Modern techniques for analysing mortality risk

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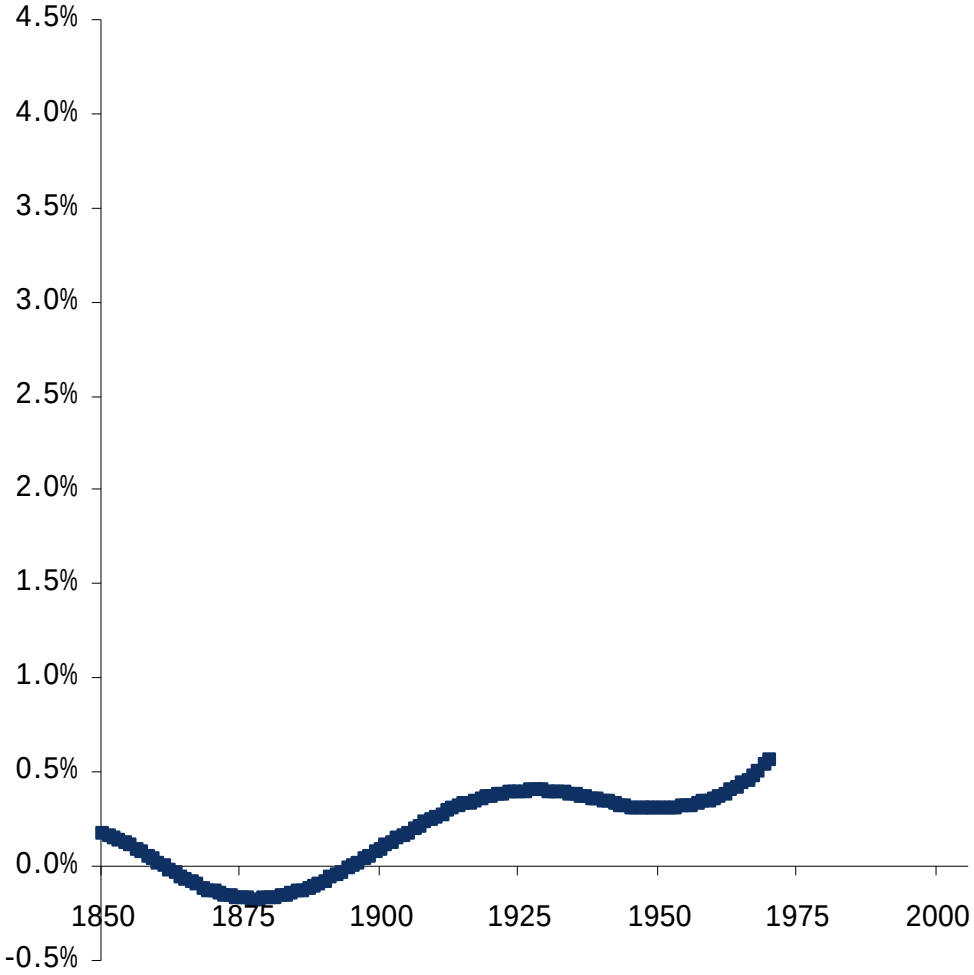
10th Global Conference of Actuaries

PATERNOSTER

Modern techniques for analysing mortality risk

Why is mortality such a "hot topic"?

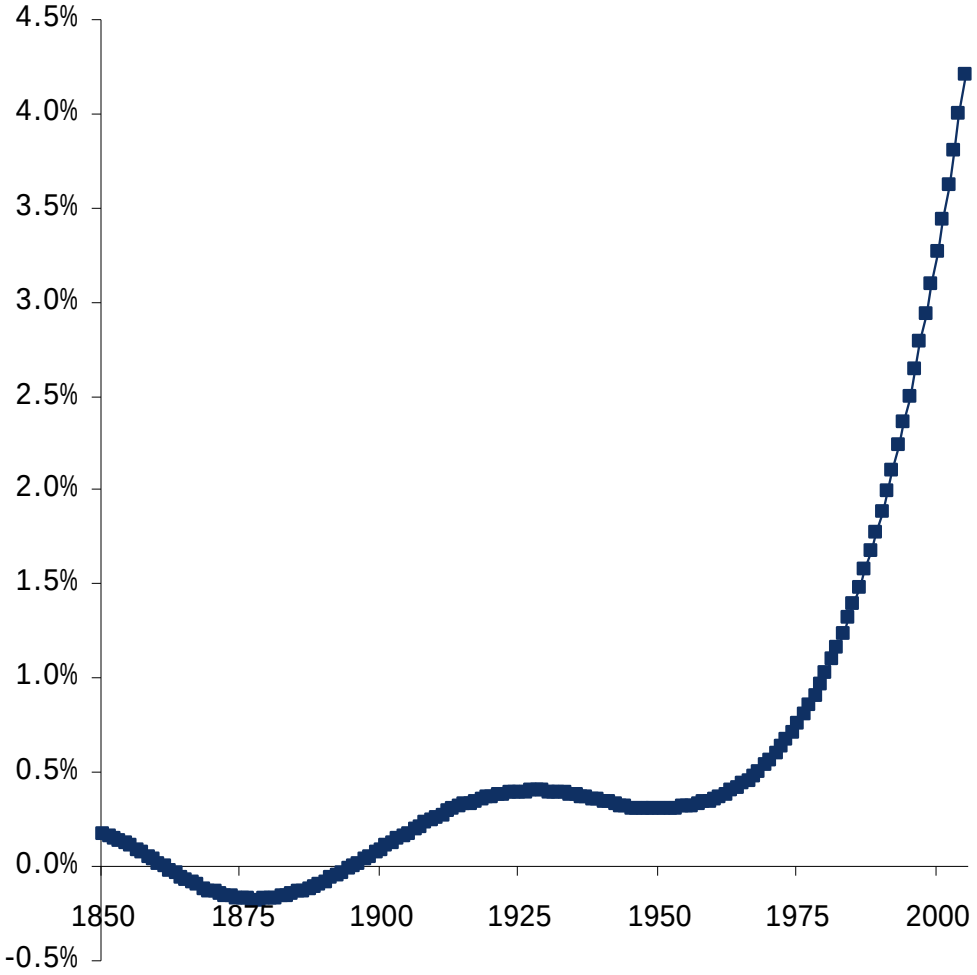
The ‘mortality revolution’



Smoothed annual rate of mortality improvement, males, England & Wales, aged 70-79

Source: Paternoster

The ‘mortality revolution’



Smoothed annual rate of mortality improvement, males, England & Wales, aged 70-79

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Modern techniques for analysing mortality risk

The new generation of mortality models

Socio-economic profiling

Models used for projecting future mortality improvements

Largely developed by actuaries working for life assurance companies selling annuities (worried about people living ‘too long’)

Modern techniques for analysing mortality risk

The new generation of mortality models

Socio-economic profiling

The ‘old generation’ approach to mortality…

Using ‘standard mortality tables’…

INTERIM LIFE TABLES

Produced by
The Office for National Statistics

EXPECTATION OF LIFE

UNITED KINGDOM, MALES

BASED ON DATA FOR THE YEARS 2004-2006

AGE x	*mx*	*qx*	*lx*	*dx*	*ex*
0	0.005592	0.005576	100000.0	557.6	76.89
1	0.000408	0.000407	99442.4	40.5	76.32
2	0.000242	0.000242	99401.8	24.0	75.36
3	0.000184	0.000184	99377.8	18.3	74.37
4	0.000127	0.000127	99359.5	12.6	73.39
5	0.000114	0.000114	99346.9	11.3	72.40
6	0.000121	0.000121	99335.6	12.0	71.40
7	0.000095	0.000095	99323.6	9.4	70.41
8	0.000114	0.000114	99314.2	11.3	69.42
9	0.000119	0.000118	99302.9	11.8	68.43
10	0.000120	0.000120	99291.1	11.9	67.44

Source: ONS

The ‘new generation’ approach…

Using statistical models in which mortality rates (or survival probabilities) are a function of **rating factors**

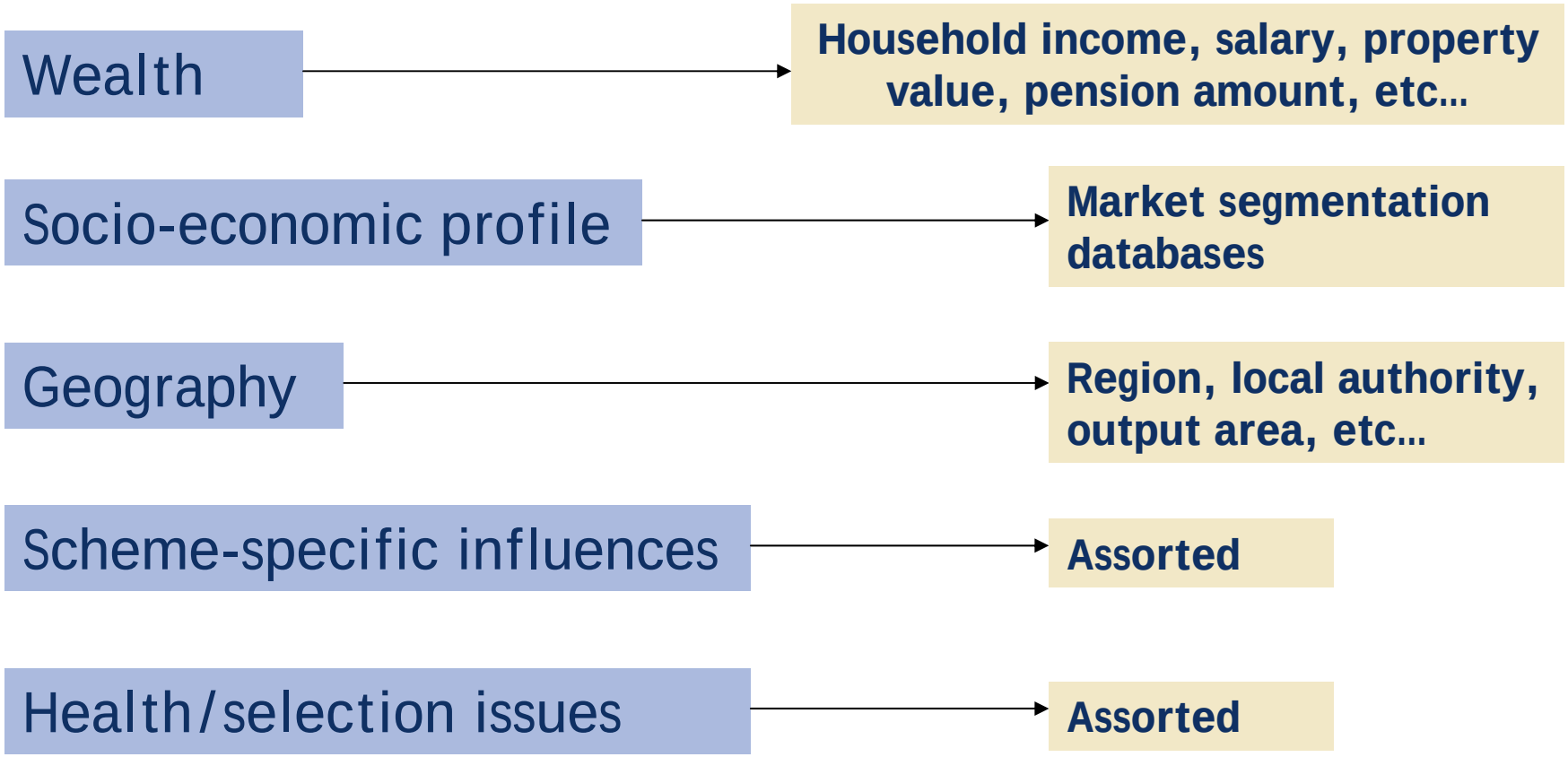
For example, using a simple Generalised Linear Model, mortality rates could be modelled as:-

$$\ln (m_{x,y,z}) = ax + by + cz + k$$

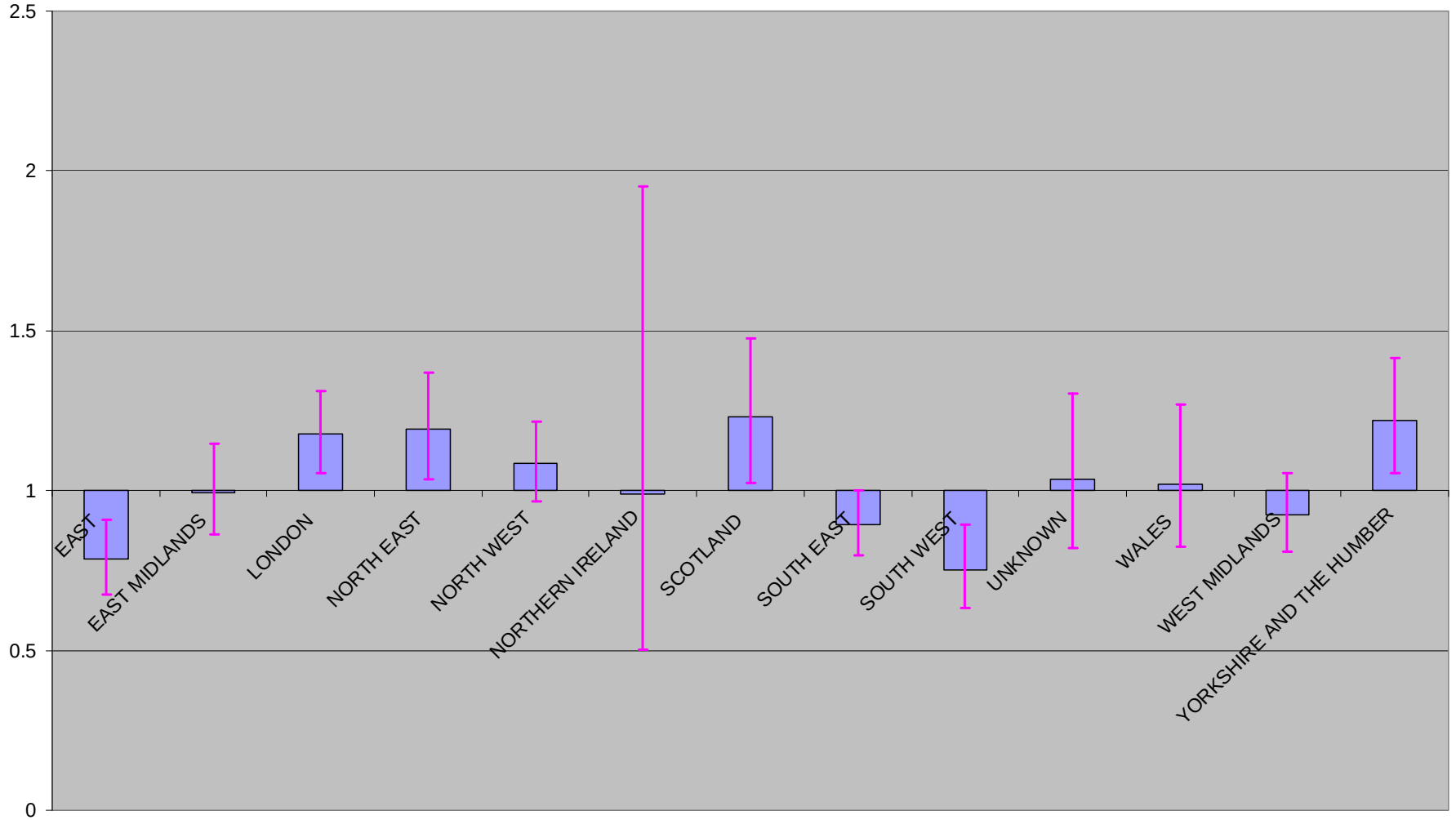
x, y and z are rating factors

a, b, c & k are coefficients derived by fitting a statistical model

Factors which influence life expectancy (other than age & gender)

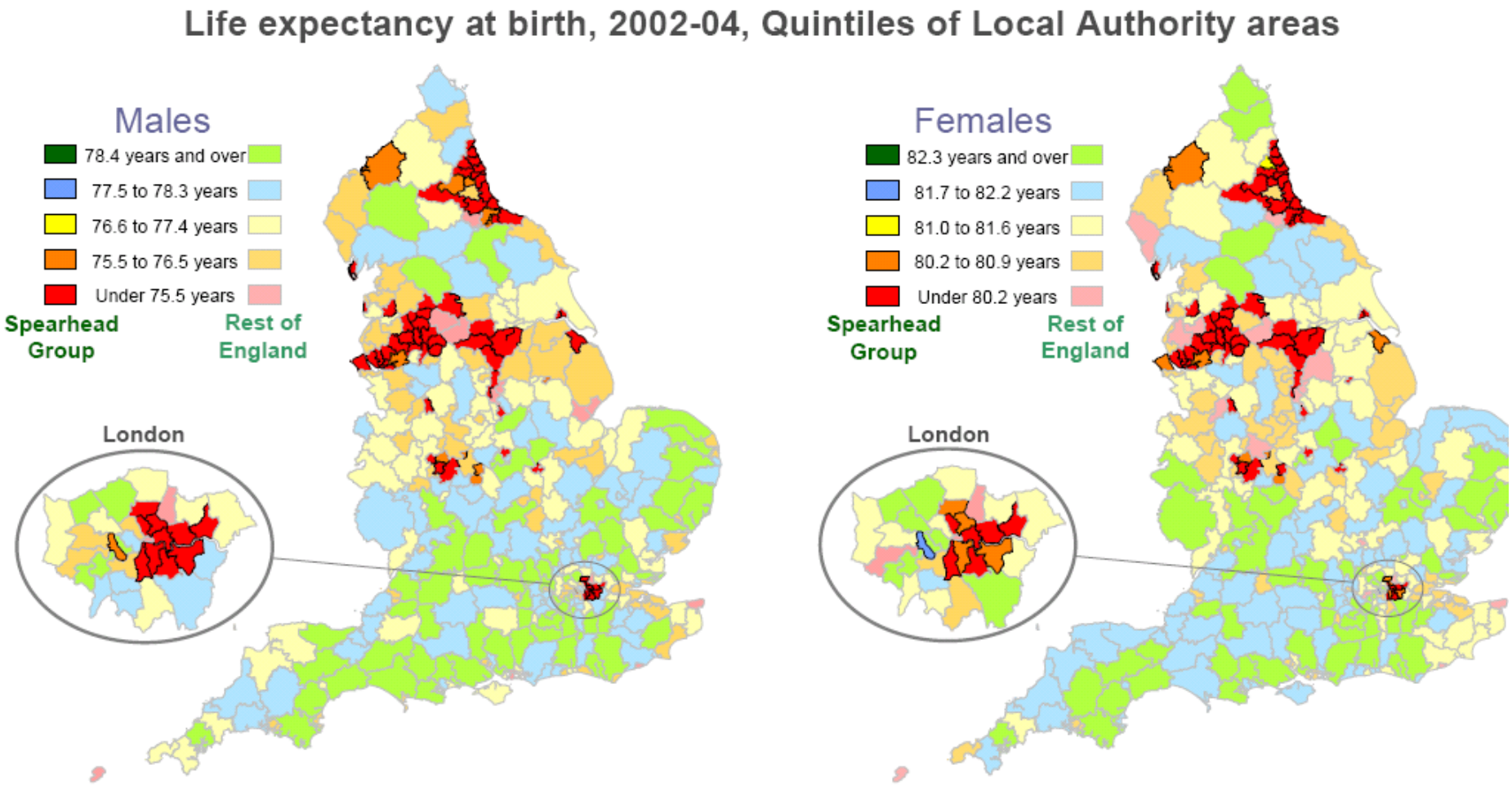


The impact of geographical region on pensioner mortality



Source: Paternoster

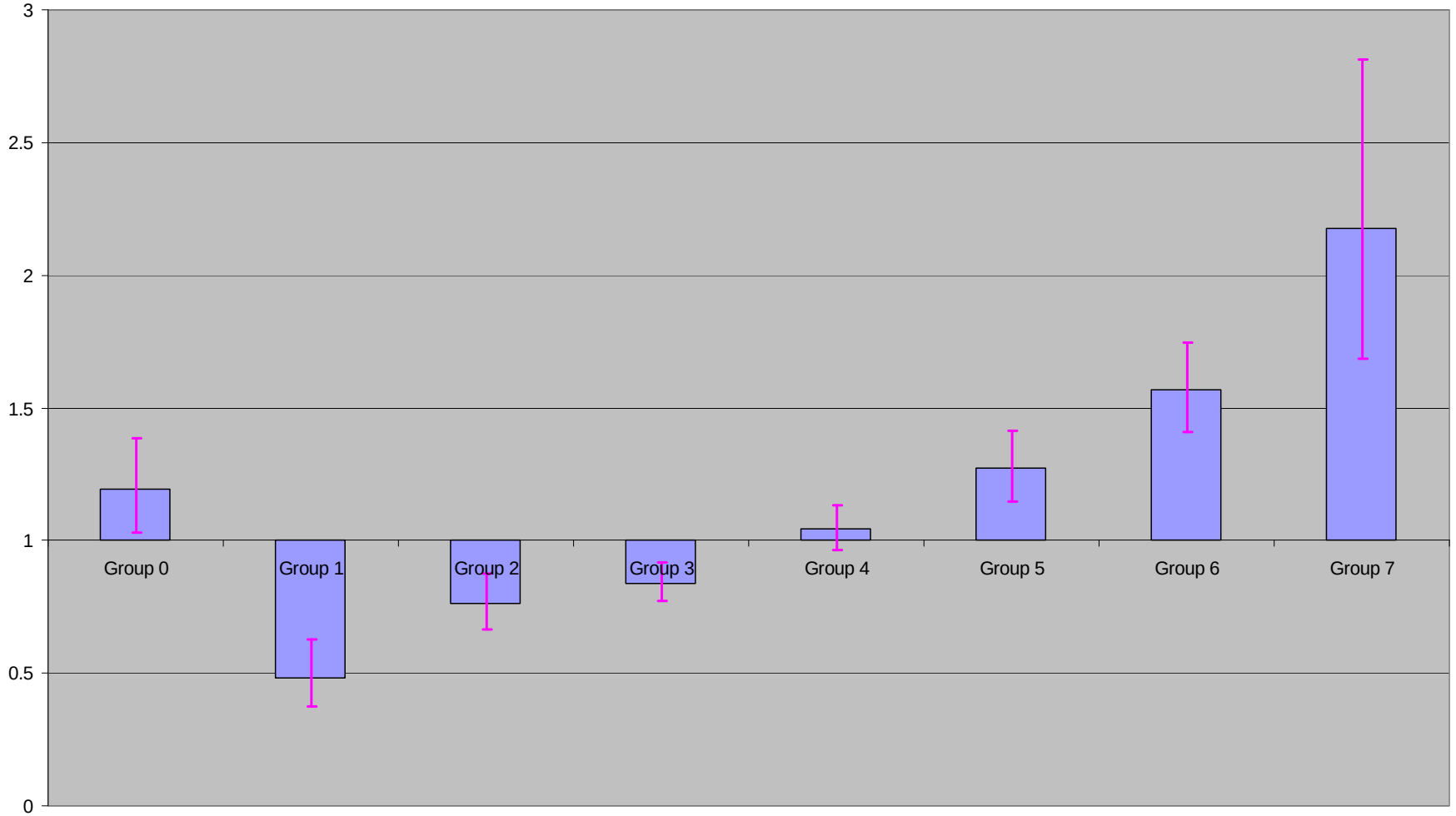
Life expectancy by local authority



Source: ONS

Postcode databases

The impact of socio-economic class group



Source: Paternoster

Wealthy, high socio-economic class pensioners are more likely to:

- …live longer
- …be married or have a financial dependant
- …have a partner who is likely to live longer than average
- …re-marry significantly younger spouses

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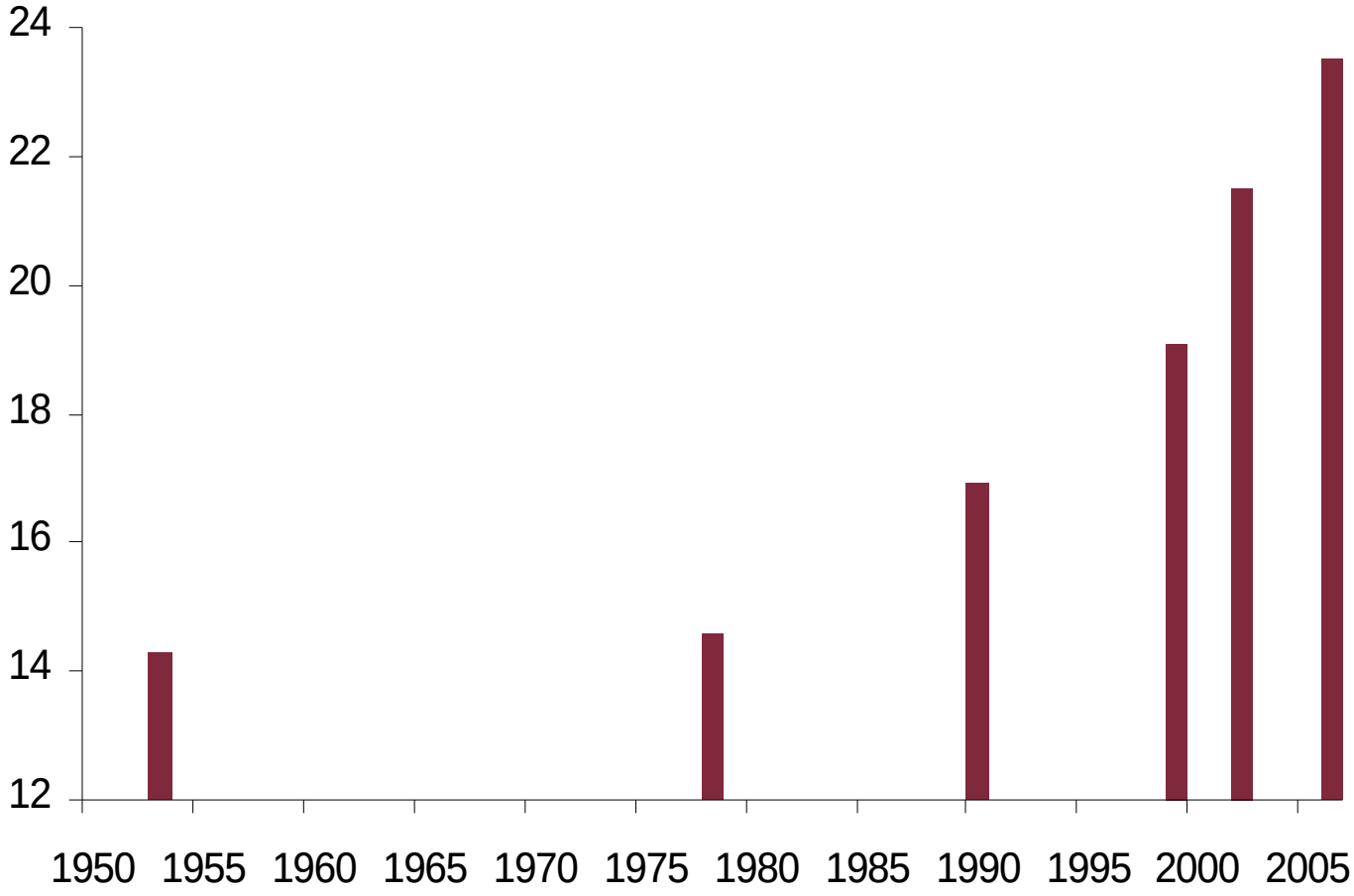
Models used for projecting future mortality improvements

We are seeing unprecedented change

In the UK actuaries' estimates of male life expectancy at retirement have probably changed more in the past **10 years** than in the previous **100 years**

We are seeing unprecedented change

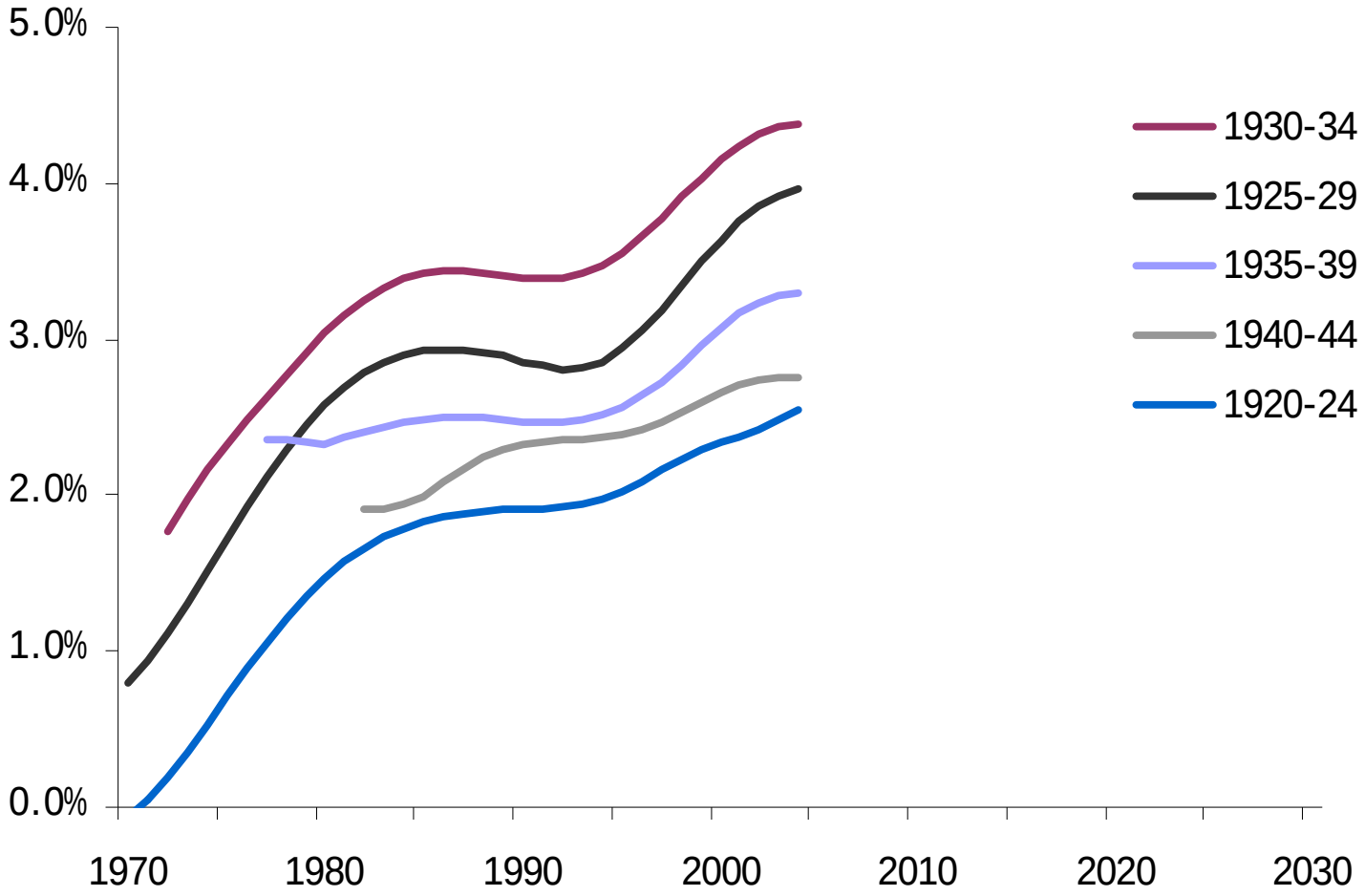
Projected life expectancy for male pensioners aged 65 based on published actuarial tables and projections



Source: Paternoster

Projecting the pace of improvement…

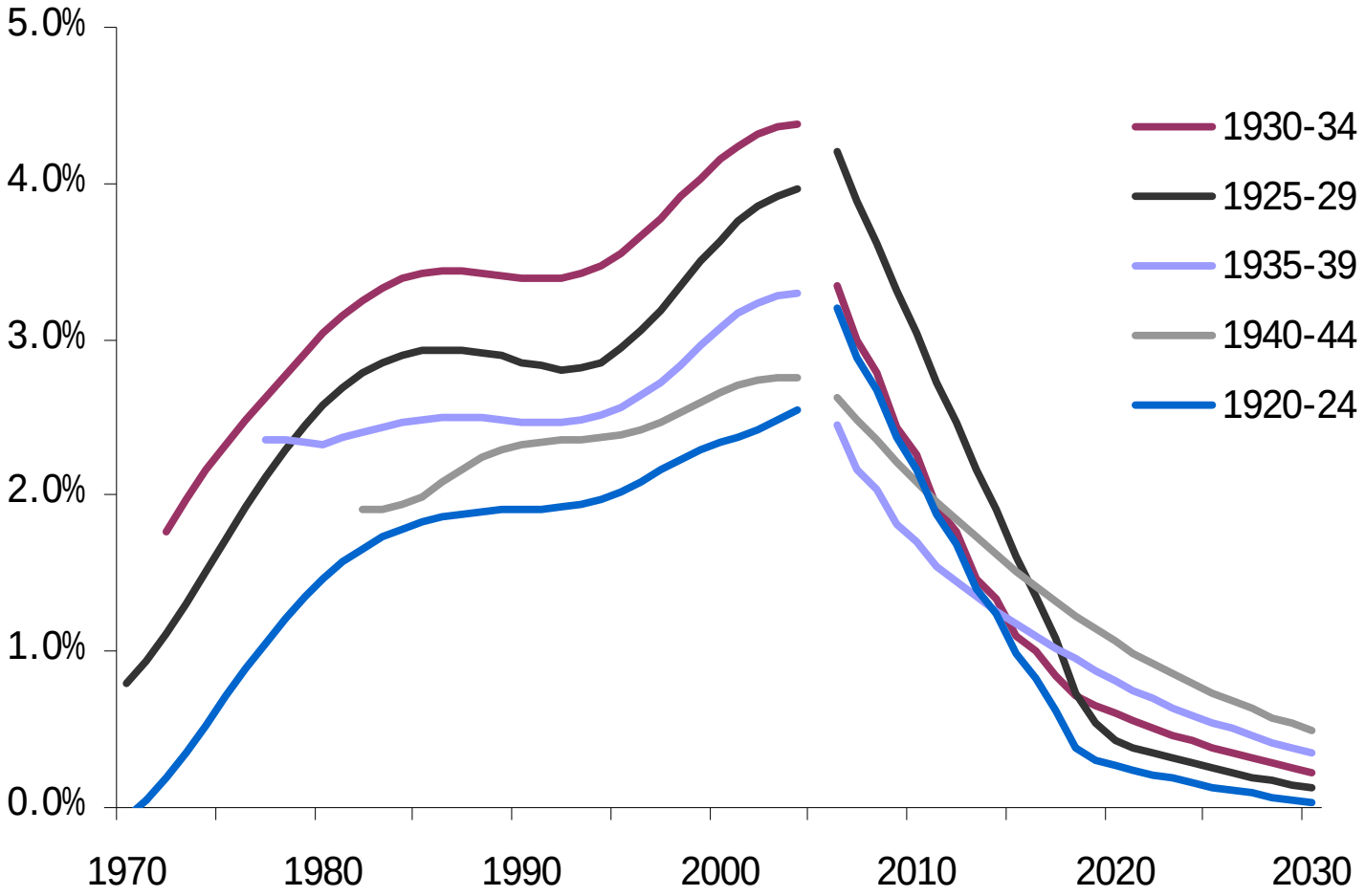
Annual reduction in mortality rates for men in England & Wales by year of birth (smoothed)



Source: Paternoster

...using the “medium cohort” basis

Annual reduction in mortality rates for men in England & Wales by year of birth (smoothed)



Source: Paternoster

Statistical models

We have seen increasing use of statistical models to project future rates of mortality

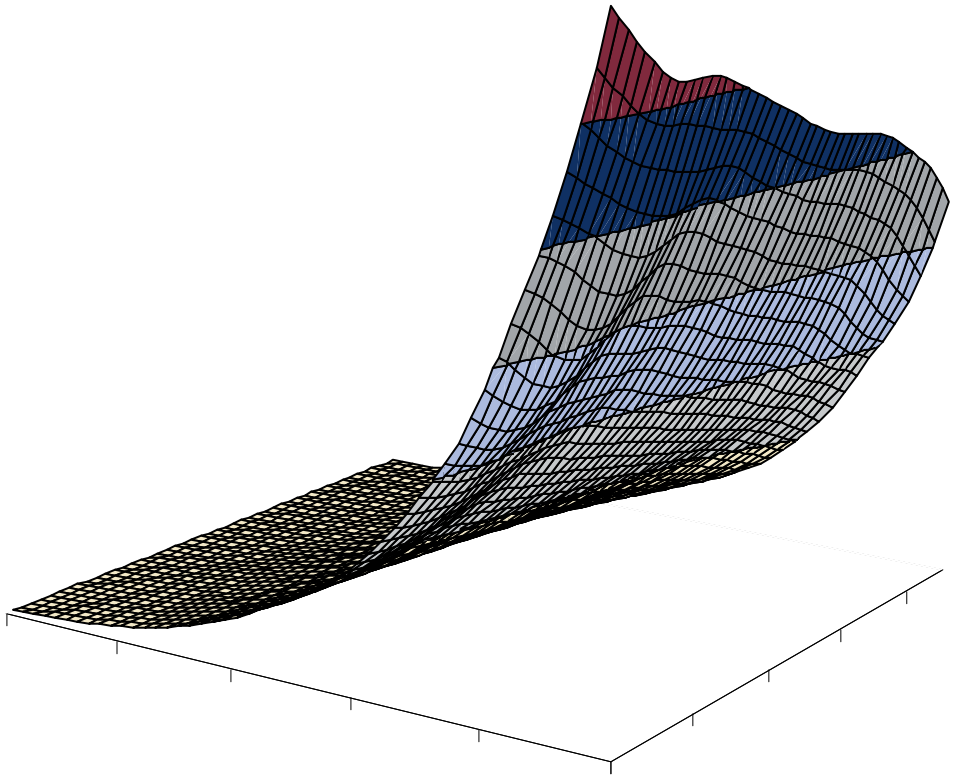
In the UK the Continuous Mortality Investigation (CMI) have published software that actuaries can use to produce their own projections

p-spline model

Lee Carter model

P-spline model

A method of optimising the smooth ‘surface’ to fit a 2-dimensional set of past mortality rates (varying by age and time)



Source: Paternoster

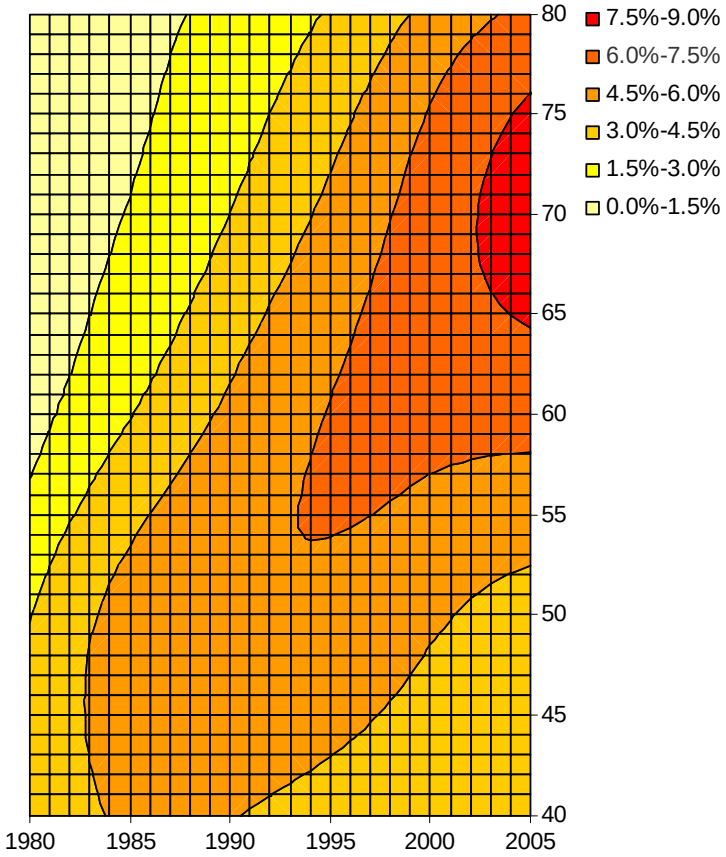
P-spline model

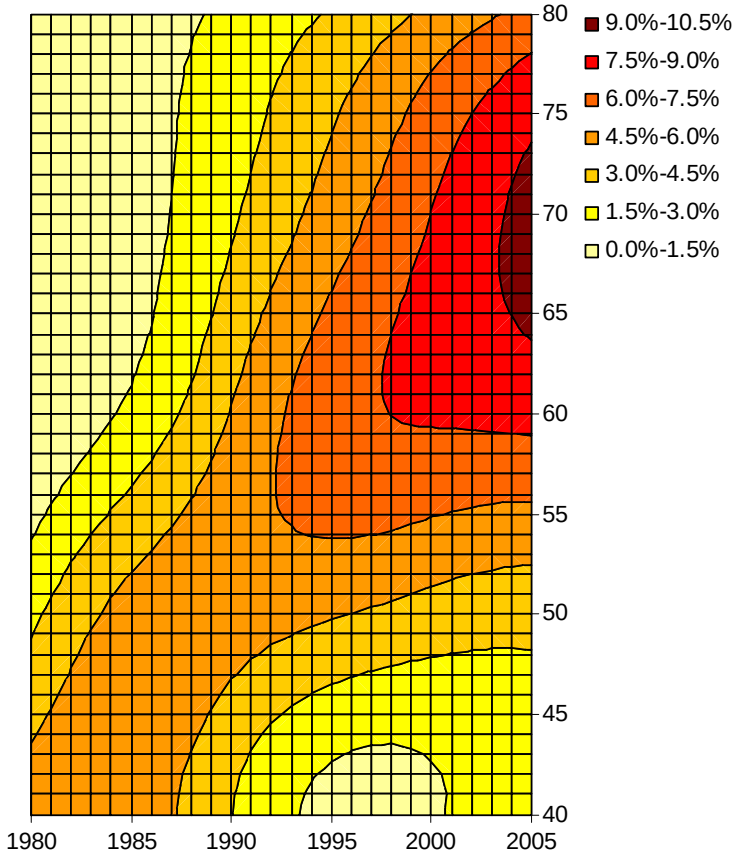
Does not impose any particular structure on past patterns of improvement, i.e. it is a ‘flexible’ data-driven approach

Tends to give a lot of weight to the most recent trends

The p-spline model in practice

Annual rate of improvement in heart disease mortality, England & Wales

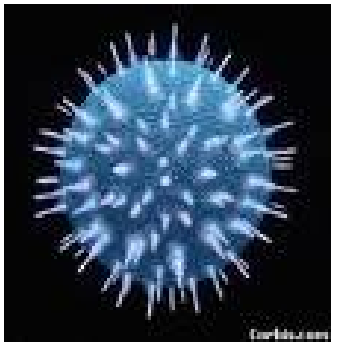




Source: Paternoster

The UK ‘cohort effect’



In the UK men and women **born in the period 1925-45** have experienced more rapid reductions in mortality rates than generations born either before, or after, this period

Lee Carter model

Widely-used by demographers in many countries

$$\ln(m_{x,t}) = \alpha(x) + \beta(x).\kappa(t)$$

- $\alpha(x)$: age function
- $\beta(x)$: age function
- $\kappa(t)$: time function [often modelled using an ARIMA(0,1) time series]

Lee Carter model

More rigid in terms of structure

In it's basic form it has struggled to accommodate the 'cohort' trends evident in UK mortality data

The outlook for future improvements

The big question is whether the pace of improvement has peaked?

No statistical model – on it's own – will help answer this question

Need to:-

1. Understand the drivers of past trends

2. Access expert medical opinion on likely future trends

Arguments for further acceleration

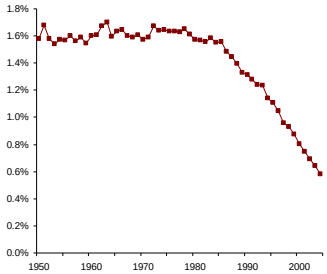
Medical advances are occurring at a faster and faster rate

Further reductions in key risk factors are likely – e.g. smoking, blood pressure & cholesterol levels

Increasing focus on healthy diets

Arguments for deceleration

Current high rates of improvement are due to big falls in deaths from circulatory causes



Increasing levels of obesity and type II diabetes

Impact of excess alcohol consumption, increasing drug use, stress, longer-working hours and more sedentary lifestyles

The outlook for future improvements

In practice it is universally assumed that the pace of change has peaked and will decelerate

What happens if it doesn't?

Extreme scenarios

In calculating capital requirements UK insurance companies are required to consider the impact of ‘extreme scenarios’ [i.e. 1 in 200 year events]

The projection used by Paternoster to calculate capital requirements assumes that **50%** of pensioners now aged 30 will survive to **age 100**

Extreme scenarios

If the pace of improvement **continues to accelerate** in line with recent trends, aggregate UK pension scheme liabilities would be understated by around **£175bn**

Key points

Increasingly sophisticated models are being used to determine appropriate life expectancy assumptions for annuitants and/or pensioners

In the UK it is universally assumed that the pace of improvement in life expectancy will slow down

Insurance companies are required to ask what would happen if it doesn't

Actuaries need to seek input from other professions to help their projections of future events