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Practical experiences of using CMI models for projecting annuitant mortality

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Workshop A13

Agenda

- Brief history of mortality projections
- Aims when setting improvement basis
- Choice of model
- Use of the model - hints & tips
- Choice of datasets / parameters
- Validating output
- Adjustments to output
- Derivation of capital

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Warning !

- This presentation will not contain
  - Formulae
  - In-depth discussions of statistical models

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Brief history of mortality projections

- a(55) – the first formal use of improvements
- PA(90) – projection of 1967-70 mortality to 1990
  - Uniform reduction of 1 year of age per 20 calendar years
- CMIR10 - to run alongside 80 tables
  - First use of geometric method
    RF (x,t) = α(x) + [1 - α(x)] (0.4) $^{t/20}$

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Brief history of mortality projections

- CMIR17 - to run alongside 92 tables
  - Revision to geometric method
- CMI wp1 - 'interim' cohort projections
  - Overlay over CMIR17 improvements
- 2005 – Spline / Lee-Carter methodologies

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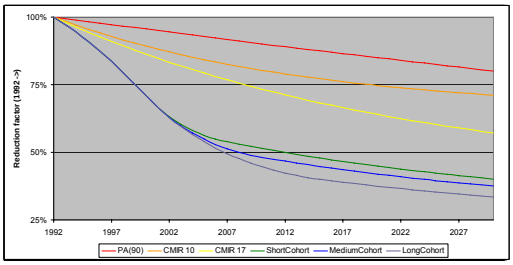
Brief history of mortality projections
(age 65, male)



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Aims when setting improvement bases

- Use of output (best estimate / reserves / ICAS)
- Affordability (on your in-force)
- Competitiveness (of new business terms)
- Sensible shape
- Consistency with base table
- Objectivity (not too much of a fiddle)
- Ease of understanding / communication

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Choice of model - Lee Carter v P-Spline

- The CMI's initial software allowed both
- But the Lee Carter functionality was flawed
- So it was deactivated for version 2
- CMI paper covering Lee Carter in "late Q3 2006"
- Other methods (eg Logistic/Weibull) are valid too
- Although software does not readily support them
- Rest of presentation will hence relate to P-Spline

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Use of the model - hints & tips

- What the model does & does not do
- Practical issues in using model
- Choice of dataset
- Choice of parameters
- Which ages / years to use
- Problems in the data

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What the model does (& does not) do

- The model
  - Fits a curve to past data, projecting it into the future
  - Blends goodness of fit with smoothing
  - Projects future as a continuation of the past
- The model does NOT
  - Opine to quality / relevance of data
  - Adjust for future items not in past
  - Adjust for past items not expected to be in the future
  - Adjust for differences in use

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Practical issues in using model

- Use the 2nd version of the software
  - More flexible (allows choice of smoothing params)
  - More informative output
  - Read the user guide !
- Automate back end
  - Log (μ) → μ
  - μ → improvements
  - Improvements → graphical output
  - Improvements → annuity factors

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Choice of dataset

- Several choices of dataset
  - CMI assured (underwritten)
  - CMI annuity
  - Population
  - Own data
  - SAPP

Volume	Trends	Relevance
√	√	√
√	x	√
√	√	√
?	?	√
√	x	√

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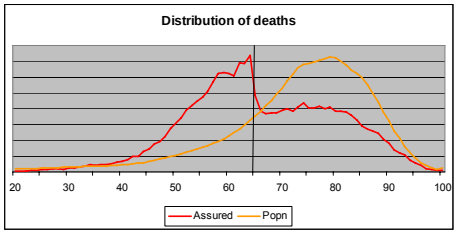
Choice of dataset



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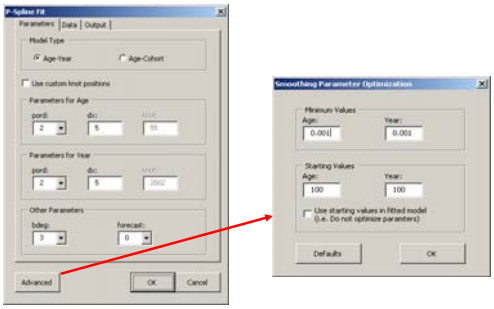
Choice of parameters



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Choice of parameters

- Model type Age-Year v Age-Cohort
- pord Degree of penalty to be applied
  Determines the (approximate) shape of the projection
  2nd order penalty gives approximately linear projection
- dx distance between spline peaks
  use 5 or less – larger makes good fit impossible
- bdeg Degree of splines (3 = quadratic)
- forecast Longer = slower

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Choice of parameters

- Knot positions
  - Allows you to specify where the knots (peaks of splines) are
  - You specify one in both the age & year dimensions
  - The rest are determined from these & dx
  - Model behaves best with knots at the last calendar year of the data

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Choice of parameters

- Do not optimise smoothing parameters ?
  - If you leave this box unchecked, the model will derive the blend between smoothness v goodness of fit
  - If you check the box, you get control over this.
- Smoothing parameters
  - Allows you to control how closely the model fits to the data (vs how much it smoothes)

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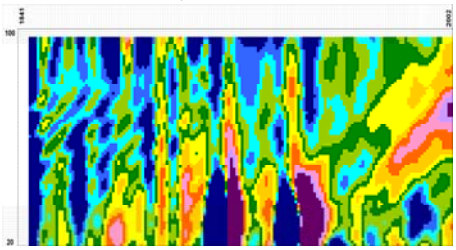
Choice of parameters (Year v Cohort)

- Consider first the past data, smoothed



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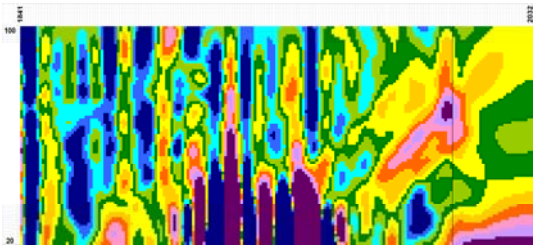
Choice of parameters (Year v Cohort)

- Age-Year seems to give a sensible fit …



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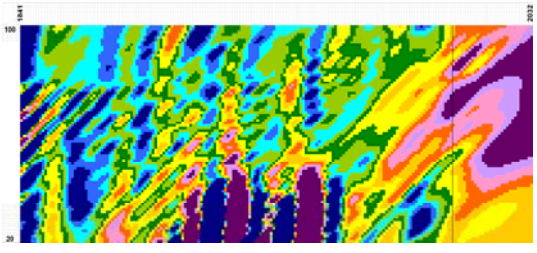
Choice of parameters (Year v Cohort)

- … Age-Cohort does not



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Which ages to use

- Clearly mortality improvements have varied hugely by age
- So it is sensible that the ages selected for our projection will impact on the answer

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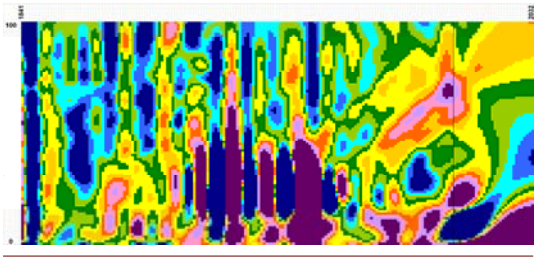
Which ages to use

Population data, ages 0 – 100 (all data)



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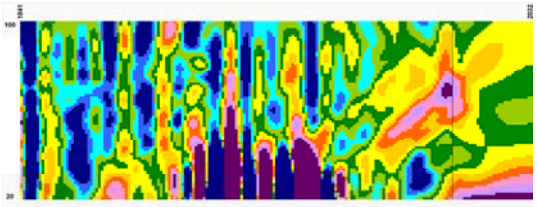
Which ages to use

Population data, ages 20 – 100



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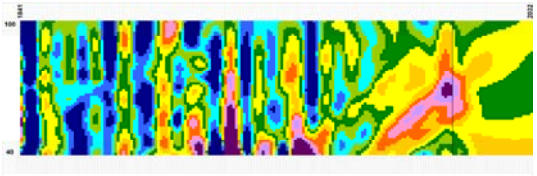
Which ages to use

Population data, ages 40 – 100



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Which ages to use

Population data, effect on annuity factors

- Male annuity factors
- at end 2005
- 100% PMA00 base table
- at 4.5%

	Popn, age range	
	age 65	age 75
0-100	13.32	9.11
20-100	13.21	9.04
40-100	13.13	8.99
Range	101.5%	101.3%

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Which calendar years to use

- Assured dataset
- Investigate choice of data
- Default parameters

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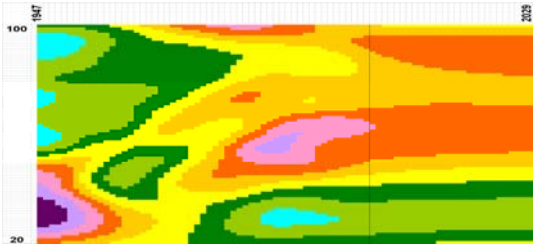
Which calendar years to use

Assured data, to 1999



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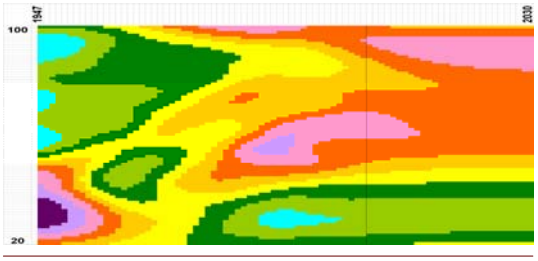
Which calendar years to use

Assured data, to 2000



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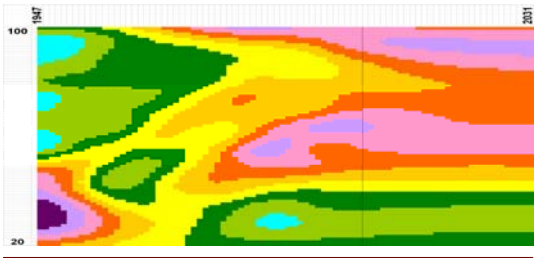
Which calendar years to use

Assured data, to 2001



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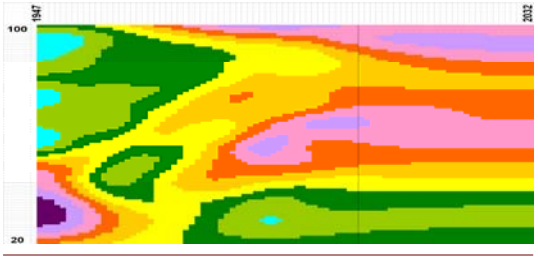
Which calendar years to use

Assured data, to 2002



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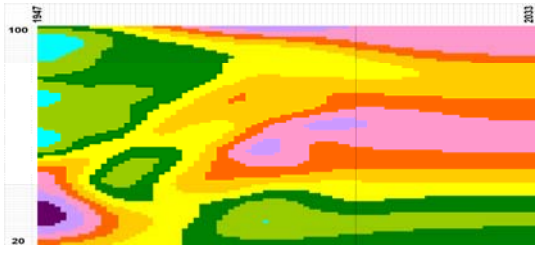
Which calendar years to use

Assured data, to 2003



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Which calendar years to use

Assured data, effect on annuity factors

- Male annuity factors
- at end 2005
- 100% PMA00 base table
- at 4.5%

	age 65	age 75
-> **1999**	13.44	9.33
-> **2000**	13.72	9.54
-> **2001**	13.85	9.63
-> **2002**	13.83	9.61
-> **2003**	13.58	9.38
Range	103.0%	103.2%

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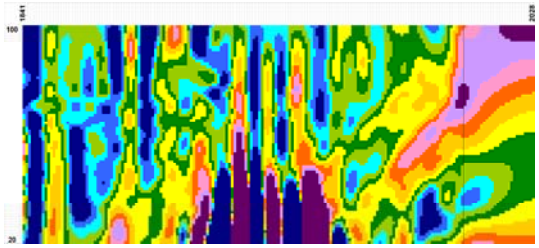
Which calendar years to use

Population data, to 1998



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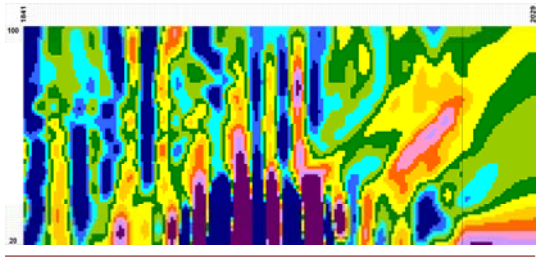
Which calendar years to use

Population data, to 1999



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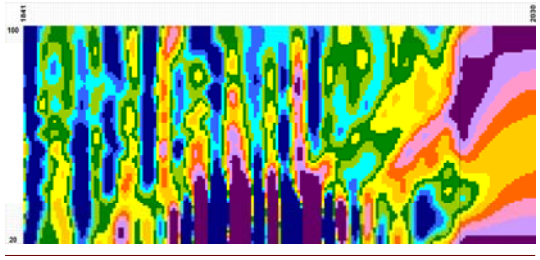
Which calendar years to use

Population data, to 2000



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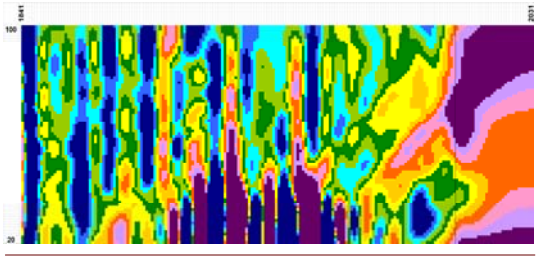
Which calendar years to use

Population data, to 2001



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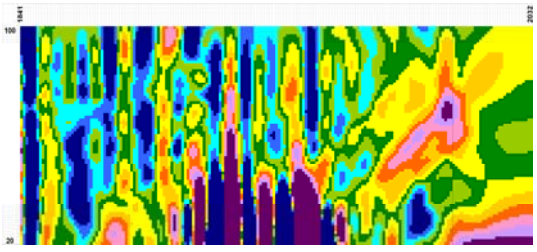
Which calendar years to use

Population data, to 2002



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Which calendar years to use

Population data, effect on annuity factors

- Male annuity factors
- at end 2005
- 100% PMA00 base table
- at 4.5%

	age 65	age 75
-> 1998	14.60	10.42
-> 1999	12.83	8.86
-> 2000	14.96	10.60
-> 2001	15.45	10.91
-> 2002	13.21	9.04
Range	120.4%	123.1%

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Problems - data distortions

- Controlled data set
- Initially with smooth qx development
- Looking at age 65 only
- Using population data (1841 – 2002)
- Graphs showing 1970+

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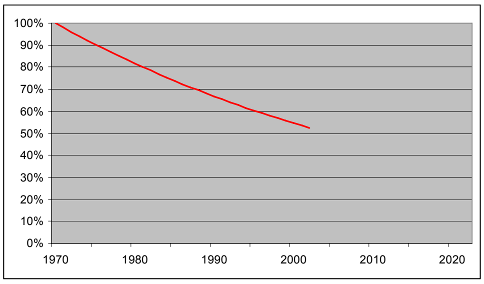
Problems - data distortions



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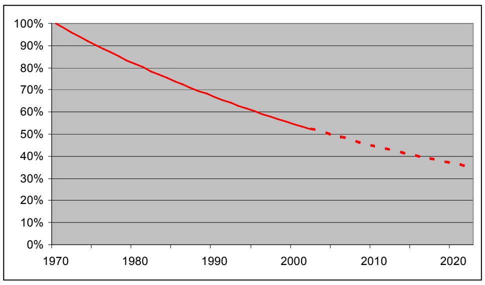
Problems - data distortions



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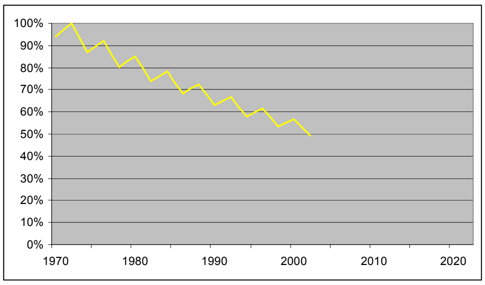
Problems - data distortions



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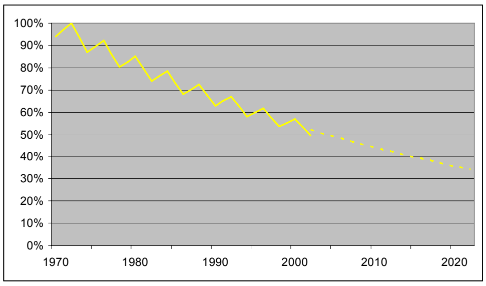
Problems - data distortions



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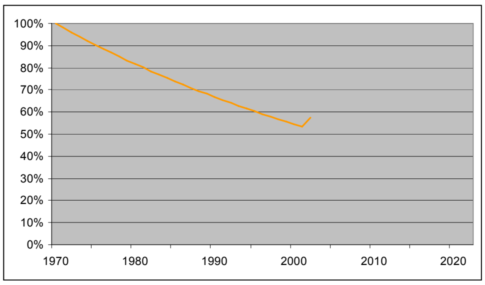
Problems - data distortions



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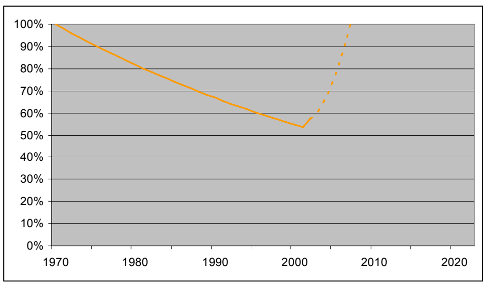
Problems - data distortions



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Validating output

- Annuity factors
- Max / min improvements (over time / ages)
- Equivalent single improvement
- Heat graphs (2-d improvements by age / year)
- Don't forget effect on in-force

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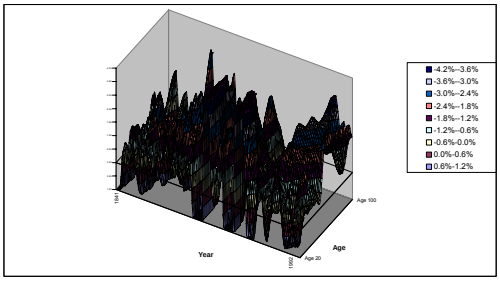
Validating output – Heat Graphs

3-d graphs are not easy to interpret !



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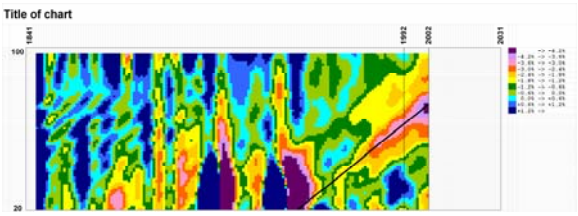
Validating output – Heat Graphs



- Above is actual past data (not fitted)
- But smoothed (Gaussian 2-d smoothing)
- Thick line is 1930 cohort

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Adjustments to output

- Minimum improvements
- Take out smoking prevalence changes in past
- Add any anticipated future changes
- Convert to annuitant improvements
- Over age 100

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Derivation of capital

- Model produces mean μ but also σ(μ)
- Hence estimate “trend risk”
- But capital required for
  - Trend risk
  - Volatility
  - Miss-pricing risk
  - (Catastrophe)
  - Other capital constituents (ALM, operational)

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Derivation of capital

- Model looks at σ of the fitted μ - NOT the raw μ
- So changing smoothing parameters changes σ
- Two projections can give largely similar future μ
- … but very different implied capital

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Derivation of capital

- For example,
  - Population dataset,
  - Years 1841 – 2002, ages 20-100

		Smoothing parameters (age/year)	
		50/15	500/150
Age 65	mean	13.67	13.70
	99.50%	14.18	13.88
	capital %	3.7%	1.3%
Age 75	mean	11.71	11.74
	99.50%	12.18	11.90
	capital %	4.0%	1.4%

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Practical experiences of using CMI models for projecting annuitant mortality

Niel Daniels, XL Re