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## Towards an Industry Standard to Assess Longevity Basis Risk

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### Where the project came from

#### Longevity Basis Risk Working Group



Life &  
Longevity  
Markets Association



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- Formed in Dec 2011
- Focused on market-friendly means of analysing basis risk
- ITT to sponsor in-depth yet practical research in Feb 2013

#### Joint Research Group



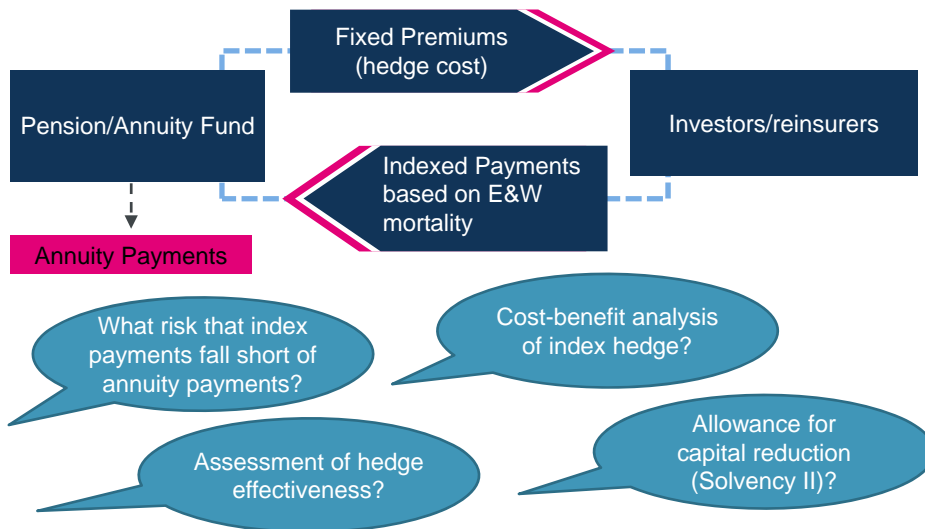
Cass Business School  
CITY UNIVERSITY LONDON

HYMANS ROBERTSON  
The Spirit of Independence

- Sponsored by LBRWG following selection process
- Formally appointed Oct 2013
- Output will be made publicly available



## Introduction: The Basis Risk Question



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## Longevity Basis Risk Working Group

What is LBRWG trying to achieve through sponsoring this project?



- The biggest challenge is how to model the demographic risk.
- Given the typical inputs for a pension scheme or annuity book:

Pre- Hedge Overlay
Target Population Size – Number of individuals
Target Population Annuity/Pension Amounts
Geographic location
Historical mortality experience information if available

- How do we simulate the two populations? (Hedge and portfolio)
- How are their mortality diffusions related?
- If  $\mu_R(x, t)$  is the force of mortality for E&W, we need to generate  $\mu_B(x, t)$  (mortality for the pool). What form should  $\mu_B(x, t)$  take?

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## Joint Research Group

How is it tackling the project?



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The Spirit of Independence

- Review existing research on different trends (and baseline) for various sub-populations
  - Extend trend research (multivariate analysis)
- } Understand past dynamics  
- informs choice / structure of model
- 
- Review existing models
  - Criteria for “good model”
  - Review models vs criteria
- } Propose a practical (stochastic) model for multiple populations  
- including example parameterisation

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## Trends (and baseline) for sub-populations

Expertise  
Sponsorship  
Thought leadership  
Progress  
Community  
Sessional Meetings  
Education  
Working parties  
Volunteering  
Research  
Shaping the future  
Networking  
Professional support  
Enterprise and risk  
Learned society  
Opportunity  
International profile  
Journals  
Support

## Wide variations in baseline longevity

### Widely known

Geographical <sup>1</sup>	Glasgow city 14.3	Kensington and Chelsea 24.4
Social Class <sup>2</sup>	Routine & Manual 15.8	Higher Managerial 18.8
Deprivation <sup>3</sup>	Most Deprived 15.7	Least Deprived 19.8
Gender <sup>1</sup>	Male 18.0	Female 20.6

Source: <sup>1</sup>Life expectancy at birth and at age 65 by local areas in the United Kingdom, 2004-06 to 2008-10 (ONS, 2011); <sup>2</sup>ONS Longitudinal Study (Johnson, 2011); <sup>3</sup>Inequality in Disability-Free Life Expectancy by Area Deprivation: England, 2003-06 and 2007-10 (ONS, 2013)

Variation in life expectancy from age 65 can be as high as 10 years

### Annuitant specific (Club Vita)



Lifestyle +4 years

Affluence +4 years

Ret health

+2 years  
(normal vs. ill health retiree)

Job

<1 year  
(manual vs. non-manual job)

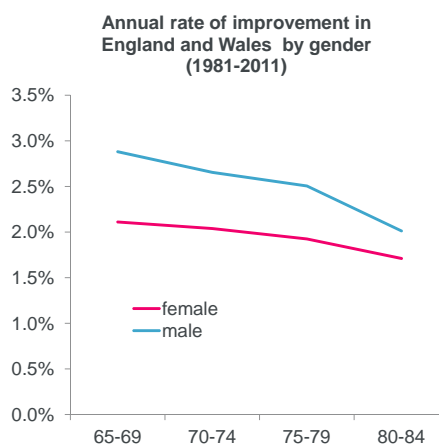
Attribution of 10 years difference in period life expectancy from age 65

Wide variation in life expectancy, but well understood by industry practitioners

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## Clear differences in improvements (1)

- Gender
- Deprivation
- NS-SEC



Source: Own calculations based on HMD data

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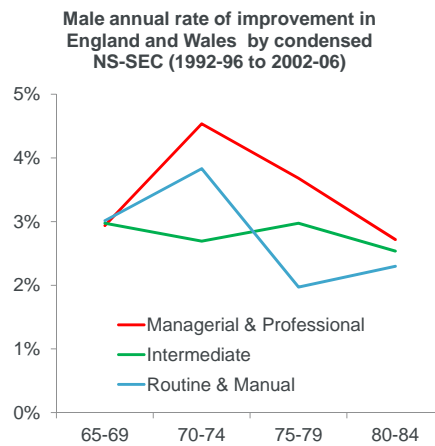


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## Recent improvements – a more complex picture

- Gender
- Deprivation
- NS-SEC



Source: ONS Longitudinal Study - Own calculations based on ONS. (2013)

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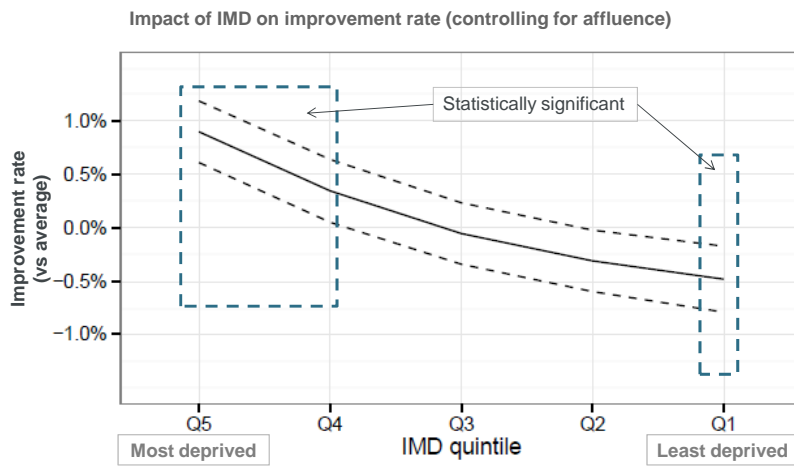
## Key predictors of historic improvements (GLM analysis of improvements using Club vita data for men)

Predictor	How predictive?
Postcode – IMD	
Pension amount	
Salary	
Postcode – lifestyle factors	
Occupation	

Postcode (IMD) and pension are key predictors of mortality trends

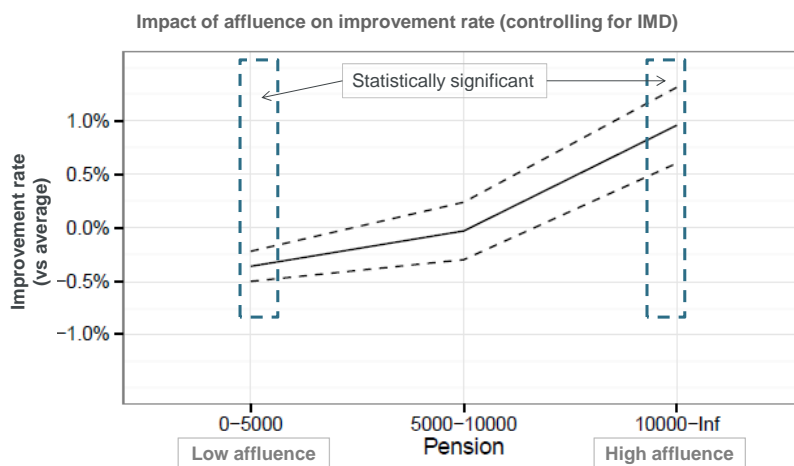
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## Improvements by postcode (IMD)



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## Improvements affluence

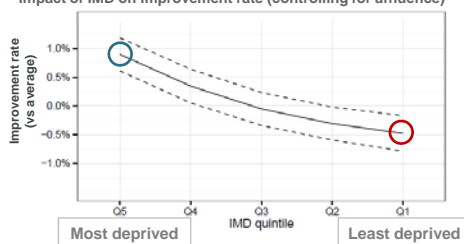


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## Improvements by postcode and affluence

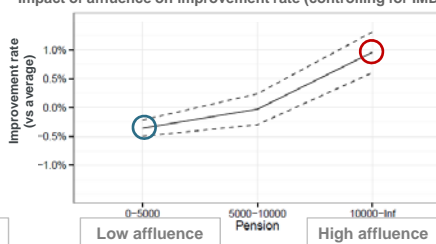
### Postcode

Impact of IMD on improvement rate (controlling for affluence)



### Affluence

Impact of affluence on improvement rate (controlling for IMD)

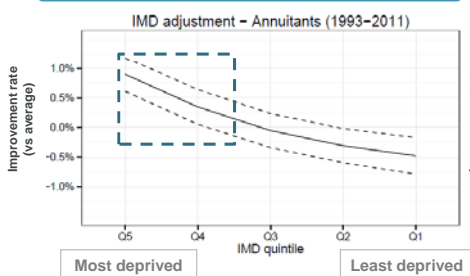


- Low improvements for low affluence are more than offset by high improvements for 'not so nice' postcodes. Combination may be typical of lower SECs
- High improvements for high affluence more than offsets the low improvements for 'very nice' postcodes. Combination may be typical of higher SECs

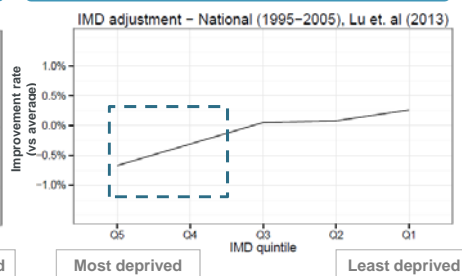
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## The deprivation paradox

### Improvements by IMD (annuitant)



### Improvements by IMD (national)



- **Select effect:** Annuitants are likely to differ from the average person in their area, particularly in most deprived quintiles

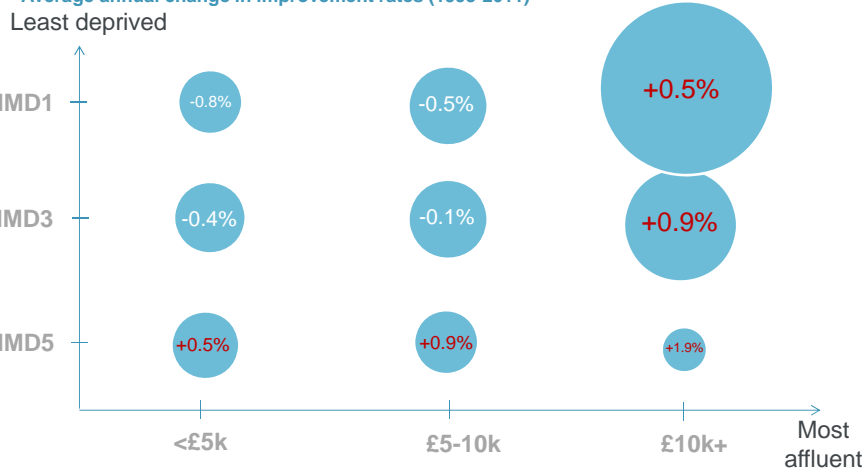
Models calibrated to national IMD data could be misleading in the management of annuitant basis risk

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## Material impact of basis risk

Average annual change in improvement rates (1993-2011)



Over last 18 years 'middle England' saw mortality improve by 42%  
The range across annuitants was between 30% and 60%

Different circle sizes refer to relative amount of pension for each socio-economic group.

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## Key conclusions from research on trends

- Difference by SEC
  - Material differences in trends by SEC – as big as impact of gender
- Key predictors
  - IMD (via postcode) has strongest link to past improvements.
  - Pension has second strongest link.
- Deprivation paradox
  - IMD effect very different to that in whole population (selection effect).
  - Should not parameterise using whole UK IMD data.
- Basis risk matters
  - IMD / pension combination has big impact on improvements
  - 20% to 40% improvement per decade, vs. 26% average UK.

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## Towards a Multi-population model

Expertise  
Sponsorship  
Thought leadership  
Progress  
Community  
Sessional Meetings  
Education  
Working parties  
Volunteering  
Research  
Shaping the future  
Networking  
Professional support  
Enterprise and risk  
Learned society  
Opportunity  
International profile  
Journals  
Support

### Initial analysis of choice of model

What risk that index payments fall short of annuity payments?

Assessment of hedge effectiveness?

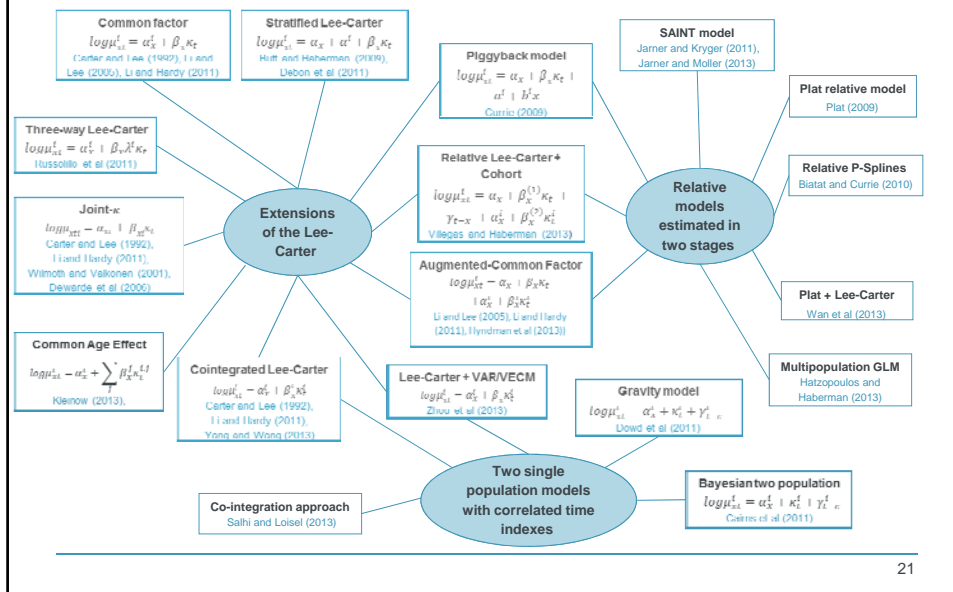
Cost-benefit analysis of index hedge?

Allowance for capital reduction (Solvency II)?

#### Narrowing down the (long) list of possible models

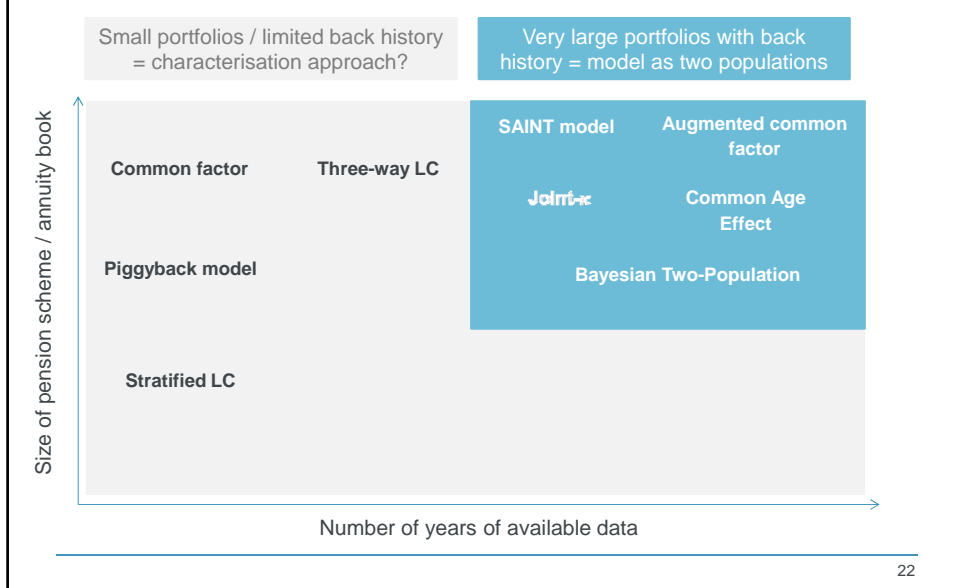
- To answer key questions requires a model
- Huge selection to choose from
- Define criteria for “good” **practical** model
- Review existing models vs. those criteria
  - Work in progress!
  - Example included today

## The landscape of two-population models



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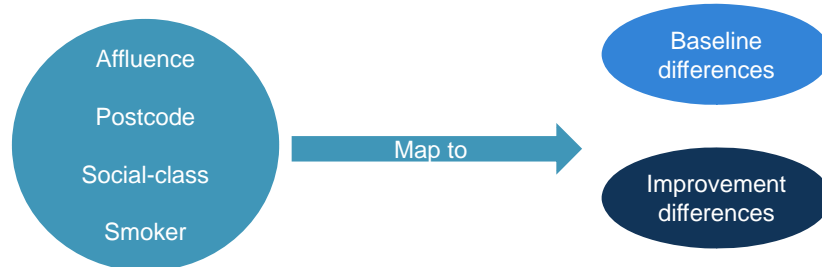
## Developing a practical framework



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## Characterisation approach

- For small pension schemes or schemes with short mortality experience could derive estimates of population mortality based upon
  - the characteristics of members
  - framework applied to larger populations with same characteristics



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## Assessment criteria for single population models

CMI Working paper 25, Cairns et al. (2008, 2009), Haberman and Renshaw (2011)

### Practical

- Ease of implementation
- Transparency
- Simple (Parsimony)

### Central estimates (Deterministic)

- Cohort effect
- Goodness of fit of rates
- Reasonable central projection of rates

### Risk assessment (Stochastic)

- Generate sample paths
- Reasonable forecast levels of uncertainty of rates
- Incorporate parameter uncertainty in simulations
- Non-perfect correlations between year on year changes in mortality at different ages

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## Assessment criteria for two population models

Practical	
<ul style="list-style-type: none"> <li>Ease of implementation</li> <li>Compatible with available data</li> <li>Handle portfolio heterogeneity</li> </ul>	<ul style="list-style-type: none"> <li>Transparency</li> <li>Simple (Parsimony)</li> <li>Disentangle baseline and improvement differences</li> </ul>
Central estimates (Deterministic)	Risk assessment (Stochastic)
<ul style="list-style-type: none"> <li>Cohort effect</li> <li>Goodness of fit of rates and rate differences</li> <li>Reasonable central projection of rates and rate differences</li> </ul>	<ul style="list-style-type: none"> <li>Generate sample paths</li> <li>Reasonable forecast levels of uncertainty of rates and rate differences</li> <li>Incorporate parameter uncertainty in simulations</li> <li>Non-perfect correlations between year on year changes in mortality at different ages</li> <li>Non-perfect correlations between mortality rates in the two populations</li> </ul>

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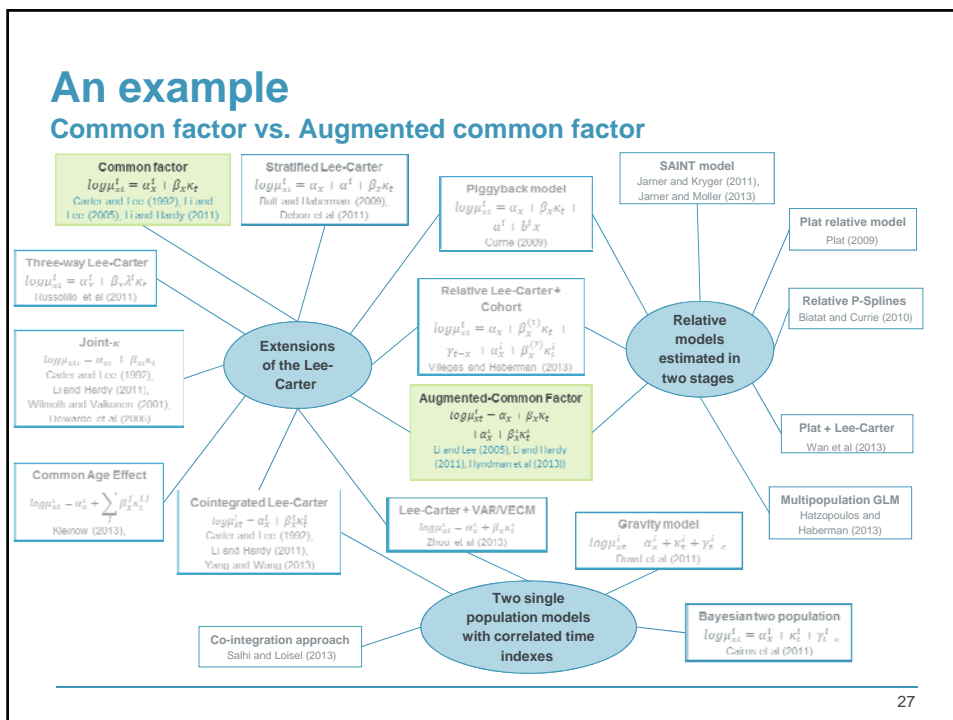
## High level critique of existing models

- Practical vs. Risk Assessment:**
  - Some models imply perfect correlations so will materially underestimate basis risk and so overestimate hedge effectiveness (e.g. common factor, joint- $\kappa$ )
  - Models with non-perfect correlations tend to require a lot of data or are less transparent / easy to use (e.g. augmented common factor, Bayesian 2 populations)
- Central Estimates?:**
  - Models often assume convergence in improvement rates which are inconsistent with historic observations (e.g. common factor, joint- $\kappa$ )
- Practical?:**
  - Models as originally stated do not allow explicitly for covariates to

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## An example

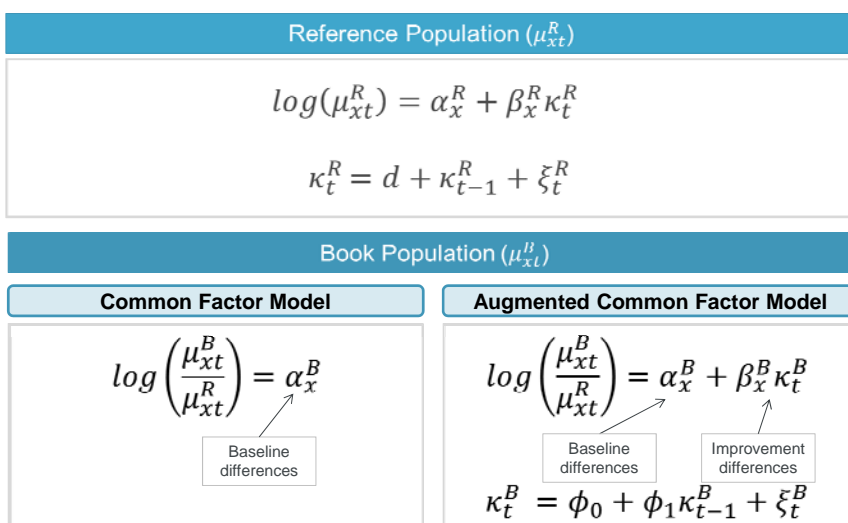
### Common factor vs. Augmented common factor



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## An example

### Common factor vs. Augmented common factor



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## An example

### England and Wales (Reference) vs. Club Vita (Book)

#### Common Factor Model

$$\log \left( \frac{\mu_{xt}^B}{\mu_{xt}^R} \right) = \alpha_x^B$$

- **Practical?** Simpler model
- **Practical?** Does not require a long experience, but a relatively big book size
- **Single population central estimates?**  
Reasonable performance
- **Single population risk assessment?**  
Reasonable performance

#### Augmented Common Factor Model

$$\log \left( \frac{\mu_{xt}^B}{\mu_{xt}^R} \right) = \alpha_x^B + \beta_x^B \kappa_t^B$$

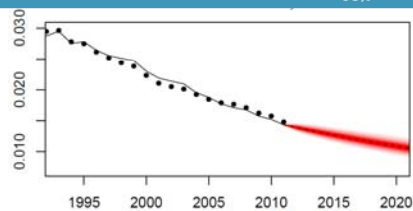
- **Practical?** More complicated model
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## Two examples

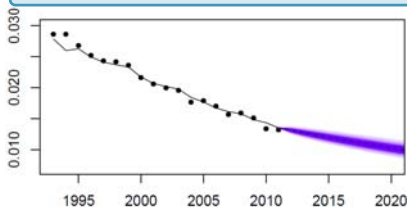
### England and Wales (Reference) vs. Club Vita (Book)

#### Reference Population ( $\mu_{65,t}^R$ )

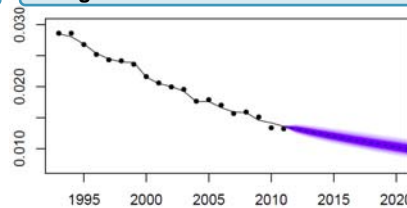


#### Book Population ( $\mu_{65,t}^B$ )

##### Common Factor Model



##### Augmented Common Factor Model



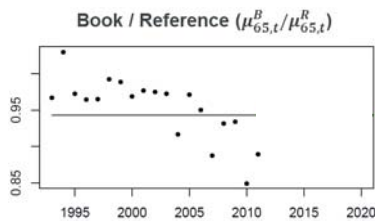
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## Two examples

### England and Wales (Reference) vs. Club Vita (Book)

#### Common Factor Model

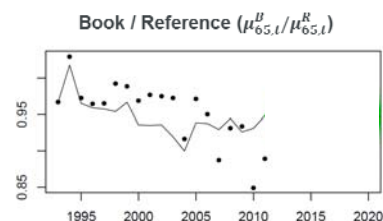
$$\log \left( \frac{\mu_{xt}^B}{\mu_{xt}^R} \right) = \alpha_x^B$$



- **Two population central estimates?**  
Assumes a constant mortality ratio between reference and book
- **Two population risk assessment?:**  
Assumes a perfect correlation between the populations
- **Conclusion:** Non-adequate for basis risk assessment

#### Augmented Common Factor Model

$$\log \left( \frac{\mu_{xt}^B}{\mu_{xt}^R} \right) = \alpha_x^B + \beta_x^B \kappa_t^B$$



- **Two population central estimates?** Does not assume a constant mortality ratio between reference and book
- **Two population risk assessment?:** Does not assume a perfect correlation between the populations
- **Conclusion:** Better performance for basis risk assessment but still unsatisfactory

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## Where we are now – and what's next

- ✓ Review existing research on different trends (and baseline) for various sub-populations
- ✓ Extend trend research (multivariate analysis)
- ✓ Understand past dynamics - informs choice / structure of model
- ✓ Review landscape of existing models
- ✓ Define criteria for "good model"
- Review models vs. criteria – shortlist possibles
- Fit possible models – select / extend preferred approach(es)
- Collate strengths & weaknesses / practical considerations of preferred approach(es)
- Publish model(s), including example parameterisation

Look out for these results next year!

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**Thank you**  
**Any questions?**