



The Actuarial Profession

making financial sense of the future

The CMI “library” of mortality projections

Edinburgh

18 July 2007

London

20 & 26 July 2007

Agenda

- Introduction *Nick Dumbreck*
- Background to the “library” *Gordon Sharp*
- The draft “library” in detail *Dave Grimshaw*
- What happens next? *Gordon Sharp*
- Discussion

Mortality Projections – the background

- "92" Series tables included projection of future mortality
- Single projection basis, derived from past trends
- Quickly found to understate actual mortality improvements
- Plus evidence had emerged of a "cohort effect"
- CMI published the "interim cohort projections" late in 2002
- MPWP established to explore possible projection methodologies for use with the "00" Series tables
- April 2006 – Working Paper 20 – Penalised-spline models
- March 2007 – Working Paper 25 – Lee-Carter models
- Issues with both P-spline & Lee-Carter

Mortality Projections – making the CMI's work more accessible

- CMI recognised its research not accessible to many actuaries
- Task Force formed to:
 - Illustrate the CMI's recent research to make it more accessible
 - Propose terminology to facilitate disclosure of mortality projections
 - Develop sets of projections which can be used as benchmarks
 - Collaborate with ECPD Board on education needs
- Membership of Task Force include life and pensions actuaries

Mortality Projections Task Force

- Gordon Sharp (Chair)
- Richard Humble
- Angus Macdonald
- George Russell
- Andrew Walton
- Richard Willets
- Brian Wilson
- Dave Grimshaw (Secretary)

Mortality Projections – the “library”

- Task Force initial proposal is to construct a “library” of projections
- “Library” comprises a “spreadsheet” with numerous projections and a supporting document
- Projections can be combined with any base table
- Library published in draft with the supporting document as a CMI Working Paper
- Consultation document including specific questions for feedback

Mortality Projections – the “library”

Draft “library” of projections includes:

- Existing projections:
 - “92” Series
 - Cohort Projections
 - ONS population projections
- Variations on existing projections in current use:
 - Imposing a minimum improvement on a Cohort Projection
 - Using a percentage of a Cohort Projection
- Examples of P-spline and Lee-Carter projections

Mortality Projections – the “library”

- What will the “library” achieve?
 - Single source of “recognised” projections
 - Standardisation of terminology for these
- What will the “library” not achieve?
 - No guidance on choice of projection
- Does this meet your needs?

Agenda

- Introduction *Stewart Ritchie*
- Background to the “library” *Gordon Sharp*
- The draft “library” in detail *Dave Grimshaw*
- What happens next? *Gordon Sharp*
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The draft “library” in detail

- The structure of the “library”
- The projections in the library
 - Previously-published projections
 - Variations on cohort projections in current use
 - P-spline projections
 - Lee-Carter projections
- Illustrating the choice of projection
- Illustrating uncertainty
- Recent trends

The structure of the “library”

- 42 “projections” in the draft library
- Each sheet contains data:
 - From age 20 to 120
 - From calendar year 1992 to 2100
- Each cell is the cumulative reduction factor:

$$RF(x,t) = q_{x,t} / q_{x,0}$$

- Improvements between 1992 and 2005 are a mixture of actual improvements and projections

The “library”: miscellanea

- Naming Convention
- Age and Year definition:
 - Age exact
 - Middle of calendar year
- Limiting age retained as 120 in every case
- No adjustments for smoker status, impaired lives, etc

The “library”: previously-published projections

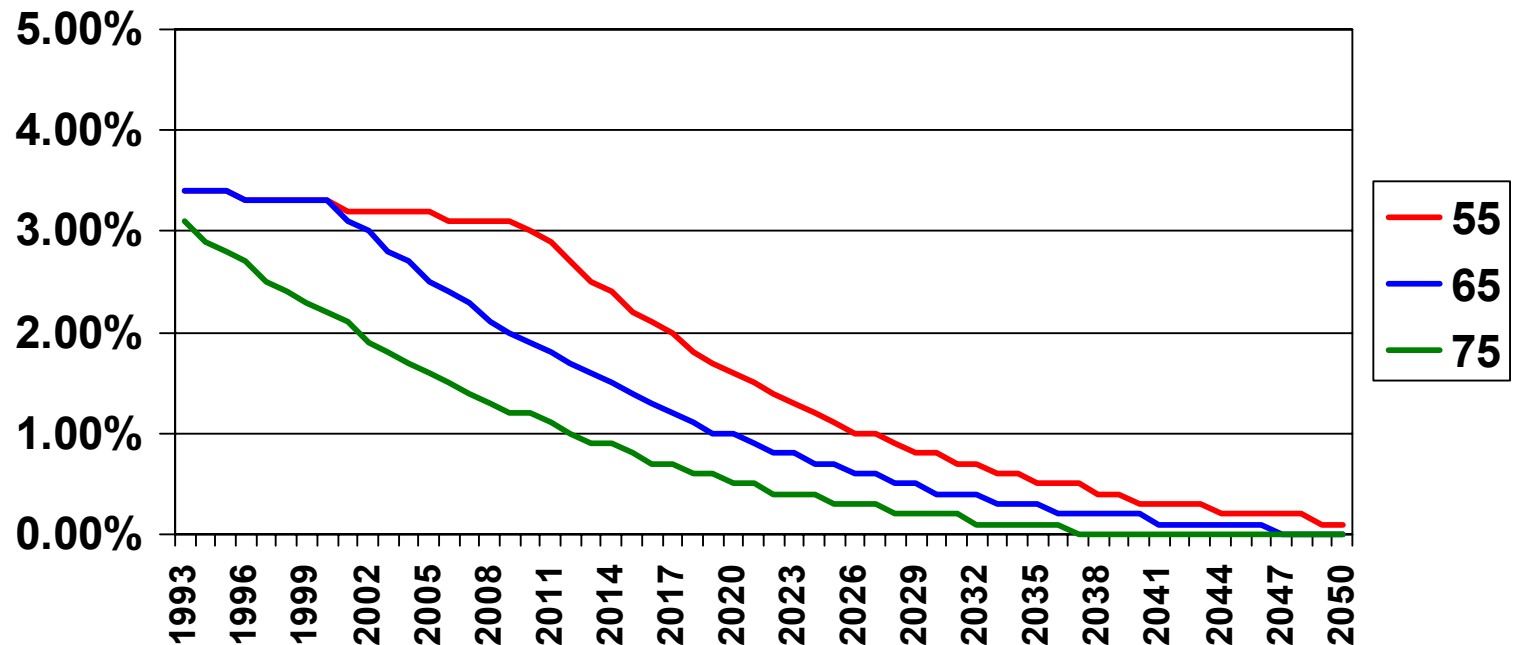
- “92” Series
- Interim Cohort Projections
- ONS 2004-based Population Projections

The “library”: previously-published projections

- “92” Series
 - Single projection incorporated into “92” Series of tables for pensioners and annuitants
 - Based on recent trends in 1975-1994 in male experience
 - Incorporated into female tables as well
 - Tend towards a % of 1992 rates – much of this trend in first 20 years
 - No improvements above age 110

The “library”: previously-published projections

“92” Series



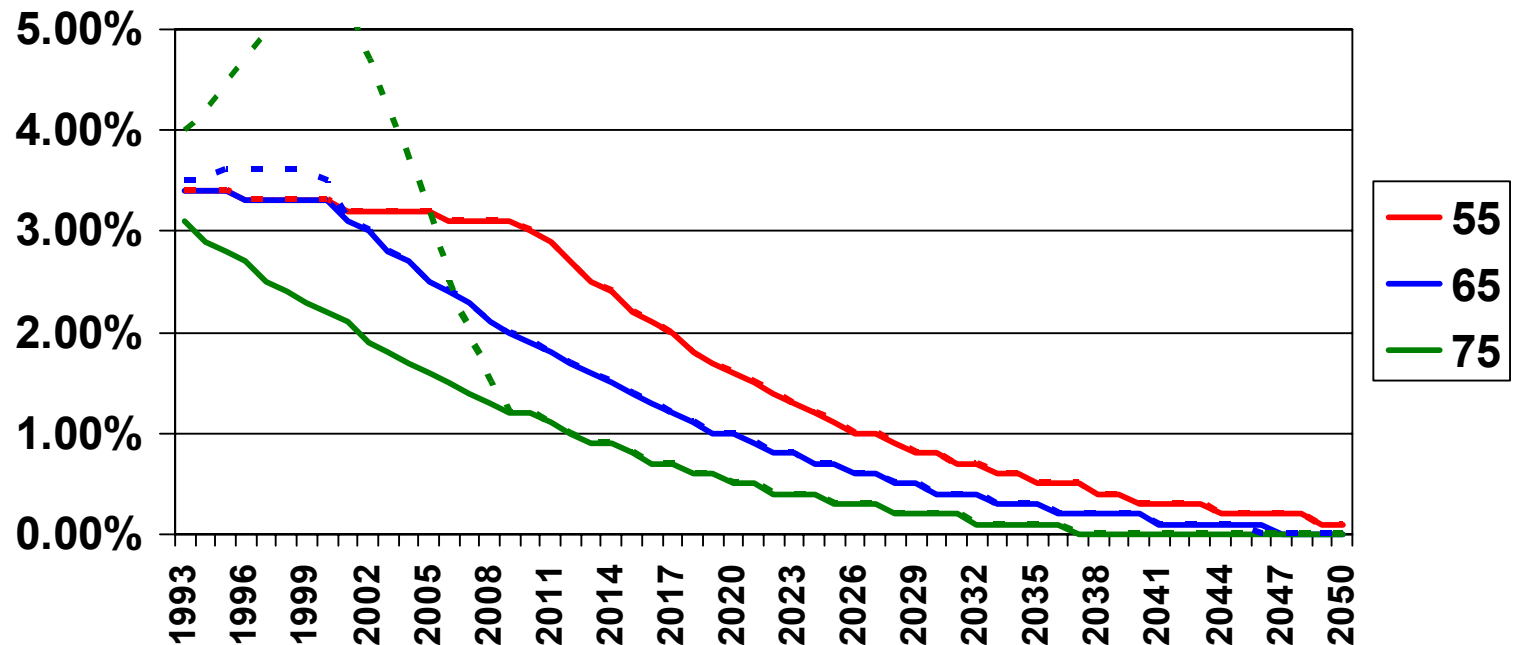
Annual improvements from 1992 to 2050 for selected ages in 2005

The “library”: previously-published projections

- Interim Cohort Projections
 - Adjustment to “92” Series projections
 - Adjustment was for a single cohort only – born around 1926
 - This cohort assumed to exhibit a faster rate of improvement for an arbitrary period:
 - 2010 (Short), 2020 (Medium) or 2040 (Long)
 - Rates of improvement from 1993-1999 based on actual improvements for that cohort.
 - From 2001, improvements assumed to reduce linearly to zero over the cohort period
 - Cohort initially included years of birth between 1910 and 1942
 - After 2000, the ‘width’ of the cohort effect was reduced to just lives born in 1926

The “library”: previously-published projections

“92” Series to Interim Cohort Projections: by age

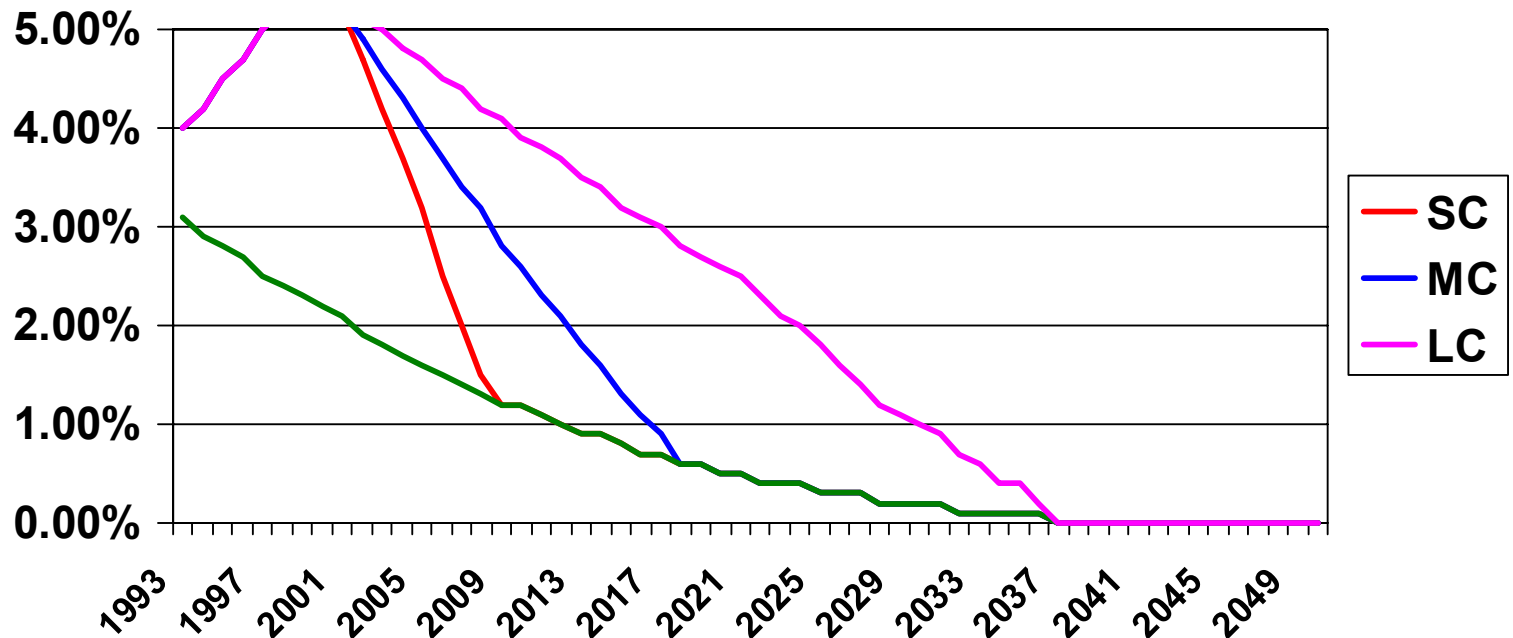


Annual improvements from 1992 to 2050 for selected ages in 2005

Dotted line indicates Short Cohort projections

The “library”: previously-published projections

“92” Series to Interim Cohort Projections



Annual improvements from 1992 to 2050 for age 75 only in 2005

The “library”: previously-published projections

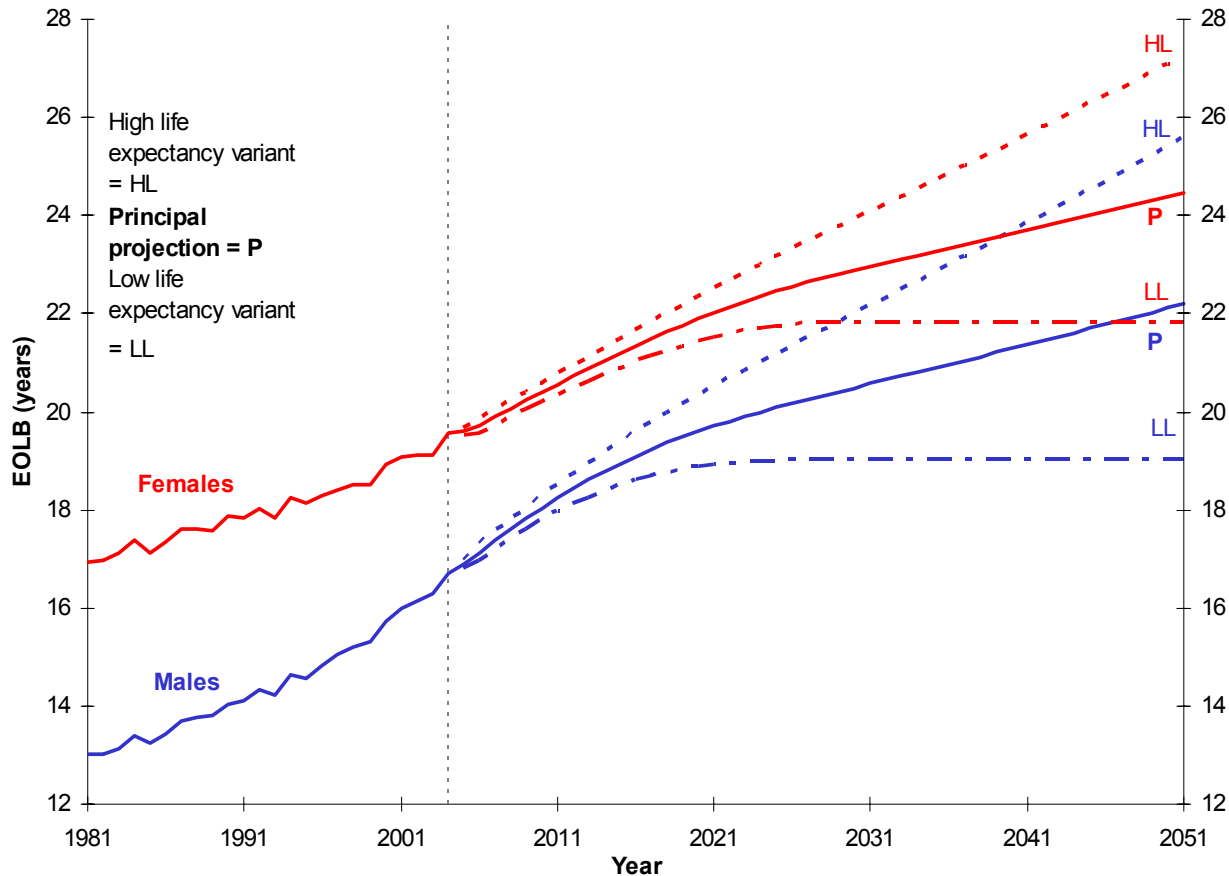
- ONS 2004-based Population Projections
 - Estimate current rates of mortality improvement by age and gender
 - Set rates of mortality improvement for some future year (the target year)
 - Make assumptions on method and speed of convergence from current improvement rates to target rates and how improvement rates change after target year

- We have appended smoothed actual improvements from 1992 to 2004

ONS 2004-based Population Projections

- Target year is 25th year of projection (ie 2029 for 2004-based projections)
 - Improvements in 2029 assumed to be 1% pa for all ages for both males and females
 - Convergence not linear; more rapidly at first for males, less rapidly for females
 - For those born before 1960, convergence assumed along cohort
 - After 2029 rates of improvement assumed to remain constant at 1% pa
 - Variants – HLE target rate 2%, LLE target rate 0%
 - Applies to UK and constituent countries
-

Period expectation of life at age 65, UK



Source: Adrian Gallop, Mortality seminar, 26 April 2007

Actual and assumed overall annual rates of mortality improvement

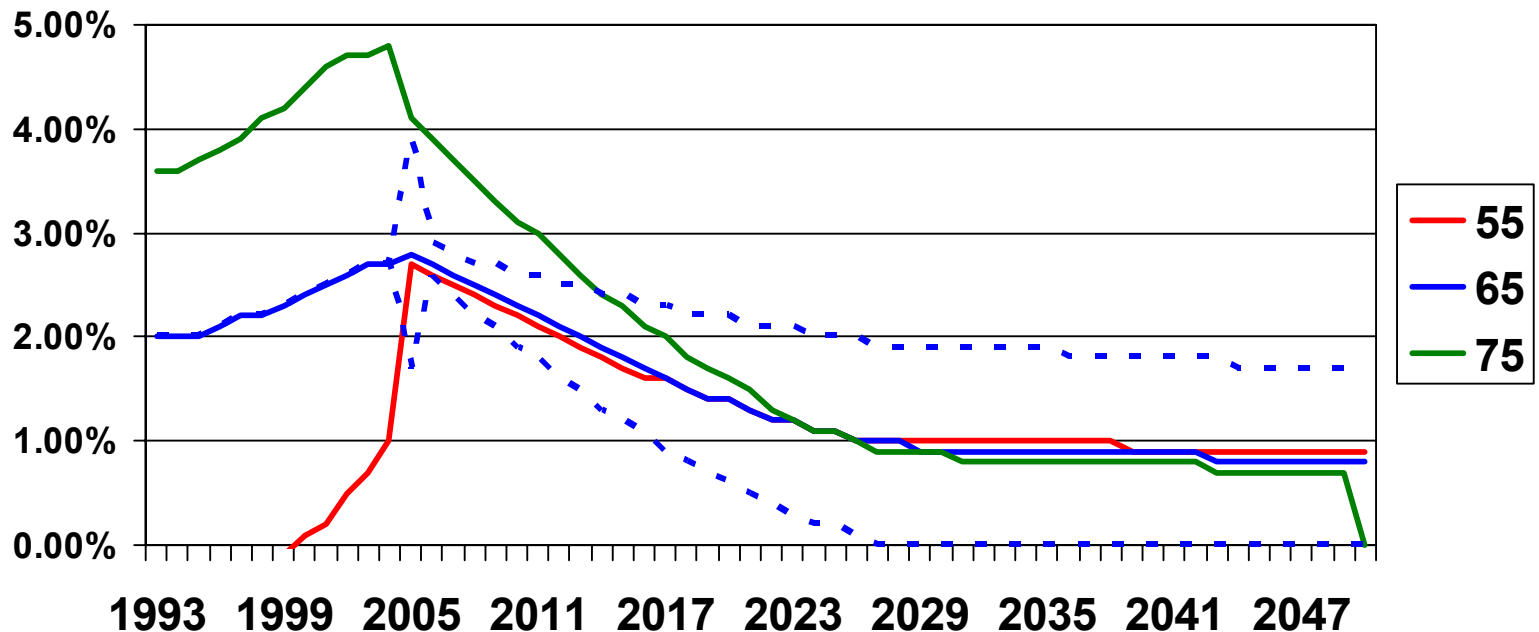
	Males		Females	
	Past (Actual)	Future (assumed)	Past (Actual)	Future (assumed)
Last/next 22 years	2.0%	1.9%	1.3%	1.8%
Last/next 42 years	1.5%	1.5%	1.3%	1.4%
Last/next 72 years	1.2%	1.3%	1.2%	1.3%

Note: Analysis relates to England & Wales. Historic estimates are based on comparison of 2002-04 Interim Life Tables with English Life Tables for 1930-32, 1960-62 and 1980-82

Source: Adrian Gallop, Mortality seminar, 26 April 2007

The “library”: previously-published projections

ONS 2004-based Population Projections



Annual improvements from 1992 to 2050 for selected ages

Solid line=Principal; Dotted lines=HLE & LLE (age 65 only)

The “library”: variations on cohort projections

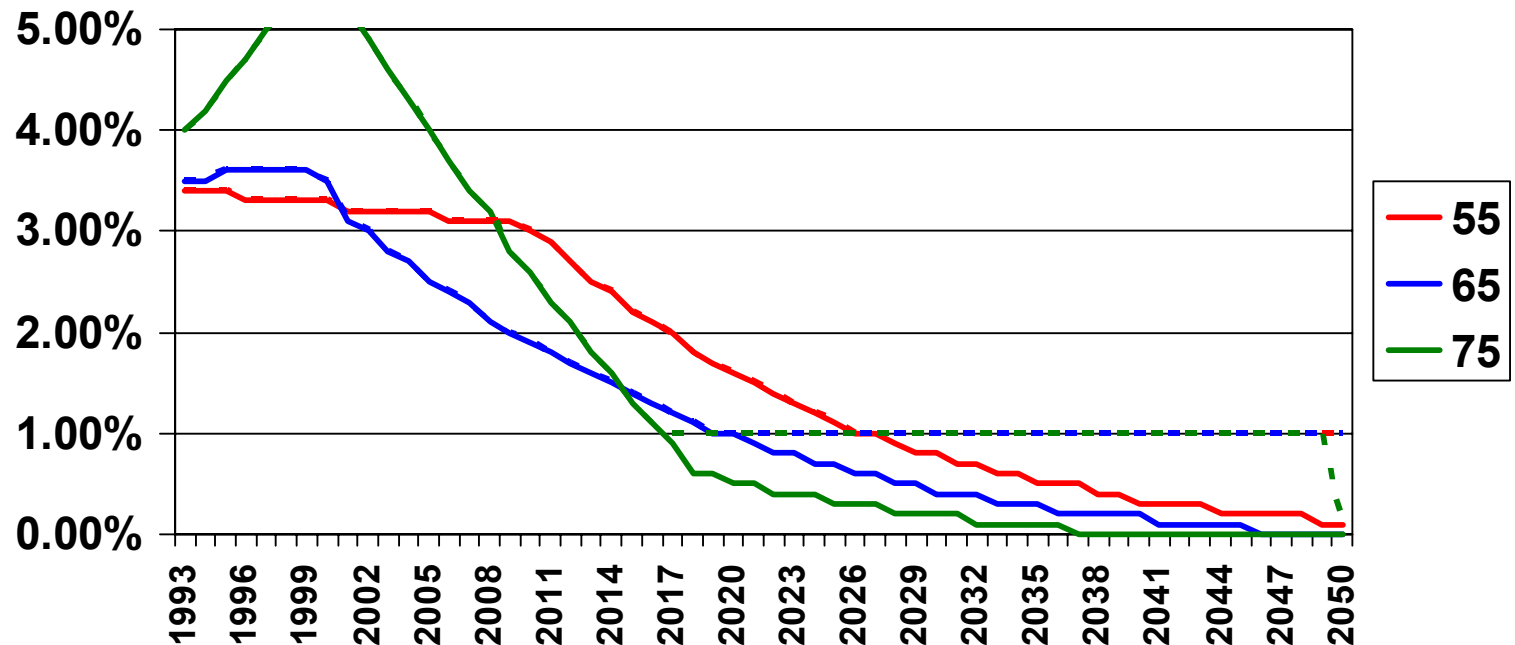
- Included because being used in practice...
- ...but not necessarily consistently
- No “right answer”, but hopefully standardise
- Not a complete list
- 1 example of each of the following included:
 - Applying a minimum value
 - Using a percentage
 - Blending 2 of the cohort projections
 - Blending and applying a minimum

The “library”: variations on cohort projections

- Applying a minimum value to medium cohort
- Take annual improvement in q_x , replace with 1% if lower
- “92”/cohort assume no improvements above age 110
 - Draft library assumes 1% minimum applies here too
- “92”/cohort assume $q_x=1$ at age 120
 - Draft library assumes $q_x=1$ at age 120

The “library”: variations on cohort projections

- Applying a minimum value to medium cohort



Annual improvements from 1992 to 2050 for selected ages

Dotted line indicates effect of applying a 1% improvement

The “library”: P-spline projections

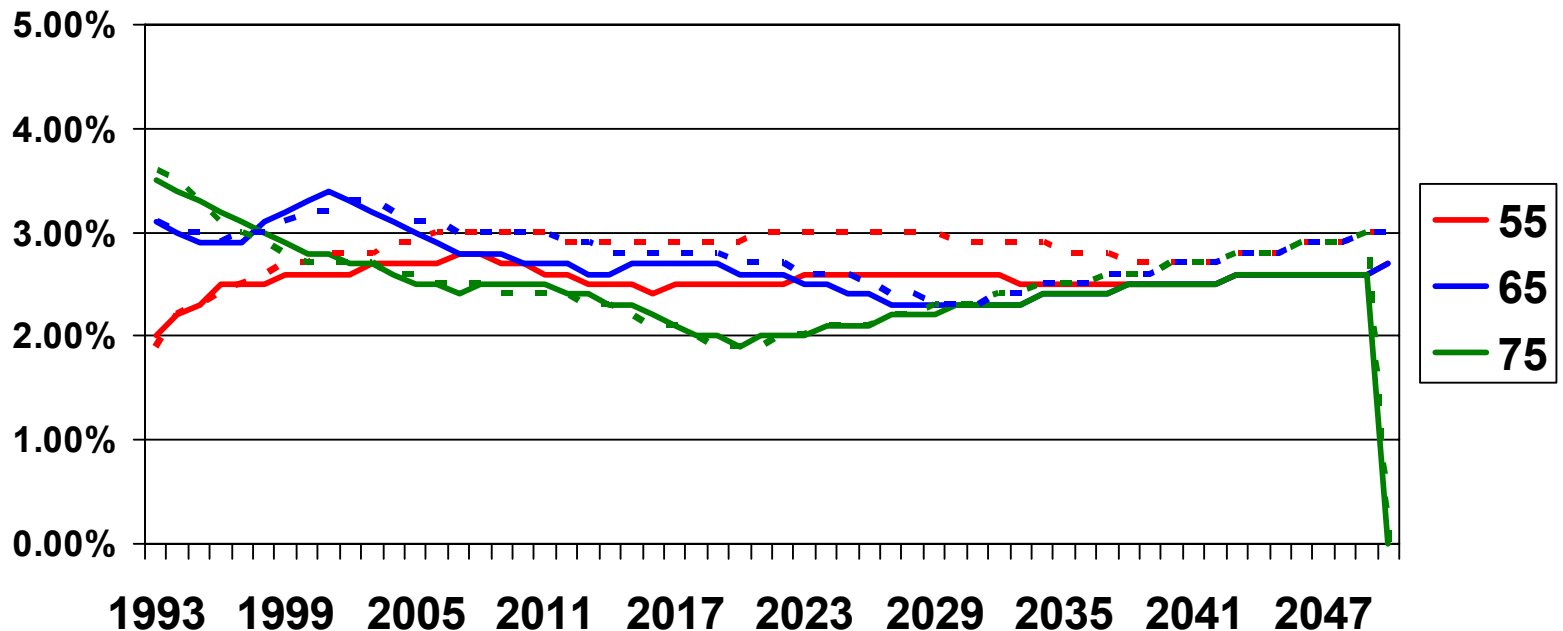
- Regression model fitted to past data
- P-splines impose a penalty on differences in adjacent co-efficients
- Choice of penalties determines balance between smoothness and closeness of fit
- Model fitted to a surface, either:
 - age and calendar year (Age-Period) or
 - age and year of birth (Age-Cohort)
- Fitting process provides:
 - Fitted $\log(\mu) \Rightarrow$ mean values
 - Standard deviations \Rightarrow determine confidence intervals

The “library”: P-spline projections

- Draft library includes 18 projections:
 - Age-Period and Age-Cohort
 - Fitted to CMI Male Assured lives, ONS males and ONS females
 - Data to 2003, 2004 and 2005
- Draft library includes 50th percentile only
- Projections are vulnerable to ‘edge effects’

The “library”: P-spline projections

- Age-Period (full lines) v Age-Cohort (dotted lines)

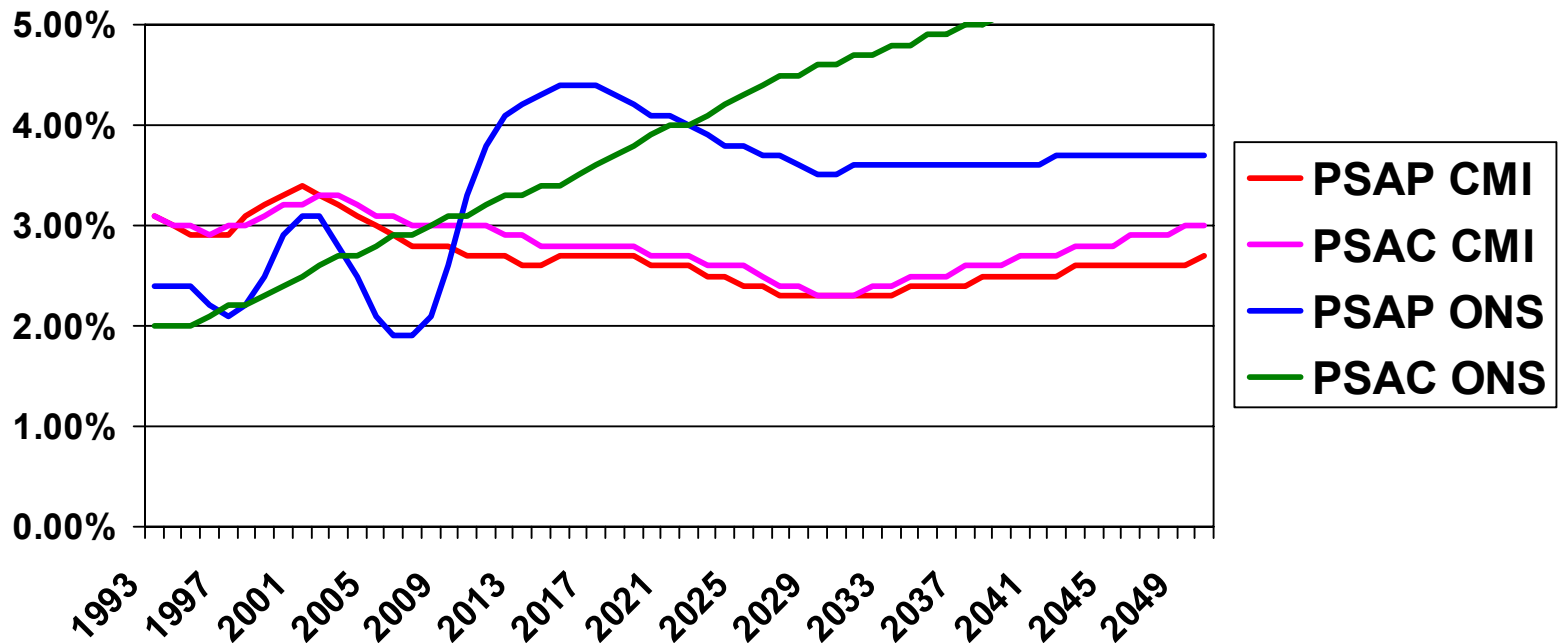


Annual improvements from 1992 to 2050 for selected ages

Fitting based on Male Assured Lives dataset to 2004

The “library”: P-spline projections

- Choice of dataset

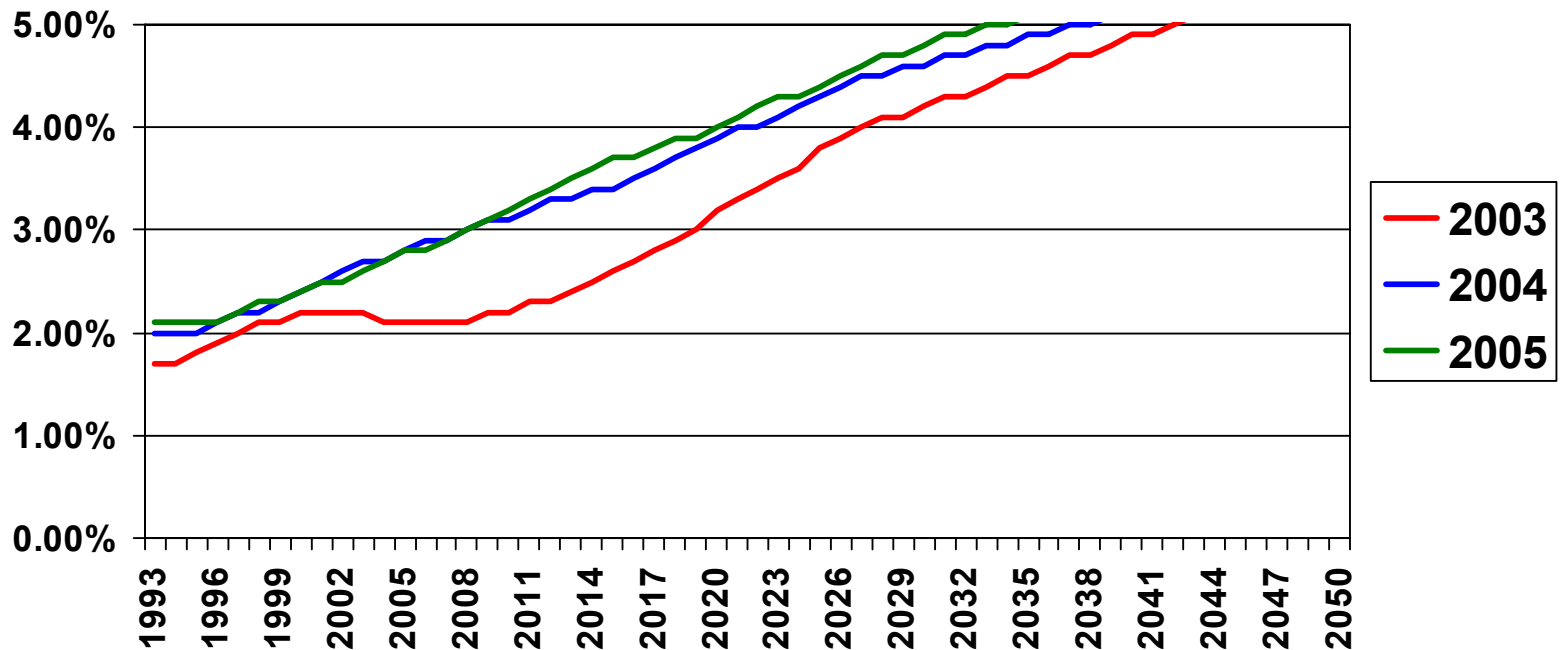


Annual improvements from 1992 to 2050 for age 65 only

Fitting based on Male datasets to 2004

The “library”: P-spline projections

■ Data Period



Annual improvements from 1992 to 2050 for age 65 only

Age-Cohort fitting based on Male ONS datasets

The “library”: Lee-Carter projections

- Structured time-series model

$$\log \mu(x, t) = a(x) + b(x)k(t) + e(x, t)$$

- No allowance for parameter uncertainty, so CMI have introduced through bootstrapping
- Basic model does not capture cohort effects
⇒ Poor fit when back-testing from 1992
- Renshaw & Haberman Lee-Carter APC model

$$\log \mu(x, t, c) = a(x) + b_1(x)k(t) + b_2(x)I(c) + e(x, t, c)$$

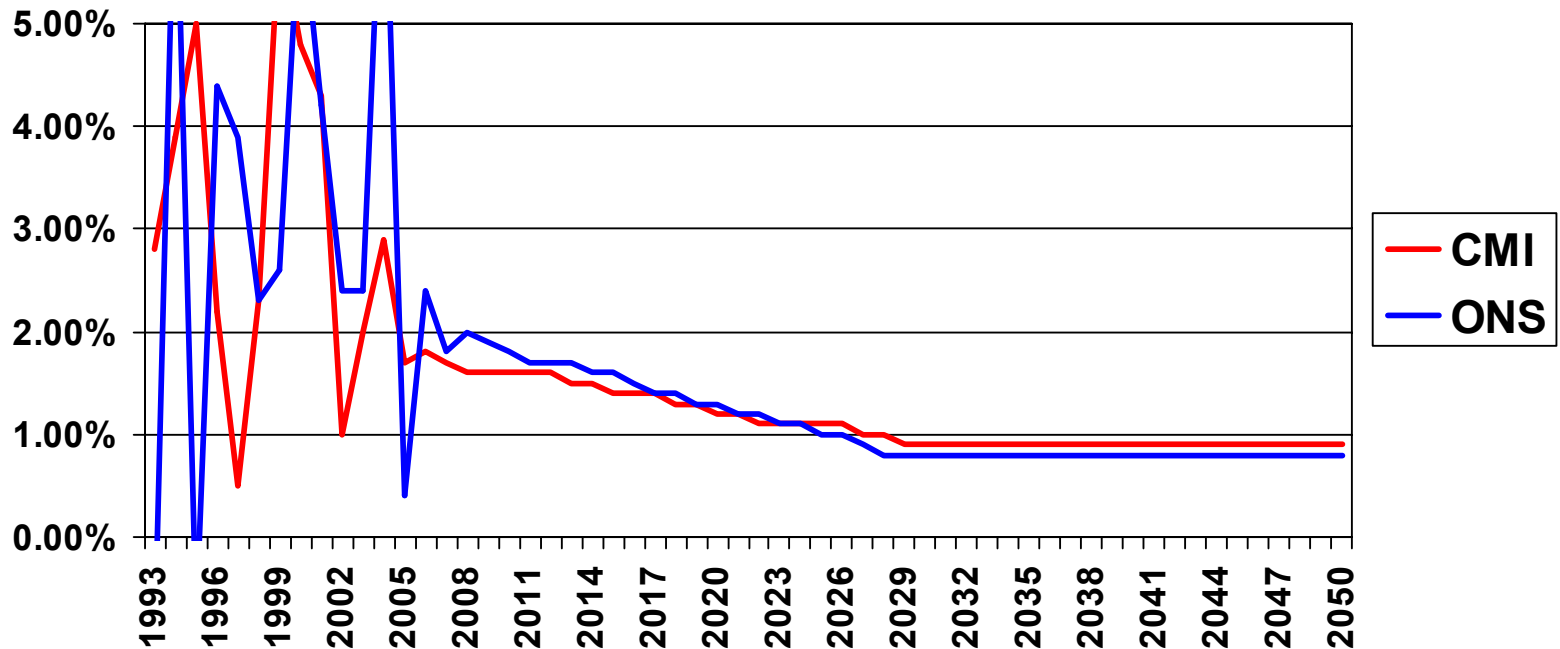
- Introduces extra parameter to model cohort effects

The “library”: Lee-Carter projections

- Draft library includes 9 projections:
 - Fitted to CMI Male Assured lives, ONS males and ONS females
 - Data to 2003, 2004 and 2005
- Draft library includes central projection only
- Basic Lee-Carter doesn't project cohort effects
- No examples of Lee-Carter APC included in draft library – needs further research

The “library”: Lee-Carter projections

- Choice of dataset

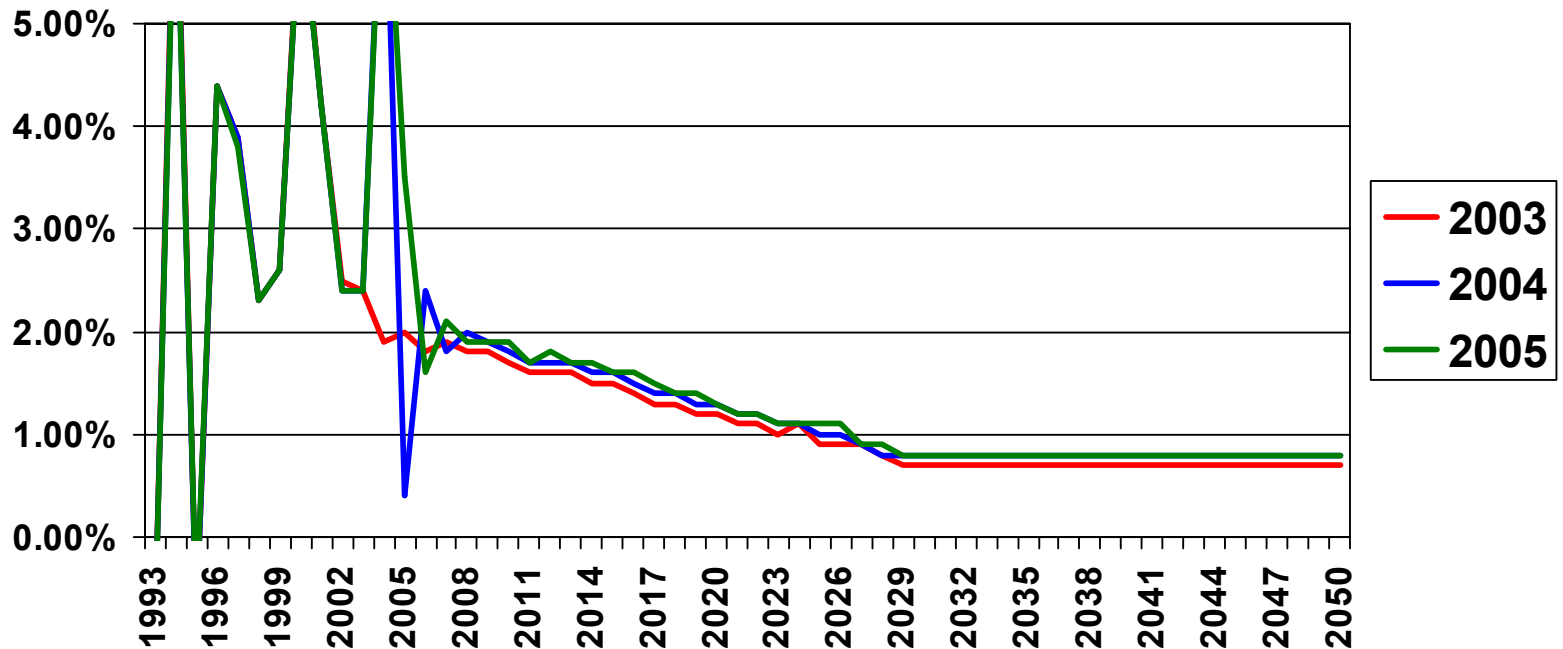


Annual improvements from 1992 to 2050 for age 65 only

Fitting based on Male datasets to 2004

The “library”: Lee-Carter projections

- Data Period



Annual improvements from 1992 to 2050 for age 65 only

Fitting based on Male ONS datasets

The draft “library” in detail

- The structure of the “library”
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- Illustrating the choice of projection
- Illustrating uncertainty
- Recent trends

The “library”: Illustrating the choice of projection

- Not seeking to standardise how projections are illustrated ...
- ...but some commonality of language and illustrations may be helpful
- Projections can be illustrated by e.g. heat maps or line graphs
- Mortality bases can be illustrated by e.g. annuity values or expectations of life

The “library”: Illustrating Uncertainty

Projections of future mortality are uncertain!!

- P-spline and Lee-Carter both illustrate some aspects of uncertainty
- Other projections don't – except in comparison between projections

The “library”: Recent trends

- Not seeking to provide a comprehensive overview
- Males
 - Improvements around 3% p.a. in recent years at ages 60-80
 - No evidence of slowing in rate of improvement
 - CMI data shows slightly lower improvements
- Females
 - Improvements slightly lower - around 2½% p.a.
- Cohort effect appears for both males and females
- Experience erratic by year

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What happens next?

- Consultation paper
- Feedback requested by 17 August to projections@cmib.org.uk
- Task Force will then review and consider modifications
- “Final” version of library published ASAP thereafter
- STP released with final library
- Future updates, as new data and methods become available

Future Updates

- No set times, updates for:
 - New data
 - Intuitive scenarios
 - New methodologies
- Draft criteria are that new projections must be:
 - A worthwhile addition to the current library
 - Publicly available
 - Clearly described and documented
 - Independently Peer Reviewed.

Consultation questions

- A number of questions in the paper:
 - Have we included the right projections?
 - Is the naming convention appropriate?
 - How do we illustrate projections?
 - How do we communicate uncertainty?
 - How do we decide what to include in future?
 - What else should the Profession or the CMI do?



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