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New Developments in Longevity Risk Transfer Market – Assessing Basis Risk for Longevity Transactions

Jackie Li PhD (Melb), PhD (Macq), FIAA

Macquarie University

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Assessing Basis Risk for Longevity Transactions – Phase 2

- This research has been co-funded by Institute and Faculty of Actuaries (IFoA) and Life & Longevity Markets Association (LLMA), UK.
- Guidance has been provided by Longevity Basis Risk Working Group (LBRWG), comprising members from both associations.
- This research has been undertaken by Macquarie University with a support from Mercer.
- The final reports can be downloaded from the IFoA website: https://www.actuaries.org.uk/learn-and-develop/research-and-knowledge/actuarial-research-centre-arc/commissioned-projects/longevity-basis-risk

Principal Researchers

Jackie Li
Department of Actuarial Studies and Business Analytics
Macquarie University

Leonie Tickle
Department of Actuarial Studies and Business Analytics
Macquarie University

Chong It Tan
Department of Actuarial Studies and Business Analytics
Macquarie University

Johnny Siu-Hang Li
Department of Statistics and Actuarial Science
University of Waterloo

The Impact of Model Uncertainty on Index-based Longevity Hedging

- This research has been sponsored by Insurance Risk and Finance Research Centre (IRFRC), Nanyang Business School (NBS), Singapore, and global reinsurer SCOR.
- Feedback has been provided by representatives from SCOR.
- More information can be found in the IRFRC website: http://irfrc.ntu.edu.sg/Research/Pages/Longevity-Risk.aspx

Insurance Risk and Finance Research Centre

Nanyang Business School

Principal Researchers

Uditha Balasooriya
Division of Banking and Finance
Nanyang Technological University, Singapore

Jackie Li
Department of Actuarial Studies and Business Analytics
Macquarie University, Australia

Johnny Siu-Hang Li
Department of Statistics and Actuarial Science
University of Waterloo, Canada

Longevity Risk

- continual decline in mortality is a global phenomenon
- improved nutrition, hygiene, medical technology, health care, lifestyle are contributing factors
- there exists longevity risk that pension funds / annuity portfolios may pay out more than expected
- *systematic* longevity risk cannot be diversified by pooling
- insurance companies / governments are cautious about taking too much longevity risk

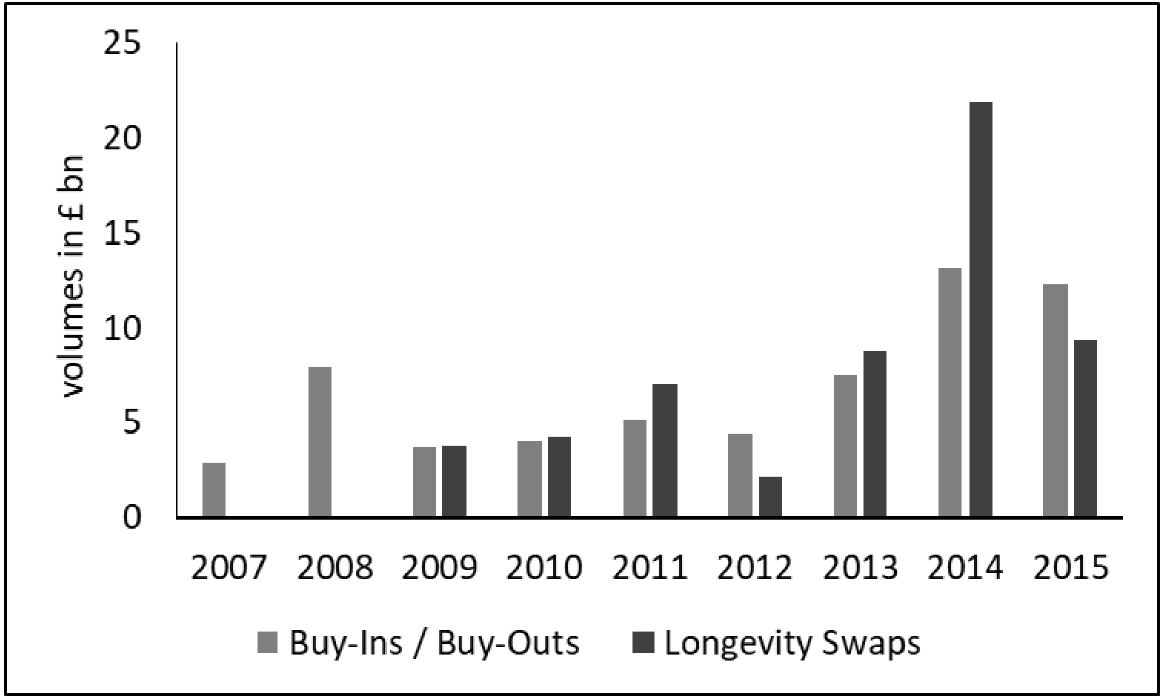
Managing Longevity Risk

- *traditional reinsurance* allows insurers to transfer longevity risk to reinsurers, but reinsurers often have limited appetite
- *natural hedging* exploits the opposite movements between the values of annuities and life insurances, but it is feasible only for certain large insurance companies
- *capital market solutions* are recently proposed and tested, such as insurance securitisation, longevity-linked / mortality-linked securities / derivatives
- market investors may be interested to diversify across an arguably uncorrelated market sector

Life Market

- Life and Longevity Markets Association (LLMA) was established in 2010 in UK
- members include several global insurers, investment banks
- LLMA promotes the development of a liquid ‘life market’
- longevity-linked / mortality-linked securities / liabilities could readily be traded amongst insurers, reinsurers, investors
- it is still in its infancy stage, far from reaching its full potential in providing diversification opportunities, enhancing market efficiency

Trading Volumes from 2007 to 2015 in UK



Capital Market Solutions

- *bespoke transactions* are tailored to individual circumstances, such as pension buy-ins, buy-outs, longevity swaps
- *index-based solutions* are constructed such that cashflows are linked to selected mortality indices
- *standardised* products based on well-specified mortality indices could draw investors' interest and develop market liquidity
- one notable example is €12bn longevity swap offered by Deutsche Bank to Dutch insurer Aegon in 2012, in which Dutch population was taken as an index and entire trade was targeted at capital market investors

Index-based Longevity Hedging

- index-based hedges have considerable potential to provide effective risk / capital management
- e.g. longevity bond, *q*-forward, longevity swap, mortality option, which are linked to the mortality of a *reference* population
- there is mismatch between the reference population and the portfolio to be hedged (*book* population)
- *longevity basis risk* includes *demographic* basis risk, *sampling* basis risk, *structural* basis risk
- difficulty in quantifying this risk is perceived to be one major obstacle to more widespread use of index-based hedges

Longevity Basis Risk

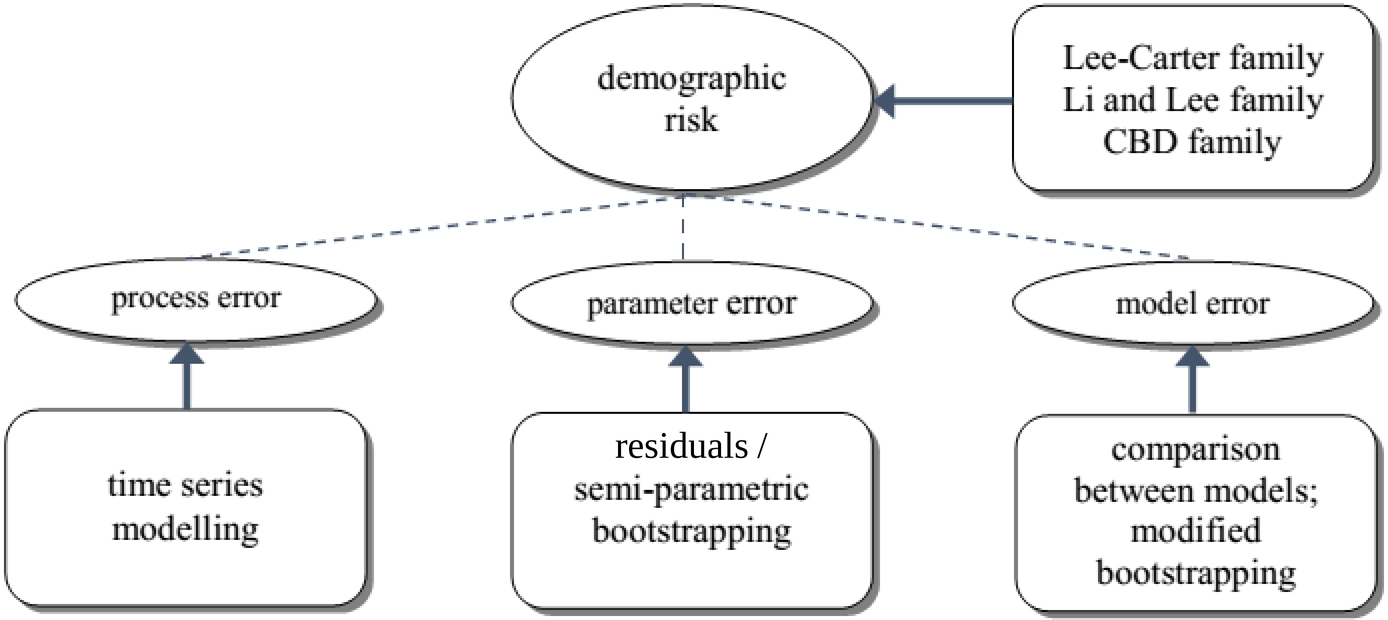
Pension Fund

Book Population

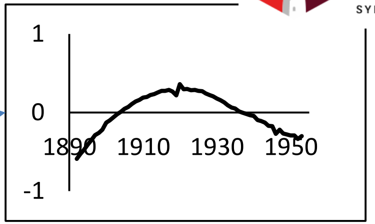
Hedging Instrument

Reference Population

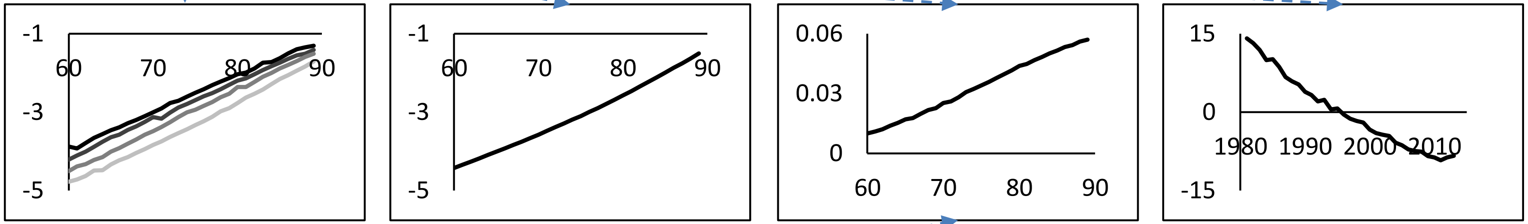
Modelling Demographic Basis Risk



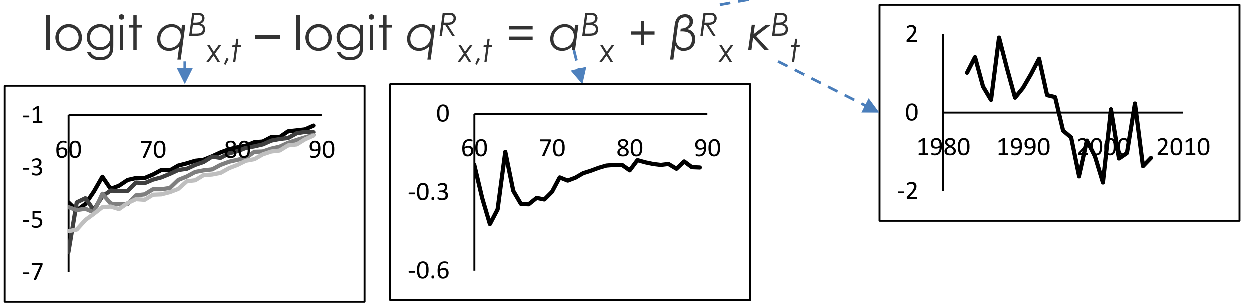
CAE+Cohorts Model



$$\text{logit } q^R_{x,t} = \alpha^R_x + \beta^R_x \kappa^R_t + \gamma^R_{t-x}$$



$$\text{logit } q^B_{x,t} - \text{logit } q^R_{x,t} = \alpha^B_x + \beta^R_x \kappa^B_t$$



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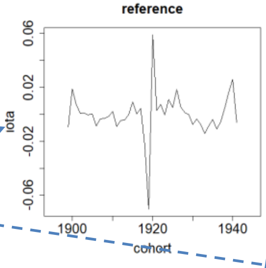
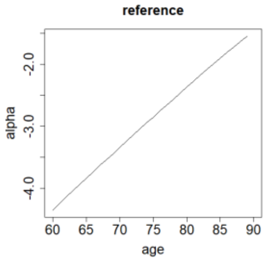
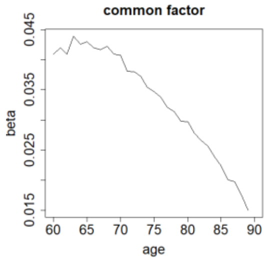
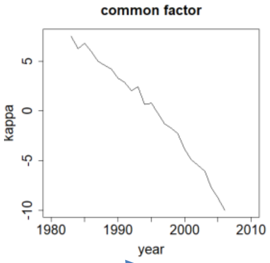
Li-Lee Model

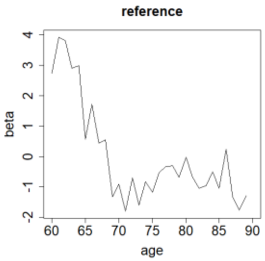
$$\text{logit}\ m^R_{x,t} = \alpha^R_x + \beta^C_x \kappa^C_t + \textstyle\sum_j \beta^R_{x,j} \kappa^R_{t,j} + \gamma^R_{t-x}$$

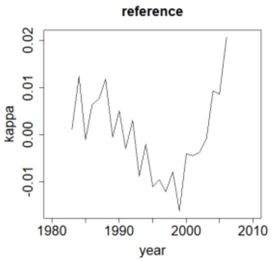




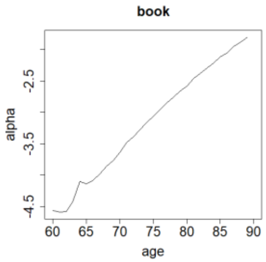


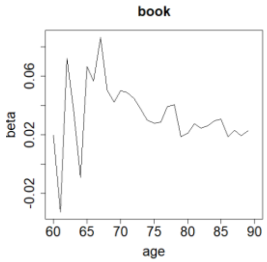


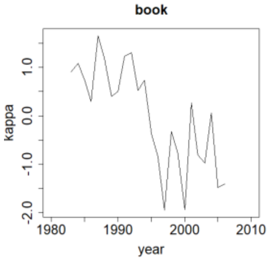


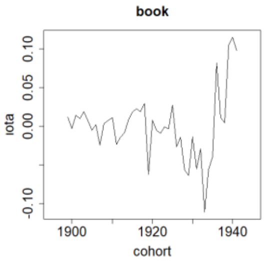


$$\text{logit}\ m^B_{x,t} = \alpha^B_x + \beta^C_x \kappa^C_t + \textstyle\sum_j \beta^B_{x,j} \kappa^B_{t,j} + \gamma^B_{t-x}$$

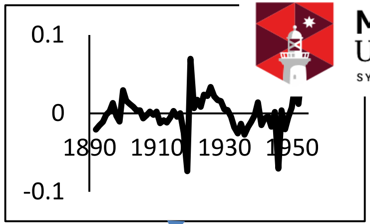




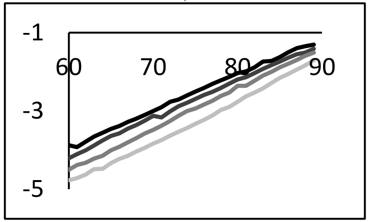


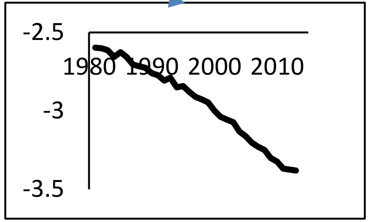


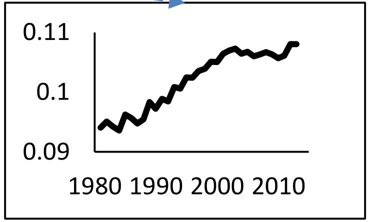
M7-M5 Model

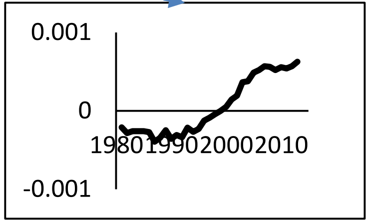


$$\text{logit}\, q^R_{x,t} = \kappa^R_{t,1} + (x-\bar{x})\,\kappa^R_{t,2} + ((x-\bar{x})^2 - \sigma^2_x)\,\kappa^R_{t,3} + \gamma^R_{t-x}$$

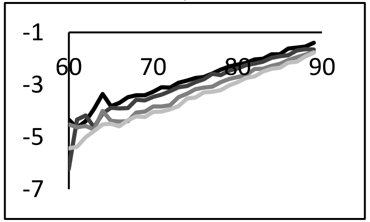


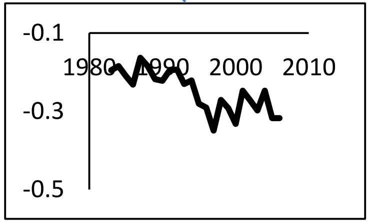


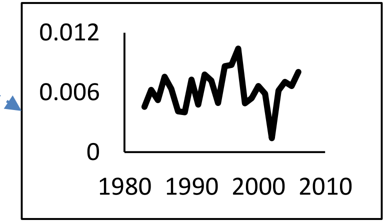




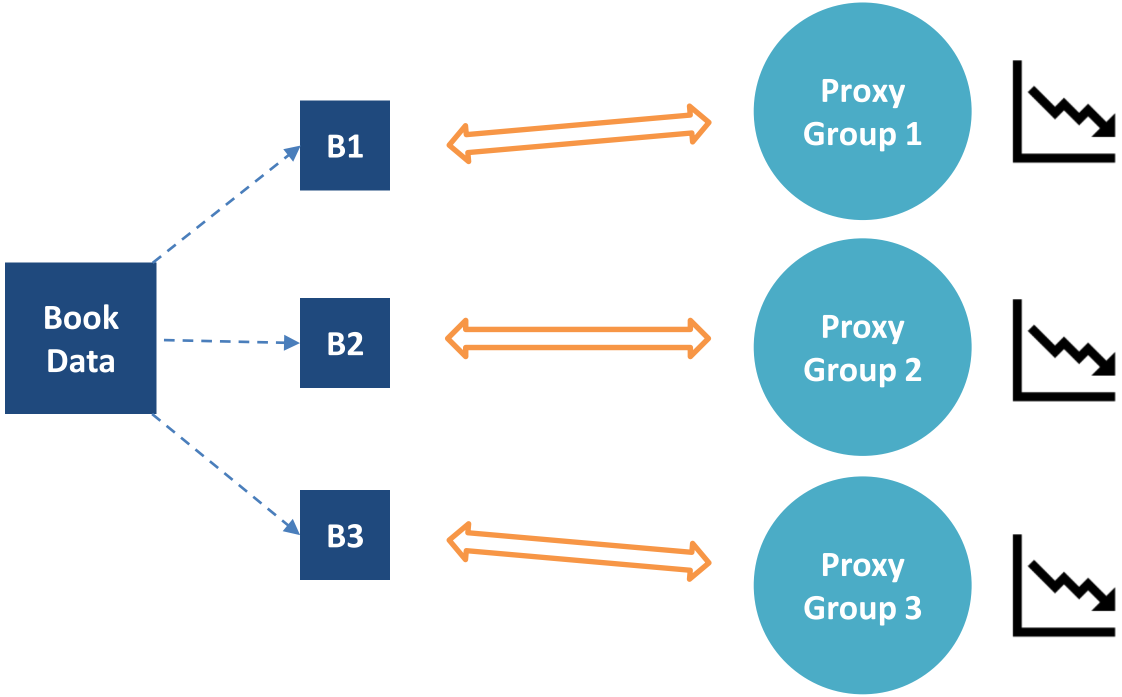
$$\text{logit}\, q^B_{x,t} - \text{logit}\, q^R_{x,t} = \kappa^B_{t,1} + (x-\bar{x})\,\kappa^B_{t,2}$$



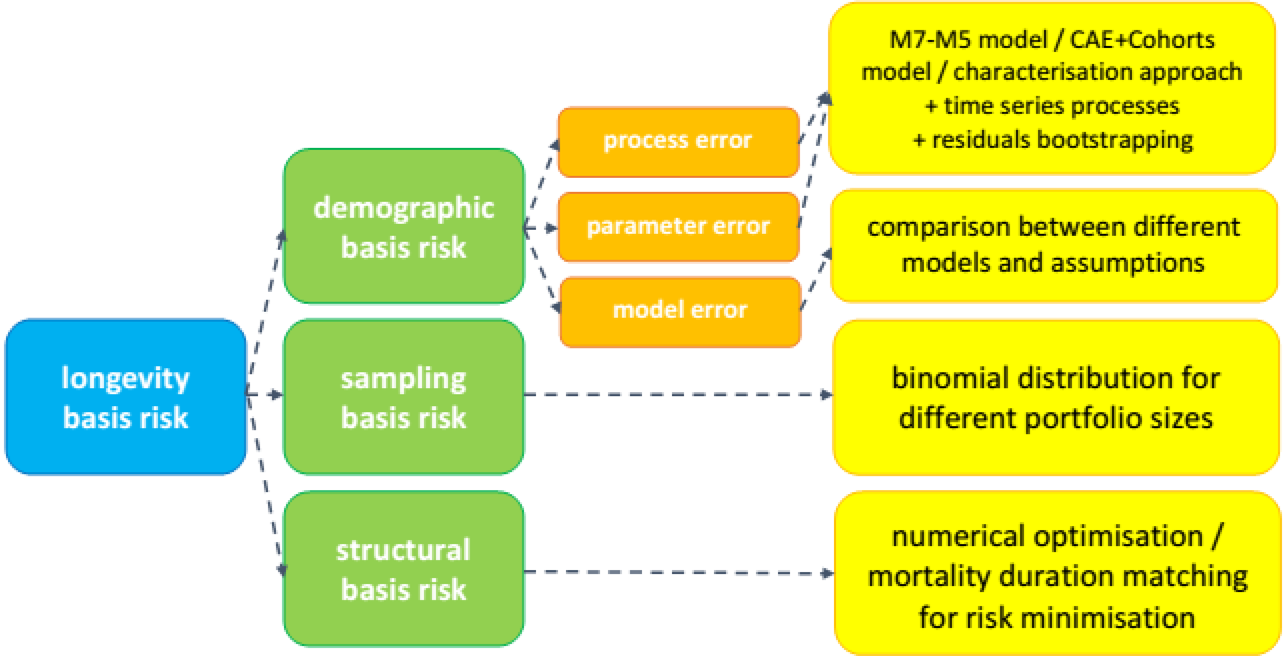




Characterisation Approach



Modelling Longevity Basis Risk



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Data Sources

Institute and Faculty of Actuaries

Continuous Mortality Investigation

Office for National Statistics

MERCER

The Human Mortality Database

Vladimir Shkolnikov, *Director*	Max Planck Institute for Demographic Research
Magali Barbieri, *Associate Director*	University of California, Berkeley and INED, Paris
John Wilmoth, *Founding Director*	United Nations and formerly University of California, Berkeley

Index-based Hedging – Hypothetical Example

all pensioners / annuitants aged 65 now

$1 p.a. on survival from 66 to 90

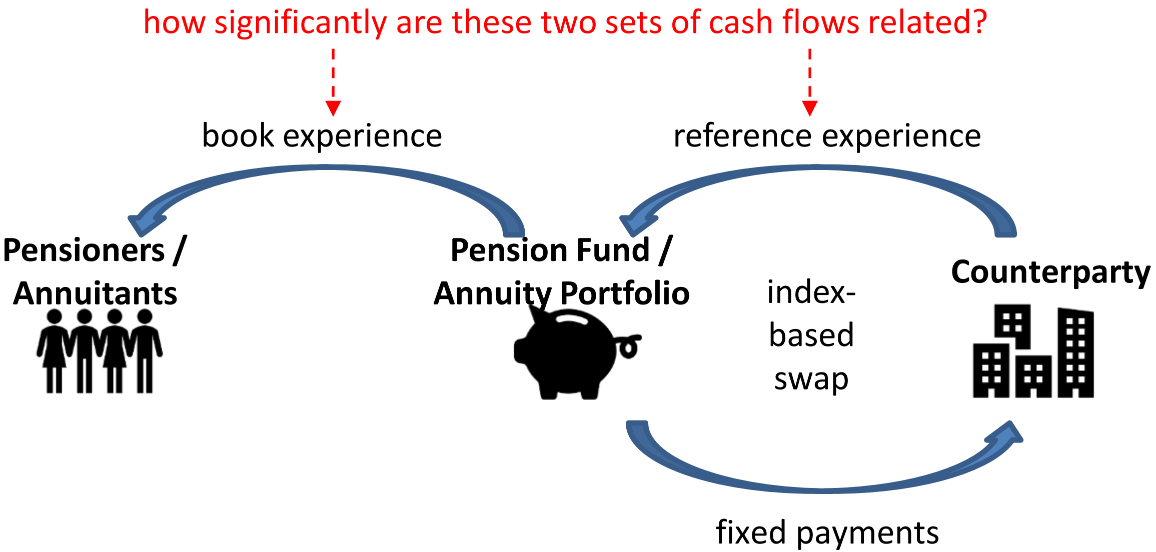
pension plan / annuity portfolio closed

hedged by 25-year index-based longevity swap

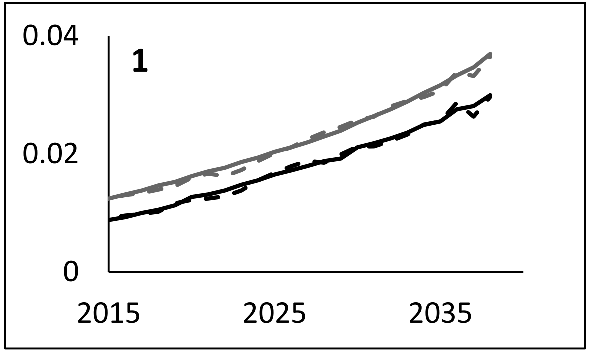
calibration based on simulated scenarios

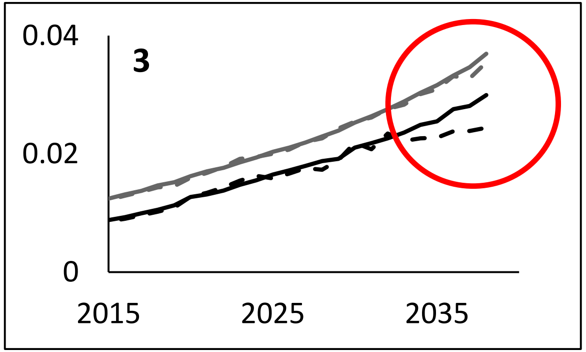
flat interest rate 1% p.a.

Index-Based Longevity Swap



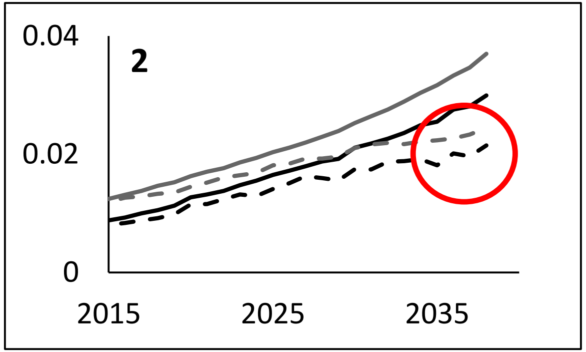
Future Book vs Reference Mortality Rates



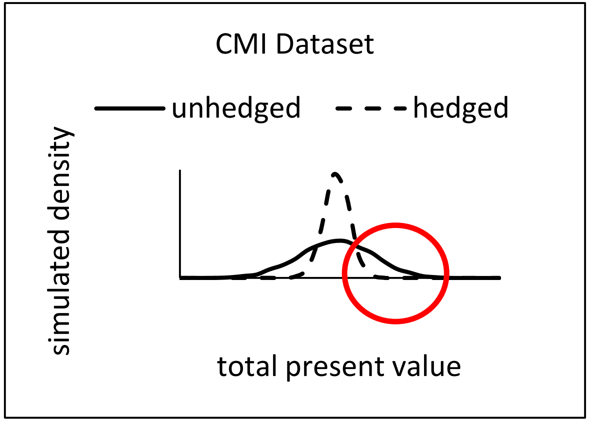


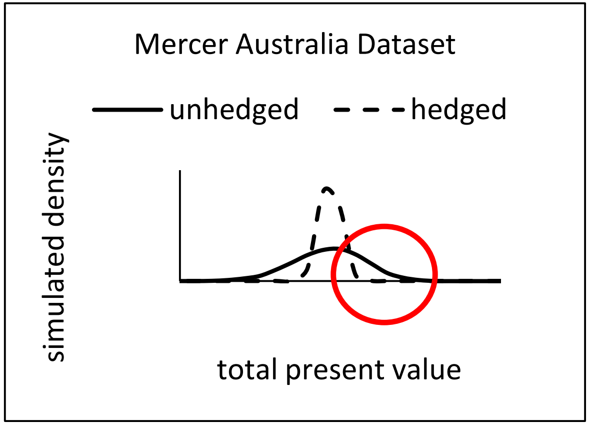
black – book cohort aged 65 now
grey – reference cohort aged 65 now

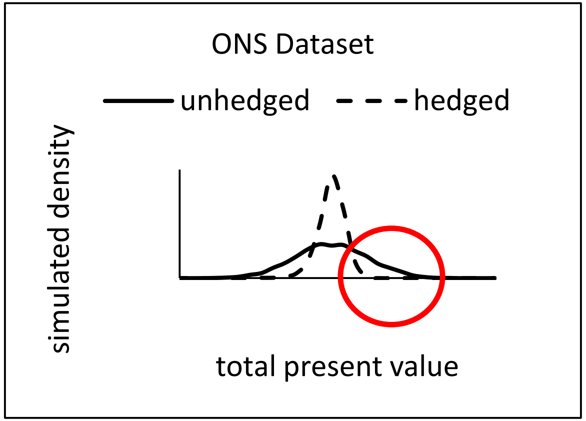
[solid lines : best estimates
dashed lines : simulated values]



Hedge Effectiveness

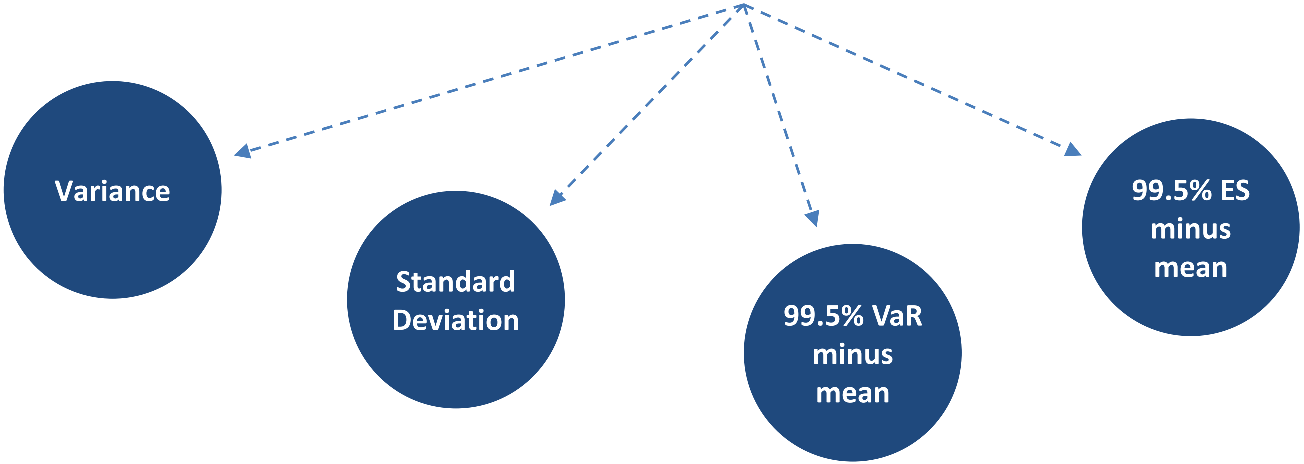






Risk Metric

$$\text{longevity risk reduction} = \left(1 - \frac{\text{risk(hedged)}}{\text{risk(unhedged)}}\right) \times 100\%$$



Maximum Longevity Risk Reduction

We have some sampling basis risk…

risk reduction = 50% - 80%

We have a lot of sampling basis risk !

risk reduction < 50%

Sensitivity Analysis (Settings & Assumptions)

- size of pension plan or annuity portfolio
- assumed coherence property
- data characteristics
- type of hedging instrument
- simulation method
- structural mortality changes

Sensitivity Analysis (Time Series Processes)

- limited book data length
- bounded future variability of ‘book minus reference’ component
- assumed pace of reaching coherence
- other correlation assumptions

Summary (Qualitative Assessment)

Does the plan have 20,000+ members?

Yes! Got 50 points.

Are book and reference very related?

Quite…6 out of 10 I think.

Is it fast to reach coherence?

Average, say, 5 points.

Would potential structural changes affect both book and reference the same way?

Maybe…I would give 4.

It looks like 65% of risk is hedged!

Summary (Rule-of-Thumb)

$$\begin{aligned}&\text{longevity risk reduction}\\&= -0.0303 + 0.0644x_1 + 0.0553x_2 - 0.0784x_3 - 0.8120x_4 - 0.1662x_5\\&\quad + 0.0006x_6 + 0.0219x_7 + 0.1204x_8 + 0.1217x_9 - 0.0762x_{10}\end{aligned}$$

x_1 : log size	x_2 : book vs reference	x_3 : hedging scheme	x_4 : interest rate	x_5 : swaps or q-forwards
x_6 : M7-M5	x_7 : CAE +Cohorts	x_8 : simulation method	x_9 : structural changes	x_{10} : AR order

Natural Hedging – Hypothetical Example
Li and Haberman (2015)

life annuity at age 65 vs life insurance at age 35

$1,400 p.a. on survival vs $100,000 on death

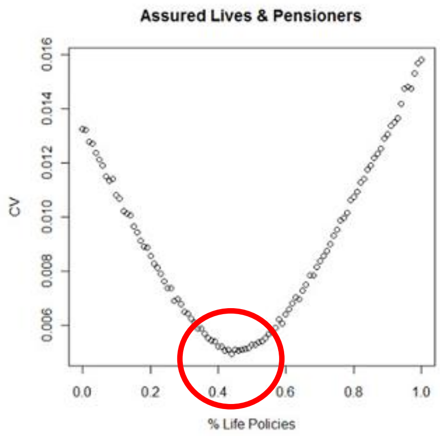
100,000 policies between annuity and life insurance

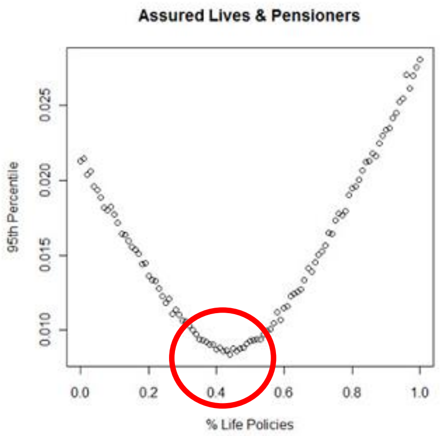
weight of life policies from 0%, 1%, 2%, … to 100%

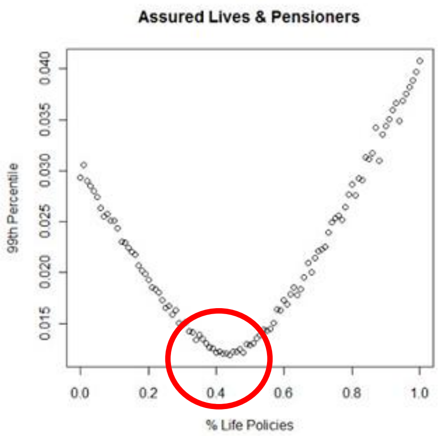
analysis based on simulated scenarios

flat interest rate 3% p.a.

Hedge Effectiveness

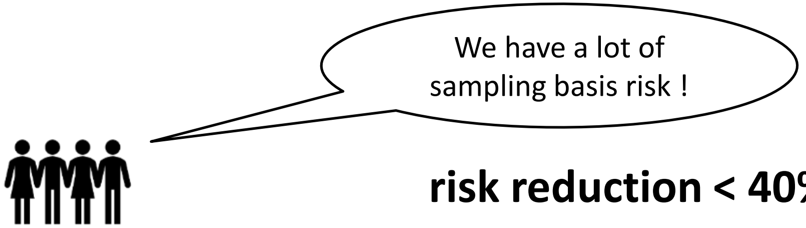






Maximum Longevity Risk Reduction

risk reduction = 40% - 70%



risk reduction < 40%

Next Step

further test more data, models, scenarios for potential capital savings

communicate results with insurers, banks, regulators, clients

standardise key factors that drive longevity basis risk

investigate dynamic hedging and market pricing of longevity risk

Questions

Comments