The Actuarial Profession
making financial sense of the future

CURRENT MORTALITY ISSUES

Edinburgh 22 September 2006

The Return of Mortality Risk

- 1980s, 1990s: Era of investment risk
- 2000s: Low inflation, low interest rates
- Move away from With-Profits
- Move away from bundled savings products
- More stand-alone mortality risk

FSA requirements (1)

- Integrated Prudential Sourcebook
- Mathematical reserves: margin for adverse deviation should be greater than or equal to market price for risk
- If risk premium not available proxy can be used such as adjusted industry mortality tables
- If large range of possible outcomes, use stochastic techniques to evaluate risk – longevity risk may fall into this category

FSA requirements (2)

In setting prudent mortality rates, should consider:

- Credibility of own experience
- Availability and reliability of published tables
- Anticipated or possible future trends (where this increases liability) including:
  - anticipated improvements
  - changes in market segmentation

Developments in Mortality

Agenda

- The CMI
- Recent CMI mortality experiences
- The cohort effect
- Projecting longevity

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The CMI

- Continuous Mortality Investigation
- Continuous data collection since 1924
- Committees: Mortality, Income Protection, Critical Illness and Self-Administered Pension Schemes
- Produces standard (now “base”) tables based on industry data

Developments in Mortality

Agenda

- The CMI
- Recent CMI mortality experiences
  - Smoker/Non-smoker mortality differences
  - Self-administered pension schemes
- The cohort effect
- Projecting longevity

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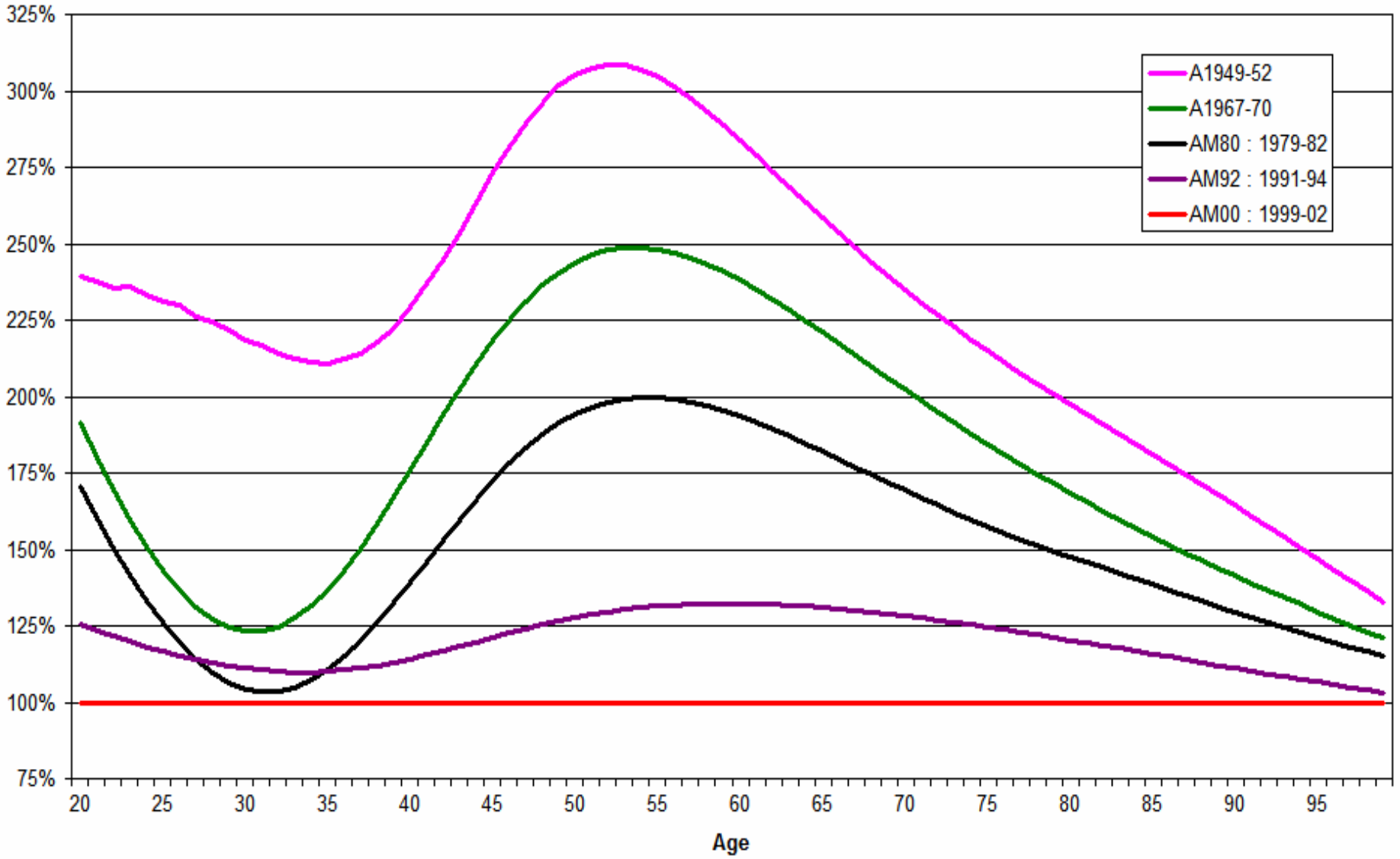
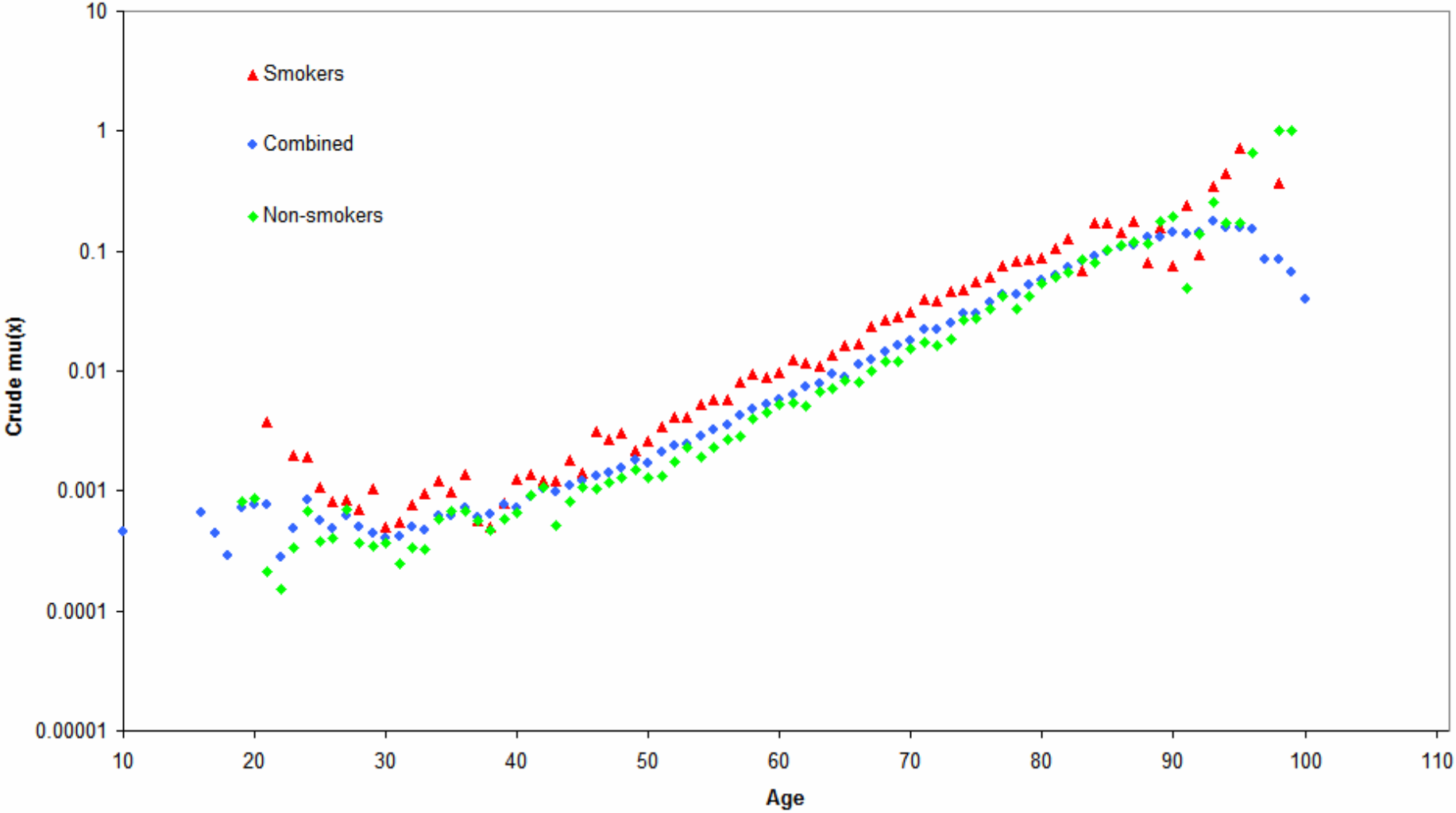
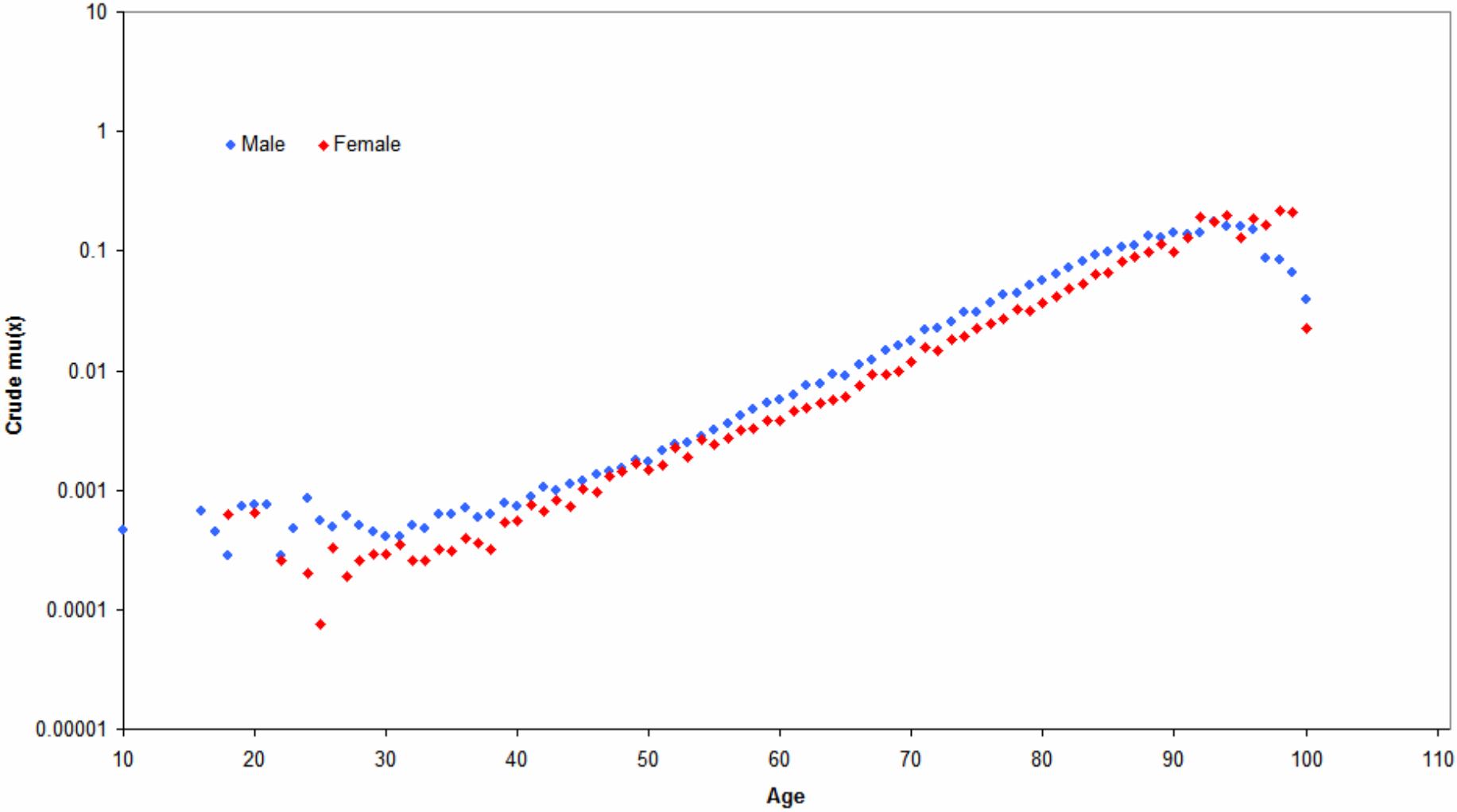
Ratios of male assured lives q(x)s - "00" Series v previous tables



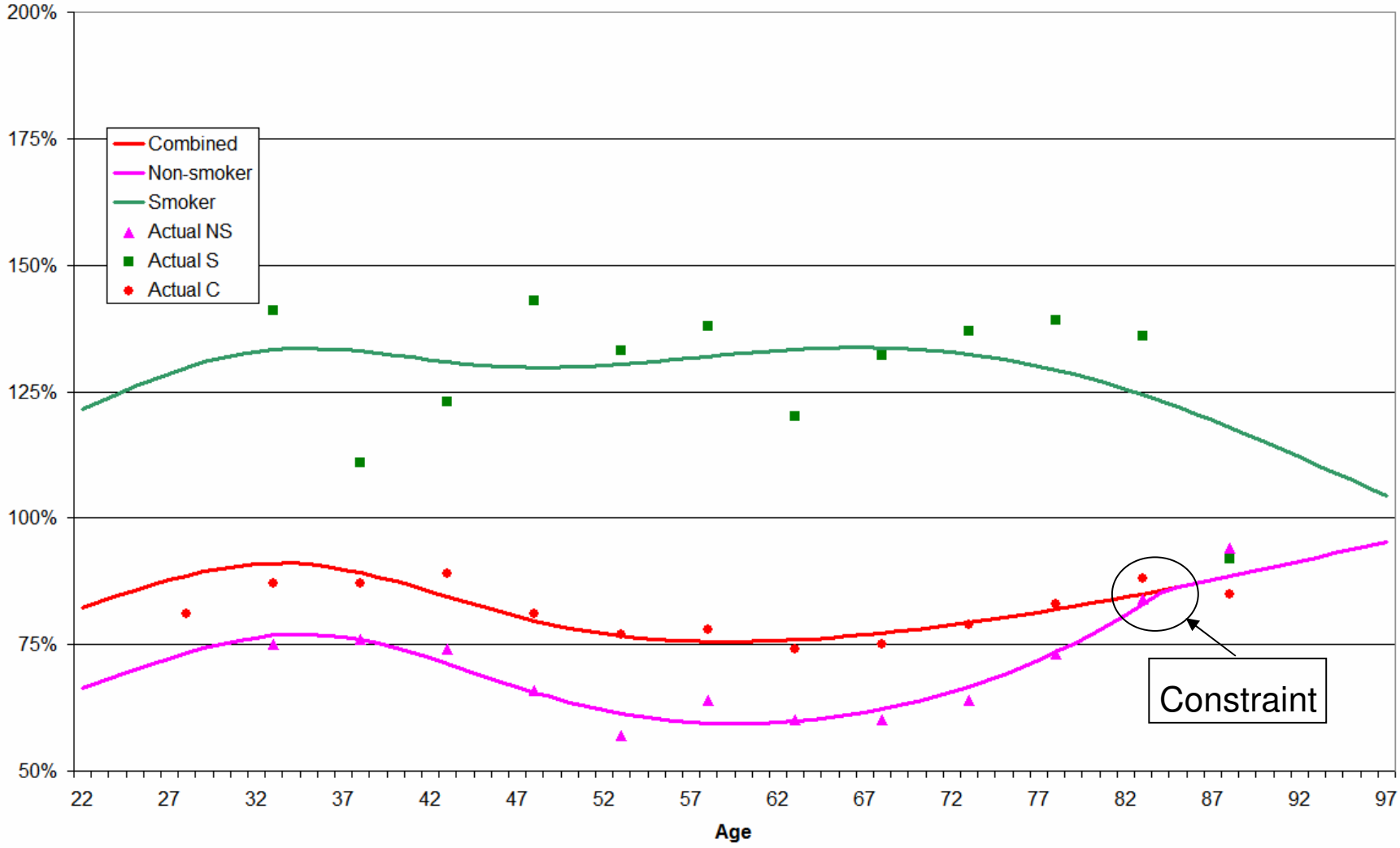
Crude Mu for Permanent Assurances, Males: Comparison of Smokers, Non-smokers and Combined

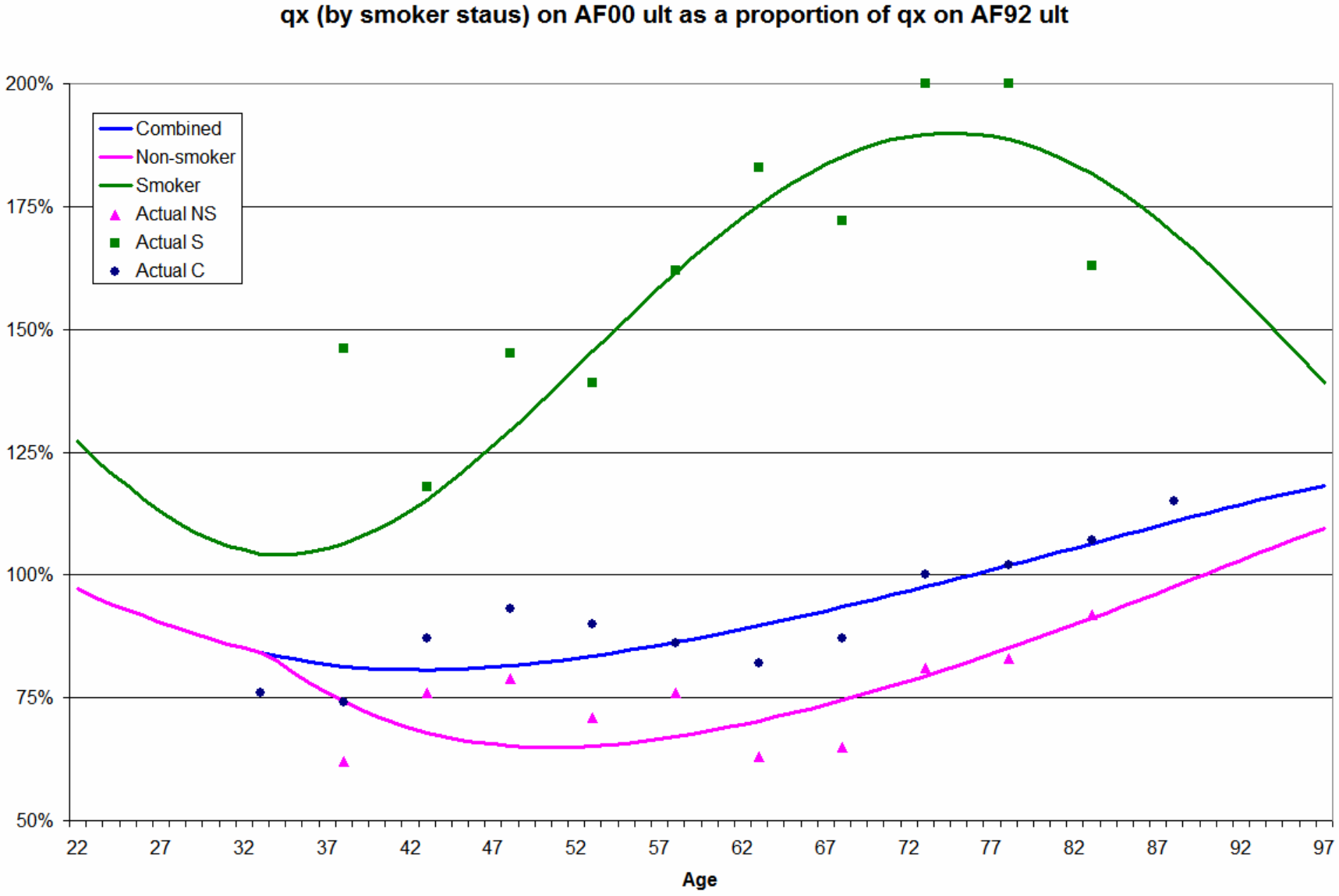


Crude Mu for Permanent Assurances, Combined: Comparison of Males and Females



qx (by smoker status) on AM00 ult as a proportion of qx on AM92 ult





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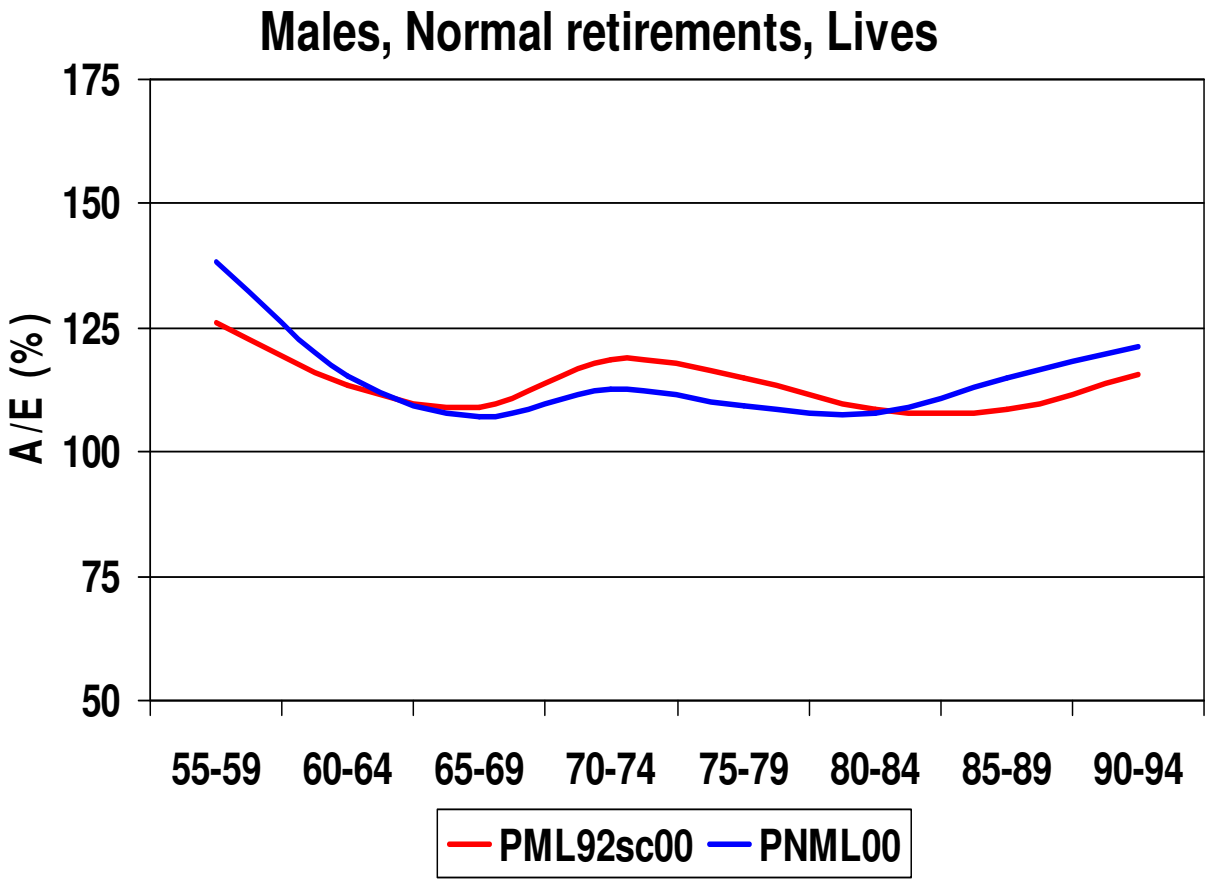
Differences in e(x)*period*

	Female–Male Yrs		N/S – S Yrs	
Age	Smokers	N/S	Males	Females
30	2.3	3.6	5.6	6.8
40	2.1	3.5	5.4	6.8
50	2.0	3.5	5.2	6.7
60	1.8	3.4	4.6	6.1
70	1.5	3.1	3.4	5.0

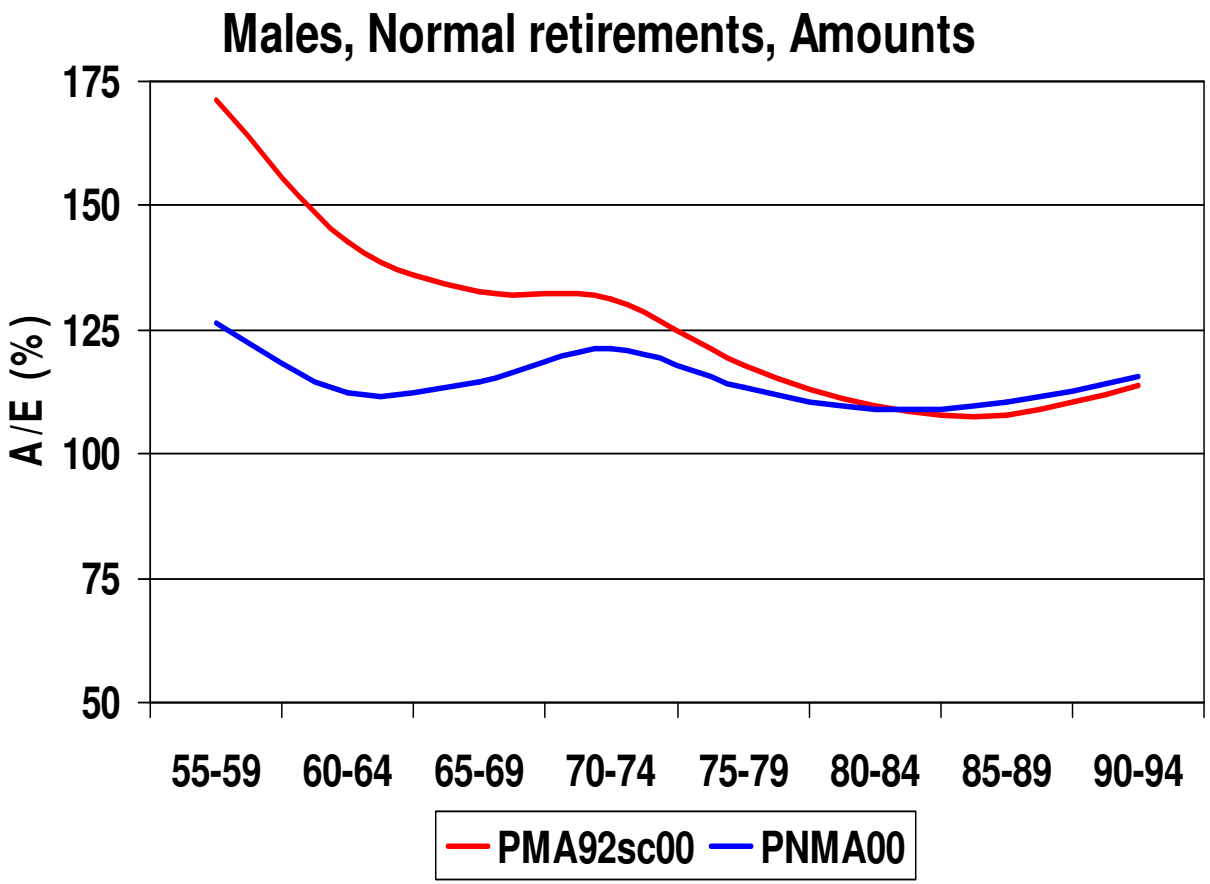
The SAPS Investigation

- Based on data from consultants to pension schemes (11 so far)
- 255 schemes with 2.67m records
- Data for individual scheme members (NEW!)
- 2000-2003 data analysed to date
- Results published as Working Papers

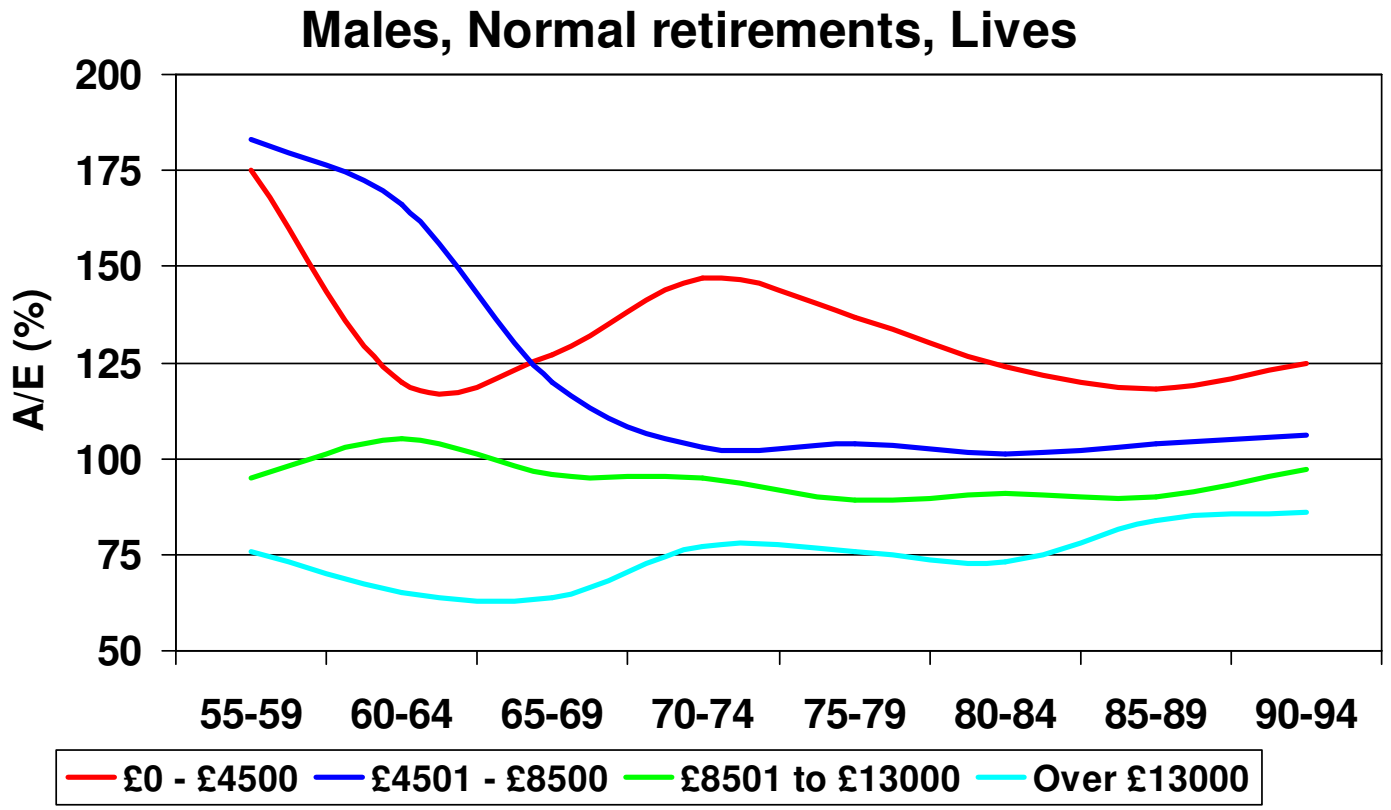
SAPS v Life Office Pensioner Tables



SAPS v Life Office Pensioner Tables



Amounts effect - *versus* 92 series sc (y=CY)



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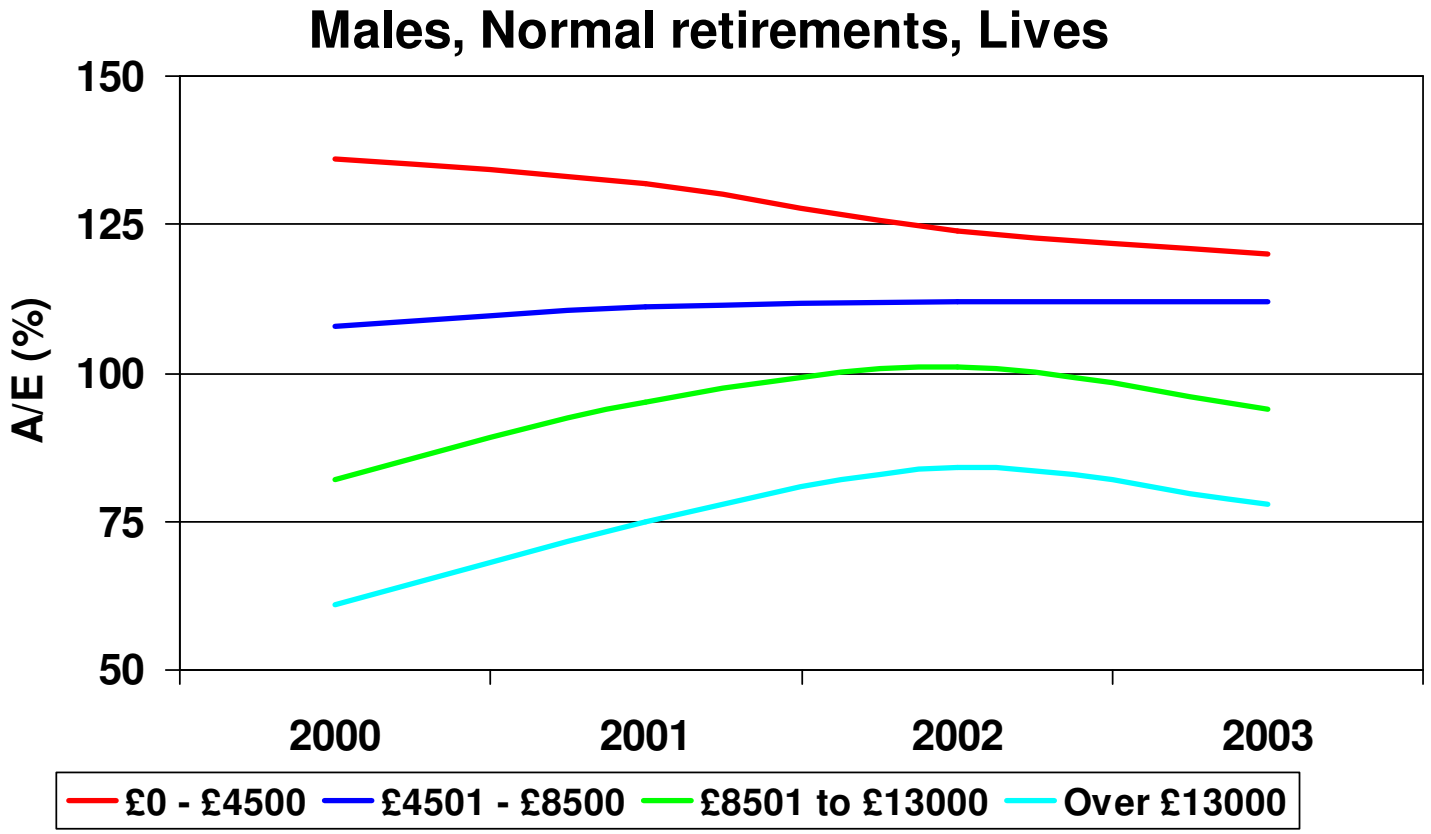
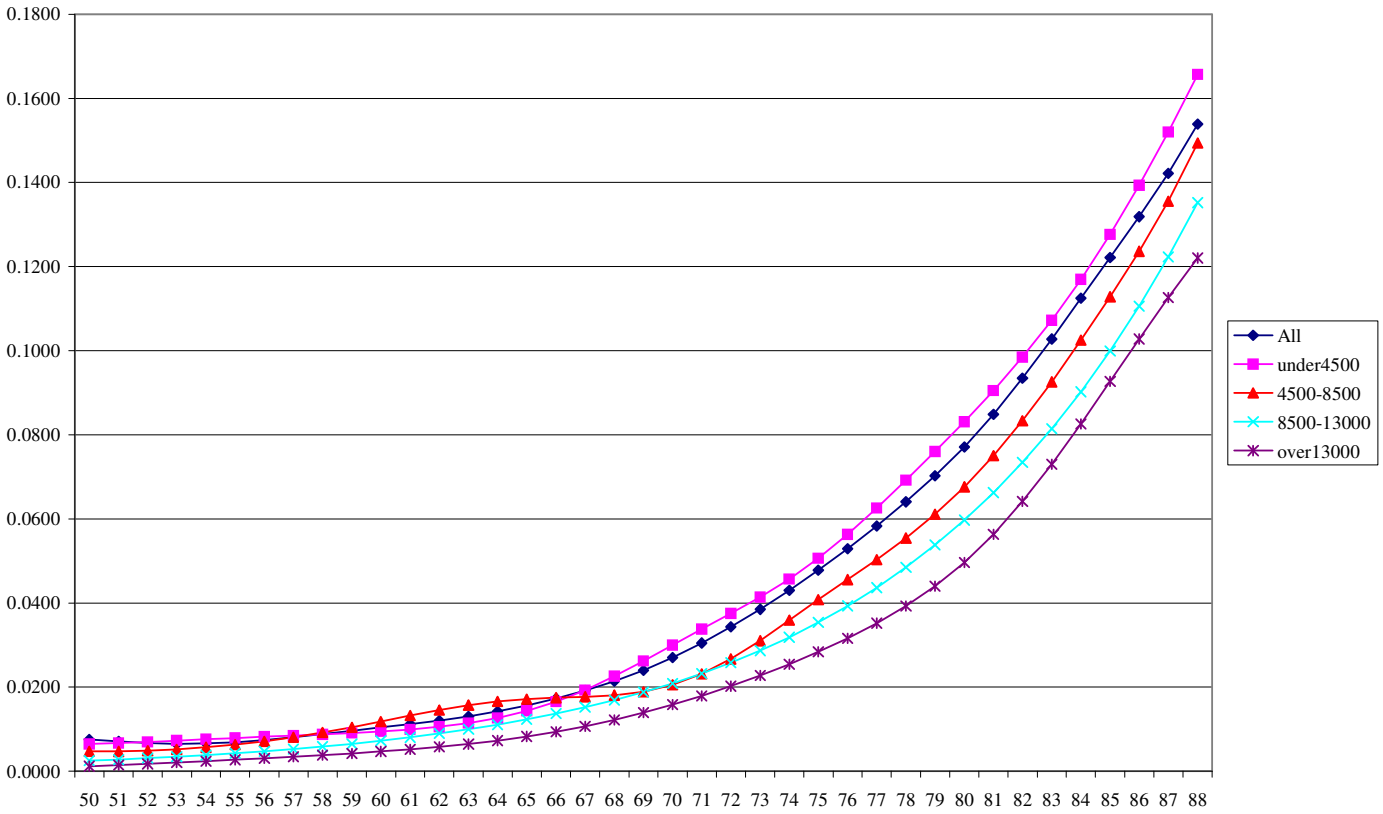


SAPS ‘Graduated’ qx – all males – in bands



Life expectancy, male age 60 in 2006

Band	Life expectancy (Medium Cohort projection)
Up to £4,500 pa	23.4 years
£4,500 - £8,500 pa	24.3 years
£8,500 - £13,000 pa	25.5 years
Over £13,000 pa	26.9 years

Developments in Mortality

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- The cohort effect
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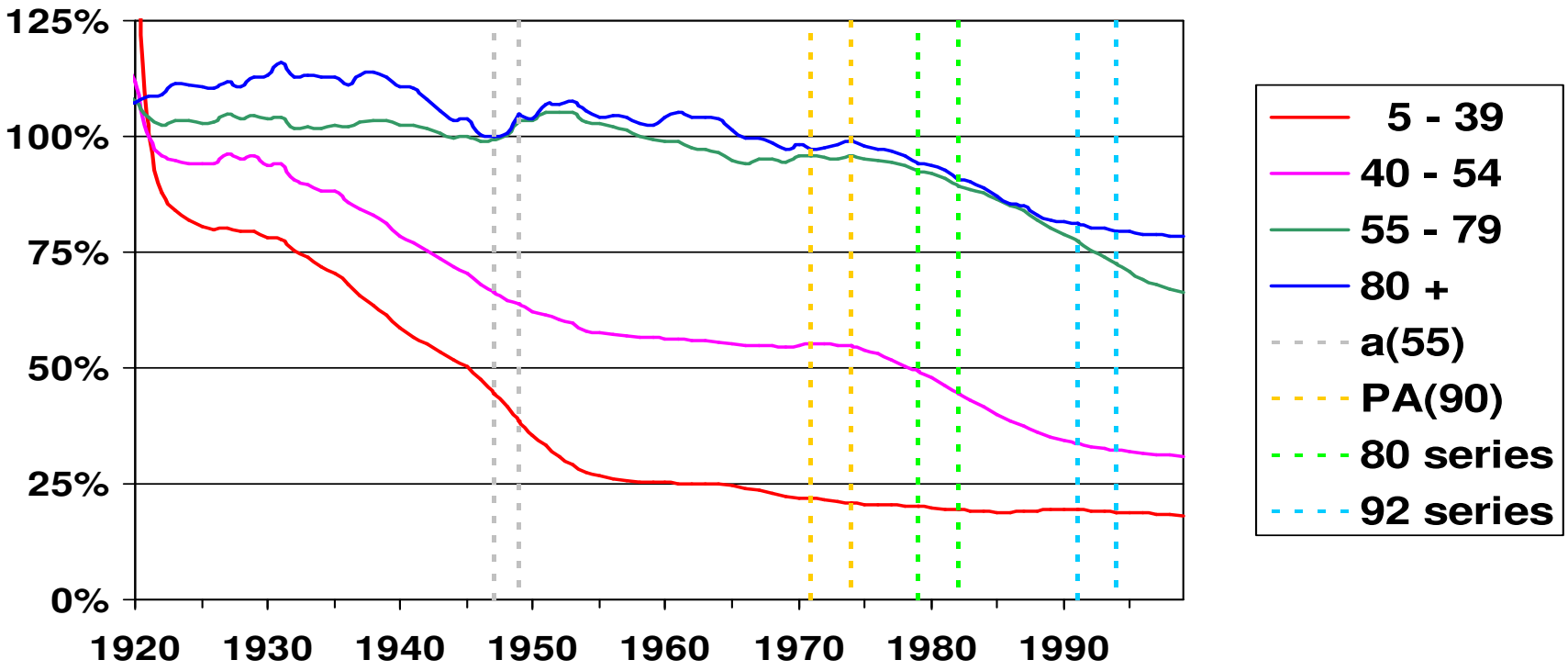
Improvements in male mortality 1920 - 1999



5-year moving averages

Improvements at younger ages

- Conquest of infectious diseases
  - TB, typhoid, measles, scarlet fever, diphtheria

% of deaths from infectious diseases (E&W)				
Ages	1901 – 1910		2001	
	Male	Female	Male	Female
1 – 14	43%	47%	6%	6%
15 – 44	46%	49%	2%	3%
45 – 64	16%	11%	<1%	<1%
65 +	4%	5%	<1%	<1%

Source – "Longevity in the 21st Century" Willets *et al* (2004)

Improvements at older ages

- Significant improvements in treatment of killer diseases
  - cancer, heart and respiratory diseases
- Smoking cessation – ongoing effects
  - Reduction in heart disease almost back to "never-smoker" status after 10 years
  - Effects on lung cancer rates take 20+ years to work off (if at all)

Source – "The Cohort Effect: Insights and Explanations" Willets (2004)

Will mortality continue to improve?

Professor Jay Olshanksy
University of Illinois, Chicago

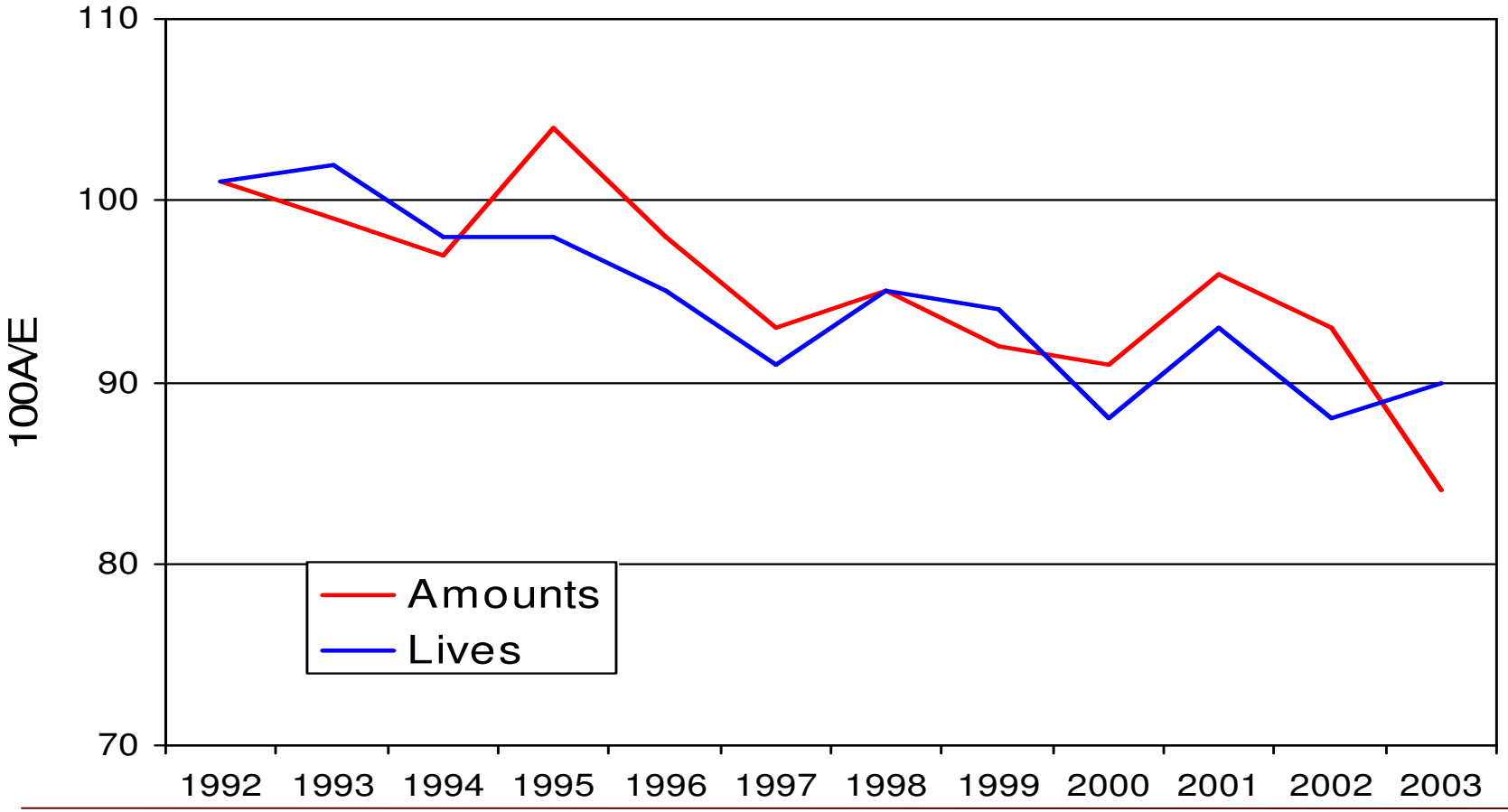
Olshanksy argues that mortality will not continue to improve at its current rate. The main reasons he gives are obesity, the spread of disease and, most importantly, the existence of biomechanical limits on our lifespan.

Professor Shripad Tuljapurkar
Stanford University, California

Study assumes that lifespans increase in line with current trends until 2010, but that anti-ageing technologies would then become available that would prolong life much further. These drugs and therapies would cause mortality to decline five times faster than historical rates between 2010 and 2030, before normal service was resumed.

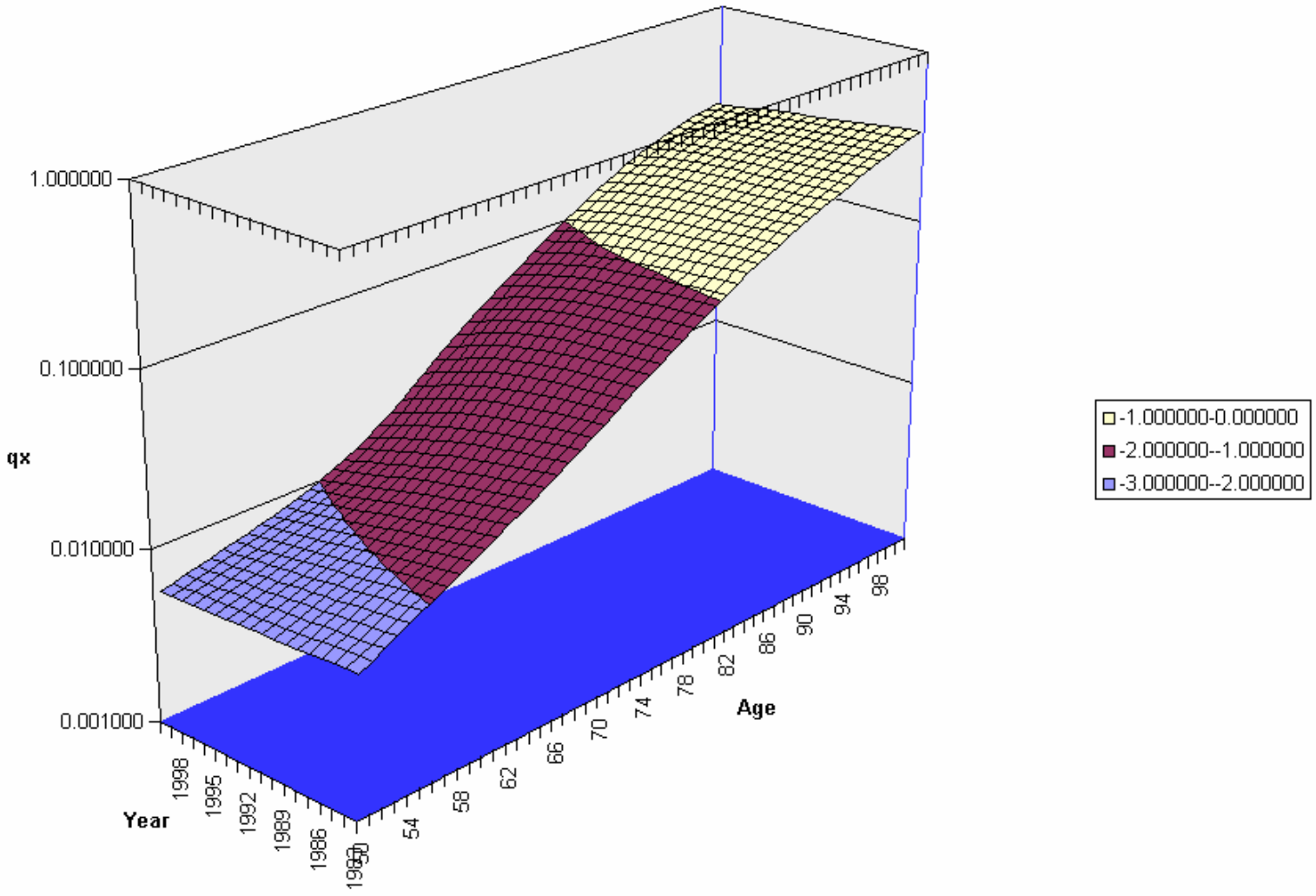
Recent CMI mortality experience

Life Office Pensioners 100A/E, E= “92” Series projected mortality rates, Males



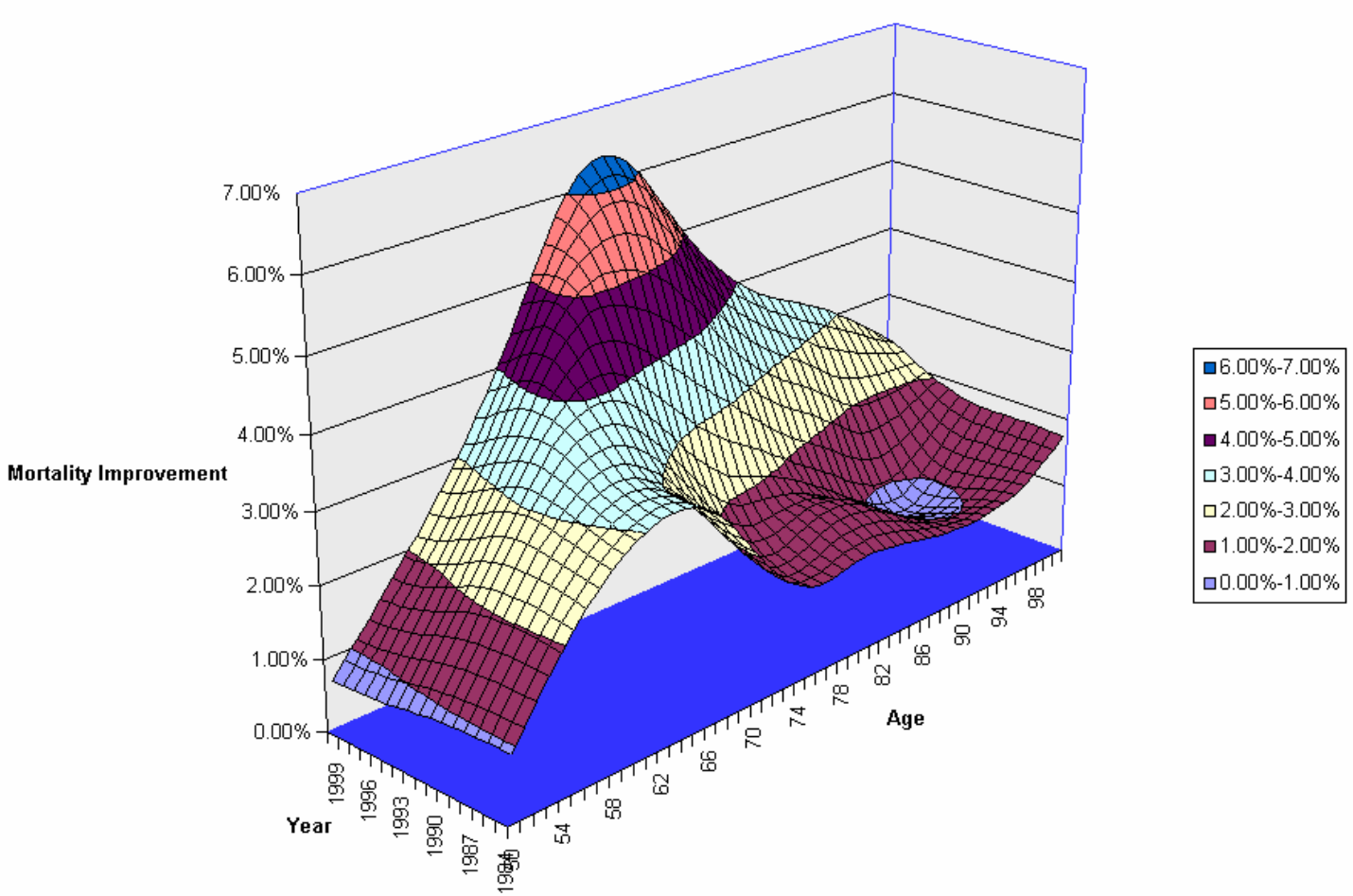
The datasets

- Crude *q(x)* by age and calendar year
- For lives with protection and savings products
  - 1947 to 2003
- For UK population
  - 1960 to 2003
- For ages 20 to 100
- Other datasets much smaller
- Used p-splines to remove noise
- Then tried to see patterns

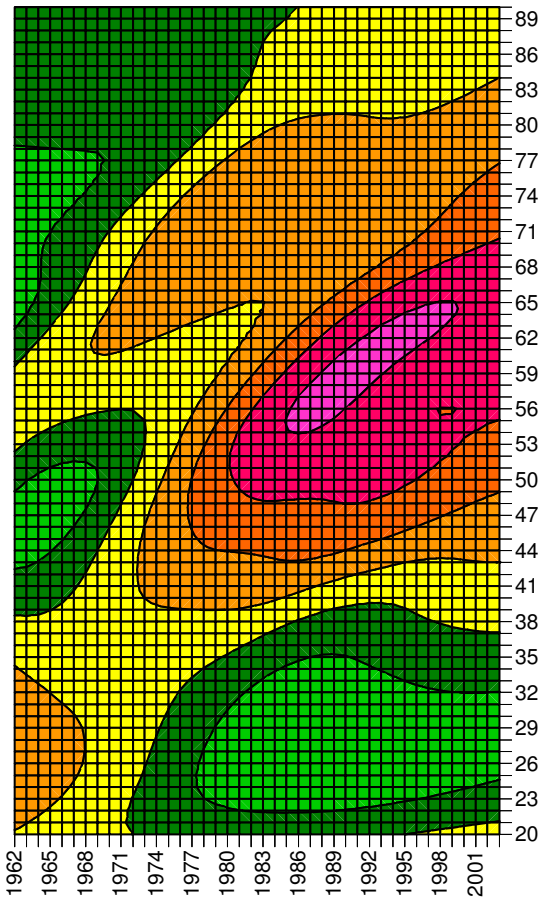

1.000000
0.100000
0.010000
0.001000
qx
Year
1998
1995
1992
1989
1986
Age
54
58
62
66
70
74
78
82
86
90
94
98
-1.000000-0.000000
-2.000000--1.000000
-3.000000--2.000000

… so looked at improvement rates

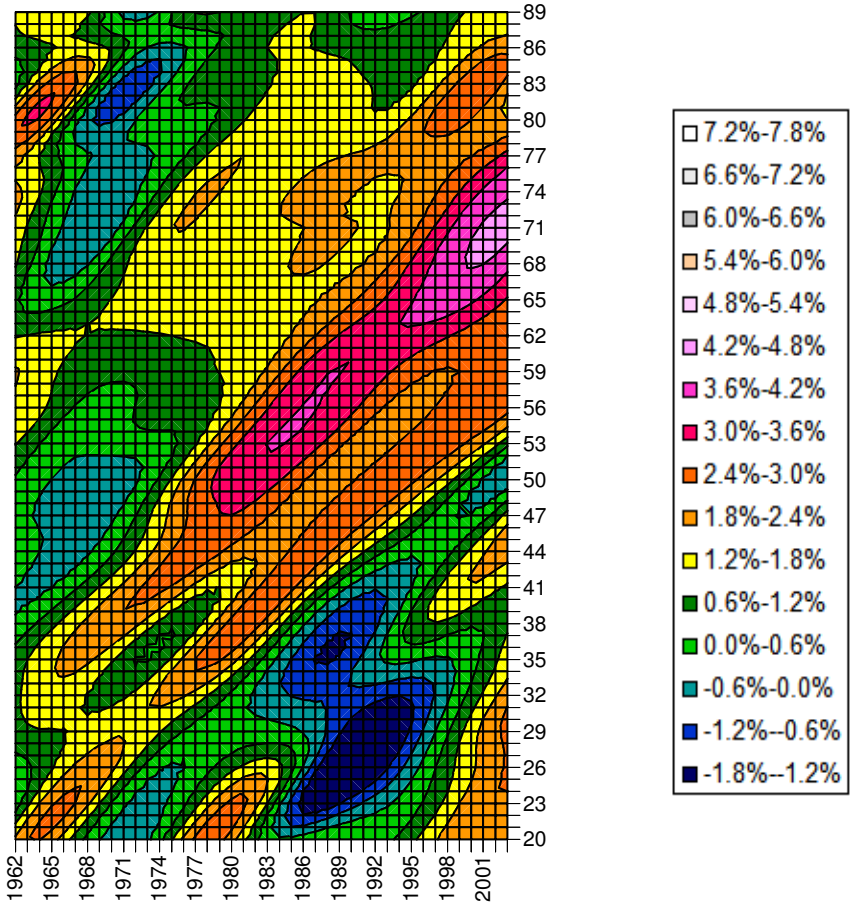
$$1 - \frac{q_{x,t}}{q_{x,t-1}}$$


Mortality Improvement
7.00%
6.00%
5.00%
4.00%
3.00%
2.00%
1.00%
0.00%
Year
1999
1996
1993
1990
1987
54
58
62
66
70
74
78
82
86
90
94
98
Age
6.00%-7.00%
5.00%-6.00%
4.00%-5.00%
3.00%-4.00%
2.00%-3.00%
1.00%-2.00%
0.00%-1.00%

Assured Lives - males

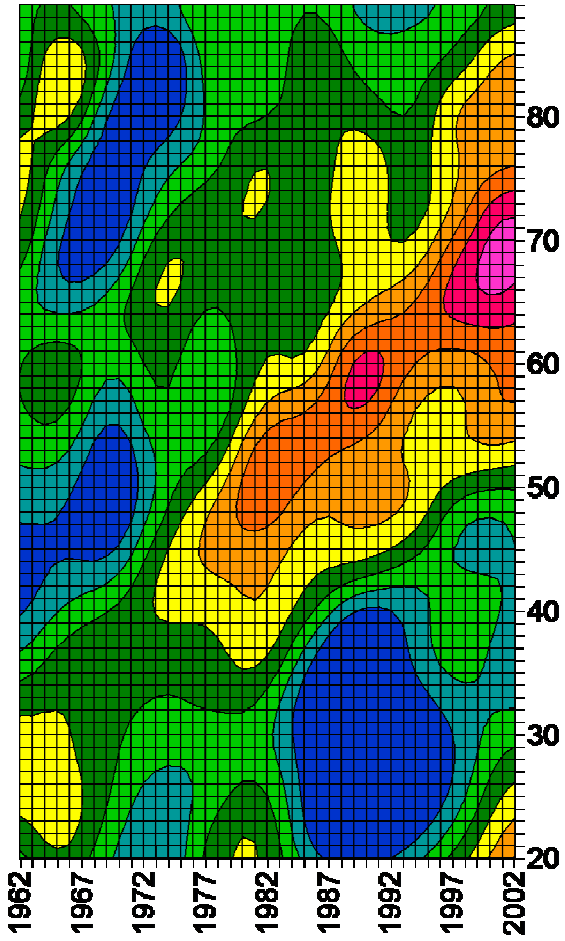


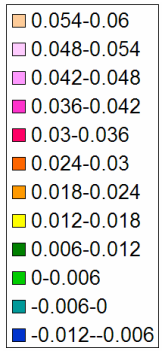
UK population - males



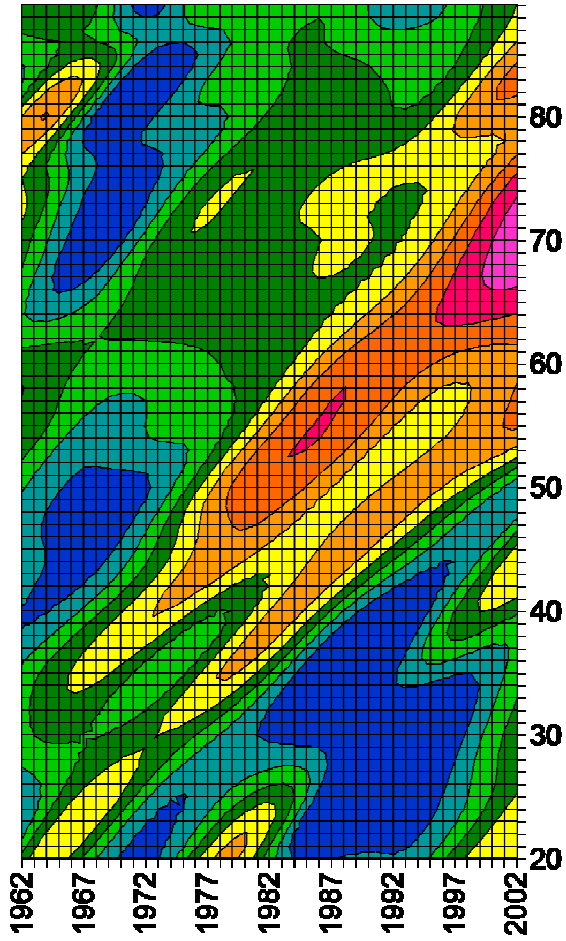
ONS data - UK Males

Period Penalty



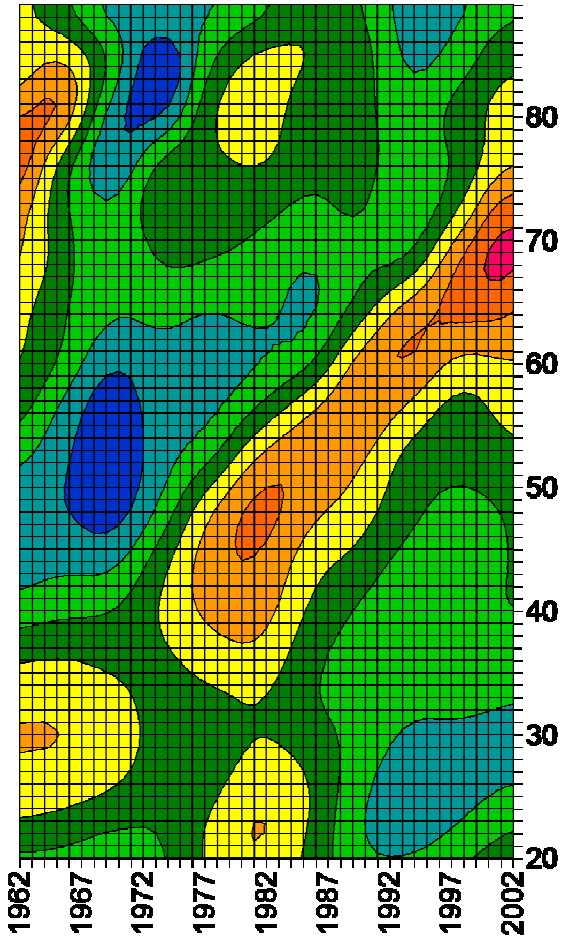


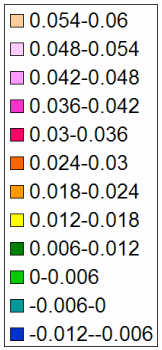
Cohort Penalty



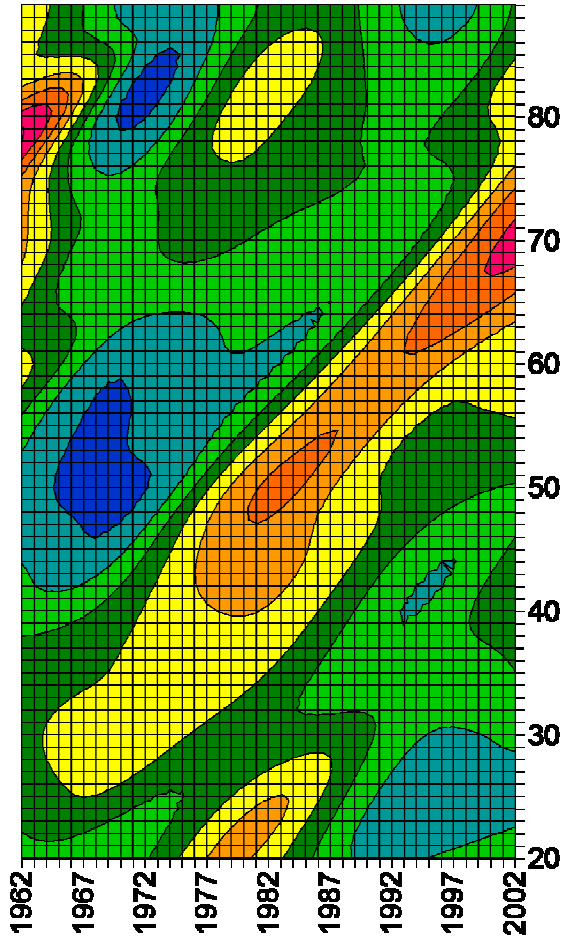
ONS data - UK Females

Period Penalty



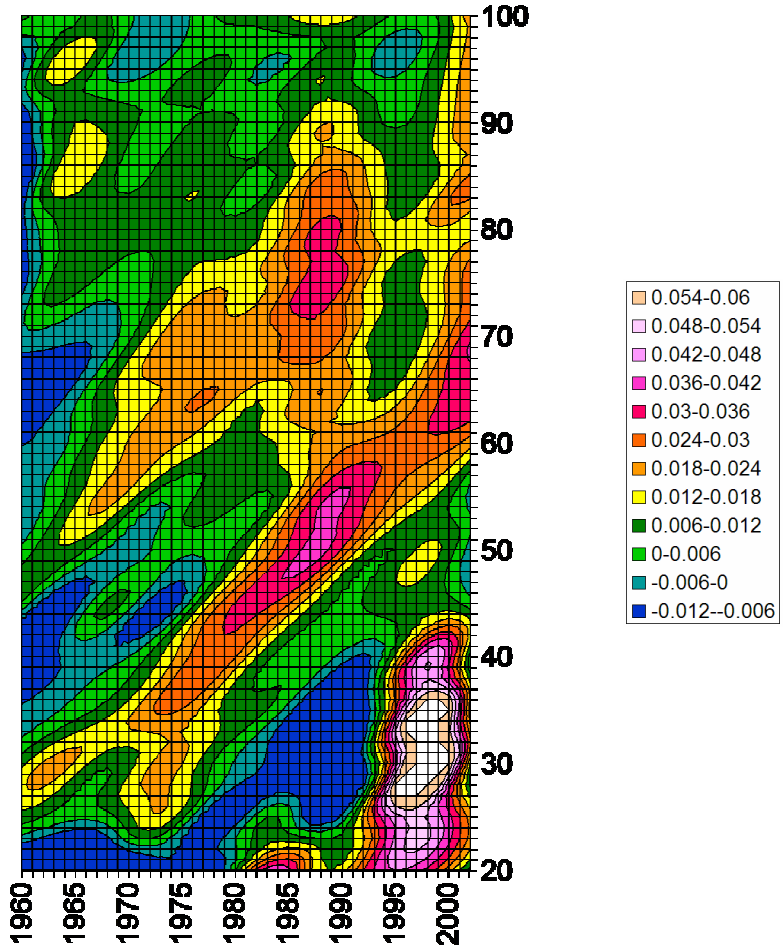


Cohort Penalty

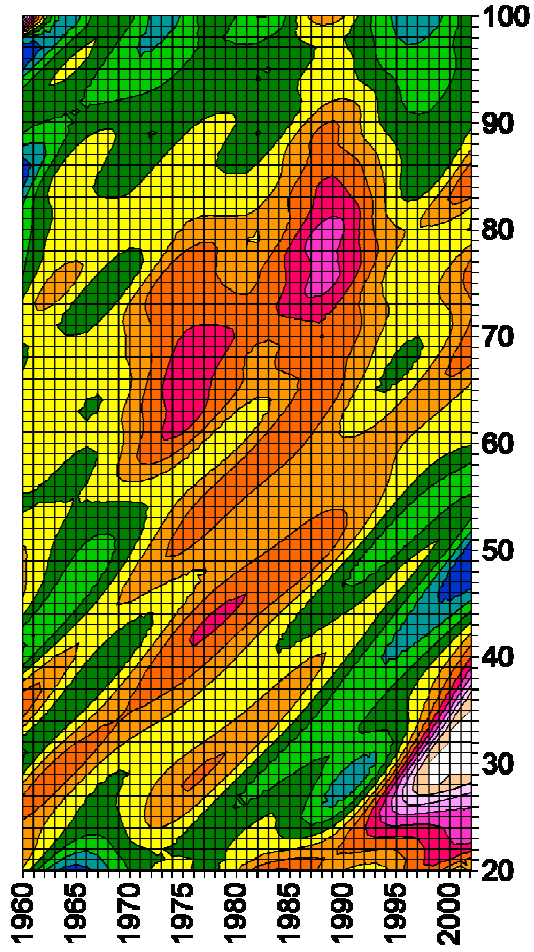


France, P-spline, age-cohort

Males

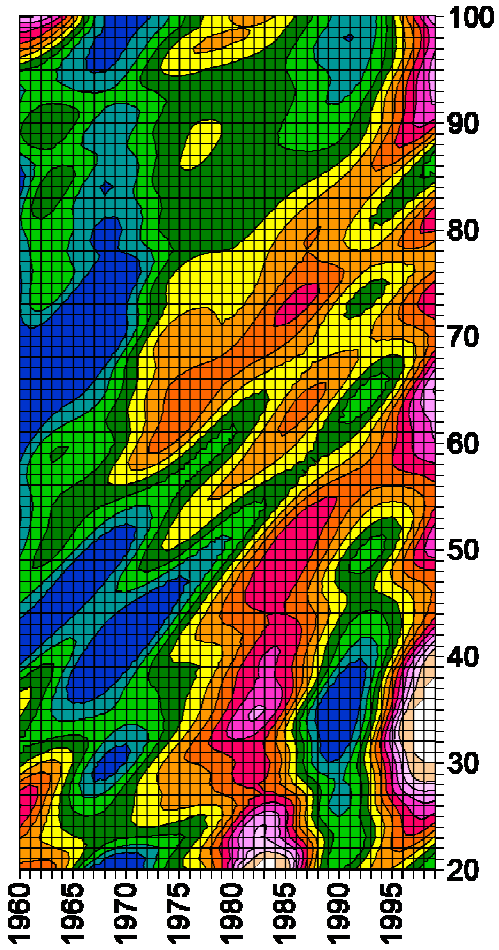


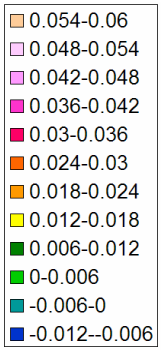
Females



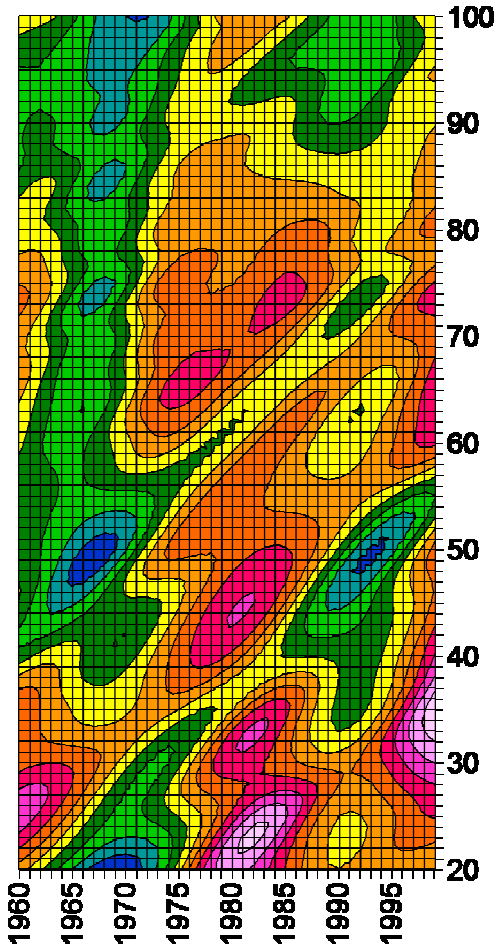
West Germany, P-spline, age-cohort

Males



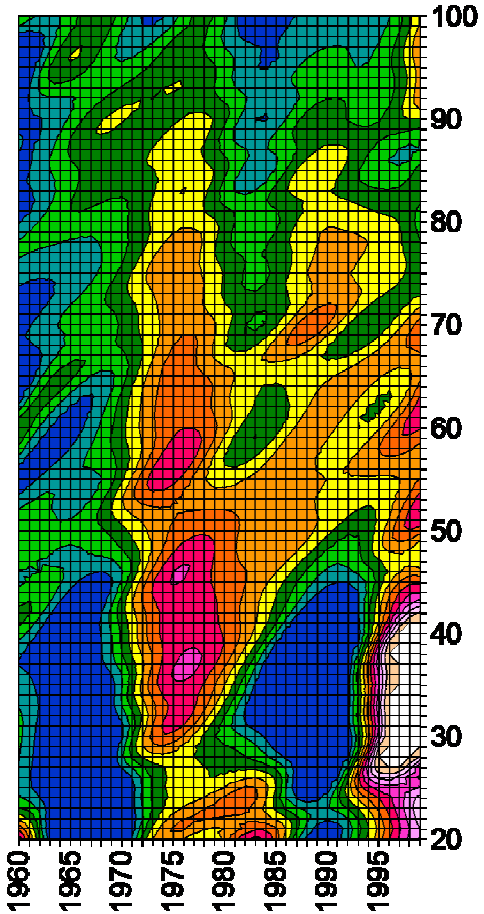


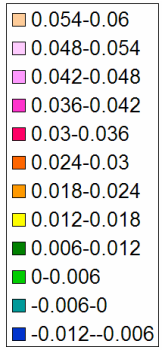
Females



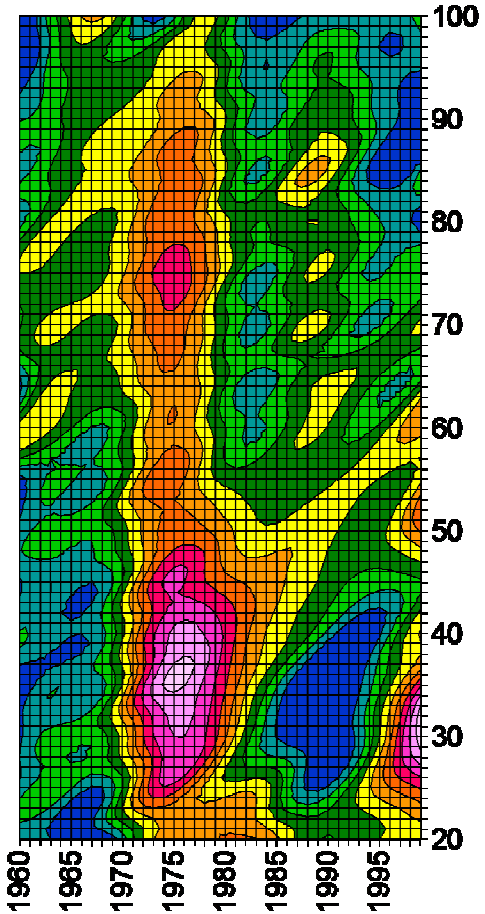
USA, P-spline, age-cohort

Males





Females



Developments in Mortality

Agenda

- The CMI
- Recent CMI mortality experiences
- The cohort effect
- Projecting longevity

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Methodologies (Plural)

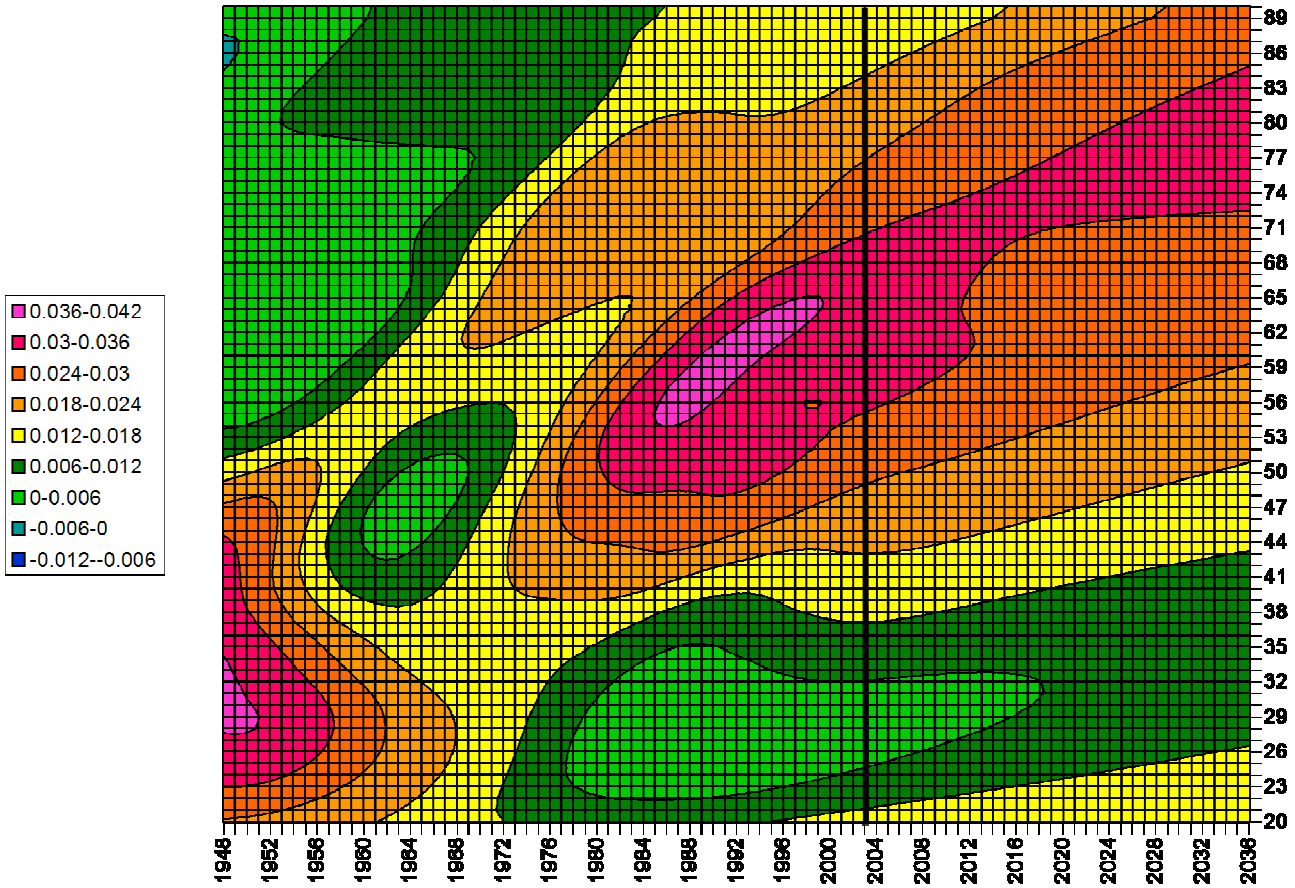
- Many different methodologies:
  - Predicting changes in mortality by cause
  - Extrapolating past trends
  - Aiming for target mortality in some future year
- Key feature for risk management is estimation of uncertainty in projected mortality
- Stochastic methodology preferred
- Cohort effect considered important

.

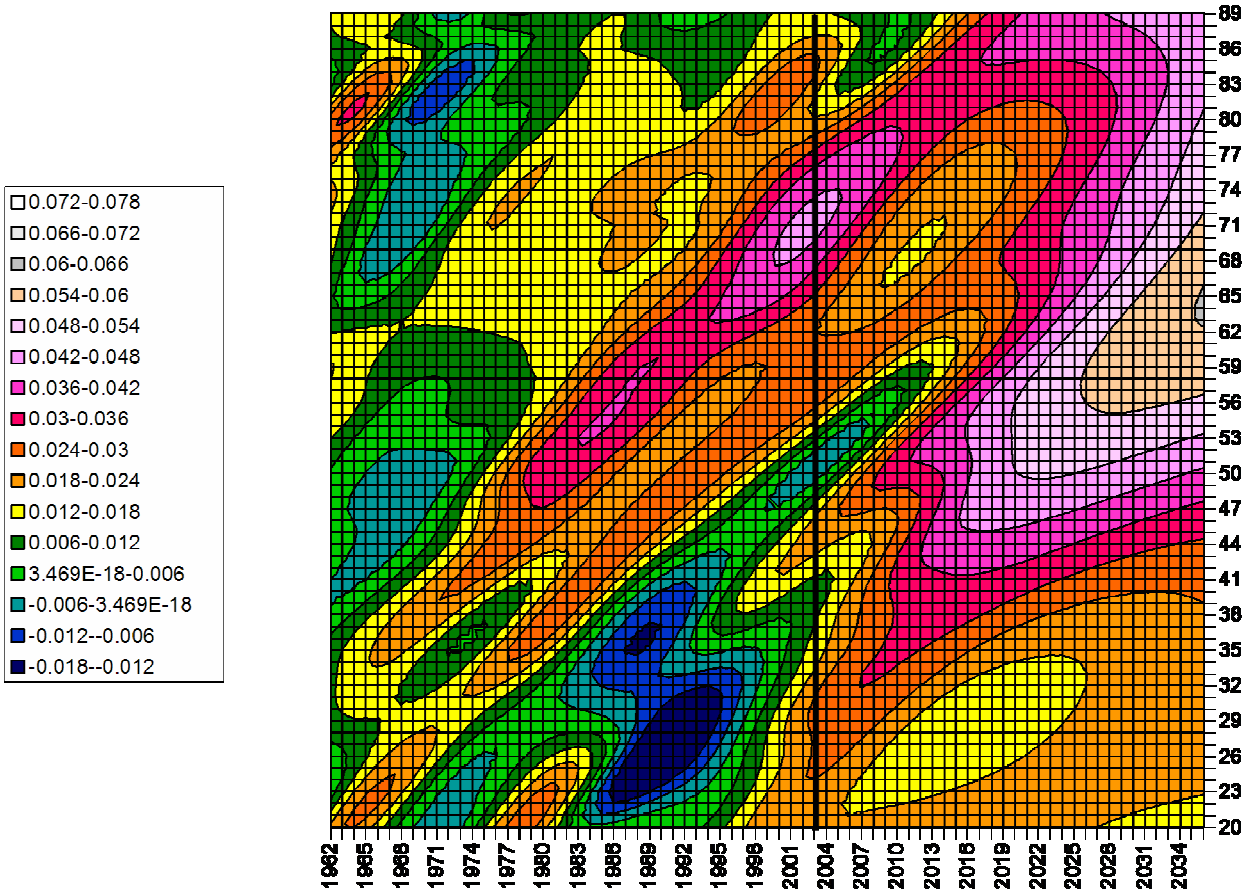
Probabilistic/Statistical Methodologies

- Many candidate methodologies
  - Regression/extrapolation/smoothing (*e.g.* P-spline)
  - Time-series (*e.g.* Lee-Carter)
  - Projection of future life tables (*c.f.* term structures)
- What has the CMI done so far?
  - Explored P-spline models in detail
  - Currently exploring Lee-Carter models in detail
- The CMI will contribute to research but does not expect to recommend particular models

P-spline 50% : Age-Cohort penalty : Assured Lives : Age range 20-90 : Projection from 2003



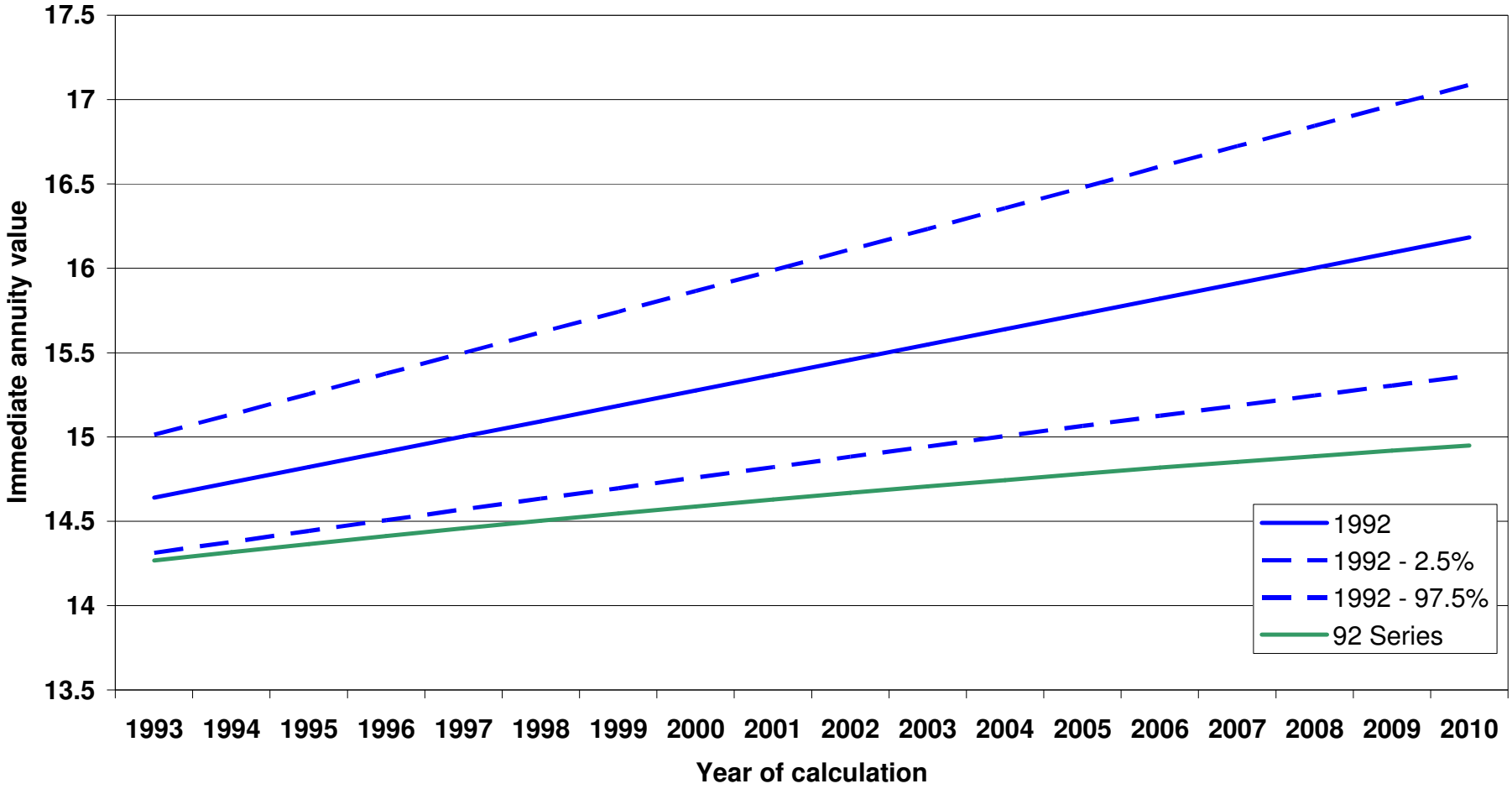
P-spline 50% : Age-Cohort penalty : ONS data Males : Age range 20-89 : Projection from 2003



Back-testing Projected Annuity Values

- Use P-spline model to fit Assured Lives data up to 1993
- Project future mortality rates and approximate confidence intervals
- Compare results with updated projections as real data replaces projections in 1994, 1995, … 2003
- Basis of comparison: annuity rates, male 60 years old

Projected annuity values for males aged 60 starting from 1993
P-Spline, age-cohort, assured lives fitted from 1947, ages 20-90, PMA92, 4.5%



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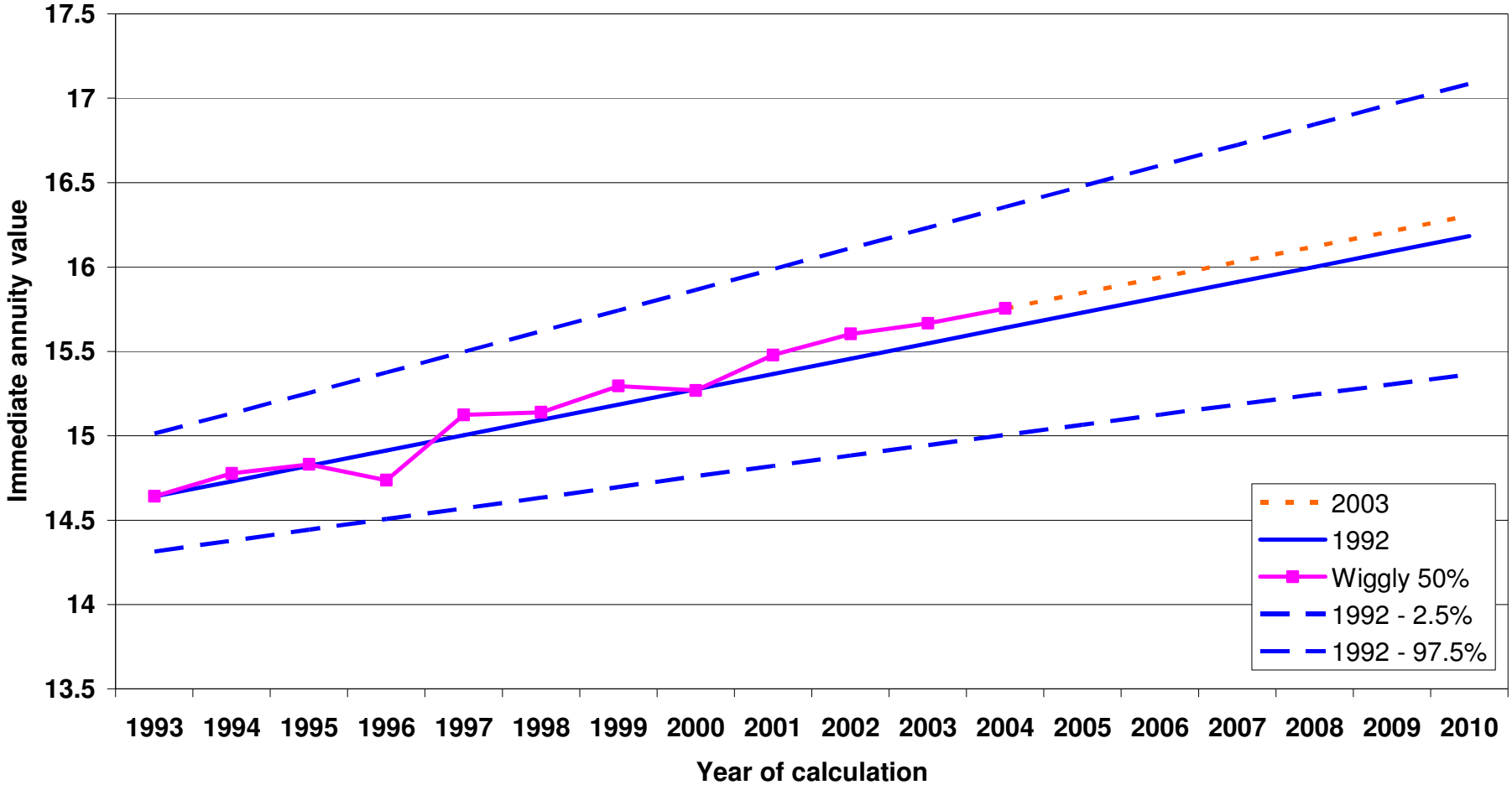

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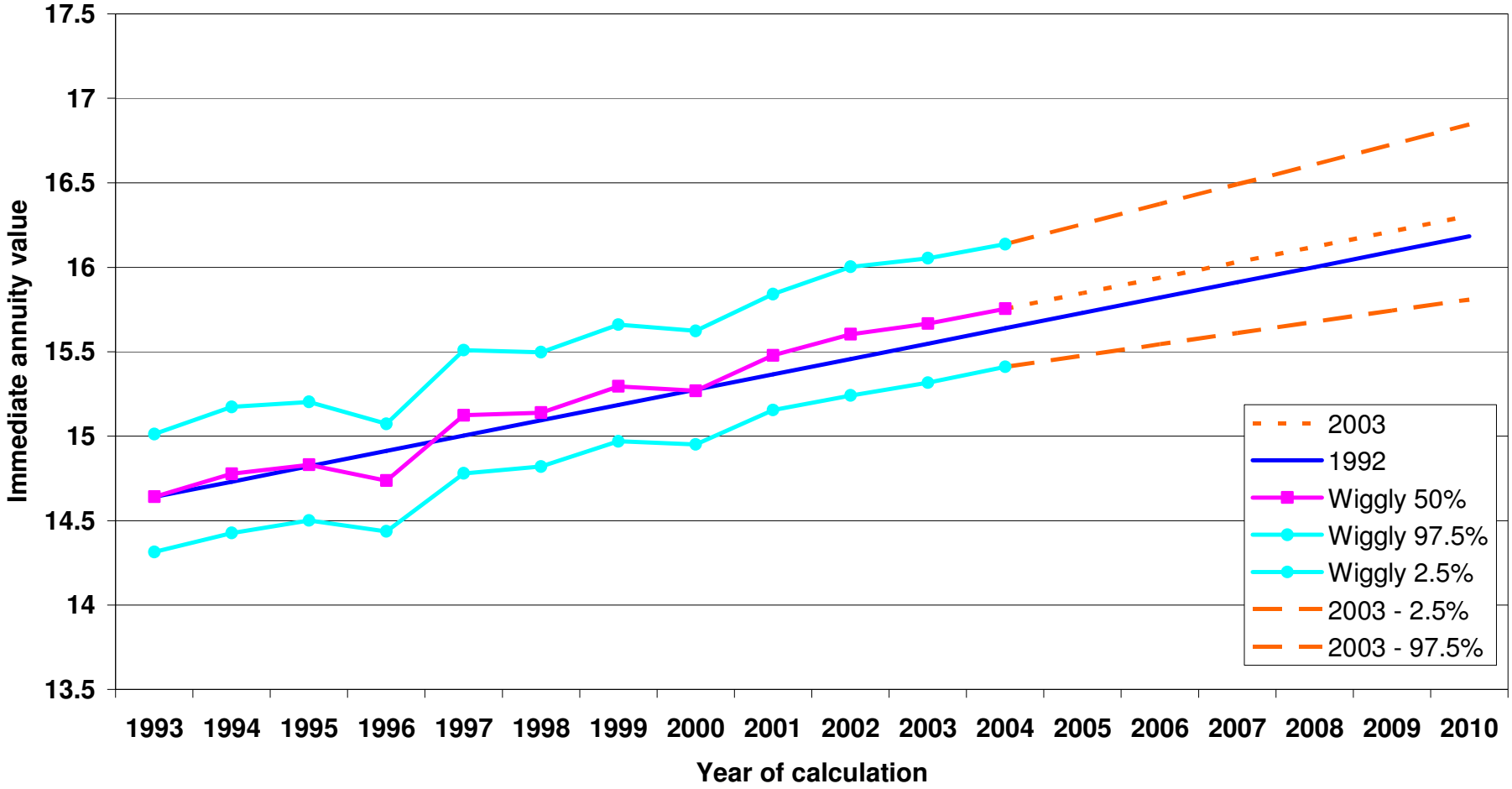

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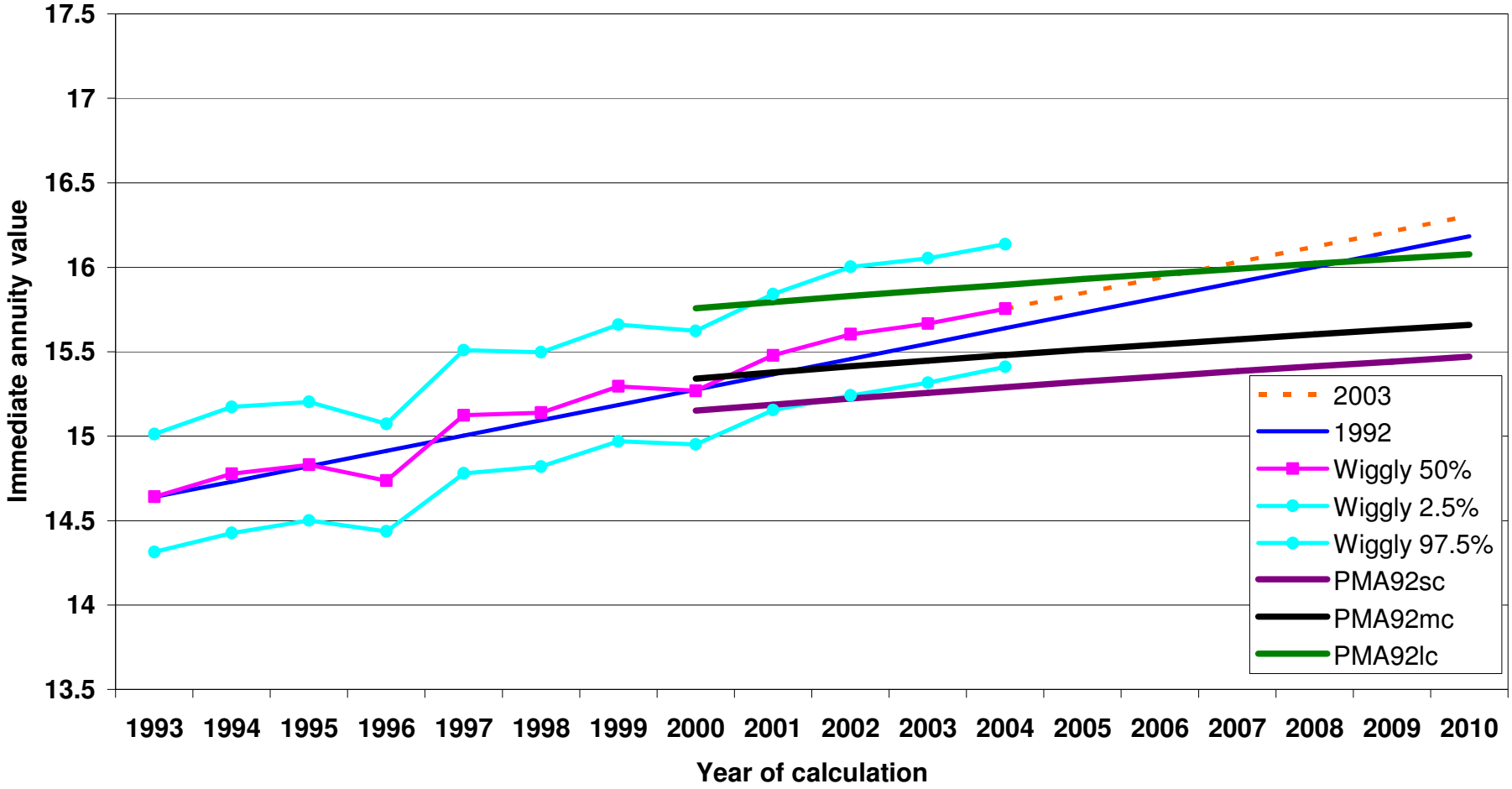
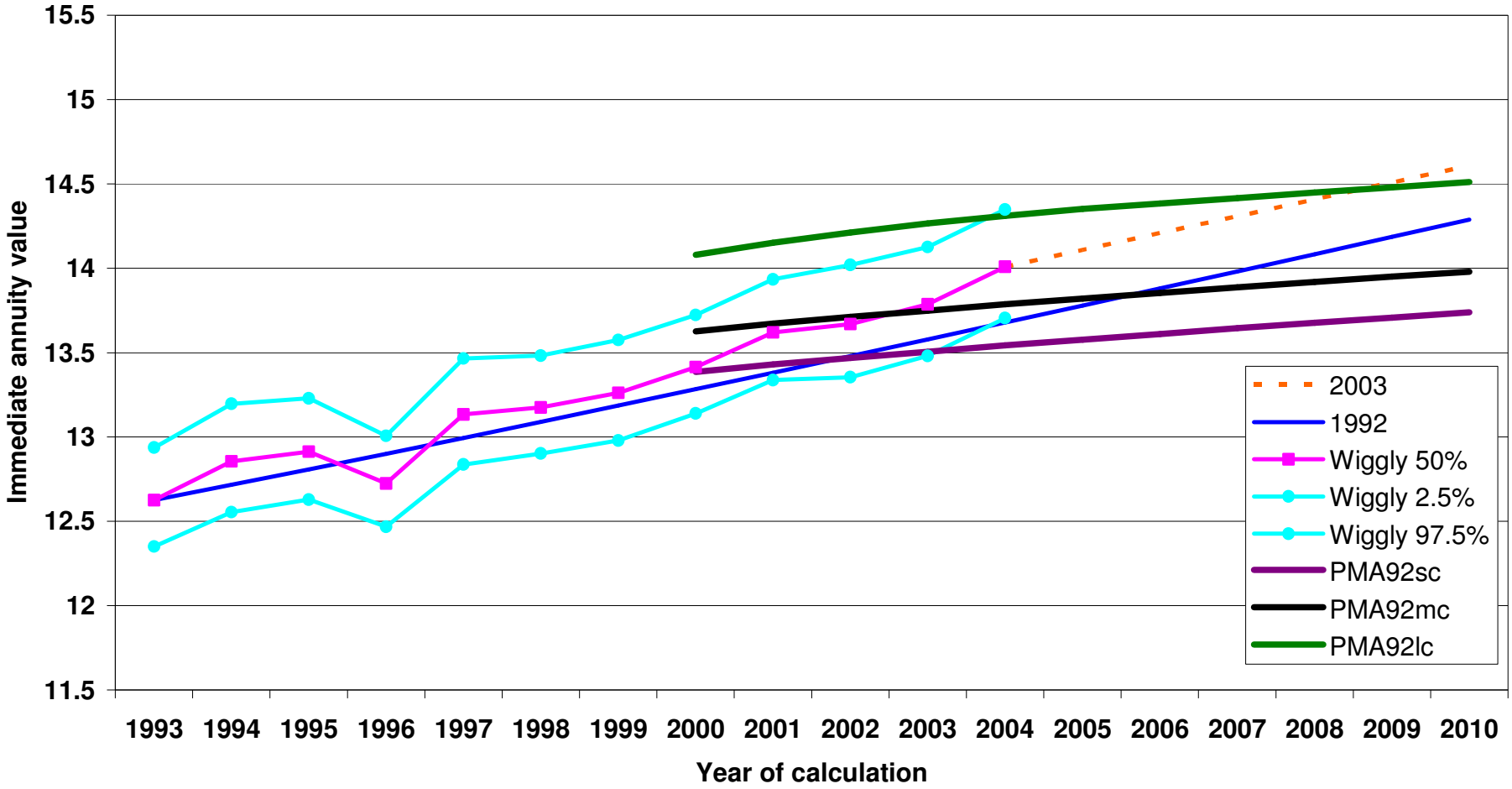
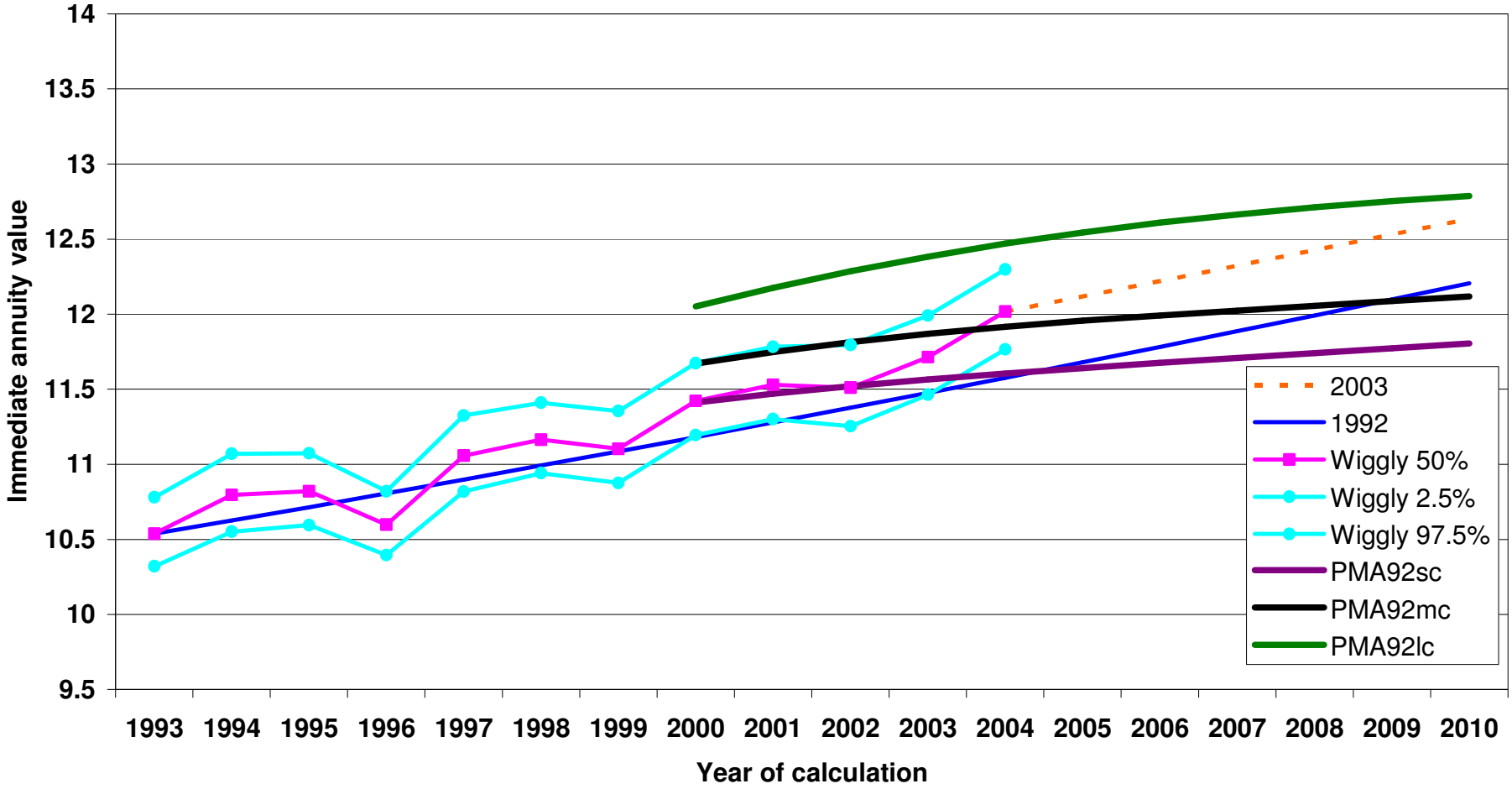


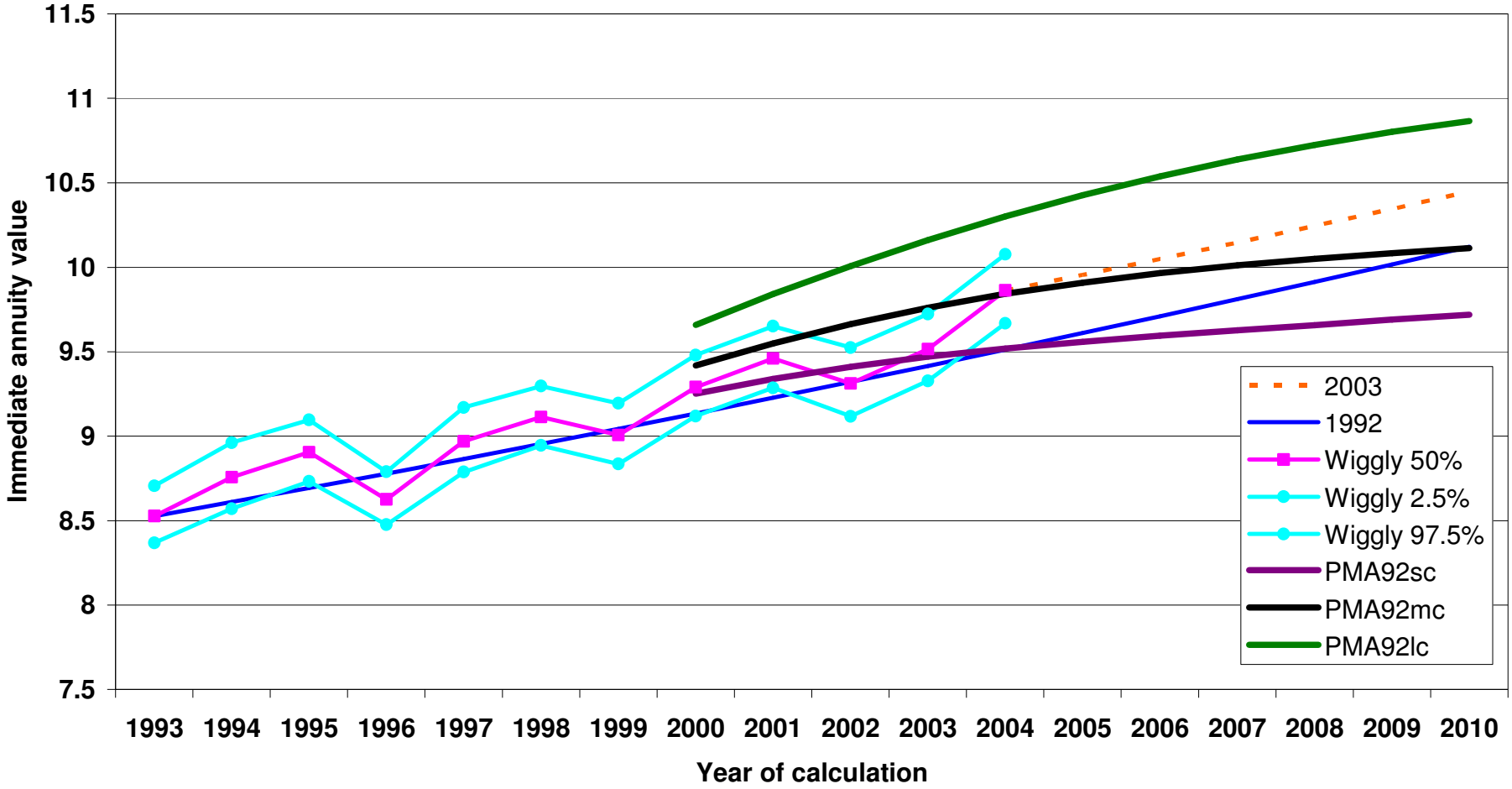
Projected annuity values for males aged 65 starting from 1993
P-Spline, age-cohort, assured lives fitted from 1947, ages 20-90, PMA92, 4.5%



Projected annuity values for males aged 70 starting from 1993
P-Spline, age-cohort, assured lives fitted from 1947, ages 20-90, PMA92, 4.5%



Projected annuity values for males aged 75 starting from 1993
P-Spline, age-cohort, assured lives fitted from 1947, ages 20-90, PMA92, 4.5%



Projections - sources of uncertainty

- Model uncertainty
- Parameter uncertainty
- Stochastic uncertainty
- Measurement error
- Heterogeneity
- Past experience may not be good guide (e.g. change in business mix)

Challenges

- Can better predictive models of mortality risk be developed?
- Where are the dangerous concentrations of longevity risk?
- What mortality models are suitable for estimating risk capital?
- Can mortality/longevity risk be securitised?

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making financial sense of the future

CURRENT MORTALITY ISSUES

Edinburgh 22 September 2006