The Actuarial Profession
making financial sense of the future

Mortality and Longevity Seminar 2012
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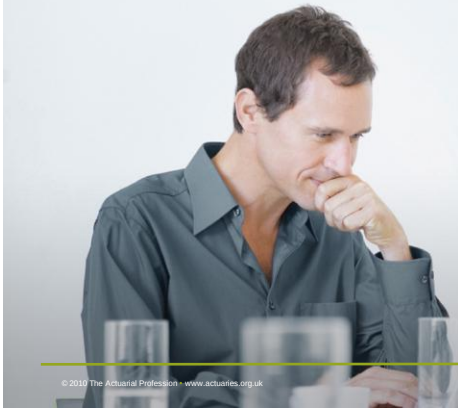


Making sense of the highly uncertain

Longevity uncertainty

12 June 2012

What kind of uncertainty?

Rules for a well-behaved risk

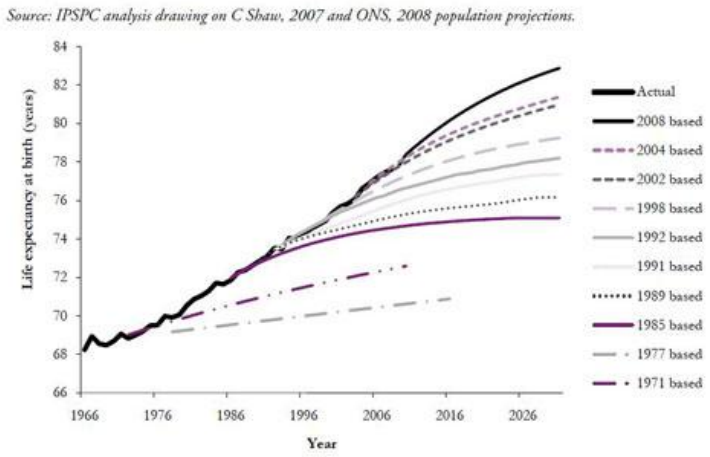
- Diversifiable within portfolio ➔ Small fluctuations
- Relevant past experience ➔ Small basis risk
- Risk segments understood ➔ Limited heterogeneity
- Aligned interests ➔ Little anti-selection
- Causation understood ➔ Few surprises
- Generally accepted model ➔ No winner's curse

Longevity breaks all the rules

- Hence the wrong kind of uncertainty

2

Best estimate keeps on moving



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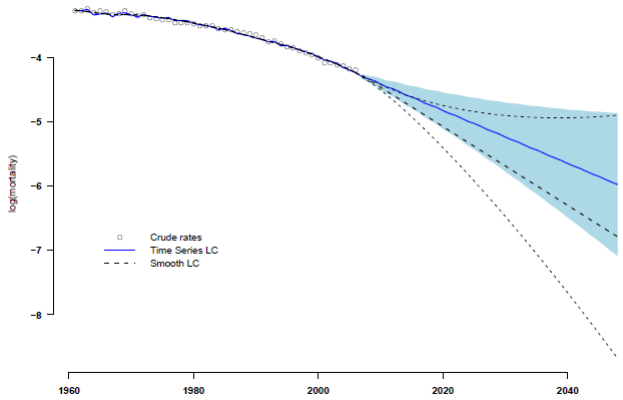
High dispersion between models



Different projections from the same data set illustrating model risk. Both models are part of the Lee-Carter family, with the only different being whether a time series or a penalty is used for projection. The data set is for males in England and Wales. (Richards and Currie 2009)

3

Users and uses of models

Long term decision makers

- Buy or sell annuity
- Offer or modify employee benefits
- Acquire or divest business

- Longevity positions are taken for their run-off value
- Most positions could be closed out, at least in theory

Short term controllers

- Prudential regulation
- Accounting and reporting
- Planning, risk management and financing

- Applied regularly to existing positions
- Often involves a close-out assumption

What kind of model?

Long term (run-off)

- Aligned with buy/sell/hold decisions
- Focus on “more likely” outcomes – e.g. quartiles
- Actuary in real time
- Risk that the model is wrong in hindsight – i.e. the “unknown unknowns”

Short term (1 year)

- Aligned with control processes and requirements
- Focus on “less likely” outcomes – e.g. 99.5%
- Actuary in a box
- Risk that the model needs to change

Long term and short term models are difficult to compare

- Equivalent points of distributions are not well-defined

What kind of inputs?

Bringing longevity within the rules

- Build relevant past experience – or apply controls for basis risk
- Understand segmentation – health, employment, socio-economic status, …
- Understand causation – medicine, lifestyle, environment, …
- Seek convergence of models – but differentiation based on the quality of risk science is appropriate

Issues that models can't fix

- Non-diversifiable risk
- Non-aligned interests

Solvency II internal model for longevity risk

Model requirements

- Six tests: use, statistical quality, calibration, P&L attribution, validation, documentation
  - Be capable of deployment into decision making
  - Cover all material risks
- Transparent and open to challenge
  - Allow users to engage with the approach, design, and calibration of risks, not just the answers
- Consistent with balance sheet processes
  - S.II tests the movement in balance sheet over 1 year

Case study

- Base Mortality
  - Conventional A/E of life table
  - Discuss other possibilities
- Future Mortality
  - Market practice using CMI Model
  - Discuss other approaches

Example Longevity Risk Assessment Framework

Steps	Activity	Example
1	Identify Key Risk Categories	Base and Future Mortality
2	Identify Sub-components	Future Mortality: -Initial mortality rates -Long-term rates etc.
3	Identify Sources	Data, Randomness, Model, Judgement, Drivers for mortality change (?)
4	Determine best estimate	
5	Determine one-year change distributions for each source in step 3	
6	Determine relationship between distributions	
7	Combine distributions	
8	Validation	

Base Mortality
Case Study: Steps 1 & 2

- Case study
  - Base Mortality
    - Ultimate A/E of life table

10

Base Mortality
Step 3: Sources of risks

- BAS (2008) identified the following sources of uncertainty
  - Random fluctuation
  - Data
  - Model/parameters
  - Decision – Judgement

11

Base Mortality Step 4

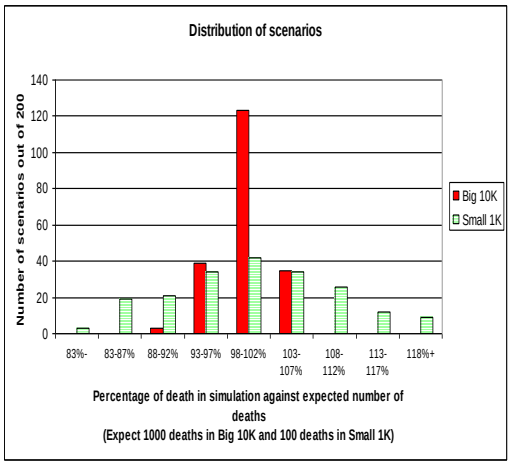
- Step 4: Determine best estimate
  - Perform goodness-of-fit to choose life table
  - Perform mortality investigation to obtain Actual vs Expected (A/E) adjustment to life table
  - Model late reported deaths

Base Mortality Step 5

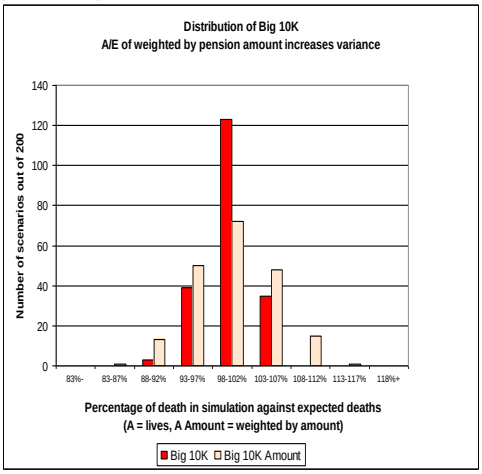
- Step 5: Determine one-year change distribution for sources of risk:
  - **Random risk** depends on number of pensioners and concentration of benefits.
  - **Risk that data** is not complete, accurate or relevant.
  - **Risk of model** is inadequate, e.g. exposure calculation or late reported deaths.
  - Justify any judgement

Base Mortality Case Study: Example of distribution of risk of random fluctuation

Experience of 10K pensioners is more certain than 1K



Experience of equal pension distribution (red) is more certain than concentrated (10% people owning 50% pension)



Base Mortality Case Study: Example of distribution of other sources of risk

Data risk

- Use historical experience of data changes and errors
- Likely to have sparse experience
- Judgement required for distribution if material
- Careful that no double counting in operational risk

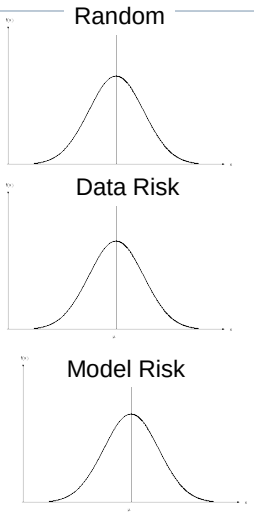
Model Risk

- e.g. Modelling for IBNR
- Use historical experience of method changes
- Likely to have sparse experience
- Judgement required for distribution if material
- Otherwise demonstrate immateriality

Base Mortality Case Study: Step 6

Step 6: Derive relationships between distributions

- Distributions of risks:
  - Random fluctuation
  - Data
  - Model
- Assume relationships:
  - Independent?
  - Correlated?
  - If correlated, how?



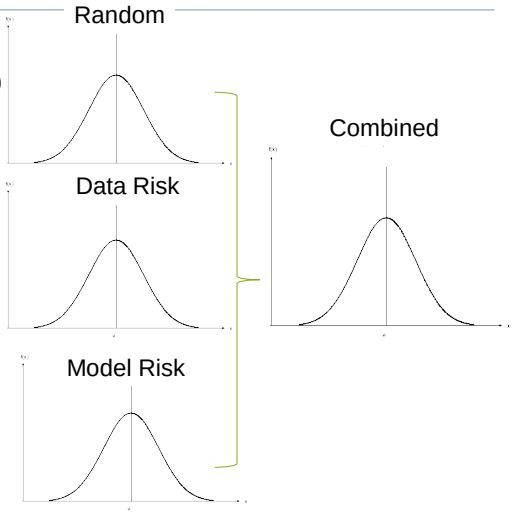
Base Mortality Case Study: Steps 7 & 8

Step 7: Combine risks

- It may be practically desirable to combine all distributions to give one distribution with adjustment for A/E
- Combine through simulation or mathematical formulae
- More straight forward if distributions are independently Normal.

Step 8: Validation

- Validate decisions or judgement

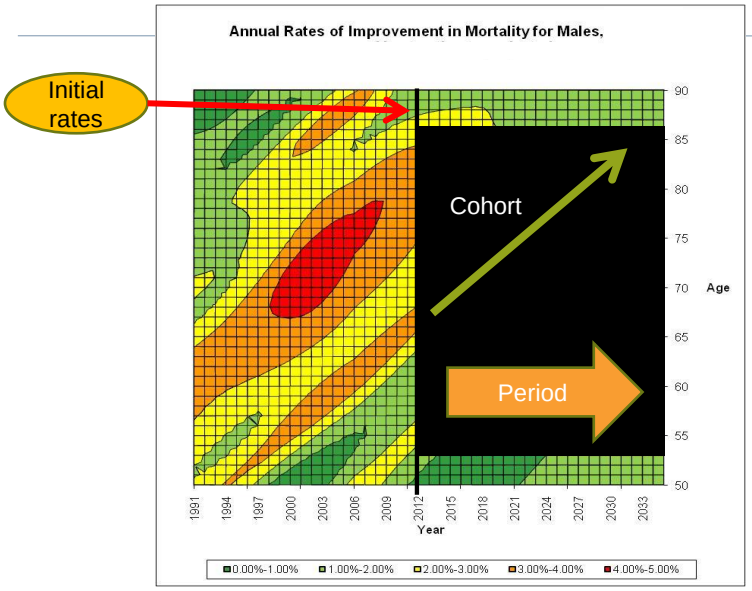


Future Mortality: Steps 1 & 2

- Case study
  - Future Mortality Trend (CMI Model)
    - Initial mortality improvement rates
    - Period Component
      - Initial mortality improvement
      - Convergence pattern
      - Long-term rates
    - Cohort Component
      - Initial mortality improvement
      - Convergence pattern
- Other methods
  - Extrapolative model
    - Lee-Carter (variants)
    - P-Spline
    - CBD etc.
  - Explanatory models
    - Smokers Model
    - Disease Based
    - Health policy
  - Combination Models
    - Cause of death
    - Other

18

CMI Model Projects Annual Rates of Mortality Improvement: Initial, Cohort Period Components



19

Step 3: Sources of risks

- BAS (2008) identified the following sources of uncertainty
  - Random fluctuation
  - Data
  - Model/parameters
  - Decision – Judgement

- Potential drivers for future longevity
  - Behavioural or lifestyle changes, e.g. smoking
  - Risk factors change, e.g. blood pressure, obesity
  - Public policies
  - Medical interventions
  - Epidemics

20

Step 3: Identify sources of risks

Risk description	Risks
Initial Rates	Data risk Risk that the annuitants that we insure exhibit different experience to that implied by the ONS England & Wales population Model risk Risk that the model for smoothing the ONS England & Wales mortality data is inappropriate. Random fluctuation Covers the impact of random fluctuation in the mortality trend experience observed in the ONS England & Wales mortality trend data
Long term improvement rate	Parameter & model risk Risk that the underlying assumptions made within the underlying model, e.g. Explanatory or Cause of Death Model, are inappropriate and result in an inappropriate long term rate
Period convergence	Model risk Risk that the emerging information changes the shape of the convergence function.
Cohort convergence	Model risk Risk that the emerging information changes the shape of the convergence function.

21

Future Mortality Case Study
Step 4: Determine best estimate

- Case study: CMI Model
  - Decide initial mortality improvement
  - Period Component:
    - Initial rates
    - Convergence pattern
    - Long-term rate
  - Cohort Component
    - Initial rates
    - Convergence pattern
- Other methods
  - Extrapolative model
    - Lee-Carter (variants)
    - P-Spline
    - CBD etc.
  - Explanatory models
    - Smokers Model
    - Disease Based
    - Health policy
  - Combination Models
    - Cause of death
    - Other

Future Mortality Case Study
Step 5: Determine one-year probability distribution

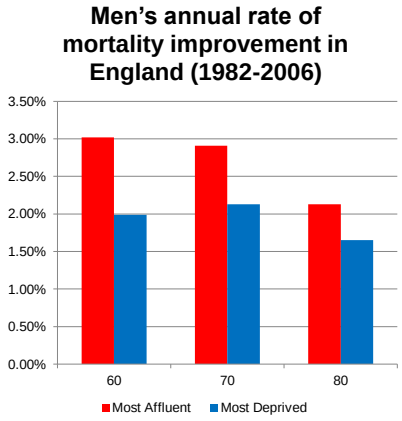
- Case study: CMI Model
  - Decide initial mortality improvement
  - Period Component:
    - Initial rates
    - Convergence pattern
    - Long-term rate
  - Cohort Component
    - Initial rates
    - Convergence pattern
- Other methods
  - Convert run-off to one-year
    - Determine 99.5th percentile run-off
    - Convert to one-year by reading 90-95th percentile, assuming independence or not
    - Thought to be a convention
    - But difficult to explain to management
  - Extrapolative model
    - Simulate one-year projections
    - Use historical and that 1 additional year's of projected data to project all future mortality
    - Derive distribution of value
    - But may be problematic if the best estimate is not derived from Extrapolative model.

Base Mortality Case Study: Example of distribution of sources of risk

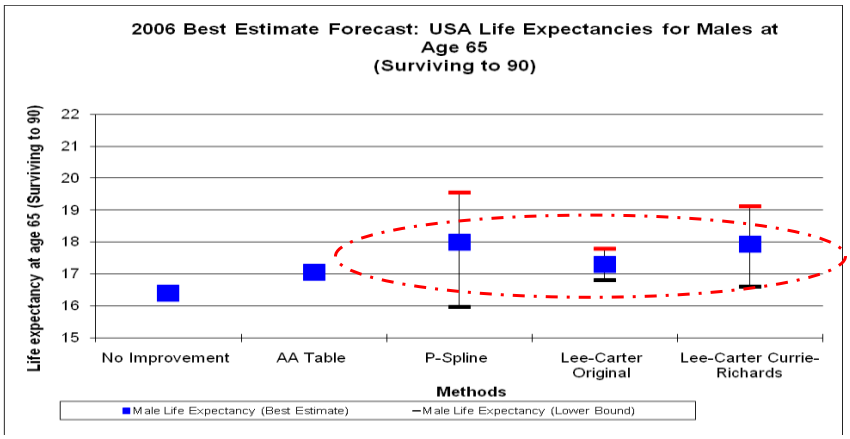
Data risk

Risk that the annuitants that we insure exhibit different experience to that implied by the ONS England & Wales population

Most affluent fifth have experienced faster mortality improvement than the least affluent fifth



Extrapolative Model Risk: Same input, different output



Base Mortality Case Study: Step 6

Step 6: Derive relationships between distributions

- Distributions of risks:
  - Initial mortality improvement
  - Period component
  - Cohort component
  - Other?
- Assume relationships:
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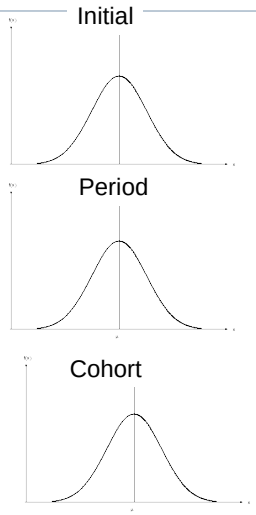
  - Correlated?
  - If correlated, how?



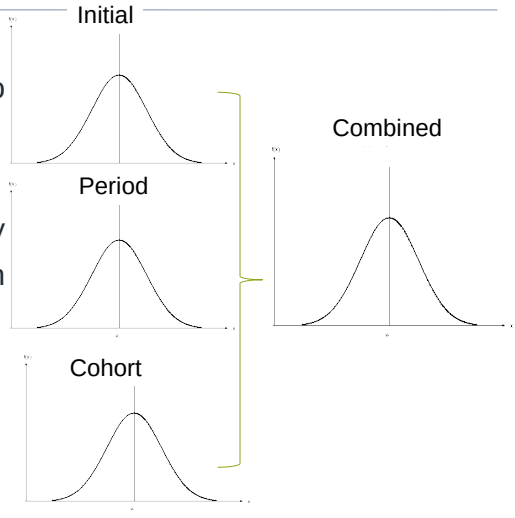
Base Mortality Case Study: Steps 7 & 8

Step 7: Combine risks

- It may be practically desirable to combine all distributions to give one distribution with adjustment for a common currency such as long-term rate or life expectancy
- Combine risk through simulation or mathematical formula

Step 8: Validation

- Validate decisions or judgement



Conclusions

"We demand rigidly defined areas of doubt and uncertainty!"

- Considerable progress in making longevity risk more tractable
- Some of the uncertainty is inherent, and resistant to risk science
- Long-term and short-term models both have important roles
- Solvency II appears to suit a short-term model that randomises the assumption setting process

Questions or comments?

Expressions of individual views by members of The Actuarial Profession and its staff are encouraged.

The views expressed in this presentation are those of the presenter.