Projecting future mortality trends

CMI Mortality Projections Committee*

Presentation to SIAS on 3 June 2014

* T J Gordon, S Bale, J E Hughes, S Rimmer, N Robjohns, B Sewell and J Palin (secretary)

Cheapside House, 138 Cheapside, London, EC2V 6BW
T: +44 (0) 20 7776 3820
E: info@cmilimited.co.uk

Setting the scene

- Longevity matters in the UK
  - £1 trillion+ of defined benefit pension liabilities, large insured annuity sector and public sector liabilities
  - pension increases + low net discount rates
  - robust legal framework
- Interest in longevity risk management is global
- Longevity modelling is still developing
- The CMI provides
  - experience data collection and analysis
  - centralised access to important data
  - reference models

  but not ‘the answer’

Steps we're taking

- General review of CMI modelling
- Working party for high age mortality
- Data we're making available
  - Consolidated dataset underlying the CMI model
  - Weekly England & Wales deaths data (quarterly)
- CMI model
  - CMI_2014 expected to be in similar form to previous models
  - CMI_2015 under review
- Base mortality
  - S2 published earlier this year
  - Annuities mortality graduation in progress

This meeting

- Broad topics
  - Data
  - Current CMI model
  - Responsiveness and stability
  - Wider issues
- 15 to 20 minutes on each topic
  - Presentation
  - Key questions
  - Discussion

Discussion topic

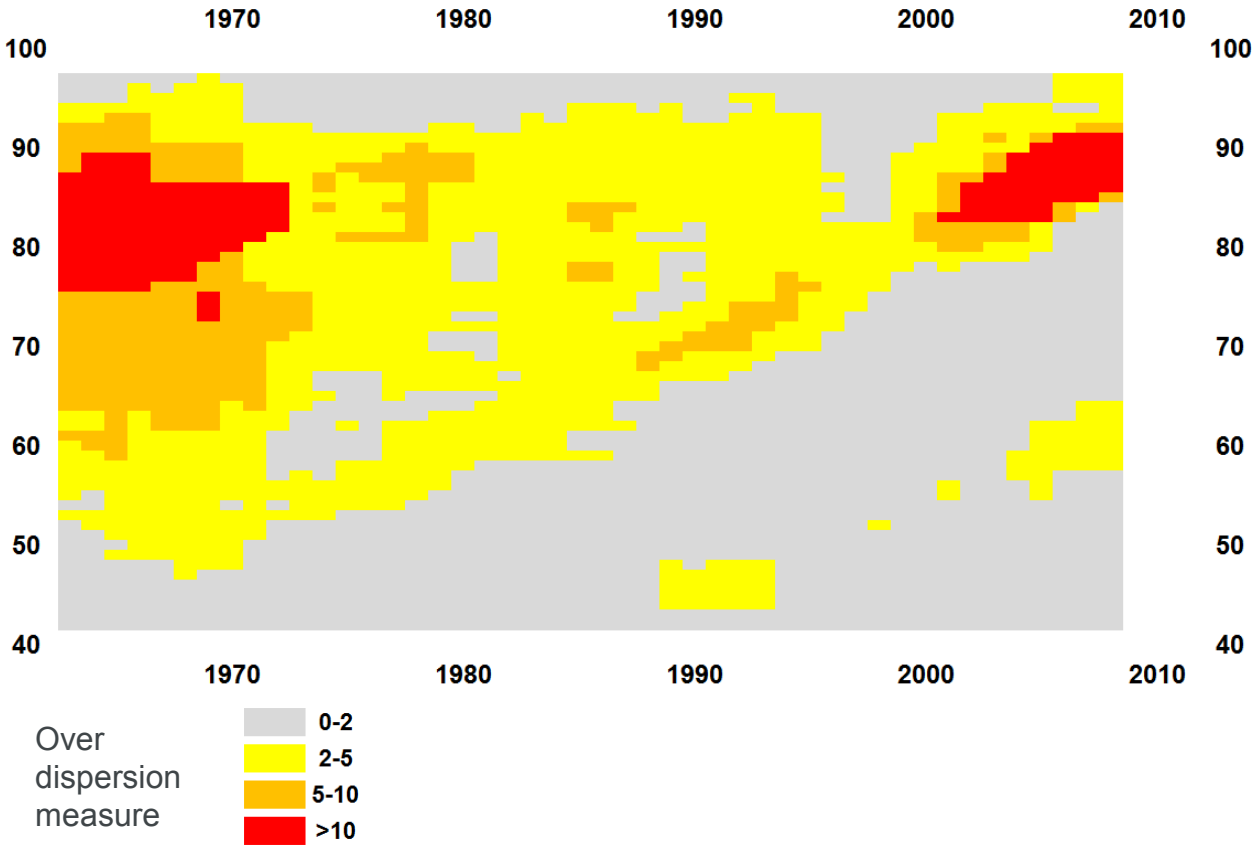
Data

Data behind the current model

- England & Wales data from the Office for National Statistics
- Consolidated dataset of death registrations and mid-year population estimates
- Broken down by
  - single year of age (0 to 104 and grouped for ages 105+)
  - calendar year (1961 to 2012)
  - gender
- Lives from decennial census – projected for intercensal years
- CMI mirrors ONS algorithm to produce mid-year population estimates by single year of age within the 90+ age group
- ***Dataset now available on the CMI website***
- Issues with the ONS dataset
  - Over-dispersion
  - 1919 and other cohorts
  - Exposures at high ages
  - Population estimates

Over-dispersion

Over-dispersion in p-spline fit to E&W ONS data

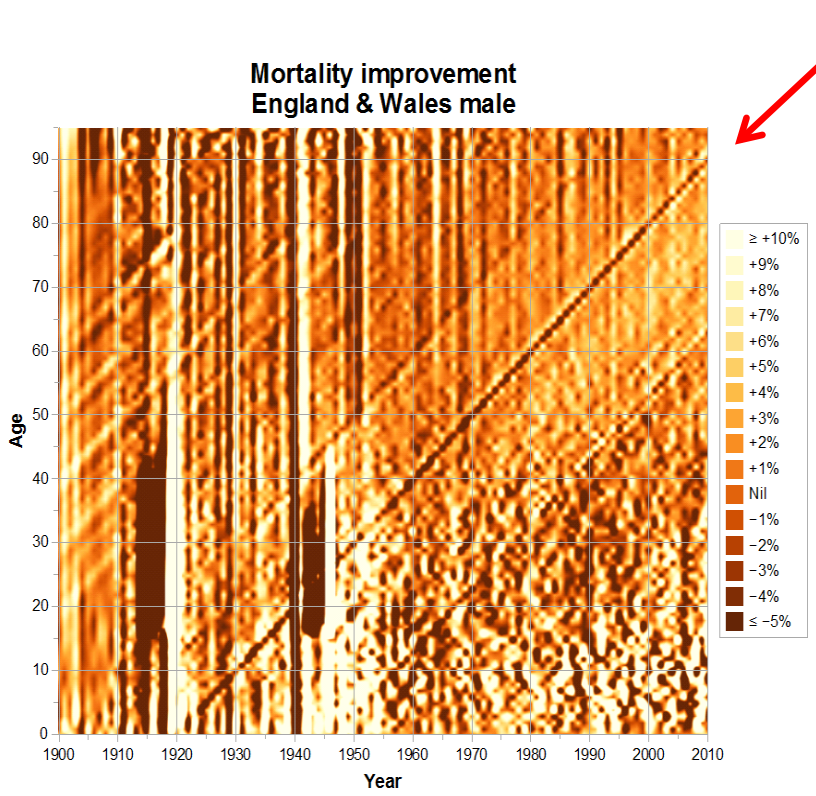


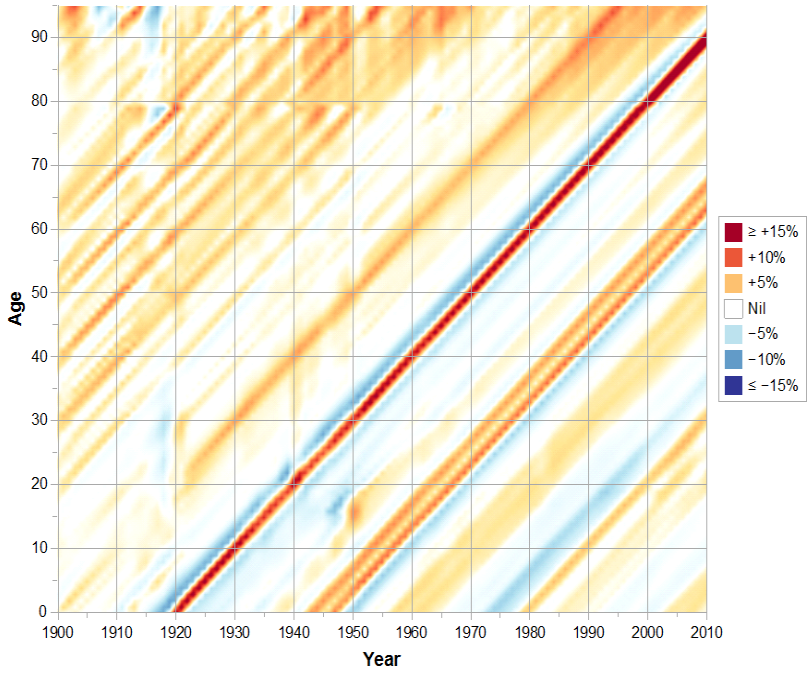
Source: ONS data + CMI calculations

Comments

- Over-dispersion is localised:
  - high ages
  - 1960s/2000s
- Would using an overall over-dispersion lead to under/over-fitting?

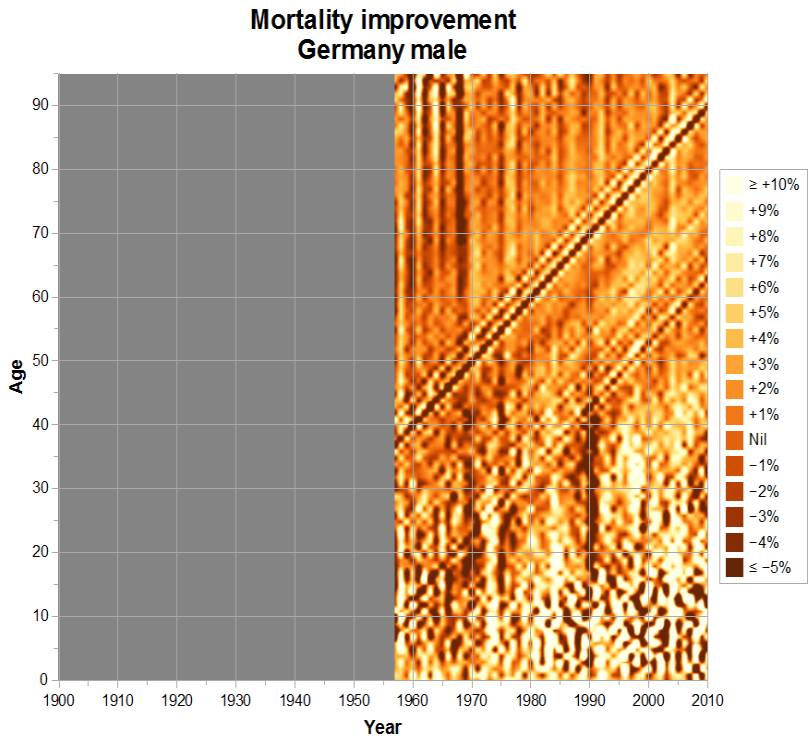
Cohort effects – England & Wales male

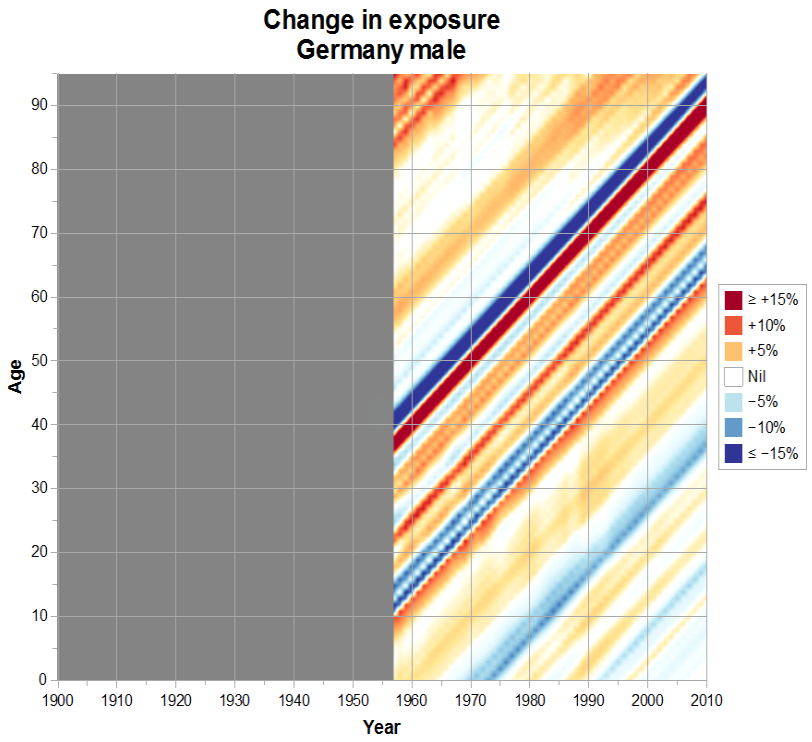




Source: Human Mortality Database. Graphs provided by Aon Hewitt.
Mortality improvement is annual difference in –log(deaths/exposure). Change in exposure is annual difference in log(exposure).

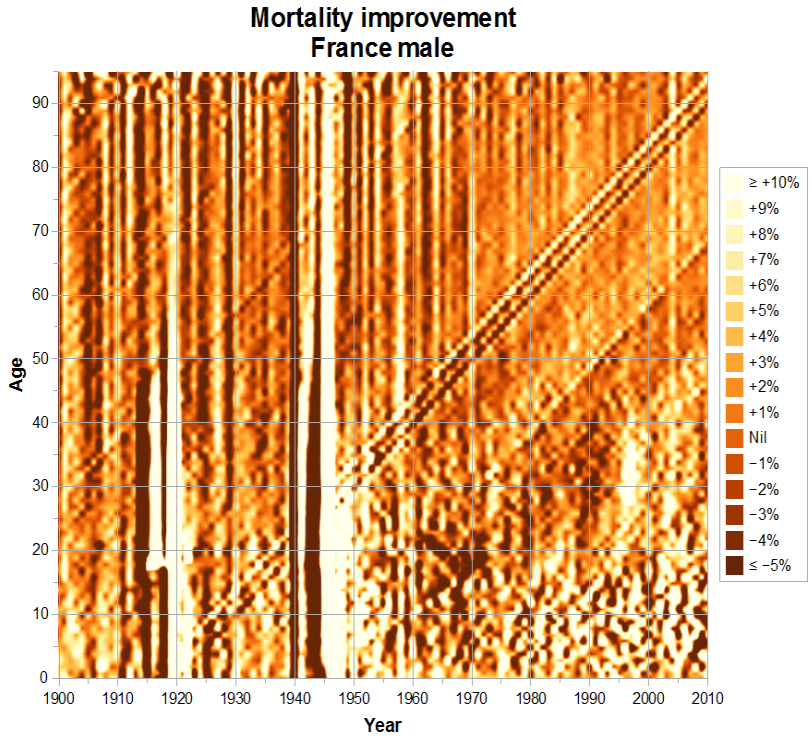
Cohort effects – Germany male

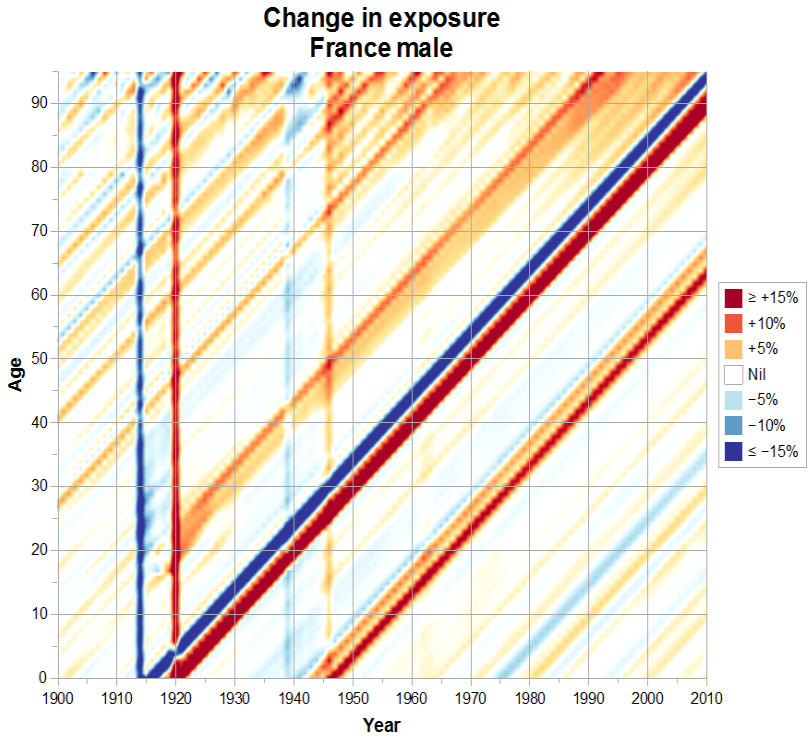




Source: Human Mortality Database. Graphs provided by Aon Hewitt.
Mortality improvement is annual difference in –log(deaths/exposure). Change in exposure is annual difference in log(exposure).

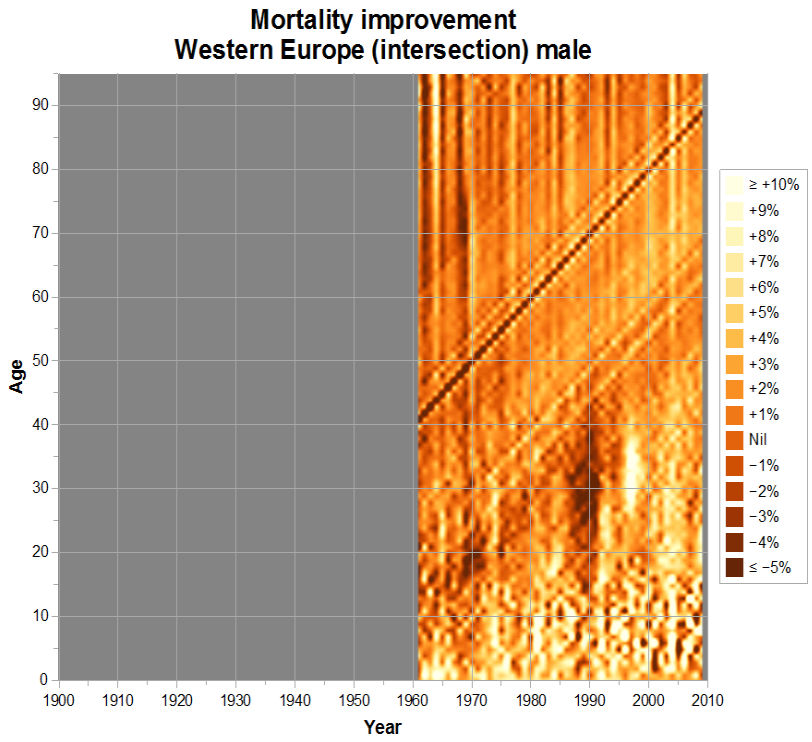
Cohort effects – France male

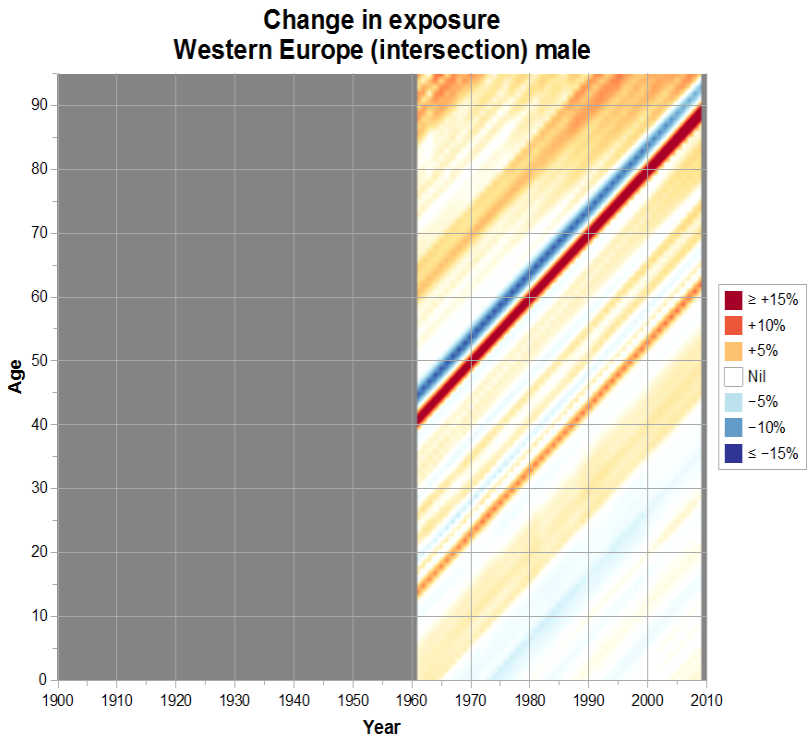




Source: Human Mortality Database. Graphs provided by Aon Hewitt.
Mortality improvement is annual difference in –log(deaths/exposure). Change in exposure is annual difference in log(exposure).

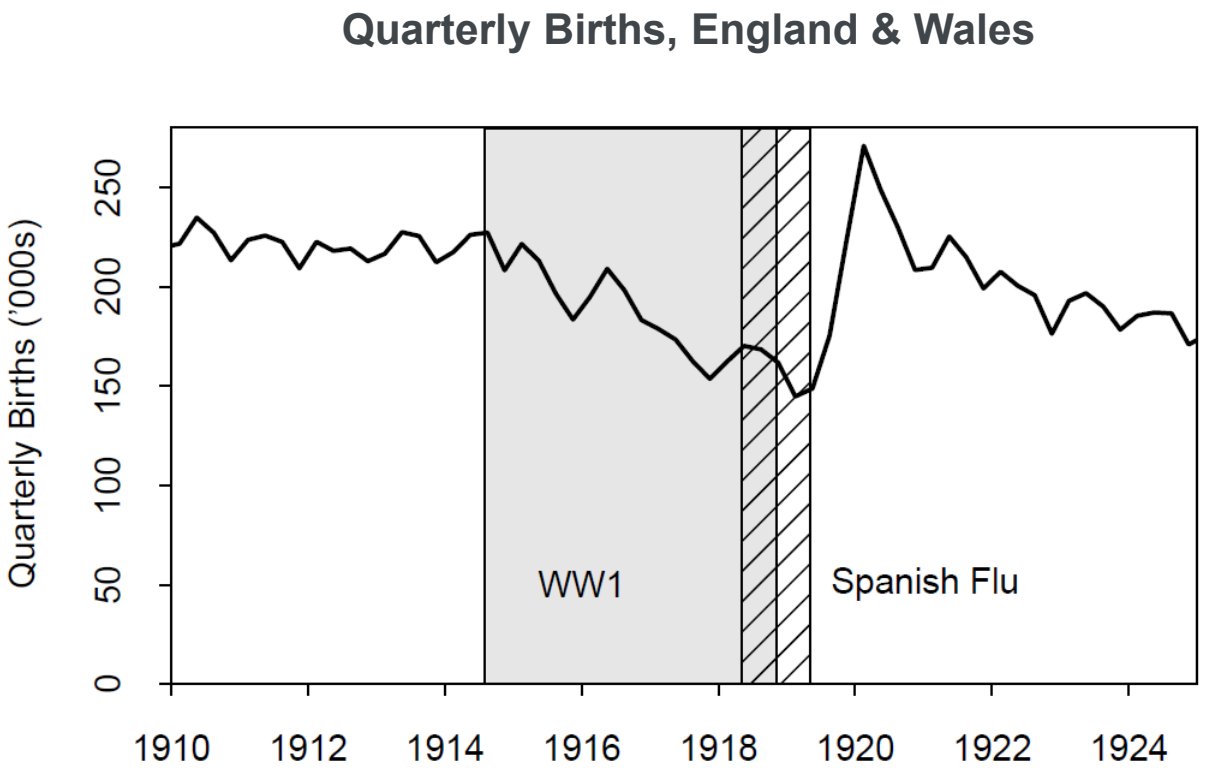
Cohort effects – Western Europe male





Source: Human Mortality Database. Graphs provided by Aon Hewitt.
Mortality improvement is annual difference in –log(deaths/exposure). Change in exposure is annual difference in log(exposure).

Mortality estimation



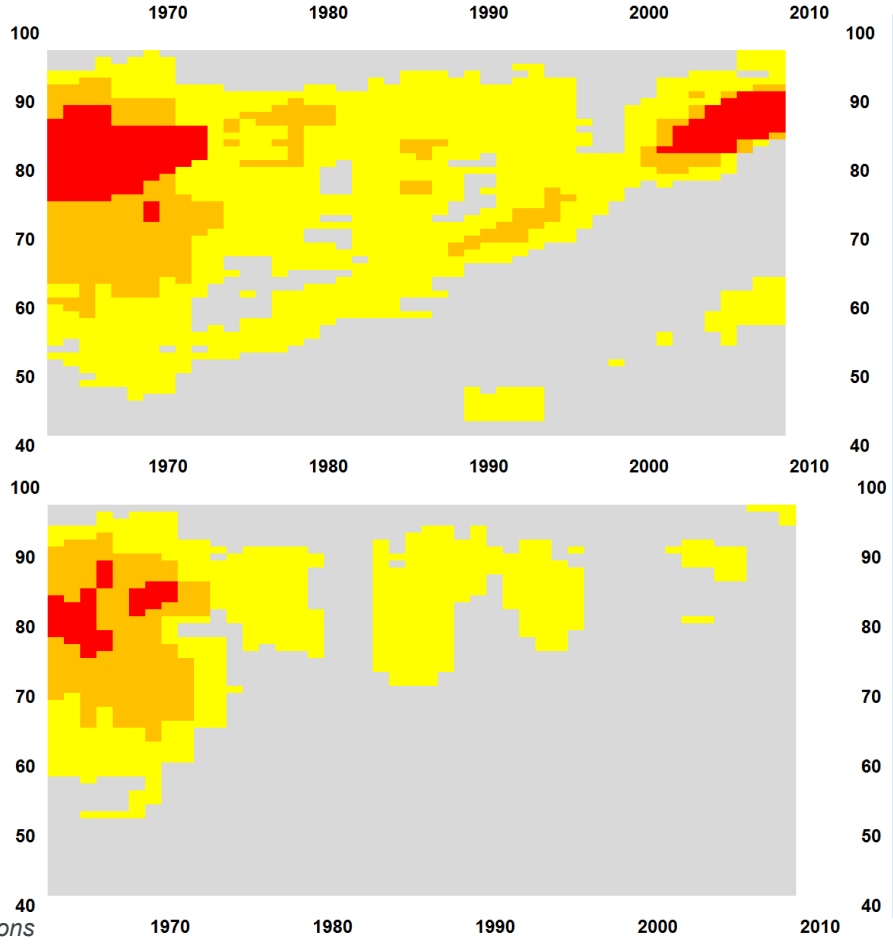
Source: Andrew Cairns

Comments

- $m(t,x) = \frac{D(t,,x)}{E(t,x)}$ for life aged x at time t
- E(t,x) typically approximated by P(t+$\frac{1}{2}$,x)
- Irregular pattern of births can distort exposure estimates

Cairns-Blake-Dowd population adjustment

Over-dispersion in p-spline fit
England & Wales males



Over dispersion measure

	0-2
	2-5
	5-10
	>10

Source: ONS data + CMI calculations

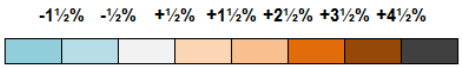
Comments

- Cairns et al: 'Phantoms never Die: Living with Unreliable Mortality Data'
- Adjustment to E&W mid year population allows for pattern of births
- Alternatively could accept the data and modify the smoothing methodology

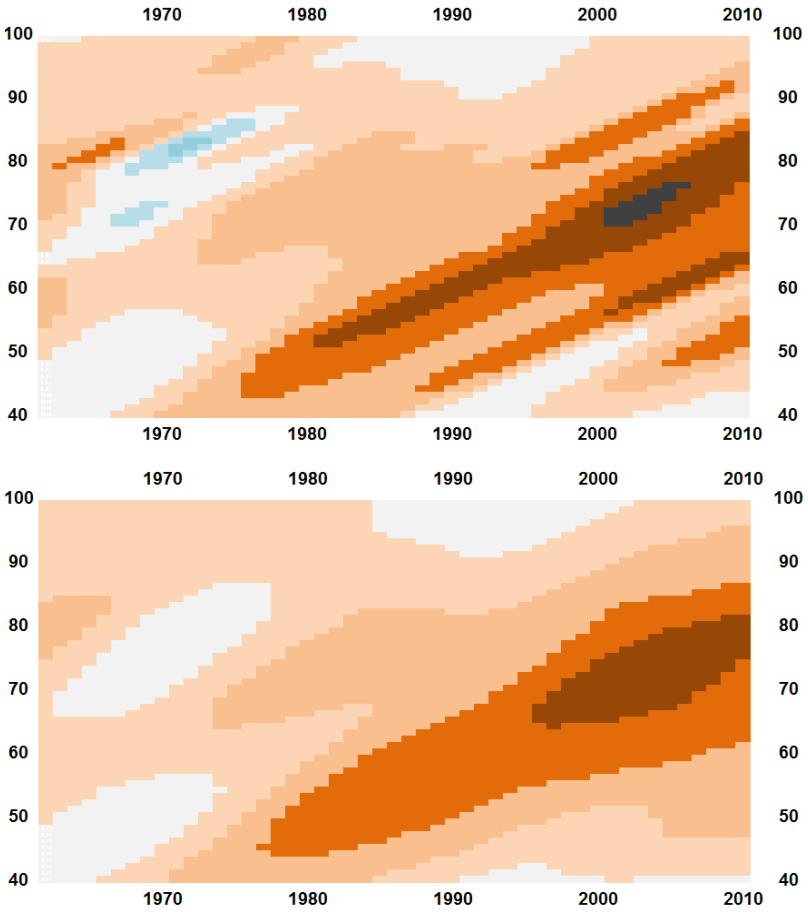
Cairns-Blake-Dowd population adjustment

Smoothed annual rates of mortality improvement
England & Wales males

Current data



Adjusted data



Source: ONS data + CMI calculations

Comments

- Applying the adjustment results in more smooth historical mortality improvements

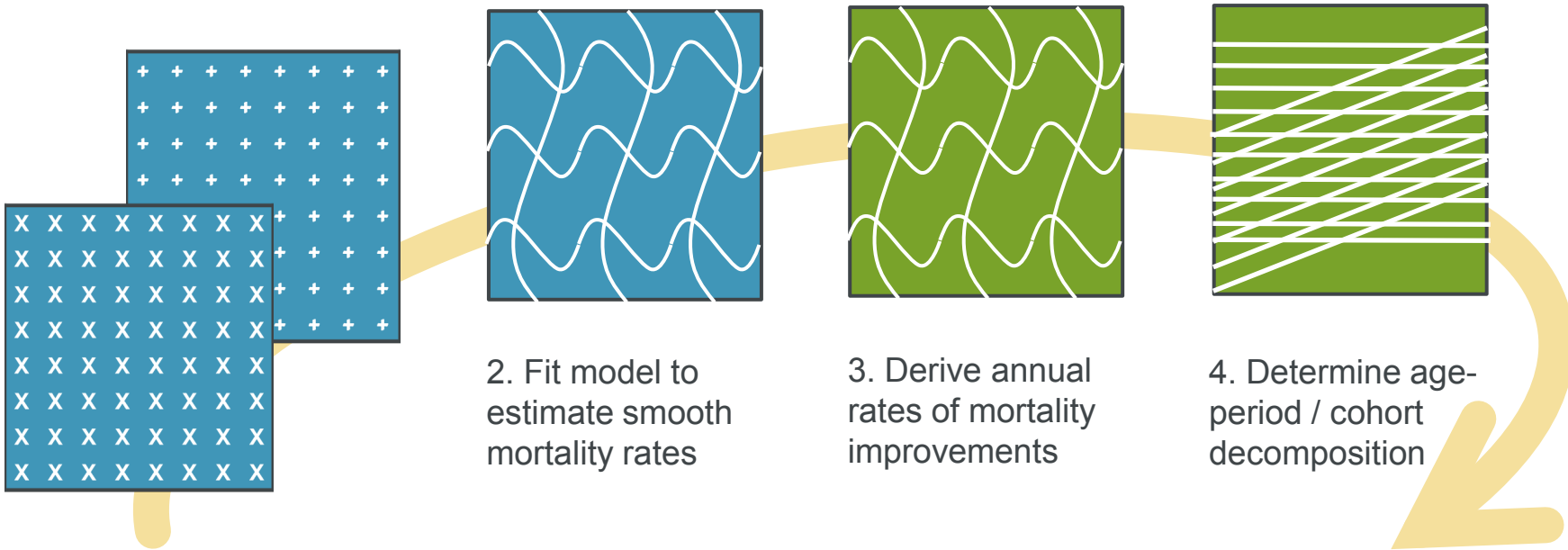
Issues

1. Over-dispersion / possible over-fitting
2. Data quality at high ages
3. General issues with population estimates
4. Other methods for dealing with data issues
5. Other data sources

Discussion topic

Current CMI Model

Current CMI model



1. ONS provides raw death and exposure (population) data for England & Wales

[Exposure (population) data at high ages constructed by CMI using ONS methodology]

2. Fit model to estimate smooth mortality rates

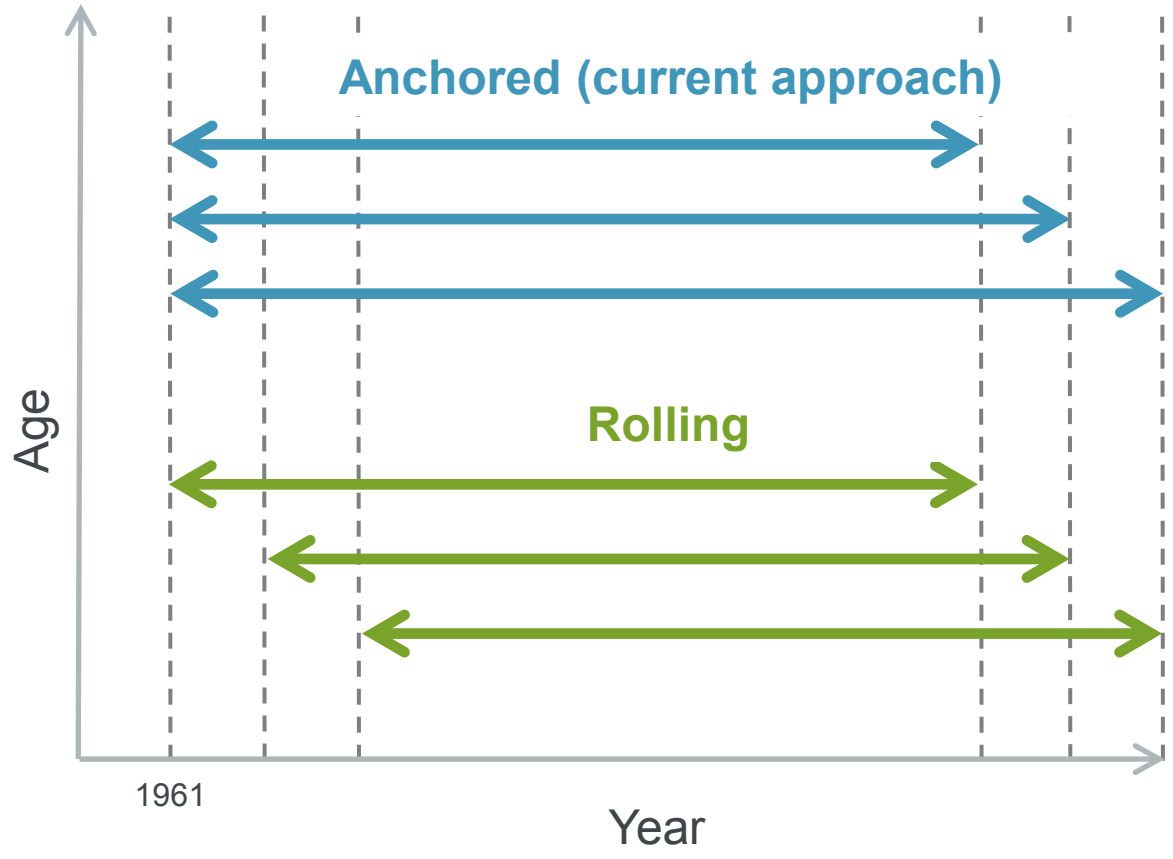
3. Derive annual rates of mortality improvements

4. Determine age-period / cohort decomposition

5. Projection
(a) Step back two years for initial rates
(b) Sum separate projections of age-period and cohort components

Rolling v anchored data period

Experience data used

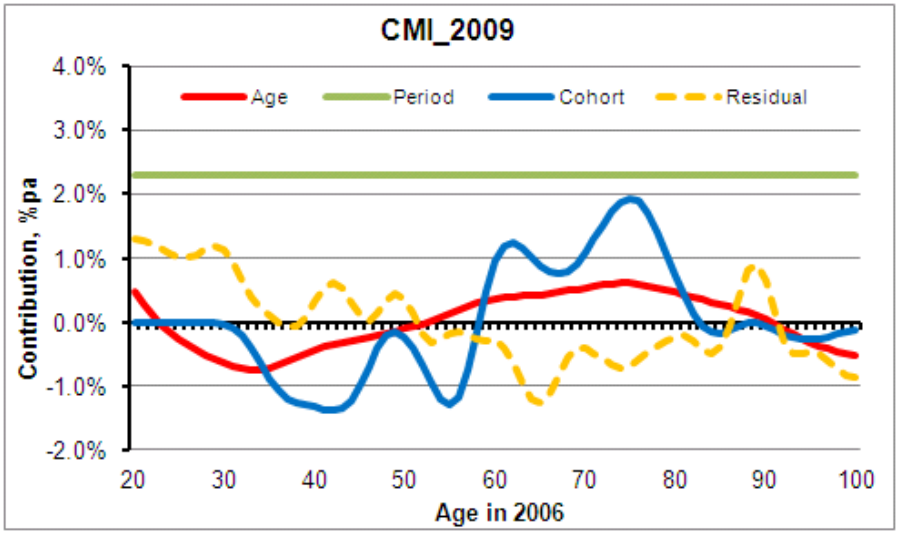


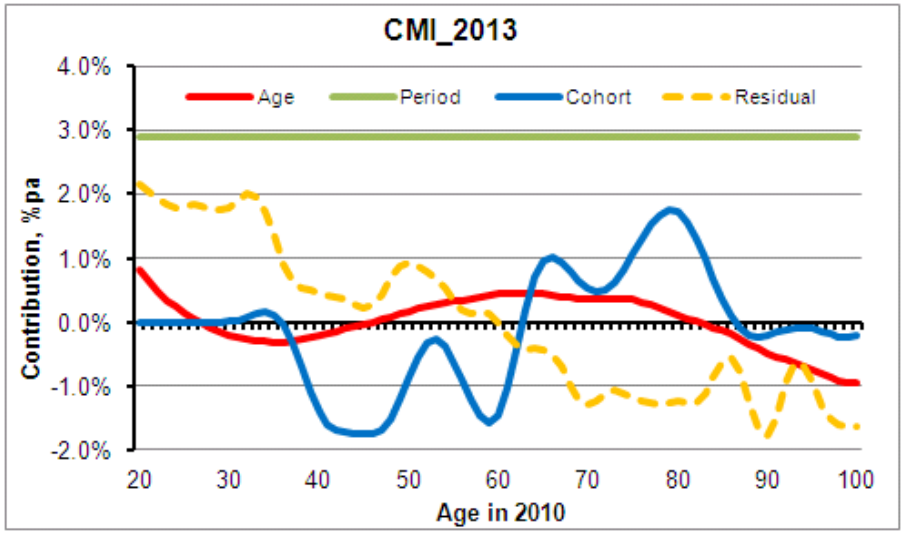
Comments

- Model currently uses all data from 1961 to latest available
- Need to balance
  - sufficient data
  - up-to-date data
- Data period particularly affects the age-period v cohort split
- A rolling period may be more appropriate to support annual updates to the model

Age-period-cohort split and residuals

Age-period-cohort components of mortality improvements for males



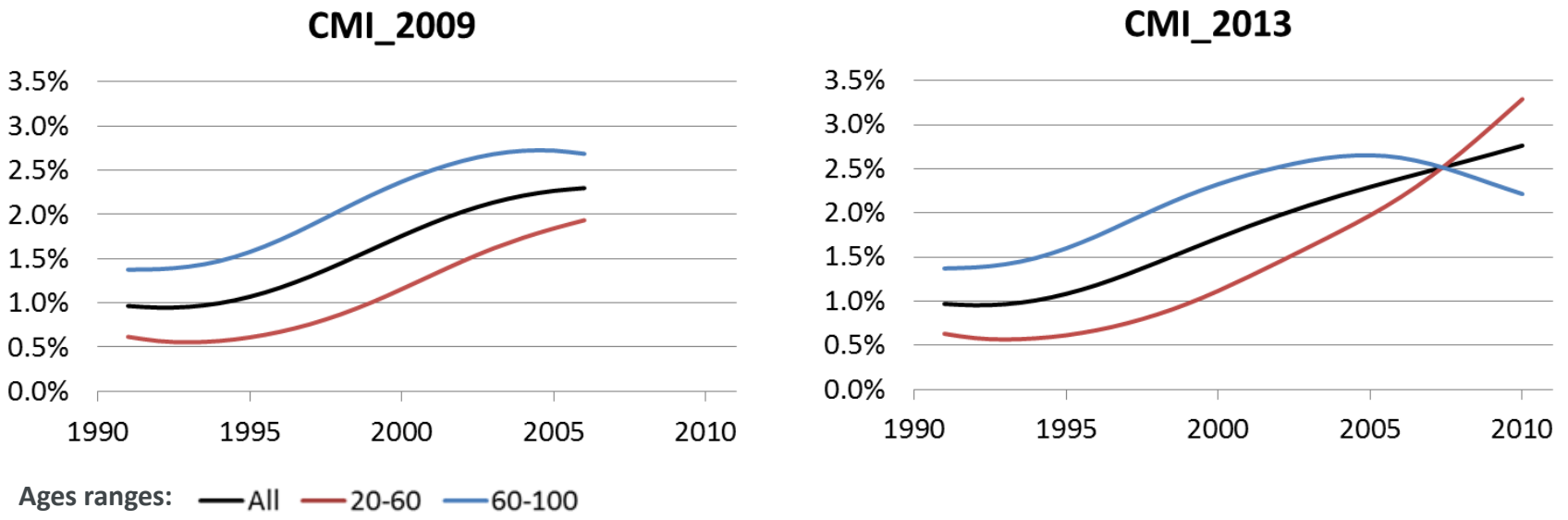


Comments

- The age-period-cohort model is fitted to the mortality improvements table for the full dataset – ages 18 to 102, years 1961-2012
- The residuals have developed a strong age-dependent pattern over recent years, suggesting the model may be too rigid and the age-period-cohort split not ideal

Slope of improvements varies by age

Average male historical p-spline mortality improvements over different age ranges

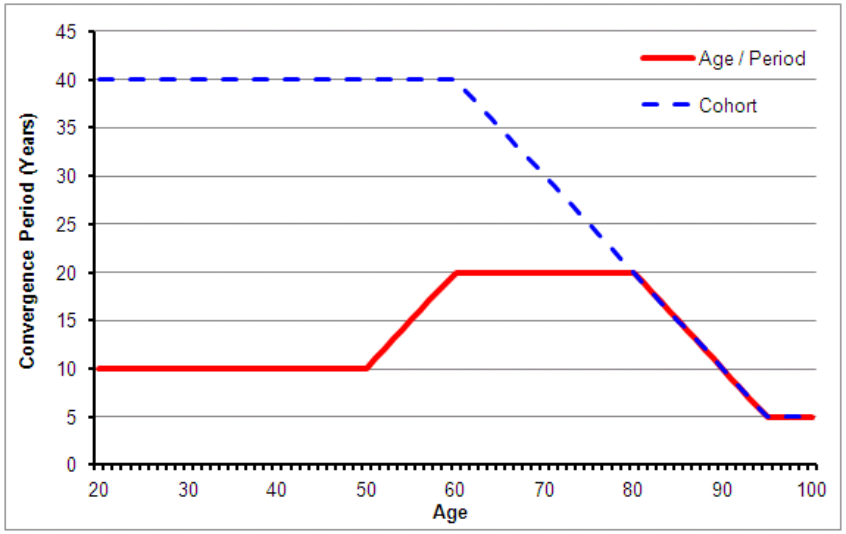


Comments

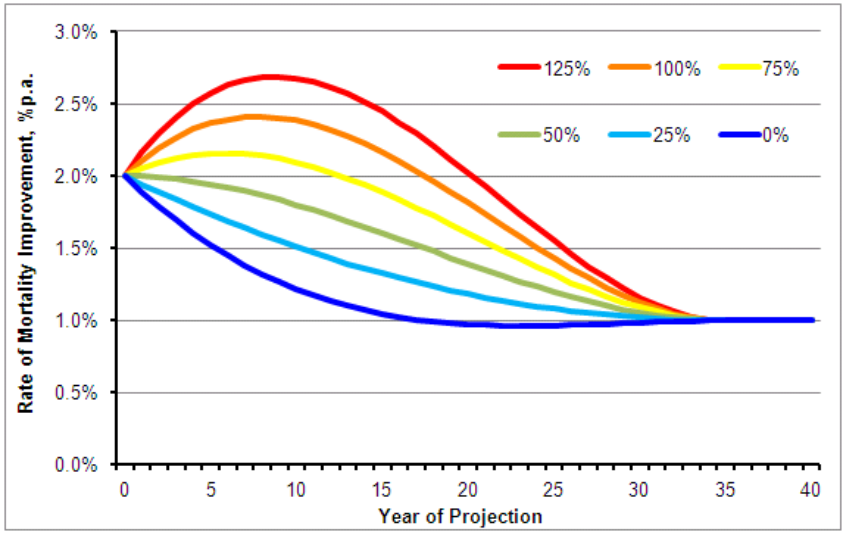
- The significant recent difference in slope of mortality improvements at different ages explains the emerging pattern of residuals in the age-period-cohort model
- It may be preferable to calibrate the APC model to a restricted dataset – fewer ages or years – and perhaps also to tailor the convergence shape to reflect recent trend differentials by age, particularly if the Model is applied for pensioners/annuitants

Convergence to the long-term rate

Default convergence periods



Convergence pattern examples



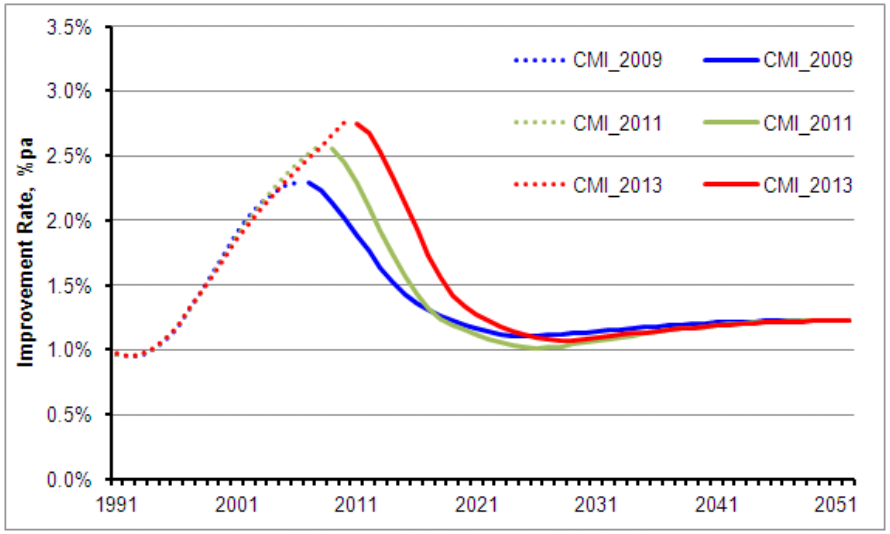
Comments

- The default (Core) convergence periods broadly reflect observed timelines of past features in mortality trends
- The convergence pattern responds to the assumed 'Proportion of convergence remaining at mid-point' – default value is 50%

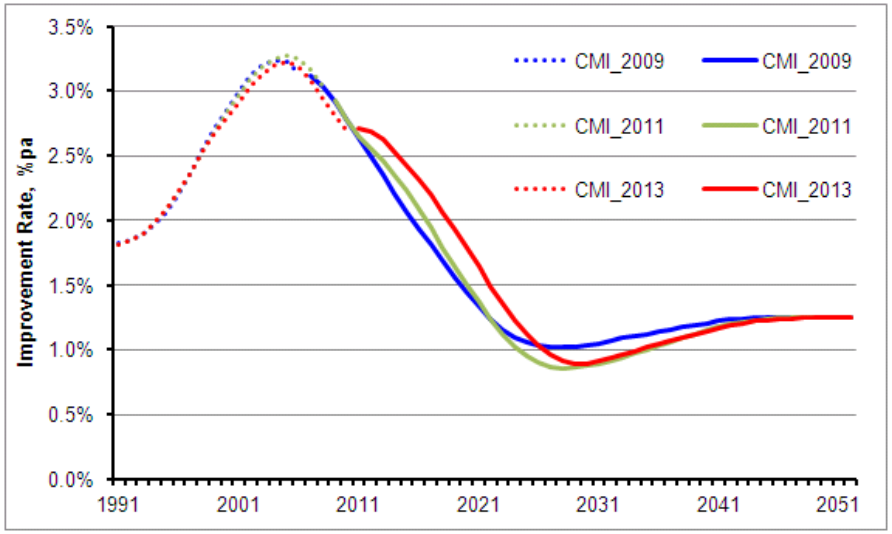
Progression from experience to projection

Average mortality improvement rate by year for males

Ages 20 to 100



Ages 60 to 90



Comments

- Over the full age range, it has been suggested the Core Model assumes 'extreme trend reversal' – an immediate downturn following a rising pattern of experience
- However, for the key pensioner/annuitant age range, the experience pattern appears to have peaked and the default convergence shape appears more reasonable

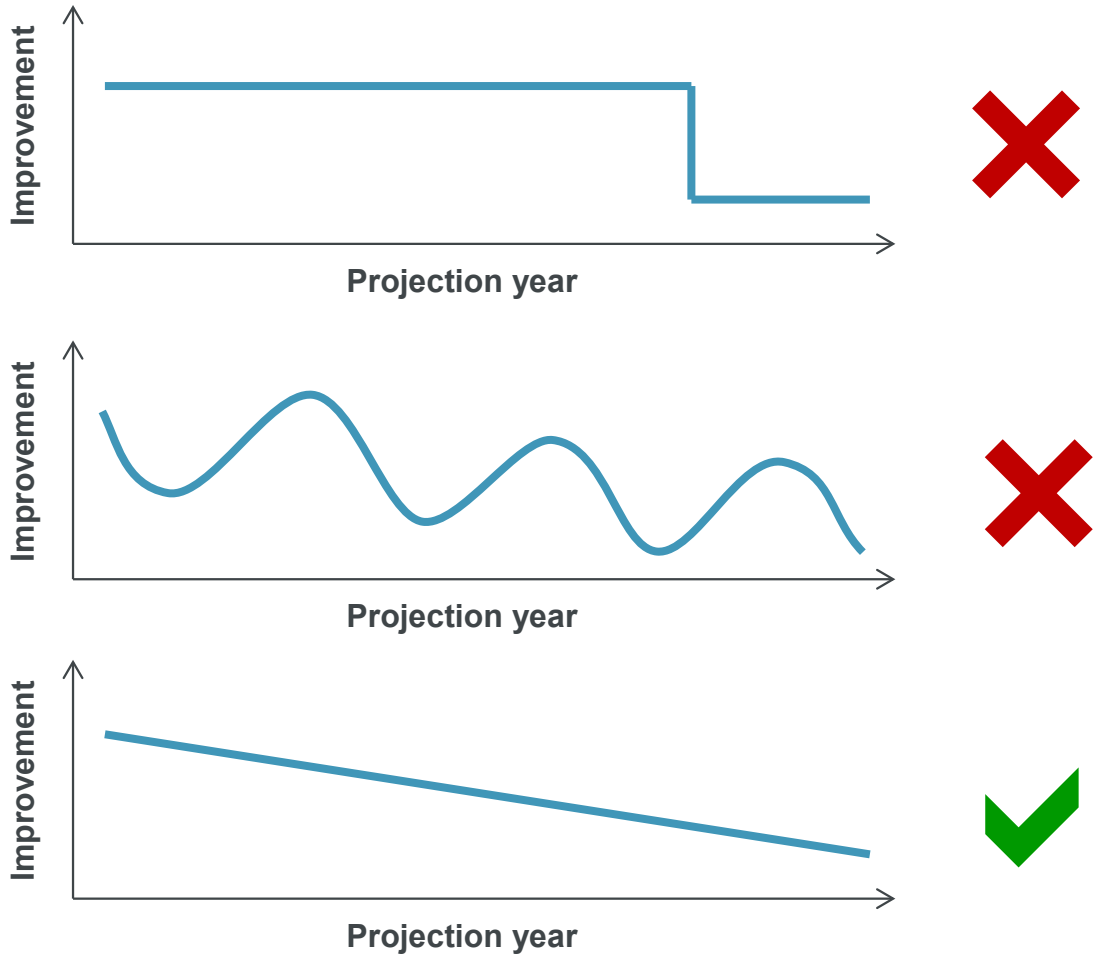
Issues

1. How do you use the model in practice – is it your reference model or do you reverse calibrate it to an alternative model?
2. CMI model complexity – too much, about right or too little?
3. Should we move to a rolling calibration dataset?
4. Is the split of age-period and cohort components of improvements appropriate and reasonable?
5. What are your views on the default convergence periods? Is it reasonable to roll them forwards when the model is updated?
6. Do you use the framework to calibrate other datasets (UK or overseas)?

Discussion topic

Responsiveness and stability

Ideal response

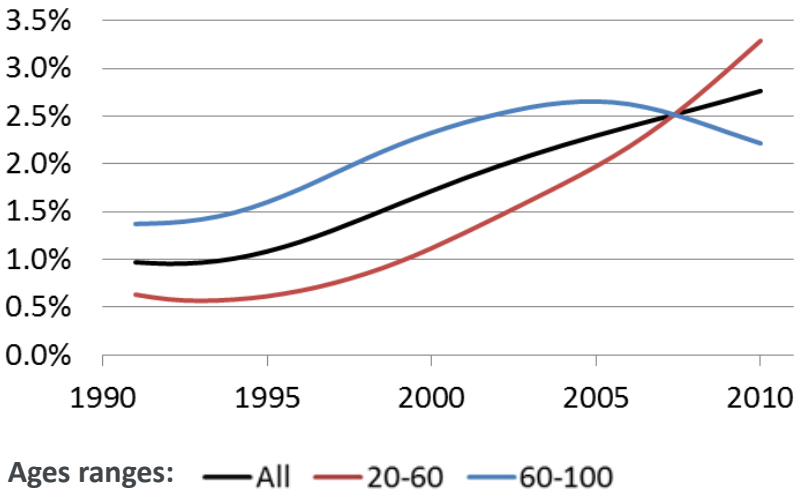


Comments

- We want balance between:
  - responsiveness
  - stability
- Testing the model on different datasets
  - helps us find an optimal balance
  - allows users to understand how we expect the model to behave

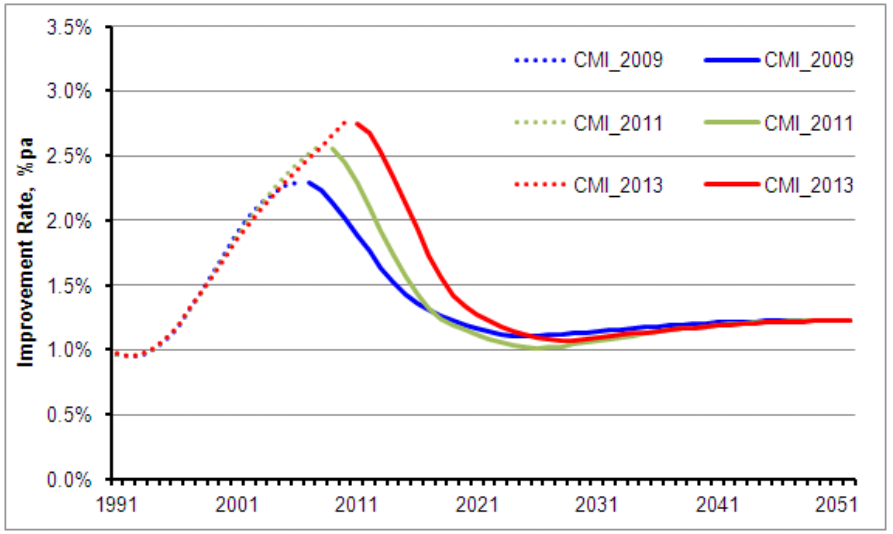
CMI model performance

Average male historical p-spline mortality improvements over different age ranges (CMI_2013)



Average mortality improvement rate by year for males

Over ages 20 to 100

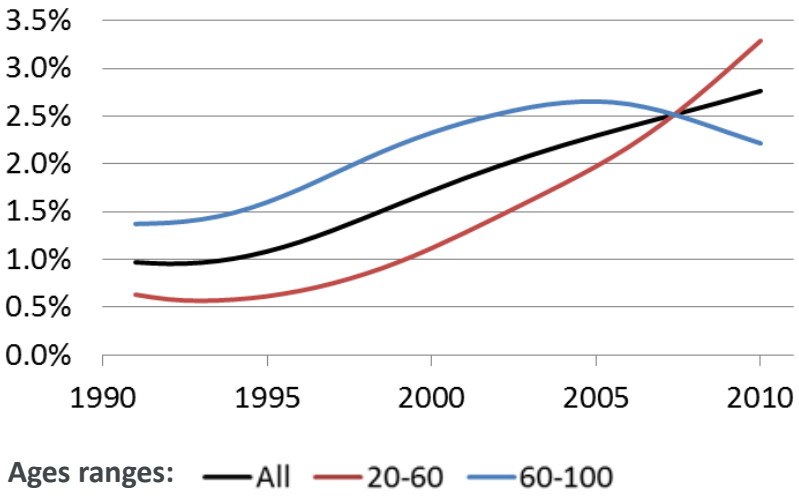


Comments

- CMI_2009 projected a reduction in mortality improvement rates, but the smoothed data up to CMI_2013 showed the All Ages average improvement rates still rising
- As a result, the projected All Ages average improvement rate for 2011 in CMI_2013 is nearly 1 percentage point higher than CMI_2009

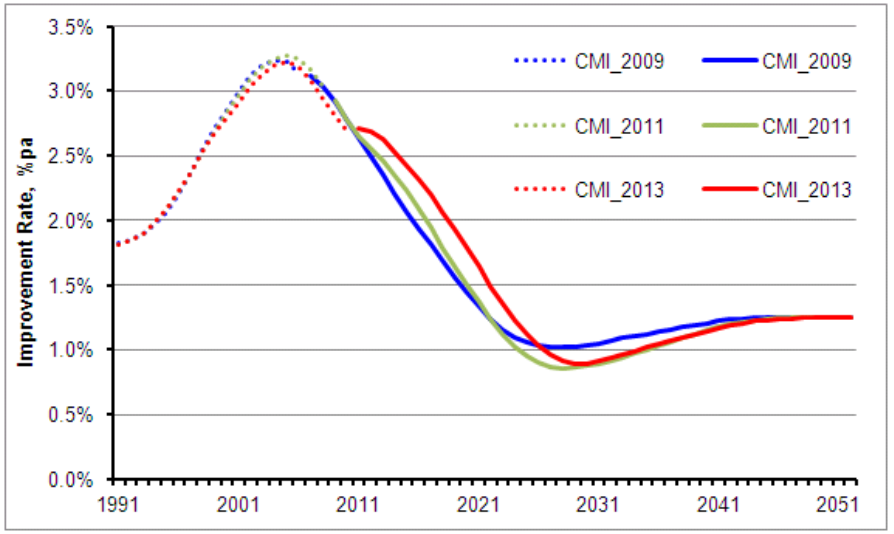
CMI model performance

Average male historical p-spline mortality improvements over different age ranges (CMI_2013)



Average mortality improvement rate by year for males

Over ages 60 to 90



Comments

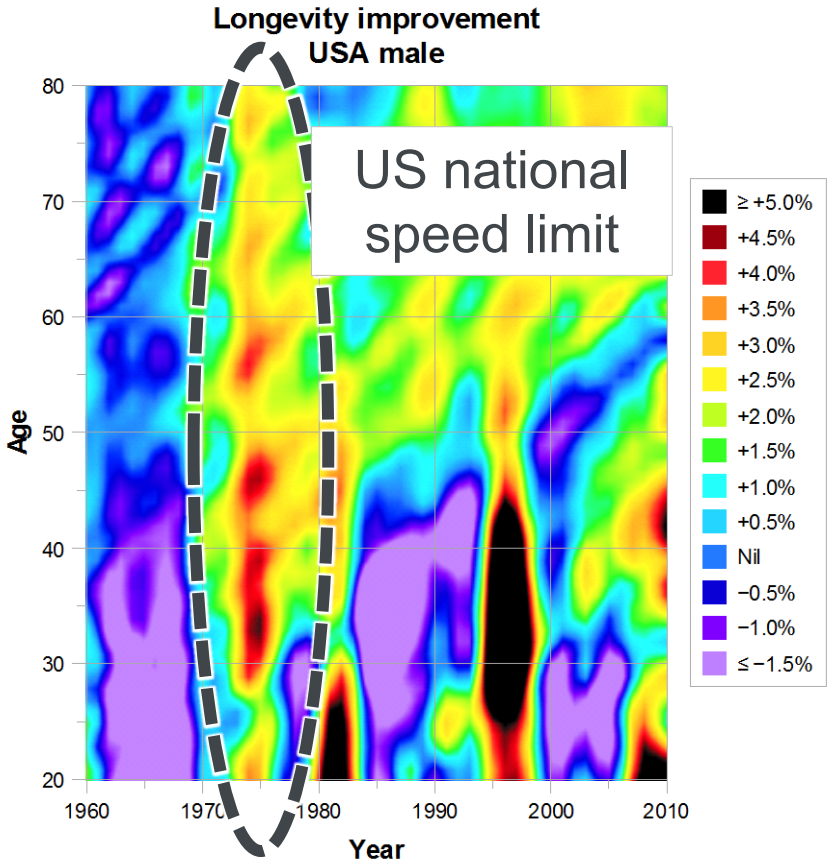
- However, the smoothed data for older ages did show a reduction in the pace of improvement.
- As a result, the projected average improvement rates for older ages have changed much less from CMI_2009 to CMI_2013

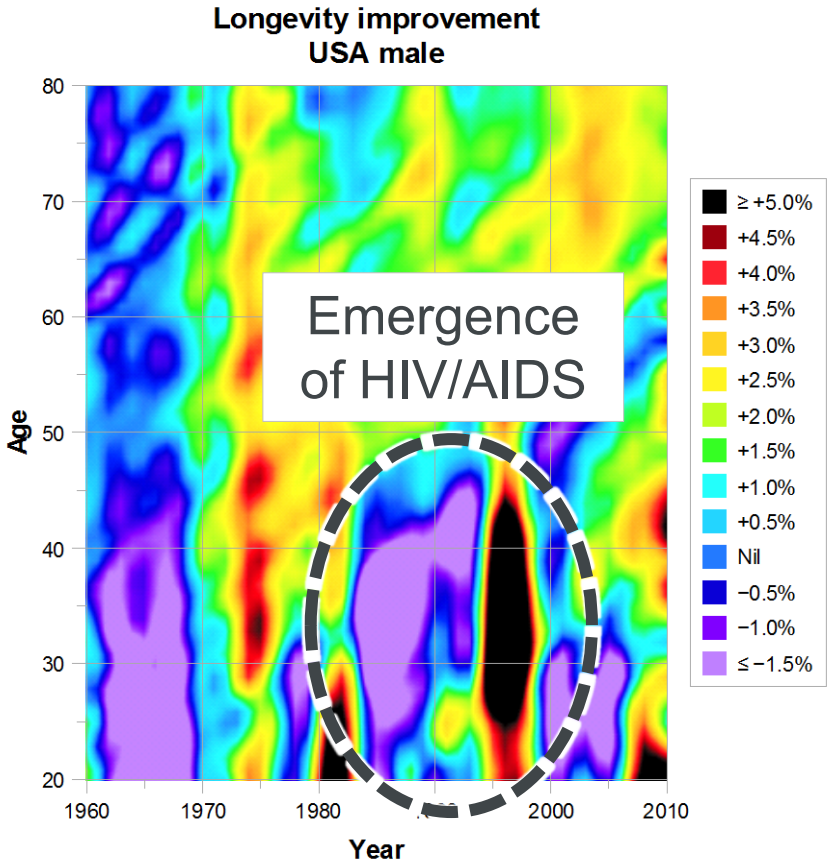
Scenario testing

- Possible test data
  - Artificial data
  - International data
  - Other UK experience data e.g. SAPS
- Process
  - Apply model to chosen dataset at time *t*
  - Add an additional year of data and measure changes
  - Repeat

- Numerous historical shifts in mortality
  - Emergence of HIV
  - US national speed limit
  - Fall of communism
- We can test how the current model reacts to these …
- … but how *should* it react?

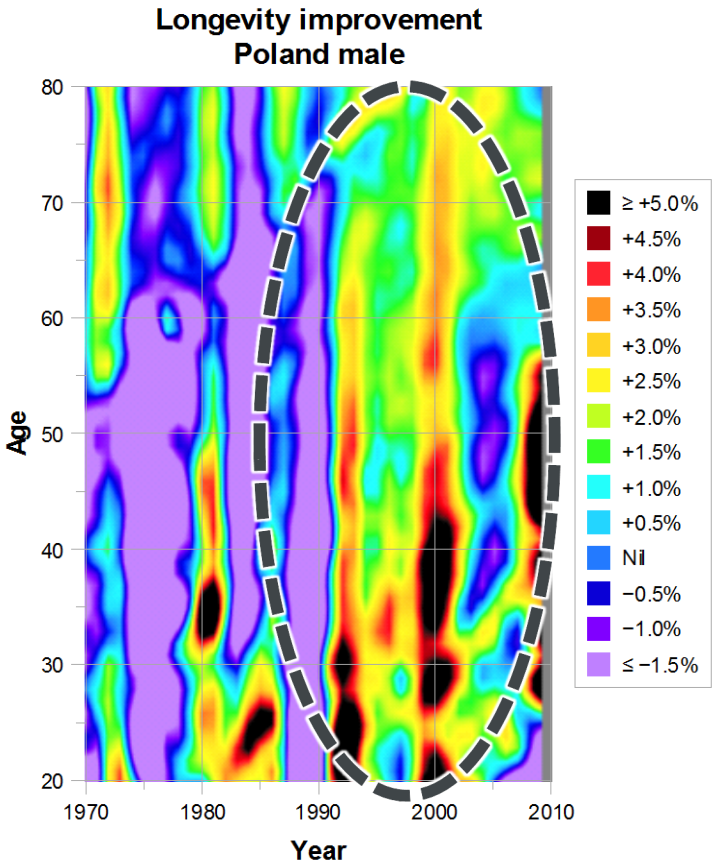
Testing − features of US mortality

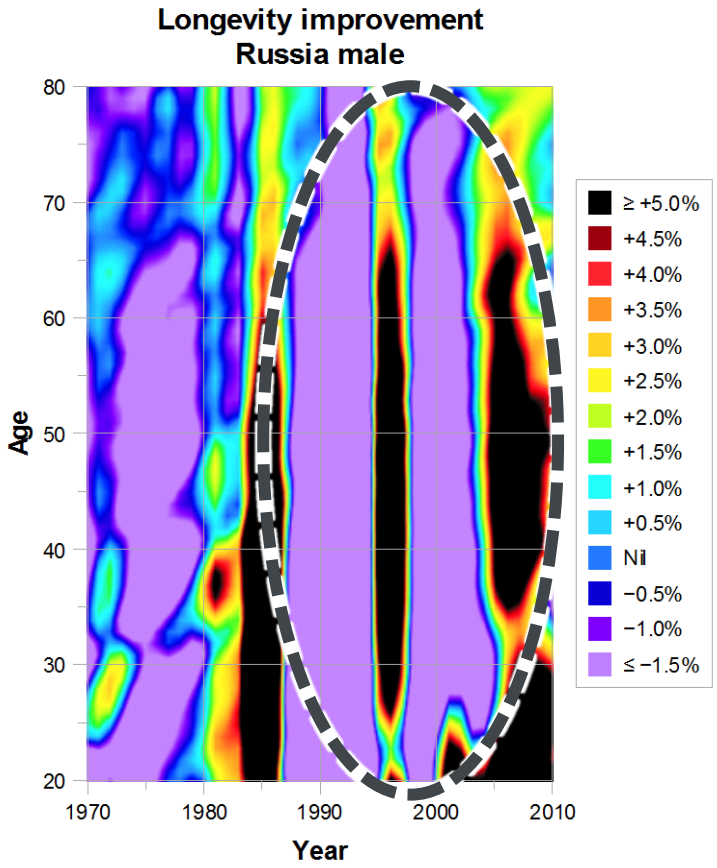




Source: Human Mortality Database.
Mortality improvement is annual difference in –log(deaths/exposure) with LOESS smoothing over ±3 years over age and period.

Testing – fall of communism





Source: Human Mortality Database.
Mortality improvement is annual difference in –log(deaths/exposure) with LOESS smoothing over ±3 years over age and period.

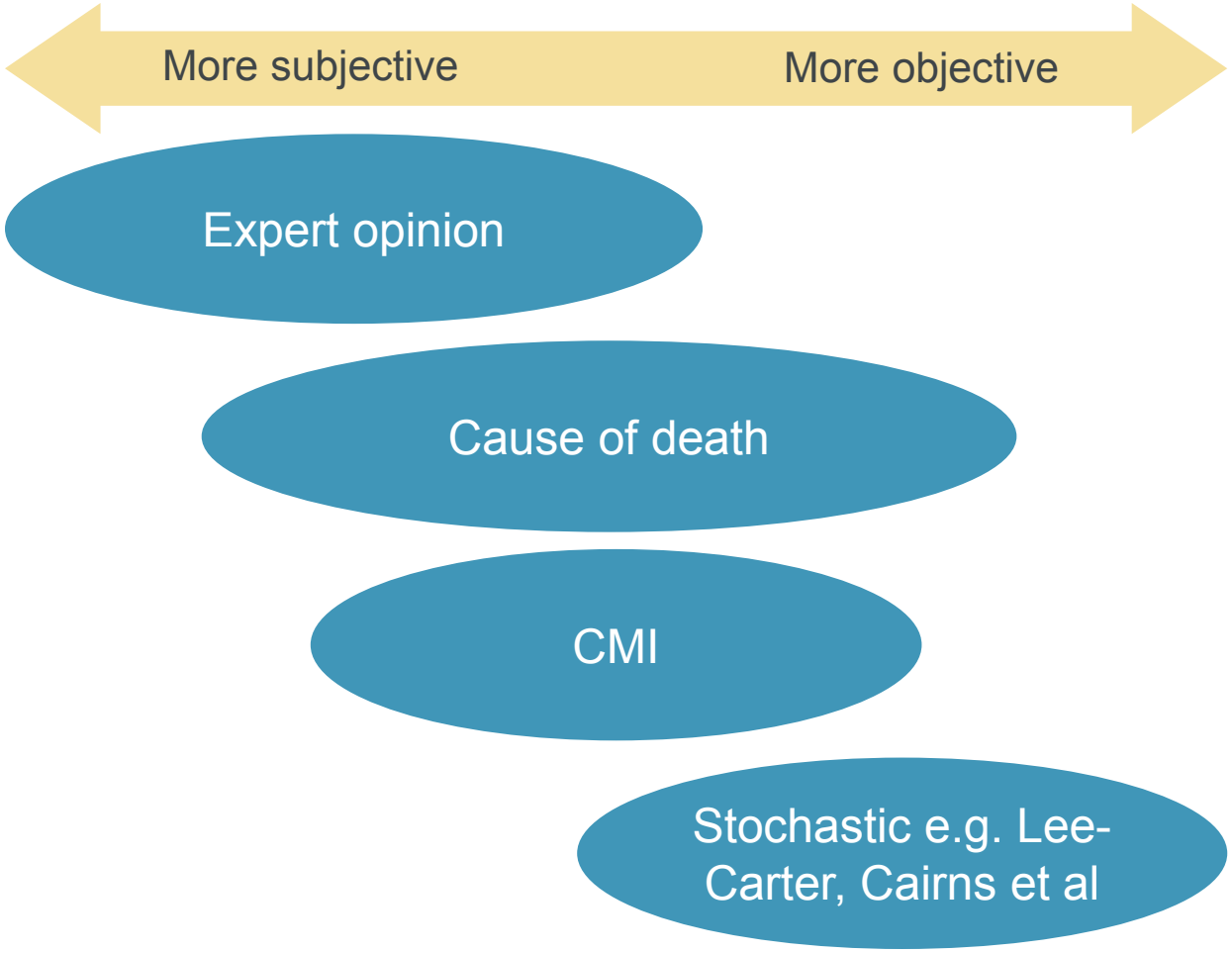
Issues

1. How responsive should the model be – what's reasonable?
2. How should we measure appropriate responsiveness – what are good scenarios?
3. If we have a choice, should we err on the side of stability or responsiveness?

Discussion topic

Wider issues

Types of model

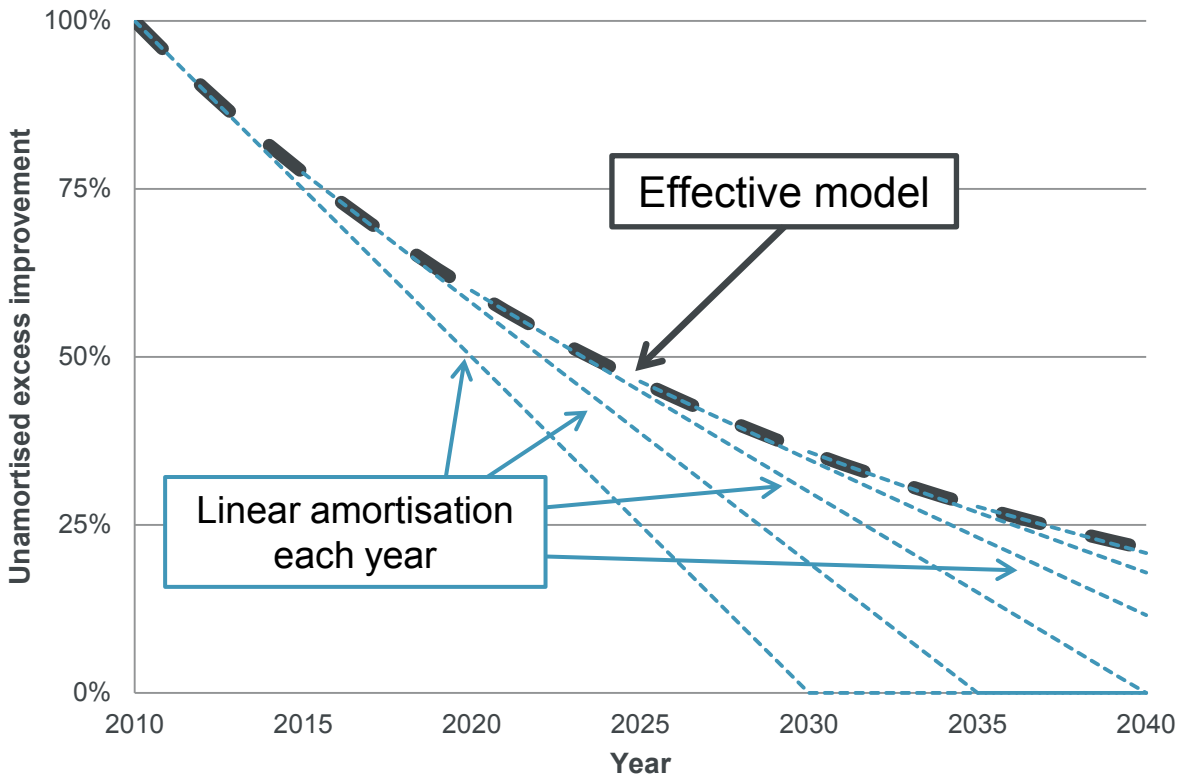


Comments

- Subjective models
  - Can take account of one-off features
  - Use all information
  - Poor track record
  - Difficult to test
- Objective models
  - Can be tested
  - Can estimate uncertainty (although model risk remains)
- The CMI projections model is not 100% objective because it requires specification of a 'long-term rate'

Consistency – amortising improvement

Effective of repeated amortisation of excess improvement

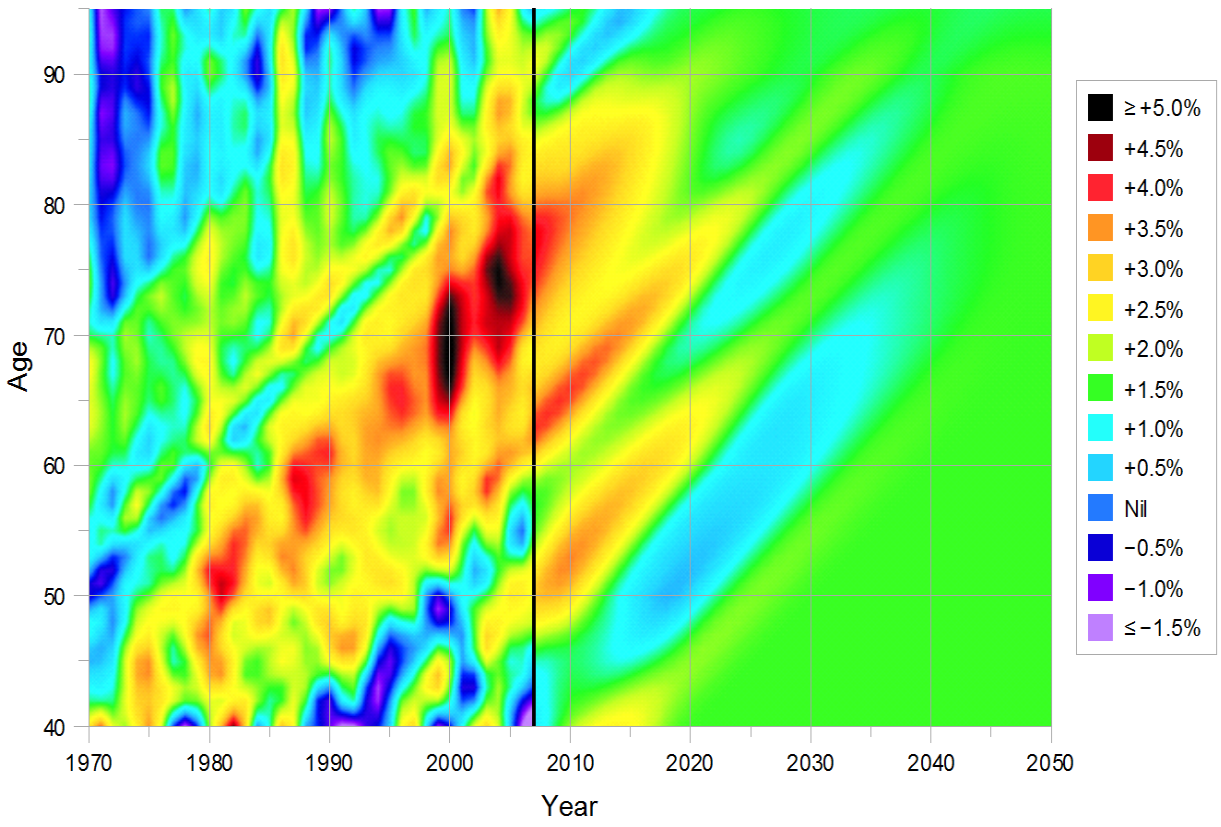


Comments

- With a repeating amortisation model
  - If the following year is exactly as predicted then …
  - … the predicted future changes
- The example shown here is repeated linear amortisation
- Is this inconsistency a problem?

Comparators – actuarial projection models

England & Wales males / CMI_2013 Core (LTR=1.5%)



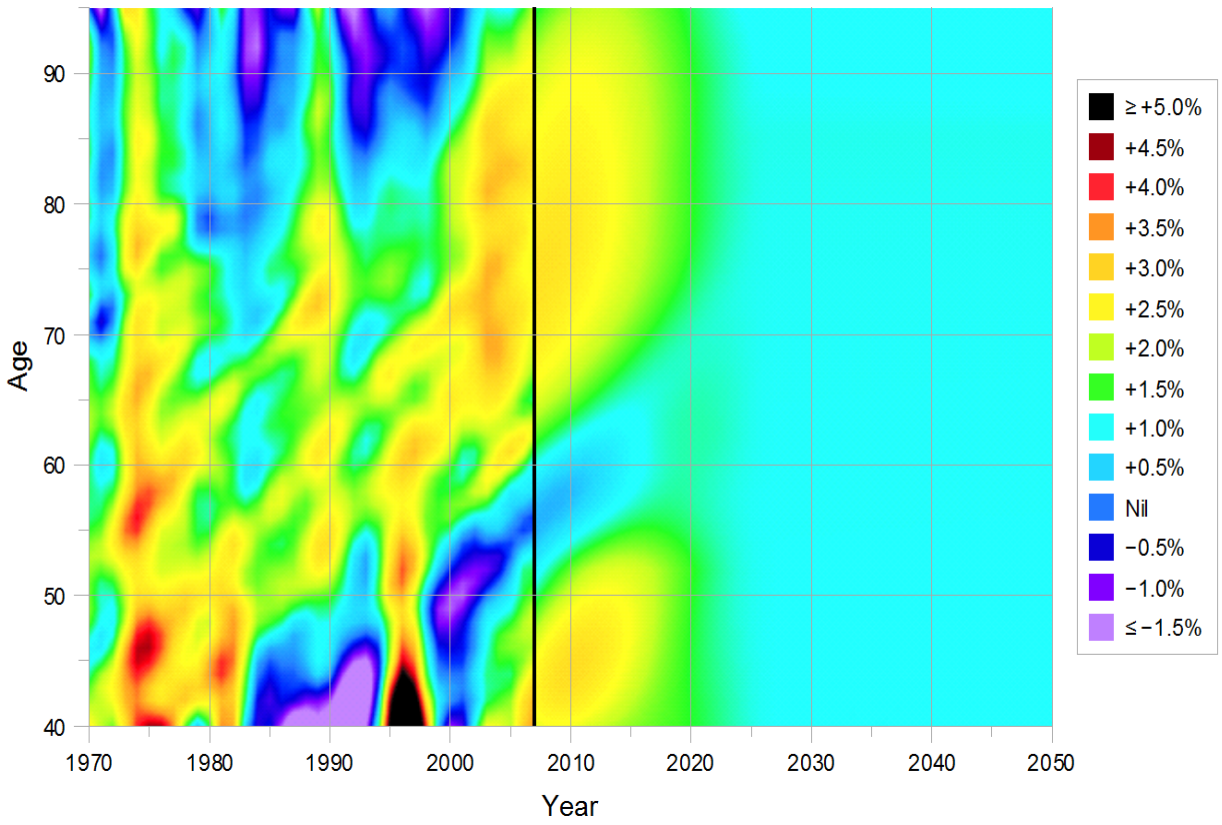
Source: Human Mortality Database/CMI. Mortality improvement is annual difference in –log(deaths/exposure) with LOESS smoothing over ±3 years over age and period for the experience data.

Comments

- No single projection
  - 'Core' requires a 'long-term rate'
  - 'Advanced' extremely flexible
- Projection features
  - Strong UK cohort effects carried over into projections
  - Long-dated projection
  - Interaction results in complex long-dated patterns

Comparators – actuarial projection models

US males / MP-2014 exposure draft



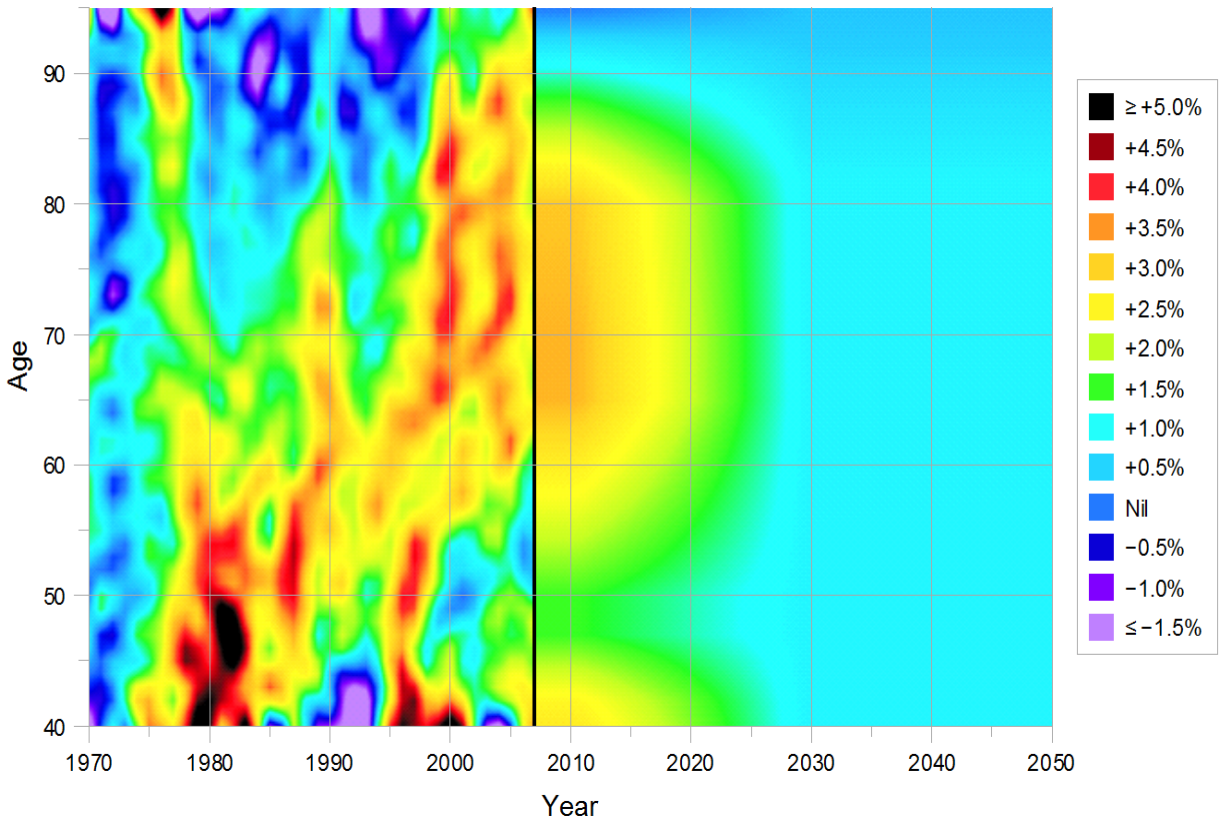
Source: Human Mortality Database/Society of Actuaries. Mortality improvement is annual difference in –log(deaths/exposure) with LOESS smoothing over ±3 years over age and period for the experience data.

Comments

- Single standard projection
- Based on CMI model
- Features compared with CMI
  - Lower long-term rate v typical UK
  - More rapid convergence
  - Less recognition of cohort effects
  - Averages by age and by cohort projections
  - Initial improvements (*including slope*) from last 2 years

Comparators – actuarial projection models

Canada males / CPM-B

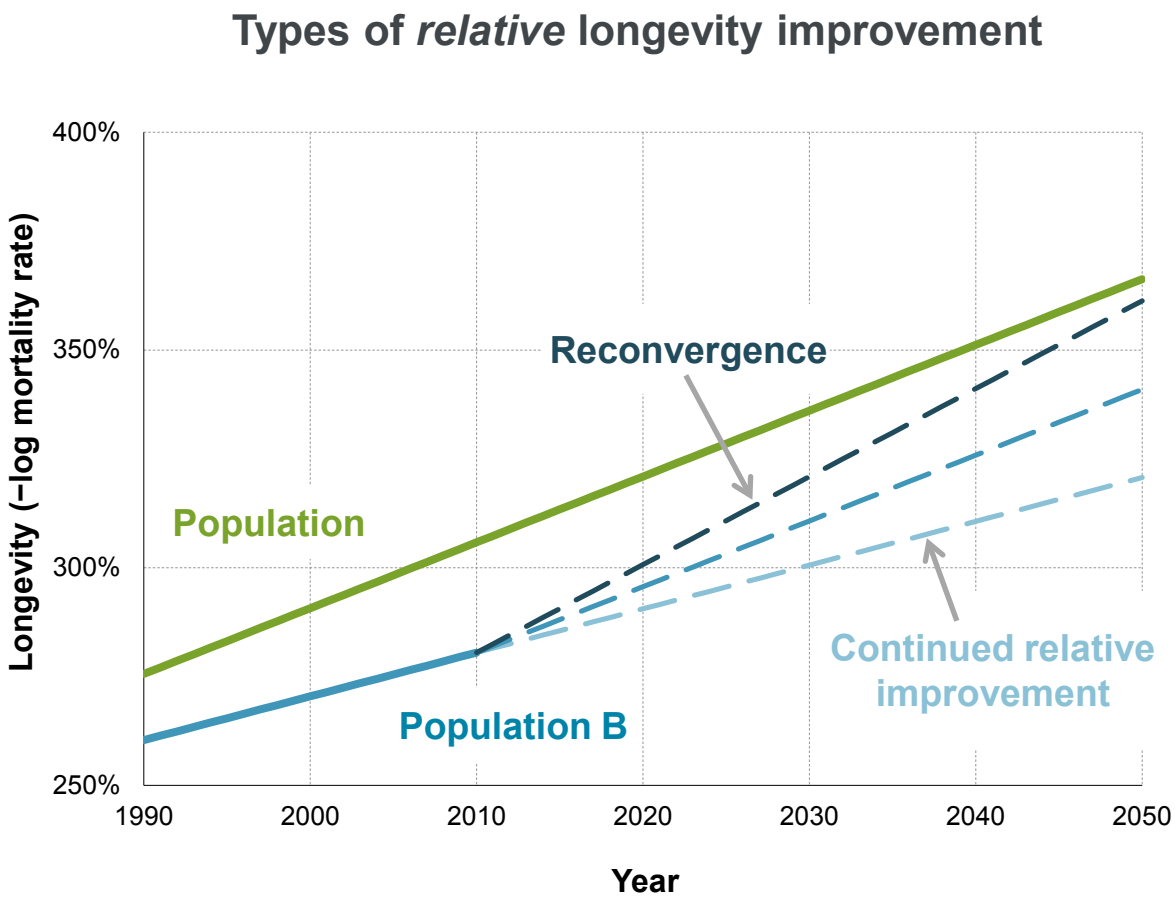


Source: Human Mortality Database/Canadian Institute of Actuaries. Mortality improvement is annual difference in – log(deaths/exposure) with LOESS smoothing over ±3 years over age and period for the experience data.

Comments

- Single standard projection
- Features compared with CMI model
  - Calibrated to national pension plan data (i.e. *not* the data shown on the left)
  - No recognition of cohort effects
  - Lower long-term rate v typical UK
  - More rapid convergence (same for period and cohort)

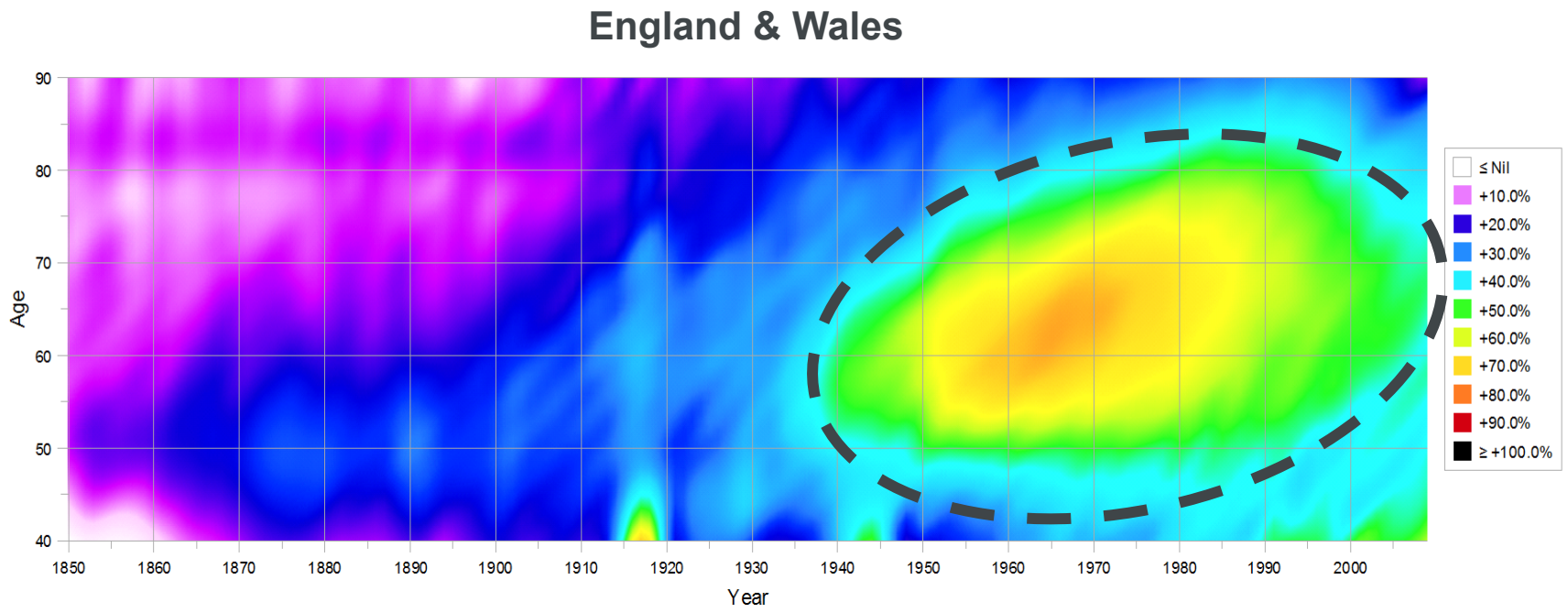
Longevity improvement by sub population



Comments

- Projecting past longevity improvement *differentials* is not straightforward
- What are we expecting?
  - Continued relative *improvements*?
  - Continued relative *absolute rates*?
  - Reconvergence?

Example: male v female mortality rates

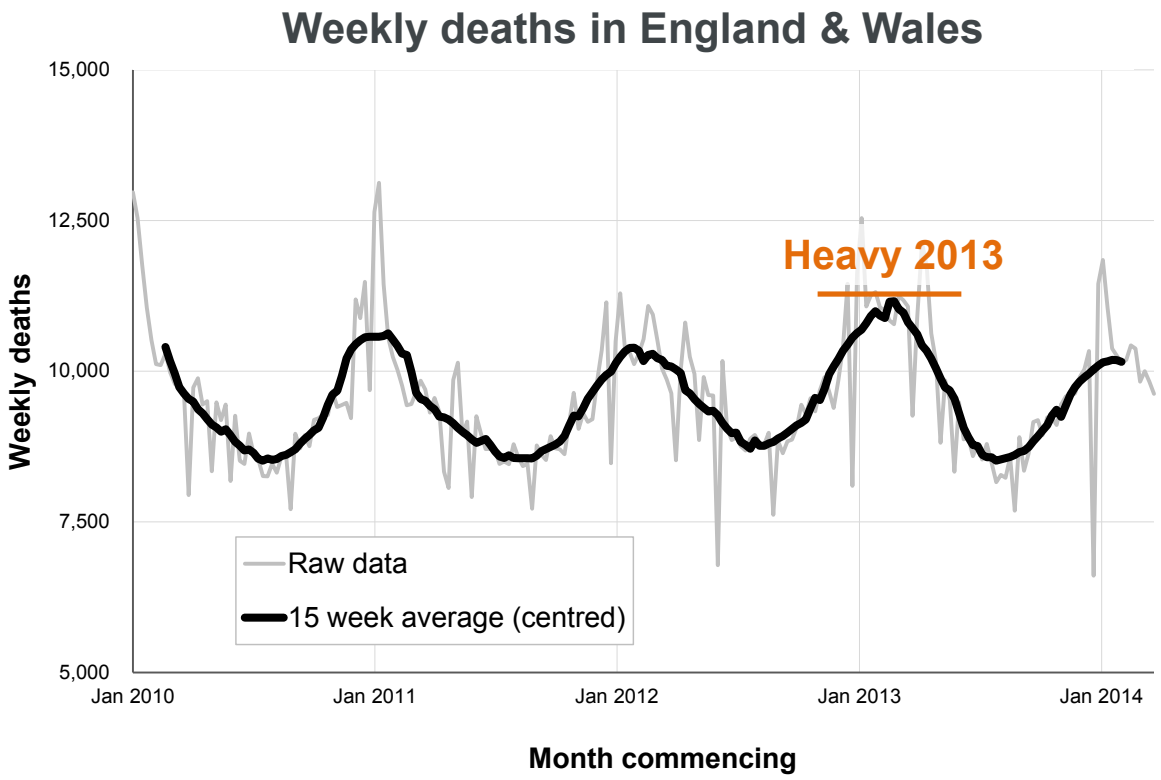


Comments

- Heatmap shows relative male v female *absolute* mortality rates (not improvements)
- Highlighted feature shows male mortality falling behind and, more recently, catching up with female mortality

Source: Data from the Human Mortality Database

Annual noise



Comments

- 2013 had unusually heavy mortality in England & Wales
- Some of the apparent annual volatility arises from using a 1 Jan cut-off date the data during winter
- This (ONS) data is now available direct from the CMI website

Source: ONS data collated by the CMI

Issues

1. Is wider change needed?
2. Should we look at causes of death or related e.g. smoking prevalence?
3. Should the model be 100% objective?
4. Should we collect a consensus view?
5. Sub-population mortality improvement (M v F, by locale, by socio-economic type)
   - How relevant is this?
   - How should past differentials be projected?

Discussion topic

Next steps