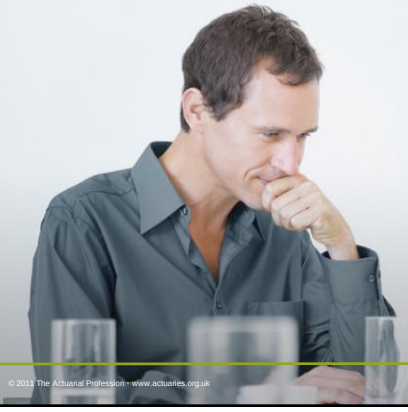
The Actuarial Profession
making financial sense of the future

Presentation to the PBSS Colloquium 2011
Gordon Sharp



The CMI Mortality Projections Model

Edinburgh, 26 September 2011

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- But the ICPs are significantly and increasingly out-of-date.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 38: Part I – Outline
  - 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.

The CMI Mortality Projections Model Background and overview of the Model

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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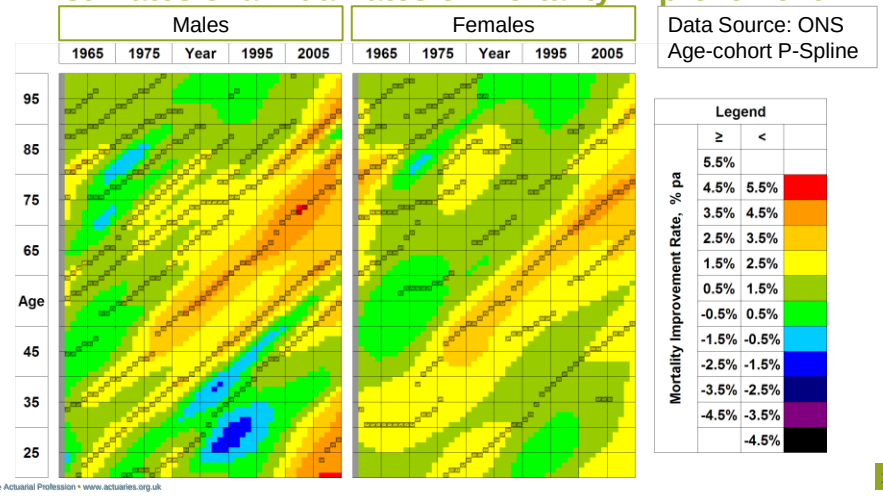
The CMI Mortality Projections Model
Highlights of the research

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



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 Σage = Σcohort = 0
- Maintained consistent methodology
  - Used for Prototype, CMI_2009 and CMI_2010.

The CMI Mortality Projections Model 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.

The CMI Mortality Projections Model Parameterisation of the Model

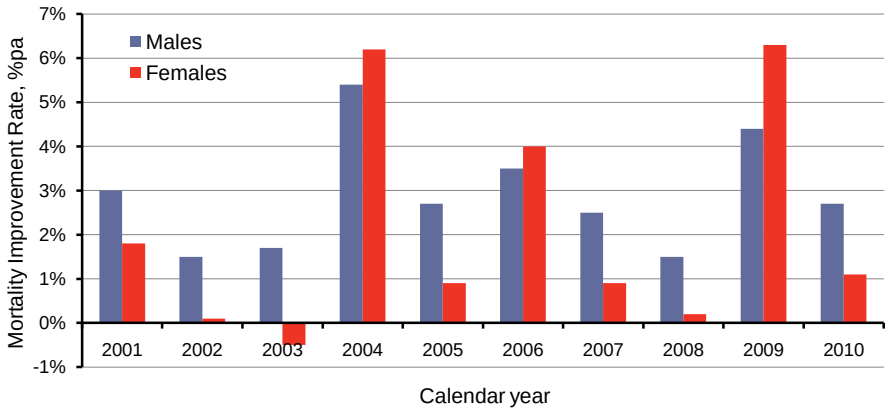
Convergence Period and Path

- 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.

The CMI Mortality Projections Model

Crude annual mortality improvement rates

Population of England & Wales; age 18-102; age standardised



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

Sensitivity of results to parameters

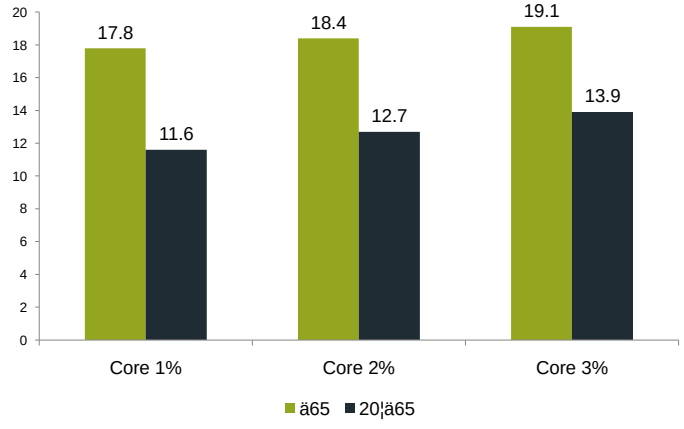
- For illustration, measure change in annuity values
- Male pensioners age 65 $\ddot{a}_{65}$
- Male deferred pensioners age 45 ${}_{20|}\ddot{a}_{65}$

- 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

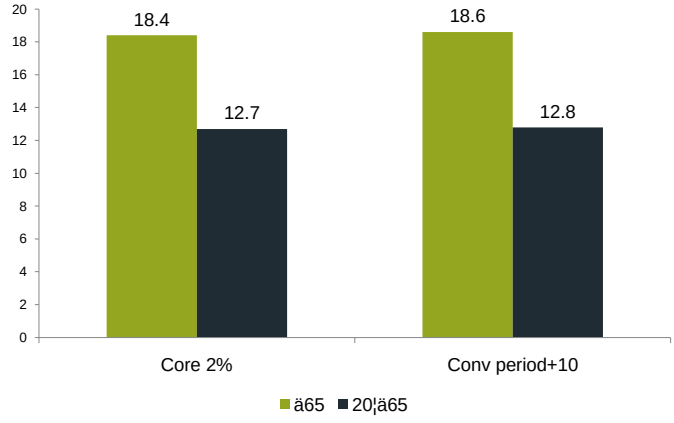
Projections : CMI_2010_M [X%]



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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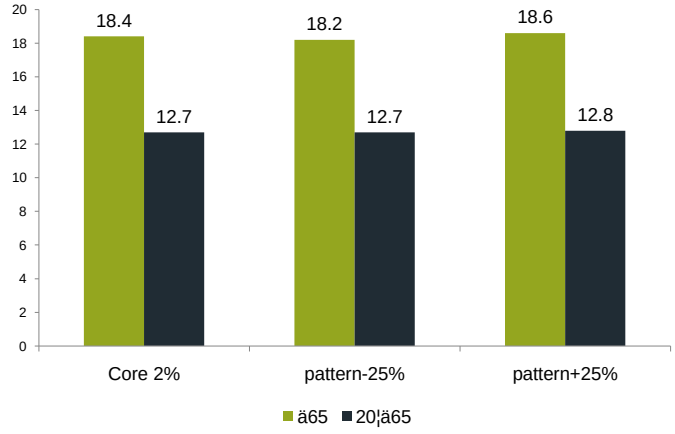
The CMI Mortality Projections Model
Sensitivity to the pattern of convergence

Annuity values (2%) males – S1PMA base table

Projections : CMI_2010_M [2%]



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

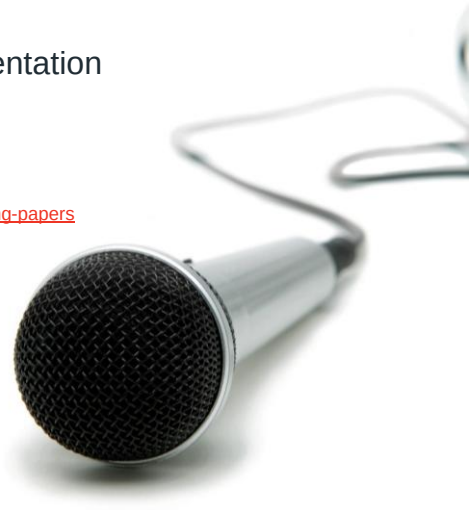
Summary

- 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



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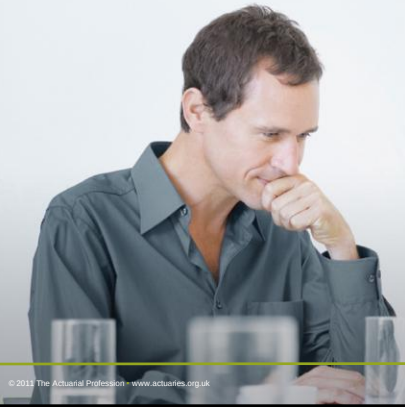

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Thank you for your attention and participation

Edinburgh, September 2011