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Mortality derivatives for hedging longevity risk

Stephen Richards
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1. Options for hedging longevity risk

- Asset transfer
- Longevity swap
- Index-based derivatives

2. Derivatives

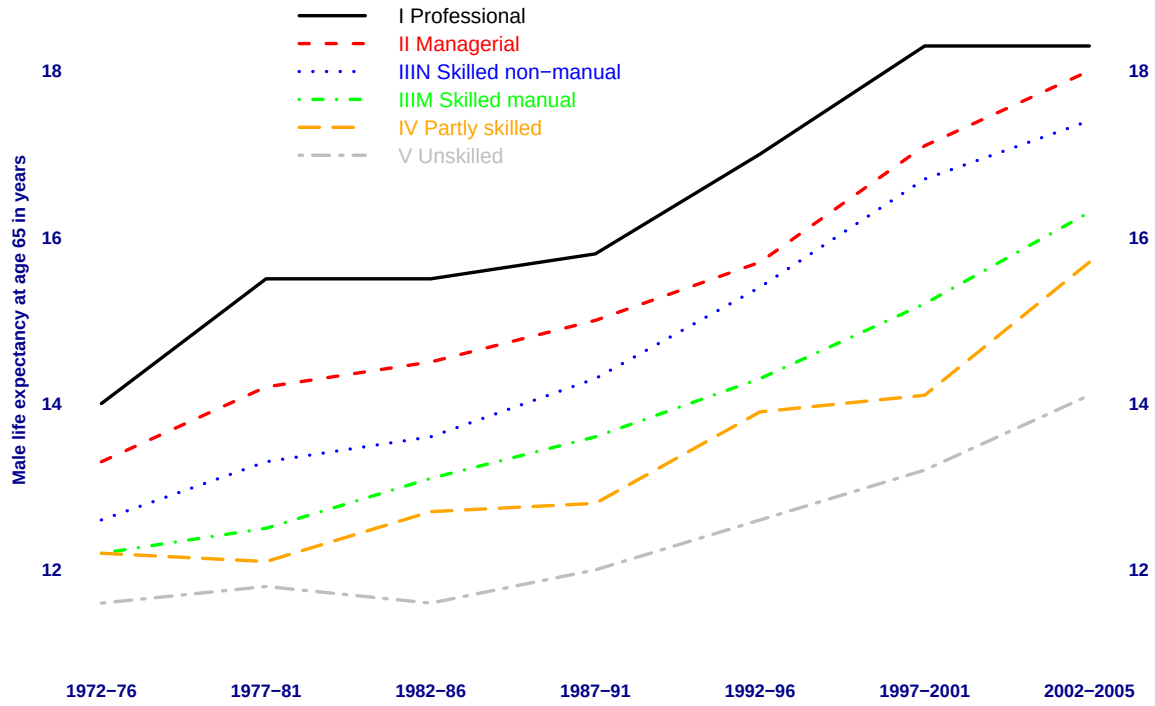
- Numerous derivatives exist for hedging longevity risk.
- A *survivor forward* is a type of derivative based on the survival curve:

$$\text{Payoff} = \text{Nominal} \times (\text{actual survival rate} - \text{strike rate})$$

- Survival rate based on population data, so basis risk exists.

3. Life expectancy at retirement

Note correlations between trends by socio-economic group:



Source: ONS Longitudinal Survey.

4. Hedging

- *Some* protection must be afforded by population-based derivatives.
- Key questions:
    1. Which hedging assets best suit your portfolio?
    2. How much protection do you get from the hedging assets?
    3. How much is that protection worth?

5. Hedging

The *hedge effectiveness* is:

$$\left(1 - \frac{\text{capital requirement with hedging assets}}{\text{capital requirement without hedging assets}}\right) \times 100\%$$

- Ideal is 100%, i.e. capital requirement reduced to zero.
- A useless hedge would have 0%, i.e. capital requirement unchanged.
- A worse-than-useless hedge would have a negative effectiveness, i.e. capital requirement increased.
- Other definitions of hedge effectiveness exist, e.g. Cairns (2011).

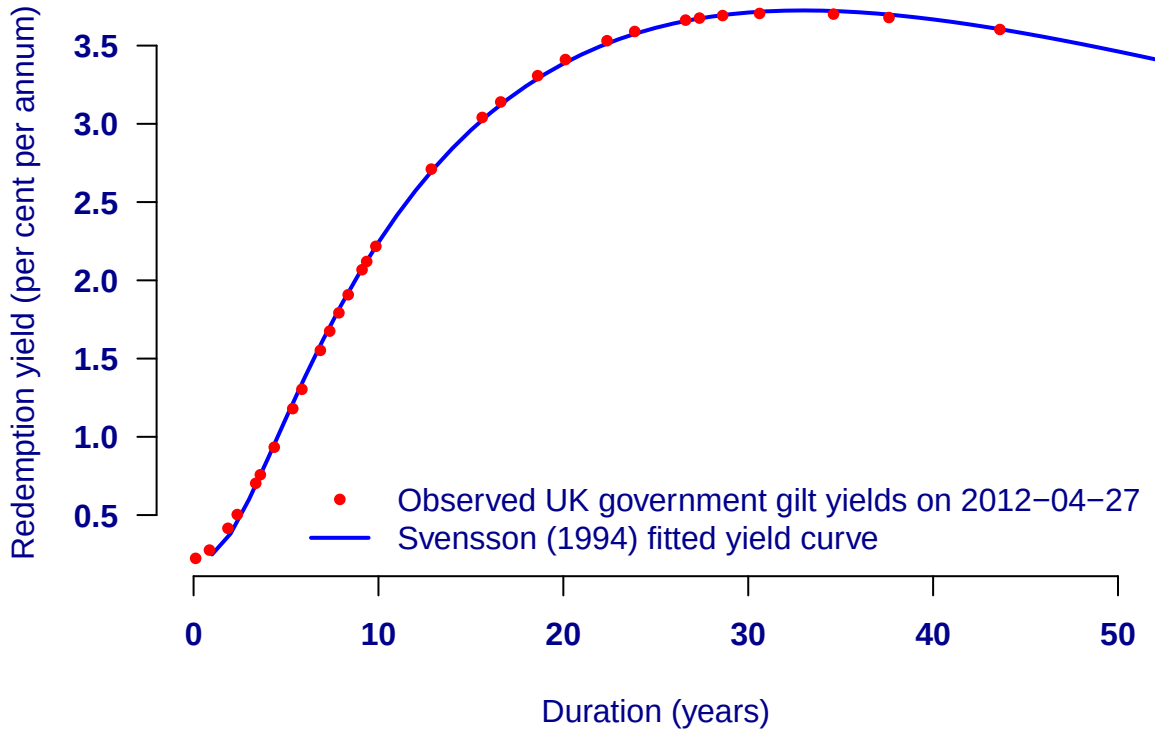
6. Hedging

- Capital requirement is 99.5th percentile run-off cost.
- Run-off simulations cover all forms of longevity risk.
- Capital therefore covers:
  - (i) trend risk
  - (ii) volatility of annual mortality rates
  - (iii) idiosyncratic risk, including concentration risk

- Survivor forward cannot cover (iii), so 100% effectiveness not expected.

7. Discounting

All cashflows and payoffs discounted using the following yield curve:



Source: Observed redemption yields implied by prices of principal strips of UK gilts on 12th January 2012 (●) and fitted Svensson (1994) model (——).

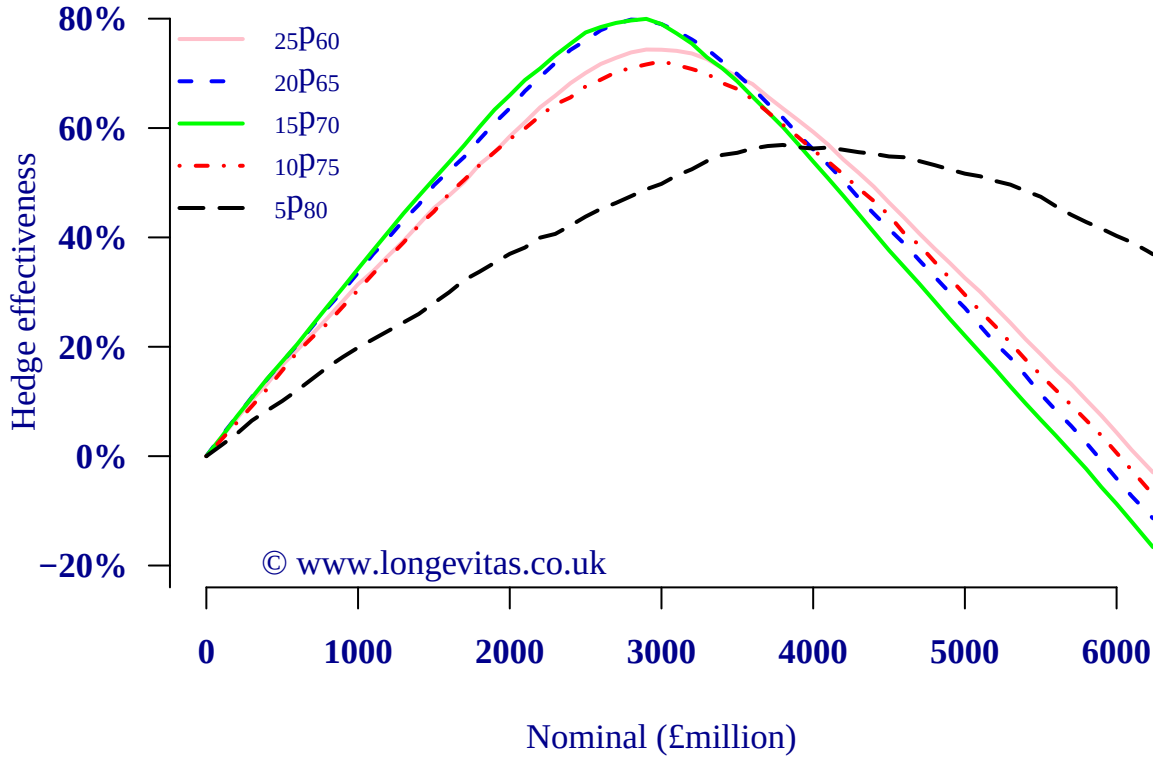
8. Hedging options

- Buy-out or Part VII transfer 100% effective, but takes time to execute.
- Reinsurance could be 100% effective, but introduces counterparty risk.
- What can index-based derivatives offer?

9. Hedge effectiveness for large pension scheme

- Consider a large pension scheme in England.
- Run-off simulations suggest maximum hedge effectiveness around 85%.
- Consider a single survivor forward, ${}_tp_x$, based on population mortality:

10. Hedge effectiveness for large pension scheme



Source: Own calculations based on 10,000 run-off simulations, similar in manner to those in Richards and Currie (2009). Hedging effectiveness for various survivor forwards defined on male mortality for England and Wales. Mortality forecasts according to Lee-Carter (1992) model with smoothed coefficients by age. Survivor forwards commenced in 2011.

11. Conclusions

- Several options for transferring or hedging longevity risk.
- Basis risk is real, but can be measured.
- Detailed analysis of risk factors in a portfolio is essential.
- Population-based derivatives do provide some protection...
- ...the only question is how much?

References

Lee, R. D. and Carter, L. **1992** *Modeling and forecasting the time series of US mortality*, Journal of the American Statistical Association, **87**, 659–671

Cairns, A. J. G. **2011** *Modelling and management of longevity risk: approximations to survival functions and dynamic hedging*, Insurance: Mathematics and Economics, **49**, 438–453

Richards, S. J. and Currie, I. D. **2009** *Longevity risk and annuity pricing with the Lee-Carter model*, British Actuarial Journal **15(II)** No. 65, 317–365 (with discussion)