Hilton Newcastle, Gateshead, NE8 2AR.

Longevity risk: asset or liability?

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Contents

1. About the speaker

1. About the speaker

- Consultant on longevity risk since 2005
- Founded longevity-related software businesses in 2006:

- Joint venture with Heriot-Watt in 2009:

2. Why care about longevity risk?

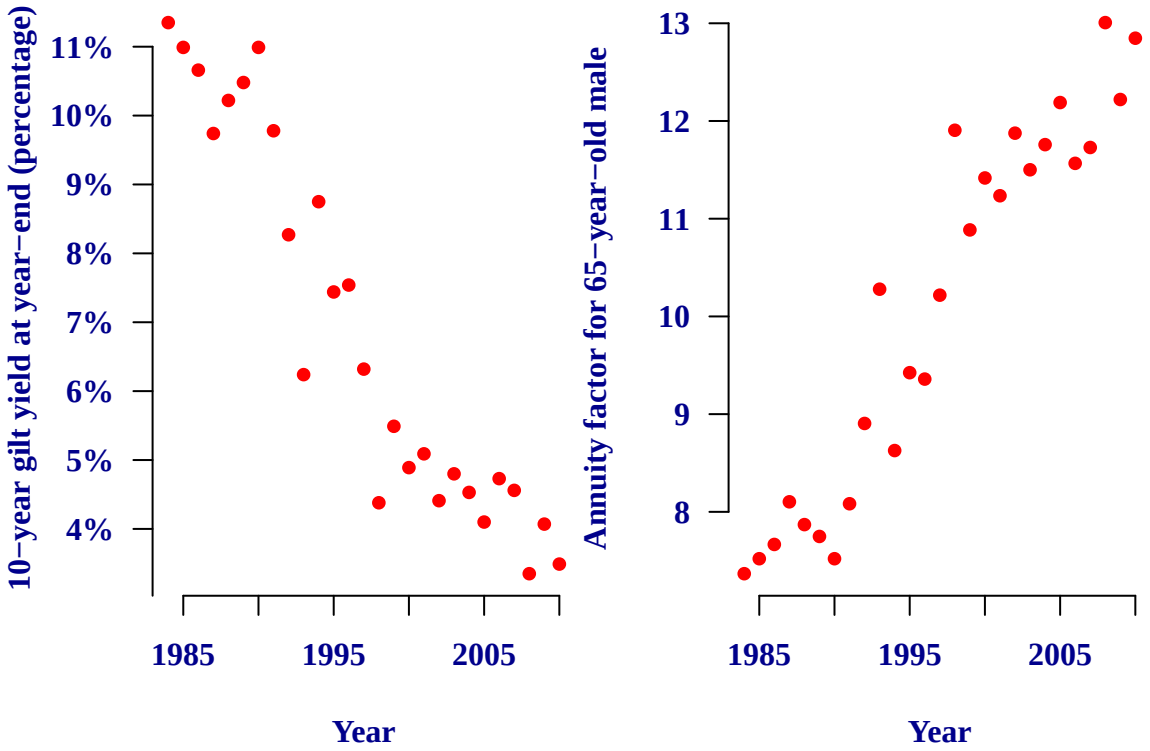
2. Why care about longevity risk?

"By providing financial protection against the major 18th- and 19th-century risk of dying too soon, life insurance became the biggest financial industry of that century [...] Providing financial protection against the new risk of not dying soon enough may well become the next century's major and most profitable financial industry."

Peter Drucker (1999)

2. Why care about longevity risk?

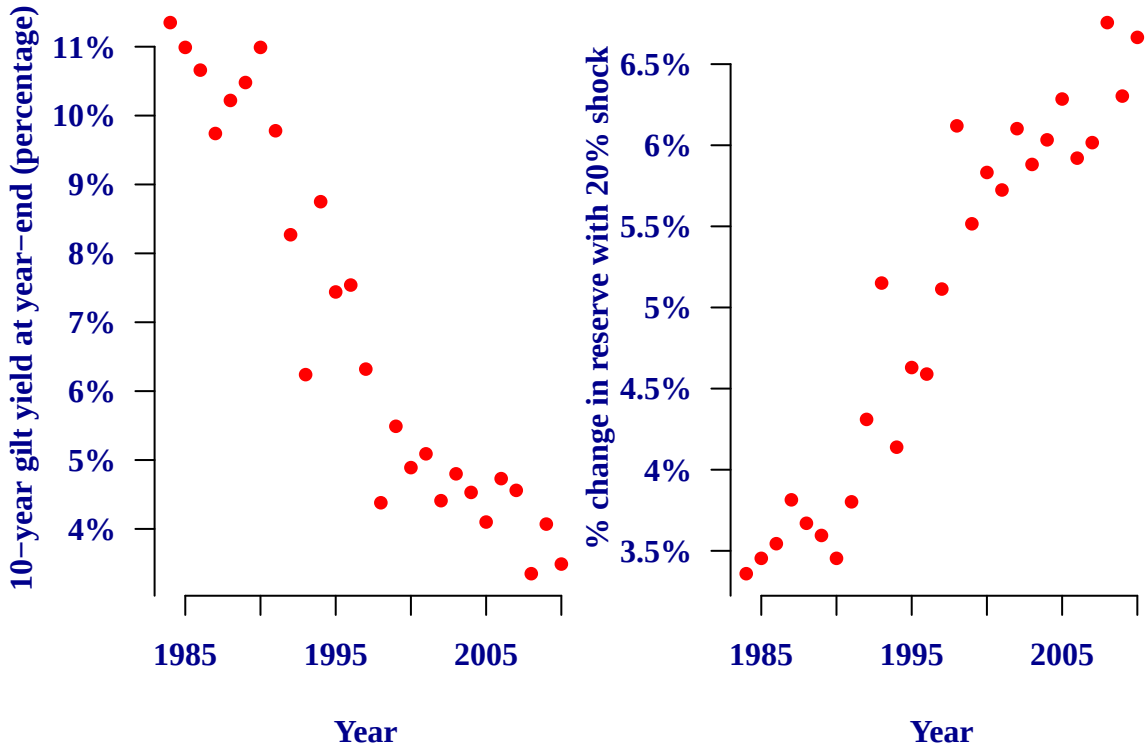
Gilt yields (left) and corresponding $\bar{a}_{65}$ for males (right)



Source: End-year yields from British Government Stock (10-year nominal par yield, series IUAM-NPY from Bank of England) and own calculations for $\bar{a}_{65}$ using S1PA (males) and same yields.

2. Why care about longevity risk?

Gilt yields (left) and change in $\bar{a}_{65}$ from 20% mortality reduction (right)



Source: End-year yields from British Government Stock (10-year nominal par yield, series IUAMNPY from Bank of England) and own calculations for $\bar{a}_{65}$ using S1PA (males) and same yields.

2. Why care about longevity risk?

- In a low-interest environment, longevity risk plays a bigger role

3. Investing in longevity risk

3. Investing in longevity risk

- Equity investors often already long in longevity risk
- Question is how well priced and managed it is

4. Spot the insurance company

Company	Longevity liability (£ billions)
Royal Dutch Shell	38.8
Prudential plc	33.4
BT	33.3
Royal Bank of Scotland	30.8

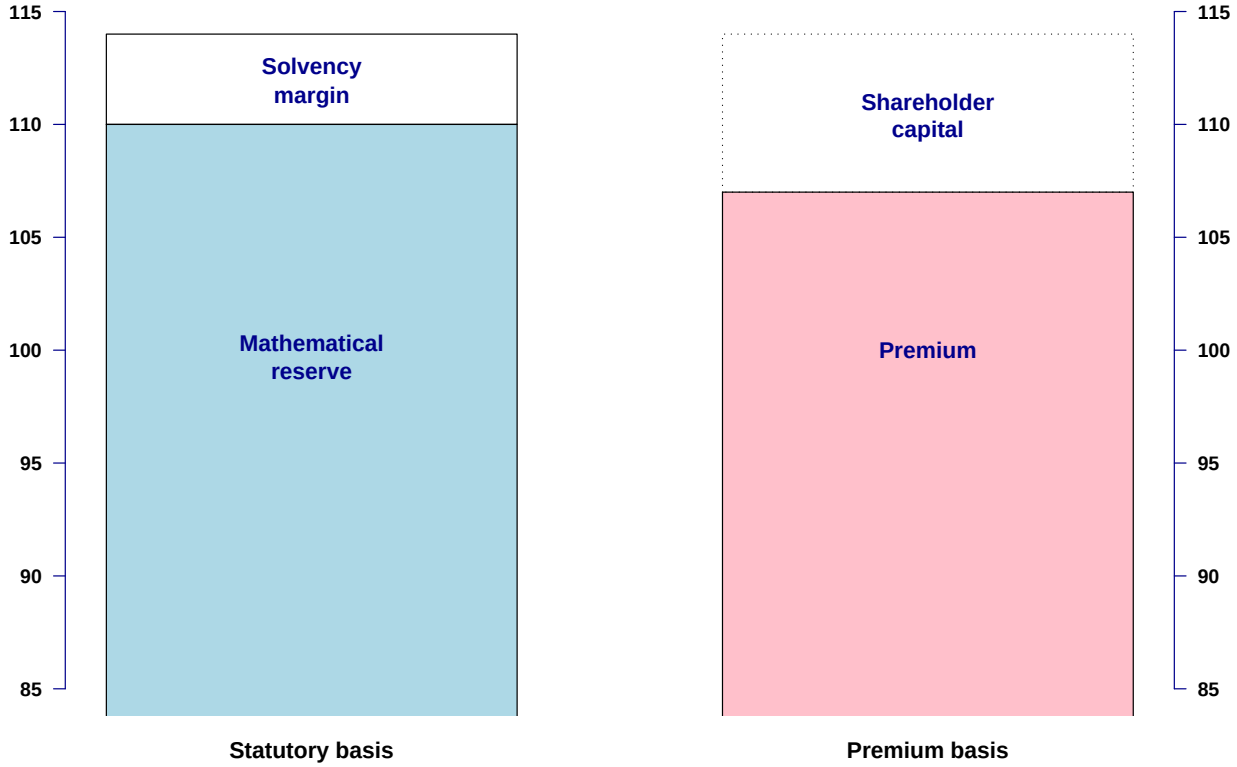
Source: Figure are 2009 pension-scheme liabilities sourced from LCP's "Accounting for pensions 2010" report. The figure for Prudential includes the end-2009 annuity liabilities in the PAL and PRIL subsidiaries.

3. Investing in longevity risk

- Longevity risk often appears in leveraged form

3. Investing in longevity risk

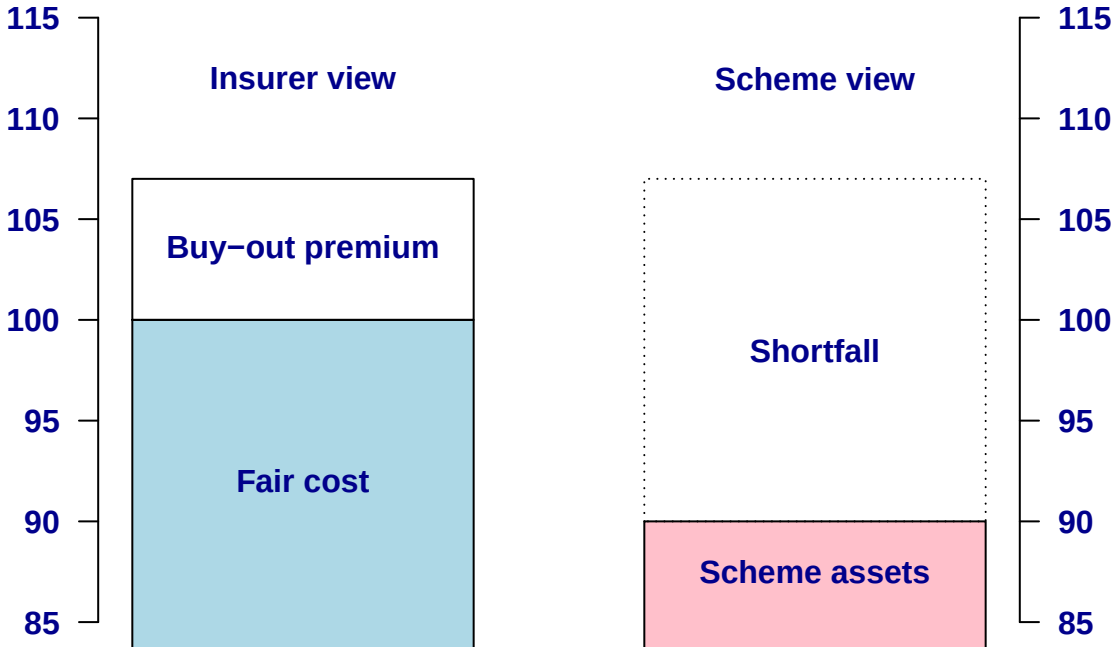
- Position for insurance-company annuities



Source: Richards Consulting

3. Investing in longevity risk

- Position for sponsoring employer



Source: Richards Consulting

3. Spot the insurance company

Company	Liability (£ billions)	Market cap. (£ billions)	Ratio L/M
British Airways	12.8	1.6	791%
BT	33.3	6.0	551%
Invensys	4.8	1.3	364%
Royal Bank of Scotland	30.8	16.6	186%
BAE Systems	20.5	12.7	162%

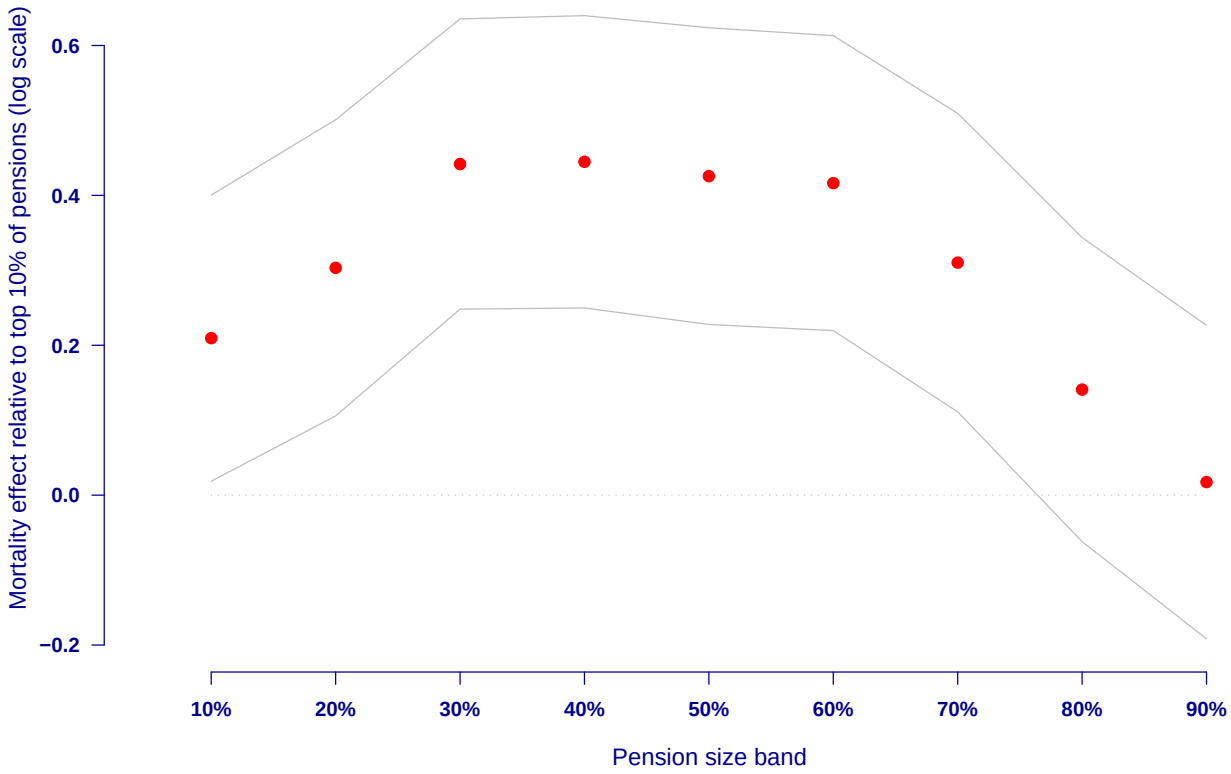
Source: Figure are 2009 pension-scheme liabilities sourced from LCP's "Accounting for pensions 2010" report.

4. Postcodes

4. Traditional risk factors

- Age and gender universally used
- Pension size as proxy for wealth and income

4. Weakness of pension size



4. Modern risk factors

- Pension size imperfect proxy for wealth or income
- Postcode used to augment picture
- Postcodes now routinely used for pricing annuities

4. How not to do postcode profiling

4. Anatomy of UK postcode

4. How not to do postcode profiling

- Compare the postcodes G1 2TD and G12 0PD
- Both in Glasgow
- Life expectancy "6.7 years less than the UK average" [1]

Source: [1] Punter Southall, Postcode Life Expectancy Tool, accessed on 6th June 2011.

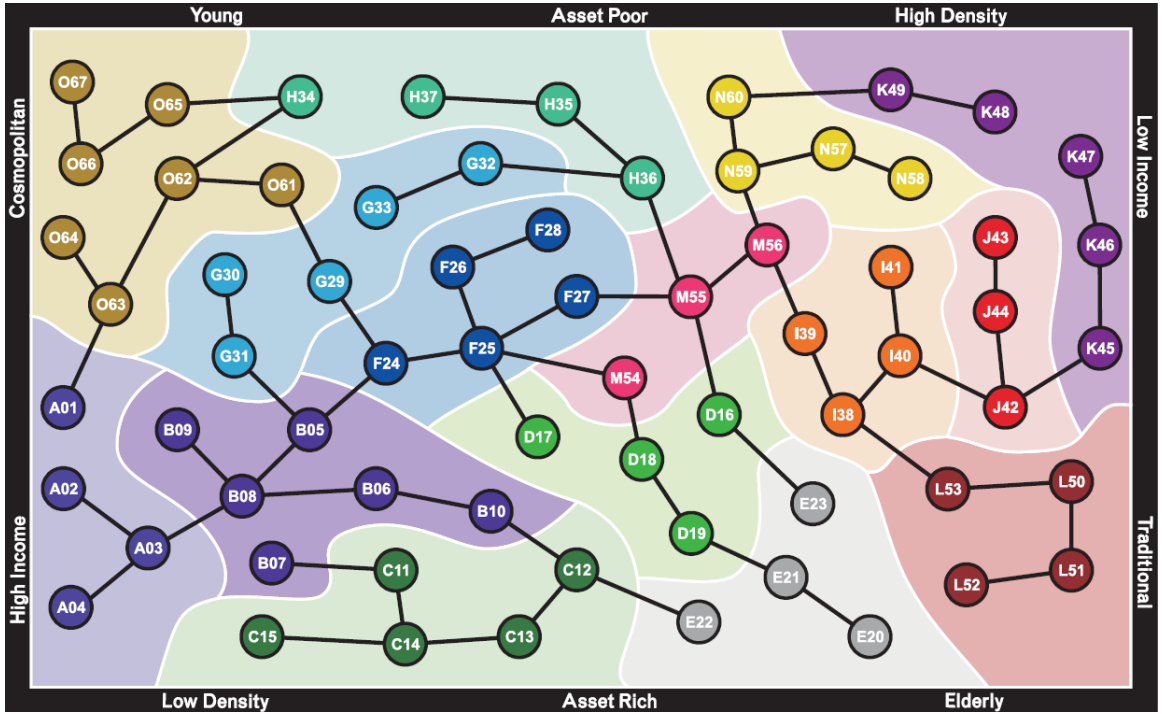
4. Anatomy of UK postcode — G1 2TD

4. Anatomy of UK postcode — G12 0PD

4. How to do postcode profiling

- 1.6 million residential postcodes
- Each maps to a *geodemographic type*

4. Geodemographic example — Mosaic

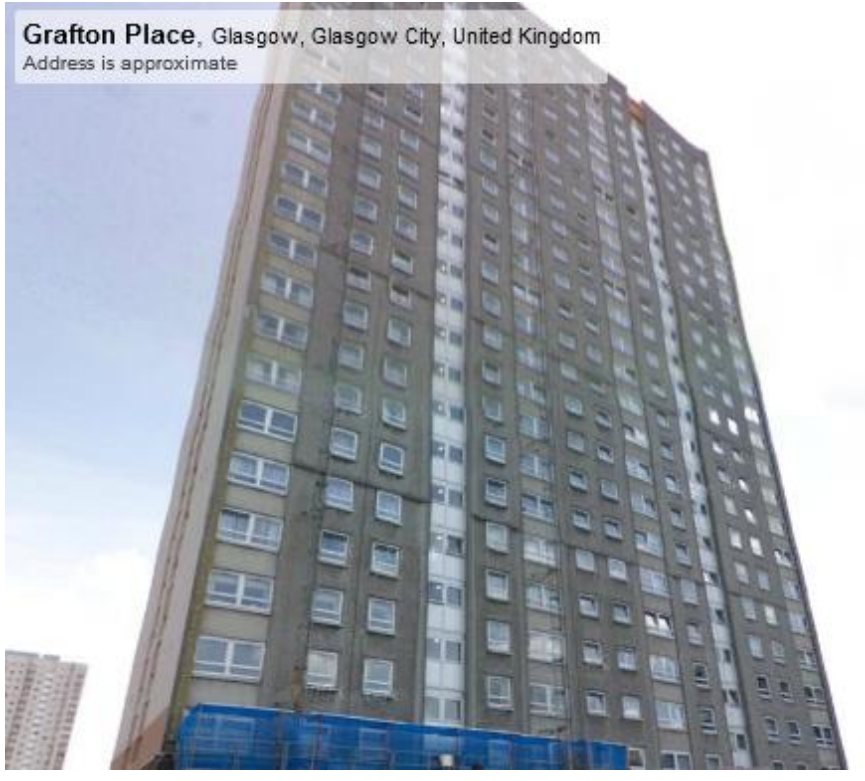


Source: Experian Ltd.

4. Anatomy of UK postcode — G1 2TD

Mosaic Type K47 — “Upper Floor Living, Deprived View”

Acorn Type P54 — “High-Rise Hardship [...] high-rise estates”



4. Anatomy of UK postcode — G12 0PD

Mosaic Type A04 — “Alpha Territory, Serious Money”

Acorn Type D13 — “Well-off professionals, larger houses [...]”

5. Mortality derivatives

5. Survivor forwards

- Derivative contract
- Party A usually has longevity risk, e.g. pension scheme
- Party B usually wants investment exposure to longevity risk

5. Survivor forwards

- Two counterparties agree:
  - (i) a notional value, e.g. £10 million
  - (ii) a reference population, e.g. UK males
  - (iii) a fixed survival rate, e.g. 47% of 60-year-olds survive to age 85
- Party A pays the fixed leg: £10 million × 47%
- Party B pays the floating leg: £10 million × actual survival rate

Source: Taken from Richards (2011)

5. Valuing mortality derivatives

- Payoff is uncertain
- Need a model to forecast future mortality ...
- ... and that model *must* be stochastic

5. Valuing mortality derivatives

- Deterministic models useless as no probability for each forecast
- Not all stochastic models are relevant
- Don't want subjective opinions
- Need model *specifically calibrated to behaviour of index*

5. Valuing mortality derivatives

Q. What is the best estimate of mortality next year?

A. This year's mortality + trend + random element

- Such models are called *extrapolative*

5. Example

- Party A offers fixed leg of survivor risk
- Offers £10 million of exposure for ${}_{25}p_{60}$ for UK males at 47%
- Party B wants to know the likelihood of losing £$\frac{1}{2}$ million or more

5. Seller's view

- Party A uses model from Delwarde, Denuit and Eilers (2007) on data for England and Wales
- Best estimate is ${}_{25}p_{60}$ =46.7%
- Party A says S-forward is £30,000 in the money for Party B
- £30,000 = £10 million × (47% - 46.7%)
- Party A says probability of Party B losing £$\frac{1}{2}$ million or more is 0.13%

Source: Own calculations using DDE model applied to data for males in England and Wales aged between 50 and 104 between 1961 and 2007. Projections are carried out by a drift model from 2008 onwards.

5. Model risk

- How does Party B know this model is correct?
- What are the consequences if it is not?

5. Buyer's view

- Party B uses same DDE model, but with ARIMA projection
- Best estimate is ${}_{25}p_{60}$ =51.6% (cf. 46.7%)
- S-forward is £460,000 *out of the money*
- -£460,000 = £10 million × (47% - 51.6%)
- Probability of losing £$\frac{1}{2}$ million or more is 46.3% (cf. 0.13%!)

Source: Own calculations using DDE model applied to data for males in England and Wales aged between 50 and 104 between 1961 and 2007. Projections are carried out by an ARIMA(3,1,3) model from 2008 onwards.

5. Model risk

- How do you know if a projection model is correct?
- You don't
- Must use different models to explore model risk

6. Basis risk

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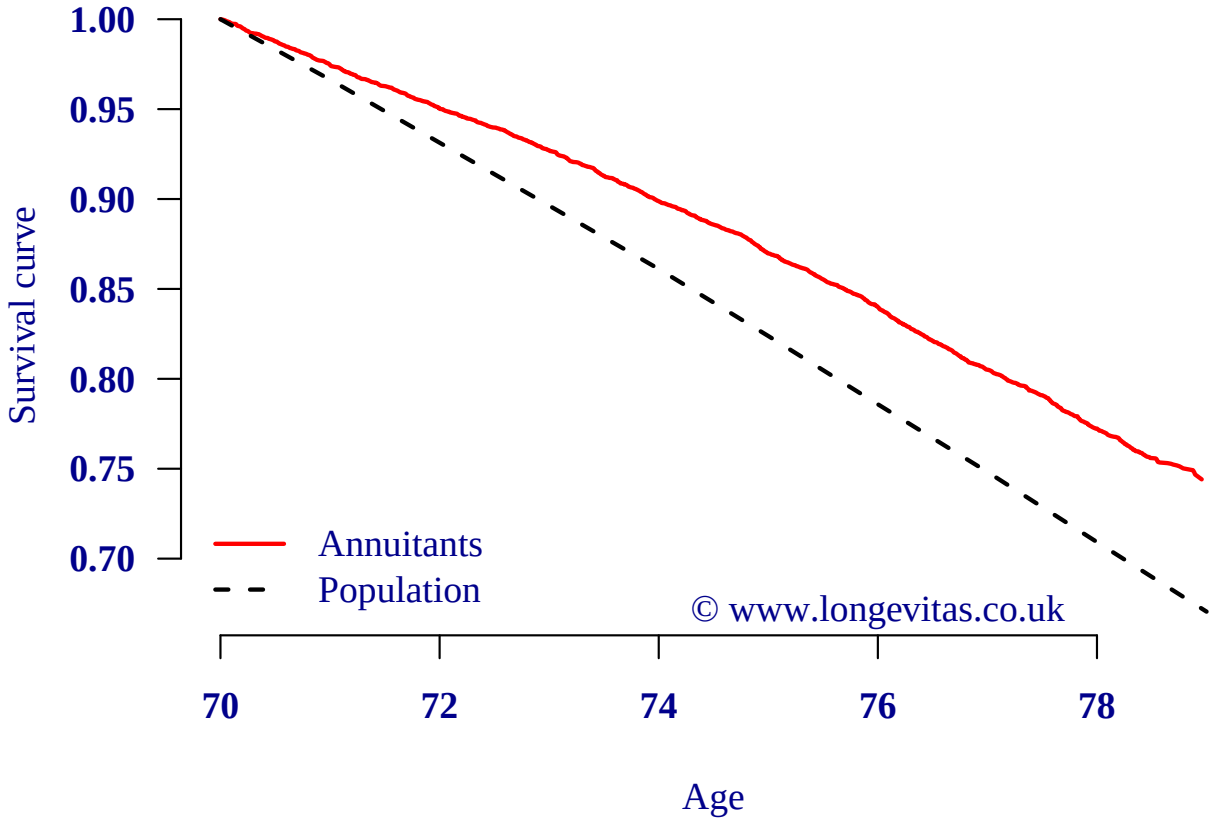
- Assume for a moment that there is a single model for the index
- Will the survivor forward act as a hedge for Party A's liabilities?

6. Basis risk



Source: Own calculations for male annuitants born in 1928 ("Annuitants") and males in England and Wales using ONS data ("Population").

7. Conclusions

- Equity investors already exposed to substantial longevity risk
- How well is it managed?
- Stochastic projection models essential to manage uncertainty
- Dangerous to rely on a single projection model

References

Delwarde, A., Denuit, M. and Eilers, P.H.C. **2007** *Smoothing the Lee-Carter and Poisson log-bilinear models for mortality forecasting: a penalized likelihood approach*, Statistical Modelling, **7**, 29–48

Drucker, P. **1999** *Innovate or die*, The Economist, September 23rd 1999

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