Longevity: a market in the making

• **Life expectancy has risen steadily** since the 1960’s in Europe and North America — by about 1 year each decade.

• Significant underestimates of past longevity improvements and still high uncertainty about future mortality have elevated longevity to a **high-profile risk** for pension funds, insurers, and other companies.

• The UK has seen the emergence of bespoke **bulk annuity transfers**, including longevity risk, between insurers, reinsurers, and pension funds. This market remains underdeveloped as it lacks a pure longevity hedge.

• New improvements in technology — in particular JPMorgan’s **LifeMetrics** — are now making it possible to develop a market for longevity for entire populations.

• Past innovations tell us a new market will only take off if its risks are large and onerous, cannot be hedged with existing instruments, and technology emerges to create liquidity. These apply today to longevity.

• To create liquidity and attract outside investors, **annuity transfers** need to graduate from an insurance to a capital markets format. This means a market in **mortality forwards**, on broad populations, and benchmark maturities, by age groups and gender.

• In aggregate, **the market is short longevity**, and thus needs to attract investors by paying a risk premium against unexpected falls in mortality. This will show up in mortality forwards falling below expected future mortality rates, similar to term premia along forward interest rate curves.

• Transparency and liquidity should allow the **cost of longevity hedging to fall** from the high prices embedded in today’s annuity market.

• The **US, UK, and the Netherlands** will likely see the birth of the longevity market given their prominent pension funds, regulatory pressure, market awareness of longevity risk, and high-quality mortality indices.

• Likely **participants** in this market will include pension funds, insurance companies, banks, hedge funds, and asset managers.

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*We received valuable input from JPMorgan’s Pension Advisory Group, foremost Guy Coughlan, David Epstein, and Alen Ong, as well as Farid Kabbaj.*

The certifying analyst is indicated by an **AC**. See pages 26 and 27 for analyst certification and important legal and regulatory disclosures.
Longevity has become a high-profile risk to pension funds

A new market is needed to trade and hedge longevity

Steady rises in longevity, though not at a constant rate

Longevity — no panacea

Improvements in health conditions across the world have had a strong positive impact on people’s life expectancy over the past century (Chart 1). Across the UK and US, life expectancy for 65-year males has on average risen by over 2 months a year over the past four decades, and by 1.5 months for females. While an undeniable blessing to the world as a whole, increasing longevity has also had a more worrying impact on those whose business it is to provide for old-age income.

Longevity has become a high-profile risk for defined benefit pension plans and a concern for plan sponsors, who must ultimately meet the cost of increasing life expectancy. Falling mortality rates have meant that pensions need to be paid much longer than expected, increasing the value of the sponsor’s obligation to members. Having underestimated improvements in life expectancy for so long (Chart 2), there is a chance that liability valuations could climb higher still if mortality rates continue to fall faster than expected. This is a huge risk for all sponsors of defined benefit pension plans.

Recently, market participants became more aware of these risks. In the US, the IRS has recently forced pension funds to review their mortality assumptions. A recent study of the companies in the UK’s FTSE100 index also found that the assumptions about mortality rates and longevity used in pension valuations were overly optimistic, to the extent that realistic longevity assumptions would raise the aggregate deficit by more than £50 billion.1 On average, each additional year of life expectancy adds approximately 3–4% to the present value of UK pension liabilities.

Increasing awareness and concerns about the impact of longevity risk are spurring the development of financial instruments to allow economic agents to hedge, diversify, and position on this risk. JPMorgan, for its part, has recently launched LifeMetrics, a platform for measuring and managing longevity and mortality risk.2 This paper gauges the likelihood of success of a market for longevity risk and what shape it is likely to take, based on past successes and failures on market innovation. We conclude that a longevity market has a good chance of success, and that it will need to move from the current focus on annuity transfers to mortality forwards to create some semblance of liquidity.

Chart 1: Period life expectancy for 65-year olds in the UK and the US

based on current mortality tables

Source: LifeMetrics, EW stands for England and Wales.

The basics of mortality and longevity

Before starting, we need to introduce basic terminology and stylized facts on longevity and mortality. The principal variable of analysis is the mortality rate, $q_x$, which is the number of people of a certain age $x$, gender and country who die in a given year. This is measured as the number of deaths as a percent, $q_x$, of start-of-the-year population, or as a percent of year-average population, $m_x$.

Other longevity statistics are all linked to the basic mortality rate. A first one is the survival rate $p_x$, which reflects the number (%) of people aged $x$ who survive in one year from the previous year. Clearly, the survival rate is given by $1 −$ mortality rate, or

$$p_x = 1 - q_x$$

Linked to this is the number (%) of people who survive $t$ more years. This is called a $t$-year survival rate and is calculated as the product of successive survival rates:

$$t_p = \prod_{i=0}^{t-1} (1 - q_{x+i})$$

Life expectancy $e_x$ is a mortality measure that equates to the expected future lifetime of an individual at a given age. Algebraically, life expectancy at age $x$ can be written as the sum of successive $t$-period survival rates:

$$e_x = \sum_{t=1}^\infty t_p$$

Finally, expected age at death equals the starting age plus life expectancy: $x + e_x$.

When using mortality data for the current period, or year, we call the former period life expectancy. It assumes that mortality rates will not change in the future. For example, in these calculations, the age 90 mortality rate that is assumed in 70 years’ time for today’s 20-year olds is the same rate as that for a 90-year old today. Period life expectancy can be useful as a headline indicator because it is an objective measure and avoids the subjectivity inherent in forecasting future mortality improvements.

Even experts have steadily underestimated improvements in life expectancy

Chart 2: Systematic overprediction of mortality rates

Actuarial Profession projections for male UK assured life expectancy after 60 by year of projection


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3 In practice the calculation is not as straightforward as this, because census and death databases record numbers for an open population, that is, one that is also impacted by migration. The mortality rates described above are sometimes referred to as “crude rates” because they are based on raw unadjusted mortality data. In different practical applications, however, mortality rates are often averaged over time and/or smoothed across ages. The latter are called graduated mortality rates.
To estimate the average future lifetime of an individual, however, it is more relevant to estimate life expectancy allowing for expected future improvements in mortality. This requires a \textit{generational} or \textit{cohort life table}. With a cohort life table, a separate set of mortality rates can be projected for each year for each birth cohort. Hence the age 90 mortality rate applying to today’s 90 year olds will differ from that applying in 70 years to today’s 20 year olds. This form of life expectancy is known as \textit{cohort life expectancy} and leads to results that are typically higher than period life expectancy.

\textbf{Stylised facts}

To judge risks and return on products that are affected by changes in longevity, we also need to understand the basic stylised facts on past changes in longevity. For this, we use the historical database that is part of JPMorgan’s \textit{LifeMetrics}, and that applies to the US and to England & Wales (EW)\textsuperscript{4}. These stylised facts are:

1. \textbf{Mortality rates rise with age}, which is not surprising. Once you reach 20 years of age, the older you are, the higher the probability you will die in a given year. The mortality rate generally rises approximately exponentially with age, but the \textit{log} of mortality rises proportionally with age. Life expectancy, the number of years you are still expected to live, thus falls with age, but expected age at death increases with age.

2. \textbf{Female life expectancy is higher} than that of men, but the gap has been narrowing over the years. Using period life expectancy for 65-year olds, the gap is now down to less than 3 years in the US and the UK.

3. \textbf{Mortality rates have fallen and life expectancy has risen dramatically over past decades} (see Charts 3 and 4). In round terms, mortality rates have fallen on average around 1% per year (of the rate itself). Since the 1960s, life expectancy for 20-year old men has risen by 2.3 months per year in the US, and by 2 months in the UK. For 20-year old women, it has risen at 1.7 months per year in the US, and 1.5 months per year in the UK. Mortality rates for women have fallen relatively uniformly across ages, but for men, the fall has been more dramatic for the middle-aged.

4. \textbf{Changes in annual mortality rates have been quite volatile} over time, although some of this is noise. Over the past 36 years, the historical volatility of US mortality was between 1% and 3% of the rates themselves (see Table 1).

\textbf{Forecasting future mortality and survivalship}

To judge the value of assets and liabilities that depend on how long people live, one needs to forecast future mortality rates. Current period life expectancy data only provide a starting point here as they assume that current mortality rates do not change over time. A complete discussion of the various methods to forecast future mortality is beyond the scope of this paper. We refer to \textit{www.Lifemetrics.com}\textsuperscript{5} for papers and references on this issue. We just briefly summarise the findings here.

1. There is \textbf{more than one way} to forecast future mortality. They range from statistical models calibrated on past trends and volatilities to those that link mortality rates to changes in public health, cohort effects or other fundamental drivers. Some government projections include discretionary inputs from actuarial experts.

\textsuperscript{4} Data are available free of charge on \textit{www.lifemetrics.com}. These are all current period life expectancies that assume no improvements in future mortality rates.

2. All models project higher life expectancies than current period tables as they incorporate likely mortality improvements, while period tables give us the life expectancies implied by current mortality rates. Chart 5 shows how over longer time horizons, these model can come up with quite different assessments of life expectancy. See LifeMetrics, Coughlan et al, pp. 53-59 for more details.

3. Many of the models provide estimates of annualised volatility in mortality which cluster around 1.5% in the US and 2.5% in the UK (which has a smaller population).

4. The most basic extrapolative model, the **Lee-Carter model (1992)**, is emerging as the benchmark model for mortality forecasts.

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**Lee-Carter model has become the benchmark**

**Chart 3: US males, initial rate of mortality curve**

![Chart 3: US males, initial rate of mortality curve](source)

**Chart 4: US females, initial rate of mortality curve**

![Chart 4: US females, initial rate of mortality curve](source)

**Table 1: Volatilities of graduated initial and crude central mortality rate improvements for England & Wales, and US males and females ages 45, 55, 65, and 75**

<table>
<thead>
<tr>
<th>Age</th>
<th>Graduated $q_x$</th>
<th>Crude $m_x$</th>
<th>Graduated $q_x$</th>
<th>Crude $m_x$</th>
</tr>
</thead>
<tbody>
<tr>
<td>45</td>
<td>2.96%</td>
<td>6.16%</td>
<td>2.82%</td>
<td>4.82%</td>
</tr>
<tr>
<td>55</td>
<td>2.57%</td>
<td>3.70%</td>
<td>2.90%</td>
<td>4.81%</td>
</tr>
<tr>
<td>65</td>
<td>2.64%</td>
<td>2.84%</td>
<td>2.36%</td>
<td>3.68%</td>
</tr>
<tr>
<td>75</td>
<td>3.03%</td>
<td>3.62%</td>
<td>2.81%</td>
<td>3.18%</td>
</tr>
</tbody>
</table>

**US Males YoY chg volatility (1968-2004)**

<table>
<thead>
<tr>
<th>Age</th>
<th>Graduated $q_x$</th>
<th>Crude $m_x$</th>
<th>Graduated $q_x$</th>
<th>Crude $m_x$</th>
</tr>
</thead>
<tbody>
<tr>
<td>45</td>
<td>2.31%</td>
<td>3.99%</td>
<td>2.41%</td>
<td>4.85%</td>
</tr>
<tr>
<td>55</td>
<td>1.53%</td>
<td>2.63%</td>
<td>1.61%</td>
<td>3.03%</td>
</tr>
<tr>
<td>65</td>
<td>1.01%</td>
<td>1.99%</td>
<td>1.52%</td>
<td>2.42%</td>
</tr>
<tr>
<td>75</td>
<td>1.47%</td>
<td>2.70%</td>
<td>1.66%</td>
<td>2.60%</td>
</tr>
</tbody>
</table>

Source: JPMorgan LifeMetrics
Why and when do new markets emerge?

A financial market is a two-way exchange of financial claims at a certain price. Economic theory tells us that the existence and number of markets are driven by the presence of what economists call different “states of the world”. A state of the world is defined as the outcome at a point in the future of a certain variable that economic agents care about. Such a state can be the level of income, rain fall, inflation, crop sizes, temperatures, elections, etc. In an idealized world, there will be enough markets, or securities, such that agents can price, and trade any state of the world that they care about. At that point, we consider the markets “complete”.

In practice, the number of markets will fall well short of this ideal number due to the costs of organizing markets. New markets are created when the value of organizing them exceeds their cost. Adding a new market allows economic agents to put a value on future states of the world and to change their exposure to this state, either by adding or reducing their exposure to particular risks. Clearly, the value of adding a market will depend on how much and how many agents are exposed to this state of the world. The greater the diversity of exposures (with some agents being short, and others long), the higher the value of organising a market. Importantly, value is created at the margin. A new security that provides exposure to a state of the world that is highly correlated with an already existing security has only modest value at the margin and is thus unlikely to survive.

Many exposures or states of the world are not traded because there are too few potential buyers and sellers relative to the cost of organizing such a market. These costs consist of the required capital of bringing together buyers and sellers, the risks to the market makers, and taxes incurred by the different parties. Other restraining factors consist of legal and technological factors. On the legal side, well-functioning markets require clear property rights. Most important on the technological side is simplicity and homogeneity of contracts which are needed to create liquidity.

In short, for a new market 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.

Among the successful innovations of recent decades are mortgage backed securities, interest rate swaps, credit-default swaps, inflation-linked bonds, and real estate investment trusts (REITs). Among the ideas for new markets that have not really

Chart 5: US unisex period life expectancy in selected projection years, by study

taken off, and that remain in infancy, are economic derivatives (inflation is traded, but not GDP) and residential property derivatives. The appendix shows how the successful innovations did indeed meet most of the above conditions for a new market, while the unsuccessful have so far not met them.

Longevity appears a good candidate to become the object of a new financial market, but it is not yet there and initial attempts have been less than fully successful. In this paper, we use the above conditions of successful financial product creation to gauge the chance of success for a market in longevity and what shape this market is likely to take.

1) Effective hedging, or the issue of basis risk

As argued below under (4), to achieve some form of liquidity, the longevity market will have to focus on broad population mortality indices. This creates basis risk for insurers and pension funds whose exposures might be concentrated in specific regions or socio-economic groups. That is, a hedge based on the full US population index might not be effective for a pension fund whose membership is mature and consists of, say, teachers in one particular state. Studies on basis risk have shown that age and gender are the two most important drivers of variations in mortality experience over time. As a result, a successful market in longevity must at least differentiate by age and gender, as indeed JPMorgan’s LifeMetrics indices do.

Differentiating by socio-economic groups is harder as the data are not clean or do not exist or are not made public in many countries. Studies on this issue find, for example, that variations across income and regions in the UK lead to cross-sectional differences in annuity prices of the order of 5% and thus in insurers’ assumptions on longevity. This cross-sectional variation is not a source of risk over time however, if the various groups’ mortality rates all develop over time in the same manner. A hedge of one particular subgroup’s longevity in a country using an instrument based on a full population mortality rate will still be effective if both are highly correlated over time. This correlation may not be very high from year to year due to pure noise in the data, but we find it is very high over 10-year periods which is a relevant period for hedgers.

For example, if we compare the England & Wales overall population with a population of individuals who have a life insurance policy (i.e. insured lives vs population at large) we find that the mortality trend improvement for the different populations are strongly correlated over 10-year periods. A similar example was applied to US data, where mortality improvements for the underlying exposure were based on the mortality improvement experience of the Californian population and those for the hedging instrument were based on the mortality experience of the US national population (reflected in the LifeMetrics Index). We draw the conclusion that historical movements in mortality rates do not lead to a significant amount of residual risk over a ten-year period, even though they may seem significant on a year-to-year basis.

2) Is longevity risk significant enough to warrant a market?

Pension funds, insurance companies, governments and individuals are exposed to longevity risk. Pension funds are short longevity through their defined-benefit (DB) pension liabilities, as their liabilities rise with longevity. The life insurance industry is

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7. For a more complete treatment of basis risk in longevity hedging see, LifeMetrics, Coughlan et al, March 2007, pp. 76-82.
long longevity as their term insurance policy liabilities fall with mortality. At the same
time, though, life insurance companies have a short exposure to longevity through
their annuity liabilities. Governments are short longevity through social security and
government pay-as-you go pension systems. Long-term care companies are long
longevity as their revenues are likely to go up as people live longer.

From all these groups, pension funds and life insurance companies are the ones that
have the potential to participate in a longevity market. Pension funds are under
pressure from both accounting and regulatory changes to better manage the mis-
match of risk between their assets and liabilities. DB pension fund liabilities are
exposed to longevity risk while their assets, typically equities, bonds and real estate,
are not. This one-sided exposure is inducing pension funds to hedge their longevity
risk either through a buyout or the purchase of a longevity security.

Insurance companies, on the other hand, are facing a potential rise in demand for
annuities. Admittedly, the individual annuity market is still small and dominated by
savings-like products in the US, but demand could rise as individuals face an
increasing risk that they will outlive their resources. Also discussions about social
security reforms and the decline in the growth of defined benefit schemes are raising
the chances that longevity risk will be increasingly passed on to individuals,
boosting further demand for individual annuities. As a result, insurance and
reinsurance companies have to also manage their longevity exposure in a more
optimal way, passing some of their longevity risk to markets (i.e. through longevity
securities) in order to expand their capacity. Reinsurers have not so far been keen to
take on longevity risk, apart from a few small-sized deals, usually for existing clients,
that were part of an overall package that includes other types of risks besides
longevity. However, growing demand for risk transfer by insurers will likely have a
positive impact on reinsurers’ appetite for longevity risk.

The balance between demand and supply for longevity and thus the likely pricing of
longevity risk depends on the relative sizes of the exposures of different agents. Box
1 provides estimates, by gauging the level of DB pension schemes (i.e. annuity type
liabilities) as well as the size of annuity and life insurance policy liabilities of life
insurance companies. Due to data limitations and the dilution between longevity
insurance and bond investment in life insurance products, this exercise should only
be seen as a rough approximation (Tables 2 and 3).

Tables 2 and 3 show that there is a strong imbalance between long and short
exposures with the short longevity exposures of DB pension funds dwarfing the
annuity and term insurance liabilities of the life insurance industry. Within the life
insurance industry, the two opposing longevity risks of annuity and term insurance
liabilities are fairly balanced especially in the UK. This means that hedging demand
will likely come from DB pension funds. Insurance companies do not face as large
imbalance in terms of longevity exposure and thus their interest in the market
for hedging purposes will be rather limited. Thus for a market to emerge this longev-
ity exposure gap needs to be filled by either governments or market participants
such as hedge funds and other asset managers willing to take over annuity exposure
from pension funds.

With governments already short longevity through pay-as-you-go pensions and the
social security system, the emergence of a new market relies on the participation of
non-traditional players such as hedge funds. Admittedly, a government-sponsored
longevity instrument could potentially help to provide a liquid benchmark around
US private pensions have $6 trillion in DB liabilities ...

... while US lifers are broadly flat longevity, due to offsetting small exposures from term insurance and annuities

UK pension funds have DB liabilities of £800bn ...

... while UK lifers have offsetting annuity and life insurance exposures to longevity risk

Exposure = bp longevity risk times duration

Box 1: Sizing longevity exposures at US and UK insurers and pension funds

In the US, private DB pension fund liabilities are currently close to $6 trillion. Annuity reserves currently held by the life insurance industry are estimated at around $2 trillion, while reserves for life insurance policies stand at around $1 trillion\(^8\). But only a fraction of these products contain life contingency. The US life insurance industry has moved away from a focus on the assumption of mortality risk and toward asset accumulation or savings products, i.e. variable annuities, universal life and variable life. So, from the $2 trillion of annuity reserves only a small fraction (5% or less on our estimates) represents single premium immediate annuities, i.e. pure annuity exposure. The rest reflects largely deferred annuities that are effectively tax-efficient investment vehicles often linked to mutual funds that are rarely annuitized, or annuities with guaranteed periods or similar features such as death benefits, which reduce their longevity element. From the $1 trillion of life insurance reserves, only a fraction, around $150bn, reflects term insurance.

In the UK, according to OECD data (Pension Markets in Focus, OECD, October 2006, Issue 3), private DB pension fund liabilities are currently close to £800bn. The present value of life insurance industry annuity liabilities is estimated at around £135bn. The reserves held for life insurance policies are approximately £38bn on our calculations\(^9\).

To calculate the size of longevity exposure we need to multiply the duration of a typical pension or life book by the amount of longevity risk in bp. Based on the historical annualised standard deviation of changes in UK annuity premia over the past 40 years and our calculations, this longevity risk is about 50bp. Admittedly this market-based estimate of longevity risk reflects both changes in expectations about mortality and morbidity factors, which are difficult to quantify. But it does provide a useful benchmark for comparison.

Table 2: US private pension fund and life insurance exposures to longevity risk

<table>
<thead>
<tr>
<th></th>
<th>US private pension funds</th>
<th>US life insurance industry</th>
</tr>
</thead>
<tbody>
<tr>
<td>DB liabilities</td>
<td>$6tr</td>
<td>&lt;£100bn</td>
</tr>
<tr>
<td>duration (years)</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>annualised longevity risk (bp)</td>
<td>50bp</td>
<td>50bp</td>
</tr>
<tr>
<td>longevity exposure</td>
<td>-$300bn</td>
<td>-$5bn</td>
</tr>
</tbody>
</table>


Table 3: UK private pension fund and life insurance exposures to longevity risk

<table>
<thead>
<tr>
<th></th>
<th>UK private pension funds</th>
<th>UK life insurance industry</th>
</tr>
</thead>
<tbody>
<tr>
<td>DB liabilities</td>
<td>£800bn</td>
<td>£135bn</td>
</tr>
<tr>
<td>duration (years)</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>annualised longevity risk (bp)</td>
<td>50bp</td>
<td>50bp</td>
</tr>
<tr>
<td>longevity exposure</td>
<td>-$40bn</td>
<td>-$7bn</td>
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</tbody>
</table>


9. See Moody’s UK Life Insurance Industry Outlook, Jan 07. The face value of UK life insurance policies is estimated indirectly by looking at the size of UK life insurance policy premia and applying the ratio of face value to insurance premia of the US life insurance industry.
life expectancy (i.e. sum of future survival rates) as well as changes in risk premia due to the uncertainty about future mortality rates. In our calculations, we find this 50bp volatility equivalent to a 1% compound annual change in mortality rates, or a 1-year change in life expectancy for 65 year olds, which has become the benchmark shock for risk analysis in longevity.

Multiplying this 50bp risk with duration (10 years for a basket of annuities of a 65-year and 75-year old), we estimate that longevity risk produces 5% return volatility to annuities and pension liabilities. This is not insignificant. It is roughly double the risk of running a high-grade corporate bond fund on a libor basis, and half that of running a bond portfolio.10

The amount of longevity risk in bp is higher for life insurance because outflows (i.e. death payments), which depend on mortality rates, are much more sensitive to mortality improvements than annuity payments which depend on cumulative survival rates. Our calculations show that the same mortality shock that results in an 1 year change in life expectancy, translates into approximately a 170bp change in the discount rate of life insurance liabilities of a relatively mature life insurance book (10 years into a 20-year term insurance contract).

Applying our estimates of annualised longevity risk (50bp to pension annuity liabilities and 170bp to life insurance liabilities) and our estimates of duration (10 years for pension fund liabilities that contain a mix of 65 and 75 year olds and 7 years for a matured life insurance book), we are able to derive the amount of longevity risk exposures in dollar and sterling amounts shown in Tables 2 and 3.

10. We calculate that this type of risk is roughly equivalent to a 1% compounded annual improvement in mortality rates per year. Because of its compounding nature, this type of mortality shock results in a much higher degree of uncertainty the further away into the future. The impact of this particular shock on the life expectancy for today’s 65 year olds is around 1 year but it rises geometrically to around 5-6 years by 2040. A standard deviation of around 1 year in life expectancy of today’s 65 year olds is equivalent to a 95% confidence of around +/-1.65 years, in line with the uncertainty bands produced elsewhere (e.g. see Appendix E, Pension Committee Report).

which a new market will develop and increase standardization, but the demand for this instrument would have to come from other market participants as governments have the same exposure as pension funds.

(3) Can longevity risk be hedged with existing markets?

This is a condition that has become the graveyard of many financial product innovations that ended up not providing enough hedging value at the margin. For example, swaps notes, which are futures on swaps, had no success as they offered little hedging value relative to bond futures or swaps themselves. With respect to longevity, the issue is thus whether we can hedge this risk with existing markets, such as equities and bonds, relative to outright longevity hedging products that we will present below.

Table 4 shows correlations between 5-year US and UK mortality changes against US and UK equity and bond returns. In the US, we find little correlation for 45- and 55-year olds, but positive correlation for older cohorts. That is, older cohort mortality rates improve (fall) most when equity and bond markets are weak. We cannot find any prior reason for such a relation, and find indeed no support for it when we turn to UK data. Taking correlations between equity and bond returns on one side with the average change in mortality rates across different cohorts, we find these to be insignificantly different from zero. We conclude that existing markets provide no effective hedge for longevity and mortality risk.
A successful market requires transparent, robust and a well understood index

**LifeMetrics** — a new index, framework, and toolkit

*LifeMetrics* is based on official data sources

... has started with US and UK, but will expand to other countries

... available to all on www.lifemetrics.com and Bloomberg LFMT <GO>

Objectivity and transparency

**Objectivity.** The methods and algorithms used in the construction of the *LifeMetrics* Index were chosen to be as objective as possible, but without sacrificing the integrity of the underlying index data. Furthermore, the calculation of the index is not performed by JPMorgan, but by a calculation agent with expertise in the field of longevity and mortality analysis. Finally, the governance and oversight of the index is performed by an advisory committee comprised of individuals from different backgrounds and organizations in order to safeguard its integrity and objectivity.

**Transparency.** The data sources, methodologies, algorithms and calculations used in the development and production of the index are fully disclosed and explained in this and other documents. These explanations include discussions of why the particular techniques and approaches employed were chosen ahead of various alternatives. In all cases these choices were made on the basis of a trade-off between simplicity, objectivity and transparency.

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(4) Is there enough standardization to create liquidity?

The development of a new market requires the existence of a transparent, robust and well understood underlying index that can be the basis for transactable contracts. Until recently, such indices did not exist for longevity. To fill this gap, JPMorgan launched in March the *LifeMetrics* Index, similar to how it launched over 10 years ago the highly successful *RiskMetrics* database and framework. *LifeMetrics* provides a transparent framework for measuring current longevity and mortality. It consists of mortality rates and life expectancies for different countries that can be used as the basis for valuation of longevity-linked and mortality-linked exposures, forecasting future longevity and mortality rates, evaluating the risk associated with these exposures and determining the payoff of longevity derivatives and bonds.

*LifeMetrics* Index is based on publicly available mortality data for national populations, broken down by country, age and gender. Initially, the *LifeMetrics* Index includes data from the US and from England & Wales, but other countries will become available in coming months. The data are calculated and published for each year, as and when the underlying data become available. In addition, historical data are available for each of these metrics as part of the *LifeMetrics* Index. The methods and algorithms used to produce these metrics are described in the *LifeMetrics* technical document.

The construction of this index will be a valuable support for the creation of a market in longevity risk as it indeed meets the important criteria of objectivity, transparency and relevancy.

**Table 4: Correlation between US and EW mortality rate percentage changes and Equity/Bond returns**

<table>
<thead>
<tr>
<th>Age</th>
<th>US Equity males</th>
<th>females</th>
<th>US Bonds males</th>
<th>females</th>
<th>UK Equity males</th>
<th>females</th>
<th>UK Bonds males</th>
<th>females</th>
</tr>
</thead>
<tbody>
<tr>
<td>45</td>
<td>-0.03</td>
<td>-0.57</td>
<td>0.19</td>
<td>-0.53</td>
<td>-0.03</td>
<td>-0.57</td>
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<td>55</td>
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<tr>
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<td>0.41</td>
<td>0.52</td>
<td>0.46</td>
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<td>0.41</td>
<td>0.52</td>
<td>0.46</td>
</tr>
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<td>0.63</td>
<td>0.01</td>
<td>0.57</td>
<td>-0.16</td>
<td>0.63</td>
<td>0.01</td>
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<td>-0.16</td>
</tr>
<tr>
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<td>-0.27</td>
<td>0.37</td>
<td>-0.01</td>
<td>0.24</td>
<td>-0.27</td>
<td>0.37</td>
<td>-0.01</td>
</tr>
</tbody>
</table>


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11. Data from private sources, e.g., individual pension plans and insurers, are not included in the LifeMetrics Index at this time. These data are generally proprietary and not widely available to market participants.
Relevancy. The toolkit creates a vocabulary that can be universally understood by pension plans, insurers, consultants, and investors which is essential for the correct functioning of a market. Breaking the index down into a number of building blocks, or sub-indices, significantly increases the degree of applicability to a wide variety of situations and exposures. The building blocks that are used in the LifeMetrics Index have initially been chosen to include mortality data broken down by country, gender and age.

What will the market for longevity look like?

The initial conditions for the emergence of a market in longevity risk are in place. Precious little has happened so far. In the following sections, we use all we have learned from past product innovations to try to forecast the likely location, shape pricing, and participants in this emerging market in longevity risk.

The location is the easier question to answer. It will be in the country where the exposures to longevity risk are largest in dollar terms, where there is greatest awareness of the existence of longevity risk; where there is greatest regulatory and market pressure for economic agents to hedge out this risk; and where there is the most progress on creating standardised longevity/mortality indices. Currently, these factors suggest that the UK will likely lead the emergence of this market as its pension funds are most aware and most under pressure to hedge longevity risk. It will be followed closely by the US and the Netherlands as both have large and sophisticated pension funds and both have high-quality mortality data.

Product design

What will longevity products look like? To some degree, there is already a fledging market in longevity risk in the form of mortality catastrophe bonds and the life settlements market. As discussed in Box 2, neither fits the role of a proper market for longevity risk that can attract outside investors, since the risks covered are idiosyncratic and the products remain insurance based. Cat bonds provide insurance against short-term tail risk or catastrophic increases in mortality risk due to such risks as bird flu. And the US life settlements markets, which is a securitization of unwanted remainders of life policies, is complex, not transparent, and has significant idiosyncratic risks.

In the UK, there are also a number of transactions taking place between insurance companies and pension funds in the form of bulk annuity buy-outs (Chart 6). Typically, the pension fund closes down its defined benefit pension scheme and pays an insurer to replace their pension liability with annuities to their pensioners. Regulatory and other pressures such as accounting changes and intense M&A activity are motivating many UK corporates to consider eliminating their pension liabilities. In these transactions, the insurer takes on both reinvestment risk, associated with pension assets, and longevity risk, associated with pension liabilities. Several dozen of such buyouts have taken place over the past few years, but most are for small pension funds. High capital requirements imposed by the FSA for insurers on such buyouts, and the lack of a liquid instrument to allow the insurer to hedge out the longevity risk they are running, are limiting the market. This is the problem that a number of investment banks and insurers are now trying to fix with a new market for longevity risk.
There have only been a limited number of structures available to capital markets investors interested in taking exposure to mortality and longevity risk. Most public issues have been in the form of short-term mortality risk transfer vehicles, such as mortality catastrophe bonds, which are intended to transfer to investors the risk of a short-term rise in mortality rates (due to, say, an influenza pandemic). Despite being linked with an esoteric risk typically unfamiliar to investors, these mortality “cat” bonds have been well received, primarily due to a low probability of loss coupled with attractive returns, investment diversification and conceptually intuitive structures.

The cat bonds issued to date have been structured as principal-at-risk notes with a fixed tenor, where the principal repayment is contingent on a catastrophic outcome for the value of a customized mortality index. The catastrophic event is defined as an extreme rise in mortality beyond a particular baseline. Cat bonds have been issued mostly by reinsurers looking to free up capital related to the extreme mortality risk they face in their life insurance books.

In contrast to mortality cat bonds, efforts to transfer longevity risk to investors have been more limited and, so far, unsuccessful. Longevity bonds, or survivor bonds, were first suggested by Blake and Burrows (2001), who proposed an annuity structure where annual payments were tied to the survivorship of a reference population. Since then, there has only been a single public attempt to issue a longevity bond and that was ultimately abandoned. In November 2004 the European Investment Bank (EIB) unveiled plans to issue a 25-year bond linked to an index based on the longevity of a cohort of England & Wales males aged 65 in 2003. The bond, structured by BNP Paribas, was targeted at annuity providers and pension plans to provide a hedge of their longevity risk. It was unsuccessful for a number of reasons including (i) the structure of the bond (one cohort of 65-year-old males made for a poor hedge of longevity for an annuity book or pension plan, unlevered exposure to longevity risk meant that it required a large amount of up-front capital for the level of protection it offered, no final settlement at maturity to reflect longevity risk in the liabilities beyond 25 years), (ii) the receptivity of the investor community (novelty of the idea, limited recognition of the threat posed by longevity risk), and (iii) a low yield.

An existing arena for investments in longevity is the life settlements market and its related securitizations. Life settlements are transactions where individuals transfer life insurance policies that they do not want or need to third-party investors instead of surrendering them back to the insurance company. This can be beneficial to both investors and policyholders when the surrender value of a life insurance policy is lower than its economic value. Policyholders, therefore, receive more than the surrender value of the policy and investors obtain exposure to longevity risk at a competitive price. Investors earn a return unless the insured individuals live longer than the life expectancy implied by the purchase price of the structure. Recently, insurance brokers and financial service providers have partnered to pool life settlements and package them for securitizations. While the returns on life settlement-backed securitizations can be attractive, there are several risks that make potential investors wary. In particular, the structures are complex, not transparent, dependent on the idiosyncrasies of each individual policy, and require extensive legal and actuarial work. They are also based on a relatively small number of lives which means there is considerable idiosyncratic sampling risk associated with this exposure.

12. See also, Insurance Linked Securities, The second leg of the growth in the ABS market?, Kian Abouhossein et al., JPMorgan Equity.
The initial response of the banks involved in creating a market for longevity risk is that anything and everything is possible around the concepts of mortality rate, survival rate and life expectancy for any age group, country, and gender at any forward point in time. This may seem an attractive feature at first blush, but in reality, to create a form of liquidity, the market will soon have to focus on a single type of product.

The successful longevity product will be the one that best meets the needs of hedgers, investors, and market makers. That is, it needs to be an efficient hedging instrument against the risks that firms want to cover; it needs to create an attractive investment vehicle, and it should be best suited to create market liquidity. These objectives are all clearly desirable, but also conflict with each other. The best instrument will thus be a compromise. In particular, the need for liquidity dictates the creation of the lowest number of instruments, while hedging efficiency requires more bespoke types of instruments.

It is our opinion that mortality is a more suitable concept to become the basis for longevity products than either survival or life expectancy itself. This mortality would apply to a particular point forward into the future, rather than a full curve, and apply to a broad population rather than a particular region or profession. It should apply to a range of ages (e.g., 70-74), and only to a few standard maturities in the future. For example, the standard contract could relate to the mortality of US males of age 70 to 74 in the years 2016-18. Given that the historical symbol for mortality has been q, we would call this instrument a q-forward for 70-74 in 2017.

The main choice the market faces is between products based on mortality rates, and those based on survival rates. Realised life expectancy does not appear eligible as a basis for longevity products as it remains almost forever an expectation and not a realization. This is because one has to wait for the last person to die out of a certain cohort before one can decide what the realised life-expectancy of that cohort was. Hence, there is no settlement of expected versus forward.

13. Coughlan et al, q-Forwards: Derivatives for transferring longevity and mortality risk, JPMorgan, July 2007
However, it is not inconceivable that calculated period life expectancy, derived purely from extrapolating mechanically the current mortality curve to a future date, emerges as the product of choice. It may have more appeal to those who like to think in positive terms (as opposed to the rather lugubrious mortality term). And it might be easier for market participants to formulate opinions about. But it creates the same path dependency problem discussed below for survivor rates. Hence, it is not our first choice for the most likely longevity product.

As presented on p. 3, mortality $q_x$ is the percent of x-year olds who die in a particular year. The survival rate, $p_x$, is the percent of x-year olds in year $y$ who are still alive $t$ years later. Chart 7 shows the diverging shape of these two rates. For the cohort of say current 60-year old US males, mortality rates start with the current 1.18% and should then rise steadily in a progressive fashion. The survival rate for this cohort starts by definition at 100%, and will then fall by the compounded mortality rate. Each set of mortality rates translates into a series of survival rates, but a single survival rate point does not create a unique set of mortality rates.

Survival/annuity swaps are more intuitive hedging vehicles for pensions and insurers

But survival/annuity swaps are path dependent, which destroys liquidity

Survival rates are the direct determinants of annuity cash flows of pension funds and life assurance and thus attractive for hedging purposes. That is because the annuity provider promises to pay policy holders a fixed monthly/annual amount until they die. As a result, the profile of the cash flow of an annuity for a fixed population and single age group will be identical to this survival rate. Given that survival rates are just a mathematical function of mortality rates, the latter could equally well be used for hedging. But the similarity in profiles between annuity flows and survival rates give the latter more intuitive appeal as a hedging instrument.

But survival rates have the disadvantage of depending on the starting year. That is, survival rates are path dependent. The survival rate of a group of 65-year olds in a particular year depends on the starting point of the annuity. There are thus as many survival rates for 65-year olds in say the year 2010 as there are starting years that one is counting from. In contrast, there is only one mortality rate for 65-year olds in 2010.

This path dependency of survival rates is a killer of liquidity, as it inhibits fungibility of different contracts relating to the same cohort and time in the future. As an analogy, two bonds with the same coupon and remaining maturity are effectively the
same instrument independently of when each one was issued. In the case of two
survivor bonds, the same is not true as survivorship and thus the coupon depend
also on the issuance date of these bonds. Therefore, pricing of this bond requires
information not only about the cohort and maturity, but also the date when the bond
was issued, increasing the dimensionality of this market and thereby inhibiting
liquidity.

**Pricing**

How do we price a mortality forward?14 The easiest way to understand its pricing is
to compare it with an instrument we all know — an interest rate forward/futures such
as Dec08 eurodollars. The latter is a market price for where 3-month libor in USD will
settle on a particular day in December 2008. We can think of the series of forward
eurodollar rates as the market’s expectation of eurodollar rates at particular points in
the future plus term premia to compensate investors for taking duration risk on bonds
(Chart 8). For most countries and periods, we find there are more economic agents
who consider cash rather than longer-duration bonds their risk-free assets. Hence,
the longer ends needs to pay a risk premium over the short end of the curve and
bonds generally outperform cash. In times and countries where agents with long-
duration liabilities become the dominant fixed income investors, such as currently in
the UK, term premia become negative and forwards will settle below expected future
short rates.

We use the same logic to define risk premia around expected future mortality (Chart
9). We know from above that there are more agents in the economy who are short
longevity (i.e., are financially hurt by unexpected rises in longevity) than those who
are long. The market is thus net short longevity. To transfer this risk, it needs to
attract investors who require compensation to take on this risk. A pension fund that
hedges its longevity risk expects to be paid by the investor if mortality falls by more
than expected and is willing to pay if mortality ends up higher, because its own cash
outflows will then be less. As a result, the mortality forward that will attract investors
into this market must lie below the expected mortality rate. This discount, therefore,
constitutes the expected return to the investor of taking on mortality risk. And this
return needs to provide a sufficient return to risk to be competitive with other assets

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14. Coughlan et al., q-Forwards: Derivatives for transferring longevity and mortality risk, JPMorgan, July 2007
the investors could buy. We know from longer-term returns that equities and bonds have generated a Sharpe ratio (excess return to cash divided by return volatility) of around 0.2 to 0.3, providing a benchmark for risk premia in liquid markets. Generally the required risk premium will be higher, the higher the underlying risk (volatility), the higher its correlation with other asset classes (low in the case of mortality), and the lower the liquidity of the asset (initially low for longevity instruments).

Chart 9 presents an example for a 10-year forward for the 75-year old cohort of US males (who are now 65-year old). Extrapolating the pace of past improvements in mortality (using, e.g., the Lee-Carter model), we project that the 2004 period mortality rate of 4.19% will fall to 3.04% in 2017. Table 1 shows the historic volatility of changes in this mortality rate has been 1.47% of the rate itself, which would thus be 4.5bp. Since longevity risk is uncorrelated to other major risks, the required Sharpe ratio should be well below the averages in riskier markets such as equities, but attractive enough to bring investors to the market. We can expect an annualized Sharpe ratio around 0.25.

An investor should interpret the cash flow of the forward as an excess return investment. A total return version would keep the notional in a safe asset (a risk-free zero coupon bond, for instance) and invest in a potentially leveraged format in the forward contract. For example, an investor could buy a zero coupon with a $100 principal and currently priced $P. At the same time, the investor enters a mortality forward agreement with the same $100 notional. Therefore, the final cash flow of this investment is $100 + $100 \times (q_{\text{delivered}} - q_{\text{forward}}). The excess return of this investment over the risk-free return embedded in $100/$P is \( \frac{q_{\text{delivered}} - q_{\text{forward}}}{10\text{ years}} \).

Given that

- Expected mortality = \( q_{\text{expected}} = 3.04\% \)
- Annualized Expected return = \( \frac{q_{\text{expected}} - q_{\text{forward}}}{\text{(10 years)}} \)
- Annualised Risk = \( 1.47\% \times q_{\text{expected}} \)
- Risk at maturity = \( 4.64\% \times q_{\text{expected}} \), as \( 4.64\% = 1.47\% \times \sqrt{10} \)
- Required Annualized Sharpe ratio = 0.25
- Annualized Sharpe ratio = Expected annual return/Annualized Risk

\[ \frac{q_{\text{expected}} - q_{\text{forward}}}{\text{(10 years)}} / (10\text{ years}) \]

\[ \frac{q_{\text{expected}} - q_{\text{forward}}}{\text{(10 years)}} \]

\[ 1.47\% \times q_{\text{expected}} \]

\[ 4.64\% \times q_{\text{expected}} \]

\[ 0.25 \]

\[ \frac{\text{Expected annual return}}{\text{Annualized Risk}} \]

\[ 15. \text{ For long-term return series, see e.g., } \text{ Stocks, Bonds, Bills, and Inflation, 2006 Yearbook, Market results for 1926-2005, Ibbotson Associates, 2006, and Triumph of the Optimists, 101 years of Global Investment Returns, Dimson, Marsh and Staunton, 2002.} \]
expected return to investor =
expected minus forward mortality

actual return to investor =
delivered minus forward mortality

\[ \text{it follows that} \]
\[ q_{\text{forward}} = (1 - 10 \times 0.25 \times 1.47\%) \times q_{\text{expected}} = 0.9625 \times 3.04 = 2.93\% \]

That is, the forward needs to be 0.11\% below the expected future mortality of 3.04\%, which is a discount of 3.75\%, to produce an expected return to risk of 0.25.

Formally, we can write this rule as
\[ q_{\text{forward}} = (1 - \text{years} \times \text{Sharpe} \times q_{\text{vol}}) \times q_{\text{expected}}^{16} \]

As mortality data may suffer from measurement error, cohort effects and serial correlation, we can reduce the required risk premium by averaging across age groups and time. Instead of trading the mortality of 75 year-old males in 2017, we could trade the mortality for a range 70-79 in 2015-2019. The diversification lowers mortality volatility of the 70’s cohort to 0.9\% and thus the required discount for a Sharpe of 0.25 on the expected mortality to 2.25\%, from 3.75\%.

In reality, and especially at the beginning of the new market, there will be no clear consensus on how to arrive at an objective expectation of future mortality. It is possible that participants will gravitate to the Lee-Carter model for this as it is simple and objective. It is also possible that participants will start off from official government projections.

How can investors access longevity risk? Some investors could access longevity in unfunded form using q forwards. Otherwise, it is also easy to create an investment vehicle for funded investments. The simplicity of the forward contract payoffs facilitates the construction of many alternatives for accessing longevity via total return vehicles.

For instance, a bank can construct a bond that pays a flow of coupons plus a leveraged version of the q forward cash flows. This bond could pay LIBOR over the life of the bond and \( 100 + \text{Leverage} \times (q_x - q_{\text{forward}}) \) at maturity. The leverage ratio is used to increase the delivered risk premium to a desired level, while maintaining the same return to risk profile. If there were a sequence of q forwards, all coupon payments could also become a function of a series of delivered mortality rates.

Obviously, the risk of the bond increases with the leverage factor. If realized mortality is below the \( q_{\text{forward}} \), the value of the returned principal also decreases, introducing a feature similar to risk of default. We could create a version that limits both the upside and downside, eliminating therefore the possibility of a negative principal at maturity.

Market participants

Chart 10 presents a diagram with all potential sellers and buyers of longevity. An institution that goes long longevity profits from an increase in longevity, while a seller loses when longevity is higher than expected. Since DB pension funds are already heavily short longevity, they are the natural potential buyers of longevity. There are, however, other market participants that could take the other side of the position. Even though insurance companies do not face large imbalances as a group, some with large life insurance books relative to annuities could also become sellers.
of longevity risks and take advantage of their expertise in the area. Endowments could also take longevity risk due to their long-term horizons, liquidity and their innovative approach. Even corporates such as pharmaceutical companies could become potential sellers as they are positively exposed to longevity.

Hedge funds and other asset managers would be potentially willing to bear longevity exposure (either in derivative or securitized form) as long as they are offered a decent Sharpe ratio, i.e. an expected return per unit of risk of 0.2 or higher. Indeed recent experience with cat bonds is that money managers are attracted by the benefit of diversification that cat or longevity exposures offer. Current retail annuity pricing for 65 year olds in the UK implies a risk premium of 100bp below swaps, i.e. a Sharpe ratio of around 0.2 assuming annualised vol of 6% (duration of 12 years × 50bp longevity risk).

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**Chart 10: Potential longevity risk landscape**

<table>
<thead>
<tr>
<th>Potential longevity buyers</th>
<th>Potential longevity sellers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Over $8tr liabilities exposed to longevity (US, UK)</td>
<td>Could write protection to synthetically gain exposure to risk</td>
</tr>
<tr>
<td>Current tables likely to underestimate risk</td>
<td>Have the sophistication to analyse risk/return</td>
</tr>
<tr>
<td>Beginning to evaluate impact of this risk</td>
<td>Exposed to declines in longevity through life insurance policies</td>
</tr>
<tr>
<td>Exposed to longevity risk through annuity policies</td>
<td>Selling longevity offsets this risk</td>
</tr>
<tr>
<td>Would look to hedge exposure</td>
<td></td>
</tr>
<tr>
<td>Exposed to longevity risk through investment portfolio</td>
<td>Sell longevity and earn premium</td>
</tr>
<tr>
<td>Buy protection to hedge general trend risk</td>
<td>Can use existing expertise to evaluate risk/return</td>
</tr>
<tr>
<td>Buy protection against longevity risks from plan acquisition</td>
<td>May synthetically add exposure</td>
</tr>
<tr>
<td>Pension Funds</td>
<td>ILS Investors</td>
</tr>
<tr>
<td>Annuity Providers</td>
<td>Other Hedge Funds</td>
</tr>
<tr>
<td>Life Insurance Companies</td>
<td>Endowments</td>
</tr>
<tr>
<td>Life Settlement / Premium Finance Investor</td>
<td>Pharma</td>
</tr>
<tr>
<td>Pension Buyout Funds</td>
<td>Others (e.g. Reverse mortgage, healthcare)</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: JPMorgan

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Impact of introducing a longevity market

What is the impact of introducing a new instrument such as longevity hedges into the market? By creating a more efficient way to trade and price a particular risk, or state of the world, it should lead to cheaper implicit pricing of the risk involved, to reduced dispersion of pricing as a single transparent price emerges, and to a greater number of transfers/trading of the risk. These impacts can be shown more clearly by looking at the current market for retail and wholesale annuities in the UK.

In retail annuities, insurance companies pay savers a fixed coupon for the remainder of their life. The annuity internal rate of return (IRR) will be lower than the yield of a bond of similar maturity to compensate for the risk that the saver will live longer than expected. In equilibrium, this thus constitutes the longevity risk premium. Academic studies generally conclude that retail annuities have been priced quite fairly over time given the implicit longevity risk. Our estimates show that for 65-year old males the annuity IRR in the UK has averaged some 50bp below gilt yields over the past 40 years, and thus some 100bp below swaps, which should be the open-market rate. Over time, the volatility of spread duration returns is a good measure of the amount of risk that annuity providers take relative to borrowing in swaps. By this measure, the longevity risk born by UK insurers selling retail annuities has averaged 6% per annum (50bp spread vol × 12 year duration on an annuity for a 65-year old). The implied Sharpe ratio has thus averaged 0.20, marginally lower than the long-run return-to-risk ratio on equities and bonds, and thus a fair compensation for risk.

Even though the introduction of longevity instruments may not reduce the risk premium per unit of risk that is currently at fair levels, the risk premium should decrease as insurers’ volatility on longevity ought to fall towards a rational level derived from fundamental longevity models, such as the Lee-Carter model. In this context, the 50bp spread vol on retail annuities can eventually drop as far as the 25bp annualised mortality risk for 65-year old UK males implicit in the Lee-Carter model, reducing the average longevity risk premium from 100bp to 50bp in the limit. We should also expect a reduction in the large dispersion in pricing on retail annuities in contrast to the variety of coupon rates insurers currently offer.

Longevity instruments should also benefit the longevity market, that is still in its infancy in the UK as most pension funds cannot afford the heavy discounts offered by insurers. They provide bulk annuities to all the members of a particular pension fund as part of a buyout and windup of a defined benefit plan. Part of the

18. To calculate UK annuity yields we solve for IRR in the approximate annuity pricing formula, where C/P is the annuity annual coupon rate and LE is at each time the more recent latest forecast for life expectancy from the Institute of Actuaries. UK annuity rates are generally linked to the value of long dated Gilt yields. These long dated Gilts, which are used to back annuities, are becoming increasingly rare. This shortage has led, in recent years, to annuity providers using corporate bonds, equities or other forms of investment to back their annuity products, albeit with higher investment risk, administrative, and capital costs. See Cannon and Tonks (2004) for a history of UK annuity rates. In the UK, the average size of the estimated annuity risk premium, i.e. the difference between the annuity IRR and the 10-year swap rate has been around 100bp since 1963. This translates to an average 10% premium in price space, somewhat higher than previous UK studies mostly because we measure the annuity risk premium against swap rates rather Gilt yields. See Cannon and Tonks (2003). Finkeinstein and Poterba (2002) and Murthi, Orszag and Orszag (1999). In the US, the annuity premium has been also found to be of similar magnitude, around 10%-15% in price space. See Mitchell, Poterba and Warshawsky (1997).
19. The size of the UK retail annuity market is £135bn, decent in size, but not overwhelming. It has grown rapidly in recent years as savers are required to take on such annuities when they retire. Most savers do not like annuities as they do not like the current level discount versus normal savings products (in addition to preferring to leave bequests after they die). In the US, the annuity market is dominated by savings products with little or no longevity exposure. The pure annuity market remains very small, as, in contrast to the UK, there is no obligation to annuitize at the end of the accumulation period.
20. Unfortunately, the information we have on the pricing of these buyouts consists not of IRRs but of premia on the accounting value of the pension fund liabilities. In the UK, these premia have ranged from 30% to 50% off FRS 17 values. The heavy discounts reflect not just longevity risk premia and but likely also a recognition that these pension funds have been underestimating longevity in their accounting valuations. As such, these discounts do not tell us much about longevity premia in annuities.
explanation for the slow development of this market is due to onerous capital require-
ments imposed by the FSA, but to us, some of this is also due to the inability of insurers to easily lay off the longevity risk embedded in these annuities, which could be addressed by a liquid longevity market.

Conclusion
Longevity risk has become a high-profile risk to many market participants. Bankers, insurers and investors are working hard on developing an efficient manner to share and transfer the current concentration of this risk among insurers and pension funds. To attract investors, the current insurance based transfer systems need to graduate to a capital market format. To us, this means we need to move to mortality forward products and derivatives. It is just a matter of time for this market to take off. We believe the benefits will be substantial and shared by many market participants. Most importantly, the emergence of a new market allows for the more efficient pricing and distribution of risk, and permits a growth in size of markets that involve longevity risk.
APPENDIX 1

Comparison with past successful, and not successful product innovations

Mortgage-backed securities (MBS) are securitised pools of residential mortgages, most prominently in the US, where the yield incorporates a risk premium against the risk of early prepayment. This prepayment risk defines the diverse states of the world that make MBS a separate asset class and attract a strong investment clientele. US banks have huge concentrations of mortgages and use MBS to diversify their portfolios. Government agencies were highly instrumental in creating standardised contracts.

Interest rate swaps (IRS) started in the late 1970s as interbank exchanges of fixed-against floating interest rate payments without an exchange of principal. The natural buyers and sellers of these instruments were the banks themselves, who needed a maturity extension of the libor money market to better manage their interest rate exposures. Interest rate swaps do not provide much risk differentiation relative to government bonds that existed well before swaps did, but they do provide an important improvement in homogeneity and thus provide much cleaner instruments to manage interest rate risk than government bonds do.

Real estate investment trusts (REITs) are pools of commercial real estate holdings or leases. They permit corporations to diversify their balance sheets away from buildings, and provide investors access to an exposure and cash flow that are very different from plain-vanilla equities and bonds. US regulations and taxation were adopted to create tax efficient instruments to create these transfers of exposures. Other countries have followed suit in recent years and REITs have recently been launched in the UK, France and Germany.

The case for the creation of inflation-linked bonds is very old. Inflation is an important state of the world that affects all economic agents and there are natural shorts and longs on this exposure. Economists have argued for the creation of this market for a long time, but the open markets failed to create it until governments decided to issue bonds whose principal and coupon are linked to the rate of inflation. The UK government was an early issuer in 1982, and was followed only in 1992 by Australia, 1995 by Canada and Sweden, the US in 1997 and France in 1998. Since then Germany, Italy and Japan have joined in. Governments are a natural issuer as they are long inflation through their tax revenues.

Credit default swaps (CDS) are insurance-like products where the “buyer” receives a risk/insurance premium from the seller in exchange for making good the latter against default of a named company on a third contract. The market started as an interbank market to transfer credit risk in a cost-effective way. Loans have been historically a long-only cash asset, with little or no ability for participants to go short risk or take on risk synthetically without selling the underlying loans. The market has grown dramatically in recent years and now involves a diverse set of market players, from insurance companies to hedge funds. BIS estimates show that the market has grown from $180 billion in notional amount in 1997 to $6 trillion by 2004 and likely $20 trillion by mid 2006. Standardized industry standards and benchmarks as well as consistent, reliable and understandable legal documentation, which greatly lowered the transactions costs to trading CDS, have been the main force behind the spectacular growth of the past few years.
What markets have not taken off and what can we learn from them?

Residential real estate derivatives. Economists have long argued that there should be a market that permits households to diversify away some of what constitutes the largest risk concentration in their financial wealth — their houses. Prof Robert Shiller has argued this most consistently and helped create the Case-Shiller index of US real estate.

Last year, a list of contracts linked to the Case-Shiller US real estate indices started trading in the CME with still small volume. The OTC market for property derivatives is also very small. Most of the demand in the financial markets for property instruments comes from long-only investors that find REITs to satisfy their needs. The important question remains: where are the potential short hedgers?

One possible problem for this incipient derivatives market is the imbalance in the demand and supply due to the substantial basis risk that short hedgers face. A potential short hedger could eliminate his current real estate exposure by selling the current exposure or hedging using instruments based on diversified indices. In the first case, the effect is more permanent as the asset is sold, but there is no basis risk as the exposure to that particular asset is fully eliminated. In the second case, the risk associated with the systematic real estate risk is eliminated, but idiosyncratic risk remains. Potential short hedgers may not find property derivatives the right instrument for multiple reasons. First, the basis risk may be too large. Second, even if the basis risk is not too large, the potential hedge may be particularly interested in eliminating the idiosyncratic component and not the aggregate risk. Third, the potential hedger may want to eliminate the asset from the balance sheet completely, which cannot be achieved with a derivative contract. And finally, investors who want exposure to real estate already have the much more liquid REIT market. The return on REITs include the all-important coupon, while the Case-Shiller residential price futures only provide exposure to capital gains/losses.

GDP derivatives: If the market has created inflation derivatives, why has it not successfully created real or nominal GDP derivatives? Banks have tried to create this market but have not had much success with it. It is clear that every economic agent has a massive exposure to the overall economy. However, there are two major problems with this potential market. One is that most agents are long the economy and there are thus no natural buyers of GDP. Second is that there is a much looser relationship between GDP and the real value of financial wealth, than there is with inflation. A GDP hedge is thus not a very good hedge against falls in bond or equity prices. An extra technical problem for an efficient derivative market is that GDP estimates get revised for many years while CPI indices are not.
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