

The Actuarial Profession
making financial sense of the future

Life conference and exhibition 2010
David Howell

How good a hedge is “good enough”?

Longevity Risk Management

7-9 November 2010

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Agenda

- Options available to manage longevity risk
- Nature & impact of basis risk
 - Key sources of basis risk
 - Scheme/portfolio characteristics
 - Sizing basis risk
- Other aspects to consider
 - Imperfect swaps
 - Collateral
- Questions

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Options available to manage longevity risk

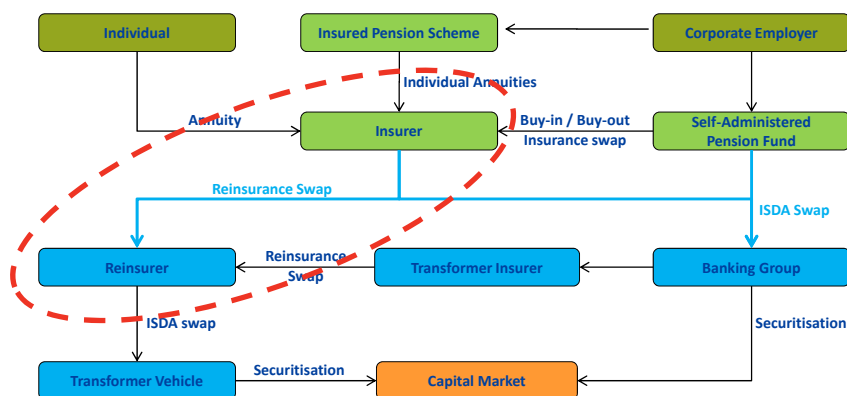
- Bundled solutions transferring range of risks:
 - pension buy-out / buy-in
 - asset-based quota share reinsurance
- Pure longevity risk transfer:
 - appetite to retain assets
 - may obtain better terms on each risk from specialist counterparties
 - first step to wider risk transfer
- This presentation compares two pure longevity risk transfer solutions:
 - Portfolio Specific Hedges
 - frequently, though not exclusively, (re)insurance instruments
 - colloquially called “Longevity Swaps”
 - Index Based Hedges => generally capital markets instruments
- Other options not currently in common use:
 - Duration limitations
 - Non-proportional structures
 - First life only cover

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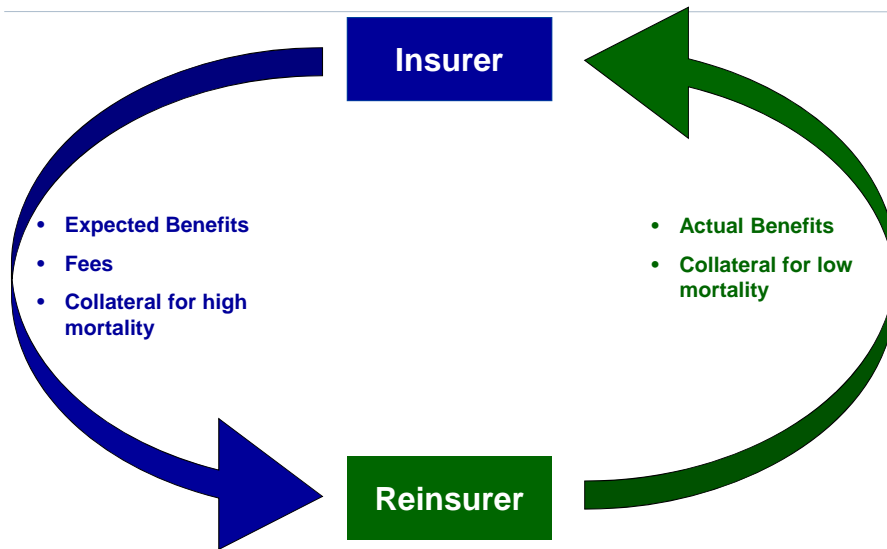
Longevity Swap Overview

- Simple proportional (re)insurance cover which fixes a set of pension/annuity benefit payments in return for an annual premium
- Term of cover tends to match the underlying benefits
- Frequently also transfers the risk of spouses and financial dependents (age and existence) which is an often overlooked and quite material risk
- Usually constructed as a insurance or reinsurance contract but may be done via and ISDA structure

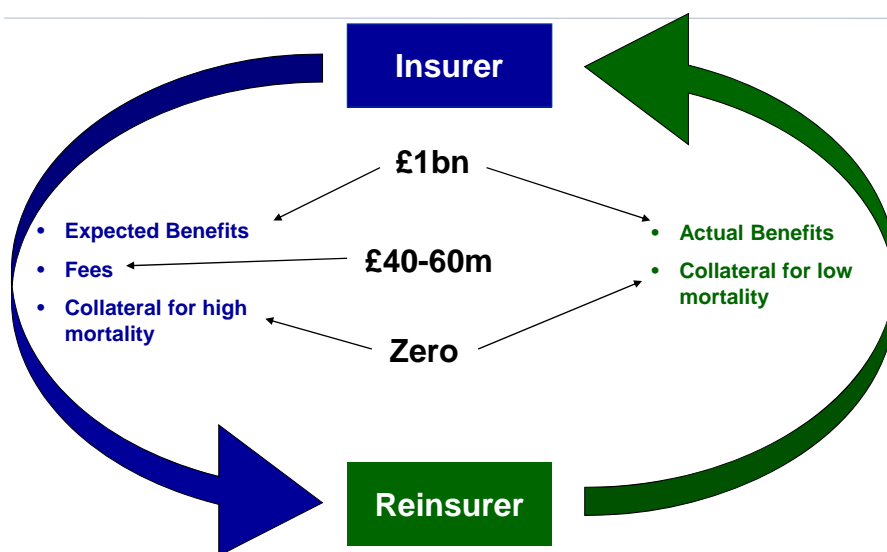
Options available to manage longevity risk



Longevity Swap Cash Flow Illustration



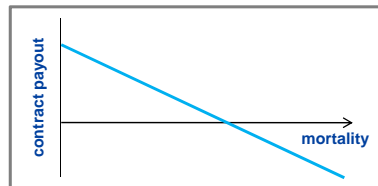
If experience followed the swap basis then the present value of payments on a £1bn swap would be roughly:



Index Based Hedges

How index based hedging works for a portfolio

- Similar to a financial derivative contract i.e. forward purchase of a nominal contract volume
- Contract payout per nominal is based on the movement in values of a chosen index:
 - e.g. chosen index could be E&W Males q_{70} based on observed crude data or graduated table
 - movement is between:
 1. initial fixed value at outset
 2. actual value at the forward date
- Range of sex/age-band specific indices available to cover portfolio
- Nominal volume of each index purchased based on sensitivity of relevant liabilities to (mortality trend) valuation assumptions
 - i.e. hedge around expected value at forward date
 - of future liabilities
 - Nominal amounts purchased can be rebalanced for additional cost



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Index Based Hedges

Actual activity to date

- Example: Lucida (Jan 2008) standardised longevity index hedge using LifeMetrics (JP Morgan)
 - 10 year q-Forward derivative contract hedging value of liabilities
 - Fully collateralised
 - Index reference: England & Wales population mortality
- Capital market ILS issues:
 - focus on Cat (shock excess mortality)
 - short term reflecting investor appetite
 - novelty premium
 - but..... huge potential capacity

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Index Based Hedges

Available published indices

<u>Company/Index</u>	<u>Reference population(s)</u>	<u>Date</u>	<u>In Force?</u>
Credit Suisse	US	2005	Discontinued
JP Morgan (LifeMetrics)	US/E&W/Netherlands/Germany	2007	Yes
Deutsche Börse (Xpect)	E&W/Netherlands/Germany (socio-demographic customisation possible)	2008	Yes
Goldman Sachs (QxX)	US impaired old age life settlement pool	2009	Discontinued

- Life expectancy of an index is ~2-3 years!!!!
- Limited usage to date in practice
- LLMA (2010) – index manual consultation paper *Longevity Index Framework August_2010*
- Desirable features:
 - Tradability, Transparency, Robustness, Objectivity, Simplicity, Clear Governance, Timeliness, Continuity, Consistency, Universality

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Index Basis Risk

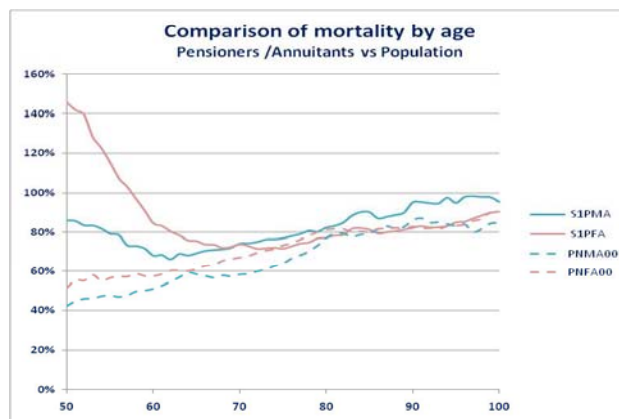
Overview

- Index hedges may not match actual change in liabilities:
 - Index reference population inappropriate:
 - Population and portfolio mortality trends may not be heavily correlated
 - Statistical volatility:
 - finite number of lives
 - liabilities skewed to larger amounts
 - escalation can amplify exposure to tail liabilities
 - Base mortality assumptions inappropriate:
 - trade based around best estimate assumptions (potentially inaccurate)
 - aggregate experience contains shape “richness” by age, term, year, socio-demographics etc.
 - differentials emerge as divergent trends as portfolio ages
 - benefit structures (e.g. reversion/escalation) further shift exposure mix over time
 - adverse existence and age profile of dependants/joint lives
 - credibility and reliability of data sometimes limited

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Index reference

- Significant differences from current level and shape of wider population mortality, even at overall industry level:

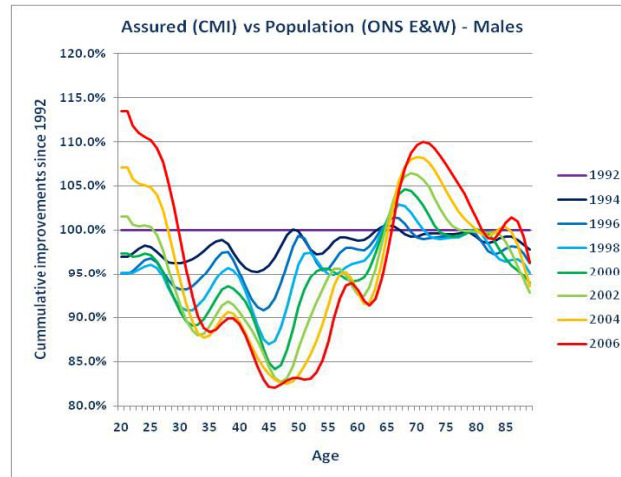


Ratio to E&W Population:
PNxA00 vs. ILT 99-01
S1PxA vs. ILT 02-04

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Index reference

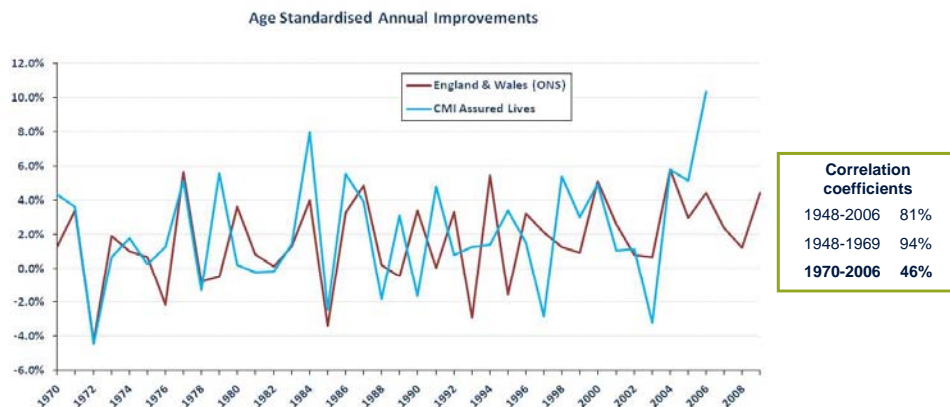
- Over the longer term despite broad consistency of overall rates of improvement divergent age patterns emerge:



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Index reference

- Short term noise is not perfectly correlated and may be a factor over short durations



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Index reference

- Longer term correlations much better but still not perfect
- Residual liability values diverge over consecutive 10 year periods:

Period	Ratio of pension values at end of 10 year period*	Difference	Implied difference in p.a. improvements within 10 year period
1961-71	97.7%	-2.3%	-0.5%
1971-81	100.5%	+0.5%	+0.1%
1981-91	96.8%	-3.2%	-0.7%
1991-2001	99.4%	-0.6%	-0.1%

Relative difference in residual annuity values based on
 - single cohort of 65 year olds using observed improvements
 - population (E&W) data vs. Assured lives (CMI) data observed trends

*Source: JP Morgan LifeMetrics Technical Document

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Statistical volatility

- Finite number of lives with liabilities skewed heavily by amount (SAPS data 2001-08 Males):

Benefit pa	Mix by lives	Mix by amount	Average amount £k
£0 - £1500	19.8%	2.3%	0.8
£1500 - £3000	19.3%	6.3%	2.2
£3000 - £4500	14.4%	7.9%	3.7
£4500 - £8500	21.1%	19.4%	6.2
£8500 - £13000	11.8%	18.2%	10.5
£13000 - £25000	10.3%	26.5%	17.4
£25000 +	3.3%	19.3%	39.6
All	100.0%	100.0%	6.8

- How big does a scheme/portfolio need to be before this is not a significant factor?

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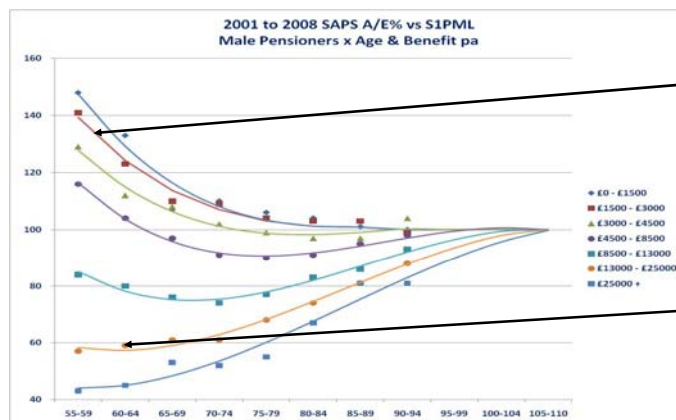
Statistical volatility

- Crude stochastic model:
 - single cohort of 70 year old males
 - benefits escalate at 3% pa; valued at 4.5% pa (no reversion)
 - deterministic S1PML mortality and CMI p-spline improvements
 - separate band benefits assumed with binomial mortality for lives in each band
 - 1000 iterations
- 4 schemes:
 - A: 5000 lives all with £6,778 current annual benefit ⇒ £520m best estimate liabilities
 - B: (small scheme) as A except 500 lives
 - C: (normal amounts spread) as A except SAPS data average band amount & mix
 - D: (skewed benefits) as C except benefit in top band is £250,000 not £39,567 pa
- Results - 95th (99.5th) percentile liability value increases vs. best estimate:
 - A: +1.2% (1.7%)
 - B: +3.7% (5.8%)
 - C: +1.8% (2.7%)
 - D: +4.1% (6.0%)

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Base mortality assumption

- Wide socio-demographic differentials for younger pensioners converge with increasing age
- Appropriate level and age slope of base mortality can vary materially by scheme:



Poor or job
hopping
executive?

Wealthy or
long service
blue collar
worker?

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Base mortality assumption

- Strong residual scheme specific factors
- Customising an index to a single scheme is problematic:

A/E by Scheme

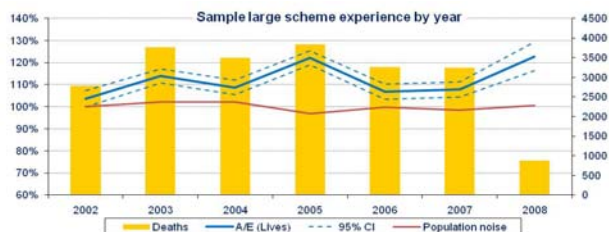
Scheme	E Fitted to Mosaic	E Fitted to Benefit	Difference
A	100.1%	101.3%	-1.3%
B	126.1%	123.4%	2.7%
C	113.9%	111.2%	2.7%
D	93.7%	92.1%	1.6%
E	78.7%	80.3%	-1.5%
F	99.5%	98.3%	1.3%
G	107.0%	109.1%	-2.1%
H	95.8%	96.9%	-1.1%
I	79.9%	79.2%	0.7%
J	115.7%	113.9%	1.8%
K	49.3%	48.1%	1.2%
L	117.1%	116.0%	1.1%
M	116.7%	116.0%	0.7%
Aggregate	100.3%	99.5%	0.9%
Std. Dev.	20.8%	20.5%	0.4%

- can fit differential mortality tables to aggregate experience using Mosaic code and/or Benefit
- very similar per scheme expectations...
- ...but both often wide of the mark!

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Other key assumptions

- Dependants:
 - best estimate liabilities often reflect assumptions about proportion of lives with dependants and their age rather than using actual data
 - liabilities values sensitive to this particularly for large escalating benefits with high reversion factors:
 - +1.2% impact on from increasing married proportion by 10%**
 - +1.9% impact on from decreasing the spouses age by 2 years**
- Scheme specific experience issues:
 - low credibility for smaller schemes increases base assumption uncertainty
 - can be hard to interpret unusual patterns in experience (even for large schemes)



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Index basis risk

Conclusions

- Key reasons why an index hedge might not match the change in liabilities – potential range of mismatch impact (**crude** estimates of **95th percentile** increase in best estimate liabilities) :
 - Index reference population inappropriate** **+/- 4 to 6%**
 - impact depends on assumed correlations/age mix,
 - affects all schemes
 - Statistical volatility** **+/- 1 to 6%**
 - impact depends on scheme size and benefit distribution
 - age profile & escalation rates also important
 - Base mortality assumptions and other assumptions** **+/- 2 to 5%**
 - impact depends on scheme experience credibility & reliability
 - married % and dependent age assumptions also important
 - highly subjective, especially where lives are heterogeneous or there are unexplained patterns in the observed experience

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Index basis risk

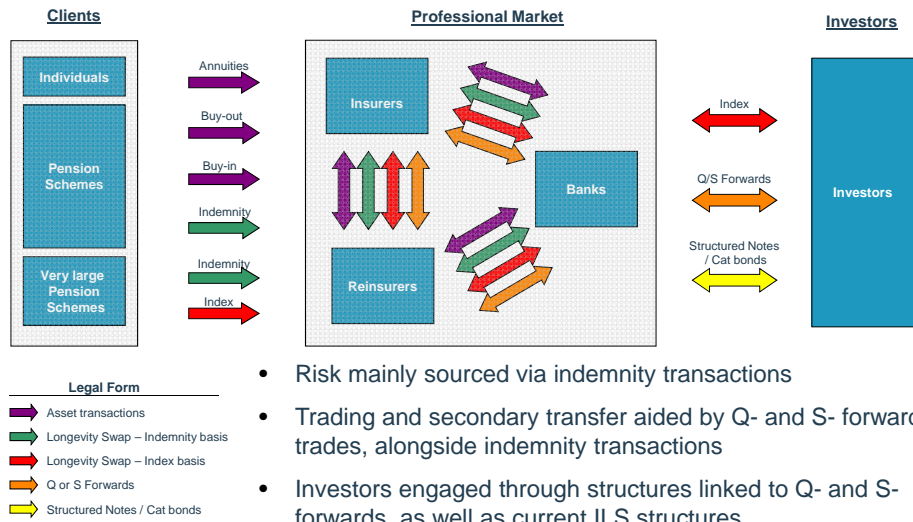
Conclusions

- Key reasons why an index hedge might not match the change in liabilities – potential range of mismatch impact (crude estimates of **95th percentile** increase in best estimate liabilities) :

Index reference population inappropriate	+/- 4 to 6%
Statistical volatility	+/- 1 to 6%
Base mortality assumptions and other assumptions	+/- 2 to 5%
- Contrast these figures with the expected variance in expected longevity trend
 - Most models will project a 99.5% scenario variance in longevity of between 6% and 10%
 - Assuming a normal distribution this suggests a **95th percentile** variance of **between 4% and 6%**
- At the 95th percentile event the volatility between the hedge result and actual mortality may be larger than the volatility between the expected mortality and actual mortality!**

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Is there a place for index hedges?



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Longevity swaps

- Can be constructed as an “indemnity” hedge which eliminates basis risk altogether however:
 - Timing and definition of reference index of linked escalations (including GMP) can be complex to model across an annuity portfolio
 - Additional legal and actuarial cost of defining/negotiation the “perfect hedge” may be greater than the risk associated with a nearly perfect hedge
 - Scheme data may not be perfect at inception but risk takers are unlikely to accept adjustment only to the floating vector
 - Cost of hedging benefits with uncapped inflation may not be attractive

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Longevity swaps

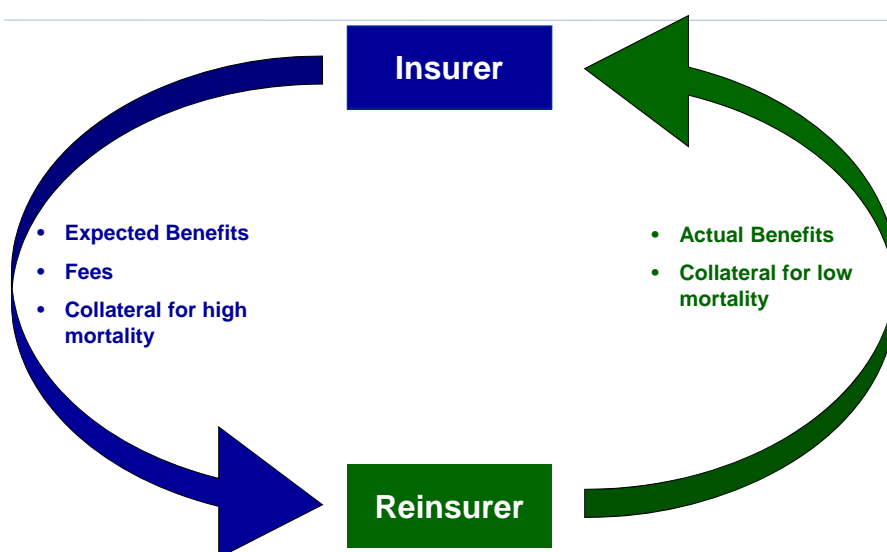
- May be better to base both fixed and floating vectors on “notional” benefits:
 - Introduces very mild basis risk
 - Much easier to model and define contractually
 - Can also be used to retain inflation risk and potentially improve longevity terms
- The key point is to ensure that fixed and floating vectors move in parallel so that no basis risk is introduced
- Over or under hedging by a few percent is a very second order risk that is generally worth the simplicity and cost savings.

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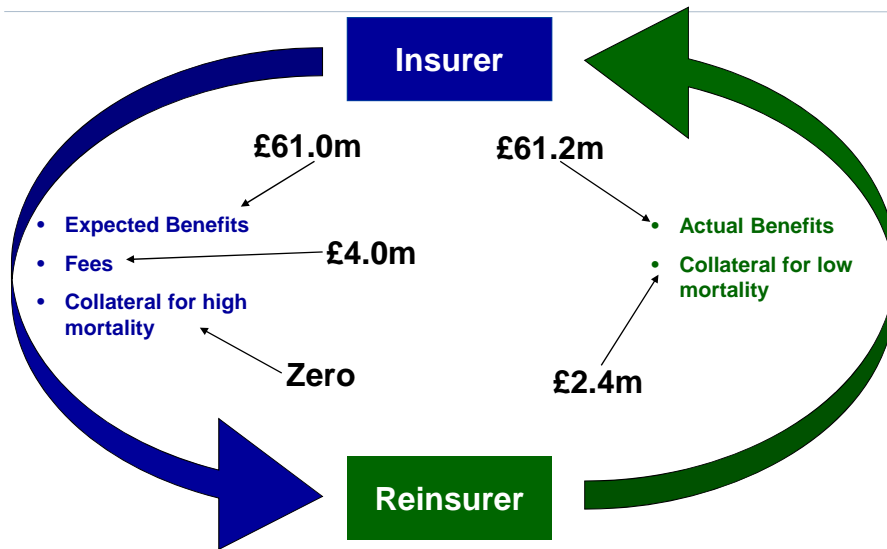
Collateral Arrangements

- On day 1:
 - The (re)insurer is exposed to the credit risk of the insured to the extent of the fees
 - The insured has only a potential exposure but this may be important if they are releasing capital requirements due to the cover
- As experience unwinds slightly differently than the swap basis, one party's credit exposure will reduce and the other's will increase due to:
 1. The future benefits on the extra or missing deaths
 2. The implied difference in the future rate of deaths
- Most (re)insurance treaties include a collateral formula which adjusts for the first of these drivers precisely and approximates the second
- The second driver is subject to interpretation and expert opinion may sometimes be included as one of the methods of determination

Longevity Swap Cash Flow Illustration

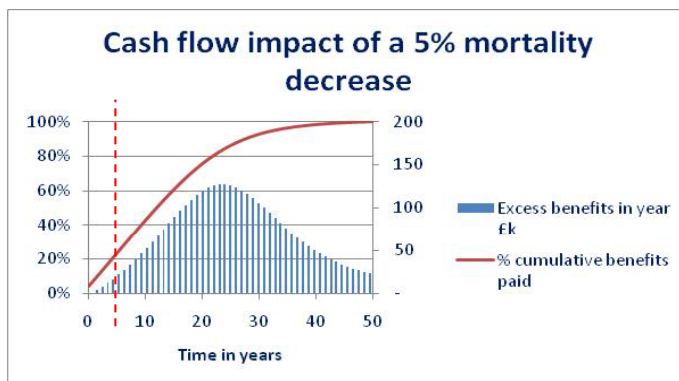


Cashflows in year five if experience follows 95% of swap basis



Collateral Arrangements

- Funded/unfunded derivative swaps
- Experience collateral on longevity reinsurance swaps
- Shifts in mortality only emerge slowly in cash flow terms:



Questions or comments?

Expressions of individual views by members of The Actuarial Profession and its staff are encouraged.

The views expressed in this presentation are those of the presenter.

