

**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

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## 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- But the ICPs are significantly and increasingly out-of-date.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

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## 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.

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## 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.

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## 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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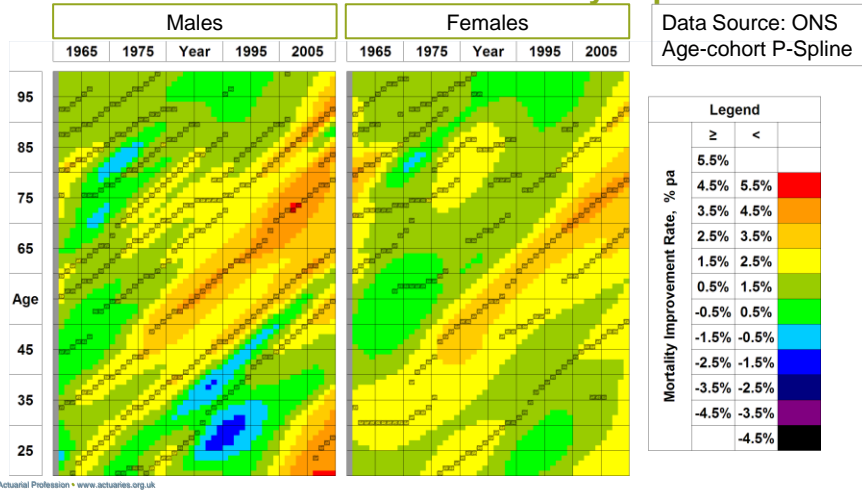
## The CMI Mortality Projections Model Highlights of the research

### 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



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## 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

### 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?

## 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.



## 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.

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## 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.

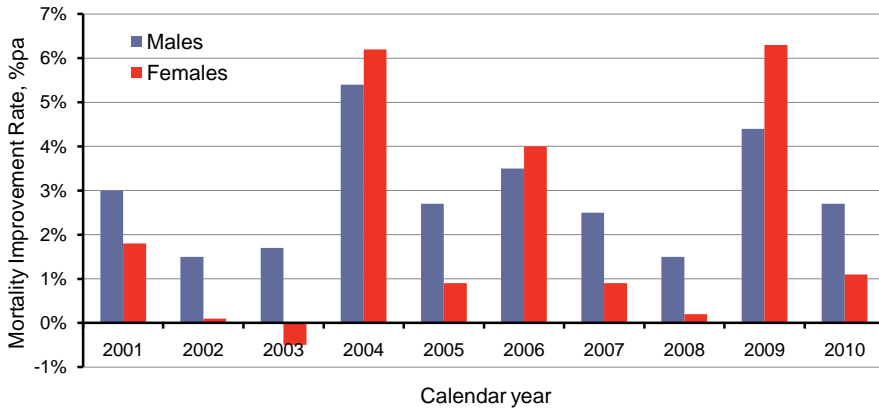
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## The CMI Mortality Projections Model

### 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.

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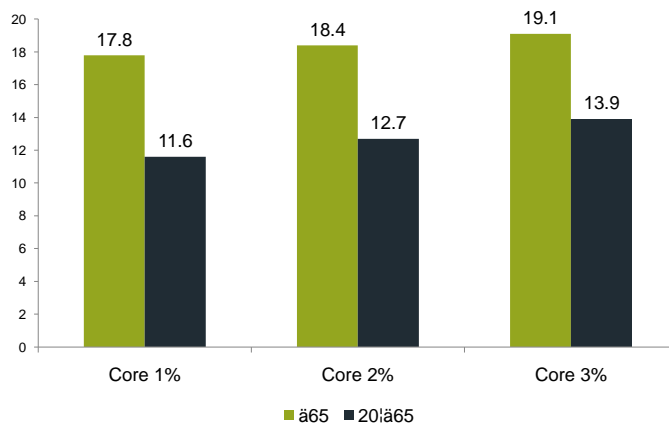
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## The CMI Mortality Projections Model

### Sensitivity to the long term rate

#### Annuity values (2%) males – S1PMA base table

Projections : CMI\_2010\_M [X%]



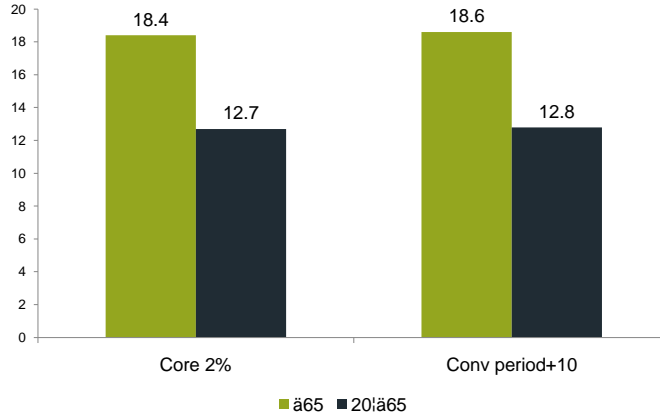
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## The CMI Mortality Projections Model Sensitivity to the convergence period

### Annuity values (2%) males – S1PMA base table

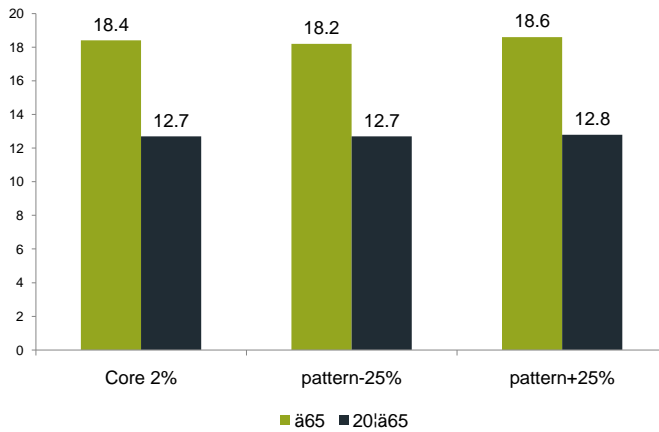
Projections : CMI\_2010\_M [2%]



## The CMI Mortality Projections Model 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

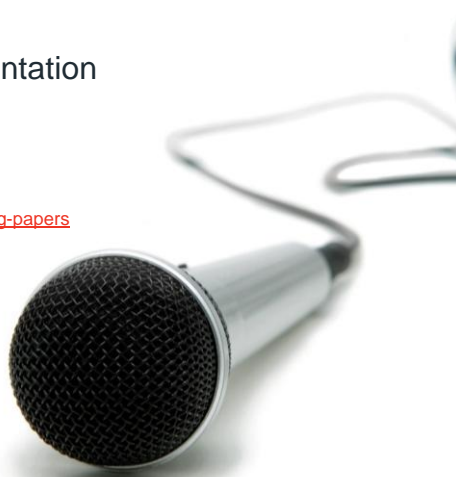
- Sensitivity of results to default parameters is generally low
  - Obvious sensitivity to Initial Rates
  - **Long term rate (user input) is key**
  - Sensitivity to methodology also assessed and disclosed

## 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>



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Thank you for your  
attention and participation

Edinburgh, September 2011

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