Longevity Risk and How to Manage it in Pension Plans

Professor David Blake  
Director  
Pensions Institute  
Cass Business School  
d.blake@city.ac.uk

June 2018
Agenda

- Longevity risk: What is it?
- Longevity risk: How to quantify it?
- Managing longevity risk using insurance solutions
- Managing longevity risk using capital market solutions
- Re-insurance sidecars: Introducing new investors
- A role for government: Issuing Longevity Bonds
- Longevity assets in a diversified portfolio
- Conclusion
Longevity risk:
What is it?
What is longevity risk?

- We systematically underestimate how long people are going to live:
  - Longevity is a slowly-developing trend risk

- Danger of:
  - Individuals outliving their savings:
    - As baby boomers retire, decumulation and longevity risk become key issues
  - Pension plans must provide retirement income security for however long people live:
    - Plan sponsors risk having to divert resources away from dividend and investment programmes
  - Annuity providers inadequately reserving
The past

(Broken limits to life expectancy – Oeppen & Vaupel)
The future

- Will longevity continue to improve?
- Recent improvements have been underestimated
- Mortality now recognized as being a stochastic process
Alternative expert views

- ‘Pessimists’ suggest that life expectancy might level off or decline (Olshansky et al)
  - Impact of obesity, poor diet, global warming etc.
- ‘Optimists’ suggest no natural limit to human life (Vaupel et al)
  - Supported by extrapolative methods
  - Future scientific advances?
Accuracy of official mortality assumptions: actual and projected period life expectancy at birth, UK males, 1966-2031

Shaw (2007, page 16)
### Individual underestimates of life expectancy by age

<table>
<thead>
<tr>
<th>Age</th>
<th>Number of years by which consumers underestimate life expectancy</th>
</tr>
</thead>
<tbody>
<tr>
<td>60-69</td>
<td>4</td>
</tr>
<tr>
<td>50-59</td>
<td>4</td>
</tr>
<tr>
<td>40-49</td>
<td>6</td>
</tr>
<tr>
<td>30-39</td>
<td>6</td>
</tr>
<tr>
<td>20-29</td>
<td>8</td>
</tr>
</tbody>
</table>

**Source:** O’Brien, Fenn, and Diacon, 2005, self-estimated life expectancy compared with GAD forecast life expectancy
Stochastic nature of mortality improvements

- Mortality clearly declining
- But declines are volatile
Range of responses

- Accept longevity risk as legitimate business risk
- Share longevity risk:
  - e.g., via participating annuities with survival credits
- Manage longevity risk using insurance solutions:
  - Buy-outs and buy-ins
- Manage longevity risk using capital market solutions:
  - Manage risk with longevity hedges
  - Securitization

Life Market
Supply and demand in the longevity market

**Hedgers**
- DB Pension Plans
- Annuity Providers
- Pension Insurers
- Reinsurers

**Insurance Markets**

**Investors**
- Life Insurers
- Reinsurers
- ILS* funds
- Other hedge funds
- Other investors

*ILS = Insurance-Linked Securities

**Supply of Longevity**

**Demand for Longevity**
Longevity risk: How to quantify it?
Analysis of causal factors underlying longevity
Causal factors underlying longevity

- Gender
- Geographical location
- Social class
- Income/wealth
- Year of birth (cohort)
Life expectancy at age 65 in the UK/US

Source: J.P. Morgan LifeMetrics data
Male life expectancy at birth: by local authority, 2004-6
Social class

Life expectancy for men at 65 by Social Class, England and Wales

Source: Longitudinal Study, Office for National Statistics
Modelling Socio-Economic Differences in the Mortality of Danish Males Using a New Affluence Index - Andrew J.G. Cairns, Malene Kallestrup-Lamb, Carsten P.T. Rosenskjold, David Blake and Kevin Dowd
Cohort effect: 1930 cohort

[Graph showing age and year with a trend line and color scale indicating annual improvement rate]
Mortality rates in England and Wales for key disease groups
Quantifying longevity risk
Variability in life expectancy

Expected distribution of deaths: male 65

- Life expectancy = 86.6
- Most likely age at death = 90
- 25% chance of dying by age 65

Expected distribution of deaths: male 85

- Life expectancy = 91.6
- Most likely age at death = 86
- 1 in 3 will reach 93 and 5% will reach 100

Source: 100% PNMA00 medium cohort 2007
Longevity risk is driven by three underlying risks:

A. **Modelling Risk**: Risk that probability distribution is incorrectly modelled due to a limited data set.

B. **Trend Risk**: Risk that large unanticipated changes in socio-economic environment or health care significantly improve longevity.

C. **Idiosyncratic Risk**: Risk that mortality rates still vary from the expected outcome as a result of random chance.

Modelling Risk and Idiosyncratic (Random Variation) Risk are greater the smaller the number of scheme members and the greater the distribution of scheme benefits.
Mortality forecasting models

- ‘Process-based’ models
  - Model process of dying or mortality improvement
  - E.g., Risk Management Solutions (RMS)
    Longevity Risk Model uses ‘vitagion categories’ or individual sources of mortality improvement:
      - lifestyle trends including smoking prevalence
      - health environment
      - medical intervention
      - regenerative medicine, such as stem cell research, gene therapy and nanomedicine
      - retardation of ageing, including telomere shortening and caloric restriction
Mortality forecasting models

- ‘Causal’ or ‘explanatory’ models
  - Model causes of death using exogenous explanatory variables
    - e.g. macro-economic variables or socio-economic indicators

- ‘Extrapolative’ projection models
  - Purely data-driven
  - Will only be reliable if the past trends continue:
    - medical advances can invalidate extrapolative projections by changing the trend
Main extrapolative models

- Lee-Carter model:
  - No smoothness across ages or years

- P-spline model:
  - Smoothness across years and ages

- Cairns-Blake-Dowd (CBD) model:
  - Smoothness across ages in same year
Longevity fan chart for 65-year old male (CBD model)
Survivor fan chart for 65-year old male (CBD model)

Note: Derived from the Cairns-Blake-Dowd stochastic mortality model, estimated on English and Welsh male mortality data for 65 year olds over the period 1991-2006
Managing longevity risk using insurance solutions
Managing longevity risk using insurance solutions

- Classified as ‘customized indemnification solutions’
  - since the insurer fully indemnifies the hedger against its specific risk exposure

- These solutions can also be thought of as ‘at-the-money’ hedges
  - since the hedge provider is responsible for any increase in the liability above the current best estimate assumption on a pound-for-pound basis

- Buy-out
- Buy-in
- Longevity insurance contract / insurance-based longevity swap
Swiss Re – Friends’ Provident Longevity swap

- World’s first publicly announced swap in April 2007
  - a pure longevity risk transfer
  - but structured as an insurance contract

- Friends Provident’s £1.7bn book of 78,000 of pension annuity contracts written between July 2001 – December 2006

- Swiss Re makes payments and assumes longevity risk
  - in exchange for undisclosed premium
Managing longevity risk using capital market solutions
Managing longevity risk using capital market solutions

- Small number of capital market securities have been successfully launched since 2006:
  - longevity-spread bond
  - longevity swap
  - $q$-forward
  - tail-risk protection (or longevity bull call spreads)

- Key feature of these is that most are index rather than customized solutions
- They provide hedges and help to securitize the risk
Swiss Re Kortis Bond

- Longevity-spread bond, December 2010
- Issuer: Swiss Re
- Issue: $50m, 8 years
- Purpose: to hedge Swiss Re's own exposure to longevity risk
- Bond holders: exposed to risk of increase in spread between annualized mortality improvements in English & Welsh males aged 75-85 v US males aged 55-65
JPMorgan – Canada Life longevity swap

- World’s first capital market longevity swap in July 2008
- Canada Life hedged £500m of its annuity book:
  - 125,000 lives
  - 40-year swap customized to insurer’s longevity exposure
- Longevity risk fully transferred to investors:
  - Hedge funds and ILS funds
- JPM acts as intermediary and assumes counter-party credit risk
The first capital markets transaction involving a $q$-forward took place in January 2008 between buy-out company Lucida and J.P. Morgan.
### Illustration of q-forward settlement for various outcomes of the realized reference rate

<table>
<thead>
<tr>
<th>Reference rate (Realized rate)</th>
<th>Fixed rate</th>
<th>Notional (GBP)</th>
<th>Settlement (GBP)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0000 %</td>
<td>1.2000 %</td>
<td>50,000,000</td>
<td>10,000,000</td>
</tr>
<tr>
<td>1.1000 %</td>
<td>1.2000 %</td>
<td>50,000,000</td>
<td>5,000,000</td>
</tr>
<tr>
<td>1.2000 %</td>
<td>1.2000 %</td>
<td>50,000,000</td>
<td>0</td>
</tr>
<tr>
<td>1.3000 %</td>
<td>1.2000 %</td>
<td>50,000,000</td>
<td>-5,000,000</td>
</tr>
</tbody>
</table>

*Source: Coughlan et al (2007, Table 1): A positive (negative) settlement means the fixed-rate receiver receives (pays) the net settlement amount.*
Portfolio of q-forward building blocks

<table>
<thead>
<tr>
<th>Age 50-59 Males</th>
<th>Age 60-69 Males</th>
<th>Age 70-79 Males</th>
<th>Age 80-89 Males</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age 50-59 Females</td>
<td>Age 60-69 Females</td>
<td>Age 70-79 Females</td>
<td>Age 80-89 Females</td>
</tr>
</tbody>
</table>
Distribution of liability value in 2018: Before and after hedging

Risk reduction = 86%,  Residual risk = 14%
Tail-risk protection (or longevity bull call spread)

- Five publicly announced deals involving tail risk protection:
  - Aegon with Deutsche Bank in 2012
  - Aegon with Société Générale in 2013
  - Delta Lloyd with RGA Re in 2014 and 2015
  - NN Life with Hannover Re in 2017

- Deep ‘out-of-the-money’ hedge
Distribution of Final Index Value and Potential for Capital Reduction
Bull call spread payoff to hedger

Exhaustion point

Attachment point
Cumulative Pension Risk Transfers by Product and Country, 2007-17

- $102bn UK Buy-outs and Buy-ins
- $79bn US All Transactions
- $22bn Canada
- $101bn UK Longevity Swaps
- $128bn UK Buy-outs and Buy-ins
- $115bn US
Re-insurance sidecars: Introducing new investors
RGA Re and RenaissanceRe set up Langhorne Re in 2018 to target in-force life and annuity business with pension funds and other life companies as third-party sidecar investors.
A role for government: Issuing Longevity Bonds
Three key reasons why governments should issue Longevity Bonds

- Interest in ensuring an efficient annuity market
- Interest in ensuring an efficient capital market for longevity risk transfers
- Best placed to engage in intergenerational risk sharing:
  - will earn longevity risk premium
Decomposition of longevity risk

Total longevity risk

= 

Systematic longevity risk

[Trend risk]

+ 

Specific longevity risk

[Idiosyncratic and modelling risks]
Potential role for government in helping to hedge longevity risk

Tail risk Longevity Bond from age 90 with terminal payment at 100 to cover post-100 longevity risk

Capital markets deal with this segment in long run

Govt. earns longevity risk premium

Expected value 90% confidence
Longevity Bond cash flows across ages and time

- Issue year of bond
- Deferment period on bond
- Payments on bond

YEAR

AGE

BIRTH YEAR
Longevity assets in a diversified portfolio
Efficient frontier with and without longevity swaps

With longevity swap:
- 75% fixed income
- 20.5% equities
- 4.5% longevity swap

Without longevity swap:
- 76.5% fixed income
- 23.5% equities

Source: Aegon
Conclusion
Conclusion

- Longevity risk is real, underestimated and expensive
- It needs to be quantified and managed
- Tools have been developed to do both:
  - Insurance solutions
    - Buy-outs and buy-ins
  - Capital market solutions
    - q-forwards and longevity swaps
Conclusion

- But insufficient capital in insurance/reinsurance industry to deal with global longevity risk:
  - Estimated at $60-80trn
- Capital markets more efficient than insurance industry in:
  - Reducing informational asymmetries
  - Facilitating price discovery
- The Life Market has risks that are uncorrelated with traditional bond and equity markets:
  - which should make it attractive to long-term investors such as SWFs, endowments, family offices, etc
Richard Sandor’s Seven Stages of Market Evolution

<table>
<thead>
<tr>
<th>Number</th>
<th>Stage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Structural change – leading to a demand for capital</td>
</tr>
<tr>
<td>2</td>
<td>Development of uniform commodity/security standards</td>
</tr>
<tr>
<td>3</td>
<td>Introduction of legal instruments providing evidence of ownership</td>
</tr>
<tr>
<td>4</td>
<td>Development of informal spot and forward markets</td>
</tr>
<tr>
<td>5</td>
<td>Emergence of formal exchanges</td>
</tr>
<tr>
<td>6</td>
<td>Introduction of organized futures and options markets</td>
</tr>
<tr>
<td>7</td>
<td>Proliferation of over-the-counter (OTC) markets, deconstruction</td>
</tr>
</tbody>
</table>
Thank you!

Longevity 14:
Fourteenth International Longevity Risk and Capital Markets Solutions Conference
20-21 September 2018
Amsterdam
http://longevity-risk.org