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HOW TO PRICE LONGEVITY SWAPS

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Longevity risk and pension plan de-risking has been an important topic in the United Kingdom for many years. In 2012, pension plan de-risking reached the United States on a large scale with Prudential Insurance Company of America transacting two of the largest pension buy-out deals in history, totalling US$36.5 billion of pension liabilities.

There are generally three ways for pension plans to reduce longevity risk in their portfolios:

a) Pension buy-out, which transfers the entire risk to an insurance company;
b) Pension buy-in, in which the pension plan retains the relationship with its pensioners, but purchases insurance from an insurance company to cover asset risk and demographic risks; and
c) Longevity swap, which transfers only the risk of pensioners living longer than expected from the pension plan to an insurer.

Reinsurers have been providing capacity for longevity risk in the U.K. risk market from around 2001, but since 2008 with little appetite for asset risk. Consequently, they developed the longevity swap, which has become an important risk transfer alternative and has been used to transfer a total of GB£19.17 billion (US$30.4 billion) in pension liabilities since 2009.[1]

Longevity swap reinsurance is a deceptively simple structure, in which a reinsurer takes on the responsibility to pay the amount of actual benefits on a specific portfolio of pensioners (or annuitants) in return for fixed reinsurance premiums. The reinsurance premiums follow the pattern of the expected pension benefits (or annuities), and reflect the reinsurer's view of future survivorship in the portfolio plus a margin for taking on the risk. (See Figure 1, above)

Figure 1: Illustration of a longevity swap with annual pension benefits of $100,000. The chart below shows the expected annual benefits as the solid line, and the reinsurance premiums as the dashed line.
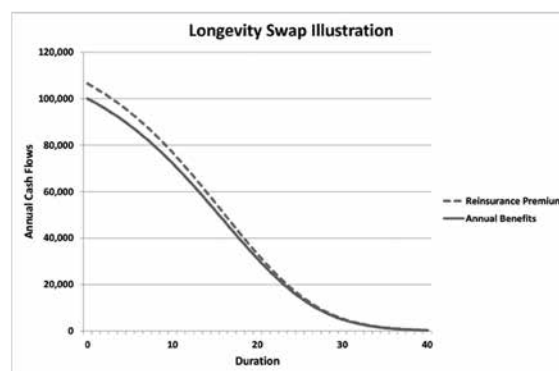
From a practitioner's view, a longevity swap requires the following main pricing assumptions:

1. Current Mortality: experience analysis of the portfolio, to identify risk factors and quantify their impact;
2. Mortality Trend: choose a model, which reflects your best estimate of future mortality for the portfolio;
3. Reinsurer's Margin: calculate the economic capital at outset and for each future period to determine the necessary margin for taking on the risk.

MORTALITY EXPERIENCE ANALYSIS

As mentioned by Gavin Jones in an article[2] in the July 2013 issue of *Reinsurance News*, the analysis of mortality risk is "at the core of the reinsurance skill set." We are used to carrying out these analyses with due care. For example, one of the things reinsurers always look at is the difference between lives-based and amounts-based mortality experience. An unusually large lives-to-amounts differential is an indicator of heterogeneity within the portfolio, which calls for a detailed portfolio-specific mortality analysis, because the portfolio likely consists of different socio-economic groups with varying mortality experience. The chart in Figure 2 (pg.19) shows an example of how mortality can vary by socio-economic class. Male pension-

ers in the United Kingdom aged 65 have a mortality differential of close to 250 percent between those with the highest pensions and the lowest pensions.

Figure 2: Socio-economic Mortality Differentials. Data collected by the CMIB on self-administered pension schemes in the United Kingdom between 2001 and 2008. Mortality of males by pension size amount band based on simple log-linear graduation for comparison (own calculations).

In life reinsurance pricing, we are used to creating bespoke mortality assumptions for each transaction and to paying close attention to the slope of the table. We are also used to differentiating mortality very accurately by risk class. For longevity swaps it is even more important to model the run-down of the portfolio as accurately as possible, because—unlike YRT reinsurance—the future premium payments are fixed at outset and the transaction typically has a very long duration (see Figure 1, pg. 18).

Groups with different mortality must be projected separately, even if the portfolio's experience data does not include sufficient information to differentiate the mortality assumptions. For instance, it may be possible that the experience data does not deliver statistically credible results for pension-amount differentials. In such instances, it is necessary to rate the mortality of the projected portfolio based on additional external data.[3] The alternative, using an average mortality rate, may give

reasonable results for the initial years. However, over time the subgroups with higher mortality become less important as their weight naturally decreases faster than the weight of subgroups with lighter mortality. Thus, the required reinsurance premium would be underestimated.

MORTALITY TREND

To properly project the survivorship of a group of pensioners or annuitants, we require assumptions about future mortality trends. Again, life reinsurers are used to estimating mortality improvement rates for insured lives. However, for longevity risk, it is important that we do not underestimate mortality improvements. This task should not be taken lightly, as generations of actuaries before us have repeatedly got it wrong.

Over the past decade, actuarial and demographic research has developed a variety of models for future mortality. Unfortunately, there is little consensus among researchers as to which model is best suited, or even as to how to pick the right model. There are those, who argue that the increase in life expectancy, which we have seen in the last few decades, cannot persist, because cardio-vascular health has been improved as far as possible, and because other causes of death are more difficult to tackle, with new phenomena like obesity and antibiotics-resistant infections also gaining importance. The opposing school of thought argues that improvements in health have historically persisted beyond the expectations of contemporaneous experts. Therefore, we should project the most recent trends of high mortality improvements forward with statistical methods.

For the purpose of analyzing longevity risk in the context of longevity swaps, it would be prudent to project the recent high level of mortality improvements into the future. It is also important to determine, whether the mortality improvement rates are only age-dependent, or whether they also vary by year of birth cohort. Analysis of U.S. population data shows that there is a moderate cohort effect present in America.

Typically, we derive mortality improvement assumptions from general population data, because portfolio-specific data or industry data do not cover a long enough history or include enough deaths to obtain statistically credible results. The potential mistake which we make by doing so is often referred to as Longevity Basis Risk. Research is ongoing to quantify the impact of longevity basis risk, but the reinsurance pricing actuary will already need to make some allowance for it in her pricing assumptions today.

In addition to model risk and longevity basis risk outlined above, the reinsurer has to deal with a difficulty described in the literature as model robustness. This term refers to the sensitivity of a projection model to the choice of the historical dataset, to which the model is calibrated. This again is a choice that the pricing actuary has to make, and which will affect her opinion on the future survivorship of the portfolio. Each of the three components of longevity trend risk has an impact on both the best-estimate liabilities and their uncertainty.

MARGIN FOR RISK

The margin charged by a reinsurer on a longevity swap includes both the reinsurer's own expenses and the cost of having to hold capital against longevity risk. Setting a margin for expenses is a straightforward exercise, while the cost of capital merits some more detailed discussion. Generally speaking, there are many methods of calculating the required profit margin. For example, one can view the required economic capital as an upfront investment, which pays down gradually as liabilities expire and capital is released. The cost of capital is then equal to the margin which achieves a target internal rate of return on this investment. For the sake of comparison, however, it makes sense to consider the method by which insurers and reinsurers in Europe have to calculate the "exit value" of a portfolio of risks, or in other words the theoretical price at which the risk would change hands.

1. Calculate the capital required at outset and at each point in time in the future;

2. The cost of capital in each period is equal to a percentage of the respective capital, i.e., Cost-of-Capital factor x Required Capital;

3. The present value of the cost of capital as defined above is called Risk Margin; and

4. The exit value mentioned before is equal to the sum of the risk margin plus the present value of best-estimate liabilities.

The profit margin for a reinsurance transaction, over and above best estimate liabilities and expenses, is then set such that the present value of future profits equals the above risk margin. Within the European Solvency II framework for regulatory capital, the supervisor has fixed the cost-of-capital factor at 6 percent. While all reinsurers will have their own internal profit targets and also their own economic capital models and ability to diversify longevity risk, one way of comparing these differences would be to find the equivalent cost-of-capital factors under a standard risk-based capital model.

CONCLUSION

Longevity swap reinsurance should be a standard pricing exercise for professional life reinsurers. However, there are a number of pitfalls along the way which we have highlighted in this article:

A. Portfolio-specific mortality is crucial.

B. Different risk classes must be projected separately, in order to avoid underpricing.

C. Mortality improvement trends come with considerable model uncertainty, longevity basis risk and lack of robustness, all of which have to be priced for in the risk margin.

Life reinsurers are well suited to take on longevity risk, because they have the required skill set, and because they are likely to require the least amount of additional capital to cover longevity risk. Nevertheless, their capacity to take on this risk is finite. Possibly, longevity swaps will be a tool with which the insurance market will be able to transfer this risk into the capital markets. However, one of the thresholds to overcome before we will be able to accomplish that is to better understand and quantify longevity basis risk. ∎

If you are interested in longevity risk and related implications and applications, you should consider signing up for the Living to 100 Symposium V which will take place Jan. 8-10, 2014 in Orlando, Fla. For details see: *http://livingto100.soa.org/*

References
[1] Lane Clark & Peacock LLP: LCP Pension Buy-outs, Buy-ins and Longevity Swaps 2013, available at www.lcp.co.uk
[2] Gavin Jones: Longevity Risk and Reinsurance, in Reinsurance News July 2013, Issue 76.
[3] Either by utilizing commercial profiling databases such as Mosaic or Acorn or by making use of industry data.