The CMI Mortality Projections Model

Agenda

- Background and overview of the Model
- Highlights of the research on mortality improvement rates
- Parameterisation of the Model
- How sensitive is the Model to its parameters?
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The CMI Mortality Projections Model
Background and overview of the Model

Background and motivation

• Interim Cohort Projections (ICPs)
  – Published in 2002, based on data to 1999, as “add-ons” to the 92 Series projections basis
• ICPs have been in widespread use (albeit with modifications)
• Perceived advantages of the ICPs were:
  – They were valued as a common currency
  – They could be modified relatively easily
  – They could be applied to any base mortality table
• But the ICPs are significantly and increasingly out-of-date.
The CMI Mortality Projections Model
Background and overview of the Model

Background and motivation

• CMI looked for stochastic projection model
  – P-spline – but vulnerable to edge effects
  – Lee-Carter – but poor fit to UK data (cohort effects)
  – No projections in “00” Series tables or SAPS tables
• CMI Library of Mortality Projections
• Many other approaches & models developing
  – Stochastic models; mortality by cause; model by disease.

The CMI Mortality Projections Model
Background and overview of the Model

Background and motivation

• CMI Working Party established in 2008 to produce a projection model which shares the desirable features of the Interim Cohort Projections, but also:
  – reflects the latest experience on trends in mortality;
  – is relatively straightforward to understand and describe;
  – allows users the flexibility to modify projections to suit their own views and purpose; and
  – can be regularly updated over time to reflect emerging experience.
The CMI Mortality Projections Model
Background and overview of the Model

Key development stages and outputs
- Published in June / July 2009 for Consultation
  - A prototype version of the CMI Model: CPMv0.0
  - CMI Working Paper 39: Part II – Detailed Analysis
- Launch of the CMI Model, November 2009:
  - CMI Working Paper 41: Feedback on the consultation
  - Updated version of the Model: CMI_2009
  - Updated User Guide and Parameter Sensitivity Test results
- First annual update, November 2010:
  - CMI Working Paper 49 and updated version CMI_2010
- Next annual update
  - CMI Working paper 54: Advancing the Release Date
  - CMI_2011: September 2011

The CMI Mortality Projections Model
Background and overview of the Model

The structure of the Model
- Project annual rates of mortality improvement
  - Relatively simple; accessible; flexible
  - Not a mathematical model of mortality fitted to data
- Deterministic projection driven by user inputs
  - Initial rates of mortality improvement
  - Long-term rate(s) of mortality improvement
  - Speed & pattern of convergence
  - Split projection by age or by year-of-birth cohort
- Core and Advanced parameter layers.
The CMI Mortality Projections Model
Background and overview of the Model

Convergence from current rates to a long-term rate
• In the short-term, the best guide to the likely pace of mortality improvement is the most recently observed experience
• In the long-term, the forces driving mortality change are likely to be very different; more subjective, better informed by expert opinion
• The Working Papers include research on:
  – Mortality improvement by cause-of-death
  – Long-run average rates of change in a range of countries
  – Analysis of implied long-term rates from sample of other projection models.

Core parameter layer
• Allows users to focus on two simplified parameters:
  – A Long-Term Rate of Mortality Improvement
  – A Constant Additional Rate of Mortality Improvement
• Default values are applied to other parameters.

Advanced parameter layer
• Gives users considerable flexibility; allowing specification of:
  – Initial Rates of Mortality Improvement
  – Cohort and Age/Period components of Initial Rates (by individual age & birth cohort)
  – Long-term Rates of Mortality Improvement (by individual age & birth cohort)
  – Period of Convergence (by individual age & birth cohort)
  – Proportion of Convergence remaining after Mid-point (by individual age & birth cohort)
  – Base Rates of Mortality.
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Highlights of the research

Research on mortality improvement rates: main conclusions

• England & Wales Population Data
  – Clearly shows 2 major features of mortality change
    – Persistent year-of-birth cohort peaks and troughs; most notable peak for 1931 cohort
    – A general increase over the last 15 years across a wide age-range
  – So model age/period and cohort components.

• Insured & Pensioner Data
  – Lower data volumes reduce clarity of observations
    – Unable to distinguish between concurrent features
    – Much more difficult to interpret trends
  – So base defaults for Model on population data.
The CMI Mortality Projections Model - Research
Patterns of mortality change: population of E&W

Estimates of annual rates of mortality improvement

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Data Source: ONS
Age-cohort P-Spline

The CMI Mortality Projections Model
Highlights of the research

Research on mortality improvement rates: round-up

- Evidence no longer supports 1926 cohort feature of the ICPs
- Step 2 years inside edge of data to reduce estimation uncertainty
- Variety of features of mortality improvement
  - cohorts (25+ yrs; above age 40);
  - age/period (typically shorter)
- Improvement rates tend to run to zero for age 100+
- No clear picture on trends by social class
- Even 25-year averages of improvement rates vary significantly.
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The CMI Mortality Projections Model
Parameterisation of the Model

Initial Rates of Mortality Improvement

• Informed by recent observed experience
• Use E&W population data for Core parameter default values
  – For CMI_2010 use data to 2009; estimate rates for 2007
  – Smooth using age-cohort P-Spline model
• Estimate age/period and cohort components
  – Use bespoke age-period-cohort model
  – Need to set constraints - arbitrarily set \( \Sigma \text{age} = \Sigma \text{cohort} = 0 \)
• Maintained consistent methodology
  – Used for Prototype, CMI_2009 and CMI_2010.
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Parameterisation of the Model

Long Term Rates of Mortality Improvement
• No default parameter values set – user input required!
  – But there is a default pattern by age (input rate to age 90, then linearly to zero at age 120)
• Some possible sources to help inform opinion
  – National and international mortality data
  – Observed trends and long-term rates of mortality improvement
  – Other mortality projections and projection tools
    – Mathematical models: CBD, Lee-Carter, P-Spline, ...
    – National and international ‘governmental’ population / mortality projections
  – Analysis / modelling of trends by cause-of-death or disease processes
  – Research on past, current and expected medical and social changes
  – Expert opinion.

Convergence Period and Path
• Convergence Periods based on qualitative research
  – Review of patterns seen in UK and international experience
• Convergence Path
  – Broadly ‘straight-line’ for Core parameter default values
• Maintained pattern for successive versions of the Model
  – Age/Period component
    – Maintained period (shift start and end forward by 1 year)
    – Re-sets the period by taking a fresh view on emerging trends
  – Cohort Component
    – Maintained rule: period runs to age 100, but min=5, max=40.
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Crude annual mortality improvement rates
Population of England & Wales; age 18-102; age standardised

Mortality Improvement Rate, %pa

Males
Females

Calendar year

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The CMI Mortality Projections Model
How sensitive is the Model to its parameters?

Sensitivity of results to parameters
• For illustration, measure change in annuity values
• Male pensioners age 65 $\bar{a}_{65}$
• Male deferred pensioners age 45 $\overline{a}_{65}^{20}$
• Base table = SAPS S1PMA
• Annuity values at 2% pa
• All figures from CMI_2010, as at 31/12/2010.

The CMI Mortality Projections Model
Sensitivity to the long term rate

Annuity values (2%) males – S1PMA base table
Projections : CMI_2010_M [X%]
The CMI Mortality Projections Model
Sensitivity to the convergence period

Annuity values (2%) males – S1PMA base table
Projections : CMI_2010_M [2%]

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Sensitivity to the pattern of convergence

Annuity values (2%) males – S1PMA base table
Projections : CMI_2010_M [2%]
The CMI Mortality Projections Model
How sensitive is the Model to its parameters?

Summary

• Sensitivity of results to default parameters is generally low
  – Obvious sensitivity to Initial Rates
  – Long term rate (user input) is key
  – Sensitivity to methodology also assessed and disclosed

The CMI Mortality Projections Model
Questions or comments?

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

http://www.actuaries.org.uk/research-and-resources/pages/continuous-mortality-investigation-working-papers
Presentation to the PBSS Colloquium 2011
Gordon Sharp

The CMI Mortality Projections Model
Thank you for your attention and participation

Edinburgh, September 2011