Valuation of Longevity linked annuities

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Abstract

Individuals increasingly face the longevity risk of outliving savings build up during their working lives their resources and seek to hedge (insure) it through public PAYGO social security systems, occupational pension plans, private life insurance and annuity products or reverse mortgages.

Although the evolution of mortality improvement is a slow but persistent process, influenced by socioeconomic, biological, environmental and behavioural developments, and past trends suggest that further changes in the level of mortality are to be expected, the truth is that future life expectancy improvements are uncertain and difficult to predict. Predicting how long can humans live is a difficult task that requires high quality mortality data, complex statistical and mathematical models and, possibly, information on the dynamics of biological factors and causes of death.

Longevity risk is the risk that future outcomes in mortality and life expectancy will turn out to be systematically different to expectations. Longevity risk expresses itself as either an idiosyncratic or a specific risk, unique to each individual, or as an aggregate risk or systematic risk which is due to uncertainty regarding overall rates of population mortality increase. Individuals, life insurance companies, annuity providers, corporate pension funds and governments alike are all carriers of longevity risk.

An individual self-managing his or her retirement income through withdrawals from defined contribution (DC) plans, individual retirement accounts or other personal savings faces the risk of outliving one's assets - individual longevity risk - as he or she may draw income at too high a rate. For institutions making payments that depend on how long individuals are going to live, aggregate longevity risk refers to the risk that mortality assumptions are not accurate and retirees live, on average, longer than expected. In a historically low (nearly zero) interest rate environment, aggregate longevity risk as emerged as one of the most significant risk sources financial institutions face, with the potential to adversely affect both their willingness and

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ability to supply retired households with financial products to manage wealth in the payout phase.

A well-functioning annuity market will become increasingly important as Governments cut social security pensions, companies move away from DB plans and as DC plans mature. Among the many demand and supply constraints that still hamper the development of annuity markets, the inability of annuity providers to hedge the aggregate longevity risk they face is one of the most significant. Aggregate longevity risk is already affecting the price and availability of annuity products in DC schemes, and will affect insurance company solvency should the Solvency II proposals be finally adopted. In fact, for insurance companies operating in the European Union the new regulatory regime will require them to hold significant additional capital to back their annuity liabilities unless longevity risk can be hedged effectively or marked to market. There is insufficient capital in the insurance/reinsurance industry to deal with total global private-sector longevity risk. The extra capital that will be required as a result of this new regulatory regime will have, at some point in time, to be passed on to customers, decreasing the money's worth of annuities.

Longevity risk management solutions comprise both traditional insurance and reinsurance techniques and recently developed capital market instruments (longevity bonds, longevity swaps,...). They all normally imply transferring (at least a fraction of) longevity risk to reinsurance companies or financial markets.

In standard level annuities annuity providers bear both systematic and idiosyncratic mortality (and financial) risks. In the recent and current scenarios, characterized by volatility in financial markets, a historically low interest rate environment and trends in mortality / longevity, risks inherent in conventional annuity guarantees have been exacerbated provided that the benefit amount is guaranteed whatever the actual investment yield and the experienced mortality may be.

On the opposite extreme, within Pooled Annuity Funds (PAF) annuitants follow a Group Self Annuitization (GSA) strategy that insures against individual longevity risk but leaves them fully exposed aggregate longevity risk. Pooled annuity funds have many similarities with standard annuities in that the funds released by the participants who die prematurely (mortality credits) are redistributed among the survivors, in that participants renounce to bequest or liquidity motives, in that the decision to purchase pooled annuity fund units is irreversible and in that the advantages of investment diversification are profited, but present a crucial difference: benefit payments are linked to the mortality experience of the group and, as such, leave annuitants' incomes and consumption possibilities exposed to the uncertainty associated with the mortality risk of the group. Pooled annuity funds introduce an automatic adjustment mechanism to "financial" and demographic risk factors in order to ensure that the fund maintains its balance between assets and liabilities. Institutions setting up a pooled

annuity fund act only as managers of the accounts and, thus, do not bear either investment or mortality/longevity risk. This means that pooled annuity funds transfer aggregate longevity risk from annuity providers to fund participants, thus offering an alternative hedging solution.

Compared to standard level annuities, pooled annuity funds include option features that, when neglected, could significantly under(over)estimate annuity payouts.

Pooled annuity funds present an interesting framework for the decumulation stage but, at least in its pure format, generate a number of potential sources of disutility that need to be tackled. First, in a scenario of longevity risk, a pure PAF is expected to pay decreasing annuity benefits, something that may spread discontent through beneficiaries. Second, as in other variable annuity contracts the annuitant does not know in advance the rate of return of the pool, hence it carries some risk.

The main purpose of this paper is to develop an annuity contract by which a fraction of the longevity risk is transferred to annuitants. Within this *longevity-linked life annuity*, benefits would follow a periodic adjustment process according to the evolution of observed longevity prospects. The product could incorporate investment profit participation, so that the potential longevity loss can be offset by the investment profit. Linking the annuity benefit to the mortality experienced in the group of annuitants (or in the overall population) means that risks arising from experienced mortality between annuitants and annuity provider are shared.

By offering this alternative longevity risk hedging mechanism to annuity providers, insurers will be to release some of the capital they are required to hold to back their annuity liabilities and in better conditions to offer more competitive annuity premium.

The dynamics of mortality rates has been modelled using discrete and continuous-time stochastic mortality models (Poisson Lee-Carter model and extensions to include cohort effects), affine jump diffusion models. We have designed different contract structures corresponding to alternative benefit adjustment processes in order to test for its impact on the price of options and guarantees. We are implementing Monte Carlo Simulation Methods to price the contract. We will use a risk neutral simulation approach to price American-style options and guarantees embedded in the longevity-linked life annuity contract.