Erskine House, Queen Street, Edinburgh.

Longevity: risk or opportunity?

Stephen Richards
13th June 2011

Contents

0. About the speaker

0. About the speaker

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

LONGEVITAS

mortalityrating.com

- Joint venture with Heriot-Watt in 2009:

PROJECTIONS TOOLKIT

1. Why care about longevity risk?

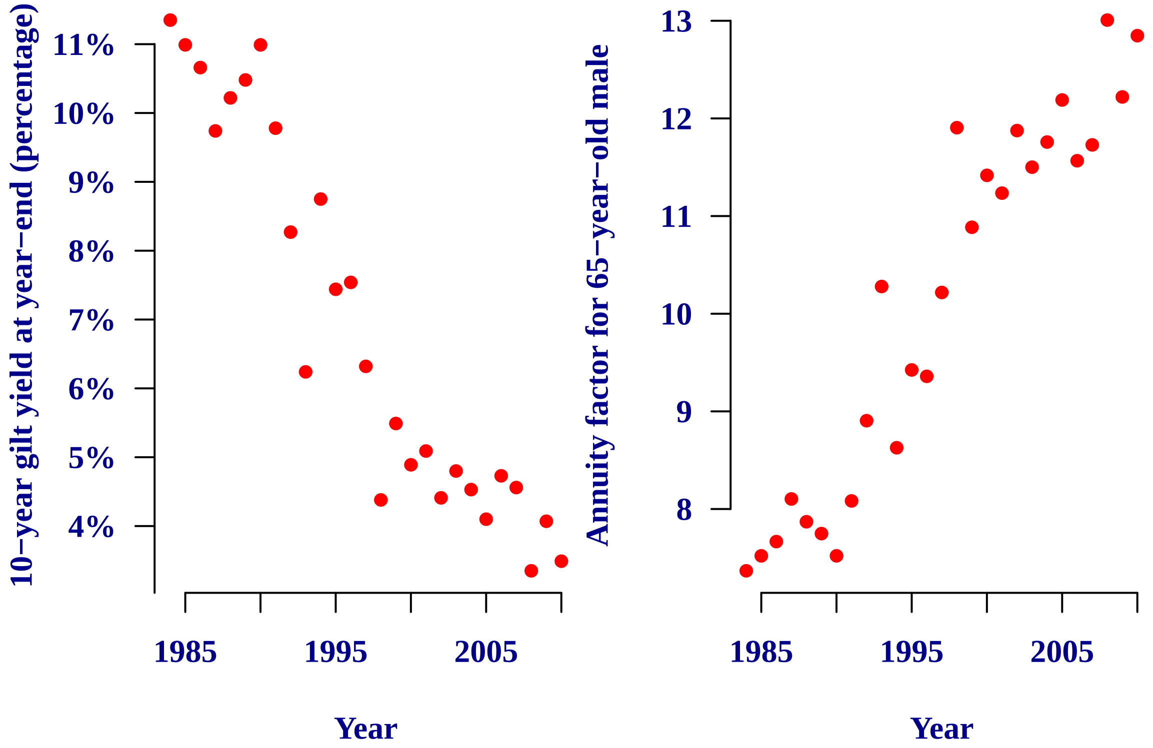
1. Why care about longevity risk?

"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)

1. Why care about longevity risk?

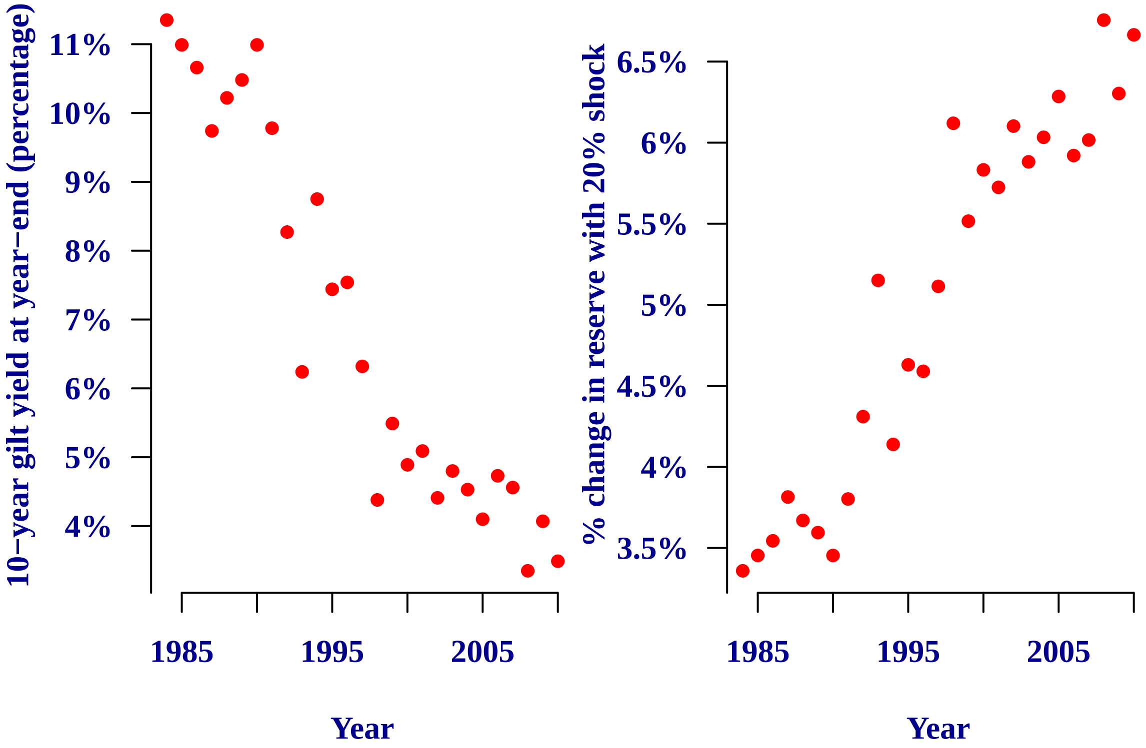
Gilt yields (left) and corresponding $\bar{a}_{65}$ for males (right)



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

1. 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 IUAM-NPY from Bank of England) and own calculations for $\bar{a}_{65}$ using S1PA (males) and same yields.

1. Why care about longevity risk?

- In a low-interest environment, longevity risk plays a bigger role
- But how realistic is a 20% error in mortality rates?

2. EU Gender Directive

2. EU Gender Directive

On 1st March 2011 the ECJ ruled that:

"Taking the gender of the insured individual into account as a risk factor in insurance contracts constitutes discrimination. The rule of unisex premiums and benefits will apply with effect from 21 December 2012."

European Court of Justice

Source: Court of Justice of the European Union, Press release No 12

2. EU Gender Directive

Poor understanding of how insurance business is run:

"different insurance risks can at most be associated statistically with gender"

Advocate General Kokott

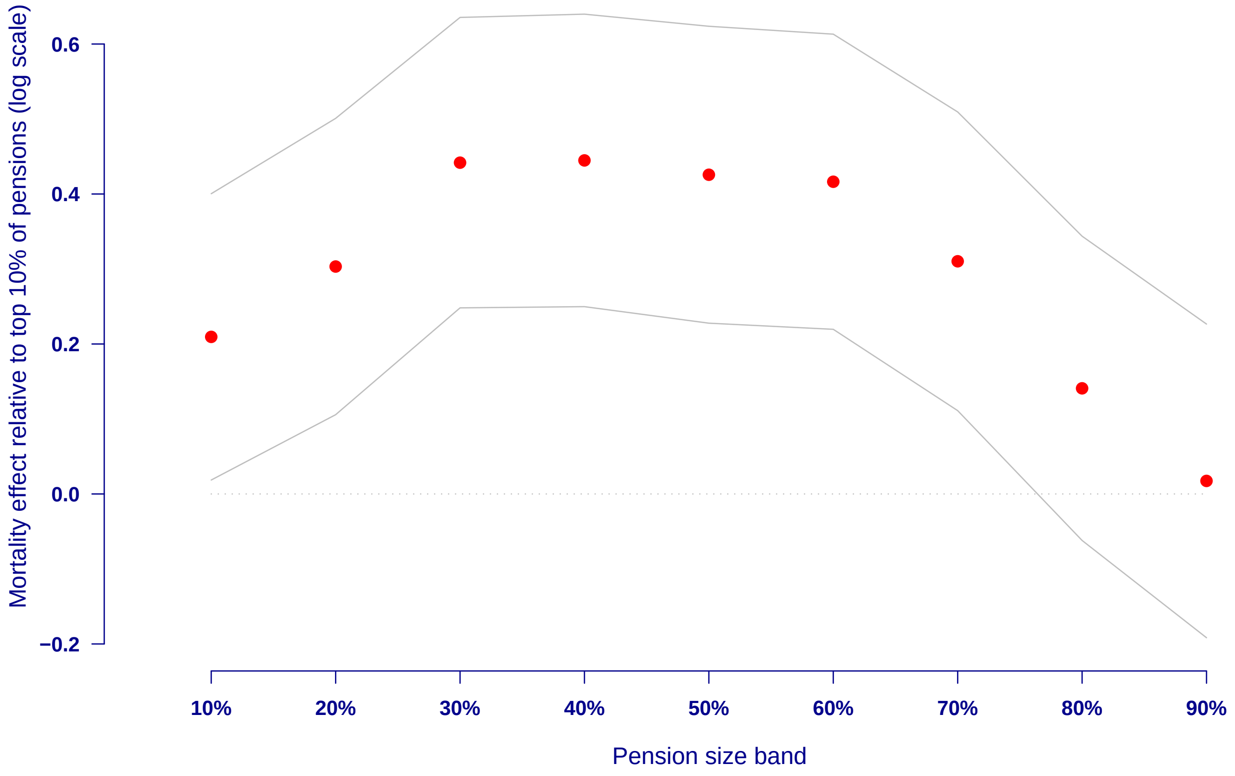
Source: Court of Justice of the European Union, Press release No 93/10

3. Postcodes

3. Traditional risk factors

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

3. Weakness of pension size



3. Modern risk factors

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

3. How not to do postcode profiling

3. Anatomy of UK postcode

3. 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.

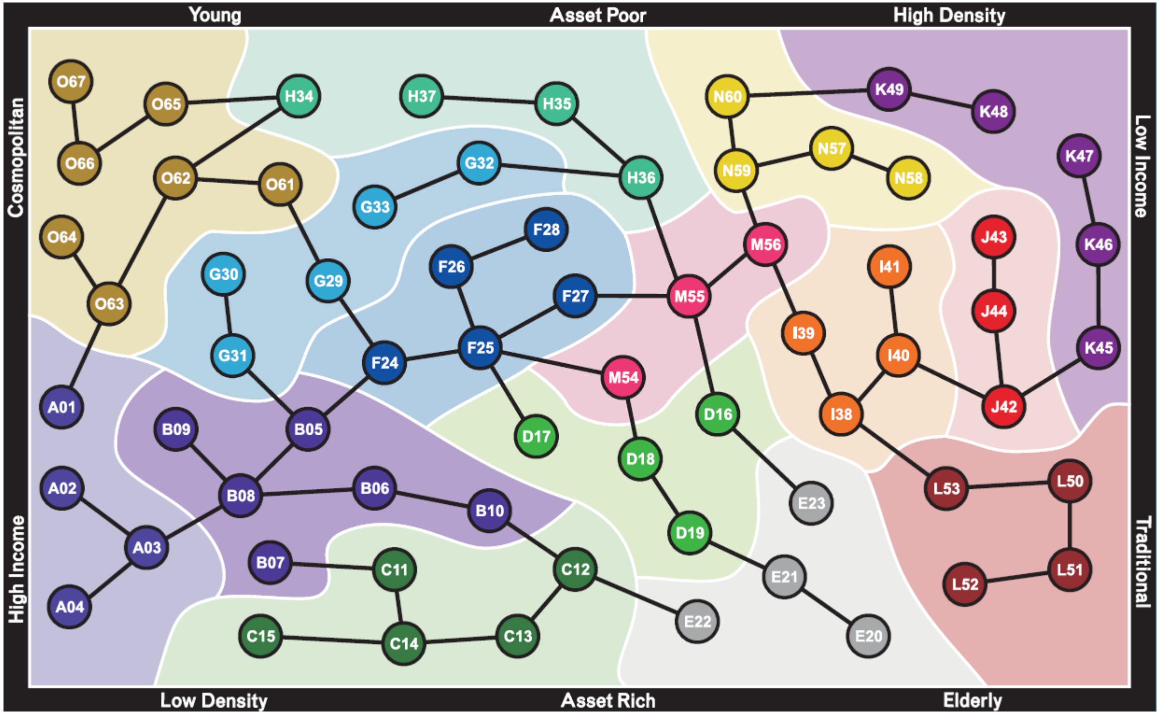
3. Anatomy of UK postcode — G1 2TD

3. Anatomy of UK postcode — G12 0PD

3. How to do postcode profiling

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

3. Geodemographic example — Mosaic



Source: Experian Ltd.

3. Anatomy of UK postcode — G1 2TD

Mosaic Type K47 — "Upper Floor Living, Deprived View"

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

3. Anatomy of UK postcode — G12 0PD

Mosaic Type A04 — “Alpha Territory, Serious Money”

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

4. Longevity risk under Solvency II

4. Spot the difference

1. An annuity is a guarantee to pay a given sum each year until death.
2. A pension is a promise to pay a given sum each year until death.

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.

4. Solvency II

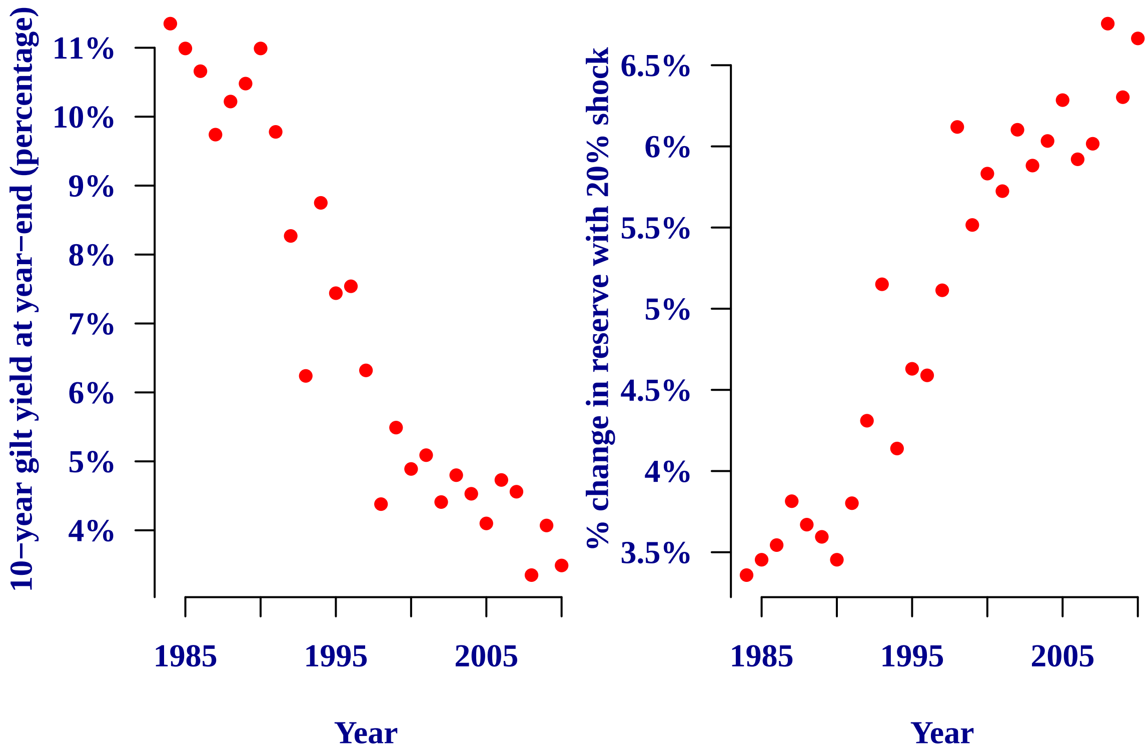
- Why are only Prudential's liabilities subject to Solvency II?
- Are the other three not also annuity businesses?

4. Longevity risk under Solvency II

- QIS 5 demands reserves withstand a 20% shock reduction in mortality
- How realistic is a 20% shock or error in mortality rates?

4. Impact of a 20% shock or error in mortality rates

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.

4. How realistic is a 20% error in mortality rates?

- Postcode G12 0PD

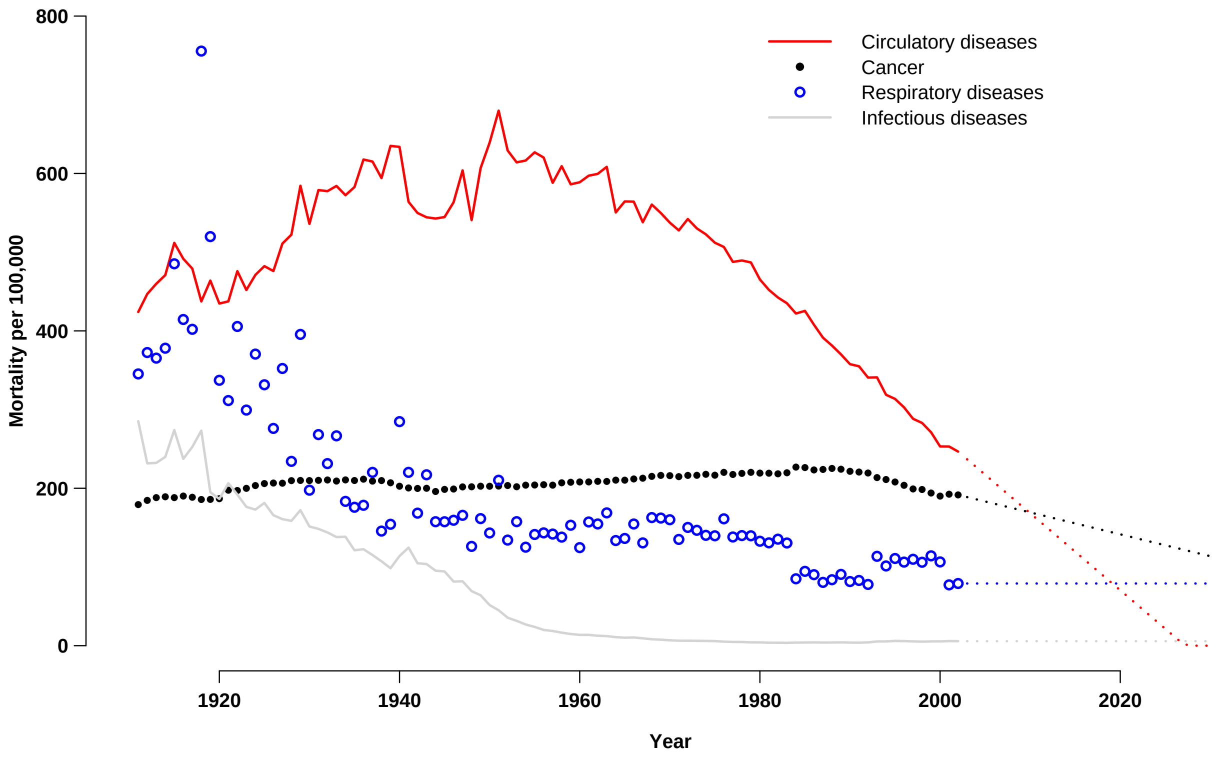
4. How realistic is a 20% error in mortality rates?

- Postcode G12 0PD
- Life expectancy "6.7 years less than the UK average"[1]
- "Theoretical difference [of 20.1%] in annuity payments compared to the UK average"[2]

Source: [1], [2] Punter Southall, Postcode Life Expectancy Tool, accessed on 6th June 2011.

5. Trends by cause of death

5. Mortality rates by broad cause groups



Source: ONS data for England and Wales.

5. Mortality projections

- Many ways to categorise mortality projections
- Contrast all-cause v. cause-of-death

5. Mortality projections — all cause

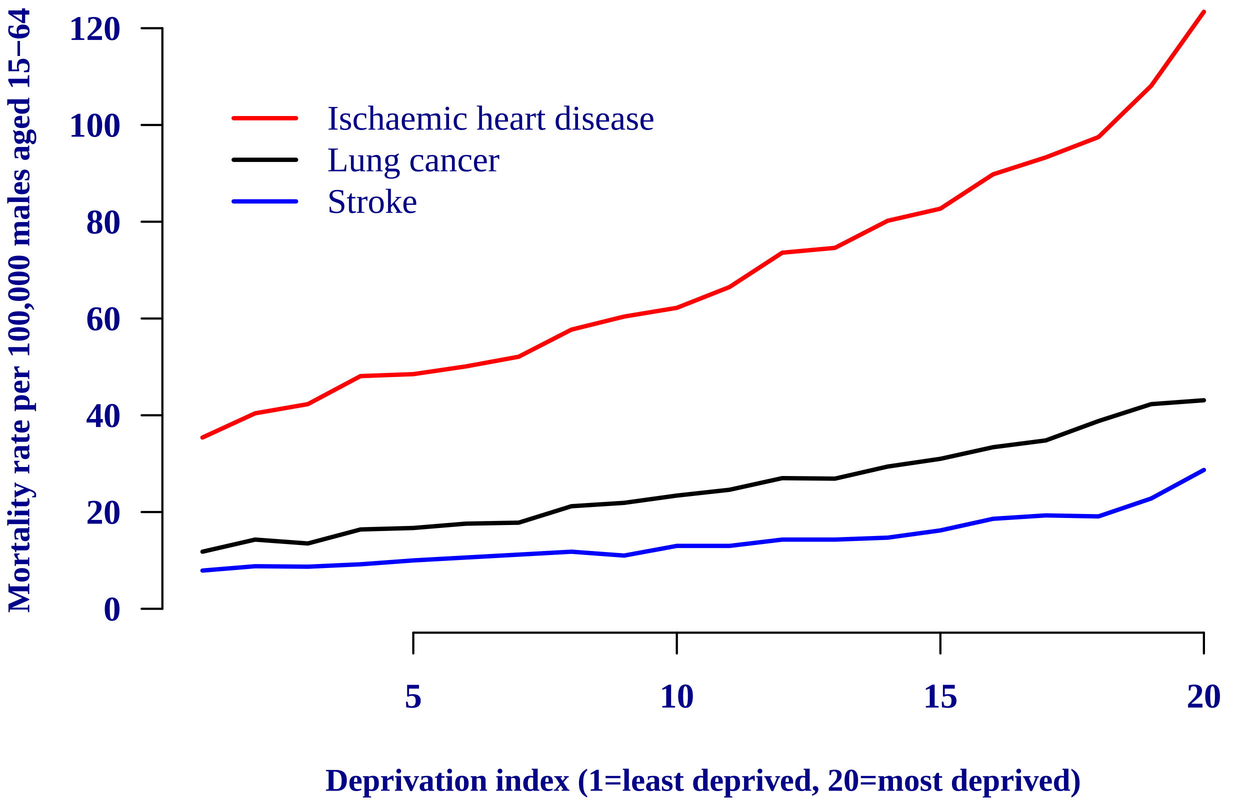
– Basis risk: population mortality different from private pensioners

+ Reliable data: little doubt is someone is dead

5. Mortality projections — cause-of-death

- Basis risk: population mortality different from private pensioners
- Extra basis risk from socio-economic skewing
- Bias to under-estimating mortality improvements (Wilmoth, 1995)
- Changing categorization
- Changes in coding guidelines for doctors
- Uncertain data quality

5. Mortality projections — cause-of-death

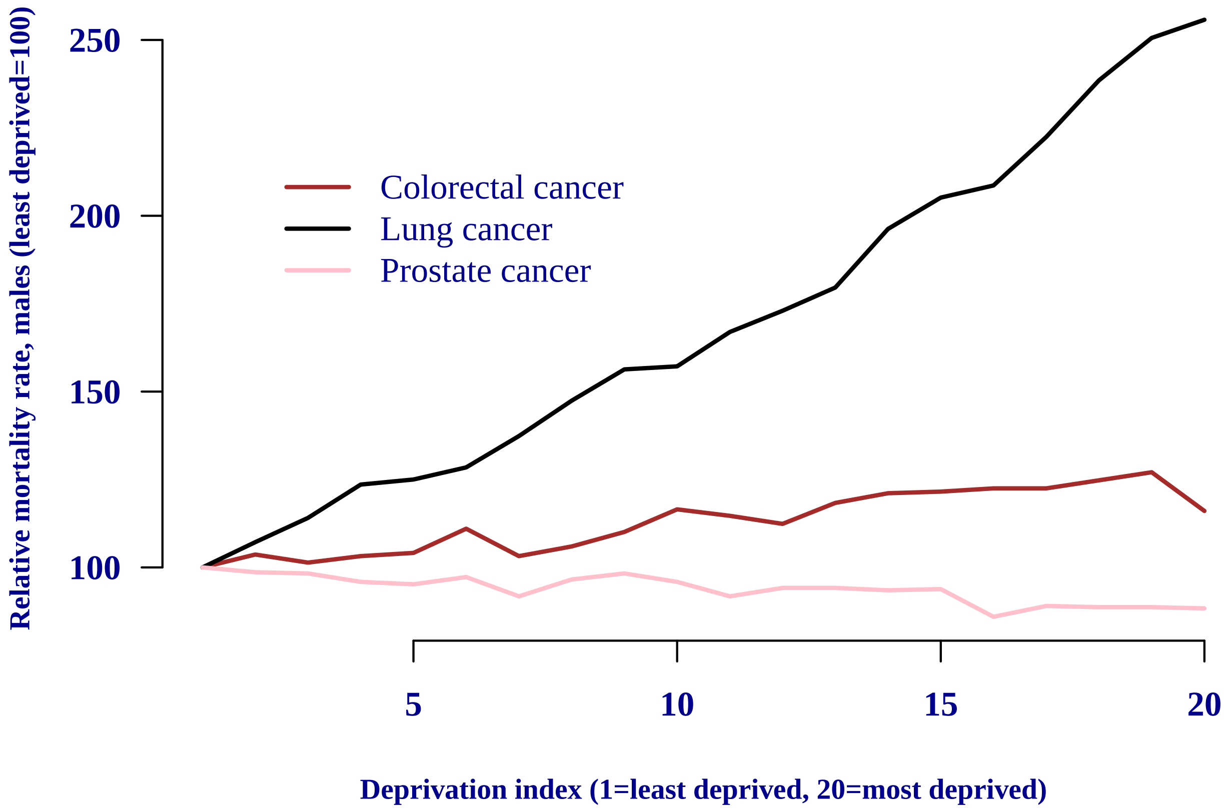


Source: Richards (2010a)

5. Mortality projections — cause-of-death

- Different socio-economic groups over- and under-represented
- Is the relationship at least constant across causes?

5. Mortality projections — cause-of-death



Source: Richards (2010a)

5. Data quality by cause

"Mortality by cause of death is thought to be particularly inaccurate at high ages [. . .] Unfortunately, it is at these high ages where most of the temporal dynamics are occurring."

Oeppen (2008)

5. Data quality by cause

Ages	Deaths
50–54	175
55–59	216
60–64	379
65–69	731
70–74	1,463
75–79	2,821
80–84	3,653
85+	7,380

Source: Male deaths for ICD-9 code 4850 (Bronchopneumonia, organism unspecified) in England and Wales in 2000. Source: 20th Century Mortality.

5. The limits of expert opinion

"Expectation is not generally a good basis for mortality forecasting, as it is subjective; expert expectations are invariably conservative [...] The disadvantage is its subjectivity and potential for bias."

Booth and Tickle (2008)

5. The limits of limits

"experts have repeatedly asserted that life expectancy is approaching a ceiling: these experts have repeatedly been proven wrong."

Oeppen and Vaupel (2002)

5. Trends by cause-of-death

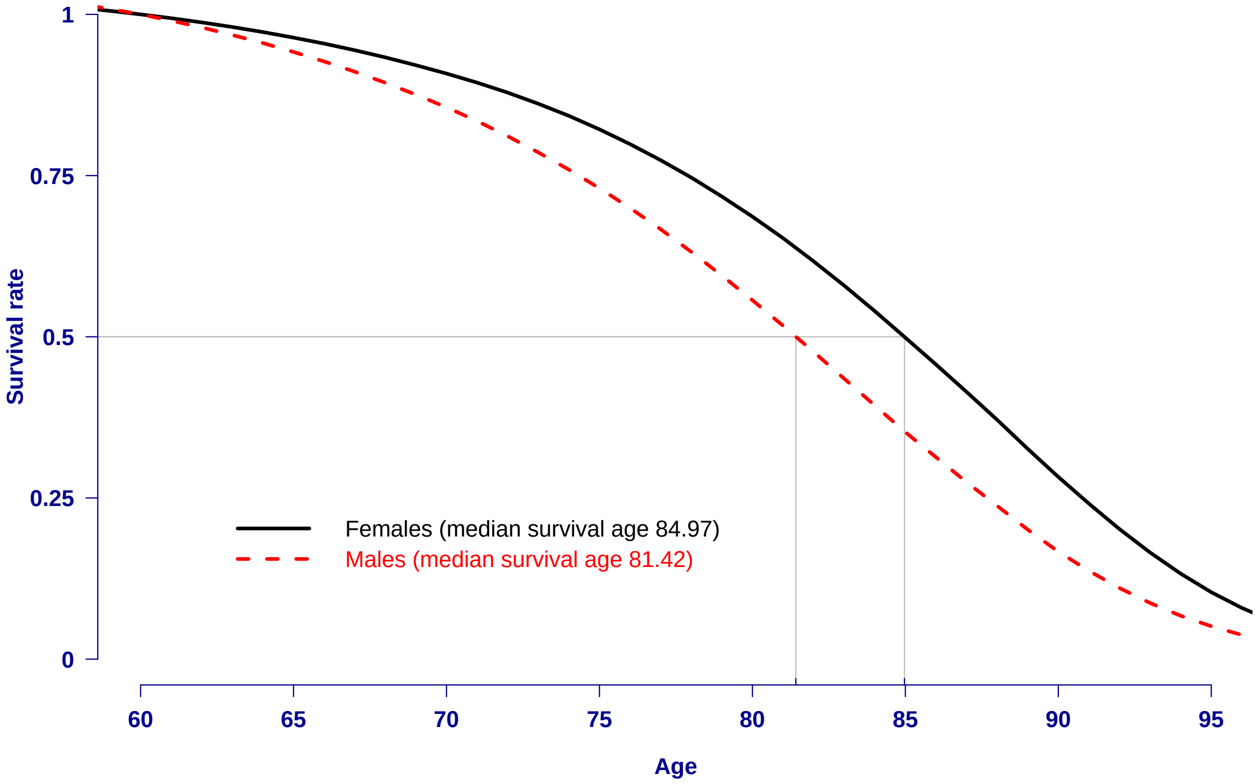
- Some interesting insights into broad sweep of past changes…
- …but a questionable basis for projections
- List of other problems at Richards (2011b)

6. Survival analysis

6. Survival curves

- A survival curve shows the proportion surviving to each age, i.e. ${}_tp_x$

6. Survival curves



Source: UK Interim life tables for 2004-2006.

6. Survival curves

- A survival curve shows the proportion surviving to each age, i.e. ${}_tp_x$
- Lots of handy technical properties:
  - (i) Area under curve is the life expectancy
  - (ii) 50% survival point is median age at death
  - (iii) Wide academic literature on survival analysis

6. Survival curves

- Survival curve is the foundation for valuing pensions and annuities
- Natural way to look at — and manage — longevity risk

7. Mortality derivatives

7. Survivor forwards

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

7. 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 (2011a)

8. Valuing mortality derivatives

8. Valuing mortality derivatives

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

8. 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*

8. 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*

8. 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

8. 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.

8. Model risk

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

8. 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.

8. Model risk

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

9. Basis risk

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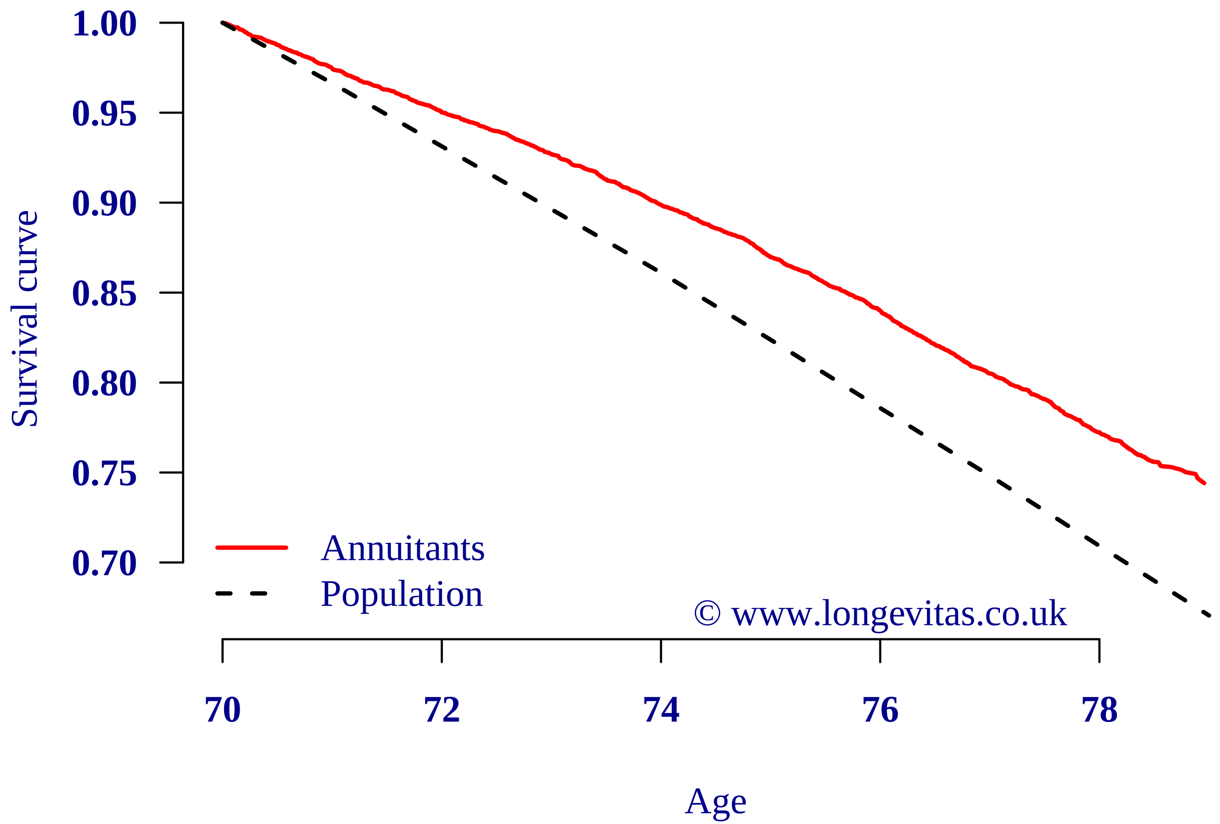
- Assume for a moment that there is a single model for the index
- Will the survivor forward act as a hedge for Party A's liabilities?

9. Basis risk



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

10. Conclusions

- Survival curves a natural way to approach longevity risk
- Stochastic projection models essential to manage uncertainty
- All-cause projections more robust than cause-of-death methods
- Dangerous to rely on a single projection model
- For hedging must consider basis risk

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