The New Life Market

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Abstract

The huge economic significance of longevity risk for corporations, governments and individuals has begun to be recognized and quantified. By virtue of its size and prevalence, longevity risk is the most significant life-related risk exposure in financial terms and poses a potential threat to the whole system of retirement income provision. This paper reviews the birth and development of the Life Market, the market related to the transfer of longevity and mortality risks. We note that the emergence of a traded market in longevity-linked capital market instruments would act as a catalyst to help facilitate the development of annuity markets both in the developed and the developing world and protect the long-term viability of retirement income provision globally.

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I. Introduction

The start of the twenty-first century has witnessed the emergence of the "Life Market", the traded market in assets and liabilities linked to longevity and mortality. As one of the world's newest capital markets – and one which is of direct relevance to individuals and institutions in all countries – it has the potential to develop into a very large global market.[1] This is because of the growing recognition that longevity risk is a huge risk that is proving to be highly burdensome to those – corporations, governments and individuals – who have to bear it. It cannot be hedged in existing capital markets, and although it can be transferred via the insurance markets, these currently lack the liquidity to support a fully-fledged traded market.

What was missing until recently were new financial instruments for transferring longevity risk, together with the technology and tools to create a transparent, liquid market (Loeys *et al*., 2007). Over the last few years, these missing ingredients have started to emerge, as evidenced by the first publicly announced longevity derivative transaction between investment bank J. P. Morgan and Lucida, a UK-based insurer, which took place in January 2008 (Lucida, 2008) and a number of similar capital markets and insurance-based transactions that have followed.

As mentioned above, the traditional method of transferring longevity risk is through insurance and reinsurance contracts. An important example of this is provided by pension plan buy-outs which have become prominent in the UK since 2006. This is a segment of the Life Market comprising annuity providers (insurers), pension funds, and reinsurers. This kind of transaction involves the transfer of *all* risks, including longevity risk and investment risk, from the pension plan to the insurance industry. This paper surveys the development of the Life Market, focusing in particular on the longevity risk transfer segment of the market.

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[1] Although the Life Market can be regarded as the world's first organized longevity-linked capital market, there are a number of historical examples of longevity-linked financial instruments that have been issued. These include:

- Tontines: invented by the Neapolitan banker Lorenzo de Tonti in 1653. Each investor paid capital into the tontine and received dividends while alive. When an investor died, his or her share was reallocated to the surviving investors. This process continued until there was only a single survivor. There was no return of principal. The government of King Louis XIV of France became the first government to issue tontine bonds in 1689. The first bond ever issued by the British government in 1693 was a tontine: the proceeds were used to fight the Nine Years War against Louis XIV. Tontines were later banned in the UK and a number of US states because they began to be used to defraud investors. However, they are still legal in other countries. For example, the European Union's First Life Directive allows tontines if they are underwritten by authorized and regulated life offices.
- Sovereign life annuities: sold, for example, by the British government between 1808 and 1929 to members of the public.
- Flower bonds: these are equivalent to a standard bond plus a life insurance policy. They were issued by the US government at a discount to enable their holder to pay federal estate taxes on the holder's death. The bonds were redeemable at par plus accrued interest when the holder died. Flower bonds have not been issued by the US government since 1971.

In Section II, we discuss the problem of longevity risk, distinguishing between so-called macro- and micro-longevity risk. We review the traditional solution for dealing with macro-longevity risk in Section III. We then consider the requirements for capital markets to develop and grow (Section IV). Next, we consider the first generation of bond-based capital market solutions for macro-longevity risk that have been tried so far (Section V). The lessons learned here have informed the design of the second generation of derivatives-based capital market solutions, although there remain barriers to further development (Section VI). Section VII reviews the micro-longevity risk market, while Section VIII discusses life securitization. Finally, we conclude in Section IX. Appendix A examines the main mortality forecasting models, while Appendix B lists some key organizations that have called on governments to support the development of the Life Market.

II. Longevity Risk

Life expectancy has been increasing in almost all the countries of the world.[2] Figure 1 shows the experience for England & Wales (EW) and the US. Male life expectancy at 65 in EW rose from 11.2 years in 1960 to 17.5 years in 2010 or by around 1.1 percent per annum. By contrast, EW female life expectancy at 65 rose from 14.4 years in 1960 to 20.2 years in 2010 or by around 0.8 percent per annum. Figure 2 shows that, maximum life expectancy at birth for females across developed countries has been increasing almost linearly at the rate of nearly three months per year for more than 150 years.[3]

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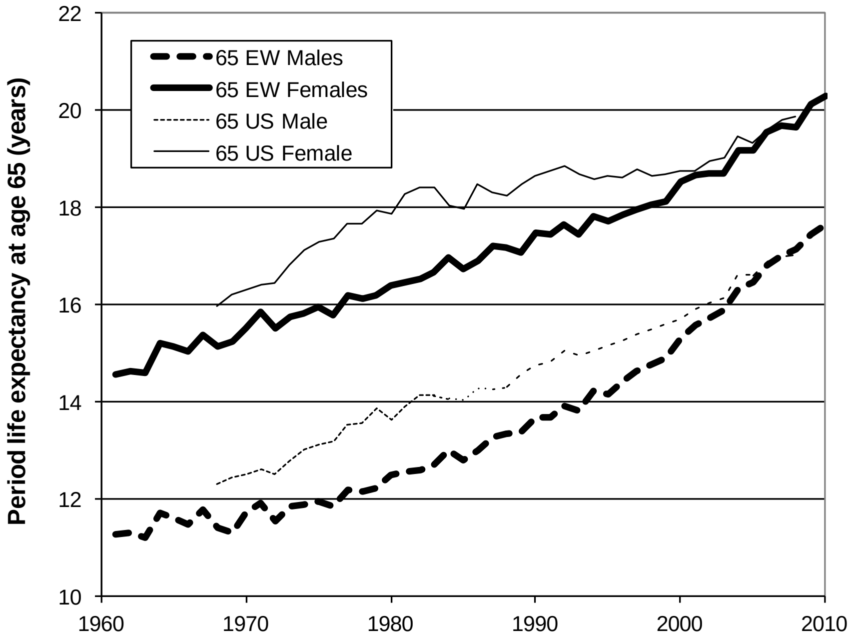
[2] There are only a few exceptions: a current example is Zimbabwe, where male life expectancy at birth has fallen to 37 for males and to 34 for females.

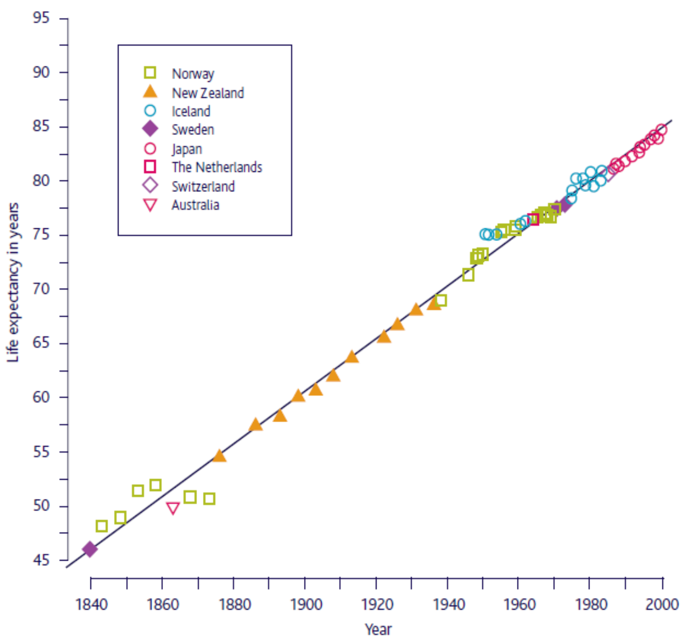
[3] There is no sign of this trend abating according to a recent study: 'Life expectancy in Europe is continuing to increase despite an obesity epidemic, with people in Britain reaching an older age than those living in the United States, according to study of trends over the last 40 years. In a report in International Journal of Epidemiology, population health expert David Leon of the London School of Hygiene and Tropical Medicine said the findings counteract concerns that the rising life expectancy trend in wealthy nations may be coming to an end in the face of health problems caused by widespread levels of obesity. The report comes as news of the US mortality rate fell to an all-time low in 2009, marking the 10th consecutive year of declines as death rates from heart disease and crime dropped. In total, rates declined significantly for 10 of the 15 leading causes of death, including cancer, diabetes and Alzheimer's disease' (Kate Kelland, 'European life expectancy rising despite obesity whilst US mortality rate falls to all time low', 18 March 2011, inside.thomsonreuters.com/trading/ILS/Pages/Europeanlifeexpectancyrisingdespiteobesity.asp. See also Swiss Re (2010a).

Figure 1: Life Expectancy at Age 65 in England & Wales and the US, 1960-2010



Source: J.P. Morgan LifeMetrics data

Figure 2: Record Female Life Expectancy Since 1840



Source: Oeppen & Vaupel (2002)

Although aggregate increases in life expectancy can place burdens on both public and private defined benefit (DB) pension systems, to name one example, they would not necessarily do so if they were fully anticipated. Indeed, many governments and pension plan sponsors have begun to respond to unanticipated increases in life expectancy by requiring individuals to pay higher contributions when they are in work, or by requiring them to work longer. Pension plan members might not like either prospect, but, separately or in combination, they offer the only realistic hope of maintaining the viability of DB pension systems. The UK government, for example, is raising the state pension age (SPA) for women from 60 to 65 between 2010 and 2018 and then raising it for both men and women to 66 by 2020, to 67 by 2028 and to 68 by 2046. It has also removed the default retirement age in private pension plans. In 2010, 8% of the UK workforce above age 65 was still in work.

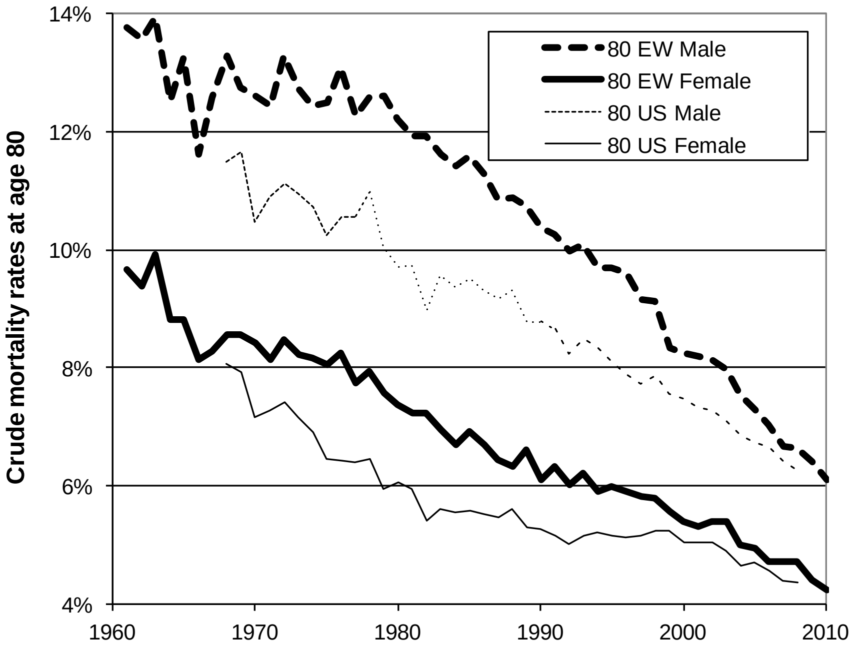
In it important to note that it is not aggregate increases in life expectancy *per se* that are challenging the viability of pension systems. Rather, it is the uncertainty surrounding these increases in life expectancy – as a result of unanticipated changes in mortality rates – that is the real problem. This is what is meant by longevity risk. Furthermore, it is only fairly recently that the stochastic nature of mortality rate changes has begun to be recognized. Figure 3 shows that aggregate mortality rates – in this case those of 80-year-olds in England & Wales and in the US – have been generally declining – in this case since the 1960s – but that changes have an unpredictable element, not only from one period to next, but also over the long run.

A large number of products in pensions and life insurance have longevity as a key source of risk, DB pension plans and annuities, as we have seen, being important examples. These products expose DB plan sponsors and annuity providers to unanticipated changes over time in the mortality rates of the relevant reference populations.

In particular, annuity providers are exposed to the risk that the mortality rates of annuitants will fall at a faster rate than accounted for in pricing and reserving calculations. If the mortality assumption built into the price of annuities turns out to be a gross overestimate, this cuts straight into profit margins of annuity providers. The same argument applies, to sponsors of DB pension plans who will see the cost of pension provision rise steeply and be required to make unexpectedly large contributions into their plans.[4]

[4] Life annuities are a desirable component of retirement income provision throughout the world: they are the only instrument capable of protecting against individual longevity risk. Without them, pension plans would be unable to perform their fundamental task of protecting retirees from outliving their resources for however long they live.

Figure 3: Mortality Rates for 80-year-olds in England & Wales and the US, 1961-2010.



Source: J.P. Morgan LifeMetrics data

Finally, we need to differentiate between what is often called macro- and micro-longevity risk. Macro-longevity risk refers to the longevity risk in a very large group of people, such as members of a large pension plan or the annuitants in the annuity book of a large insurer. The key risk facing those bearing macro-longevity risk is trend risk, the risk of getting the trend improvements in life expectancy wrong. Trend risk is an example of a systematic or aggregate risk. In contrast, micro-longevity risk deals with the longevity risk in a small group of individuals, such as those underlying a life settlements fund – these are investment funds containing individual life assurance policies for a relatively small number of people. The key risk facing those bearing micro-longevity risk is idiosyncratic longevity risk, the risk of underestimating the life times of the individuals whose policies are held in the fund.

III. The Traditional Solution for Dealing with Macro-Longevity Risk

The traditional solution for dealing with unwanted longevity risk in a DB pension plan or an annuity book is to sell the liability via an insurance or reinsurance contract. This is known as a pension buy-out (or pension termination) or, in an insurance context, a group/bulk annuity transfer. Pension buy-outs have come under increasing attention in the UK since 2006 when a number of new insurers started setting up specifically to provide these solutions. In this section we will examine buy-outs and related traditional risk transfer solutions.

Pension Buy-outs

The most common traditional solution for DB pension plans is a full pension buy-out, implemented by a regulated life assurer. The procedure can be illustrated using the following example.

Consider UK-based Company ABC with pension plan assets (A) of 85 and pension plan liabilities (L) of 100, valued on an 'ongoing basis'[5] by the plan actuary; this implies a deficit of 15. ABC approaches life assurer XYZ to effect a pension buy-out. On a full 'buy-out basis', the insurer values the pension liabilities at 120, a premium of 20 to the plan actuary's valuation, implying a buy-out deficit of 35. The insurer, subject to due diligence, offers to take on both the plan assets A and plan liabilities L provided the company contributes 35 from its own resources (or from borrowing) to cover the buy-out deficit. Following the acquisition, the insurer implements an asset transition plan which involves exchanging certain assets, e.g., equities, for bonds, and implementing interest rate and inflation swaps to hedge the interest-rate and inflation risk associated with the pension liabilities.[6]

The advantages to the company are that the pension liabilities are completely removed from its balance sheet. In the case where the company does not have the cash resources to pay the full cost of the buy-out, the pension deficit (on a buy-out basis) is replaced by a loan which, unlike pension liabilities, is an obligation that is readily understood by investment analysts and shareholders. The company avoids volatility in its profit and loss account coming from the pension plan,[7] the payment of levies to the Pension Protection Fund (PPF),[8] administration fees on the plan and the potential drag on its enterprise value attached to the pension plan. The advantages of a buy-out to the pension trustees and plan members are that pensions are now secured in full (subject to the credit risk of the life assurer).

Pension Buy-ins

Buy-ins are insurance transactions that involve the bulk purchase of annuities by the pension plan to hedge the risks associated with a subset of the plan's liabilities, typically associated with retired members. The annuities become an asset of the plan and reflect the mortality characteristics of the plan's membership in terms of age and gender. Buy-ins are often part of the journey to full buy-out. They can be thought of as providing a 'de-risking' of the pension plan in economic terms. They enable the plan to lock-in attractive annuity rates over time, without the risk of a spike in pricing at the very time they decide to proceed directly to a full buy-out. Buy-ins also offer the sponsor the advantage of full immunization of a

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[5] In the UK, this would also be known as the FRS 17 (the UK Pension Accounting Standard) basis.

[6] Traditional UK insurers running annuity books interpret UK regulatory capital requirements as restricting them to invest in government and investment-grade corporate bonds and related derivatives.

[7] This volatility is generated by the way in which accounting standards treat DB pension liabilities.

[8] A statutory fund established by the UK Pensions Act 2004 'to provide compensation to members of eligible defined benefit pension schemes, when there is a qualifying insolvency event in relation to the employer, and where there are insufficient assets in the pension scheme to cover the Pension Protection Fund level of compensation.'

portion of the pension liabilities for a much lower (or even zero) up-front cash payment relative to a full buy-out. Since the annuity contract purchased in a buy-in is an asset of the pension plan, rather than an asset of the plan member, the pension liability remains on the balance sheet of the sponsor.

Longevity Insurance Swaps

A more recent variation on the traditional pension buy-out is the longevity insurance contract, or insurance-based longevity swap. This is effectively an insurance version of the capital-markets-based longevity swap (discussed later), which targets the transfer of longevity risk only. No assets are transferred and the pension plan typically retains the investment risks associated with the asset portfolio. Longevity swaps have the advantage that they remove longevity risk without the need for an upfront payment by the sponsor and allow the pension fiduciaries (such as pension plan trustees) to retain control of the asset allocation. Although insurance-based longevity swaps have been around since the 1990s, they have undergone a transformation in terms of structure and collateralization which has been driven by their capital-markets-based versions. The first customized (non-index) capital-markets-based longevity swap was pioneered between J.P. Morgan and Canada Life (UK) in July 2008, after which insurance companies, such as Rothesay Life, adapted the product to insurance format.

The Early Development of the Market

As previously mentioned, the pension buy-out/buy-in market in the UK began to become active in 2006. Prior to this time, the market was dominated by two life assurers, Prudential (UK) PLC and Legal & General, which did business of approximately £2 billion a year across a large number of small transactions. The total potential size of the buy-out market exceeds £1,000 billion in the UK alone and this encouraged a raft of new players to enter the market. The first of these was Paternoster (which was later acquired by Rothesay Life), but others quickly followed including Pension Insurance Corporation (PIC), Synesis (which was later acquired by PIC) and Lucida (which closed for business in 2012), all of which were backed by investment banks and private equity investors. In February 2007, Goldman Sachs established its own pension insurer, Rothesay Life.

Paternoster conducted its first UK pension buy-out in November 2006 of the Cuthbert Heath Family Plan, a small plan with just 33 members. By the end of 2011, some £40 billion of pension-plan longevity transactions of various types (buy-outs, buy-ins and longevity swaps) had been completed in the UK since 2006[9] out of total potential private sector pension liabilities of £2.1 trillion.[10] This ignores other longevity transactions that did not directly involve pension plans, such as reinsurance deals between insurers and reinsurers

[9] LCP's *Pension Buy-ins, Buy-outs and Longevity Swaps 2012*; Hymans Robertson's *Managing Pension Scheme Risk Report 2011*.

[10] Pensions in the National Accounts: A Fuller Picture of the UK's Funded and Unfunded Pension Obligations, Office for National Statistics, 27 April 2012 [www.ons.gov.uk/ons/rel/pensions/pensions-in-the-national-accounts/uk-national-accounts-supplementary-table-on-pensions--2010-/index.html].

and the longevity swaps pioneered by J.P. Morgan, RBS and Swiss Re. The buy-outs for private sector pension plans had all involved plans that were closed to future accrual. However, in March 2012, PIC executed the first buy-out of a plan open to future accrual: the sponsoring employer, the high-tech manufacturer Denso, will pay PIC an annual premium based on the number of active members and their salaries, but PIC will assume all the liabilities. PIC had previously conducted an innovative buy-in in May 2011 with the London Stock Exchange's defined benefit pension plan which not only insured current pensioner members, but will also automatically insure active and deferred members when they reach retirement.

Recent Market Developments

Recently there have been several other kinds of market developments. For example, in February 2010, Mercer launched a pension buy-out index for the UK to track the cost charged by insurance companies to buy out corporate pension liabilities: at the time of launch, the cost was some 44% higher than the accounting value of the liabilities which highlighted the attraction of using cheaper alternatives, such as longevity swaps. In December 2011, Long Acre Life entered the market to offer cheaper pension insurance solutions to larger schemes with liabilities above £500 million. Under these solutions companies offload their pension plans to an insurance vehicle in which they also invest and so share the profits along with external investors: the target return is 15% p.a. In January 2012, Legal & General began offering longevity insurance (deferred buy-ins) for the 1,000 smaller schemes with liabilities in the range £50-£250 million. In February 2012, Punter Southall, a medium-sized UK pension consultant, adopted PensionsFirst's pension liability and risk management software (PFaroe) to automate the production of actuarial valuations and hence cut costs for pension plans, particularly small ones. In the same month, another medium-sized pension consultant, Hymans Roberton, launched a pension de-risking monitoring service which compares the costs of a full buy-out with the costs of a buy-in covering only pensioner members and the costs of a longevity swap.

In December 2012, the enhanced buy-in market began in the UK for defined benefit pension schemes. An enhanced buy-in is where a scheme's trustees buy a group annuity as in investment of the scheme, where some or all of the members covered by the policy are medically underwritten. Medical underwriting, which is now commonplace in the individual annuity market (i.e., in relation to defined contribution pensions), has the potential to reduce the cost to the scheme of the longevity hedge compared with standard annuities, on the grounds that certain members might have lower than average life expectancy as a result of their lifestyle or some serious life-shortening illness. The market was introduced by two specialist insurers, Partnership and Just Retirement, but other larger insurers followed, e.g., Legal & General which offers a Large Individual Defined Benefit Annuity (LIBDA) service.

Although the UK has led the way in the longevity de-risking of pension plans, certain other countries are showing some progress in this direction, in particular the US, Canada, the Netherlands and Australia.

The US and Canada have fledgling buyout markets, but the level of awareness of, or concern about, longevity risk in the industry is still minimal. However, the US market received a boost in May 2011, when Prudential (US) announced a $75 million buy-in – the first of its kind – that it provided to the pension plan of Hickory Springs Manufacturing Company.

Canada is a market which sees a regular flow of DB pension buyouts and buy-ins, with an annual market size of around CAD $1.5 billion. According to Sun Life Financial, buyouts have been a feature of the Canadian pensions landscape for over a century. Moreover, eight insurance companies regularly quote an annuity proxy rate that is published by the Canadian Institute of Actuaries. In 2011 the biggest buyout conducted in Canada was CAD $400 million. Although buy-ins have been happening in Canada for many years, the first UK-style buy-in that was executed as part of a de-risking plan took place in 2009. This buy-in was CAD $50 million in size and provided by Sun Life Financial. In May 2011, a new regulation was approved by the Ontario government to allow Nortel to execute a de-risking program and transfer the whole plan to another provider, which need not necessarily be an insurer (Pichardo-Allison, 2011). Nortel had been Canada's biggest company and had filed for bankruptcy in 2009, leaving its underfunded CAD $2.5 billion pension plan without a viable sponsor. This regulatory change included a one-time approval for Nortel pensioners to commute their benefits (i.e., take a lump sum). Contrary to what was initially reported, the purchase of annuities has not yet been completed, but is expected in 2013/14. More recently, in 2012 Sun Life announced a second buy-in worth CAD $20 million for an un-named Canadian DB pension plan.

In June 2012, General Motors Co. (GM) announced a huge deal to transfer up to $26 billion of pension obligations relating to its blue-collar retirees to the Prudential (US) (General Motors, 2012). This is by far the largest ever longevity risk transfer deal globally. The transaction is effectively a partial pension buyout involving the purchase of a group annuity contract for GM's salaried retirees who retired before December 1, 2011 and refuse a lump sum offer in 2012. To the extent retirees accept a lump sum payment in lieu of future pension payments, the longevity risk is transferred directly to the retiree.[11] The deal is a 'partial buyout' rather than a buy-in because it involves settlement of the obligation. In other words, the portion of the liabilities associated with the annuity contract will no longer be GM's obligation. Moreover, in contrast to a buy-in, the annuity contract will not be an asset of the pension plan, but instead an asset of the retirees. In October 2012, GM did a $3.6 billion buy-out of the pension obligations of its white-collar retirees. Also in October 2012, Verizon Communications executed a $7.5 billion bulk annuity buy-in with Prudential (US).

Pension buyouts have been a feature of the industry in the Netherlands for a number of years, but have been typically small in size, EUR20 – 50 million. In November 2009, the food manufacturer Hero pension plan implemented the first buy-in in the Netherlands, a EUR44 million deal with Dutch insurer, Aegon. The pension plan was looking to execute a buyout, but, being just 100% funded on a buyout basis, was concerned that market volatility

[11] In fact, the lump sum is only being offered to limited cohorts of plan members.

might push the buyout out of reach before the necessary consent from participants and the regulator could be obtained (Aegon, 2010). The buy-in ensured that the funding level was locked-in and provided time to get these approvals. Then the buyout followed in early 2010. Aegon also closed a larger buyout in early 2011, with a EUR270 million deal for the Nutreco pension plan.

Then in February 2012, Deutsche Bank executed a massive EUR12 billion index-based longevity solution for Aegon in the Netherlands (Deutsche Bank, 2012). This solution was based on Dutch population data and enabled Aegon to hedge the liabilities associated with a portion of its annuity book. Because the swap is out of the money, the amount of longevity risk actually transferred is far less than that suggested by the EUR 12 billion notional amount. Nonetheless the key driver for this transaction from Aegon's point of view was the reduction in economic capital it achieved. Most of the longevity risk has been passed to investors in the form of private bonds and swaps. This was the first such deal executed in continental Europe, but contrary to what was claimed in the press release, it was not the first longevity transaction to target directly the capital markets. That first was achieved by J.P. Morgan four years earlier in 2008. Indeed, J.P. Morgan's q-forward with Lucida in January 2008 and its customized longevity swap with Canada Life UK were pure capital markets transactions in which the longevity risk was placed with capital markets investors.

While Australia does not boast a large defined benefit pension market for which longevity risk is a huge concern, it has nonetheless seen two longevity swap hedges executed by local insurers (Swiss Re, 2010b). Swiss Re provided these insurance-based swaps to hedge the longevity risk associated with the insurers' lifetime annuity portfolios by transferring longevity risk via a reinsurance treaty. Under the treaty, each insurer pays a stream of regular fixed premium amounts and receives a stream of regular floating annuity benefits. The two Australian insurance companies involved have wished to remain anonymous.

In a separate US development in_September 2011, CAMRADATA Analytical Services launched a new pension risk transfer (PRT) database for US pension plans. The database provides insurance company organizational information, pension buy-in and buy-out product fact sheets and screening tools, pricing data, up-to-date information on each PRT provider's financial strength and relevant industry research. Users can request pension buy-in and buy-out quotes directly from providers, including Pacific Life, American General Life Companies, MetLife, Principal Financial Group, Prudential (US), Transamerica and United of Omaha.

The Benefits of Pension De-risking

There is some recent evidence that the markets reward corporate pension de-risking. A study by the law firm Freshfields Bruckhaus Deringer analyzed 26 de-risking deals in the UK, comprising 6 buy-outs, 15 buy-ins and 5 longevity swaps; 23 of the deals were by FTSE350 companies and 3 by international corporations with UK subsidiaries. Although the share price fell immediately following the announcement of a de-risking transaction in two-thirds of cases, it eventually rose by 1.3% (relative to the market) over a longer period. There was a larger impact on UK companies with the share price rising on average by 1.9% (relative to the market). In the case of the international companies – Denso, BMW and Pall – the share price actually fell by 1.6% on average (Towler, 2012).

IV. Capital Market Solutions for Macro-Longevity Risk

How Does a New Capital Market Start?

Loeys *et al*. (2007) explain that for a new capital market to be established and to succeed, 'it must provide *effective exposure*, or hedging, to a state of the world that is *economically important* and that *cannot be hedged through existing market instruments*, and it must use a *homogeneous and transparent contract* to permit exchange between agents.' They argue that 'longevity meets the basic conditions for a successful market innovation.' We will examine these conditions in more detail.

Effective Hedging. There are a number of ways in which those exposed to longevity risk can respond:

- Accept longevity risk as a legitimate business risk and hope to earn a risk premium from bearing it;
- Share longevity risk: e.g., by requiring pension plan members to work longer, by capping the plan sponsor's contributions and requiring an increase in members' contributions if the costs of longevity increases exceed the cap, or by selling participating annuities where payments are rebased in the light of mortality experience;
- Insure/reinsure;
- Securitize;
- Manage or hedge longevity risk with longevity-linked instruments traded in the capital market.[12]

To ensure long-term viability, it is critical that a traded capital market instrument meets the needs of both hedgers and speculators (or traders). The former require hedge effectiveness, while the latter demand liquidity. Liquidity requires standardized contracts. The fewer the number of standardized contracts traded, the greater the potential liquidity in each contract, but the lower the potential hedge effectiveness. There is therefore an important tradeoff to be made, such that the number of standardized contracts traded provides both adequate hedge effectiveness and adequate liquidity.

If it is ever to achieve adequate liquidity, it is likely that the Life Market will have to adopt mortality indices based on the national population as the primary means of transferring longevity risk. However, potential hedgers, such as life assurers and pension funds, face a longevity risk exposure that is specific to their own policyholders and plan members: for

[12] See Blake et al. (2006b, p. 155-156) for further details about these five ways of responding to longevity risk.

example, it might be concentrated in specific socio-economic groups or in specific individuals such as the sponsoring company's directors. Hedging using population mortality indices means that life assurers and pension funds will face basis risk if their longevity exposure differs from that of the national population.[13] Herein lies the tension between index-based hedges and customized hedges of longevity risk.

The two most important factors influencing mortality differences are age and gender. Socio-economic status is an important third factor, capturing lifestyle influences such as smoking, fitness and diet. While there is official publicly available information on age and gender mortality trends within national populations, the same is not true for socio-economic status. Population mortality indices will therefore be restricted to covering age and gender. But these will still be sufficient to minimize basis risk over time if the mortality rates of different socio-economic groups also change over time in a similar manner. Coughlan *et al*. (2007a, 2011) show that, although the correlations between mortality rates across different socio-economic groups are not high on an annual basis due to noise from one year to the next, they are very high when averaged over the 10-year periods that are more relevant for hedgers. This means that the basis risk from using population mortality rates turns out to be low over the hedging period relevant for life assurers and pension funds. This, in turn, means that capital market hedging instruments based on national mortality indices can, in principle, provide effective hedges. The hedges will not, however, be perfect, because of residual basis risk.

<u>Economic Importance</u>. To justify the establishment of a capital market to trade longevity risk, the collective needs of its users must be sufficiently large. A number of institutions are "short" longevity in the sense that their liabilities increase if longevity increases. These include life companies selling annuities, pension funds and the state via the state pension system and the pension plans of its own employees. Swiss Re estimates the total global exposure to be around $21 trillion.[14]

Other institutions are 'long' longevity in the sense that their liabilities reduce or revenues increase if longevity increases. These include life companies selling term life and whole-of-life insurance policies, pharmaceutical companies selling medicines to the elderly, long-term care homes, and 'gray gold' states like Florida which attract rich elderly residents and hence benefit from the taxes these residents pay (White, 2002).

Of all these entities, life companies and pension funds have the greatest potential to benefit from the establishment of the Life Market. However, a market needs to have a good balance between the demand for and supply of longevity instruments: this will influence the overall size of the market as well as the market price of longevity risk. Collectively, life companies and pension funds are net short longevity and need to offer a risk premium to encourage investors to take the requisite long positions. In other words, hedgers – annuity providers

[13] Basis risk is the risk associated with imperfect hedging where the movements in the underlying exposure are not perfectly correlated with movements in the hedging instrument.
[14] See Katy Burne 'Swiss Re Longevity-Risk Deal Opens Door to More', *Wall Street Journal*, 7 January 2011.

and pension funds – need to pay an appropriate risk premium to lay off the longevity risk they currently assume.

Annuity providers and pension plans can already, as has already been mentioned, sell their liabilities using insurance contracts, but the cost of selling the longevity risk is bundled up with the costs of selling the other risks. This lack of transparency has often given the impression that insurance is an expensive option for pension plans. The reality is simply that the common metrics used by the pensions industry for measuring pension liabilities (particularly accounting and funding metrics) are not economically realistic and do not capture the true cost of the liabilities and their associated risks. The capital markets are already facilitating the unbundling of risks, improving transparency and raising the awareness among pension plan fiduciaries and their advisors of the true cost of longevity risk.

Another structural aspect of the market that can be addressed by capital markets solutions is that of capacity. Although it has grown significantly, there is currently a limited amount of capacity and capital within the insurance and reinsurance industry to assume these risks. If the entire DB pension market in the UK wished to effect a buy-out in the next two years, there simply wouldn't be enough insurance and reinsurance capacity available globally. The capital markets can bring new investors into the market who can provide new capital in new ways to support the longevity and other risks attached to pension provision.

The involvement of the capital markets will help to reduce the cost of managing longevity risk. This is because it should lead to an increase in capacity, together with greater pricing transparency (as a result of the activities of arbitrageurs[15]) and greater liquidity (as a result of the activities of speculators). These conditions should attract the interest of hedge funds, endowments, sovereign wealth funds, family offices and other investors seeking asset classes that have low correlation with existing financial assets. Longevity-linked assets naturally fit this bill.

Governments could help to both encourage and facilitate the development of this market. Governments have an important role in maintaining the stability of the financial system and in ensuring that the infrastructure is in place for an ageing population to be supported by a fair and adequate pension system. In this capacity, governments could also play a pump-priming role, as argued some years ago by the UK Pensions Commission (2005). Governments could issue longevity bonds (see Section V below) to establish the riskless term structure for the longevity risk premium as they do in the inflation-linked bond market in respect of the inflation risk premium. Regular issuance of longevity bonds – even in small size – would provide pricing points to catalyze the development of the market, in addition to providing value as a hedging instrument. Of particular concern is the over 90s, the age group that has been described in the UK as the 'toxic tail' of the annuity business: these are people who live very much longer than expected. It has been suggested that the UK government, in particular, could help by selling deferred annuities for those aged 90 and

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[15] However, to be effective, arbitrageurs need well-defined pricing relationships between related securities and we are still at the very early days in the development of this market.

above.[16] There would be a form of risk sharing between the state and the private sector. The state's contribution to hedging aggregate longevity risk would be to issue these instruments, leaving the private sector (life companies and the capital markets) to design better annuity products and trade longevity risk up to age 90. The main benefit from a capital market perspective of a government-issued longevity instrument would be to offer a standardized liquid benchmark that would help to establish the risk-free price of longevity risk at different terms to maturity.

Ineffectiveness of Existing Hedging Instruments. There would be little point in establishing a new class of hedging instrument to hedge longevity risk if this risk could be hedged with existing financial instruments. Loeys *et al*. (2007) examine the correlations between 5-year US and UK mortality changes against US and UK equity and bond returns and show that these are not significantly different from zero. They conclude that 'existing markets provide no effective hedge for longevity and mortality risk.'

Homogeneous and Transparent Instruments. The final requirement for a capital market to succeed is for the instruments that are traded to be homogeneous and transparent. In Sections V and VI below, we examine the success to date of attempts to create a capital market in longevity risk transference, but before doing so we briefly examine the process by which markets evolve.

How Do Capital Markets Evolve?

Richard Sandor, Director of Chicago Climate Exchange, argues that there are seven stages of market evolution. These are shown in Table 1. Sections V and VI of this paper will also help us assess the current stage in the development of the Life Market.

Table 1: Sandor's Seven Stages of Market Evolution

Number	*Stage*
1	Structural change – leading to a demand for capital
2	Development of uniform commodity/security standards
3	Introduction of legal instruments providing evidence of ownership
4	Development of informal spot and forward markets
5	Emergence of formal exchanges
6	Introduction of organized futures and options markets
7	Proliferation of over-the-counter (OTC) markets, deconstruction.

Source: Sandor (1994, 2003).

[16] This suggestion has been made by Tom Boardman, former director of Prudential PLC and Visiting Professor at the Pensions Institute at Cass Business School.

V. First Generation Capital Market Solutions

Mortality Bonds

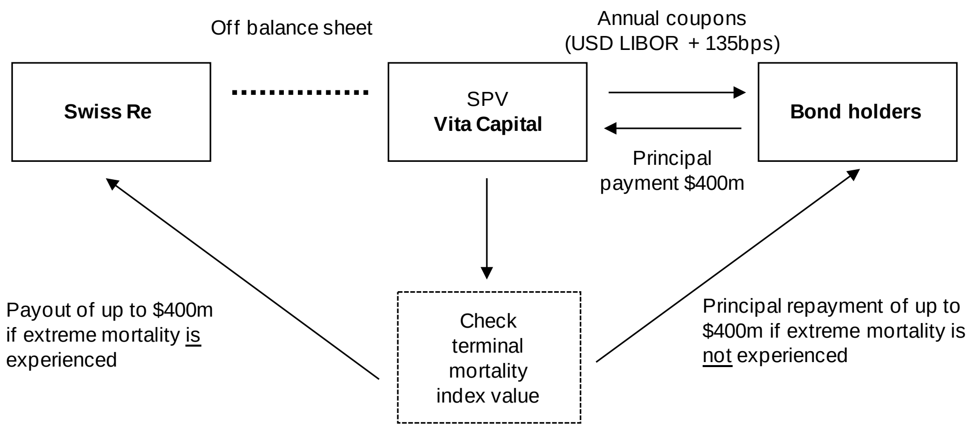
Mortality bonds are short-dated, market-traded securities whose payments are linked to a mortality index. They are similar to the catastrophe bonds that are linked to earthquakes and storms. As such, they are designed to hedge mortality or 'brevity' risk, rather than hedge longevity risk – the principal concern of this paper – but, as an important successful example of a Life Market instrument, they are included in the paper for completeness.

The first such bond issued was the Swiss Re mortality bond – known as Vita I – which came to market in December 2003. This was designed to securitize Swiss Re's own exposure to mortality risk. Vita I was a 3-year bond – maturing on 1 January 2007 – which allowed the issuer to reduce exposure to catastrophic mortality events: a severe outbreak of influenza, a major terrorist attack using weapons of mass destruction or a natural catastrophe. The mortality index had the following weights:

- US (70%), UK (15%), France (7.5%), Italy (5%), Switzerland (2.5%);
- Male (65%), Female (35%);
- For various age bands.

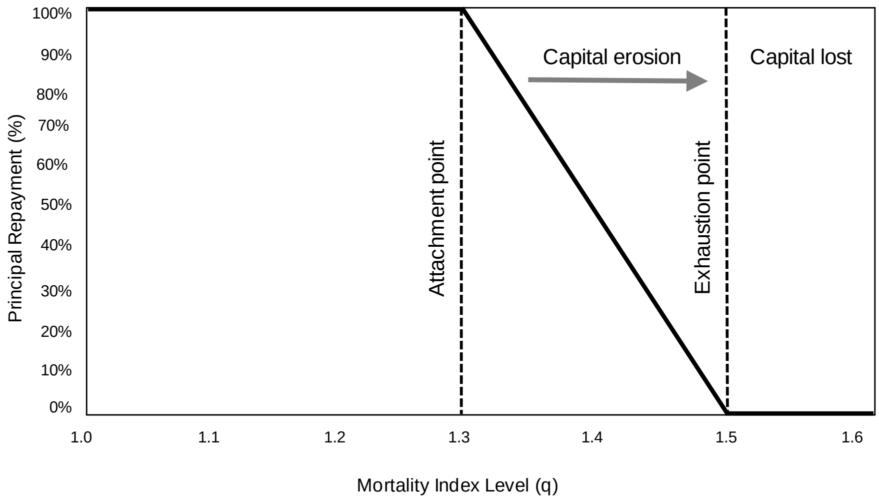
The $400 million principal was at risk if, during any single calendar year, the combined mortality index exceeded 130 percent of the baseline 2002 mortality level, and would be exhausted if the index exceeded 150 percent. This is equivalent to a call option spread on the mortality index with a lower strike price of 130 percent and an upper strike price of 150 percent. In return for having their principal at risk, investors received quarterly coupons of 3-month USD LIBOR + 135bp (see Figures 4 and 5).

Figure 4: The Structure of the Swiss Re Mortality Bond



Source: Blake et al. (2006b, Figure 2)

Figure 5: Principal-at-risk in the Swiss Re Mortality Bond



Source: Adapted from Blake et al. (2006b, Figure 1)

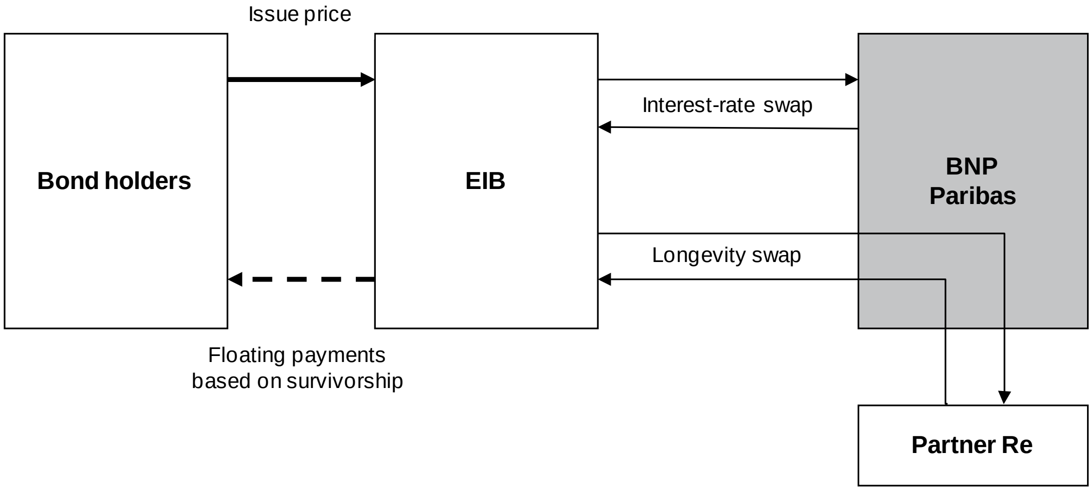
The bond was valued by Beelders and Colarossi (2004) using extreme value theory. Assuming a generalized Pareto distribution, the authors estimated the probability of attachment (i.e., Prob[MI(t)>1.3MI(2002)], where t = 2004, 2005 or 2006) to be 0.33 percent, and the probability of exhaustion (i.e., Prob[MI(t)>1.5MI(2002)]) to be 0.15 percent. The expected loss was estimated to be 22bp which was below the 135bp risk premium paid to investors. The main investors were pension funds. For them, the bond provided both an attractive return and a good hedge: if there had been a catastrophic mortality event during the life of the bond, the bond's principal would have been reduced, but so would the payouts to pensioners who would also be victims of the event.

This bond was a big success and led to additional bonds being issued on much less favorable terms to investors: e.g., Vita II – Swiss Re 2005 ($362 million), Vita III – Swiss Re 2007 ($705 million), Vita IV – Swiss Re 2009/10 ($175 million), Vita V – Swiss Re 2012 ($275 million), Tartan – Scottish Re 2006 ($155 million) and OSIRIS – AXA 2006 ($442 million).

Longevity Bonds

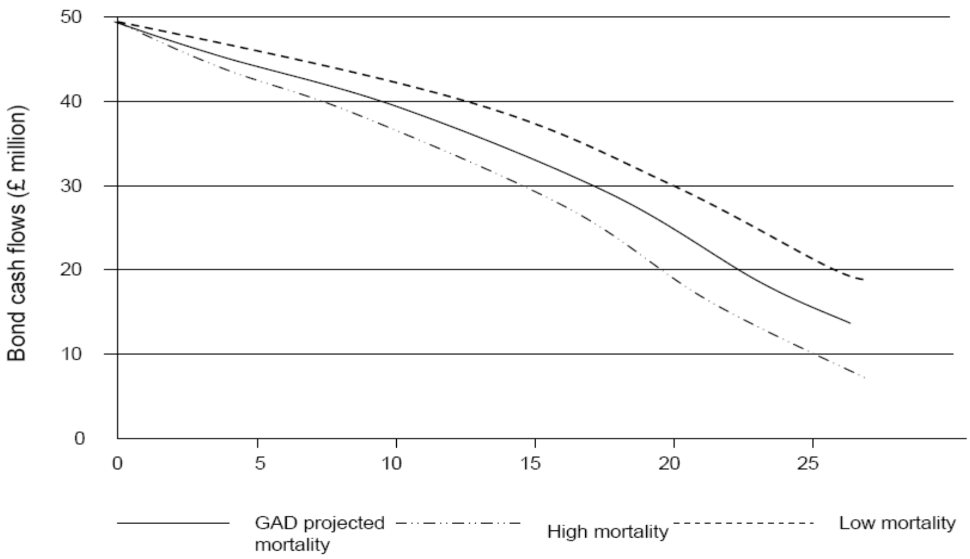
One of the earliest attempts at creating a capital market in longevity-related instruments was the proposal to issue long-dated longevity bonds (or survivor bonds) made over a decade ago (see, e.g., Blake and Burrows, 2001; and Blake *et al.*, 2006a). These are life annuity bonds with no return of principal whose coupon payments decline in line with a mortality index, e.g., based on the population of 65-year olds on the issue date. As this population cohort dies out, the coupon amounts decline but continue in payment for a fixed term (in the case of longevity bonds) or until the entire cohort dies (in the case of survivor bonds). To illustrate, if after one year, 1.5 percent of the reference population has died out, the second year's coupon payment will be 98.5 percent of the first year's payment, etc.

Figure 6: The Structure of the EIB Longevity Bond



Source: Adapted from Blake et al. (2006b, Figure 4)

Figure 7: Coupons on the EIB Longevity Bond



Source: UK Government Actuary's Department

The first attempt to issue a longevity bond was in November 2004 when the European Investment Bank (EIB) attempted to launch a 25-year £540 million longevity bond with an initial coupon of £50 million. The reference mortality index was based on 65-year-old males from the national population of England & Wales as produced by the UK Government Actuary's Department (GAD). The structurer/manager was the French bank BNP Paribas which assumed the longevity risk, but reinsured it through PartnerRe, based in Bermuda: see Figure 6. The target group of investors was UK pension funds. Figure 7 shows how the coupons might change on the bond: if mortality is lower than projected by the GAD, the coupons on the bond will decline by less than anticipated and vice versa. The bond holder, e.g., a pension fund paying pensions to retired workers, is therefore protected from the aggregate longevity risk it faces.

Problems

After a year of marketing, the EIB longevity bond had not generated sufficient demand to be launched and was withdrawn. There are a number of reasons why the BNP bond did not launch: design issues which made the bond an imperfect hedge for longevity risk, pricing issues, institutional issues and educational issues. We examine each of these in turn.

<u>Design Issues</u>. The EIB bond had a number of design weaknesses. The basis risk in the bond was considered to be too great. The bond's mortality index was a single cohort of 65-year-old males from the national population of England & Wales. While this might provide a reasonable hedge for male pension plan members in their 60s, pension plans also have male members in their 70s and 80s as well as female members.

<u>Pricing Issues</u>. The longevity risk premium built into the initial price of the EIB bond was set at 20 basis points (Cairns *et al.*, 2005). Given that this was first ever bond brought to market, investors had no real feeling as to how fair this figure was. There was concern that the up-front capital was too large compared with the risks being hedged by the bond, leaving no capital for other risks to be hedged. In addition to hedging interest rate risk, this bond also hedged longevity risk, but the bond's payments were in nominal terms and hence did not hedge inflation risk.

<u>Institutional Issues</u>. There were a range of institutional issues that the bond's designers at BNP failed to confront. For a start, the issue size was too small to create a liquid market: market makers did not welcome the bond because they believed it would be closely held and they would not make money from it being traded.

Further, BNP did not consult sufficiently widely with potential investors or their advisers before the bond was announced. Advisers were reluctant to recommend it to pension plan trustees. They said they welcomed the introduction of a longevity hedge, but did not like the idea of the hedge being attached to a bond. Indeed, they were somewhat suspicious of capital market hedging solutions *per se*, preferring instead insurance indemnification solutions, such as buy-outs. In other words, advisers and trustees were used to dealing with risk by means of insurance contracts which fully removed the risk concerned and were not yet comfortable with capital market hedges that left some residual basis risk. Fund managers at the time did not have a mandate to manage longevity risk, and similarly saw no reason to hold the bond.

The reinsurer, Partner Re, was not perceived as being a natural holder of UK longevity risk. This turned out to be a rather significant point, since it was discovered that no UK-based or

EU-based reinsurer was willing to provide cover for the bond, and Partner Re itself was not prepared to offer cover above issue size of £540 million.

Educational Issues**.** The longevity bond was a very new concept that was completely unfamiliar to most players in the market. For it to be successful, a major educational effort would have been needed on all the issues discussed above, especially, structure, basis risk, hedge effectiveness and liquidity. This education process needed to be broad enough to cover the entire industry and involve DB plan sponsors, fiduciaries, investment consultants, plan actuaries and insurers.

Lessons Learned

The EIB bond was a very innovative idea and it is disappointing that it was not a success. Nevertheless important lessons have been learned from its failure. Two of the most important lessons relate to mortality indices and mortality forecasting.

Mortality Indices. The EIB bond's actual cash flows would have been linked to the mortality of 65-year-old males from England & Wales. This single mortality benchmark was considered to be inadequate to create an effective hedge. It soon became apparent that what was needed was a set of mortality indices against which capital market instruments could trade. The first attempt to do this was the Credit Suisse Longevity Index in 2005 (which was developed for the US population). However, this index lacked transparency and was not actively marketed by Credit Suisse.

A much more successful effort was the launch of the LifeMetrics Indices in March 2007, by J. P. Morgan in conjunction with the Pensions Institute and Towers Watson.[17] The indices comprise publicly available mortality data for national populations, broken down by age and gender. Both current and historical data are available and the indices are updated to coincide with official releases of data. The indices cover the key countries, the UK, the US, Holland and Germany, where longevity risk is perceived to constitute a significant economic problem. In launching LifeMetrics, J.P. Morgan recognized the critical importance of education and provided educational materials, including documentation, software, data and presentations to the industry at no cost.

In March 2008, the Market Data & Analytics department of the Deutsche Börse followed J.P. Morgan's lead and began publishing monthly indices (named Xpect-Indices) on mortality and life expectancy, the purpose of which is to aid the 'securitization for life and pension insurance risks or as the basis for other financial products'. The indices are

[17] LifeMetrics is also the name of a toolkit for measuring and managing longevity and mortality risk, designed for pension plans, sponsors, insurers, reinsurers and investors. LifeMetrics enables these risks to be measured in a standardized manner, aggregated across different risk sources and transferred to other parties. It also provides a means to evaluate the effectiveness of longevity/mortality hedging strategies and the size of basis risk. The components of the toolkit are: (1) *Indices*: data for evaluating current and historical levels of mortality and longevity, (2) *Framework*: a set of tools, methods and algorithms for measuring and managing longevity and mortality risk. These are fully documented in the LifeMetrics Technical Document (Coughlan *et al.*, 2007a), (3) *Software*: software for developing mortality projections [www.lifemetrics.com].

published for Germany and its regions, Holland and England & Wales. In March 2012, Deutsche Börse teamed up with Club Vita, a UK longevity data and analytics company, to launch a series of Xpect – Club Vita longevity indices to make it easier for small pension plans to hedge their longevity risk.

In October 2012, RMS launched a series of mortality indices and models via a platform called RMS LifeRisks. The two principal models are the RMS Longevity Risk Model and the RMS Excess Mortality Risk Model for pandemic, terrorism and natural catastrophe risk. The platform allows life insurance companies and pension funds in the UK, the US, France, Germany, Holland and Canada to model and manage their exposure to longevity and mortality risks, taking into account recent medical research and social change projections.

The availability of these indices should greatly aid the development of the Life Market as the indices are objectively calculated (by an independent calculation agent, and subject to oversight by an international advisory committee), transparent (the data sources and calculation methodologies are fully disclosed) and relevant (the mortality indices are available by country, age and gender and useful longevity risk hedging instruments are being designed using them). This view is supported by the Organization for Economic Cooperation and Development (OECD) which began a two-year research project on managing longevity risk in January 2011. It is expected that the project will recommend the governments issue official life expectancy indices.

Mortality Forecasting Models. The EIB bond's projected cash flows depended on projections of the future mortality of 65-year-old males from England & Wales. These projections were prepared by the UK GAD, but the model used to make these predictions was not published and the projections themselves were adjusted in response to expert opinion in a way that is not made transparent. What was needed to complement transparent mortality indices were more transparent stochastic mortality forecasting models.

This deficiency was addressed over the subsequent years by a number of researchers who developed and published different forecasting models (see Appendix A) and by the provision of transparent software by J.P. Morgan in its LifeMetrics product and by the UK Actuarial Profession's Continuous Mortality Investigation (CMI) group.

Longevity Notes

In December 2010, building on the successful Vita Capital programme of mortality bonds and taking on board the lessons learned from the EIB bond, Swiss Re launched a series of eight-year longevity-based insurance-linked securities (ILS) notes valued at $50 million. To do this, it used a special purpose vehicle, Kortis Capital, based in the Cayman Islands. As with the mortality bonds, the longevity notes are designed to hedge Swiss Re's own exposure to longevity risk.[18]

The note holders are exposed to the risk of an increase in the spread between the annualized mortality improvement in English & Welsh males age 75 to 85 and the corresponding improvement in US males age 55 to 65. The mortality improvements will be measured over eight years from 1 January 2009 to 31 December 2016. The notes mature on 15 January 2017, although there is an option to extend the maturity to 15 July 2019. The principal will be at risk if the Longevity Divergence Index Value (LDIV) exceeds the attachment point or trigger level of 3.4% over the risk period. The exhaustion point, at or above which there is no return of principal, is 3.9%. The principal will be reduced by the principal reduction factor (PRF) if the LDIV lies between 3.4% and 3.9%.

The LDIV is derived as follows. Let $m^y(x,t)$ be the male death rate at age *x* and year *t* in country *y*. This is defined as the ratio of deaths to population size for the relevant age and year. Annualized mortality improvements over *n* years are defined as:

$$Improvement_n^y(x,t) = 1 - \left[\frac{m^y(x,t)}{m^y(x,t-n)}\right]^{\frac{1}{n}} \tag{1}$$

The annualized mortality improvement index for each age group is found by averaging the annualized mortality improvements across ages in the group:

$$Index(y) = \frac{1}{1+x_2-x_1}\sum_{x=x_1}^{x=x_2} Improvement_n^y(x,t) \tag{2}$$

The LDIV is defined as:

$$LDIV = Index(y_2) - Index(y_1) \tag{3}$$

where y_2 is the England & Wales population aged 75-85 and y_1 is the US population aged 55-65. The PRF is calculated as follows:

$$PRF = \frac{LDIV - Attachment\ point}{Exhaustion\ point - Attachment\ point} \tag{4}$$

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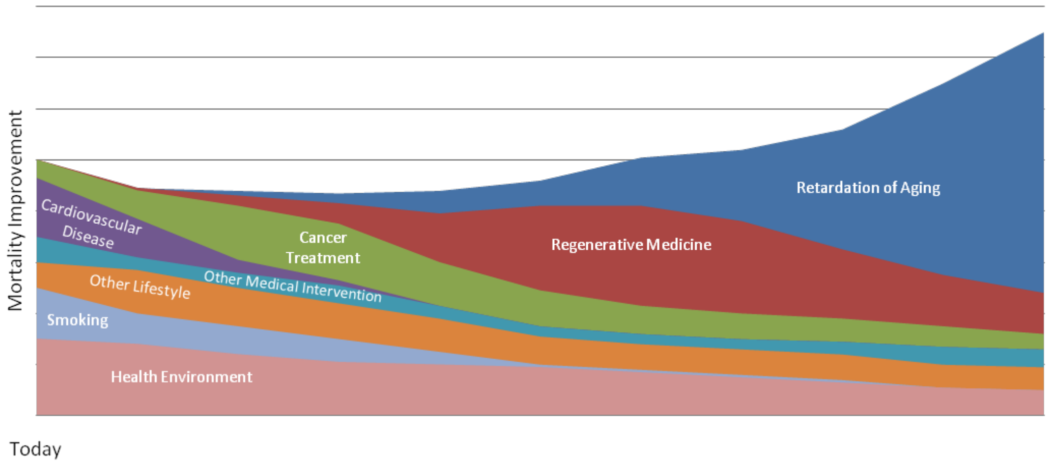
[18] It is important to recognize that the Kortis longevity note was not a true longevity bond in the sense we have described above, because it involved transferring the risk associated with the spread (or difference) between the longevity trends for two different population groups, rather than the trends themselves.

Proceeds from the sale of the notes were deposited in a collateral account at the AAA-rated International Bank for Reconstruction and Development (i.e., the World Bank). If there is a larger-than-expected increase in the spread between the mortality improvements of 75-85 year old English & Welsh males and those of 55-65 year old US males, part of the collateral will be sold to make payment to Swiss Re and, as a consequence, the principal of the notes will be reduced. The exposure Swiss Re is hedging comes from different sources. For example, Swiss Re is the counterparty in a £750 million longevity swap with the Royal County of Berkshire Pension Fund which was executed in 2009, and so is exposed to high-age English & Welsh males living longer than anticipated. It has also reinsured a lot of US life insurance policies and is exposed to middle-aged US males dying sooner than expected. The longevity note provides a partial hedge for both exposures and will help Swiss Re reduce Solvency II capital.

Standard & Poor has rated the notes BB+ which takes into account the possibility that investors will not receive the full return of their principal. This rating was determined using two models developed by Risk Management Solutions (RMS) who were appointed as the calculation agent for the notes.

The first model is the RMS longevity model. This is the base model used to project mortality and variations in mortality during normal conditions when there are no extreme mortality events. The projections depend on a number of so-called ‘vitagion categories’ or individual sources of mortality improvement (see Figure 8). The five categories used by RMS are: lifestyle trends; health environment; medical intervention; regenerative medicine, such as stem cell research, gene therapy and nanomedicine; and the retardation of ageing, including telomere shortening and caloric restriction. RMS projects annual deaths arising from each vitagion category in the base model in order to determine the baseline probability of default of the notes.

Figure 8: Timeline into the Future



Note: Structural Modelling of medical-based mortality improvement explores the timing, magnitude, and impact of different phases of new medical advances on the horizon.
Source: RMS (2010) 'Longevity Risk'.

The second model is the RMS infectious diseases model. This is used to estimate the additional mortality arising from the outbreak of certain infectious diseases, e.g., pandemic influenza. Such an outbreak is likely to be the principal reason that the attachment point is reached during the life of these notes.

Table 2 shows estimated loss probabilities for the notes using the RMS models, while Table 3 shows the estimated exceedance probabilities.

Table 2: Estimated Loss Probabilities for the Swiss Re Longevity Notes

	Cumulative (%)	*Six-year annualized (%)*
Attachment probability	5.31	0.88
Exhaustion probability	1.81	0.30
Expected loss	3.27	0.55
Source: Standard & Poors		

Table 3: Estimated Loss Exceedance Probabilities for the Swiss Re Longevity Notes

Principal reduction factor (%)	*Six-year annualized exceedance probability (%)*
100	0.30
80	0.38
60	0.47
40	0.58
20	0.72
0	0.88
Source: Standard & Poors	

In exchange for putting their capital at risk, investors receive quarterly coupons equal to three-month LIBOR plus a margin. This is the first time that the risk of individuals living longer than expected has been traded in the form of a bond. If the notes can deal with the data and modelling problems discussed above and, as a result, generate some trading liquidity, this would make a significant breakthrough for the Life Market. Investors have been reluctant to hold longevity risk long term, but short-term notes might make holding the risk more acceptable.

Sovereign Annuities

In 2011, the Irish government passed legislation which created sovereign annuities. This followed a request from the Irish Association of Pension Funds and the Society of Actuaries in Ireland. According to the Irish Pensions Board: 'A sovereign annuity is an annuity contract issued by insurance companies where the annual income payment is linked directly to payments under bonds issued by Ireland or any other EU Member State (known as reference bonds). Sovereign annuities can only be purchased by the trustees of occupational pension schemes (both defined benefit and defined contribution schemes)'.[19] If the bonds are purchased by Irish pension funds, this will have a beneficial effect on the way in which the Irish funding standard values pension liabilities.

Longevity Bonds Again

We end this section with a second example of a failed attempt to issue longevity bonds.

In 2006, the World Bank engaged the insurance regulator in Chile, the *Superintendencia de Valores y Seguros* (SVS), on longevity hedging (Zelenko, 2011). The SVS showed a willingness to promote longevity risk management and to provide explicit regulatory capital relief to insurers who hedged the risk. An initial feasibility project was then conducted with the involvement of BNP Paribas in 2008, but the effort stalled due to the high cost of the proposed World Bank-issued longevity bond structure. Then the World Bank turned to the

[19] www.pensionsboard.ie/en/Regulation/Sovereign_Annuities

J.P. Morgan longevity team in 2009, which developed a more cost effective 25-year maturity longevity bond structure that was designed to provide an effective hedge, with minimal basis risk, for all Chilean insurers. The longevity bond was to be issued out of a collateralized special purpose vehicle, with Munich Re providing the longevity hedge to the entity and J.P. Morgan managing the cash flow mismatch between the various payment streams (Coughlan, 2009; Life and Pensions Risk, 2010).

This bond, like its predecessor, faced a number of obstacles and was not successful. Some of the most significant included:

- The separation between the investment and actuarial departments at Chilean insurers meant that there was no clear focus for decision-making responsibility.
- The insurers perception of longevity risk was that it was not significant and, therefore, not in need of hedging. As a result they regarded the cost as relatively high, despite the capital relief, and despite the return on the bond being above government yields.
- Basis risk was perceived as slightly too high, despite being minimized by indexing the bond to the universe of actual annuitants.

VI. Second Generation Capital Markets Solutions – Derivatives

The lack of success in issuing long-dated longevity bonds led to a redirection of design effort towards derivatives.

Mortality Forwards

The first capital markets derivative that was executed as a longevity hedge took place in January 2008. The hedger was Lucida PLC, a pension buy-out insurer (Lucida, 2008; Symmons, 2008). The instrument was a mortality forward contract, or so-called 'q-forward', linked to a longevity index based on England & Wales national male mortality for a range of different ages. The hedge was provided by J.P. Morgan and was novel not just because it involved a longevity index and a new kind of product, but also because it was designed as a hedge of value rather than a hedge of cash flow. In other words, it hedged the value of the annuity liability, not the actual annuity payments.

A mortality forward rate contract is referred to as a 'q-forward' because the letter 'q' is the standard actuarial symbol for mortality rate. It is the simplest type of instrument for transferring longevity (and mortality) risk (Coughlan *et al.*, 2007b).

The importance of q-forwards rests in the fact that they form basic building blocks from which other, more complex, life-related derivatives can be constructed. When appropriately designed, a portfolio of q-forwards can be used to replicate and to hedge the longevity exposure of an annuity or a pension liability, or to hedge the mortality exposure of a life assurance book.

A q-forward is an agreement between two parties in which they agree to exchange an amount proportional to the actual, realized mortality rate of a given population (or subpopulation), in return for an amount proportional to a fixed mortality rate that has been mutually agreed at inception to be payable at a future date (the maturity of the contract). In this sense, a q-forward is a swap that exchanges fixed mortality for the realized mortality at maturity, as illustrated in Figure 9. The variable used to settle the contract is the realized mortality rate for that population in a future period. In the case of hedging longevity risk in a pension plan using a q-forward, the pension plan will receive the fixed mortality rate and pay the realized mortality rate (and hence locks in the future mortality rate it has to pay whatever happens to actual rates). The counterparty to this transaction, typically an investment bank, has the opposite exposure, paying the fixed mortality rate and receiving the realized rate.

The fixed mortality rate at which the transaction takes place defines the ‘forward mortality rate’ for the population in question. If the q-forward is fairly priced, no payment changes hands at the inception of the trade, but at maturity, a net payment will be made by one of the two counterparties (unless the fixed and actual mortality rates happen to be the same). The settlement that takes place at maturity is based on the net amount payable and is proportional to the difference between the fixed mortality rate (the transacted forward rate) and the realized reference rate. If the reference rate in the reference year is below the fixed rate (implying lower mortality than predicted), then the settlement is positive, and the pension plan receives the settlement payment to offset the increase in its liability value. If, on the other hand, the reference rate is above the fixed rate (implying higher mortality than predicted), then the settlement is negative and the pension plan makes the settlement payment to the hedge provider, which will be offset by the fall in the value of its liabilities. In this way, the net liability value is locked-in regardless of what happens to mortality rates. The plan is protected from unexpected changes in mortality rates.

Table 4 presents an illustrative term sheet for a q-forward transaction, based on a reference population of 65-year-old males from England & Wales. The q-forward payout depends on the value of the LifeMetrics Index for the reference population on the maturity date of the contract. The particular transaction shown is a 10-year q-forward contract starting on 31 December 2008 and maturing on 31 December 2018. It is being used by ABC Pension Fund to hedge its longevity risk over the next 10 years; the hedge provider is J. P. Morgan. The hedge is a ‘directional hedge’ and will help the pension fund hedge its longevity risk so long as the mortality experience of the pension fund and the index change in the same direction

On the maturity date, J. P. Morgan (the fixed-rate payer or seller of longevity risk protection) pays ABC Pension Fund (the floating-rate payer or buyer of longevity risk protection) an amount related to the pre-agreed fixed mortality rate of 1.2000 percent (i.e., the agreed forward mortality rate for 65-year-old English & Welsh males for 2018). In return, ABC Pension Fund pays J. P. Morgan an amount related to the reference rate on the maturity date. The reference rate is the most recently available value of the LifeMetrics Index. Settlement on 31 December 2018 will therefore be based on the LifeMetrics Index value for the reference year 2017, on account of the ten-month lag in the availability of official data. The settlement amount is the difference between the fixed amount (which depends on the agreed forward rate) and the floating amount (which depends on the realized reference rate).

Table 5 shows the settlement amounts for four realized values of the reference rate and a notional contract size of £50 million. If the reference rate in 2017 is lower than the fixed rate (implying lower mortality than anticipated at the start of the contract), the settlement amount is positive and ABC Pension Fund receives a payment from J. P. Morgan that it can use to offset the increase in its pension liabilities. If the reference rate exceeds the fixed rate (implying higher mortality than anticipated at the start of the contract), the settlement amount is negative and ABC Pension Fund makes a payment to J. P. Morgan which will be offset by the fall in its pension liabilities.

It is important to note that the hedge illustrated here is structured as a 'value hedge,' rather than as a 'cash flow hedge.' A value hedge hedges the value of the hedger's liabilities at the maturity date of the swap. So although the swap has a duration of only 10 years, it nevertheless hedges the longevity risk in the hedger's cash flows beyond 10 years. This is achieved by exchanging a single payment at maturity. By contrast, a cash flow hedge hedges the longevity risk in each one of the hedger's cash flows and net payments are made period by period. The J. P. Morgan-Canada Life longevity swap (see below) is an example of a cash flow hedge, while the J. P. Morgan-Lucida q-forward is an example of a value hedge. The capital markets are more familiar with value hedges, whereas cash flow hedges are more common in the insurance world. Value hedges are particularly suited to hedging the longevity risk of younger members of a pension plan, since it is much harder to estimate with precision the pension payments they will receive when they eventually retire. The world's first swap for non-pensioners (i.e., involving deferred members) took place in January 2011 when J. P. Morgan executed a value hedge in the form of a 10-year q-forward contract with the Pall (UK) pension fund.

Longevity Swaps

Following swiftly on the heels of the Lucida q-forward transaction, J.P. Morgan recorded a second first in July 2008, this time with Canada Life in the UK (Trading Risk, 2008; Life & Pensions, 2008). But the hedging instrument in this transaction was different. It was a 40-year maturity £500 million longevity swap that was linked not to an index, but to the actual mortality experience of the 125,000-plus annuitants in the annuity portfolio that was being hedged. It also differed in being a cash flow hedge of longevity risk. But most significantly, this transaction brought capital markets investors into the longevity market for the very first time, as the longevity risk was passed from Canada Life to J.P. Morgan and then directly on to investors. This has become the archetypal longevity swap upon which other transactions are based.

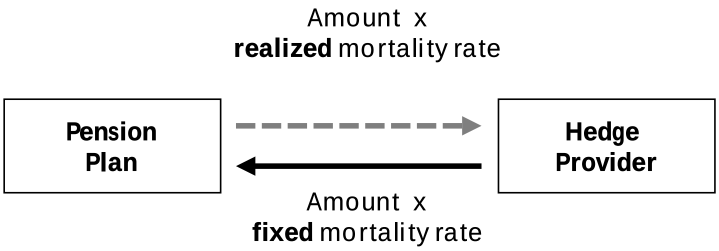
A longevity survivor swap – frequently abbreviated to simply 'longevity swap' – can be either a capital markets derivative or an insurance contract. In either case, it is an instrument which involves exchanging actual pension payments for a series of pre-agreed fixed payments, as indicated in Figure 10 (Dowd *et al.*, 2006; and Dawson *et al.* 2010). Each payment is based on an amount-weighted survival rate.

In any longevity swap, the hedger of longevity risk (e.g., a pension plan) receives from the longevity swap provider the actual payments it must pay to pensioners and, in return, makes a series of fixed payments to the hedge provider. In this way, if pensioners live longer than expected, the higher pension amounts that the pension plan must pay are offset by the higher payments received from the provider of the longevity swap. The swap therefore provides the pension plan with a long-maturity, customized cash flow hedge of its longevity risk.

Although the J.P. Morgan-Canada Life transaction was the first capital markets longevity swap, there was an earlier publicly announced insurance swap that took place in April 2007 between Swiss Re and Friends' Provident, a UK life insurer. Like the J.P. Morgan-Canada Life swap, it was a pure longevity risk transfer and was not tied to another financial instrument or transaction. The swap was based on Friends' Provident's £1.7 billion book of 78,000 of pension annuity contracts written between July 2001 and December 2006. Friends' Provident retains administration of policies. Swiss Re makes payments and assumes longevity risk in exchange for an undisclosed premium. However, it is important to note that this particular swap was legally constituted as an insurance contract and was not a capital markets instrument.

Table 6 lists the publicly announced longevity swaps that have been executed between 2007 and 2012 in the UK.

Figure 9: A q-Forward Exchanges Fixed Mortality for Realized Mortality at the Maturity of the Contract



Source: Coughlan et al. (2007b, Figure 1)

Table 4: An Illustrative Term Sheet for a Single q-Forward to Hedge Longevity Risk

Notional amount	GBP 50,000,000
Trade date	31 Dec 2008
Effective date	31 Dec 2008
Maturity date	31 Dec 2018
Reference year	2017
Fixed rate	1.2000%
Fixed amount payer	J. P. Morgan
Fixed amount	Notional Amount x Fixed Rate x 100
Reference rate	LifeMetrics graduated initial mortality rate for 65-year-old

	males in the reference year for England & Wales national population Bloomberg ticker: LMQMEW65 Index <GO>
Floating amount payer	ABC Pension Fund
Floating amount	Notional Amount x Reference Rate x 100
Settlement	Net settlement = Fixed amount – Floating amount

Source: Coughlan *et al.* (2007b, Table 1).

Table 5: An Illustration of q-Forward Settlement for Various Outcomes of the Realized Reference Rate

Reference rate (Realized rate)	*Fixed rate*	*Notional (GBP)*	*Settlement (GBP)*
1.0000%	1.2000%	50,000,000	10,000,000
1.1000%	1.2000%	50,000,000	5,000,000
1.2000%	1.2000%	50,000,000	0
1.3000%	1.2000%	50,000,000	-5,000,000

Source: Coughlan *et al.* (2007b, Table 1): A positive (negative) settlement means the hedger receives (pays) the net settlement amount.

Figure 10: A longevity survivor swap involves the regular exchange of actual realized pension cash flows and pre-agreed fixed cash flows.

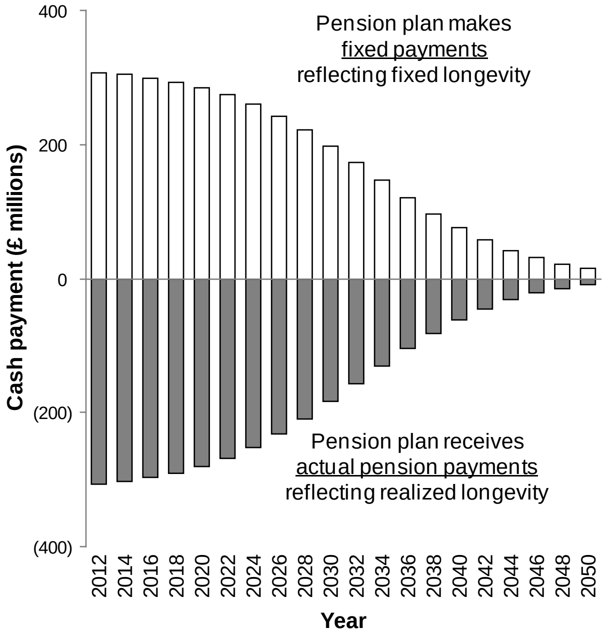


Table 6: Publicly-announced Longevity Swaps in the UK, 2007-12

Date	*Hedger*	*Type*	*Size (£m)*	*Term (yrs)*	*Format*	*Intermediary*
April 2007	Friends' Provident	Ins	1700	Run-off	Reinsurance contract	Swiss Re
Jan 2008	Lucida	Ins	100	10	Index-based hedge; exposure placed with capital market investors	J. P. Morgan
July 2008	Canada Life	Ins	500	40	Exposure placed with capital market investors	J. P. Morgan
Feb 2009	Abbey Life	Ins	1500	Run-off	Insurance contract	Deutsche Bank
Mar 2009	Aviva	Ins	475	10	Exposure placed with capital market investors & Partner RE	RBS
May 2009	Babcock	PF	500-750	50	Insurance contract	Credit Suisse

July 2009	RSA	Ins	1900	Run-off	Insurance contract; combined with inflation & interest rate swaps	Goldman Sachs/ Rothesay Life
Nov 2009	Berkshire Council	PF	750	Run-off	Insurance contract	Swiss Re
Feb 2010	BMW	PF	3000	Run-off	Insurance contract	Deutsche Bank/Abbey Life,
July 2010	British Airways	PF	1300	NA	Synthetic buy-in (longevity and asset swaps)	Goldman Sachs/Rothesay
Jan 2011	Pall (UK)	PF	70	10	Index-based hedge; exposure placed with capital market investors	JPMorgan
Aug 2011	ITV	PF	1700	NA	Insurance contract	Credit Suisse
Nov 2011	Rolls Royce	PF	3000	NA	Pensioner bespoke longevity swap	Deutsche Bank
Dec 2011	British Airways	PF	1300	NA	Pensioner bespoke longevity swap	Goldman Sachs/Rothesay
Jan 2012	Pilkington	PF	1000	NA	Pensioner bespoke longevity swap	Legal & General
April 2012	Berkshire Council	PF	100	Run-off	Insurance contract	Swiss Re
May 2012	Akzo Nobel	PF	1400	NA	Insurance contract	Swiss Re
Dec 2012	LV=	Ins	800	NA	Insurance contract	Swiss Re

Note: Ins – hedger is insurance company; PF – hedger is pension fund

Index Hedges vs. Customized Hedges

Lucida and Canada Life implemented two very different kinds of capital markets longevity hedges in 2008. Lucida executed a standardized hedge linked to a mortality index, whereas

Canada Life executed a customized hedge linked to the actual mortality experience of a population of annuitants. It is important to understand the differences between these.

Table 7: Standardized Index Hedges vs. Customized Hedges

	Advantages	*Disadvantages*
Standardized index hedge	• Cheaper than customized hedges • Lower set-up/operational costs • Shorter maturity, so lower counterparty credit exposure	• Not a perfect hedge: o Basis risk o Roll risk o Base table estimation risk
Customized hedge	• Exact hedge, so no residual basis risk • Set-and-forget hedge, requires minimal monitoring	• More expensive than standardized • High set-up and operational costs • Poor liquidity • Longer maturity, so larger counterparty credit exposure • Less attractive to investors

Source: Coughlan (2007)

Standardized index-based longevity hedges have some advantages over the customized hedges that are currently more familiar to pension funds and annuity providers. In particular they have the advantages of simplicity, cost and liquidity. But they also have obvious disadvantages, principally the fact that they are not perfect hedges and leave a residual basis risk (see Table 7) that requires the index hedge to be carefully calibrated.

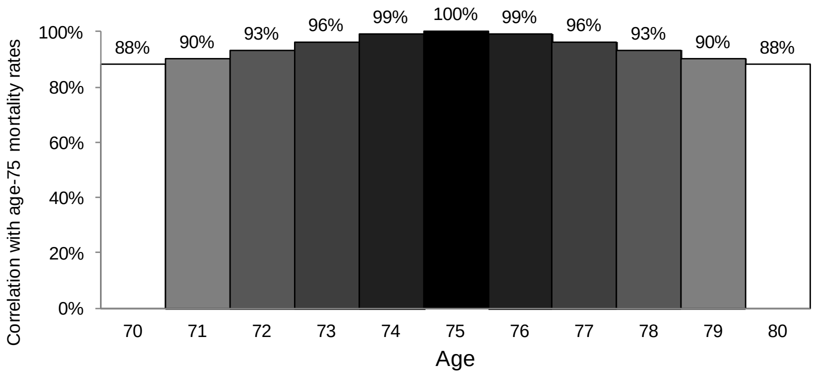
Coughlan *et al.* (2007b) argue that a liquid, hedge-effective market could be built around just eight standardized contracts with:

- a specific maturity (e.g., 10 years);
- two genders (male, female);
- four age groups (50-59, 60-69, 70-79, 80-89).

Figure 11 presents the mortality improvement correlations within the male 70-79 age bucket which is centered on age 75. These figures show that the correlations are very high and that contracts based on 75-year-old males will provide good hedge effectiveness for plans with members in the relevant age buckets. Coughlan (2007) estimates that the hedge effectiveness is around 86 percent (i.e., the standard deviation of the liabilities is reduced by

86 percent, leaving a residual risk of 14 percent) for a large and well diversified pension plan or annuity portfolio: see Figure 12.[20]

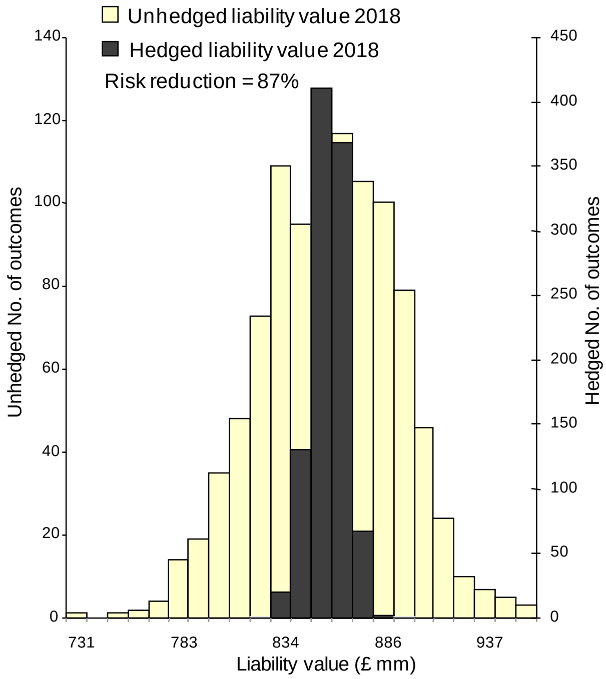
Figure 11: Annual Mortality Improvement Correlations
with England & Wales Males Aged 75



Source: Coughlan et al. (2007a, Figure 9.6)

[20] A subsequent study by Coughlan *et al*. (2011) reconfirmed the high degree of effectiveness available with longevity hedges based on national population indices for large pension plans. This study considered a pension fund with a membership whose mortality experience was the same at the UK CMI (Continuous Mortality Investigation) assured lives population; with a hedge based on the England & Wales LifeMetrics Index, hedge effectiveness of 82.4% could be achieved. The study also considered a pension fund with a membership whose mortality experience was the same at the population of California; with a hedge based on the US LifeMetrics Index, hedge effectiveness of 86.5% could be achieved.

Figure 12: The Hedge Effectiveness of q-Forwards



Source: Coughlan (2007)

The Longevity Risk Premium

The provider of any longevity hedge requires a premium to assume longevity risk. This means that, the forward rate agreed at the start of any q-forward contract will be below the anticipated (expected) mortality rate on the maturity date of the contract. Similarly, the implied forward life expectancy in any longevity swap will be longer than the anticipated (expected) life expectancy. Figure 13 shows the relationship between the expected and forward mortality rate curves and the risk premium for a particular year (in this case 2017) for ages 65-75.[21] Figure 14 shows the relationship between the expected and forward mortality rate curves and the risk premium for a particular age cohort (in this case 65-year-old English & Welsh males) for years 2005-25.

Collateral

A key feature of any derivative transaction, especially after the Global Financial Crisis of 2007-09, is collateral. The role of collateral is to reduce if not entirely eliminate counterparty credit risk. This is the risk that one of the counterparties to, say, a q-forward

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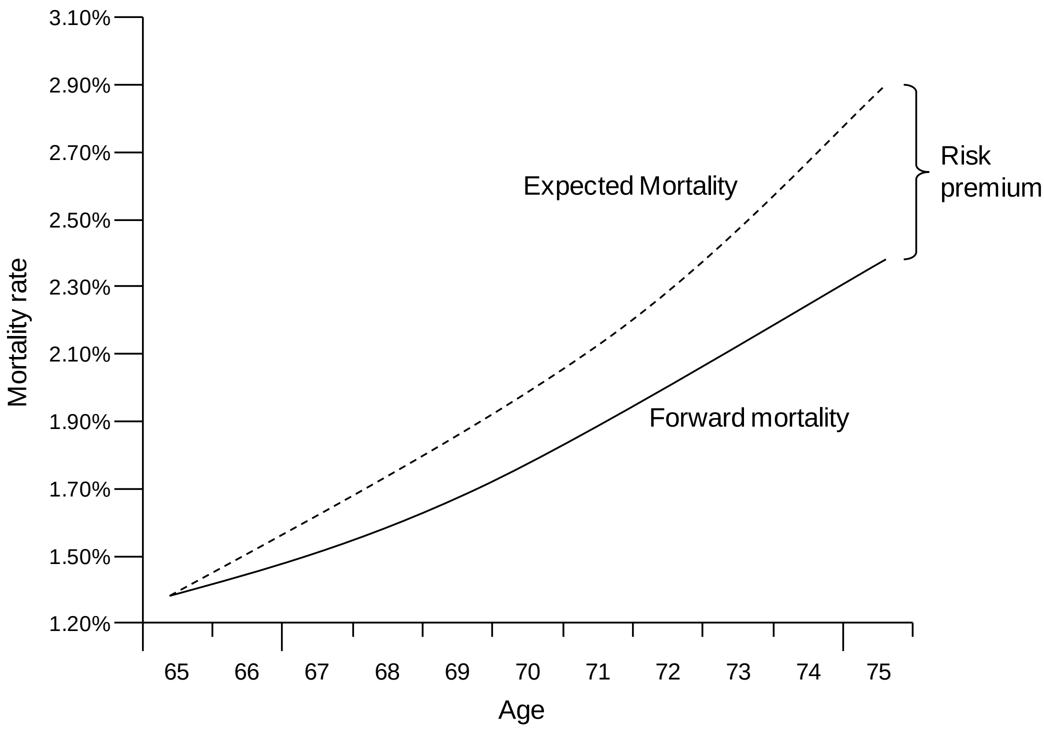
[21] Coughlan *et al*. (2007b) show that the forward mortality rate is determined from the expected mortality rate using $q^f = (1 - T \times \lambda \times \sigma) q^e$, where q^f is the forward mortality rate, q^e is the expected mortality rate, T is the time to maturity, σ is the volatility (annualized standard deviation) of changes in the mortality rate , and λ is the annualized Sharpe ratio required by the counterparty.

contract defaults owing money to the other counterparty. When a swap is first initiated, both counterparties have zero profit or loss. But over time, as a result of realized mortality rates deviating from the rates that were forecast at the time the swap started, one counterparty's position will be showing a profit and the other will be showing an equivalent loss. Collateral in the form of high quality securities needs to be posted by the loss-making counterparty to cover such losses. However, the collateral needs to be funded and the funding costs will depend on the level of interest rates. Further, the quality of the collateral and the conditions under which a counterparty can substitute one form of collateral for another need to be agreed. This is done in the credit support annex (CSA) to the ISDA Master Agreement that establishes the swap. The CSA also specifies how different types of collateral will be priced.

All these factors are important for determining the value of the swap at different stages in its life. Biffis et al. (2011) use a theoretical model to show that the overall cost of collateralization in mortality or longevity swaps is similar to or lower than those found in the interest-rate swaps market on account of the diversifying effects of interest rate and longevity risks.

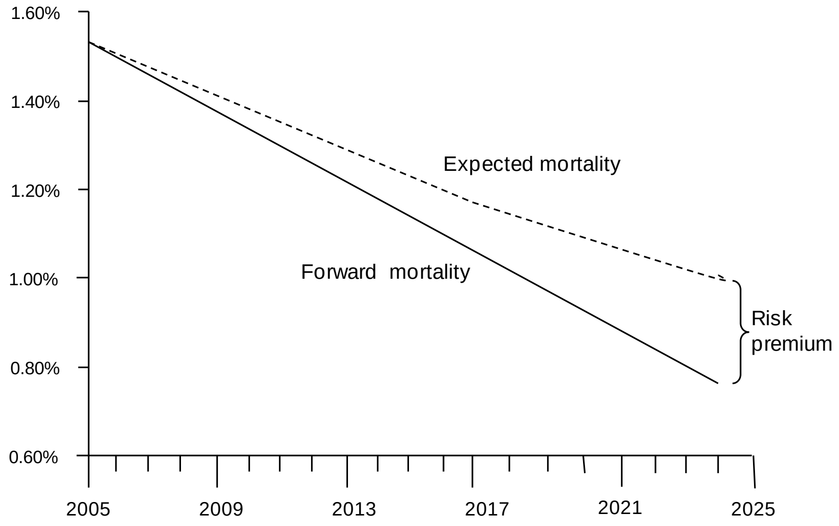
Figure 13: Expected and Forward Mortality Rate Curves for 2017
for Ages 65-75



Note: Lines are illustrative only

Source: Adapted from Loeys et al. (2007, Chart 9)

Figure 14: Expected and Forward Mortality Rate Curves
for 65-year-old English & Welsh Males, 2005-25



Note: Lines are illustrative only
Source: Adapted from Coughlan (2007)

The Life and Longevity Markets Association

In February 2010, the Life and Longevity Markets Association (LLMA)[22] was established in London by AXA, Deutsche Bank, J.P. Morgan, Legal & General, Pension Corporation, Prudential (UK), RBS, and Swiss Re. The original members were later joined by Morgan Stanley, UBS, Aviva and Munich Re. The aim is 'to support the development of consistent standards, methodologies and benchmarks to help build a liquid trading market needed to support the future demand for longevity protection by insurers and pension funds.' In April 2011, the LifeMetrics indices were transferred to LLMA with the aim of establishing a global benchmark for trading longevity and mortality risk.

Barriers to Further Development

Looking back to Sandor's seven stages of market evolution in Table 1, it is arguable that we are now in stage 4 in the evolution of the Life Market.[23] We need to examine the barriers to the further evolution of the market.

[22] www.llma.org
[23] This is the same stage that we argued the market was just starting in Blake *et al*. (2008a).

One barrier that remains to the further development of stage 4 is the continuing resistance of pension plan trustees and their advisers, as well as insurers and reinsurers, to imperfect hedging solutions of the capital markets. The industry as a whole still prefers the full risk transfer solutions of insurance indemnification contracts.

Another barrier relates to the differing maturity requirements of hedgers and investors. Hedgers prefer instruments that provide a very long-term hedge of longevity risk, since longevity is a risk that manifests itself over a long timescale. By contrast, most investors prefer shorter dated instruments, particularly for novel kinds of risk such as longevity, as evidenced in the relatively short maturities associated with catastrophe bonds. It has been suggested that a 10-year maturity instrument is a suitable compromise and indeed Lucida and Pall Corporation have transacted q-forward hedges with 10-year maturities. However, these hedges leave a residual roll-over risk beyond 10 years, even beyond the basis risk.

If these barriers can be overcome, then the next stages in the evolution of the Life Market are the development of formal spot and derivatives – especially futures – exchanges. Blake *et al.* (2006b) examined the reasons why some futures contracts succeed and why others fail.

A successful futures market – defined as having a consistently high volume of trade and open interest – requires a large, active and liquid spot market in the underlying, with spot prices being sufficiently volatile to create both hedging needs and speculative interest. The underlying must be homogeneous or have a well-defined grading system. The market also requires active participation by both hedgers and speculators and this clearly depends on end users recognizing a hedging need and the futures contract being effective in reducing risk. However, the market in the underlying must not be heavily concentrated on either the buy or sell side, since this can lead to market distortions, such as price manipulation. Finally, trading costs in futures contracts must not be significantly higher than those operating in any existing cross-hedge futures contract.

It is instructive to examine the history of inflation-related financial futures contracts. These were initially unsuccessful but eventually succeeded and inflation indices have similar characteristics to mortality indices, especially the low frequency of publication. The first inflation-related contracts were CPI (consumer price index) futures contracts listed on the US Coffee, Sugar and Cocoa Exchange in June 1985. They were delisted in April 1987 with only 10,000 contracts traded. The key reasons for the failure of these contracts were: there were no inflation-linked securities market at the time, the underlying was an infrequently published (i.e., monthly) index, and there was no stable pricing relationship with other instruments to attract the attention of arbitrageurs.

A second attempt came in June 1997 when a futures contract on Treasury inflation-protected securities (TIPS) was listed on the Chicago Board of Trade. The contract was delisted before the end of the year with only 22 contracts traded. The contract failed because TIPS had only started trading five months before, there was just a single 10-year TIPS trading, the futures contract competed with the underlying for liquidity, and there was uncertainty over the future of the TIPS program.

In February 2004, the Chicago Mercantile Exchange launched a CPI futures contract which is still trading. This time the contract succeeded because inflation-linked securities have gained acceptance amongst investors, with TIPs having evolved into a recognized asset class. There is a well understood pricing relationship allowing for arbitrage opportunities between TIPS, fixed-interest Treasury bonds and CPI futures. The US Treasury is now committed to long-term TIPS issuance. CPI futures do not compete directly with but rather complement TIPS and use the same inflation index. The contract is traded on the Globex electronic trading platform, which provides automated two-sided price quotes from a leading market maker and thereby enhances liquidity.

What are the lessons for the development of a longevity-linked futures market?

A large, active and liquid spot market in the underlying is regarded as the most important criterion for the success of a futures market. With one exception, no futures contract has ever survived without a spot market satisfying these conditions. The one exception is weather futures, which were introduced by the Chicago Mercantile Exchange (CME) in 1999. This contract has a so-called 'exotic underlying' rather than a physical underlying, but nevertheless has been a success despite this. This provides hope for longevity-related futures contracts which also have an exotic underlying.[24]

The mortality index underlying longevity-linked instruments must be a fair estimate of true mortality and have minimal time basis risk.[25] The CPI index suffers from similar potential problems, so the survival of the CPI futures contract on CME suggests these problems can be overcome. Although mortality indices are calculated infrequently (typically annually), spot prices of traded longevity bonds would exhibit a high degree of volatility on account of the bonds' high duration.

The underlying longevity-risk hedging instruments must be few in number and well-defined. A small number of contracts helps to increase liquidity, but as already mentioned, also leads to contemporaneous basis risk, arising from the different mortality experience of the population cohort covered by the mortality index and the cohort relevant to the hedger.

One potential weakness in the development of the Life Market is insufficient investor interest. However, Figure 15 shows how the market might eventually come into balance, with increasing numbers of longevity sellers attracted by a suitable risk premium to enter the market to meet the potentially huge demands of longevity buyers.

Theoretical developments

At the same time as these practical developments in the capital markets were taking place, academics were continuing to make theoretical contributions, building on the original idea

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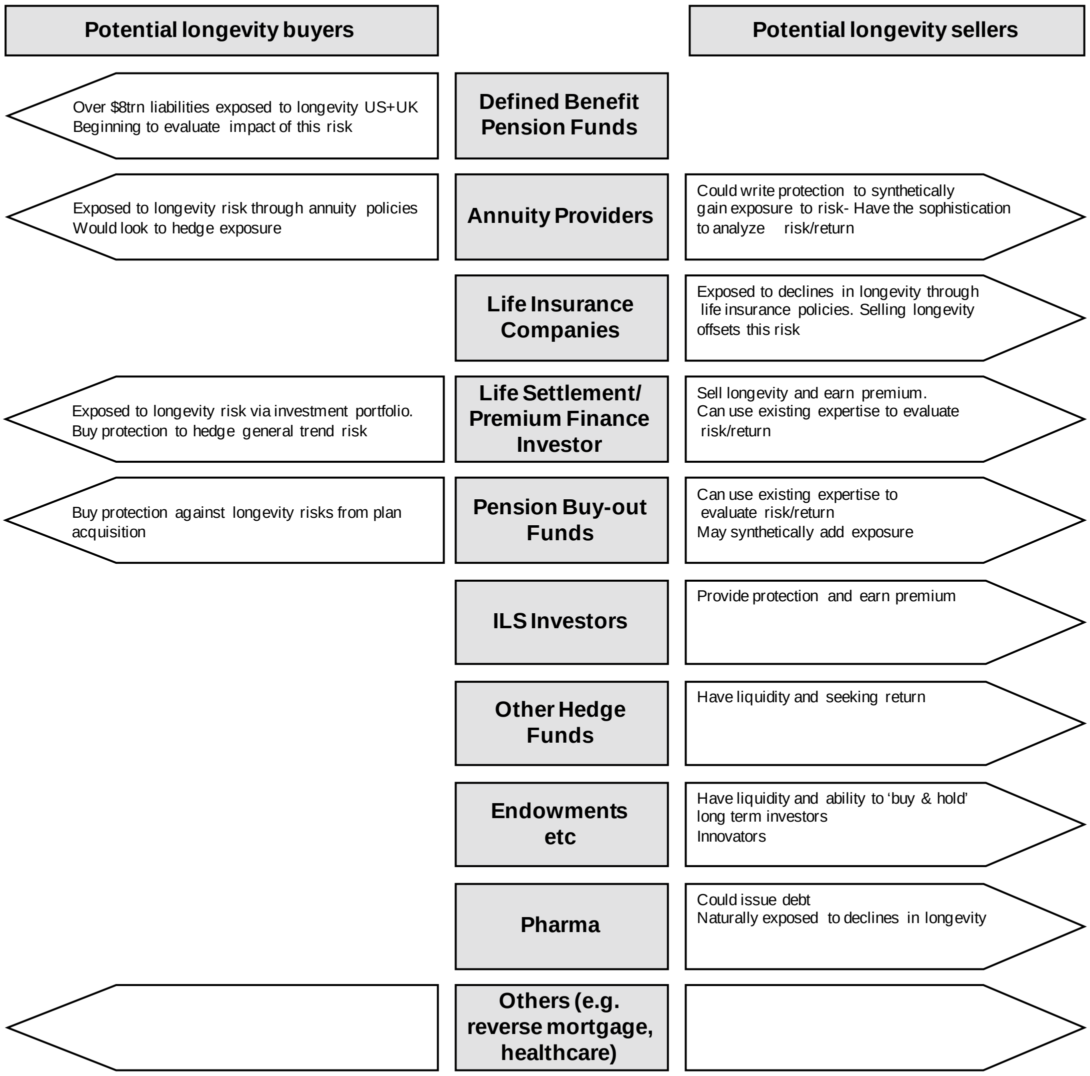
[24] At least until a liquid market in longevity bonds develops.

[25] Time basis risk will be low if a hedging instrument with a given maturity date provides a good hedge for an exposure with a different maturity date. This is important because of publication lags. The q-forward example illustrated in Table 4 above had a maturity date of 2018, but a reference year for determining the settlement mortality rate of 2017.

of using longevity bonds to hedge macro-longevity risk in the capital markets (Blake and Burrows, 2001). These included:

- Design and pricing of longevity bonds and other longevity-linked products (e.g., Blake *et al.*, 2006a; Bauer, 2006; Bauer and Ruβ, 2006; Denuit *et al.*, 2007; Barbarin, 2008; Bauer *et al.*, 2010b; Chen and Cummins, 2010; Kogure and Kurachi, 2010; Dowd *et al.*, 2011a; Lane, 2011; Li and Ng, 2011; Mayhew and Smith, 2011; and Zhou *et al.*, 2011).
- Design and pricing of longevity-linked derivatives, such as survivor swaps (e.g., Dowd *et al.*, 2006), survivor forwards and swaptions (e.g., Dawson *et al.*, 2010), *q*-forwards (e.g., Deng *et. al.*, 2012) and mortality options (e.g., Milevsky and Promislow, 2001).
- Longevity indices (e.g., Denuit, 2009)
- Longevity risk hedging (e.g., Dahl and Møller, 2006; Friedberg and Webb, 2007; Cairns *et al.,* 2008, 2013; Coughlan *et al.*, 2008; Tsai *et al.*, 2010; Wang *et al.*, 2010; Coughlan *et al.*, 2011; Li and Hardy, 2011; Tzeng *et al.*, 2011; and Wang *et al.*, 2011b)
- Improvements in the analysis and design of longevity-linked retail products (e.g., Gong and Webb, 2010; Stevens at al., 2010; Richter and Weber, 2011; and Denuit *et al.*, 2011).

Figure 15: Potential Longevity Risk Landscape



Source: Based on Loeys *et al.* (2007, Chart 10)

VII The Micro-Longevity Risk Market

The principal product subject to micro-longevity risk is a life settlement. This is a life insurance policy sold by its owner for more than the surrender value[26] but less than face value. The secondary market in life insurance policies began in 1844, when Foster and Cranfield auctioned an endowment life insurance policy in the UK. The US secondary market dates back to 1911, when the US Supreme Court confirmed the legality of selling life insurance policies in the case of Grigsby v Russell, 222 U.S. 149 (1911). This decision established a life insurance policy as transferable property that contains specific legal rights

[26] This is the value paid by the original life company to cancel the policy.

to: name the policy beneficiary, change the beneficiary designation (unless subject to restrictions), assign the policy as collateral for a loan, borrow against the policy, and sell the policy to another party.

The secondary market in the US really began to take off in the 1990s when viatical settlements were introduced. Viators are owners of life policies who are very close to dying, such as AIDS sufferers who needed to sell their policies to pay for medical treatment. That market ceased suddenly in 1996 when protease inhibitors were introduced. It was replaced by a senior life settlements (SLS) market which deals with the whole life policies[27] of elderly high net worth individuals. Two medical doctors or underwriters are used to assess each policyholder's life expectancy. The most important criterion for successful investment in life settlements is a good estimate of life expectancy (LE). The investor purchasing the life settlement has to continue paying the premiums on the underlying policy while the original policyholder is still alive.

Underestimating LE is the key micro-longevity risk faced by investors in life settlements, since this makes the promised returns on life settlements more attractive than the realized returns. The SLS market experienced a significant setback when, in 2008, the shortest of the LE underwriters revised upwards their LEs by between 20 and 25%, while the second longest revised upwards by between 5 and 10%. LE providers were forced to respond by establishing the Life Expectancy Providers Focus Group in October 2010 with the aim of offering a comprehensive and consistent set of best practices and performance standards to all life markets that make use of life expectancy and mortality information. The group also addresses issues such as privacy, fraud, and confidentiality policies. The group's founding members were Advanced Underwriting Solutions, AVS Underwriting, Examination Management Services, Inc., ISC Services and 21st Services.

A number of solutions have been put forward to hedge micro-longevity risk or 'extension risk' as it is more commonly known. One is a hedge offered by certain investment banks based on a synthetic index of life settlements. Another is known as FAIRE and consists of both individual and portfolio extension risk hedges, priced off the LE underwriter Fasano's LEs. FAIRE is provided by Fasano Associates and Augur Capital, a German investment manager of life insurance and life settlement assets.

In 1994, the Life Insurance Settlement Association (LISA) was established in Orlando, Florida as a trade association for viatical and life settlement companies.[28]

In 2005, the Life Exchange was established with an objective 'to provide the secondary life insurance market with the most advanced and independent electronic trading platform

[27] A whole life policy has two components, a life insurance component and an investment component: periodic premiums (monthly, quarterly, annual, single, for example) cover the cost of the life insurance, with the surplus going into an investment fund. In the US market, the insurance company typically invests the surplus premium in fixed-income securities to build up a 'cash value'. The cash value is separate from the 'face value' of the policy, which is the guaranteed insurance value.

[28] www.lisassociation.org

available by which to conduct life settlement transactions with the highest degree of efficiency, transparency, disclosure, and regulatory compliance'.[29] In 2007, the Institutional Life Markets Association (ILMA), started in New York with the mission is 'to expand and apply capital market solutions in life insurance, educate consumers that their insurance may be a valuable asset, expand consumer choices about how to manage it, and support the responsible growth and regulation of the industry. We believe that expanded consumer choice and full disclosure of all fees is good for the consumer and for the industry'.[30] In 2008, Institutional Life Services (ILS) and Institutional Life Administration (ILA), a life settlements trading platform and clearing house, were launched by Goldman Sachs, Genworth Financial, and National Financial Partners. ILS/ILA was designed to modernize dealing in life settlements and meet the needs of consumers (by ensuring permanent anonymity of the insured) and of the capital markets (by providing a central clearing house for onward distribution of life settlement assets, whether individually or in structured form). In 2010, National Financial Partners became the sole owner of ILS/ILA.

One of the latest developments is the attempt to introduce a synthetic life settlements market. This is to avoid some of the costs, monitoring, and ethical issues associated with the physical life settlements market.[31] The synthetic market will be based on indices and the returns will depend on the performance of the pool of lives in the index. The first attempt to do this was by Goldman Sachs which introduced a QxX Life Settlements Index in 2007. This market failed to take off – the spreads offered were too wide to making trading profits – and the index was discontinued in 2009. In 2008, Credit Suisse initiated a longevity swap with Centurion Fund Managers, whereby Centurion acquired a portfolio of synthetic life policies, based on a longevity index built by Credit Suisse. In 2010, the Fasano Longevity Life Settlements Index was introduced. In April 2011, the International Society of Life Settlement Professionals (ISLSP)[32] formed a life settlement and derivatives committee and announced that it was developing a life settlement index. The purpose of the index is to benchmark net asset values in life settlements trading. Investors need a reliable benchmark to measure performance and the index will help turn US life insurance policies into a tradable asset class according to ISLSP. The calculation agent for the index is AA Partners.

There are a number of other much smaller secondary markets in life insurance policies, including the following:

- Traded endowment policies in the UK. The maturity date of policies is fixed, but the maturity value of the policy depends on the performance of an investment fund. The policy premiums are invested in a risk-graded with-profits fund established by the

[29] www.life-exchange.com
[30] www.lifemarketsassociation.org
[31] It is an expensive process to acquire suitable life policies for settlement with a range of intermediaries who need paying. In addition, premiums need to be financed. There is also a laborious process of monitoring policy holders between the purchase and policy maturity dates. In addition, there are ethical issues associated with the sale of policies by elderly individuals: these issues were considered by, amongst others, Blake and Harrison (2008).
[32] www.islsp.org

life company selling the policy. There is a fixed minimum return in the event of policy holder dying during term.

- Secondary market for life insurance in Germany. German consumers have been able to sell life and pension insurance policies to professional policy buyers since 1999. The trade body for the secondary market in life insurance is the Bundesverband Vermogensanlagen im Zweitmarkt Lebensversicherungen (BVZL).[33] There is also the European Life Insurance Settlement Association (ELSA).[34]

Some academic studies of life settlements have recently emerged, e.g., Deng et. al. (2011) Mazonas et. al. (2011) and Braun et. al. (2012).

VIII Life Securitization

Securitization involves the sale of a pool of assets (or liabilities or the rights to a set of cash flows) to a special purpose vehicle (SPV) and the subsequent repackaging of those assets (or liabilities or cash flow rights) into securities that are traded in the capital markets.[35] The SPV finances the purchase of the assets by issuing bonds to investors which are, in turn, secured against the assets or promised cash flows.[36] Six types of securitization have taken place involving longevity-related assets or liabilities: blocks of business, regulatory reserving (XXX), life settlements, annuity books and reverse mortgages. The new securities created are known as insurance-linked securities (ILSs) (Krutov, 2006).[37]

Block of Business Securitization. The earliest securitizations were 'block of business' securitizations (Cowley and Cummins, 2005). These have been used to capitalize expected future profits from a block of life business, recover embedded values (EVs), or exit from a geographical line of business. The last of these motivations is obvious, and the first two arise from the fact that the cost of writing new life policies is usually incurred in the first year of the policy and then amortized over the remainder of its term. This means that writing new business puts pressure on a company's capital. Securitization helps to relieve this pressure by allowing the company immediate access to its expected future profits, and it is

[33] www.bvzl.de
[34] www.elsa-sls.org
[35] Securitization began in the 1970s when banks in the US began to sell off pools of mortgage-backed loans.
[36] Most securitizations also involve credit enhancement features to protect one or more participating parties against default risk. These features include over-collateralization (where the value of the assets transferred to the SPV exceeds the value of the securities it issues), subordination (where the SPV issues securities with varying levels of seniority), and external guarantees such as parent company guarantees, letters of credit, credit insurance, and reinsurance. Many SPVs also include an arrangement by which the originating life institution continues to service the original customers. This is especially important in life settlement securitizations where there is a need to ensure that policyholders do not allow their policies to lapse.
[37] See also Cowley and Cummins (2005), Lin and Cox (2005), Dahl (2004), Cairns *et al.*(2006a), Cox and Lin (2007), Biffis and Blake (2010a), Cox *et al.* (2010), Wills and Sherris (2010), Kim and Choi (2011), Huang et al. (2011) and Yang (2011).

an especially attractive option when the company is experiencing rapid growth in a particular line of business. An example of this type of securitization is the set of 13 transactions carried out by American Skandia Life Assurance Company (ASLAC) between 1996-2000.

Regulatory Reserving (XXX) Securitization. Another form of life securitization is regulatory reserving securitization, sometimes also known as reserving funding or XXX securitization. These arrangements are designed to give US life assurers relief from excessively conservative regulatory reserving or capital requirements under Regulation XXX, and are used to release capital that can be used to finance new business or reduce the cost of capital. An early example of this type of securitization was a $300 million deal arranged by First Colony Life Insurance Company through an SPV known as River Lake Insurance Company to obtain capital relief under Regulation XXX. This regulation imposes extremely conservative regulatory reserve requirements on some types of life policies with long-term premium guarantees.

Life Settlement Securitization. Senior life settlement (SLS) securitization began in 2004. The first SLS securitization was Tarrytown Second, involving $63 million SLSs backed by $195 million life policies. Legacy Benefits concluded a $70 million securitization in the same year. Very few securitizations have followed these, however, although America International Group (AIG) securitized 3,400 life policies with a total value of $8.4bn in 2009.

A number of reasons have been put forward to explain this low number of life settlement securitizations (see, e.g., Rosenfeld, 2009):

- The use of inaccurate mortality tables with unrealistically low LEs.
- The absence of meaningful protection against extension risk.
- Huge intermediary fees from brokers and portfolio aggregators, which can average more than 20% gross proceeds.[38]
- Credit (counterparty) risk: covers life insurance company issuing policy and the participants in the acquisition process (e.g., fraud). This risk can be mitigated by diversifying across insurers and undertaking due diligence of the acquisition chain.
- Operational risk: relates to risks in designing a portfolio and in the procuring and managing the assets. This risk can be mitigated by due diligence and a good pricing model.
- Market risk: a fall in the market value of all policies, regardless of credit quality or LE accuracy. This will depend on the balance between the number of policies available for settlement and the availability of funds to purchase life settlements. This risk can be partly mitigated by portfolio diversification.
- Market impediments. There are a number of issues here: poor price transparency, since purchase prices are private; and each policy has slightly different terms and conditions, so there is no universal standard trading platform or exchange for life-

[38] Conning Research has estimated agent, broker and provider fees to be 9.5% of face amount.

based products. A possible solution is a trading platform which trades 'standard' policies as reference points, with an indication of an individual policy's percentage deviation from the closest reference asset.

- Regulatory and taxation risks. This relates to the risks that the regulations covering life settlements or the taxation regime might change adversely. This risk can be mitigated by following a financially sound and transparent acquisition policy.

Annuity Book Securitization. Annuity book securitizations involve the packaging together and selling off of a life assurer's book of annuity business (Lin and Cox, 2005). The resulting securities are attractive to investors because they are highly leveraged investments in equities. For example, if the liability side of the SPV's balance sheet comprises 90 percent annuities and 10 percent shareholder funds, then this implies a leverage factor of 10. Every 1bp additional return on equities generates 10bp return to the investor. This is equivalent to a collateralized debt obligation (CDO) with annuitants as senior debt. Investors are effectively borrowing assets from annuitants. There is established investor interest in CDOs with the added benefit that longevity risk provides diversification from market risk.[39]

Reverse Mortgage Securitization. Reverse mortgages – also known as home equity release plans – allow home owners to borrow from the equity in their homes while still living in them. They are particularly attractive to the elderly who might have low pensions, but substantial net housing wealth (Bishop and Shan (2008), Sun *et al.*, 2008). They started in US in the 1980s, where they are available from age 62. The most common type is the home equity conversion mortgage, which allows borrowers to take a reverse mortgage in form of: a lump sum, a lifetime income (the least popular form) or a line of credit (the most popular form). The amount that can be borrowed is negatively related to the interest rate. Interest (Treasuries + 150bps) is capitalized and repayable on moving or death, so there is no credit risk. However, the total interest payable is capped at the sale price of property and lenders are protected against total interest costs rising above this limit[40] (as a result of the home owner living a very long time) by a mortgage insurance policy that the borrower is required to take out (at a cost of 2 percent of the amount borrowed + 50bp p.a.).[41] The securitization of reverse mortgages is a fairly recent phenomenon (Zhai, 2000; Standard & Poor, 2006; Wang *et al.*, 2008; Yang (2011); and Huang *et al.*, 2011).

Mortality-linked Credit Default Swap Notes. In November 2010, Goldman Sachs issued $200 million in mortality-linked credit default swap (CDS) notes to hedge the mortality risk in a block of level, term-life insurance policies. The notes were issued by the SPV Signum Finance Cayman Ltd and were rated A+ by Fitch Ratings. The proceeds from the issue were used to buy collateral in the form of 15-year senior unsecured bonds issued by Goldman Sachs. The SPV will simultaneously enter into a 15-year CDS with Goldman Sachs and will

[39] Investor interest in CDOs was damaged, at least temporarily, by the Global Financial Crisis of 2007-08.
[40] Known as cross-over risk.
[41] This market has obviously found an effective solution to extension risk.

make payments to GS if the actual mortality experience of the insurance policies exceeds set trigger levels, while the fixed payments from GS to the SPV will be paid to the notes' investors.

IX. Conclusions

Longevity is now recognized as an important risk that is faced by insurers, pension plans, corporations, governments and individuals. By virtue of its size and prevalence, it is the most significant life-related risk exposure in financial terms and could potentially threaten the whole system of retirement income provision.

The emergence of a traded market in longevity-linked capital market instruments should act as a catalyst to facilitate the development of annuities markets both in the developed and the developing world. This market offers the promise of new capacity for bearing longevity risk, increased flexibility in the way it is transferred, and new tools with which the insurance industry can manage capital and risk. A functional annuity market is an important ingredient in the long-term viability of a stable retirement system. Furthermore, with DB pension plans in decline in many countries, annuities offer the only alternative for individuals to secure retirement income free from longevity risk.

Nevertheless, there are still major challenges that remain and we highlight two of them.

First, the long-term investors, such as endowments, sovereign wealth funds and family offices, which must ultimately be persuaded to hold longevity-linked assets if the Life Market is to be a success, are still not completely comfortable with the asset class. This can partly be overcome with appropriate education, but it is also necessary to get the design of the investment instrument right. The most successful way to date of hedging longevity risk has been via the longevity swap, but swaps and other derivatives are not the type of investment preferred by these long-term investors. Rather, they are more familiar with, and hence prefer, bonds. While short-term mortality bonds have been a success, long-term longevity bonds have not been successful so far. So important work needs to be done in making the design of longevity bonds more attractive to both issuers and holders. However, the Swiss Re strategy of gradual iteration from a successful innovation – as exemplified in the Kortis longevity note which is a modest adaptation of the mortality bond in terms of design and maturity – appears to show a way forward. The two key prizes, if successful, are a much bigger investor base and much greater market liquidity.

Second, it seems likely that the regulatory responses to the Global Financial Crisis will have some effect in slowing down the growth of the Life Market. Regulation restricting the risk-taking activities of investment banks and new bank capital rules known as Basel III are limiting the role that banks can play in the development of this market. It has become much less attractive for banks to warehouse risk while matching longevity hedgers and longevity investors. Furthermore, it has even become much less attractive for them to intermediate, standing in the middle between hedgers and investors, because the long-dated, illiquid credit exposure associated with longevity transactions now carries increased capital charges.[42]

These two challenges will need to be addressed in the next stage of the development of this market. But innovation has been an important feature of the longevity market since 2006 and there is every reason to believe that this will continue as the different players in the industry seek to reduce costs, optimize capital and manage risks.

Appendix A: Mortality Forecasting Models

There are three classes of time-series-based stochastic mortality forecasting model in existence.[43] The oldest is the Lee-Carter model (Lee and Carter, 1992) which makes no assumption about the degree of smoothness in mortality rates across adjacent ages or years. The most recent is the Cairns-Blake-Dowd (CBD) model (Cairns, Blake and Dowd, 2006b) which builds in an assumption of smoothness in mortality rates across adjacent ages in the same year (but not between years).[44] Finally, there is the P-splines model (Currie *et al.*, 2004) which assumes smoothness across both years and ages.[45] These models were subjected to a rigorous analysis in Cairns *et al.* (2009 and 2011a) and Dowd *et al.* (2010a and 2010b). The models were assessed for their goodness of fit to historical data and for both their *ex-ante* and *ex-post* forecasting properties.

Cairns *et al.* (2009) used a set of quantitative and qualitative criteria to assess each model's ability to explain *historical* patterns of mortality: quality of fit, as measured by the Bayes Information Criterion (BIC); ease of implementation; parsimony; transparency;

[42] In April 2012, a number of investment banks – UBS, Credit Suisse and Nomura – pulled out of the Life Market as a result of the additional capital requirements under Basel III. But new insurers and reinsurers entered: Munich Re, Scor and Prudential (US).

[43] Apart from the extrapolative models considered here, there are two other types of mortality forecasting model: process-based models, which examine the biomedical processes that lead to death, and explanatory or causal models, which use information on factors which are believed to influence mortality rates such as cohort (i.e., year of birth), socio-economic status, geographical location, housing, education, medical advances and infectious diseases. These models are not yet widely used, since the relationships between these factors are not sufficiently well understood or because the underlying data needed to build the models are unreliable. Nevertheless, some academic researchers have recently begun experimenting with causal variables (e.g., Hanewald (2011) and Gaille and Sherris (2011)), while practitioners have started to use post code or zip code as a measure of socio-economic status in their mortality models, especially for pricing annuities. Further, RMS has recently built an infectious diseases model which was briefly described above in the section on Longevity Notes. For more details, see Blake and Pickles (2008).

[44] The CBD model was specifically designed for modeling higher age mortality rates. It has recently been generalised to account for the different structure of mortality rates at lower ages by Plat (2009) and Hunt and Blake (2013).

[45] Other academic studies of mortality models include Booth *et al*. (2002a,b), Brouhns *et al*. (2002, 2004), Biffis (2005), Czado *et al*. (2005), Koissi *et al*. (2005), Renshaw and Haberman (2006), Delwarde *et al*. (2007), Blake et al. (2008b), Bauer *et al*. (2008, 2010a), Hari *et al*. (2008), Hatzopoulos and Haberman (2009, 2011), Biffis *et al*. (2010b), Debonneuil (2010), Cox *et al*. (2010), Yang *et al*. (2010), D'Amato *et al*. (2011), Milidonis *et al*. (2011), Wang *et al*. (2011a), Zhu and Bauer (2011), Aleksic and Börger (2012) and Hainaut (2012).

incorporation of cohort effects; ability to produce a non-trivial correlation structure between ages; and robustness of parameter estimates relative to the period of data employed. The study concluded that a version of the CBD model allowing for a cohort effect[46] was found to have the most robust and stable parameter estimates over time using mortality data from both England & Wales and the US.[47]

Cairns *et al.* (2011a) focused on the qualitative forecasting properties of the models[48] by evaluating the *ex-ante* plausibility of their probability density forecasts in terms of the following qualitative criteria: biological reasonableness;[49] the plausibility of predicted levels of uncertainty in forecasts at different ages; and the robustness of the forecasts relative to the sample period used to fit the models. The study found that while a good fit to historical data, as measured by the BIC, is a good starting point, it does not guarantee sensible forecasts. For example, one version of the CBD model allowing for a cohort effect produced such implausible forecasts of US male mortality rates that it could be dismissed as a suitable forecasting model. This study also found that the Lee-Carter model produced forecasts at higher ages that were 'too precise', in the sense of having too little uncertainty relative to historical volatility. The problems with these particular models were not evident from simply estimating their parameters: they only became apparent when the models were used for forecasting. The other models (including the age-period-cohort (APC) model[50]) performed well, producing robust and biologically plausible forecasts.

It is also important to examine the *ex post* forecasting performance of the models. This involves conducting both backtesting and goodness-of-fit and analyses. Dowd *et al.* (2010a), undertook the first of these analyses. Backtesting is based on the idea that forecast distributions should be compared against subsequently realized mortality outcomes and if the realized outcomes are compatible with their forecasted distributions, then this would suggest that the models that generated them are good ones, and *vice versa*. The study examined four different classes of backtest: those based on the convergence of forecasts through time towards the mortality rate(s) in a given year; those based on the accuracy of forecasts over multiple horizons; those based on the accuracy of forecasts over rolling fixed-length horizons; and those based on formal hypothesis tests that involve comparisons of realized outcomes against forecasts of the relevant densities over specified horizons. The study found that the Lee-Carter model, the APC model and the CBD model (both with and without a cohort effect) performed well most of the time and there was relatively little to choose between them. However, another

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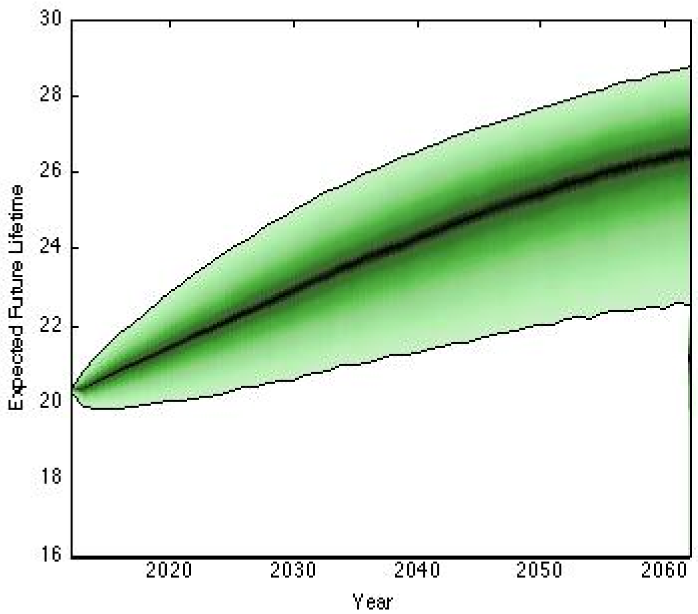
[46] A cohort effect recognizes that year of birth (in addition to age) influences life expectancy; see Willets (2004).
[47] The CBD model with a cohort effect is also known as Model M7, a naming convention introduced in Cairns *et al.* (2009). The original CBD model without a cohort effect is also known as Model M5.
[48] The P-splines model was excluded from the analysis because of its inability to produce fully-stochastic projections of future mortality rates.
[49] A method of reasoning used to establish a causal association (or relationship) between two factors that is consistent with existing medical knowledge.
[50] An extension of the Lee-Carter model to allow for a cohort effect: see Currie, 2006; Osmond, 1985; and Jacobsen *et al.*, 2002).

version of the Lee-Carter model allowing for a cohort effect repeatedly showed evidence of instability.[51]

Dowd *et al.* (2010b) set out a framework to evaluate the goodness of fit of stochastic mortality models and applied it to the same models considered by Dowd *et al.* (2010a). The methodology used exploited the structure of each model to obtain various residual series that are predicted to be independently and identically distributed (iid) standard normal under the null hypothesis of model adequacy. Goodness of fit can then be assessed using conventional tests of the predictions of iid standard normality. For the data set considered (English & Welsh male mortality data over ages 64-89 and years 1961-2007), there are some notable differences amongst the different models, but none of the models performs well in all tests and no model clearly dominates the others. In particular, all the models failed to capture long-term changes in the trend in mortality rates. Further development work on these models is therefore needed. It might be the case that there is no single best model and that some models work well in some countries, while others work well in other countries.

The CBD model appears to work well in England & Wales for higher ages, and Figures A1 and A2 show two applications of the model using LifeMetrics data for England & Wales.

Figure A1: Longevity Fan Chart for 65-year-old English & Welsh Males

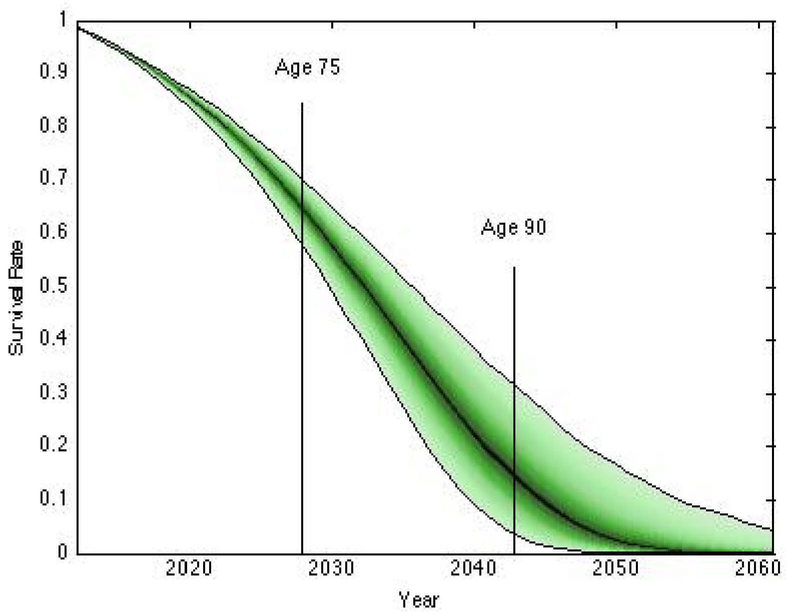


Source: Dowd *et al.* (2010c, Figure 3, updated)

[51] See Renshaw and Haberman (2006).

The first is a longevity fan chart (Figure A1) which shows the increasing funnel of uncertainty concerning the future life expectancies out to 2062 of 65-year-old males from England & Wales.[52] By 2062, the best expectation of life expectancy is around 26 years, shown by the dark central band and an increase of 6 years on the expectation for the year 2012. This band represents a 10-percent confidence interval, so we can only be 10-percent confident about this projection. Surrounding the central band are eight bands of increasingly lighter shading, each representing a 10-percent confidence interval. Adding these together, the whole fan chart shows the 90-percent confidence interval for the forecast range of outcomes. We can be 90-percent confident that by 2062, the life expectancy of a 65-year-old English & Welsh male will lie between 22 and 29. This represents a huge range of uncertainty. Since every additional year of life expectancy at age 65 adds around 3 percent to the present value of pension liabilities,[53] the cost of providing pensions in 2060 could be 9 percent higher than the best expectation for 2060 made in 2010.[54]

Figure A2: Survivor Fan Chart for 65-year-old English & Welsh Males



Source: Blake *et al.* (2008b, Figure 2, updated)

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[52] Note projections run from 2012 based on the CBD model estimated using data for ages 60-80 (higher ages not available) and years 1961-2010.

[53] Pension Protection Fund and the Pensions Regulator (2006, Table 5.6)

[54] Even this might be an underestimate, since companies do not even use up-to-date estimates of current life expectancy, i.e., their 'best expectation' is too low. A study by Pension Capital Strategies (reported in *Pensions Week* on 8 November 2007) calculated that the UK's top 100 companies (i.e., the FTSE100) were underestimating pension liabilities by as much as £40 billion (or 3.5 percent of GDP) as a result.

The second is a survivor fan chart which shows the 90-percent confidence interval for the survival rates of English & Welsh males who reached 65 in 2012. Figure A2 shows that there is very little survivorship risk before age 75: a fairly reliable estimate is that 20 percent of this group will have died by age 75.[55] The uncertainty increases rapidly after 75 and reaches a maximum at around age 90, when anywhere between 10 and 45 percent of the original population will still be alive. We then have the long 'tail' where the remainder of this cohort dies out some time between 2037 and 2062.

An important recent contribution to mortality forecasting deals with the consistent modelling and hence forecasting of the mortality rates of two or more related populations. Two key studies are Dowd *et al.* (2011b) and Cairns *et al.* (2011b).[56] Suppose the aim is to forecast the mortality of the members of a small pension plan, but both the quantity and quality of the mortality data are poor. Suppose the quantity and quality of the mortality data of the national population in which the pension plan resides are much better. Because the mortality dynamics of the smaller sub-population will be related to that of the larger national population, the mortality forecasts of the pensioner population will be improved if it is treated as part of a system that involves the larger population.

Dowd *et al.* (2011b) employ a 'gravity' model to do this. The larger population is modelled independently, but the smaller population is modelled in terms of spreads (or deviations) relative to the evolution of the larger population. The spreads in the period and cohort effects between the larger and smaller populations depend on gravity or spread reversion parameters for the two effects. The larger the two gravity parameters, the more strongly the smaller population's mortality rates move in line with those of the larger population in the long run. This is important where it is believed that the mortality rates between related populations should not diverge over time on grounds of biological reasonableness, as would be expected in the example here.

Cairns *et al.* (2011b) also make use of a mean-reverting stochastic spread that allows for different trends in mortality improvement rates in the short-run, but parallel improvements in the long run. However, this study uses a Bayesian framework that allows the estimation of the unobservable state variables that determine mortality and the parameters of the stochastic processes that drive those state variables to be combined into a single procedure.[57] The key benefits of this include a dampening of the impact of Poisson variation in death counts,[58] full allowance for parameter uncertainty, and the flexibility to deal with missing data.

Building off a good mortality forecasting model estimated using data from an objective, transparent and relevant set of mortality indices, fan charts provide a very useful tool for both quantifying and visually understanding longevity and survivor risks.

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[55] This is one of the reasons why the EIB bond was considered expensive: the first 10 years of cash flows are, in present value terms, the most costly cash flows of a bond, and, in the case of the EIB bond, incorporate a longevity hedge that is not really needed.
[56] See also Li and Lee (2005), Jarner and Kryger (2011), and Li and Hardy (2011).
[57] Dowd *et al*. (2011b), by contrast, uses an iterative procedure to do this.
[58] The study uses the common assumption that individual deaths follow a Poisson distribution.

Appendix B: Key organizations that have called on governments to support the development of the Life Market

UK Pension Commission

The Pensions Commission has suggested that the government should consider the use of longevity bonds to absorb tail risk for those over 90 or 95, provided it exits from other forms of longevity risk pre-retirement (which it has done by raising state pension age to 68 by 2046):

‘One possible limited role for government may, however, be worth consideration: the absorption of the “extreme tail” of longevity risk post-retirement, i.e., uncertainty about the mortality experience of the minority of people who live to very old ages, say, beyond 90 or beyond 95.”

Source: A New Pension Settlement for the Twenty-First Century, Pension Commission, Second Report, 2005, page 229

UK Insurance Industry Working Group

‘Against this background, the government could issue longevity bonds to help pension fund and annuity providers hedge the aggregate longevity risks they face, particularly for the long-tail risks associated with people living beyond age 90.’

‘By kick-starting this market, the Government would help provide a market-determined price for longevity risk, which could be used to help establish the optimal level of capital for the Solvency II regime of prudential regulation.’

Source: Vision for the Insurance Industry in 2020 – A Report from the Insurance Industry Working Group, July 2009

UK Confederation of British Industry (CBI)

‘Government should press ahead with changes that make it more possible for schemes to adapt to changing circumstances – for instance … seeding a market for products that help firms manage their liabilities, like longevity bonds.’

‘Government should drive development of a market in longevity bonds, a similar instrument to annuities, by which the payments on the bonds depend on the proportion of a reference population that is still surviving at the date of payment of each coupon. This should be done through limited seed capital and supporting policy work on the topic. Government could also consider how best to match government bond issues to pension scheme needs, including the provision of more long-dated bonds and whether government should issue mortality bonds itself.’

Source: Redressing the Balance – Boosting the Economy and Protecting Pensions, CBI Brief, May 2009

Organization for Economic Cooperation and Development

‘Governments could improve the market for annuities by issuing longevity indexed bonds and by producing a longevity index.

Source: Antolin, P. and H. Blommestein (2007) ‘Governments and the Market for Longevity-Indexed Bonds’, OECD Working Papers on Insurance and Private Pensions, No. 4, OECD Publishing.

World Economic Forum

‘Given the ongoing shift towards defined contribution pension arrangements, there will be a growing need for annuities to enhance the security of retirement income. Longevity-indexed bonds and markets for hedging longevity risk would therefore play a critical role in ensuring an adequate provision of annuities.’

Source: World Economic Forum – Financing Demographic Shifts Project, June 2009

International Monetary Fund

‘Although the private sector will further develop market-based transfer mechanisms for longevity risk if it recognizes the benefits of doing so, the government has a potential role in supporting this market. Measures could include provision of better longevity data, better regulation and supervision, and education to promote awareness of longevity risk. Those governments that are able to limit their own longevity risk could consider issuing a limited quantity of longevity bonds to jumpstart the market.’

Source: The Financial Impact of Longevity Risk, Chapter 4 of Global Financial Stability Report, April 2012

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