i + Y_{it}, \text{ where } Y_{it} = \beta_i Y_{i(t-1)} + \varepsilon_{it} \text{ and } \varepsilon_{it} \sim N(0, \sigma_i^2).$$

The error terms

- are assumed to be independently distributed across time $t$;
- which are directly connected to each other are dependent;
- which are indirectly connected are still dependent, but more weakly so.
Stochastic model: Longevity

The mortality model used is developed in three steps:

**Step 1:** Set S1PM and S1PF as the baseline mortality tables for males and females respectively.

**Step 2:** Project these base mortality tables from year 2006 to year 2012 using the mortality projection table published by the Institute and Faculty of Actuaries.

**Step 3:** Finally, model the future stochastic mortality improvements starting from 2012 by modelling stochastic uncertainty around the central mortality projection (Sweeting (2008)).
Agenda

1. Introduction
2. Economic capital
3. Stochastic model
4. Model assumptions
   - Membership profile
   - Model points
   - Investment
5. Results
6. Conclusions
### Membership Profile

**Table:** Average membership profile of eligible schemes.

<table>
<thead>
<tr>
<th>Membership group (Members)</th>
<th>Number of schemes</th>
<th>Active (Members)</th>
<th>Deferred (Members)</th>
<th>Pensioner (Members)</th>
<th>Total (Members)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A: (5-99)</td>
<td>2,260</td>
<td>6 (13%)</td>
<td>23 (52%)</td>
<td>15 (35%)</td>
<td>44</td>
</tr>
<tr>
<td>B: (100-999)</td>
<td>2,828</td>
<td>56 (16%)</td>
<td>182 (52%)</td>
<td>113 (32%)</td>
<td>351</td>
</tr>
<tr>
<td>C: (1,000-4,999)</td>
<td>824</td>
<td>384 (17%)</td>
<td>1,103 (49%)</td>
<td>754 (34%)</td>
<td>2,241</td>
</tr>
<tr>
<td>D: (5,000-9,999)</td>
<td>192</td>
<td>1,231 (17%)</td>
<td>3,297 (46%)</td>
<td>2,601 (37%)</td>
<td>7,129</td>
</tr>
<tr>
<td>E: (Over 10,000)</td>
<td>212</td>
<td>6,651 (19%)</td>
<td>14,763 (42%)</td>
<td>13,608 (39%)</td>
<td>35,022</td>
</tr>
</tbody>
</table>
### Model Points

**Table:** Eligible schemes model points.

<table>
<thead>
<tr>
<th>Membership types</th>
<th>Age</th>
<th>Gender</th>
<th>Accrued service/benefit</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Active</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>Male/Female</td>
<td>7 years past service</td>
</tr>
<tr>
<td></td>
<td>40</td>
<td>Male/Female</td>
<td>16 years past service</td>
</tr>
<tr>
<td></td>
<td>50</td>
<td>Male/Female</td>
<td>25 years past service</td>
</tr>
<tr>
<td></td>
<td>60</td>
<td>Male/Female</td>
<td>34 years past service</td>
</tr>
<tr>
<td><strong>Deferred</strong></td>
<td>50</td>
<td>Male</td>
<td>Accrued pension of £3,000 per year</td>
</tr>
<tr>
<td></td>
<td>50</td>
<td>Female</td>
<td>Accrued pension of £1,500 per year</td>
</tr>
<tr>
<td><strong>Pensioner</strong></td>
<td>70</td>
<td>Male</td>
<td>Pension of £6,000 per year</td>
</tr>
<tr>
<td></td>
<td>70</td>
<td>Female</td>
<td>Pension of £3,000 per year</td>
</tr>
</tbody>
</table>
Assets, Liabilities and Investment Strategies

Table: Comparison of assets and liabilities.

<table>
<thead>
<tr>
<th></th>
<th>Estimated</th>
<th>Actual</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assets</td>
<td>£1,018b</td>
<td>£1,027b</td>
</tr>
<tr>
<td>Liabilities</td>
<td>£1,218b</td>
<td>£1,231b</td>
</tr>
</tbody>
</table>

Table: Distribution of eligible scheme by investment strategies.

<table>
<thead>
<tr>
<th>Investment strategy</th>
<th>Asset allocation</th>
<th>Proportion of eligible schemes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Equities</td>
<td>Bonds</td>
</tr>
<tr>
<td>L</td>
<td>25%</td>
<td>75%</td>
</tr>
<tr>
<td>M</td>
<td>50%</td>
<td>50%</td>
</tr>
<tr>
<td>H</td>
<td>75%</td>
<td>25%</td>
</tr>
</tbody>
</table>

PPF broadly follows investment strategy L.
Agenda

1. Introduction
2. Economic capital
3. Stochastic model
4. Model assumptions
5. Results
   - Eligible Schemes
   - PPF
6. Conclusions
Aggregate Economic Capital for Eligible Schemes

As at 31 March 2012

Economic Capital
£ 1,231 billion

Assets
£ 1,018 billion

Liabilities
£ 1,218 billion
Economic Capital: Eligible Scheme in A

Membership group A

Liability and economic capital (£ million)

2020 2040 2060 2080 2100

0 2 4 6 8 10

ρ_{t}^{AH}
ρ_{t}^{AM}
ρ_{t}^{AL}
L_{t}^{A}
Eligible Schemes: Liability Comparison

$L^X_t / L^X_0$ as multiples of $L^A_t / L^A_0$ where $X=A,B,C,D,E$
Eligible Schemes: Economic Capital Comparison

\( \rho_t^{XY} / L_0^X \) as multiples of \( \rho_t^{AY} / L_0^A \) where \( X=A,B,C,D,E \) and \( Y=L,M,H \)
PPF: Some Additional Assumptions

- PPF levy: 0.072% of the total s179 liabilities.
- Amortisation period: 10 years.
- Funding cap: 120% of s179 liabilities.
- Insolvency rates:

<table>
<thead>
<tr>
<th>Membership group</th>
<th>Annual insolvency rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1.60%</td>
</tr>
<tr>
<td>B</td>
<td>0.95%</td>
</tr>
<tr>
<td>C</td>
<td>0.90%</td>
</tr>
<tr>
<td>D</td>
<td>0.53%</td>
</tr>
<tr>
<td>E</td>
<td>0.72%</td>
</tr>
</tbody>
</table>
PPF: Base Case Results

PPF schemes liability and economic capital: Base case

- Liability
- Economic capital

£ billion

2020 2040 2060 2080 2100
PPF: Sensitivity Results

As at 31 March 2012

1: Base Case
2: 4-year Amortisation
3: 50% Buffer
4: (2) + (3)

Economic capital (£ billion)
PPF Takes Over All Schemes With Insolvent Sponsors

PPF takes over all schemes with insolvent sponsors

- **Base**
- **All schemes**
  + 50% buffer and
  4-year amortisation

Economic capital (£ billion)

<table>
<thead>
<tr>
<th>Year</th>
<th>2020</th>
<th>2040</th>
<th>2060</th>
<th>2080</th>
<th>2100</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All schemes</td>
<td></td>
<td>100</td>
<td></td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>+ 50% buffer and 4-year amortisation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0</td>
</tr>
</tbody>
</table>

P Tapadar (University of Kent)

Economic Capital

December 2, 2014
Agenda

1. Introduction
2. Economic capital
3. Stochastic model
4. Model assumptions
5. Results
6. Conclusions
Conclusions

Summary

- Aggregate economic capital requirement:
  - On eligible scheme basis: £1,200 billion.
  - For PPF: £35 billion.

- Reasonable capital buffer + shorter amortisation period can bring down the economic capital requirement further.

Need a holistic view, taking PPF into account, while devising regulations for defined benefit pension sector.

References