

Mortality Projections

Current Issues in Life Assurance seminar
23 / 31 May 2007

Dave Grimshaw
Secretary, CMI

Mortality Projections

- Background
- Recent CMI research
- The "library" of projections
- Recent CMI experience
- Mortality improvements – where next?

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

Recent CMI research: P-splines

- 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

Recent CMI research: Lee-Carter

- 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
 \Rightarrow Poor fit when back-testing from 1992
- Renshaw & Haberman Lee-Carter APC model

$$\log \mu(x, t, c) = a(x) + b_1(x)k(t) + b_2(x)l(c) + e(x, t, c)$$
- Introduces extra parameter to model cohort effects

Recent CMI research: Conclusions

Objective	P-Spline age-cohort	P-Spline age-period	Lee-Carter	Lee-Carter APC
Ease of use	Y	Y	Y	Y
Parameter Interpretation	N	N	Y	Y
Structure & fit	Y	Y	N	?
Cohort effects	Y	N	N	Y
Best estimate	Y	Y	Y	Y
Confidence Intervals	Y	Y	Y	Y
Sample paths	N	N	Y	Y

Recent CMI research: Conclusions

- Issues with both P-spline & Lee-Carter
- Both dependent on improvements within past data
- CMI cannot recommend any specific method
- No “Holy Grail” !!

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Mortality Projections – further work

- 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

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Mortality Projections – further work

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

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Mortality Projections – further work

Initial “library” of projections will include:

- 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

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Mortality Projections – further work

- 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?

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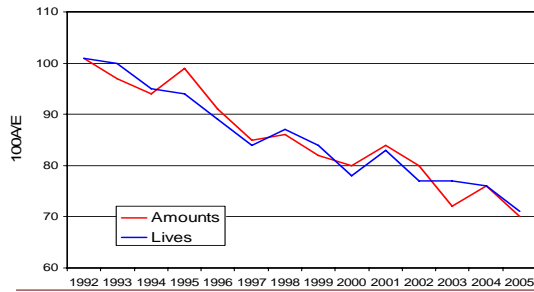
Recent CMI experience

- Results released to members for 2003 and 2004
- Assured lives data to 2004 also made available with software
- 2005 results will be released to members soon

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Recent CMI experience

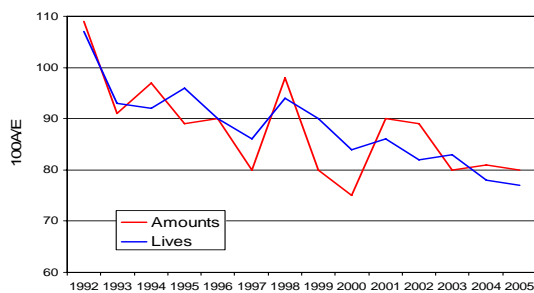
Male Life Office Pensioners 100A/E, E= "92" Series mortality rates, Normals



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Recent CMI experience

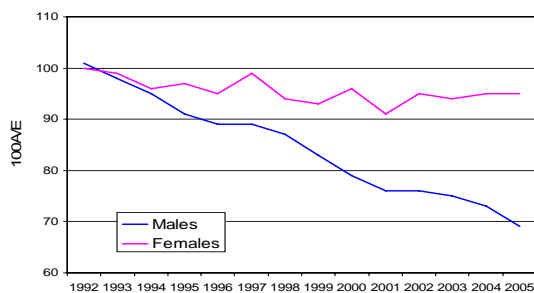
Female Life Office Pensioners 100A/E, E= "92" Series mortality rates, Normals



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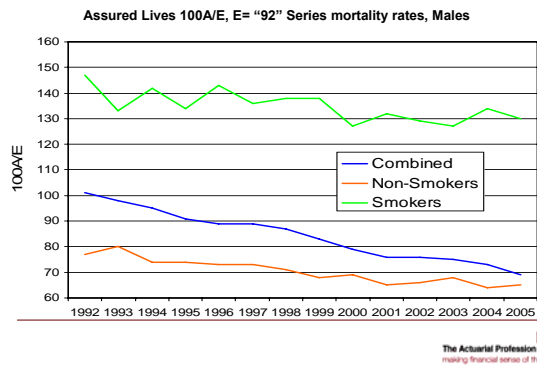
Recent CMI experience

Assured Lives 100A/E, E= "92" Series mortality rates



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Recent CMI experience



Recent CMI experience

- Male experience has continued to improve to 2005
- Female experience appears to have improved for Life Office Pensioners, not so for Assured lives
- Improvements on Assured Lives at least partially explained by changes in prevalence of smoking
- Individual year results vulnerable to changing mix of offices
- All-ages results mask changes by age

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Mortality improvements – where next?

- Statistical methods:
 - P-spline – *age-period or age-cohort?*
 - Lee-Carter – *Basic or age-period-cohort?*
+ choice of dataset, parameterisation, etc
- ... or something simpler?

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Mortality improvements – where next?

Assumption on future improvements in male mortality
from selected 31/12/2006 FSA Returns:

(All unchanged from 31/12/2005)

- Friends Provident: Average (MC,LC) min 0.50%
- L&G: Average (MC,LC) min 0.80%
- Norwich Union: MC min 2.00%
- Prudential: MC min 1.25%
- Standard Life: MC min 1.50%

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Mortality improvements – where next?

- “Should projections of mortality improvements
be subject to a minimum value?”

Steven Baxter, Institute sessional meeting, 26 Feb 2007

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Mortality improvements – where next?

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- “Possibly...”

Dave Grimshaw, CILA, 23 May 2007

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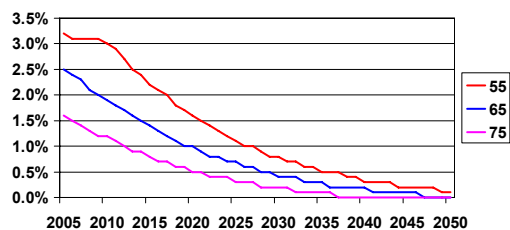
Mortality improvements – where next?

- “Should projections of mortality improvements be subject to a minimum value?”
Steven Baxter, Institute sessional meeting, 26 Feb 2007
- “Possibly...”
Dave Grimshaw, CILA, 23 May 2007
 - ➔ Which projection?
 - ➔ What minimum value?

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Mortality improvements – which projection?

“92” Series implies a rapid slow-down in mortality improvements

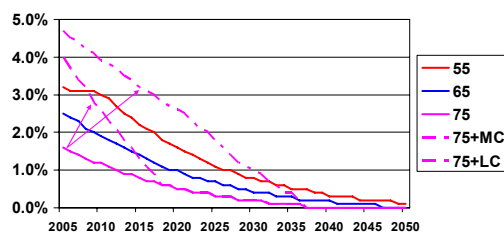


Age in 2005

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Mortality improvements – which projection?

“92” Series implies a rapid slow-down in mortality improvements
... Cohort projections are ad hoc adjustments to some ages

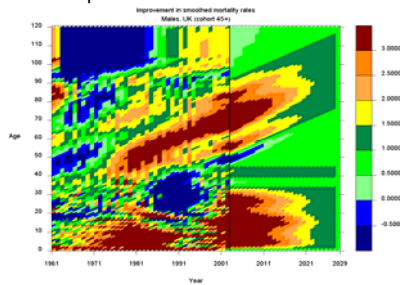


Age in 2005

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Mortality improvements – what minimum?

1% minimum improvement is much lower than in recent past

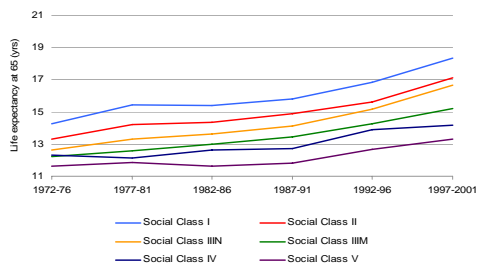


Annual improvement in smoothed mortality rates, Males, UK
Source: Adrian Gallop, Mortality seminar, 26 April 2007

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Mortality improvements – what minimum?

Mortality improvements have been faster for higher social classes



Trend in male period life expectancy at age 65 by social class, 1972-2001
Source: Adrian Gallop, Mortality seminar, 26 April 2007

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UK Population Mortality 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

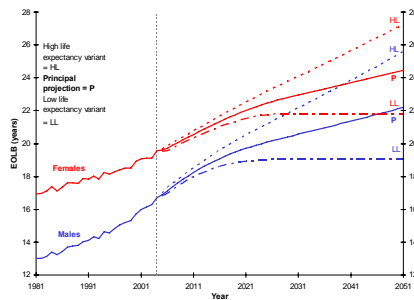
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UK Population Mortality Projections

- 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

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Period expectation of life at age 65, UK



Source: Adrian Gallop, Mortality seminar, 26 April 2007

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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%

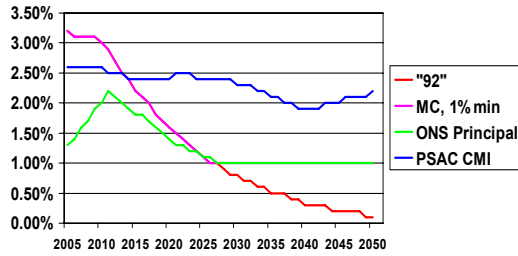
Note: Analysis relates to England & Wales. Historic estimates are based on comparison of 2002-04 Interim Life Tables with English Life Tables for 1930-32, 1960-62 and 1980-82

Source: Adrian Gallop, Mortality seminar, 26 April 2007

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Comparison of projections

Male age 55 in 2005

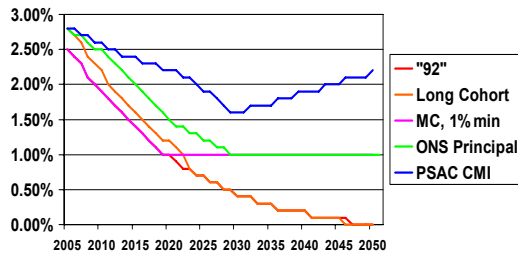


Source: own calculations

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Comparison of projections

Male age 65 in 2005

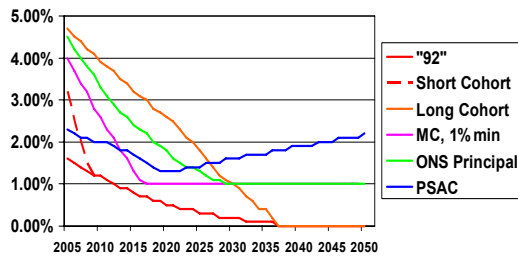


Source: own calculations

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Comparison of projections

Male age 75 in 2005



Source: own calculations

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Comparison of projections

	${}_{20 }\ddot{a}_{45}$	${}_{10 }\ddot{a}_{55}$	\ddot{a}_{65}	\ddot{a}_{80}
PMA92	4.539	7.462	12.542	7.054
PMA92sc	4.624	7.613	12.816	7.303
PMA92mc	4.698	7.738	13.034	7.531
PMA92lc	4.862	8.015	13.508	7.869
PMA92mc/1%	4.781	7.823	13.109	7.581
PSac CMI 2004	5.164	8.167	13.206	7.397
PSac ONS 2004	5.873	9.060	14.212	7.944

Annuity values @ 5%, base mortality = 100% PCMA00 for a life aged x in 2005. Source: own calculations

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Comparison of projections

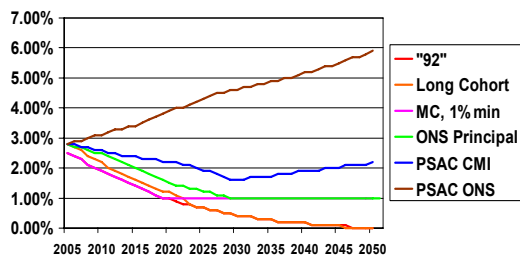
	${}_{20 }\ddot{a}_{45}$	${}_{10 }\ddot{a}_{55}$	\ddot{a}_{65}	\ddot{a}_{80}
PMA92	100%	100%	100%	100%
PMA92sc	102%	102%	102%	104%
PMA92mc	104%	104%	104%	107%
PMA92lc	107%	107%	108%	112%
PMA92mc/1%	105%	105%	105%	107%
PSac CMI 2004	114%	109%	105%	105%
PSac ONS 2004	129%	121%	113%	113%

Annuity values @ 5%, base mortality = 100% PCMA00 for a life aged x in 2005. Source: own calculations

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Male age 65 in 2005

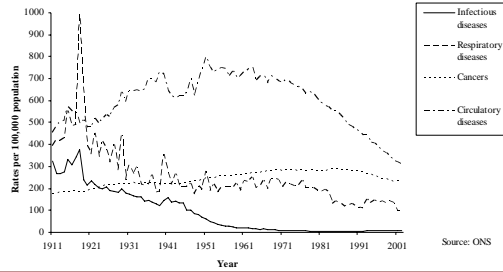


Source: own calculations

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Male mortality by major cause, England & Wales, 1911-2002

Age standardised mortality rates for selected broad disease groups



Source: ONS

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Mortality improvements – where next?

Conclusions:

- There is no "right" answer
- P-spline and Lee-Carter project continued high rates of improvement (at most ages) – is it prudent to assume lower?
- But they are not extreme, e.g. compared to a continued acceleration in rate of improvement
- Medium Cohort now implies a very rapid fall in improvements – cannot be considered prudent
- Long Cohort plus a minimum represents a more gradual reversion to longer-term trends in improvements...
- ... and not dissimilar from adapting ONS principles for social mix
- Appropriateness will depend on age-profile

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Mortality improvements – where next?

Conclusions:

- There is no "right" answer
- Need to explain uncertainty in ways that Boards or trustees can comprehend
- Need to consider trends by cause
- Need for more research –
 - Life Research Committee proposing working party into modeling mortality by cause – volunteers to dave.grimshaw@barnett-waddingham.co.uk
- Can we do more on (new) projection methodologies?

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