Uncertainty in mortality-related cashflows

Agenda

- Components of mortality risk
  - Process risk
  - Level risk
  - Trend risk
- Context-driven expressions of mortality uncertainty
  - Survival curve
  - Pension scheme example
  - Whole-of-life cover example
- Summary
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Mortality Process Risk

• Uncertainty in random incidence of the underlying mortality rate

• Degree of uncertainty (when measuring by lives)
  – Is a function of number of expected deaths, N
  – % standard error, $\sigma$, approximately $\sqrt{1/N}$
  – So is a function of portfolio size and mortality rate

• Degree of uncertainty (when measuring by amounts)
  – Additional variation arises if lives have different benefits
  – Depends on range and skewness of distribution
  – Perhaps increases lives $\sigma$ by 25% to 100%
Mortality Process Risk
Sample distributions of outcomes by portfolio size

- Range of Outcomes as % of Expected Mortality Rate

![Graph showing range of outcomes as % of expected mortality rate for different portfolio sizes.](image)

Mortality Level Risk

- Uncertainty over the current estimated level of mortality
- Degree of uncertainty
  - Depends on information used to make estimate
- Experience analysis ‘sampling error’
  - Another expression of process risk
  - So a function of number of deaths and distribution of amounts
- Independent estimates
  - For example using socio-economic profile
  - Improve estimates and provide upper bound for uncertainty
Mortality Level Risk
Sample distributions of outcomes by portfolio size

- Range of Outcomes as % of Expected Mortality Rate

![Graph showing sample distributions of outcomes by portfolio size.](image)

Mortality Trend Risk

- Uncertainty in the future path mortality improvements
- Degree of uncertainty
  - Difficult to establish!
  - Use projection models, by cause-analysis, expert opinion, ...
- Unlikely to be correlated with size of group
  - But possible variation by socio-economic profile of group
- Trend risk starts from effective date of mortality level estimate
- Simplistic model used for these example
  - In particular, ignore short term variations
Mortality Trend Risk
Sample distribution of outcomes

• Projected mortality rate by year as % of best estimate rate

Components of Mortality Risk
Sample distributions of outcomes by component

• Projected mortality rate by year as % of best estimate rate
  — 10,000 lives; age 60 at outset; outcomes allow for distribution of benefit amounts
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Projected Survival Curve
Sample distributions of outcomes by portfolio size

• Projected surviving benefit amount by year
  – age 60 at outset; outcomes allow for distribution of benefit amounts

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Portfolio example 1: Pension Scheme
Sample distributions of outcomes by portfolio size

- Projected net cashflow by year

- PV [projected cashflows] as % best estimate by risk component
Portfolio example 1: Pension Scheme
Relative contributions by risk component

- Contribution to extreme scenarios by risk component
  - Average percentile rank by risk component for ‘All Risks’ scenarios above each threshold
  - 10,000 lives; using PV [cashflows]; series are 90th, 95th, 97.5th, 99th and 99.5th percentiles

Portfolio example 1: Pension Scheme
Sample distributions of outcomes by portfolio size

- Contribution to extreme scenarios by risk component
  - Average percentile rank by risk component for ‘All Risks’ scenarios above each threshold
Portfolio example 1: Pension Scheme
Relative contributions by risk component

- Projected relative contribution by risk component by year
  - calculated as ratio of component to 'All Risks' using width of central 90\textsuperscript{th} percentile ranges
  - 10,000 lives; using projected yearly cashflows

![Graph showing relative contributions by year for different risk components.](image)

Portfolio example 1: Pension Scheme
Sample distributions of outcomes by portfolio size

- Projected relative contribution by risk component by year

100 lives

![Graph showing relative contributions for 100 lives.](image)

1,000 lives

![Graph showing relative contributions for 1,000 lives.](image)

10,000 lives

![Graph showing relative contributions for 10,000 lives.](image)

100,000 lives

![Graph showing relative contributions for 100,000 lives.](image)
Portfolio example 2: Whole-of-life
Sample distributions of outcomes by portfolio size

- Projected net cashflow by year
  - 100,000 lives

Portfolio example 2: Whole-of-life
Sample distributions of outcomes by portfolio size

- PV [cashflows] as % best estimate by risk component
Portfolio example 2: Whole-of-life

Relative contributions by risk component

- Projected relative contribution by risk component by year
  - calculated as ratio of component to ‘All Risks’ using width of central 90th percentile ranges
  - 100,000 lives; using PV [cashflows]

![Graph showing relative component contribution by risk component over years]

Portfolio example 2: Whole-of-life

Sample distributions of outcomes by component

- Projected net cashflow by year

![Graphs showing sample distributions of outcomes by component]

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Summary

• Quantify mortality uncertainty in 3 main components
  – Process, Level and Trend (ignore catastrophe risk for now)
• The expression of mortality uncertainty is context sensitive
  – Depends on nature of mortality-related cashflows
• Interaction and relative contribution of components varies
  – over time; with size of group; and with risk threshold
• Manage mortality-related uncertainty by
  – Better information to improve estimates
  – Targeted transfer of risk, for example:
    – Life cover: Surplus, quota share and stop-loss reinsurance
    – Pensions: Selective buy-ins; full or partial swap or hedge
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.