Pensions Convention, St Andrews

Longevity — the hidden risk

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About the author

- 1990 — graduated Heriot-Watt
- 1994 — qualified F.F.A.
- 1995 — consulting in Germany
- 1997 — joined Standard Life
- 2003 — Head of Mortality Risk at Prudential
- 2005 — independent consultant on longevity risk

New capacity in bulks market

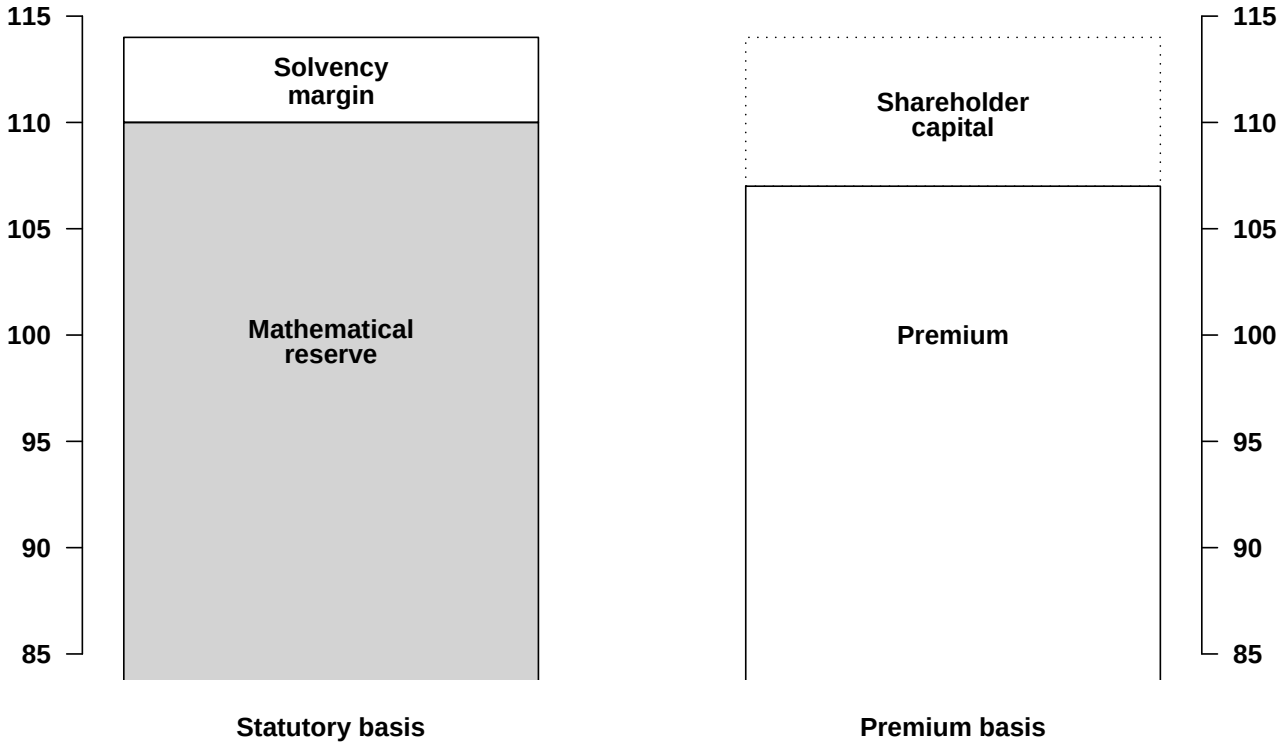
- Established insurers entering bulks market (NU, AIG)
- Start-ups entering bulks market (Paternoster, Synesis)

Longevity risk — plan of talk

- How investors (should) view longevity risk
- How life offices approach longevity risk
- New developments and techniques
- Summary and questions

How investors (should) view longevity risk

Annuity business is highly leveraged



Source: Richards Consulting report on Pricing and Capital Management for Annuity Portfolios.

What investors want to know

- How much capital do you need?
- When will I get it back?
- What return on my capital will I get?
- What volatility does this return have?
- Traditional actuarial calculations don't answer these questions.

Pricing and return on capital (IRR)

Age at outset (years)	IRR (% per annum) Males	Females
55	27	32
60	22	25
65	20	21
70	20	20
75	22	21
80	26	23

Source: Richards Consulting report on Pricing and Capital Management for Annuity Portfolios. Level annuity payable continuously to a single life. Pricing and assumed actual experience: (i) 4.50% annual interest rate, earned continuously; (ii) 100% of μ_x according to PMA92/PFA92, with no mortality improvements; (iii) 75bps margin offset to annual interest rate. Statutory reserving basis: (i) 40bps offset to realistic interest rate; (ii) 10% deduction from mortality table percentage; (iii) 5% EU solvency margin.

Reduced average IRR achieved if mortality experience is 10% lighter

Age at outset (years)	IRR (% per annum) Males	IRR (% per annum) Females	Change in IRR (% per annum) Males	Change in IRR (% per annum) Females
55	25	30	-2.3	-2.1
60	19	22	-3.6	-3.2
65	15	17	-5.3	-4.5
70	13	14	-7.2	-6.0
75	12	13	-9.8	-7.9
80	13	12	-13.2	-10.3

Source: Richards Consulting report on Pricing and Capital Management for Annuity Portfolios. Level annuity payable continuously to a single life. Pricing: (i) 4.50% annual interest rate, earned continuously; (ii) 100% of μ_x according to PMA92/PFA92, with no mortality improvements; (iii) 75bps margin offset to annual interest rate. Statutory reserving basis: (i) 40bps offset to realistic interest rate; (ii) 10% deduction from mortality table percentage; (iii) 5% EU solvency margin. Actual mortality experience is assumed to be 90% of pricing level.

How life offices approach longevity risk

- Rediscovery of longevity as a stochastic process
- Future lifetime is a random variable
- Identification of components of longevity risk
- Each component has a cost, and therefore a price

Sources of uncertainty over longevity risk

1. Concentration
2. Stochastic risk
3. Heterogeneity
4. Trend risk
5. Estimation risk

Concentration of risk

Scheme	Members	Concentration*
E	40	11%
H	800	12%
C	5,300	6%

Largest scheme (C) pays 50% of all pensions to just 6% of members.

Source: Richards Consulting calculations using Prudential data.

*Concentration is the percentage of members accounting for half of all pensions in payment.

Stochastic risk

Scheme	Safety premium* 95%	99%
E	25.6%	37.2%
H	4.8%	6.7%
C	2.1%	3.0%

Law of large numbers favours schemes with more members.

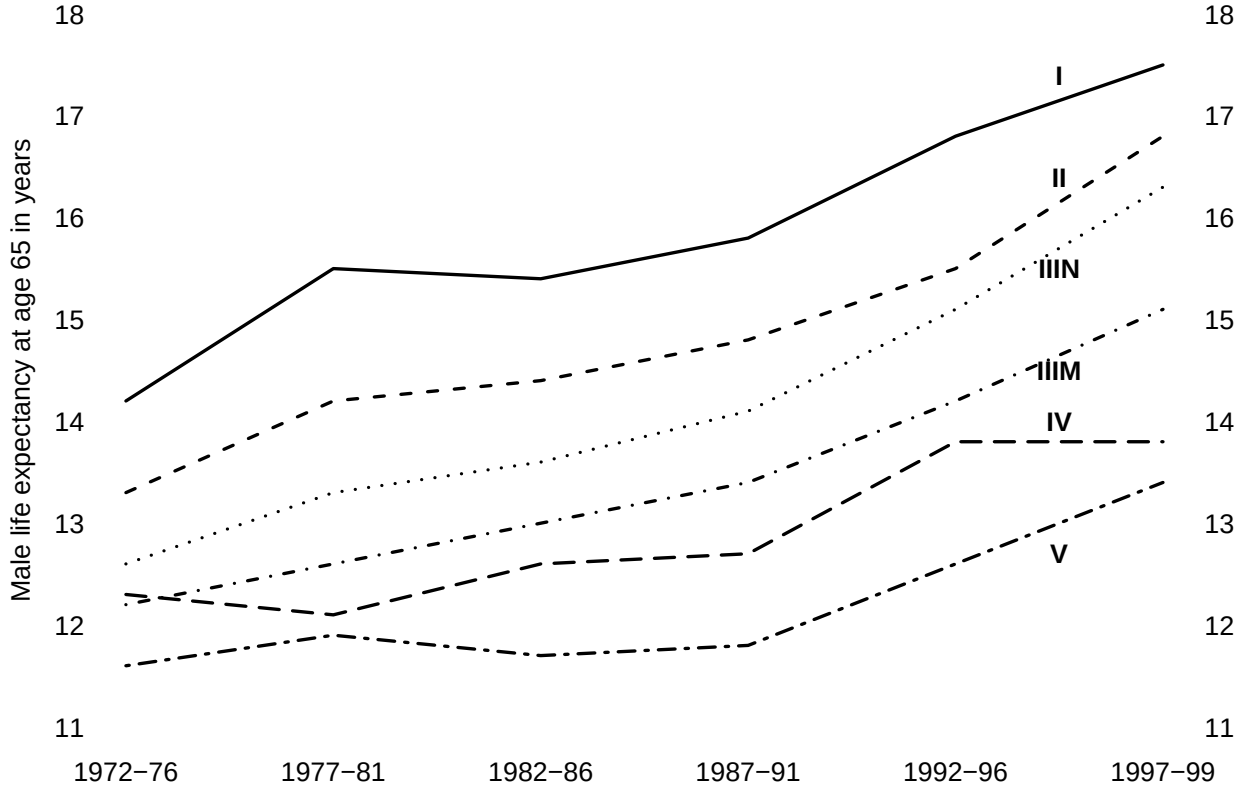
Source: Richards Consulting calculations using Prudential data.

*Safety premium is the extra funds above average in 10,000 simulations to ensure given probability of meeting all benefits in run-off according to PM/FA00 without any future improvements. Benefits valued at 2.5% per annum interest to allow for indexation.

Heterogeneity risk

- Lives not identical
- Longest-lived lives tend to be those with biggest liabilities
- Figures for stochastic risk are therefore under-estimates.

Retirement life expectancy by socio-economic group



Source: ONS Longitudinal Survey.

Trend risk

Basis	e_{65}	a_{65}
No improvements	16.53	12.85
Central projection	20.09	14.84
95^{th} percentile	20.92	15.28

- 15.5% extra reserves between 'no improvements' and central projection.
- Further 3.1% reserves between central projection and 95^{th} percentile.
- Trend risk not diversifiable like stochastic risk.

Source: Richards Consulting calculations using population data for males aged 20–100 in England & Wales between 1961 and 2003. Projection is P-spline with age and cohort penalties. Annuities calculated in arrears using 2.5%.

Estimation risk — Part I

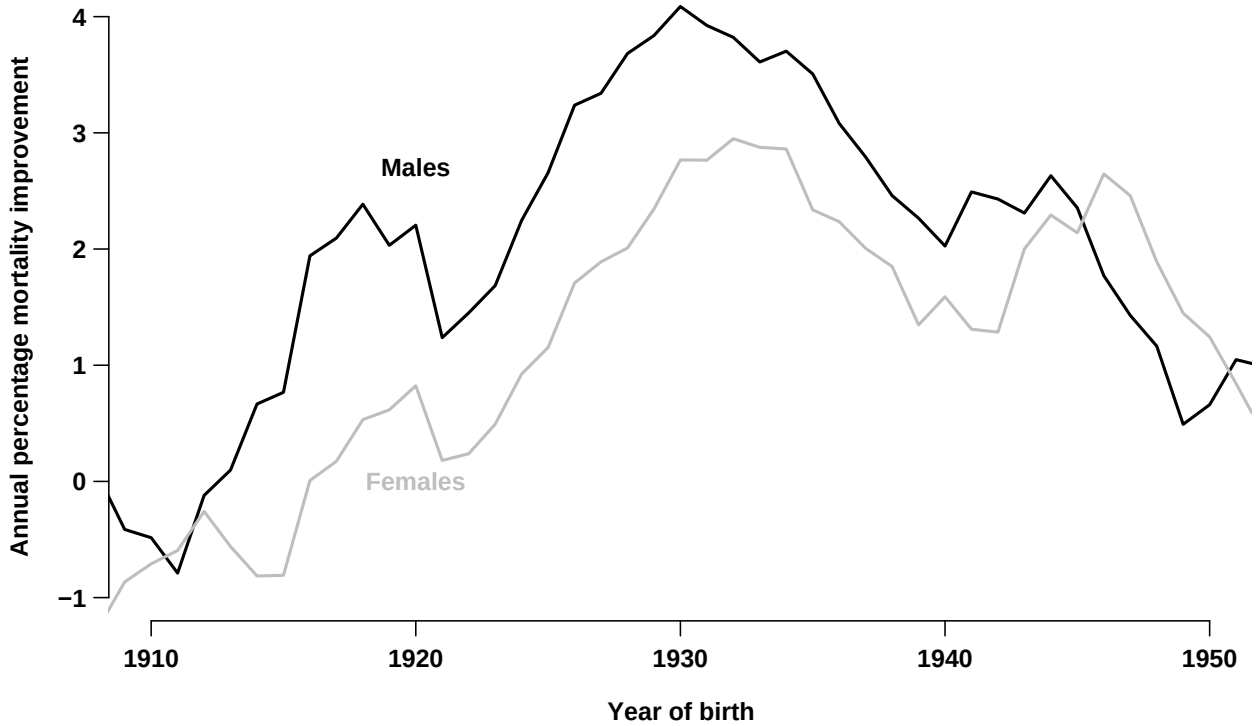
Financial impact of mortality rating factors

Factor	Step change	Reserve	Change
Base case	-	13.39	-
Gender	Female-male	12.14	-9.3%
Lifestyle	Top-bottom	10.94	-9.9%
Duration	Short-long	9.88	-9.7%
Pension size	Large-small	9.36	-5.2%
Region	South-North	8.90	-4.9%
Overall	-	-	-33.6%

Source: Richards and Jones (2004), page 39.

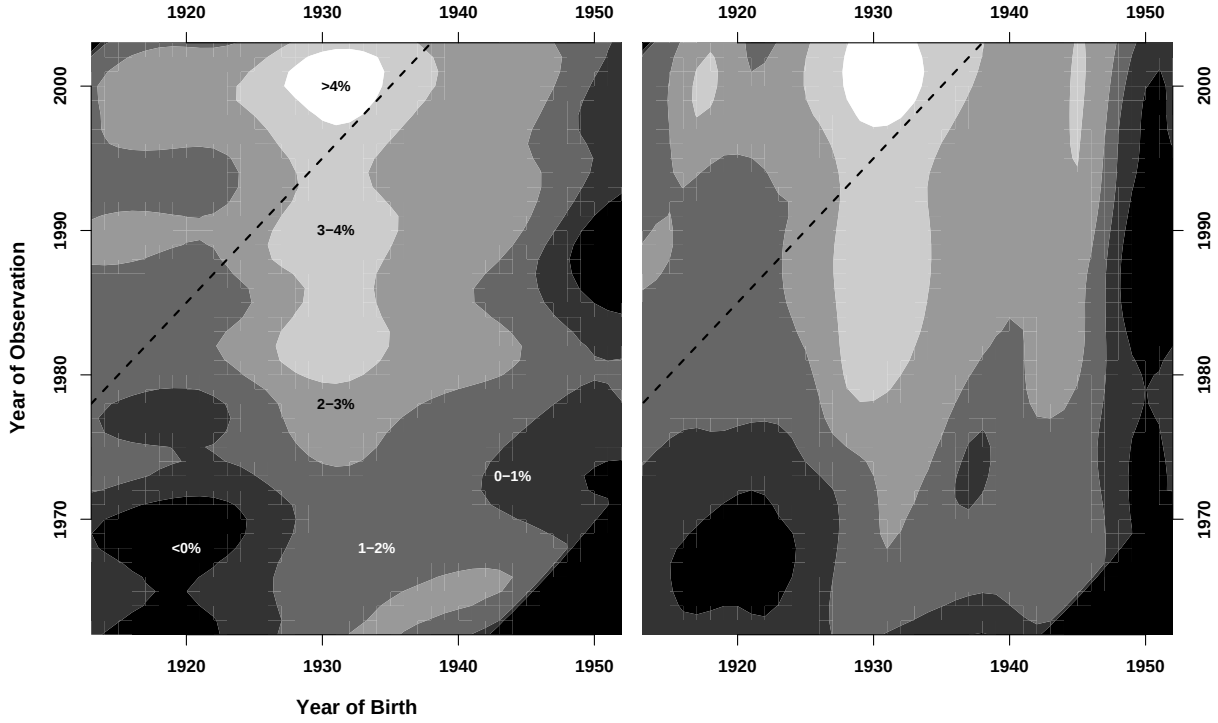
New developments and techniques

Mortality improvements by year of birth



Source: Own calculations with GAD interim life tables for 2000–2002 and 2001–2003.

Mortality improvements



Source: Richards, Kirkby and Currie (2005). Male mortality improvements after smoothing mortality rates in two dimensions using penalised splines.

Mortality improvements

- Improvements accelerated over the past forty years
- Why would this stop soon?
- Do the peak improvements really lie in the past?
- Will improvements really tail off to zero in ten years?

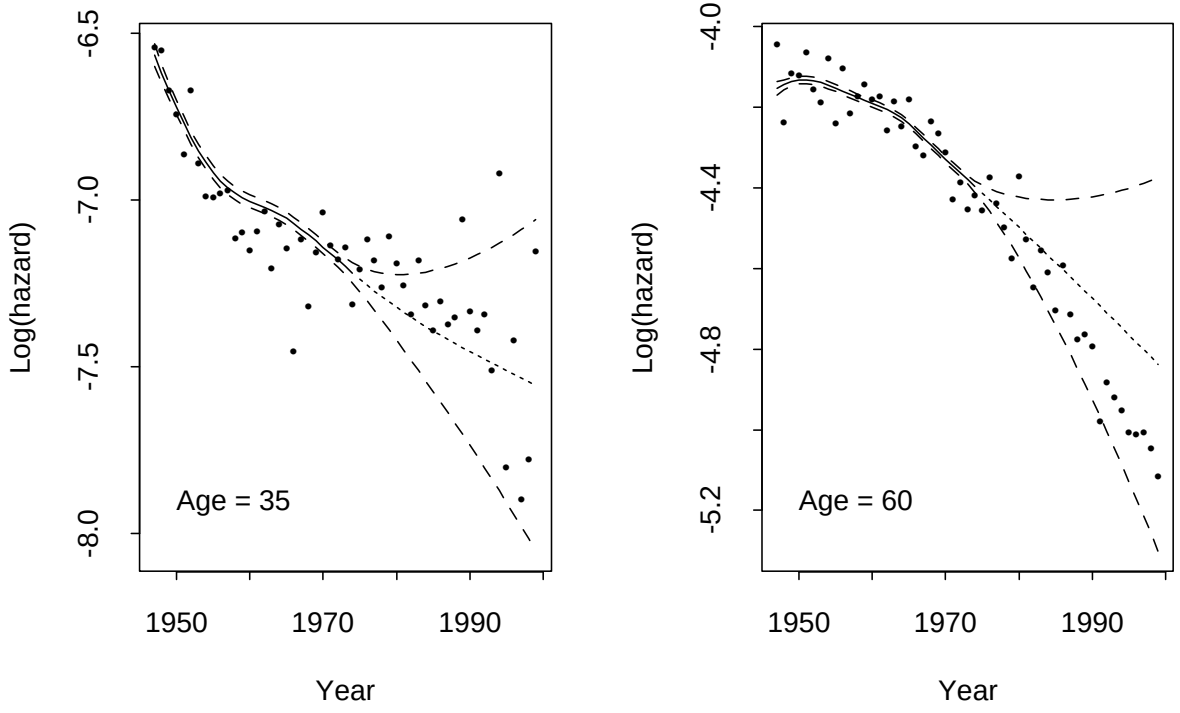
Back-testing projections

- What if we had these methods in the past?
- How good would they have been in predicting mortality?
- Subjective choice — if a model fits the data better, we presume it will give better projections

Back-testing P-spline projections

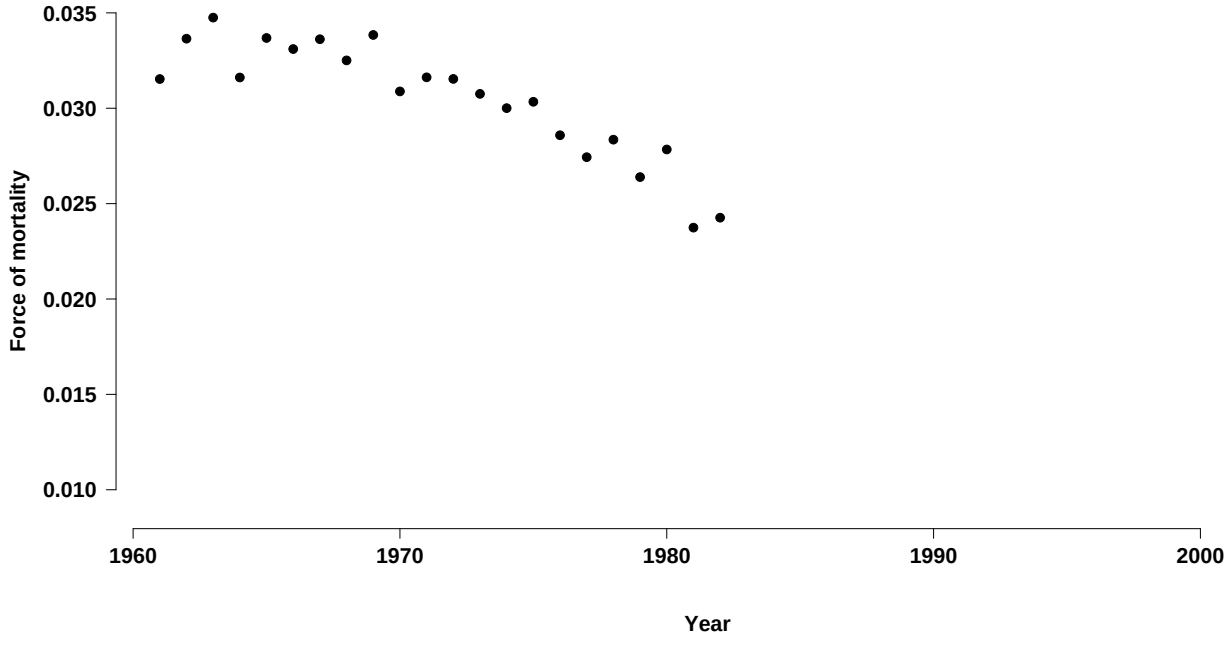
- Discard latter half of data
- Fit model to first half and project
- Compare projection with discarded half of data

Back-testing P-spline projections



Source: I. D. Currie, Heriot-Watt University. P-spline projections with penalties across age and calendar time.

French male mortality rates at age 65



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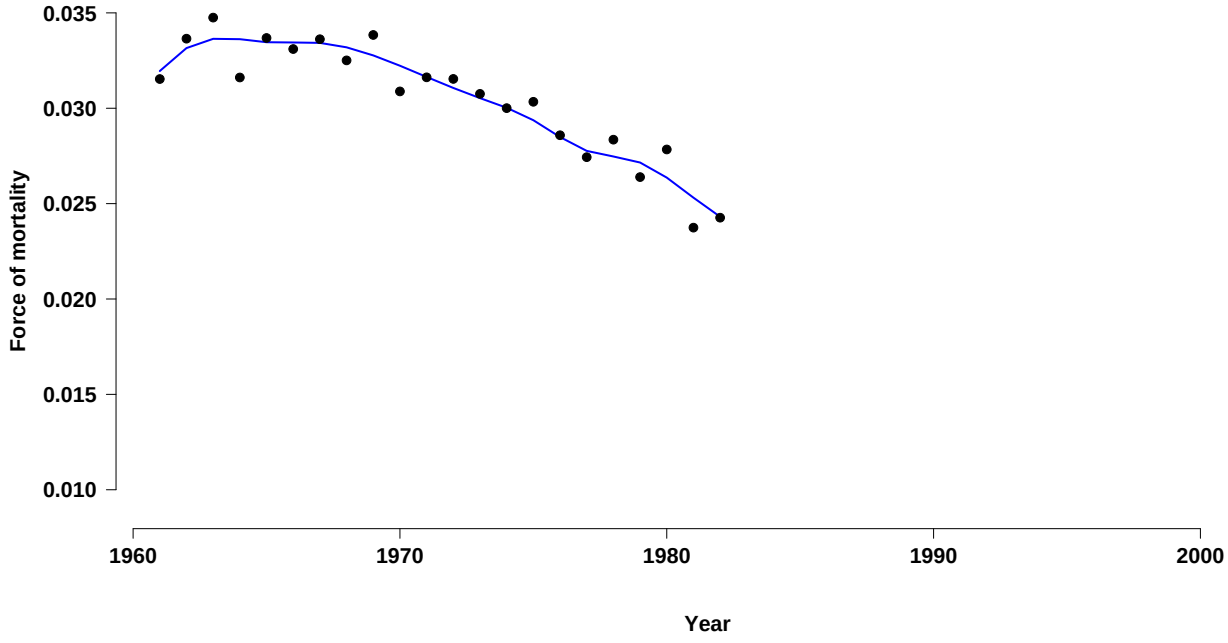

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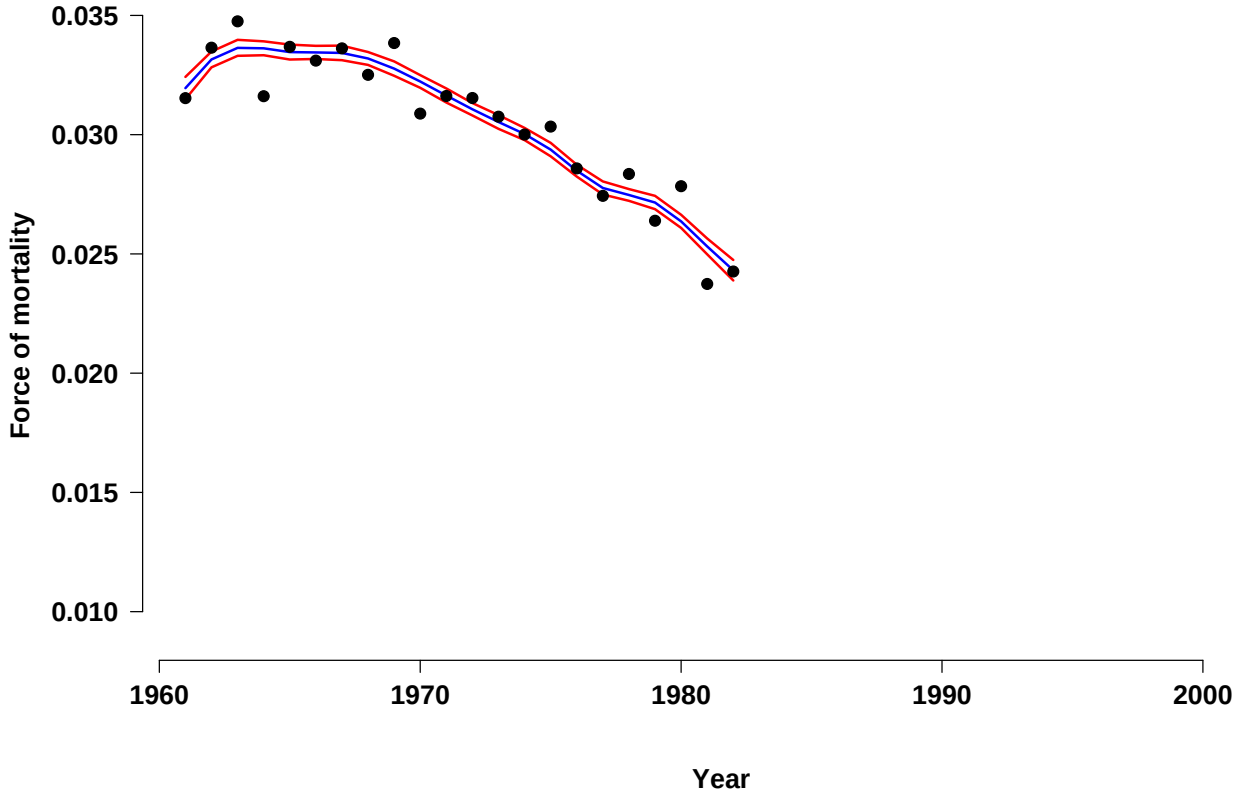

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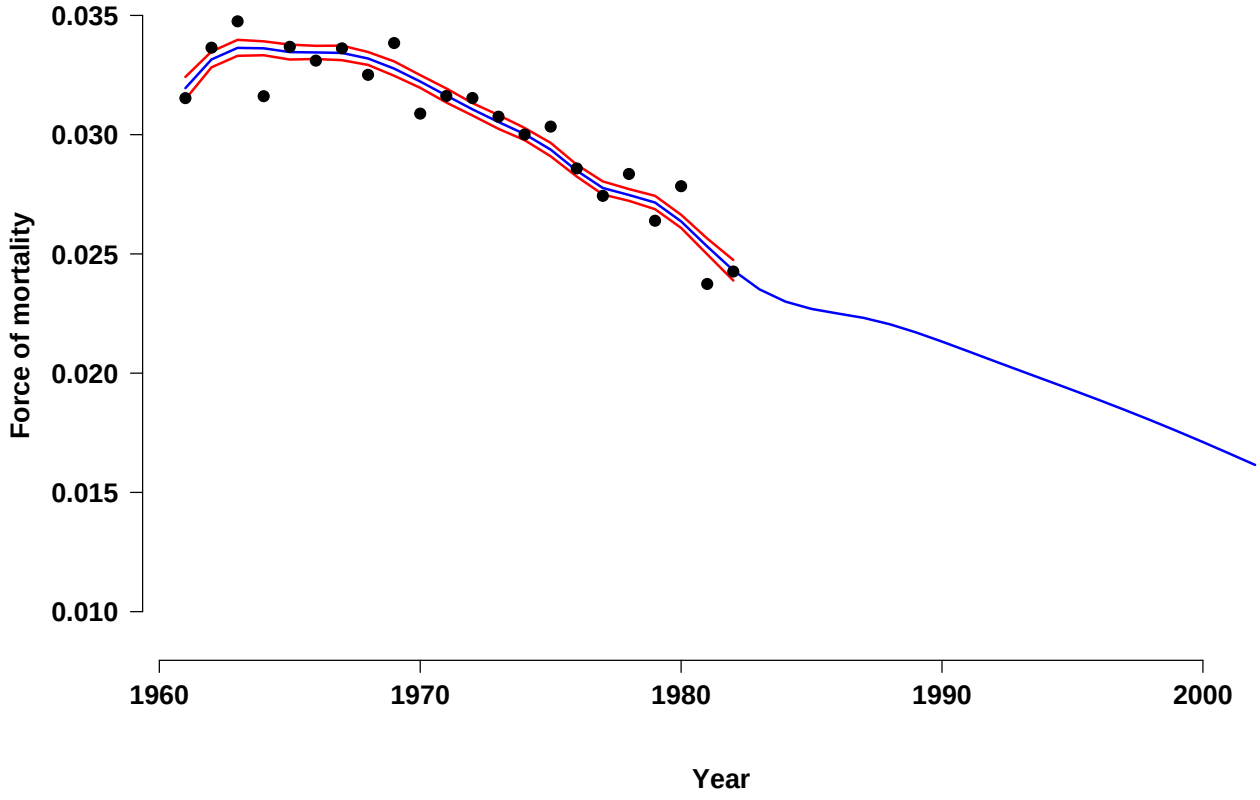

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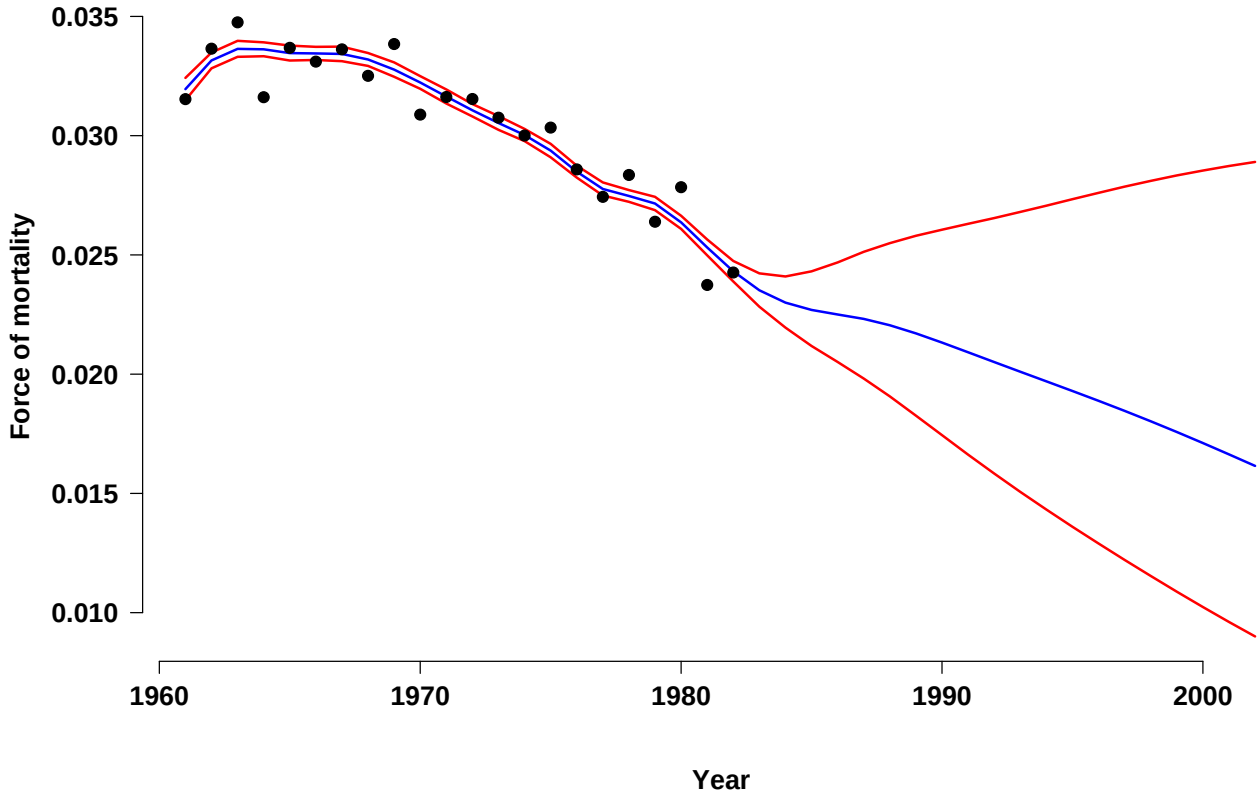

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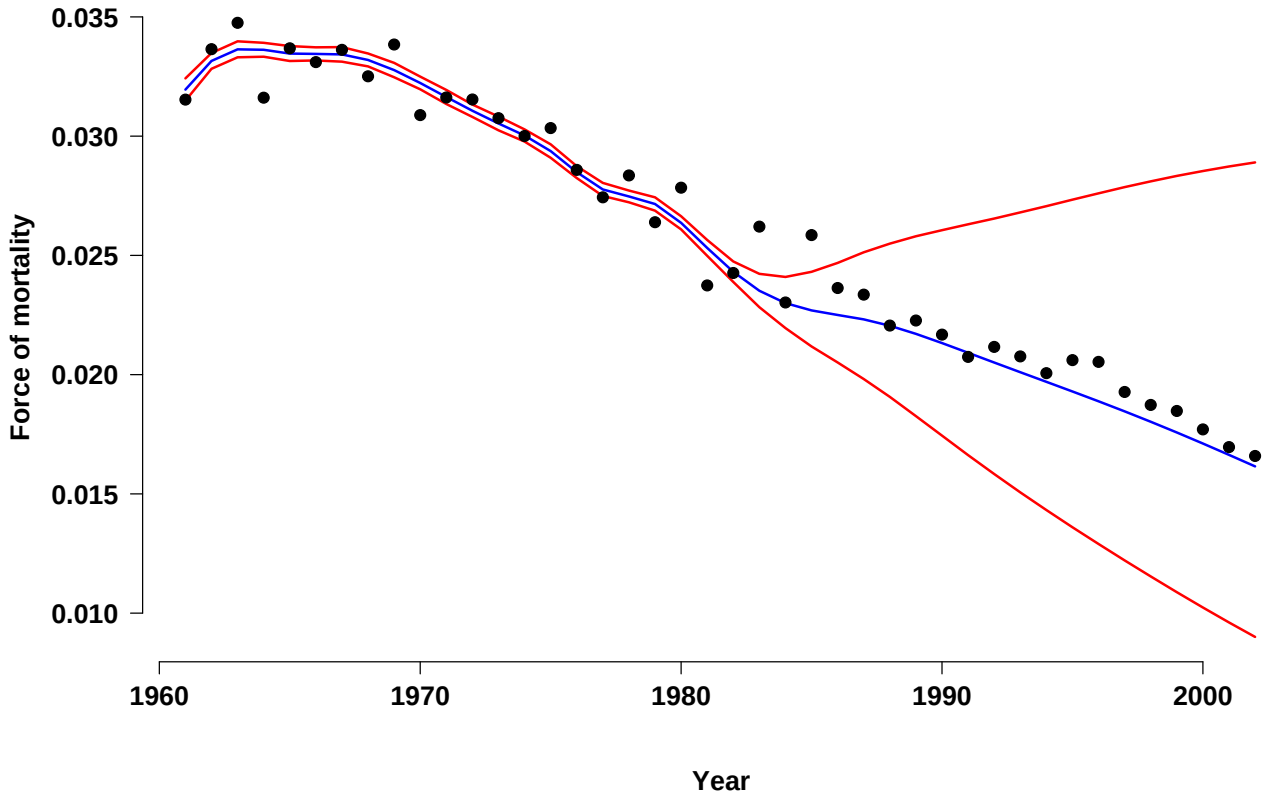

Source: J. Hubbard, AXA Group Risk Management

Impact of improvements at age 65

Projection	e_{65}
Central projection	20.1
2.5% percentile	19.1
97.5% percentile	21.1
No improvements	16.5
PMA00	18.0

Source: Richards Consulting calculations using England and Wales population data for males with P-spline projection using age and cohort penalties for ages 20–100 between 1961 and 2003. Figures shown are complete years lived, i.e. curtate expectation of life.

Financial impact of improvements

Projection	a_{65}
Central projection	15.84
2.5% percentile	15.32
97.5% percentile	16.36
No improvements	13.85
PMA00	15.56

Source: Richards Consulting calculations using England and Wales population data for males with P-spline projection using age and cohort penalties for ages 20–100 between 1961 and 2003. Annuity factors are annual annuities paid in arrears, discounted at 2.5%.

Financial impact of improvements

Projection	a_{65} relative to central projection
Central projection	0%
2.5% percentile	-3.3%
97.5% percentile	+3.3%
No improvements	-12.5%
PMA00	-1.8%

Source: Richards Consulting calculations using England and Wales population data for males with P-spline projection using age and cohort penalties for ages 20–100 between 1961 and 2003. Annuity factors are annual annuities paid in arrears, discounted at 2.5%.

Estimation risk — Part II

- Several major life offices each have hundreds of thousands of annuitants
- Huge advantage in depth and breadth of experience data
- Increasing use of GLMs to model mortality

Relative strength of rating factors

Factor	Strength
Age	2,095
Gender	100
Lifestyle	51
Duration	25
Amount	8
Region	8

Source: Richards and Jones (2004), page 37.

Financial impact of mortality rating factors

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Base case	-	13.39	-
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Overall	-	-	-33.6%

Source: Richards and Jones (2004), page 39.

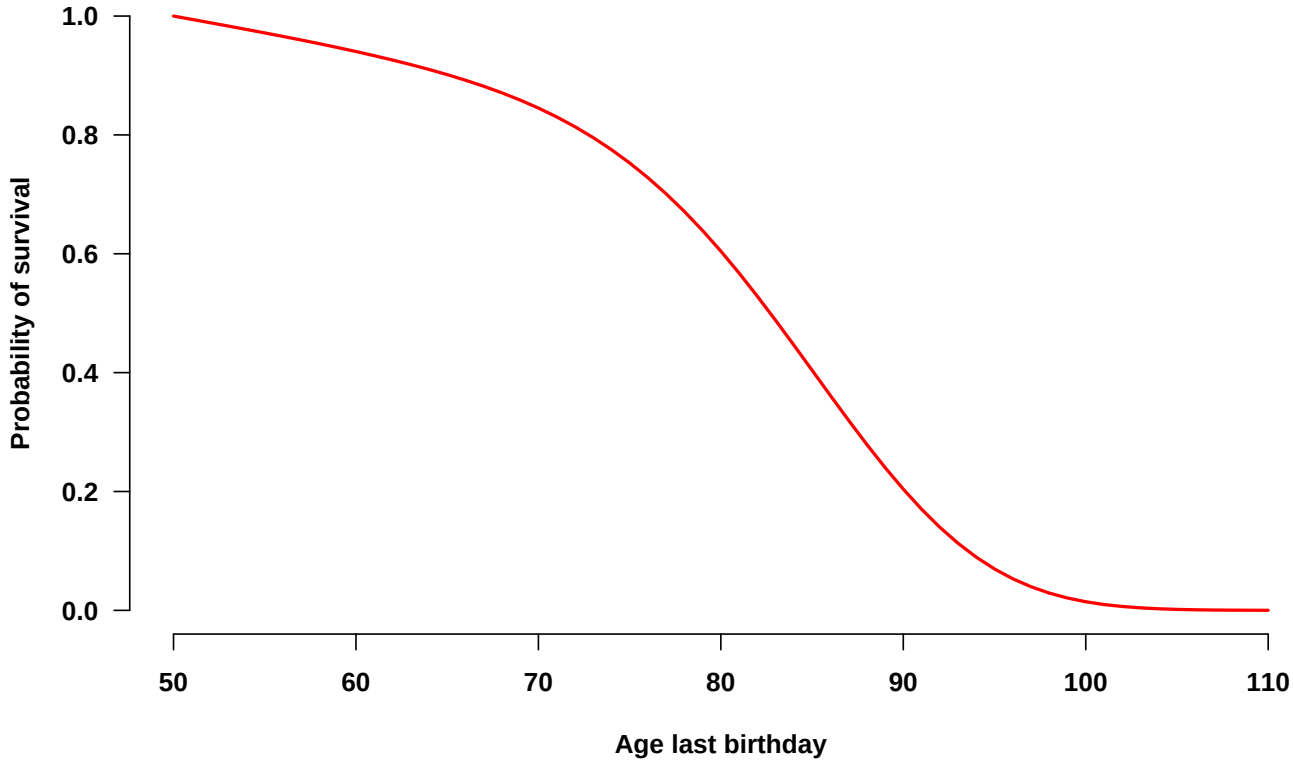
Limitations of a GLM

- Requires large volumes of data.
- Only a single year's experience can be used.
- Discards data on exact time of death.
- Cannot easily use fractional years' exposure.

How to catch up with life offices

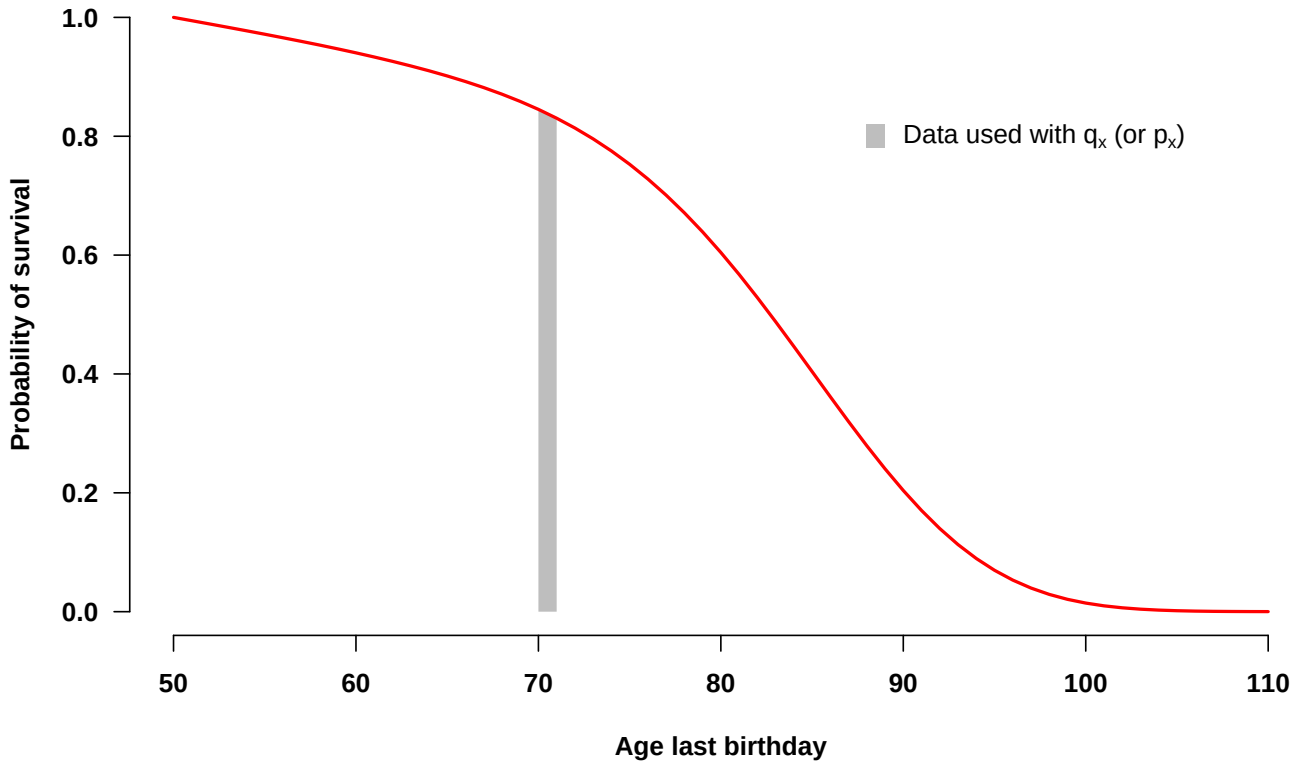
- Small boost from richer personal data, e.g. marital status
- Massive boost in power from consecutive years' data

Survival curve under PMA00



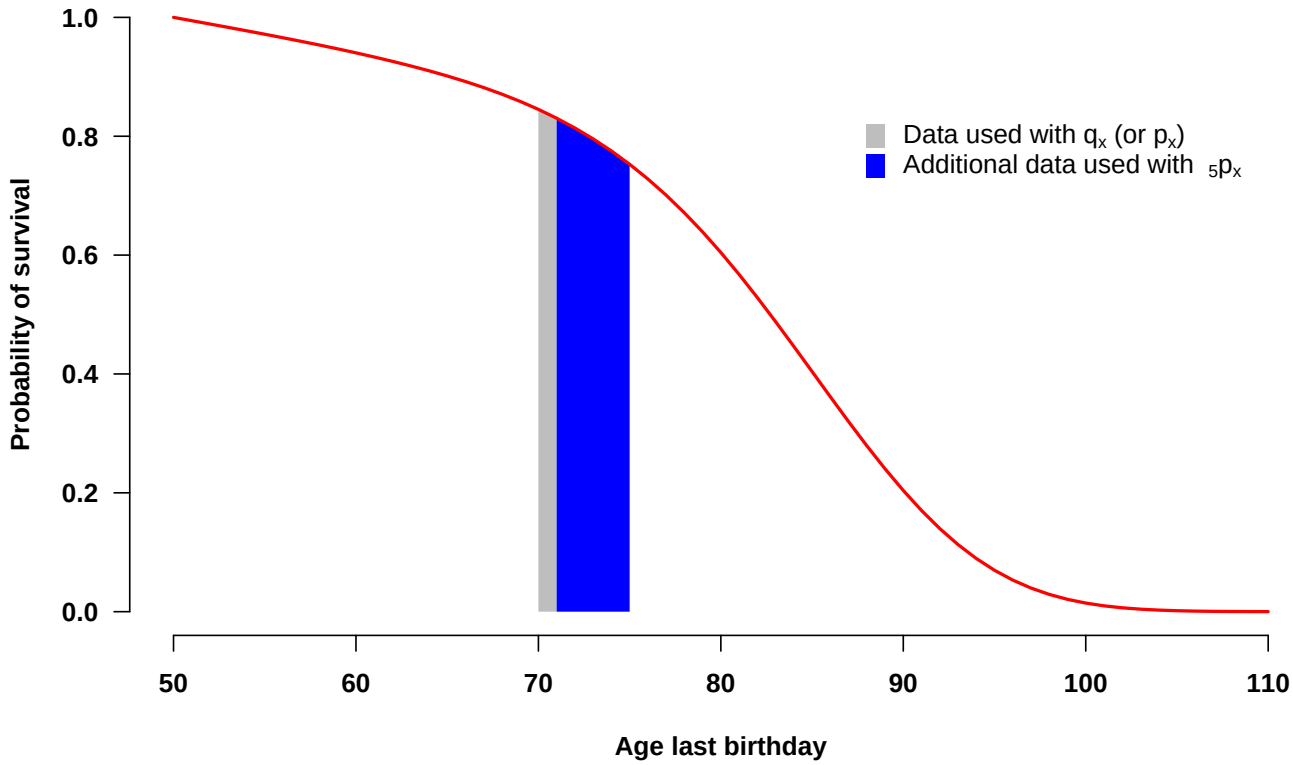
Source: Longevitas Ltd using CMIB data.

Survival curve under PMA00 — modelling q_x



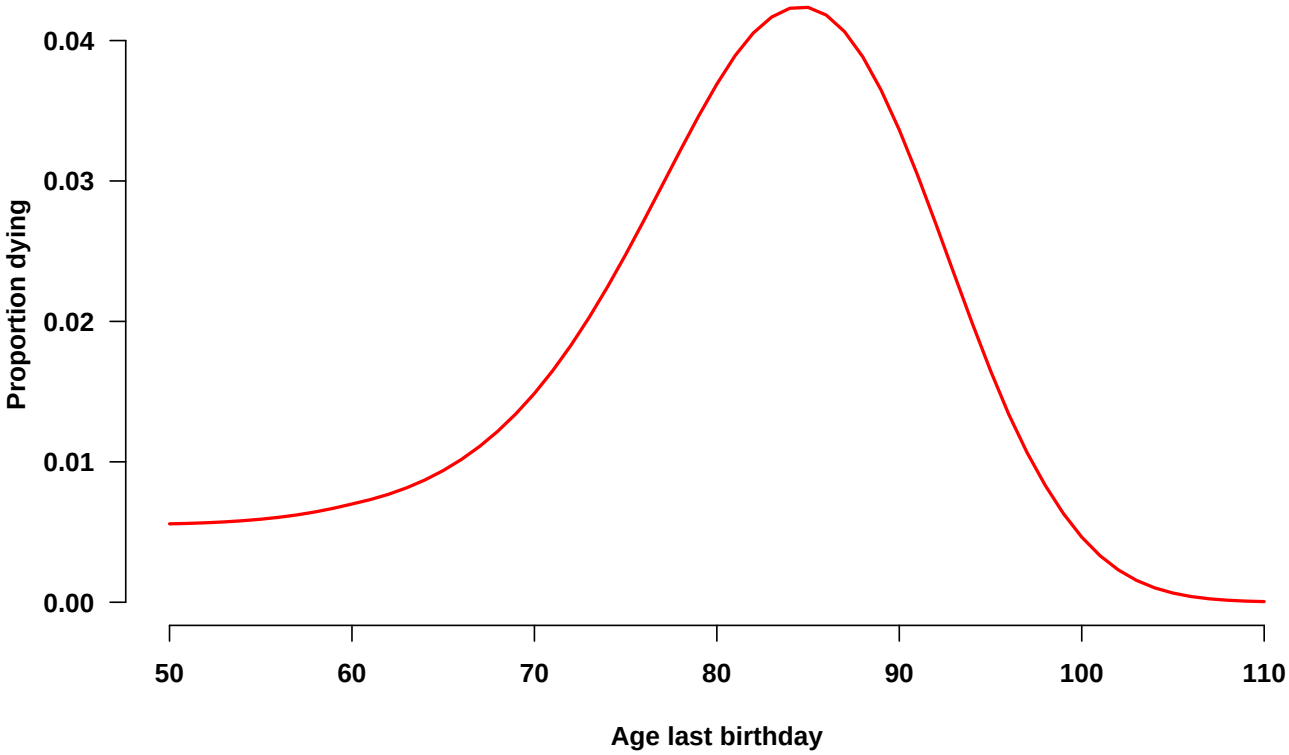
Source: Longevitas Ltd using CMIB data.

Survival curve under PMA00 — modelling ${}_tp_x$



Source: Longevitas Ltd using CMIB data.

Distribution of age at death under PMA00



Source: Richards Consulting calculations using CMIB data.

How to catch up with life offices

- Don't model q_x ...
- ... use ${}_tp_x$.
- Don't model death (dead v. alive)...
- ... model time until death, T.

Summary and questions

- Annuity business highly geared with volatile returns.
- Longevity risk complex with many components.
- New techniques boost mortality knowledge to life-office standard.
- Reprints of papers available at the front.

References

Longevitas **2006** *Modelling pensioner mortality*, www.longevitas.co.uk

Richards, S. J. and Jones, G. L. **2004** *Financial aspects of longevity risk*, SIAS

Richards, S. J., Kirkby, J. G. and Currie, I. D. **2005** *The Importance of Year of Birth in Two-Dimensional Mortality Data*, Presented to Institute of Actuaries