

# How to deal with longevity risk: A capital market perspective

## The importance of longevity risk

“By providing financial protection against the major 18th and 19th century risk of dying too soon, life insurance became the biggest financial industry of that century... 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, “Innovate or Die”,  
The Economist, 23 September 1999

referred to as “longevity risk“. In recent years, interest in this topic has picked up both among individuals and policymakers, as baby boomers approach retirement and start to think about how they will organize their finances to last.

## Potential solutions for investors

There are several ways for investors to deal with longevity risk. First, they can decide to bear it. Second, individuals can transfer their own longevity risk to an insurance company by purchasing a life annuity to protect themselves. A life annuity is an insurance contract that pays out a regular income for life. Until now, this has been the standard option for investors to protect themselves against outliving their assets.

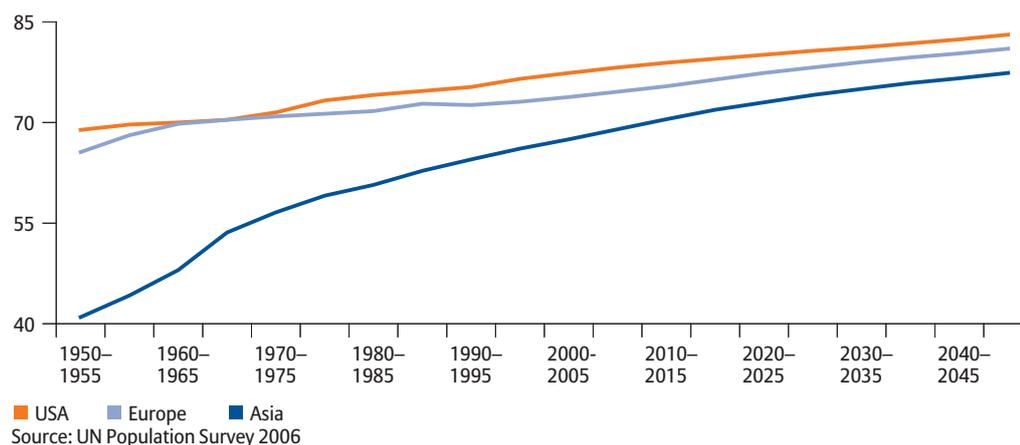
A third alternative recently emerged in the form of longevity-linked financial instruments such as longevity bonds or swaps. Asset managers can create investment solutions that make use of longevity instruments to offer individuals a convenient way to hedge longevity risk. In contrast to a life annuity that protects against individual longevity risk, such solutions can only hedge against systematic

## The longevity problem

Modern health care has extended the average life span of people all over the world (see Figure 1), and it continues to increase. For instance, the life expectancy of an individual in Asia has risen from 40 years in the 1950s to almost 70 years today.

Most people would agree that increasing life expectancy is good news. But it is a double-edged sword, as many people may outlive their savings and be forced to accept a lower standard of living late in life. The risk of outliving one’s assets is now commonly

Figure 1: Life expectancy at birth [years]



longevity risk, defined as the risk that a certain age group will live longer than expected. Such a solution should come at a more attractive price, however. In the following, we will focus on this third alternative.

## Longevity-linked financial instruments

Recently introduced longevity-linked financial instruments offer a new approach to transferring longevity exposures efficiently. Longevity-linked securities can take various forms, and there are two prominent examples of first-generation capital market instruments that are linked to mortality rates.

In December 2003, Swiss Re and Vita Capital were the first companies to issue a three-year bond whose performance was linked to the evolution of a mortality index. The Swiss Re bond can be classified as a “principal-at-risk longevity bond” that pays annual coupons at an above-market rate and a refund of principal at maturity. Should an event occur where mortality is high, the repayment of principal is reduced (in line with the mortality index). As the principal was unprotected, investors ran the risk of losing the capital they invested in the bond. In fact, Swiss Re used the bond to hedge its exposure to catastrophic mortality risk.

In November 2004, the European Investment Bank issued a longevity bond that is a “coupon-based longevity bond”. Coupon payments were linked to a cohort survivor index based on the mortality rates of 65-year-old English and Welsh males in 2003. As longevity increases, rising coupon payments help pension plans manage their exposure to longevity risk.

To assess the risk/return profile of longevity instruments, the characteristics of mortality rates must first be understood. The main properties of mortality rates are:<sup>1</sup>

- Mortality rates rise with age
- Women generally live longer than men
- Mortality rates have fallen and life expectancy has risen dramatically
- Changes in annual mortality rates have been quite volatile

For pricing, risk management and investing into longevity-linked instruments, future mortality rates are relevant. There are several ways of forecasting future mortality, ranging from statistical models that are fitted to historical data, to more fundamental models that link mortality rates to factors such as changes in public health. The classical benchmark model for mortality forecasts is the Lee-Carter Model (1992), which belongs to the category of statistical models.

The market for longevity and mortality derivatives has not yet taken off. This is because there is considerable demand for selling longevity risk, but only a limited supply of buyers. Natural longevity risk sellers are pension plans and annuity providers that are willing to offset some of their longevity exposure. Potential longevity buyers are hedge funds, endowments and other institutional investors seeking a new asset class that promises uncorrelated returns to traditional asset classes. However, for both parties to enter into a trade, the longevity product under consideration must be sufficiently customized to provide an effective hedge for the longevity seller and sufficiently standardized to ensure liquidity for the longevity buyer. Another major challenge in creating a liquid longevity market is basis risk, meaning the mismatch in longevity risk between the reference population and the investor’s own risk. Examples are different population characteristics and/or different age profiles.

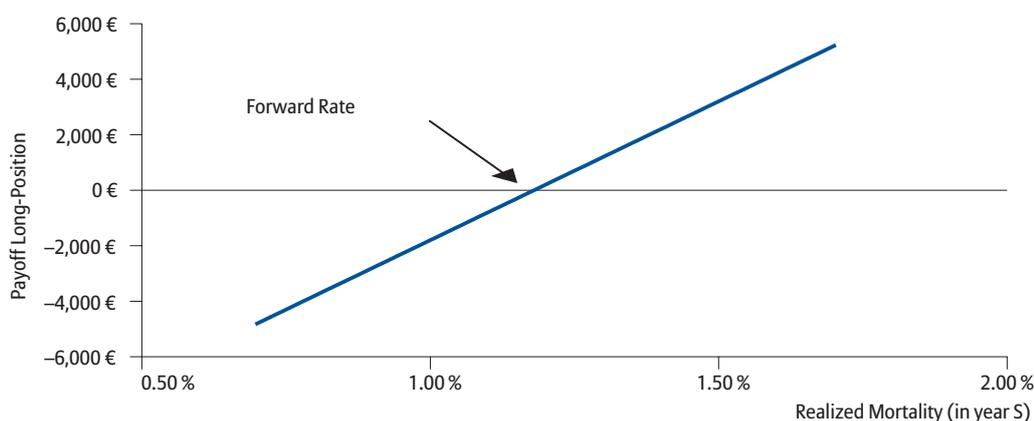
A number of different longevity/mortality risk transfer products have been proposed, including long-term longevity bonds, short-term catastrophe bonds, survivor swaps and annuity futures. A particularly interesting concept was just recently introduced by JP Morgan: q-forwards. The term “ $q_x$ ” originates from the discipline of actuarial science and refers to the mortality rate of x-year-olds in a

<sup>1</sup> See Loeys et al (2007)

particular year. For example, a mortality rate  $q_{60}=1.18\%$  means that for a given population, 1.18% of the cohort of 60-year-olds are expected to die the following year. The payoff of a long position of a q-forward with a notional of EUR 1m, maturity T, and reference year S ( $S<T$ ) is given by

Since each set of mortality rates translates into a series of survival rates, q-forwards can be seen as building blocks to more complex longevity/mortality derivatives. They can be integrated into a portfolio to hedge pension or life insurance liabilities.

Figure 2: Payoff diagram of a q-forward contract with a forward rate of 1.18% and a notional of EUR 1 m



$$\text{EUR } 1 \text{ m} * (q_{\text{realized}} - q_{\text{forward}}),$$

where  $q_{\text{realized}}$  is the realized mortality rate in year S and  $q_{\text{forward}}$  is the forward price/strike price set at the inception of the contract, i.e. at time  $t=0$ . Figure 2 graphically illustrates the payoff function for a forward rate of 1.18%. If the realized mortality rate is above (or below)  $q_{\text{forward}}$ , the holder of a long position in the forward contract receives a positive (or negative) cash flow.

To determine the “fair” price, namely the forward rate of such a contract, several models can be applied. They can be divided into two broad groups: models under the real-world (or physical) measure or models under the risk-neutral measure, also known as no-arbitrage models. Since there is still no underlying market for mortality instruments, the no-arbitrage approach is difficult to apply. For this reason, it is standard market practice to use statistical or actuarial models, such as the aforementioned Lee-Carter Model, to forecast future mortality. Investors willing to take on longevity risks demand a (risk) premium. It is therefore likely that the mortality forward rate is set below the expected mortality rate of a statistical model.

## Life-cycle investing with longevity risk protection

Life-cycle investing refers to how people should make investment decisions throughout their lifetime. Today, investing for retirement is a major issue for billions of people around the world.

Throughout their lifetime, investors have to deal with three major sources of risk: market risk (e.g. equity market risk), inflation risk, and longevity risk. Market and inflation risk are well understood and can be actively managed using liquid derivatives contracts (e.g. inflation swaps to hedge against inflation risk). Longevity risk, however, has thus far not been well understood and is difficult to manage.

Whether (or when) an investor outlives his or her assets is driven by three key variables: market return, inflation rate and longevity. Longevity is important, as it determines the time span during which accumulated wealth is distributed. If an individual lives longer than expected, the amount available for consumption is reduced. This presents a major risk to investors and should therefore be considered in life-cycle models.

Including longevity bonds or derivatives in life-cycle asset allocation provides protection against increases in “systematic” longevity. An increase in longevity during the accumulation phase of a life-cycle impacts actuarial assumptions (mortality tables), making a potential fixed annuity less attractive at the time of retirement. It should be noted, however, that the price or cash flow of longevity instruments increases, too. If correctly balanced, the net effect should be sufficiently small.

As the individual likelihood of death within the accumulation phase is relatively low, longevity/mortality instruments that refer to a large population are well-suited to hedge against systematic longevity risk. During the decumulation phase, individual longevity risk gains relevance over systematic longevity risk. This is also a consequence of the increasing volatility of life expectancy. As a result, efficient hedging of individual longevity risk in the decumulation phase requires the use of customized insurance components that can be supplemented by standardized longevity instruments.

## Summary

Increasing life expectancy is a source of risk to individuals, as it generally implies higher consumption in relation to accumulated capital. The standard way to hedge against longevity risk is to purchase life-long annuities. Just recently, capital market products (bonds, swaps, options) that promise a hedge against “systematic” longevity risk have been proposed. Investors employing longevity-linked financial securities during the accumulation phase to cover systematic longevity risk would particularly benefit from greater liquidity and flexibility. The market is at an early stage of development and is often compared with the credit derivatives market from a decade ago.

The emergence of a market for longevity products is good news for clients, investors and asset management firms, as they will gain easy access to capital market instruments that enable the management of longevity risk, one of the major risks of life-cycle investing.

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## References

Bauer, D./Börger, M./Ruß, J./Zwiesler, H.-J. (2007): The Volatility of Mortality.

Lee, R.D./Carter, L. (1992): Modeling and Forecasting the U.S. Mortality. *Journal of the American Statistical Association*, 87:659-671.

Lin, Y./Cox, S. (2005): Securitization of Mortality Risks in Life Annuities. *The Journal of Risk and Insurance*, 72: 227–252.

Loeys, J./Panigirtzoglou, N./Ribeiro, R.M. (2007): Longevity: a market in the making, JP Morgan Global Market Strategy.