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ALTERNATIVE INVESTMENT QUARTERLY

The Birth of the Life Market[1]

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By providing financial protection against the major 18th and 19th century risk of dying too soon, life assurance became the biggest financial industry…providing financial protection against the new risk of not dying soon enough may well become the next century's major and most profitable financial industry.

Peter Drucker, *The Economist*, 1999

1. Introduction

The life market, the traded market in assets and liabilities linked to longevity (or mortality), is the world's newest capital market. It has the potential to develop into a very large global market indeed. 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 insurance markets, these lack the capacity and liquidity to support a fully-fledged traded market. What is needed are new financial instruments, together with the technology and tools to create a liquid market. These conditions are just starting to emerge, as evidenced by the first publicly-announced longevity derivative transaction between investment bank JPMorgan and Lucida, a UK-based insurer, on 15 February 2008 (Loeys *et al*, 2007 and Lucida, 2008).

The traditional method of transferring longevity risk is through insurance and reinsurance contracts. A current example of this is the market for bulk annuity transfers and pension fund buy-outs in the UK. This is a market between annuity providers, pension funds, insurers and reinsurers. The market involves the transfer of all risks, including longevity risk.

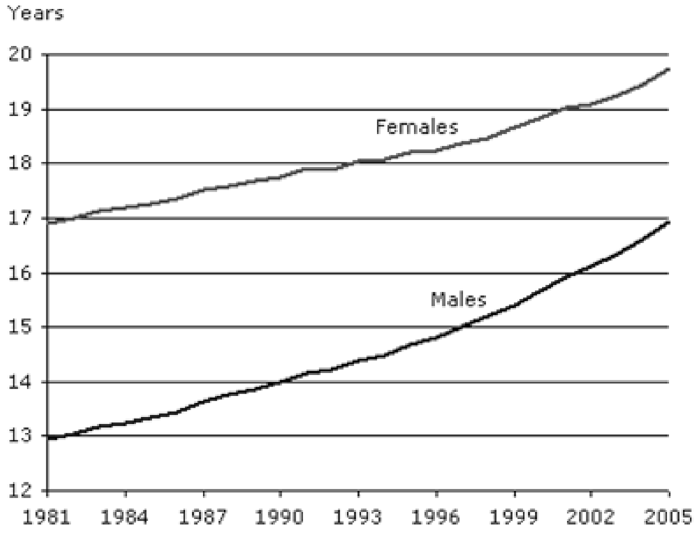
In this article, we discuss the problem of longevity risk (section 2) and review the traditional solution for dealing with it (section 3). We then consider what the capital markets need to develop (section 4). Next, we consider the first generation of bond-based capital market solutions that have been tried so far (section 5). The lessons learned here have informed the design of the second generation of derivatives-based capital market solutions, although barriers remain to further development (section 6). Finally, we draw our conclusions (section 7).

2. Longevity risk

Life expectancy has been increasing in almost all the countries of the world.[3] Figure 1 shows the experience for the UK. Male life expectancy at 65 rose from 13 years in 1981 to nearly 17 years in 2005, or by around

1.1% p.a. By contrast, female life expectancy at 65 rose from 17 years in 1981 to 19.7 years in 2005, or by around 0.6% p.a. Figure 2 shows that, in developed countries, life expectancy at birth (for females) has been increasing almost linearly at the rate of nearly three months per year for more than 150 years.

Figure 1: Life expectancy at age 65 in the UK, 1981-2005



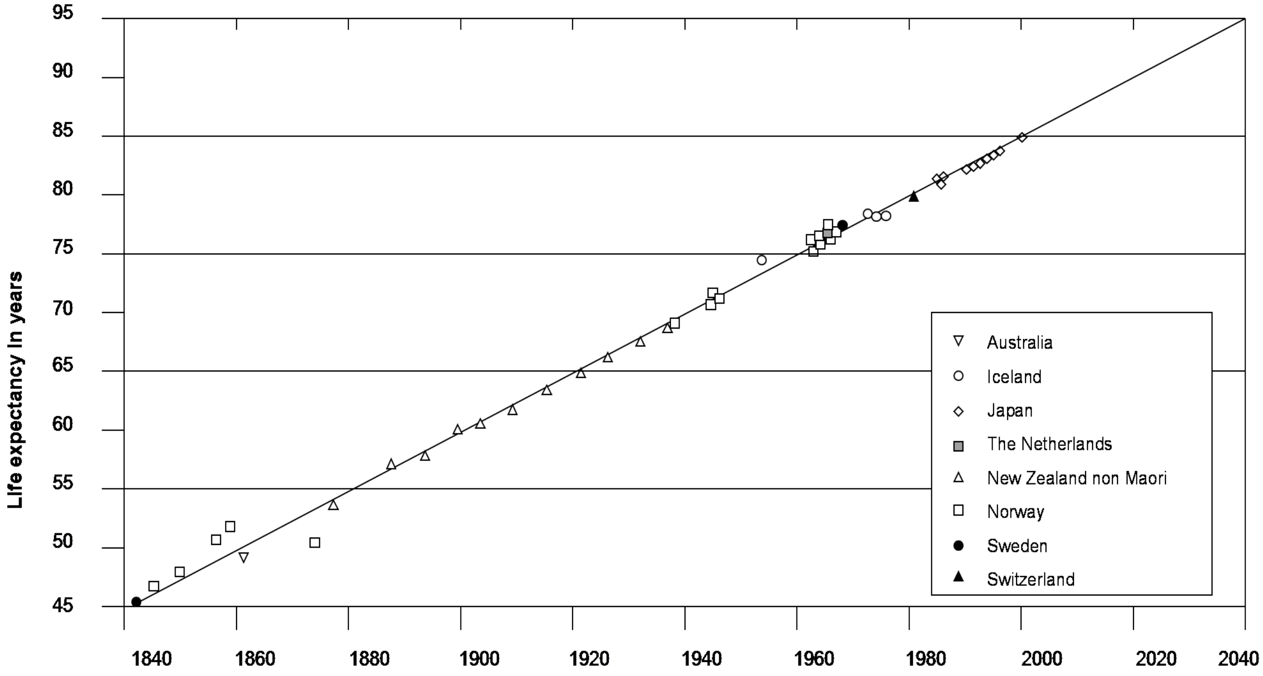
Source: Office for National Statistics (2007)

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. The pension systems could respond by requiring participants to pay higher contributions when they are working or by requiring them to work longer. Pension plan members might not like either prospect, but, separately or in combination, they could be used to maintain the viability of pension systems.

So, it is not aggregate increases in life expectancy *per se* that is challenging the viability of pension systems almost everywhere. 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. It is only recently that the stochastic nature of mortality rate changes has begun to be recognised. Figure 3 shows that aggregate mortality rates (in this case those of 65-year-old English and Welsh men) have been generally declining (in this case since the 1970s), but that changes have an unpredictable element, not only from one period to next, but also over the long run.

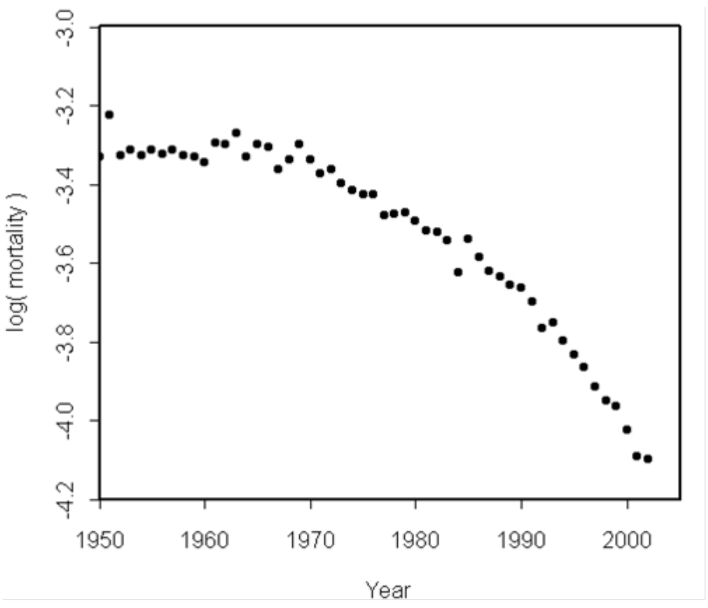
A large number of products in pensions and life assurance have longevity as a key source of risk, DB pension plans and annuities being important examples. These products expose DB plan sponsors and annuity providers to unanticipated changes over time in the mortality rates of the relevant reference populations.

Figure 2: Record female life expectancy since 1840



Source: Oeppen and Vaupel (2003, Fig 1)

Figure 3: Logarithm of mortality rates for 65-year-old English and Welsh men, 1950-2002



Source: Office for National Statistics

To be more specific, 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. Annuities are commoditised products selling on the basis of price, and profit margins have to be kept low in order to gain market share. If the mortality assumption built into the price of annuities turns out to be a gross overestimate, this cuts straight into the profit margins of annuity providers. Many life companies in the UK – where more than half of the world's life annuities are sold — claim to lose money on their annuity business or offer them only on the most unfavourable terms. The same argument applies, *mutatis mutandis*, to sponsors of DB pension plans.

Yet life annuities are a desirable component of retirement income provision throughout the world: they are the only financial instrument ever devised 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. There is a real danger that they might disappear from the financial scene and, hence, leave pension plan providers and members exposed to aggregate longevity risk that cannot be hedged effectively.

3. The traditional solution for dealing with longevity risk

The traditional solution for dealing with the longevity risk in an annuity book or DB pension plan is to sell the liability via an insurance or reinsurance contract. This is known as a bulk annuity transfer or a pension fund buy-out. Bulk annuity transfers have come under increasing attention in the UK since 2006, and we will examine the main types.

The most common type is a full buy-out. This is usually implemented using a life assurer regulated in the UK by the Financial Services Authority (FSA). The procedure can be illustrated using the following example.

Consider Company ABC with scheme assets (A) of 85 and pension plan liabilities (L) of 100, valued on an 'ongoing basis'[4] by the scheme actuary; this implies a deficit of 15. ABC approaches life assurer XYZ. On a full 'buy-out basis', XYZ values ABC's liabilities at 120, implying a full buy-out deficit of 35. XYZ, subject to due diligence, offers to take on both A and L at XYZ's own valuation. ABC has to find 35 from its own resources to cover the deficit or borrow it (possibly from XYZ) at the bank base rate plus 1, 2 or 3%, depending on ABC's credit rating; regulations require this must be paid off over 10 years. Following the acquisition, XYZ exchanges the assets, which are likely to contain a high equity weighting, into bonds, or alternatively uses duration and inflation swaps to hedge the interest-rate and inflation risk in the pension liabilities.[5]

The advantages to the company are that the pension liabilities are completely removed from its balance sheet and replaced by a regular loan (in the case where the company does not have the resources to pay the full cost of the buy-out) which, unlike pension liabilities, is readily understood by investment analysts, etc; the loan can be conveniently paid off over 10 years. The company escapes volatility to its profit and loss account,[6] levies to the Pension Protection Fund (PPF),[7] and asset management fees on pension assets. The company can also attempt to reduce liabilities prior to wind-up by revising plan rules on inflation indexation (of deferred pensions and pensions in payment), so that they meet the statutory minimum and no more.[8] The advantages to the trustees and plan members are that pensions are now secured in full (subject to the credit risk of the life assurer).

The advantages to the life assurer are that it: gains a buffer of 20 (ie, 120–100) in the valuation of the liabilities over the valuation on an ongoing basis; gets an attractive return on the loan (if any) to ABC of 35; and can use its market power to buy newly-issued gilts on more favourable terms than other smaller investors, such as the ABC pension fund. Further, it gains from being a better manager of the mortality pool than the pension fund. It is not necessarily, nor does it claim to be, a better asset manager than the pension fund.

There are a number of variations on the above. One variation is the same, except that ABC retains the pension assets, believing it can be a better asset manager now that it is no longer encumbered by pension liabilities. ABC Company takes the view that by retaining a large investment in equities, these are bound to outperform bonds over a 10-year horizon. The company will keep any surplus from this strategy (thereby reducing the cost of the buy-out). This variation is not common, however, since the company has to have access to sufficient resources to pay the full buy-out cost of the liabilities.

Another variation is again the same as the original case, but it is now XYZ who believes it is a better asset manager. XYZ decides to use more innovative investment strategies such as ‘diversified growth’ which involves targeting an absolute return (in excess of LIBOR), but uses a wider range of asset classes to achieve this, such as public and private equity, property, commodities, infrastructure and, potentially, hedge funds. Such strategies might be used to back, say, the deferred annuities of the deferred members of the buy-out plan. They are permissible under UK regulations, so long as the internal risk-based model that XYZ uses satisfies the FSA’s various stress tests. However, there is some chance that the FSA will impose additional capital requirements; but even these can be partially offset if XYZ sets up an offshore reinsurance company.[9] By pooling plans, XYZ also gains from economies of scale on both the investment and mortality sides.

An alternative to a full buy-out is a partial buy-out or ‘de-risking’ (ie, risk reduction) strategy. A pension fund might use liability-driven investing (LDI) to manage liabilities out, say, 15 years and buy-out liabilities over 15 years. Or, it might buy-out all members over 70, or buy-out spouses’ pensions, or buy-out deferred pensions, or buy-out level pensions in payment. There is also a refundable buy-out plan, with refunds if the reserving basis turns out to be too conservative. The underlying rationale is the ‘ongoing risk management of the business’. Even large solvent employers will consider these de-risking strategies as part of normal pension risk management.

The buy-out market in the UK has become very active since 2006.[10] The traditional buy-out market was dominated by two life assurers, Prudential and Legal & General, who did business of approximately £2 billion a year. The total potential size of the buy-out market is £800 billion in the UK and this has encouraged a raft of new players.

Most of these have set themselves up as life companies (regulated by FSA): Paternoster (run by Mark Wood; conducted the very first buy-out in November 2006 of the Cuthbert Heath Family Plan with 33 pensioners), Pension Corporation (run by Edmund Truell), Pearl (run by Hugh Osmond), Lucida (run by former Prudential chief executive Jonathan Bloomer), Rothesay Life (owned by Goldman Sachs), Canada Life (bought the £4 billion closed annuity book of Equitable Life), Aegon Scottish Equitable, Aviva and AXA.

Some new players have avoided the assurance company route to a buy-out and retained the legal status of the pension fund after the buy-out. This is known as a non-insured buy-out. An example of this is Citigroup which in August 2007, bought Thomson Regional Newspapers’ closed pension fund. Citigroup became the sponsor of the pension fund, which will continue to be run under UK pensions legislation by a trustee board that includes the existing member-nominated trustees. In other words, after the buy-out, the pension plan still exists but has a new principal employer. Another example is Occupational Pensions Trust (OPT), which was established in September 2007 by Robin Ellison, former chairman of the National Association of Pension Funds; OPT claims that buy-out costs will be up to 20% lower than that charged by life companies. This method of buying out has been the slowest to develop, since the change of principal employer worries the UK

Pensions Regulator as it ends the covenant with original employer.

The buy-out market has become so competitive that some of the buy-out companies have started to buy the sponsoring companies themselves, in order to gain access to the pension plan assets and liabilities. One example of this is the Pension Corporation which purchased the off-licence chain Threshers in June 2007, retained the pension fund, but sold 75% of the operating business to private equity firm Vision Capital two weeks later.[11]

Another alternative to a full buy-out is dealing with the deficits while retaining them on the books. One example of this is to insure the pension deficit against default by the sponsoring company. Subject to due diligence, XYZ charges ABC a premium of between 1-2% per annum. of the deficit. The insurance contract is classified as a contingent asset and ABC can benefit from a PPF levy reduction. The asset allocation chosen by the pension fund is of no concern to the life assurer. The company can become more adventurous with investing pension assets, now that the plan sponsor has the insurance contract in place. An example of this is PensionsRisk Insurance (PRi) established in 2007. Suppose ABC has a £30 million closed fund deficit which is insured for 10 years at a cost of £5 million. PRi takes the assets and pays the member pensions. After 10 years, PRi hands back assets equal at least to the value of liabilities and the deficit is extinguished. A variation on this is the 'insured investment option' of Pension Capital Strategies and Tactica Assurance. ABC transfers assets equal to the IAS19[12] value of the pension liabilities. In return, ABC gets an insurance policy guaranteeing all the pension payments over a 10-year period, as well as the return of assets equal to the IAS19 value of the pension liabilities at the end of the 10-year period.

The traditional full buy-out market involves the transfer of all risks involved in delivering annuities and pensions, including interest rate risk, inflation risk, investment risk and reinvestment risk, as well as longevity risk. As a result, the buy-out companies now bear the aggregate longevity risk, but are unable to hedge it themselves. What is needed is a pure longevity hedge. Further, there is lack of transparency over pricing the buy-outs, especially over the pricing of longevity risk. This is where the capital markets can help, by providing pure longevity hedges and setting the longevity term structure, ie, the price of longevity risk at different ages and maturities. Without this crucial help from the capital markets, the buy-out companies are little more than position takers — as opposed to hedgers — of longevity risk, wholly dependent on their own judgements about future mortality improvements. Although longevity risk can be reinsured, there is inadequate reinsurance capacity on a global basis for reinsurance to be an effective way of managing this risk. To provide an effective solution on a global basis, again we need to look to the capital markets.

4. Capital market solutions

4.1 How does a new capital market start?

Loeys *et al* (2007, p. 6) explain that for a new capital market to be established and to succeed, 'it (1) must provide effective exposure, or hedging, to a state of the world that is (2) economically important and that (3) cannot be hedged through existing market instruments, and (4) it must use a homogeneous and transparent contract to permit exchange between agents'. They argue (p. 7) 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;
- share longevity risk: eg, via participating annuities with survival credits;
- insure/reinsure;
- securitise; and

- manage or hedge longevity risk with longevity-linked instruments traded in the capital market.

To ensure long-term survival, 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. The fewer the number of contracts traded, the greater the 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 contracts traded provides both adequate hedge effectiveness and adequate liquidity.

To achieve adequate liquidity, it is most likely that the life market will have to adopt mortality indices based on the national population. 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 example, it might be concentrated in specific socio-economic groups. 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]

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 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 minimise 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, pp. 76-82) 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 complete, because of residual basis risk.

Economic importance

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 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. Table 1 provides estimates of the total exposure to longevity risk of these institutions in the UK at the end of 2003. The total exposure is very large, around £2,520 billion. Coughlan (2007) estimates the total global exposure to be in excess of $20 trillion. What is noteworthy, however, is how little of this exposure is held by those with any expertise in understanding and managing longevity risk, namely life companies: of £1150 billion of exposure post-retirement and currently in payment in the UK, only £70 billion (or 6%) is in the hands of experts.[14]

Some institutions are long in longevity in the sense that their liabilities reduce or revenues increase if longevity increases. These include life companies selling term and life assurance 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 institutions, 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

Table 1: Longevity risk in UK pension provision, £billion of total liabilities, end 2003

	Pre-retirement: Still in employment	Post-retirement: Already in payment
Life companies	10?	70?
Pension funds	400?	400?
Unfunded public employee pensions	260	190
State pensions (earnings-related)	190	100
Total earnings-related	860	760
State pensions (basic)	510	390
Total	**1370**	**1150**

Source: Pensions Commission (2005, Table 5.17)

between the demand for, and supply of, longevity: this will influence the overall size of the market as well as the 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 and pension funds — need to pay an appropriate risk premium to lay off the longevity risk they currently assume.

Annuity providers and pension funds can, as has already been mentioned, sell their liabilities currently 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 makes insurance an expensive option. Further, there is limited capacity and capital within the insurance and reinsurance industry to assume these risks, and this raises the price of selling them even more.

The involvement of the capital markets will help to reduce the cost of managing longevity risk. This is because there will be a big 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 will attract the interest of hedge funds, endowments and other investors seeking asset classes that have low correlation with existing financial assets. Longevity-linked assets naturally fit this bill. Some investors might even be willing to take synthetic exposures in longevity, if the risk premium is sufficiently attractive.

The government could help to both encourage and facilitate the development of this market as it has a general role in promoting financial innovation and market stability. The government could also play a pump-priming role in the longevity bond market, as argued by the Pensions Commission (2005, p. 182). It could issue longevity bonds (see section 5.1 below) at different maturities and, hence, establish the risk-free term structure for longevity risk as it does in the fixed-income and inflation-linked bond markets. Of particular concern are the over 90s, the group that has been described as the 'toxic tail' of the annuity business: these are people who live very much longer than expected. Tom Boardman of Prudential in the UK has recommended that the government sell deferred annuities for those aged 90 and over. 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 standardised 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, p. 10) examine the correlations between five-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 5 and 6 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.

4.2 How do capital markets evolve?

Dr. Richard Sandor, Director of Chicago Climate Exchange, argues that there are seven stages of market evolution. These are shown in Table 2. Sections 5 and 6 will also help us to assess at what stage of development the life market currently is.

Table 2 : 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 organised futures and options markets
7	Proliferation of over-the-counter (OTC) markets, deconstruction.

Source: Sandor (1994, 2003)

5. First generation capital market solutions: bond-based

5.1 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 — see, eg, 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, eg, 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% of the reference population has died out, the second year's coupon payment will be 98.5% of the first year's payment etc. The bond holder, eg, a pension fund paying pensions to retired workers, is protected from the aggregate longevity risk it faces.

The first attempt to issue a longevity bond was in November 2004, when the European Investment Bank (EIB) attempted to launch a 25-year longevity bond with an issue price of £540 million and an initial coupon of £50 million. The reference mortality index was based on 65-year-old males from the national population of England and Wales as produced by the UK Government Actuary's Department (GAD). The structurer/manager was BNP Paribas which assumed the longevity risk, but reinsured it through PartnerRe, based in Bermuda (see Figure 4). The target group of investors was UK pension funds. Figure 5 shows how the coupons might change on the bond — eg, if mortality is lower than projected by the GAD, the coupons on the bond will decline by less than anticipated and vice versa.

5.2 Mortality bonds

Short-dated mortality bonds are market-traded securities whose payments are linked to a mortality index. They are similar to catastrophe bonds. As such, they are designed to hedge 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 this article 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 securitise Swiss Re's own exposure to mortality risk. Vita I was a three-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 (WMD) or a natural catastrophe. The mortality index (MI) had the following weights:

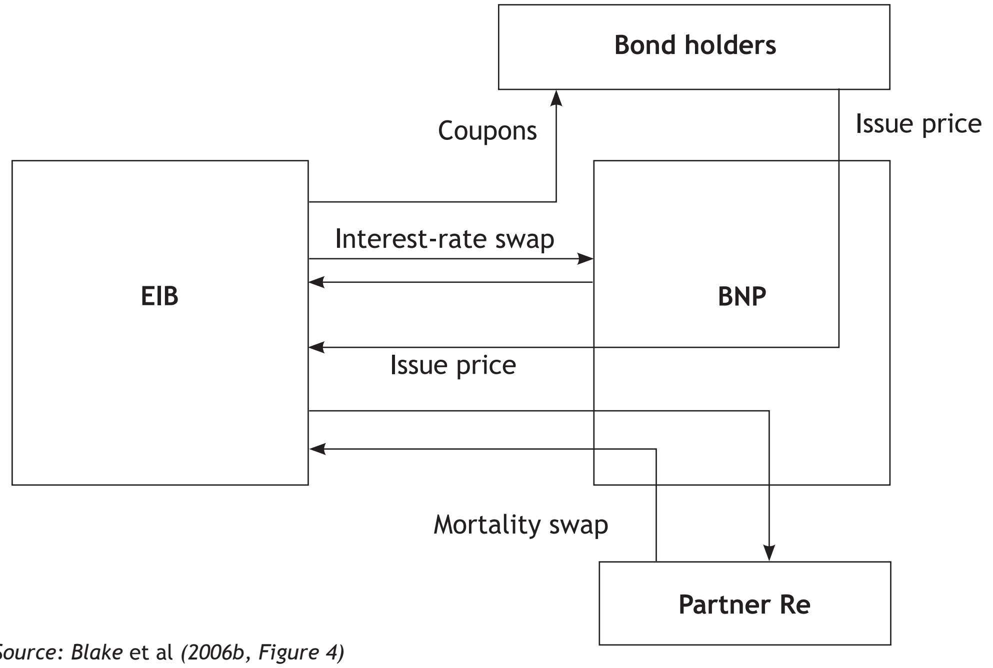
- US (70%), UK (15%), France (7.5%), Italy (5%), and Switzerland (2.5%);
- male (65%) and female (35%); and
- also age bands.

The $400 million principal was at risk if, during any single calendar year, the combined mortality index exceeded 130% of the baseline 2002 level, and would be exhausted if the index exceeded 150%. This was equivalent to a call option spread on the index with a lower strike price of 130% and an upper strike price of 150%. In return for having their principal at risk, investors received quarterly coupons of three-month USD Libor + 135bp (Figures 6 and 7).

The bond was valued by Beelders and Colarossi (2004) using extreme value theory. Assuming a generalised Pareto distribution, the authors estimated the probability of attachment (ie, Prob[MI(t)>1.3MI(2002)], where t = 2004, 2005 or 2006) to be 0.33%, and the probability of exhaustion (ie, Prob[MI(t)>1.5MI(2002)]) to be 0.15%. 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 favourable terms to investors — eg, Vita II - Swiss Re 2005 ($362 million), Vita III - Swiss Re 2007 ($705 million), Tartan - Scottish Re 2006 ($155 million) and OSIRIS – AXA 2006 ($442 million).

Figure 4: The structure of the EIB bond



Source: Blake et al *(2006b, Figure 4)*

Figure 5: Coupons on the EIB bond

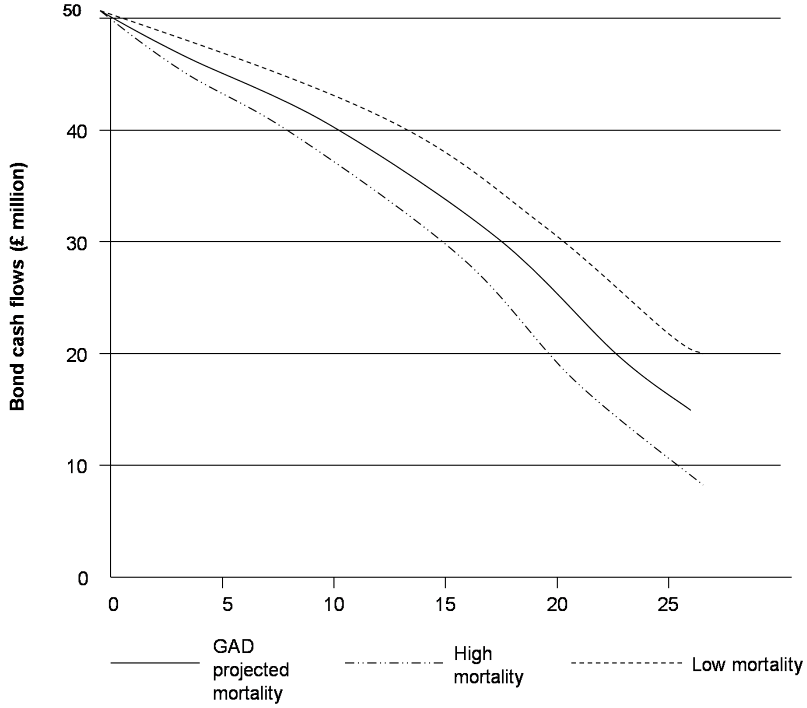
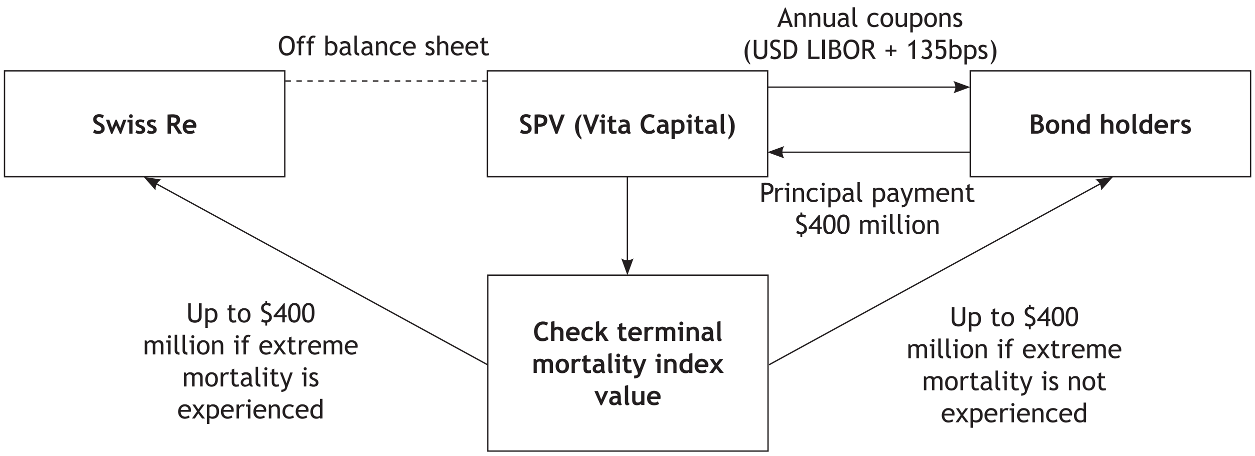
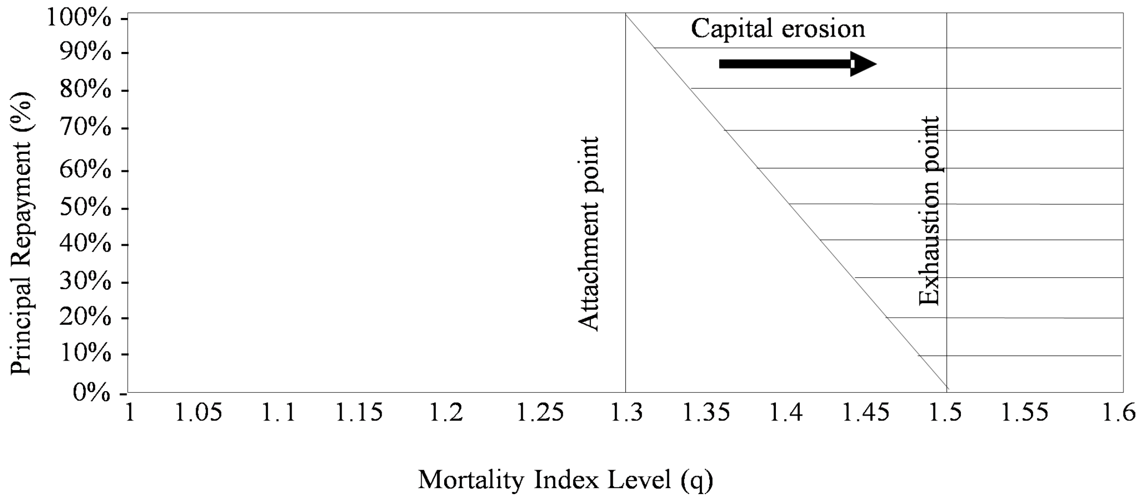


Figure 6: The structure of the Swiss Re bond



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

Figure 7: Principal-at-risk in the Swiss Re bond



Source: Blake et al *(2006b, Figure 1)*

5.3 Life securitisation

Securitisation 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.[16] 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.[17] Five types of securitisation 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).

'Block of business' securitisation

The earliest securitisations were 'block of business' securitisations (Cowley and Cummins, 2005). These have been used to capitalise expected future profits from a block of life business, recover embedded values 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. Securitisation helps to relieve this pressure by allowing the company immediate access to its expected future profits, and it is an especially attractive option when the company is experiencing rapid growth in a particular line of business. An example of this type of securitisation is the set of 13 transactions carried out by American Skandia Life Assurance Company (ASLAC) over 1996-2000.

Regulatory reserving (XXX) securitisation

Another form of life securitisation is regulatory reserving securitisation, sometimes also known as reserving funding or XXX securitisation. These arrangements are designed to give US life assurers relief from excessively conservative regulatory reserving or capital requirements, 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 securitisation 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 excessively conservative assumptions in the calculation of the regulatory reserve requirement on some types of life policies with long-term premium guarantees.

Life settlement securitisation

With life settlements, life policies are sold by their owner for more than the surrender value, but less than the face value. They are then packaged together in a SPV and sold on to investors.

The market began with the securitisation of viatical settlements in the US in 1990s. Viators are owners of life policies who are very close to dying, such as AIDS sufferers. That market ceased suddenly in 1996, when protease inhibitors were introduced.

Senior life settlement (SLS) securitisation began in 2004. This market deals with the life policies of elderly high net worth individuals. Two medical doctors or underwriters are used to assess each policyholder's life expectancy. The first SLS securitisation was Tarrytown Second, involving $63 million SLSs backed by $195 million life policies.

In January 2005, Life-Exchange was established with a mission 'to provide the secondary life insurance market with the most advanced and independent electronic trading platform available, by which to conduct life settlement transactions with the highest degree of efficiency, transparency, disclosure and regulatory compliance' (www.life-exchange.com). In April 2007, the Institutional Life Markets Association started in New York, as the trade body for the life settlements industry. In December 2007, Goldman Sachs launched a monthly index suitable for trading life settlements. The index, QxX.LS, is based on a pool of 46,290 anonymised lives over the age of 65 from a database of life policy sellers assessed by the medical underwriter AVS (www.qxx-index.com)

Annuity book securitisation

Annuity book securitisations 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% annuities and 10% 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 collateralised 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.[18]

Reverse mortgage securitisation

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 unrealised net housing wealth (Sun *et al*, 2007). They started in the 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 the 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 capitalised and repayable on moving or death, so there is no credit risk. However, the total interest is capped at the sale price of the property, and lenders are protected against total interest costs rising above this limit (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% of the amount borrowed + 50bp p.a.). The securitisation of reverse mortgages is a fairly recent phenomenon (Zhai, 2000, Standard & Poor's, 2006, Wang *et al*, 2007).

5.4 Problems and lessons learned

After a year of marketing, the EIB longevity bond had not generated sufficient demand to be launched and was withdrawn for a 'redesign'. This suggests that there are still significant barriers that need to be overcome before a sustainable life market develops. 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; and institutional issues. We examine each of these in turn.

Design issues

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 were 65-year-old males from the national population of England and 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. Further, the bond only matched cash flows under level pensions, yet a large portion of pensions paid by pension funds and life assurers are indexed to inflation.

Pricing issues

The longevity risk premium built into the initial price of the EIB bond was set at 20bp. Given that this was the 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. All bonds hedge interest rate risk, and this bond, in addition, hedged longevity risk, but the bond's payments were in nominal terms and, hence, did not hedge inflation risk.

Institutional issues

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 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 indemnifications. 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 the issue size of £540 million.[19]

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 and 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 good 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 JPMorgan in conjunction with the Pensions Institute and Watson Wyatt.[20] 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 key countries, such as the UK, the US, Holland and Germany, where longevity risk is perceived to constitute a significant economic problem.[21]

In March 2008, the Market Data & Analytics department of the Deutsche Börse announced it would publish monthly indices (named Xpect-Indices) on mortality and life expectancy, the purpose of which will be to aid the 'securitisation for life and pension insurance risks or as the basis for other financial products'. Initially, the indices will be published for Germany and its regions. Later the indices will be extended to other countries.

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).

Mortality forecasting models

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

There are three classes of time-series-based stochastic mortality forecasting model in existence.[22] 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). Finally, there is the P-spline model (Currie, *et al*, 2004) which assumes smoothness across both years and ages. These models were subjected to a rigorous analysis in Cairns *et al* (2007, 2008) and Dowd *et al* (2008a, b). The models were assessed for how well they fit to historical data and for both their ex-ante and ex-post forecasting properties. The studies concluded that the CBD model[23] performed most satisfactorily.[24] Two applications of this model are presented in Figures 8 and 9 using LifeMetrics data for England and Wales.

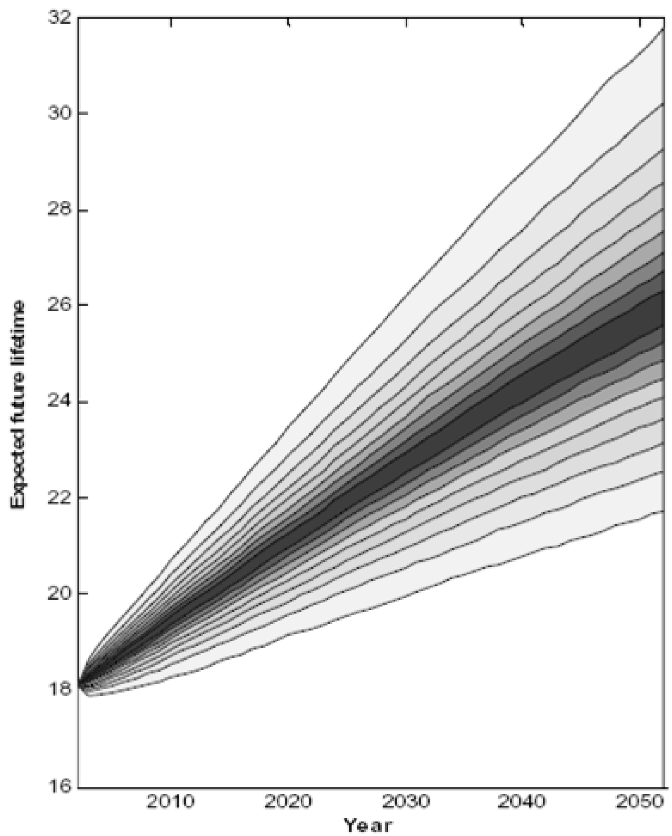
The first is a longevity fan chart which shows the increasing funnel of uncertainty concerning the future life expectancies until 2050 of 65-year-old males from England and Wales. By 2050, the best expectation of life expectancy is around 26 years, shown by the dark central band. But we can only be 10% confident about this figure. Surrounding the central band are bands of increasingly lighter shading: these are 10% confidence interval bands; and adding these together, the whole fan chart shows the 90% confidence interval for the forecast range of outcomes. We can be 90% confident that by 2050, the life expectancy of a 65-year-old English and Welsh male will lie between 21 and

32. This represents a huge range of uncertainty. Since every additional year of life expectancy at age 65 adds around 3% to the present value of pension liabilities,[25] the cost of providing pensions in 2050 could be 18% higher than anticipated today.[26]

The second is a survivor fan chart which shows the 90% confidence interval for the survival rates of English and Welsh males who reached the age of 65 in 2003. Figure 9 shows that there is very little survivorship risk before age 75: a fairly reliable estimate is that 25% of this group will have died by age 75.[27] The uncertainty increases rapidly after age 75 and reaches a maximum at around age 90, when anywhere between 15% and 35% of the original population will still be alive. We then have the long 'toxic tail' where the remainder of this cohort dies out some time between 2035 and 2045.

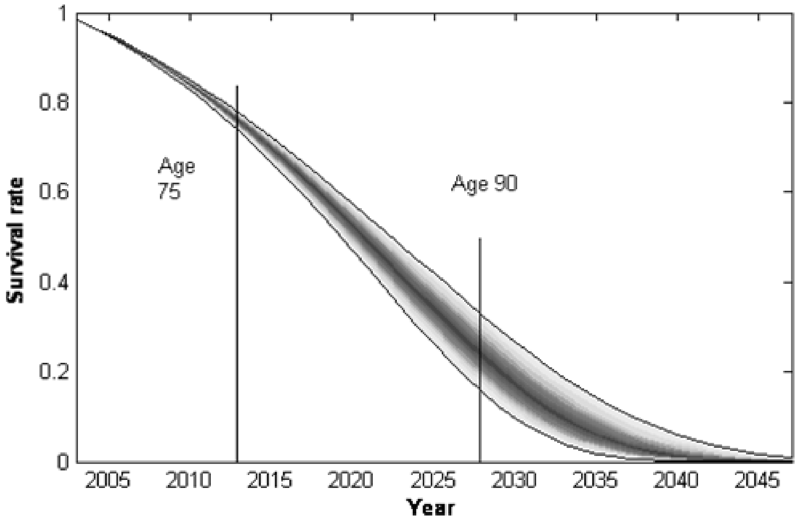
Building off a good mortality forecasting model estimated using data from an objective, transparent and relevant set of mortality indices, fan charts provide a very useful tool for both quantifying and visually understanding longevity and survivor risks.

Figure 8: Longevity fan chart for 65-year-old English and Welsh males



Source: Dowd ***et al*** *(2007, Figure 3)*

Figure 9: Survivor fan chart for 65-year-old English and Welsh males



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

6. Second generation solutions: derivatives based

The mixed success in the cash market and, to date, only at the short end, led to a redirection of design effort towards derivatives.[28]

6.1 Mortality and longevity (or survivor) swaps

The key derivative of interest is the mortality and longevity (or survivor) swap (see Dowd *et al,* 2006, and Dawson *et al*, 2008). Counterparties swap fixed series of payments in return for series of payments linked to the numbers of a given cohort who die in a given year (in the case of a mortality swap) or who survive in a given year (in the case of a longevity (or survivor) swap).

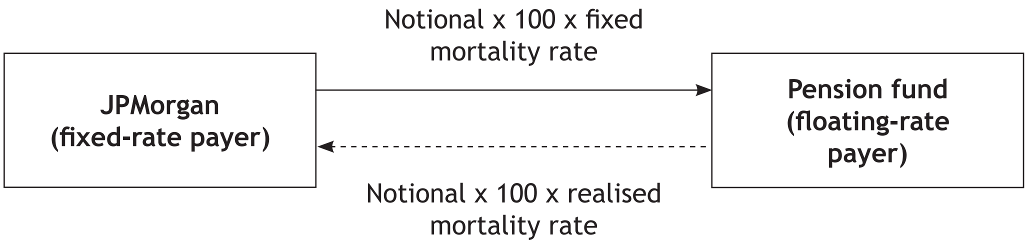
One example would be a swap based on 65-year-old males from England and Wales. A longevity swap was actually used in the construction of the EIB longevity bond (see Figure 4),[29] but is now being used on a stand-alone basis. As another example, a UK annuity provider could swap cash flows based on a UK mortality index for cash flows based on a US mortality index from a US annuity provider counterparty: this would enable both counterparties to diversify their longevity risks internationally.

The world's first publicly-announced longevity swap took place in April 2007.[30] It was between Swiss Re and Friends' Provident, a UK life assurer. 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 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 market instrument.

6.2 Mortality and longevity (or survivor) forwards

In July 2007, JPMorgan announced the launch of a mortality forward contract with the name ‘q-forward’ (Coughlan *et al*, 2007b). It is a forward contract linked to a future mortality rate: ‘q’ is standard actuarial notation for a mortality rate. The contract involves the exchange of a realised mortality rate relating to a specified population on the maturity date of the contract, in return for a fixed mortality rate agreed at the beginning of the contract (Figure 10).[31]

Figure 10: A q-forward exchanges fixed mortality for realised mortality at the maturity of the contract



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

Table 3 presents an illustrative term sheet for a q-forward transaction, based on a reference population of 65-year-old males from England and 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 2006 and maturing on 31 December 2016. It is being used by ABC Pension Fund to hedge its longevity risk over the next 10 years; the hedge provider is JPMorgan.

Table 3: An illustrative term sheet for a single q-forward to hedge longevity risk

Notional amount	GBP 50,000,000
Trade date	31 Dec 2006
Effective date	31 Dec 2006
Maturity date	31 Dec 2016
Reference year	2015
Fixed rate	1.2000%
Fixed amount payer	JPMorgan
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 and 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)*

On the maturity date, JPMorgan (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% (ie, the forward mortality rate for 65-year-old English and Welsh males for 2016). In return, ABC Pension Fund pays JPMorgan 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 2016 will, therefore, be based on the LifeMetrics Index value for the reference year 2015, 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 transacted forward rate) and the floating amount (which depends on the realised reference rate).

Table 4 shows the settlement amounts for four realised values of the reference rate and a notional contract size of £50 million. If the reference rate in 2015 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 JPMorgan 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 JPMorgan which will be offset by the fall in its pension liabilities.

Table 4: An illustration of q-forward settlement for various outcomes of the realised reference rate

Reference rate (realised 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.*

A q-forward is a standardised longevity or mortality hedge building block. A portfolio of q-forwards with suitably chosen reference ages and maturity dates (ie, a synthetic swap) can be constructed to provide an effective hedge for the longevity risk in a pension fund or annuity book, or the mortality risk in a book of life assurance policies.[32]

However, it is important to note that the hedge illustrated here is structured as a 'value hedge', rather than as a 'cash flow hedge'. With a value hedge, the net payments are rolled up and paid at maturity. With a cash flow hedge, the net payments are made period by period; the Swiss Re — Friends' Provident longevity swap is an example of a cash flow hedge. The capital markets are more familiar with value hedges, whereas cash flow hedges are more common in the insurance world.

It is also important to note that standardised hedges have advantages over the customised hedges that are currently more familiar to pension funds and annuity providers. They also have disadvantages. These are listed in Table 5. But the key advantages of simplicity, cost and liquidity that standardised hedges have over customised hedges, mean that they will eventually come to dominate customised hedges.

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

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

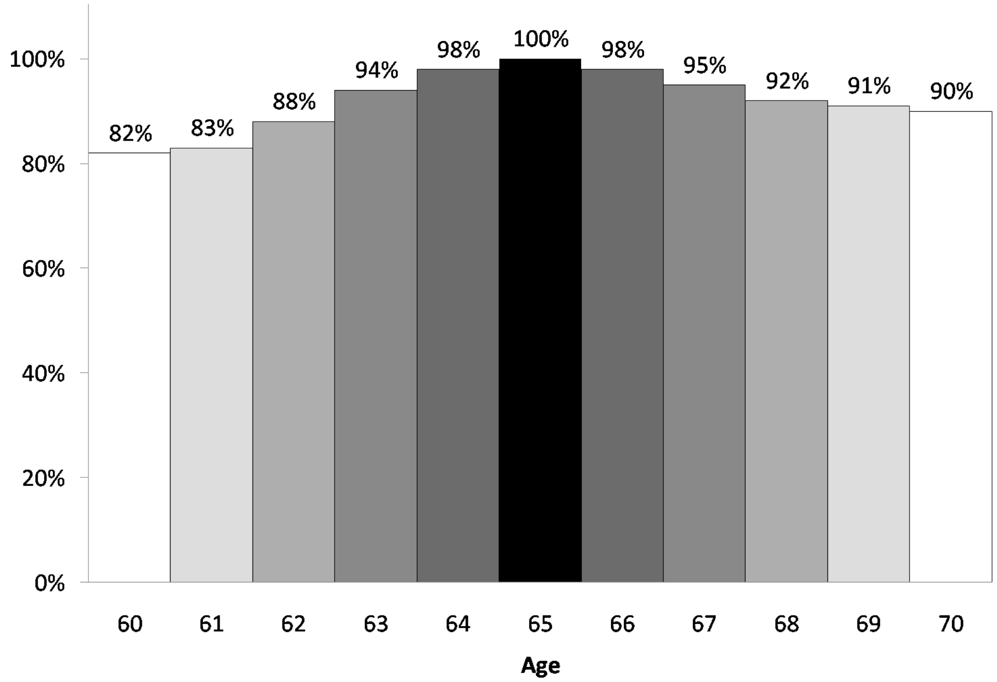
Figures 11 and 12 present the mortality improvement correlations within the male 60-69 and 70-79 age buckets, which are centred on ages 65 and 75, respectively. These figures show that the correlations are very high and that contracts based on 65-year-old and 75-year-old males will provide good hedge effectiveness for schemes with members in the relevant age buckets. Coughlan (2007) estimates that the hedge effectiveness is around 86% (ie, the standard deviation of the liabilities is reduced by 86%, leaving a residual risk of 14%): see Figure 13.

Table 5: Standardised vs. customised hedges

	Advantages	*Disadvantages*
Standardised hedge	• Cheaper than customised hedges. • Lower set-up/operational costs. • Shorter maturity, so lower counterparty credit exposure.	• Not a perfect hedge: - basis risk; - roll risk.
Customised hedges	• Exact hedge, so no residual basis risk. • Set-and-forget hedge, requires minimal monitoring.	• More expensive than standardised. • High set-up and operational costs. • Poor liquidity. • Longer maturity, so larger counterparty credit exposure. • Less attractive to investors.

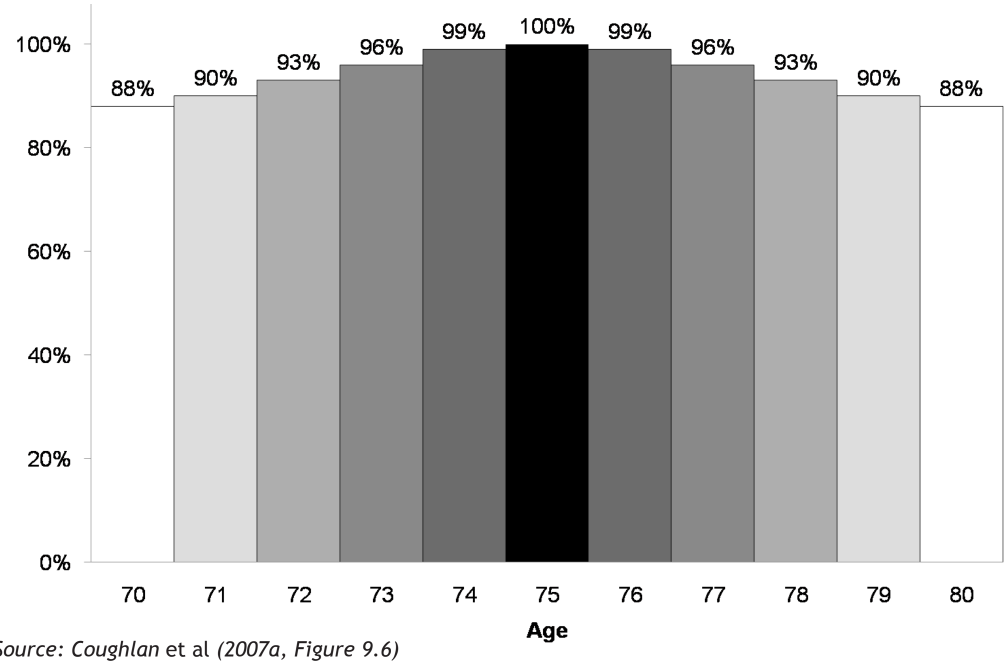
Source: Coughlan (2007)

Figure 11: Annual mortality improvement correlations with English and Welsh males aged 65



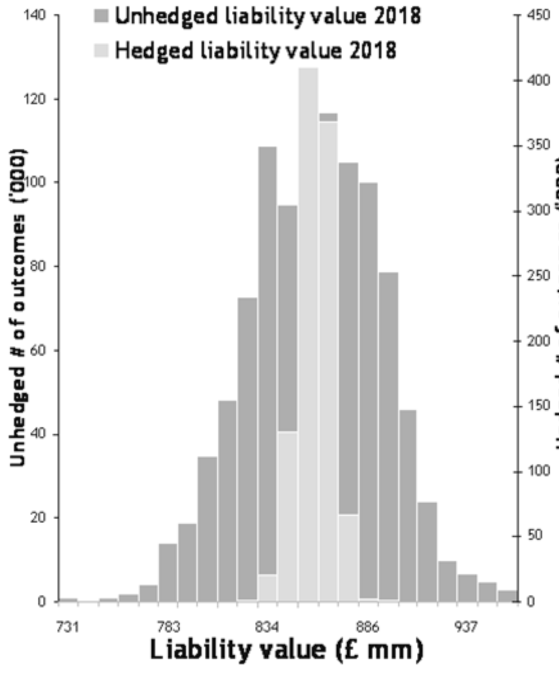
Source: Coughlan et al *(2007a, Figure 9.5)*

Figure 12: Annual mortality improvement correlations with English and Welsh males aged 75



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

Figure 13: The hedge effectiveness of q-forwards

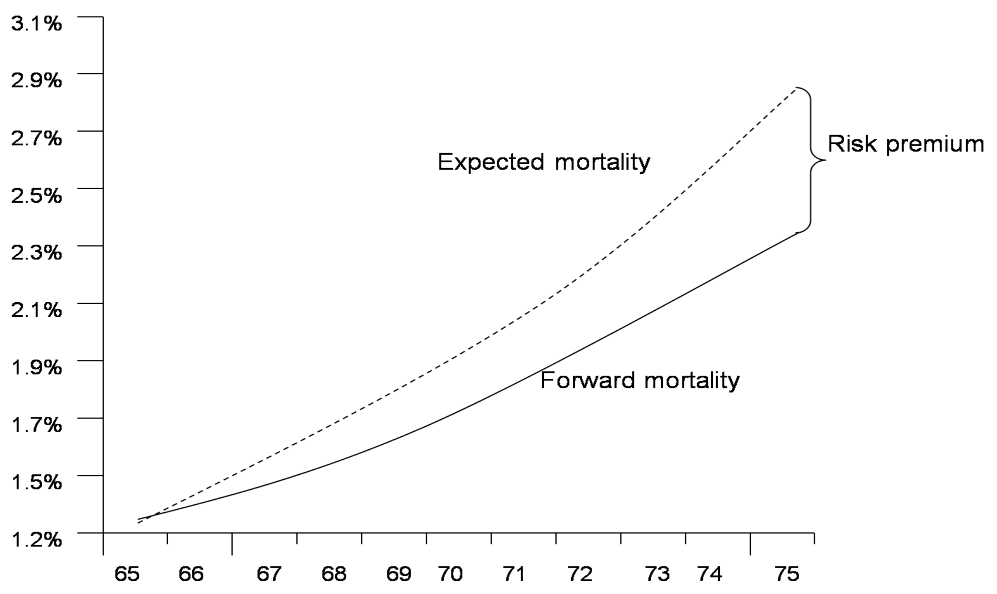


Note:
risk reduction = 86%
residual risk = 14%

Source: Coughlan (2007)

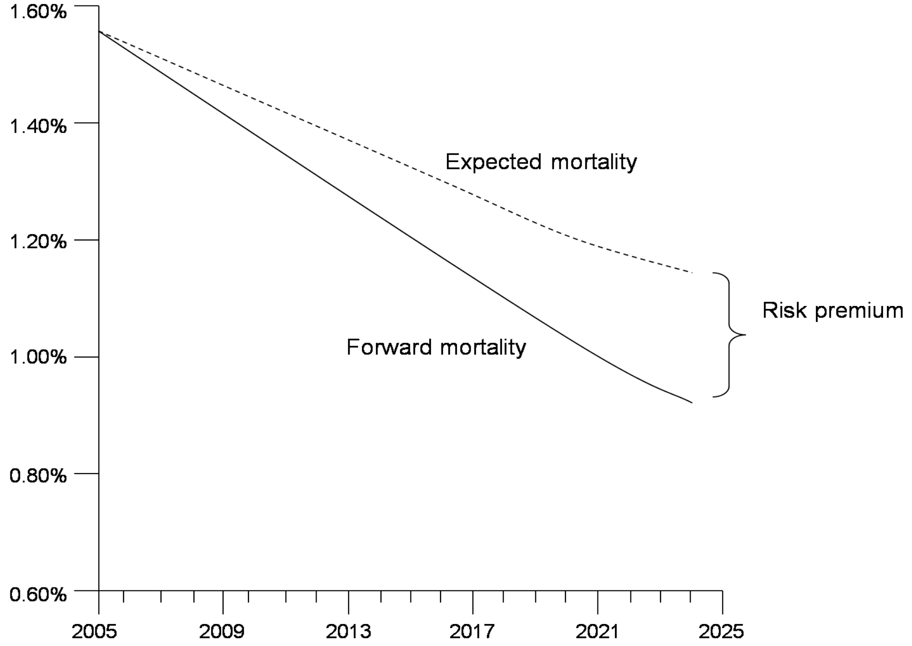
Because the hedge provider requires a premium to assume mortality or longevity risk, the fixed forward rate agreed at the start of the q-forward contract will be below the anticipated mortality rate on the maturity date of the contract. Figure 14 shows the relationship between the expected and forward mortality rate curves and the risk premium for a particular year (in this case 2017) for ages 65-75. Figure 15 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 and Welsh males) for years 2005-25.

Figure 14: Expected and forward mortality rate curves for 2015 for ages 65-75



Source: adapted from Loeys et al *(2007, Chart 9); lines are illustrative only*

Figure 15: Expected and forward mortality rate curves for 65-year-old English and Welsh males, 2005-25



Source: adapted from Coughlan (2007); lines are illustrative only

The size of the mortality risk premium is determined by market forces, but, in principle, a q-forward is a simple longevity derivative around which a traded market could develop. To ensure long-term survival, a traded market needs to meet the needs of speculators, hedgers and investors. As discussed above, speculators demand liquidity, while the hedgers require hedge effectiveness. The fewer the number of contracts traded, the greater the liquidity in each contract, but the lower the potential hedge effectiveness. There is, therefore, an important trade-off to be made, with a balance of contracts providing both adequate hedge effectiveness and adequate liquidity. In addition, investors want standardised, fixed-maturity investments. Derivative contracts based on mortality rates, such as q-forwards, would appear to be the most likely type of instrument capable of meeting all these demands. They are simple building blocks that allow a small number of standardised, fixed-maturity contracts to be structured. They can be combined to create effective hedges for all types of hedgers, such as pension funds, annuity providers and life assurers. JPMorgan states that it is committed to developing a liquid market in q-forwards. Longevity (or survivor) forward contracts based on forward survival rates are also being developed; these are the basic building blocks of longevity (or survivor) swaps.

6.3 Mortality and longevity (or survivor) futures and options

To date, there are no futures or options markets on longevity-linked instruments.

Our understanding is that AFPEN (*Association Française Professionnelle de l'Épargne Retraite*) are considering the introduction of annuity futures, based on UK market annuity rates. While there have been no formal options contracts, a number of life assurers in the UK and elsewhere have sold deferred annuity policies with guaranteed annuity rates, which are, in effect, options on annuity payouts, exercisable against a specific pre-agreed mortality table. If the mortality rates embodied in current annuity prices are lighter than those implied by the pre-agreed mortality table when the policyholder retires and begins to draw his/her annuity, the policyholder will exercise his/her option and receive the higher annuity payments implied by the table. The most famous life assurer to offer such an option was also the world's oldest, Equitable Life. It offered such guaranteed annuity policies since the 1950s based on mortality tables from the 1950s, but failed to hedge its mortality exposure as mortality improved. As a consequence, Equitable Life had to close for business in 2000 (Blake, 2001, 2002).

6.4. Barriers to further development

Looking back to Sandor's seven stages of market evolution in Table 2, it is arguable that we are just about at the beginning of stage four in the evolution of the life market. We now need to examine the barriers to the further evolution of the market.

One remaining barrier to the further development of stage four is the continuing resistance of pension plan trustees and their advisers to the incomplete and imperfect hedging solutions of the capital markets. They still prefer the full risk transfer solutions of insurance contracts. A substantial education exercise is required to overcome this psychological barrier.

If this barrier 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 assets (usually just shortened to '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 recognising 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 price manipulation. Finally, trading costs in a futures contract 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 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 was no inflation-linked securities market at the time, the underlying was an infrequently published index (ie, monthly), and there was no stable pricing relationship with other instruments.

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 earlier, 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 programme.

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 among investors, with TIPs having evolved into a recognised asset class. There is a well understood pricing relationship allowing for arbitrage possibilities 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 TIPS, 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.

The mortality index underlying longevity-linked instruments must be a fair estimate of true mortality and have minimal time basis risk.[33] 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, they are updated 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. These lessons have been learned by JPMorgan in its design of q-forwards.

One potential weakness in the development of the life market is insufficient investor interest. However, Figure 16 shows how the market might eventually come into balance, with increasing numbers of longevity protection sellers attracted by a suitable risk premium to enter the market to meet the potentially huge demands of longevity protection buyers. Another potential current weakness is a limited appetite for exposure to longevity risk over long horizons. For example, hedge funds, one of the key potential investors in longevity products, are used to short exit horizons (no more than five years) and longevity risk manifests itself over long horizons. The investment banks are currently trying to persuade hedge funds to extend the length of their exit horizons to 10, 15 or even 20 years on the grounds that, over these horizons, longevity is largely predictable and trend-driven and medical advances will not have had time to feed through to increased longevity.

Figure 16: Potential longevity risk landscape

Potential longevity protection buyers		Potential longevity protection sellers
Over $8 trillion liabilities exposed to longevity (US & UK). Current tables likely to underestimate risk. Beginning to evaluate impact of this risk.	Pension funds	
Exposed to longevity risk through annuity policies. Would look to hedge exposure.	Annuity providers	Could write protection to synthetically gain exposure to risk. Have the sophistication to analyse risk/return.
	Life insurance companies	Exposed to declines in longevity through life insurance policies. Selling longevity offsets this risk.
Exposed to longevity risk through investment portfolio. Buy protection to hedge general trend risk.	Life settlement/ premium finance investor	Sell longevity and earn premium. Can use existing expertise to evaluate risk/return.
Buy protection against longevity risks from plan acquisition.	Pension buyout funds	Can use existing expertise to evaluate risk/return. May synthetically add exposure.
	ILS investors	Provide protection and earn premium.
	Other hedge funds	Have liquidity and seeking return.
	Endowments	Have liquidity and ability to 'buy & hold'. Long-term investors. Innovators.
	Pharma	Could issue debt. Naturally exposed to declines in longevity.
	Others (eg, reverse mortgage, healthcare)	

Source: Loeys et al *(2007, chart 10)*

7. Conclusion

The existence of longevity-linked instruments will facilitate the development of annuities markets in the developing world and could well save annuities markets in the developed world from extinction. Indeed, they are essential to prevent annuity providers and pension plans from going bust as baby boomers retire. If such products fail to be issued in sufficient size, then we face the following very unattractive possibilities: the state (in effect the next generation of taxpayers) will be forced to bail out pensioners, or companies withdraw from pension provision, or life companies stop selling annuities, or pensioners risk living in extreme poverty in old age, having spent all their accumulated assets.

However, we are confident that a fully developed capital market will emerge soon. There is insufficient reinsurance capacity to deal with global longevity risk. Capital markets are more efficient than the insurance industry in reducing informational asymmetries and in facilitating price discovery. Longevity risk is now recognised as an important risk and its scale is being quantified and as Drucker (1992) said 'what gets measured, gets managed'. We are witnessing the sure, if slow and sometimes difficult, birth of the life market.[34]

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Endnotes

1. Updated version of keynote address to Longevity Three: The Third International Longevity Risk and Capital Markets Solutions Conference in Taiwan, 20 July 2007. We are grateful to Guy D. Coughlan for some very useful comments. Longevity One was held at Cass Business School, London on 18 February 2005 and Longevity Two was held at the Sheraton Hotel in Chicago on 24 April 2006.

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3. 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.

4. This is also known as the FRS17 (ie, the UK pension accounting standard) basis.

5. 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.

6. This volatility is generated by the UK pension accounting standard, FRS17.

7. A statutory fund established by the 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'.

8. This will require the agreement of the plan trustees.

9. In other words, the UK insurer engages in regulatory arbitrage with its captive reinsurer.

10. A survey by PricewaterhouseCoopers published in October 2007 indicated that 35% of the largest UK companies were considering full buy-outs, with 10% expecting to execute one within the next five years.

11. This could be described as a buy-out operating under a corporate M&A transaction.

12. IAS19 is the international pension accounting standard.

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. It is also worth noting that none of the exposure was held in capital market instruments as of the end of 2003.

15. However, to be effective, arbitrageurs need well-defined pricing relationships between related securities.

16. Securitisation began in the 1970s when banks in the US began to sell off pools of mortgage-backed loans.

17. Most securitisations also involve credit enhancement features to protect one or more participating parties against default risk. These features include over-collateralisation (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 parental 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 securitisations where there is a need to ensure that policyholders do not allow their policies to lapse.

18. Investor interest in CDOs was damaged, at least temporarily, by the US sub-prime crisis of 2007-08.

19. It has been questioned whether the EU's solvency requirements render reinsurance cover within the EU prohibitively expensive.

20. 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 standardised 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) index: 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).

21. Indices for other countries are being developed.

22. 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 (ie, year of birth), socio-economic status, geographical location, housing, education and medical advances. These models are not yet widely used since the relationships are not sufficiently well understood or because the underlying data needed to build the models are unreliable. For more details see Blake and Pickles (2008).

23. With an added cohort effect to reflect the importance of year of birth in influencing life expectancy; see Willets, 2004.

24. However, all the models failed to capture long-term changes in the trend in mortality rates. Further development work on these models is, therefore, needed.

25. Pension Protection Fund and The Pensions Regulator (2006, Table 5.6, p. 48)

26. Even this might be an underestimate, since companies do not even use up-to-date estimates of current life expectancy, ie, 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 (ie, the FTSE100) were underestimating pension liabilities by as much as £40 billion (or 3.5% of GDP) as a result.

27. 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.

28. Long-term, bond-based solutions have not died out, however. In November 2007, PensionsFirst started operating in the UK with backing from Shinsei Bank and hedge fund BlueCrest Capital Management. It will provide bonds whose cash flows match future pension payments. It estimates that hedging all pension plan risks (interest rate, inflation and longevity risk) will cost the same as the cheaper insurance buyouts (about 120-125% of the FRS17 liabilities). PensionsFirst says it will repackage most of the longevity risk and sell it in tranches (with exposures of 10,

15 and 20 years) to investors, such as hedge funds and endowments, that wish to hold assets that are uncorrelated with standard fixed-income bonds.

29. So was an interest-rate swap, since the EIB wanted to pay floating interest-rate payments, while investors wished to receive fixed-interest payments.

30. There are rumoured to be earlier swaps of a similar kind, but there have been no official announcements of these.

31. The following discussion summarises the characteristics of the q-forward contract and more details can be found in Coughlan *et al*, 2008.

32. The bearer of longevity risk faces increased liabilities when longevity or survival rates are higher than expected; the bearer of mortality risk faces increases liabilities when mortality rates are higher than expected.

33. 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.

34. Watson Wyatt, 2007, reported that, by October 2007, 25% of UK companies had implemented measures to limit longevity risk (eg, by changing the pension plan design to share longevity risk), while 25% of plans were considering hedging (eg, via q-forwards or longevity swaps).