De-risking Longevity

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Abstract

Today's context has led to record-low conversion rates for traditional annuities. This is due in part to regulatory changes, in part to the current economy with historically low interest rates. New retirees have little incentive to invest into a traditional annuity, rather than other financial products. Actuaries have given thoughts to how to alter annuity products in order to make them more competitive and various answers have emerged, from longevity derivatives that are meant to cut the cost of capital on annuity books, to new product features. This paper joins in the conversation and attempts to bring innovation to improve the financial return of annuities. This paper will firstly make some observations to explain the high price of annuities, and then in a second part, we will look at a product design that allows the transfer of systemic longevity risk from an annuity provider to the annuitant. This paper follows on previous work on Mortality-Indexed Annuities (Richter & Weber, 2009). It looks at the usefulness of transferring systemic longevity risk within the framework of Solvency II. The goal, of course, is for the annuity provider to be able to offer higher returns to the annuitant, in exchange for a riskier investment. This paper will assess the possible impact of such product design in terms of conversion rates for the annuitant and coverage ratio for the annuity provider.

Key words: Longevity, Annuity, Solvency II, longevity-indexed, unit-linked

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1. CONTEXT

Traditional lifetime annuities have become less attractive due to increasing downward pressure on annuity rates. Several factors contribute to putting pressure on annuity rates in the UK but also to various degrees in Europe and elsewhere. Current annuity rates in the UK are at a historically low level (Cheong, 2015), and here are some elements to understand the trend:

- Life expectancy is still on the increase. The increase of life expectancy has been a very significant driver of the decrease of annuity rates. For many years, longevity risk analysts have tried to predict the future increase of life expectancy. Though the increase is slowing down in the Western countries, it is still a significant aspect of the trend.

- Longevity risk is very costly with Solvency II in terms of capital requirement (1/200 level of sufficiency). Annuity providers have had to anticipate the cost of longevity risk in Solvency II and price annuities accordingly. Calculations of the impact of Solvency II on an annuity rate will be provided later in the paper and will show the price of longevity risk is a significant deterrent to investors.

- Gilt yields are at a historically low level in the UK and Europe. This has affected the price of annuities in recent months – conversion rates decreasing when interest rates are low. Monetary policies have had the effect of driving interest rates to a historically low level.

- Announcement in the 2014 UK budget that Defined Contribution retirement incomes would be available in whichever way pensioners wish, thereby ending a long era of compulsory annuitization. This is arguably putting pressure on the annuity market as pensioners may direct their cash to whatever investment will provide good returns. In other countries like Australia, retirees are traditionally more inclined to drawdown rather than annuitize their retirement income.

All these factors contribute to making annuities a less attractive investment. In order to address the problem of this lack of competitiveness, annuity professionals have worked from a number of angles:

i. A better assessment of longevity risk through the development of stochastic models[1]. This allows annuity providers to improve knowledge of the risk and in some cases be more competitive;

ii. Risk management strategies, including reinsurance strategies, longevity swaps and other derivatives to transfer longevity risk. Risk management strategy lead to lower capital requirement in Solvency II[2];

[1] Cairns (2013) devotes a paper on the review of the different longevity risk models. As pointed out by Cairns, there is no shortage of longevity models, many of which having been developed only in recent years. More on longevity modelling is found in the Cass Business School Paper (2014). The critique made by Cairns is that developing complex stochastic models may not necessarily lead to a better appreciation of the overall exposure to longevity risk of annuity providers. Once models can predict future mortality, the next step, perhaps just as important as the first, is to then 'manage' the risk, whether this means accepting it in full, transferring it or hedging it. What is the longevity risk appetite of the company? What tools will be used to mitigate the risk, such as reinsurance or longevity swaps? These are the questions that will occupy the actuary as much as establishing the mortality rates of annuitants.

iii. Investment strategies, with the rise of unit-linked annuities. UL Annuities are able to escape the decrease of the Gilt Yields[3];
iv. Product innovation, with a number of retirement products that are no longer "annuities" (Drawdown, mutual funds).

At this stage, before we quantify the cost of longevity risk in annuities, it is important to note longevity risk can be decomposed in a number of ways, and we propose the following description. It is not the only one found in actuarial circles, but it seemed useful for the current analysis:

i. Long-term trend risk, also called systemic risk: the risk that the mortality rates of the general population will change significantly over time, and by consequence that of the annuitants.
ii. Selection risk, which can be split even further:
    - The risk due to the fact the mortality rates of the annuitants move away from that of the general population (Adverse selection).
    - The risk due to large annuities (Weighted average mortality may move away from average mortality).
iii. Sampling risk: the risk of volatile mortality due to the size of annuity book. The smaller the annuity book, the more volatile the observed mortality will be.

Selection risk and sampling risk are sometimes considered together as 'idiosyncratic risk', that is the risk that remains once we exclude the systemic risk. From an actuarial point of view, the risks due to selection effect and sampling effect are part of the 'normal' uncertainty of all insurance policies. It is the role of the insurer to manage idiosyncratic risks through the normal tools of pricing and pooling. The long-term trend risk is however an element specific to annuities. What differentiates annuities from other insurance policies is the time distance between the pricing undertaking and the termination of the payment obligation. Such a gap in annuity policies creates a systemic risk for insurers.

So far, we have only listed longevity sub-risks, but one should add the following risks that contribute to the overall risk of annuity product:
iv. ALM mismatch, which is due to the fact the liability is longer than the investment horizon;
v. Other investment risks.

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[2] "Insurance and reinsurance undertakings may take full account of the effect of risk-mitigation techniques in their internal model, as long as credit risk and other risks arising from the use of risk-mitigation techniques are properly reflected in the internal model." (DIRECTIVE 2009/138/EC Art. 121-6)

[3] "Where the benefits provided by a contract are directly linked to the value of units in an UCITS as defined in Directive 85/611/EEC, or to the value of assets contained in an internal fund held by the insurance undertakings, usually divided into units, the technical provisions in respect of those benefits must be represented as closely as possible by those units or, in the case where units are not established, by those assets.(Art 132)"

2. PRUDENTIAL REGULATION AND LONGEVITY RISK

This chapter will look at the price of longevity risk in a typical traditional annuity, under Risk-based capital standards.

Risk-based capital (RBC) standards (Solvency II in Europe, LAGIC in Australia) have made annuities more costly in terms of capital requirement than in the previous Solvency / Capital Adequacy frameworks. European QIS5 Calibration Paper prescribes a stress of 25% permanent decrease in mortality rates (3.275). Australian LAGIC framework requires a 20% permanent decrease. This prescribed calibration contributes to the high capital-cost of lifetime annuities.

We consider the "prudential price" of an annuity. We define the prudential price as the best estimate price paid as a lump sum, plus the frictional cost of the regulatory capital as required in an RBC framework that prescribes a longevity stress for the calculation of the capital requirement.

We will calculate an estimate of this prudential price in an RBC framework.

The prudential price of annuities may be written as :

$$P = R.a_x + y \times \sum_{k=0}^{\infty} \frac{SCR_k}{(1+r)^k}$$

See (Pitacco & Olivieri, 2009).

With:

$R.a_x$	Best estimate valuation of an annuity paying the annuitant R each year from the age of x, using the risk-free discount rate.
y	Cost of capital above the risk-free rate.
r	Risk-free rate.
SCR_k	Solvency Capital Requirement at year k of the policy.

The Solvency Capital Requirement can be decomposed into different components:

- Market risk component
- Longevity risk component
- Operational risk component

For the purpose of the calculation, we will make the following assumptions in order to derive a calculation of the prudential price of the annuity:

- Market risk will be limited to changes in the risk-free rate. This means the underlying asset is a government bond considered risk-free and therefore we don't assess credit spread risk, equity risk and other market-related risks. This assumption will lead to a lower estimation of the prudential price.
- The stress on the risk-free rate is 40%, as seen in RBC calibrations.
- Longevity risk will be a 25% decrease in mortality rates as proposed in the European QIS5 Calibration Paper.
- Market risk and longevity risk are not correlated. So the total SCR can be derived by a simple addition of components.
- There is no allowance for a Capital Surplus above the Solvency Capital Requirement.[4] Again, this assumption will lead to a lower estimation of the price.
- Operational risk will be overlooked as it is not within the scope of this paper.

[4] A Capital Surplus would cover the risk of falling under the Solvency Capital Requirement. Since the level of sufficiency to cover this risk is viewed as too arbitrary for the purpose of pricing, it was decided not to include any Capital Surplus in the calculation.

- Expenses / administrative costs will also be overlooked for the same reason. Although they cannot be ignored in the retail price of an annuity, they will not be considered in the prudential price.

To summarize, the premium we will consider is the sum of the *best estimate* valuation of annuity payments plus the cost of holding the *Solvency Capital Requirement* in a Solvency II (Risk-Based Capital) framework.

The simplifying assumptions tend to lower the prudential price. This is not an issue in itself, since the purpose of the paper is not to give the most accurate prudential price of an annuity, but to quantify the magnitude of the decrease of this prudential price when the systemic risk is later transferred to the annuitant.

The Solvency Capital Requirement may be divided into:

(a) Longevity SCR

$$SCR_k^{long} = \Delta_{long}(R.\,a_{x+k}) = R.\left(a_{x+k}^{long} - a_{x+k}\right)$$

Where a_{x+k}^{long} is the longevity-stressed annuity factor at age x+k. The longevity SCR is what the insurer needs to hold to cover a scenario of decrease in mortality rates.

(b) Interest rates SCR

We look at the Interest rates SCR from the point of view of a pricing actuary who wants to include it in the price of an annuity, rather than the company's level.

$$SCR_k^{int} = \Delta_{int}(A_k) - \Delta_{int}(R.\,a_{x+k})$$

A_k Asset corresponding to the lifetime annuity reserves;
Δ_{int} Difference due to stress on interest rates.

The SCR due to interest rates may be modelled as the drop in asset value due to the stress on interest rates, with deduction of the drop in reserves due to the same stress.

If Asset and Liability are perfectly matched, the two parts cancel each other out. But it is likely the asset will be shorter than the liability, showing an ALM mismatch.

For the purpose of pricing, it may be useful to calibrate the Interest rates SCR to the actual SCR due to Asset risk at the company's level, so that on aggregate there may be a match:

$$SCR_k^{int} = \alpha \times \left(\Delta_{int}(A_k) - \Delta_{int}(R.\,a_{x+k})\right)$$

α such that:

$$\sum SCR_k^{int} = SCR^{int}$$

<u>Results:</u>

We have compared results to the Milliman Researh Report (Corrigan, 2009) that also attempts to quantify the price of lifetime annuities under Solvency II. Here are some comments about the results:

(a) We seem to get a higher price for longevity risk than the Milliman Researh Report (6.6% SCR for Milliman compared to 9.1% calculated for this paper). This could be due to different mortality assumptions & methodology. It leads to a ratio of 3.7% for Frictional Cost of Required Capital on Lump Sum Premium.

(b) For interest risk, we originally had 1.2% for an assumption of maturity 15 years, which was in line with 1.1% SCR found in the Milliman Research Report. However, the report (p. 9) showed 4.4% of credit spread risk, due to the fact the asset is not risk-free. We decided to bring the maturity to 10 years instead of 15 years so that (i) the maturity reflects an actual average maturity (ii) the SCR at 5.1% of the reserve is more in line with an actual market risk premium. It leads to a ratio of 1.5% for Frictional Cost of required Capital on Premium (Lump Sum).

(c) We get a total ratio for Frictional Cost of required Capital on Premium of 5.2%. This is the part of the Prudential Premium that funds the SCR.

On a lifetime annuity book, it is estimated the Frictional Cost of Required Capital represents around 30% of the SCR, which itself represents 14% to 18% of the reserves – depending on risk profile of the book, on the investment policy, on the distribution policy. At this point, it sounds reasonable to say around 5% of a lifetime annuity premium is used to fund the SCR in the case of a traditional guaranteed annuity – this is of course before allowing for any risk management strategy.

Reducing the Prudential price

Annuity providers can use a number of strategies to manage their longevity exposure and thus reduce the prudential price of an annuity. Some of them are as follows:

- In-house hedging: accounting for exposure to mortality risk on other lines of business so that exposure to mortality and longevity cancel each other out. This is a natural risk management strategy although it can be noted there is no perfect match between an annuity book and a death benefit book.

- Reinsurance: Ceding longevity risk. Problem: Systemic risk is not hedged but only transferred to another entity. It is not clear the prudential price can be reduced with only reinsurance unless the reinsurer applies strategies to manage risk effectively.

- Longevity swaps and derivatives: These strategies have been developed in recent years and take many forms. BT, Aviva secured large deals in 2014. These deals allow different entities to swap their risks in order to decrease the total SCR.

- Product design: One strategy is to design products such that insurers keep enough flexibility in prices / guarantees to minimise the SCR. This is the strategy we look at in the next part of this paper. This paper will present a product design for lifetime annuities that will substantially decrease the solvency requirement.

3. De-risked annuities

The purpose of this paper is to present annuity product features that allow the annuity provider to leave more risk with the annuitant, while still providing a stream on income during the lifetime of the annuitant. This idea might sound counter-intuitive at first, but it has long been applied to other types of insurance, namely renewable term insurance, where the premium can be adjusted yearly according to the latest available information on mortality and market conditions. We suggest that a similar approach could be taken with annuity products: the annuity payments would be adjusted every year contingently to the latest data in mortality and to market conditions. This feature is to be differentiated from a system of tontine. A tontine is not an insurance product since there is no uncertainty as to the total amount of payments from the insurer's point of view. The uncertainty lies with who actually receives the payments. In this paper, we present a product feature that remains within the perimeter of insurance: there is still uncertainty around the benefits that will be paid to the annuitants. The aim is indeed not to defeat the very principle of insurance, which is defined as a benefit that is uncertain for both the policyholder and the insurer. Rather, the aim is to allow for the use of the latest available information for the appreciation of uncertainty.

For the annuitant, it is a matter of choosing between the two following options:

- Purchasing a stable income at a high price; Or
- Purchasing a less stable income, contingent to current information, at a lower price.

We may draw a parallel with a totally different financial instrument, the mortgage. On the mortgage market, borrowers would usually have the choice between a fixed interest rate or a variable interest rate. The variable interest rate would be lower than the fixed interest rate but subject to market fluctuations. Thus, the borrower would be doing a trade-off between price and risk: lower price means more risk and vice versa. The annuitant should be given a similar trade-off: to receive a very secure income at a higher price or to receive a less secure income at a lower price. Obviously, such annuities should be used carefully, since the whole idea of the annuity – to provide a secure stream of income – may be compromised. The client should be made fully aware of the risks.

Step 1 : Transfer of the interest risk

ALM mismatch risk is the risk due to the fact assets and liabilities have a different maturity, which is inevitable for an annuity book.

The technique to reduce ALM mismatch risk is unitization of the annuity, whereby a portion or the totality of the annuity is not expressed as a dollar amount, but as a number of units of a fund. The annuity payment changes with the value of the units. The Solvency II framework states that benefits linked to the value of units should have technical provisions represented as closely as possible by those units.

If the annuity provider allows a portion of the annuity amount to fluctuate with the market value of the underlying bonds by unitizing the annuity, the ALM risk is transferred from the insurer to the annuitant for that portion of the annuity amount.

The prudential premium of the annuitant is P, with:

$$P = N_0(1 + y_0) \times V_0$$

N_t Number of units in the best-estimate liability at time t;

V_t Value of the unit at time t;

y_t Prudential factor at time t. It increases the number of units to hold to allow for longevity stress over a 1-year period.

The annuity payments are expressed as a number of units, with calculation of the number of units done using the target rate r.

$$n_1 = \frac{N_0 \times V_0}{a_x^{(c)}}$$

n_1 Number of units paid at the end of the first period

$a_x^{(c)}$ Lifetime annuity factor calculated at initial age x, using the target rate c.

For the following periods, the number of units to be paid to the annuitant is as follows:

$$\forall k > 1, n_k = n_{k-1} \times (1 + c)^{-1}$$

$$n_k = n_1 \times (1 + c)^{-k+1}$$

The number of units paid at each period decreases according to the target rate c, which is set at the inception of the policy in the pricing.

Step 2 : Transfer of longevity risk

The annuity provider will rely on an external longevity index to define the systemic risk on longevity and offset it with an annual adjustment on the number of units to be paid to the annuitant. This adjustment removes the longevity risk due to long-term trend from the annuity. Uncertainty over long-term mortality trend is no longer borne by the annuity provider but by the annuitants themselves.

See also Longevity-Indexed Life Annuities (Denuit, Haberman, & Renshaw, 2011) which develops ways to share longevity risk with the annuitants, based on an external mortality index. This paper can’t help but point to the 2009 paper by Richter and Weber saying in p. 8: “For annuities of the above-mentioned type that make benefits contingent on mortality experience the term mortality-indexed annuity (MIA) will be used throughout this paper. Surprisingly, such products do not seem to be offered yet by insurers in the most important insurance markets nor visibly discussed in academia.” To paraphrase the authors, the so-called MIAs are “missing in action” on the annuity market.

The adjustment to the annuity amount in year k after purchase, due to systemic improvement in longevity is defined as:

$$A_k = \frac{a_{x+k}^{(c)}\{k\}}{a_{x+k}^{(c)}\{0\}}$$

$a_{x+k}^{(c)}\{0\}$ is the present value of an annuity with cashflow of 1 p.a. from age x+k, with discount rate c and with mortality rates as known at the inception of the contract.

$a_{x+k}^{(c)}\{k\}$ is the present value of an annuity with cashflow of 1 p.a. from age x+k, with discount rate c and with mortality rates as known at after k years (latest available data).

We then adjust the number of units payable accordingly:

$$n_k{}' = n_k \times A_k$$

This adjustment means that every year, the annuity provider resets the number of units payable to the annuitant according to the available mortality data. The number of units payable to an annuitant becomes independent to the year when the annuity was purchased, and is established based on mortality data. With an annual adjustment, the mortality risk taken by the annuity provider is comprised of:

- The uncertainty of mortality rates over the next 12 month-period, until the next adjustment of the number of units payable (As opposed to uncertainty of mortality rates over the next 30-40 years).
- The risk that the annuity book doesn't follow the trend (Which may be due to the size of the book, or to a situation where the profile of annuitants is significantly different from that of the general population of annuitants).

We note the liability is a function of the number of units to be paid and the survival rates of the annuitants. It is independent of a discount rate – which means there is no interest rate risk.

The number of units the insurer must hold as best-estimate in order to cover future payments is:

$$\mathrm{N_t} = \sum_{\mathrm{k \geq 0}} \mathrm{n_{k+t}} \times \ {}_{\mathrm{k}}\mathrm{p_{x+t}}$$

For t = 0, the liability equals the initial investment, as expected.

The best-estimate liability can be expressed as follows:

$$\mathrm{N_t} = \sum_{\mathrm{k \geq 0}} n_1 \times (1+c)^{-(k+t)+1} \times \ {}_{\mathrm{k}}\mathrm{p_{x+t}}$$

$$\mathrm{N_t} = \frac{n_1}{(1+c)^t} \times a_{x+t}^{(c)}$$

The insurer will hold the best-time number of units to be distributed to the annuitant increased by the prudential factor y_t to allow for the risk of longevity being different than expected.

4. EXAMPLE

We look at a numerical example, with a new retiree wanting to invest 100,000 into an annuity. Traditional and De-risked annuities are compared:

	Traditional Annuity	De-Risked Annuity
Net Premium	100,000	100,000
Best-Estimate Liability (BEL)	90,000	94,950
Frictional Cost of Required Capital (FCRC)	5,000	50
Present Value of Future Profits (PVFP)	5,000	5,000
NAV	10,000	5,050
SCR	15,000	150
Coverage ratio	**67%**	**3367%**
Annuity amount (target rate 2%)	6,000	6330 *+5.5%*

With a stress over a 1-year period instead of the remaining duration of the annuity, the SCR is only a fraction of what it was. Consequences are:

- The annuity amount is 5.5% higher;
- Coverage ratio is 50 times higher.

Note: The SCR of de-risked annuities would vary according to the risk profile of the book, especially whether it is sufficiently diversified to assume that the mortality rates will follow the mortality index.

5. SUMMARY AND CONCLUSION

In this paper, we have attempted to present the challenge of longevity risk in a Risk-Based Capital framework, in particular considering stress margins prescribed by prudential frameworks and the issue of ALM mismatch. We then presented a risk-management strategy based on product features that transfer longevity risk and interest risk to the annuitant.

Richter and Weber (2009) presented an annuity product with a transfer of longevity risk and analysed with Monte-Carlo simulations the impact of the product features. In their conclusion, they propose furthering the concept with investment-linked participation. They acknowledge simulating such mortality-indexed, investment-linked annuities would be a very complex exercise. The present paper decided to take a different approach by incorporating standard calculations of a Solvency Capital Requirement instead of using the probability of loss with stochastic modelling. The outcome is that the impact on prices (through what is called the "prudential price") is much simpler to assess than by using stochastic simulations. It seemed that assessing the decrease in Frictional Cost of Required Capital would be easier to translate into price reduction and increase in solvency coverage ratio.

Some areas of further work would include the analysis of selection risk of an annuity book as compared to say a national mortality index and incorporating this risk in the prudential price of the annuity. This would fall under the required analysis of idiosyncratic risk of an insurer.

As pointed out by Richter and Weber, there are still *discussion and deliberations* to be had to incorporate mortality indices into annuity payments. This paper would like to invite this discussion.

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