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## Longevity Risk and Capital Markets: The 2008-2009 Update

David Blake, Anja De Waeganaere, Richard McMinn and Theo Nijman

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The Pensions Institute
Cass Business School
City University
106 Bunhill Row London
EC1Y 8TZ
UNITED KINGDOM

http://www.pensions-institute.org/

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Editorial

# Longevity risk and capital markets: The 2008–2009 update

This issue of *Insurance: Mathematics and Economics* contains 11 contributions to the academic literature all dealing with longevity risk and capital markets. Draft versions of the papers were presented at *Longevity Four: The Fourth International Longevity Risk and Capital Markets Solutions Conference* that was held in Amsterdam on 25–26 September 2008. It was hosted by Netspar and the Pensions Institute (at Cass Business School), and organized by PensionSummit.

Longevity risk and related capital market solutions have grown increasingly important in recent years, both in academic research and in the real world life markets. Mortality improvements around the world are putting more and more pressure on governments, pension funds, life insurance companies as well as individuals, to deal with the longevity risk they face. At the same time, capital markets can, in principle, provide vehicles to hedge longevity risk effectively. Many new investment products have been created both by the insurance/reinsurance industry and by the capital markets. Mortality catastrophe bonds are an example of a successful insurance-linked security. Some new innovative capital market solutions for transferring longevity risk include longevity (or survivor) bonds, longevity (or survivor) swaps and mortality (or q-) forward contracts. The aim of the *International Longevity Risk and Capital Markets Solutions Conferences* is to bring together academics and practitioners from all over the world to discuss and analyze these exciting new developments.

The conferences have followed closely the developments in the market. The first conference (*Longevity One*) was held at Cass Business School in London in February 2005. This conference was prompted by the announcement of the Swiss Re mortality catastrophe bond in December 2003 and the European Investment Bank/BNP Paribas/PartnerRe longevity bond in November 2004.

The second conference was held in April 2006 in Chicago and hosted by the Katie School at Illinois State University.[1] Since *Longevity One*, there had been further issues of mortality catastrophe bonds, as well as the release of the Credit Suisse Longevity Index. Life settlement securitizations were also beginning to take place in the United States. In the UK, new life companies backed by global investment banks and private equity firms were setting up for the express purpose of buying out the defined benefit pension liabilities of UK corporations. Goldman Sachs announced it was setting up such a buy-out company itself because the issue of pension liabilities was beginning to impede its mergers and acquisitions activities. It decided that the best way to deal with pension liabilities was to remove them altogether from the balance sheets of takeover targets. So, there was now clear evidence that a new global capital market in longevity risk transference was beginning to emerge. However, as with many other economic activities, not all progress follows a smooth path. The EIB/BNP/PartnerRe longevity bond did not attract sufficient investor interest and was withdrawn in late 2005. But a great deal was learned from this about the conditions and requirements needed to launch a successful capital market.

The third conference was held in Taipei, Taiwan, on 20–21 July 2007. It was hosted by National Chengchi University.[2] It was decided to hold *Longevity Three* in the Far East, not only to reflect the growing importance of Asia in the global economy, but also in recognition of the fact that population ageing and longevity risk are problems that affect all parts of the world and that what we need is a global approach to solving these problems.[3] Since the Chicago conference, there had been many new developments, including the release of the LifeMetrics Index in March 2007 by JP Morgan, the Pensions Institute and Watson Wyatt (www.lifemetrics.com); the world's first publicly announced longevity swap between Swiss Re and the UK life office Friends' Provident in April 2007 (although this was structured as an insurance contract or indemnification rather than a capital market transaction); and the launch of the Institutional Life Markets Association also in April 2007.

Since the Taiwan conference, there were further developments in the capital markets. In December 2007, Goldman Sachs launched a monthly index suitable for trading life settlements.[4] The index, QxX.LS, is based on a pool of 46,290 anonymized US lives over the age of 65 from a database of life policy sellers assessed by the medical underwriter AVS (www.qxx-index.com). Xpect Age and Cohort Indices were launched in March 2008 by Deutsche Börse. These indices cover, respectively, life expectancy at different ages and survival rates for given cohorts of lives in Germany and the Netherlands. In July 2008, Institutional Life Services (ILS) and Institutional Life Administration (ILA), a life settlements trading platform and clearing house, were launched by Goldman Sachs, Genworth Financial and National Financial Partners. ILS/ILA are designed to modernize dealing in life settlements and meet the needs of consumers (by ensuring permanent anonymity of the insured) and of the capital markets (by providing a central clearing house for onward distribution of life settlement assets, whether individually or in the structured form).

[1] The conference proceedings for *Longevity Two* were published in the December 2006 issue of the *Journal of Risk and Insurance*.

[2] The conference proceedings for *Longevity Three* were published in the Fall 2008 issue of the *Asia-Pacific Journal of Risk and Insurance*.

[3] In fact, Asia has the world's largest and fastest growing ageing population (United Nations, 2007).

[4] Life settlements are traded life policies. In April 2007, the Institutional Life Markets Association started in New York, as the dedicated institutional trade body for the life settlements industry.

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The world's first capital market derivative transaction, a q-forward contract[5] between JP Morgan and the UK pension fund buy-out company Lucida, took place in January 2008. The world's first capital market longevity swap was executed in July 2008. Canada Life hedged £500 m of its UK-based annuity book (purchased from the defunct UK life insurer Equitable Life). This was a 40-year swap customized to the insurer's longevity exposure to 125,000 annuitants. The longevity risk was fully transferred to investors, which included hedge funds and insurance-linked securities funds. JP Morgan acted as the intermediary and assumes counter-party credit risk.

At the same time as these practical developments in the capital markets, academics were continuing to make progress on theoretical developments, building on the original idea of using longevity bonds to hedge longevity risk in the capital markets (Blake and Burrows, 2001). These included:

- Design and pricing of longevity bonds (e.g. Blake et al., 2006)
- Design and pricing of longevity-linked derivatives, such as survivor swaps[6] (e.g. Dowd et al., 2006), survivor forwards and swaptions (e.g., (Dawson et al., forthcoming)), and mortality options (e.g. Milevsky and Promislow, 2001).
- Securitization and hedging in life insurance and annuities (e.g., Cowley and Cummins (2005), Dahl and Møller (2006) and Lin and Cox (2005)).
- Mortality modeling (e.g., Cairns et al. (2006, 2008, 2009)), Dowd et al. (2008), Blake et al. (2008) and Hari et al. (2008)).
- Mortality term structure modeling and pricing (e.g., Bauer (2006), Bauer and Ruß(2006) and Biffis et al. (forthcoming)).

As with the previous conferences, *Longevity Four* consisted of both academic papers and more practical and policy-oriented presentations. The conference location in Amsterdam was motivated by the fact that pension providers in Holland, like the UK and Ireland, have significant occupational defined benefit liabilities and hence have a significant exposure to longevity risk. The conference was addressed, among others, by the following key-note speakers:

- Joanne Kellermann, Executive Director of De Nederlandsche Bank (DNB): Longevity risk and regulation of pension funds.
- Anton Kunst, Netspar and Associate Professor of Medical Demography, Erasmus MC: Epidemiological perspectives on life expectancy.
- Gilles Dellaert, vice president in Goldman Sachs' Longevity Markets Group: Longevity: A developing asset class.
- Søren Fiig Jarner, Chief Analyst of ATP: Small-region mortality modeling.
- Ronald Wuijster, Director of Strategy & Research at APG Investments: Longevity problems and investment solutions.
- Guy Coughlan, Managing Director and Global Head of LifeMetrics and ALM Advisory JP Morgan Pension Solutions Group: The effectiveness of longevity hedges and the attractiveness of longevity investments.

The academic papers that were selected by us as the editors of this Special Issue of *Insurance: Mathematics and Economics* went through a refereeing process subject to the usual high standards of *Insurance: Mathematics & Economics*. They cover the following themes: longevity bonds and derivatives, the securitization of longevity risk, the role of different types of annuities in individual portfolios, the role of product design and product mix in mitigating the longevity risk facing product providers, and stochastic mortality modeling. We briefly discuss each of the 11 papers selected.

For annuity providers, longevity risk—the risk that future mortality trends differ from those anticipated—constitutes an important risk factor. In order to manage this risk, new financial products, so-called longevity derivatives, may be needed, even though the first attempt to issue a longevity bond in 2004 was not successful. While different methods of how to price such securities have been proposed in the recent literature, no consensus has been reached. In "On the Pricing of Longevity-Linked Securities", Daniel Bauer, Matthias Börger and Jochen Ruß analyze and critically appraise the different approaches. They then use data from the UK to derive fair prices for the first proposed longevity bond and an alternative security design, namely a longevity derivative with an option-type payoff. The authors argue that an option-type longevity derivative would allow an insurer to keep the "equity tranche" of the longevity risk it carries on the company's own books. This would make the securitization of longevity risk much more attractive for investors who need to be induced to take "the other side" of the transaction.

In "Longevity Bond Premiums: The Extreme Value Approach and Risk Cubic Pricing", Hua Chen and J. David Cummins analyze the securitization of longevity risk using longevity bonds. They also recognize that there has been one unsuccessful attempt by the capital markets to issue a longevity bond. By contrast, the Swiss Re mortality catastrophe bond in December 2003 was a big success. After carefully assessing the pros and cons of previous securitizations, the authors propose a new type of longevity bond, one whose payoffs are structured as a series of put option spreads. They utilize a random walk model with drift to fit small variations of mortality improvements and employ extreme value theory to model rare longevity events. Their new approach to longevity risk securitization has the advantage of both capturing mortality improvements within sample and extrapolating rare, out-of-sample longevity events. The authors demonstrate that the risk cubic model developed for pricing catastrophe bonds can be applied to both mortality and longevity bond pricing and use the model to calculate risk premiums for longevity bonds.

Atsuyuki Kogure and Yoshiyuki Kurachi present a Bayesian approach to pricing longevity risk using the Lee–Carter model in "A Bayesian Approach to Pricing Longevity Risk Based on Risk-Neutral Predictive Distributions". Their pricing methodology is based on the risk neutralization of the predictive distribution of future survival rates using the entropy maximization principle discussed by Stutzer (1996). They use the approach to price both longevity bonds and survivor swaps, using Japanese mortality data for illustration.

Pricing and risk management for longevity risk has increasingly become a major challenge for life insurers and pension funds around the world. Risk transfer to financial markets, with their capacity for efficient risk pooling, is an area of significant development for a successful longevity product market. The structuring and pricing of longevity risk using modern securitization methods, common in financial markets, has yet to be successfully implemented for longevity risk management. There are many issues that remain unresolved in order to ensure the successful development of a longevity risk market. In "Securitization, Structuring and Pricing of Longevity Risk", Samuel Wills and Michael Sherris consider the securitization of longevity risk focusing on the structuring and pricing of a longevity bond using techniques developed in the financial markets, particularly for mortgages and credit risk. A model based on Australian mortality data and calibrated to insurance risk-linked market data is used to assess the structure and market consistent pricing of a longevity bond. Age dependence in the securitized risks is shown to be a critical factor in structuring and pricing longevity-linked securitizations.

In "Securitizing and Tranching Longevity Exposures", Enrico Biffis and David Blake consider the problem of optimally designing

[5] Coughlan et al. (2007).

[6] In 2009, survivor swaps began to be offered to the market based on Deutsche Börse's Xpect Cohort Indices.

longevity risk transfers under asymmetric information. They focus on holders of longevity exposures, such as annuity providers, who have superior knowledge of the underlying demographic risks—in the sense that they have private access to better experience data or forecasting technologies—but are willing to take them off their balance sheets because of capital requirements. In equilibrium, the original holders transfer longevity risk to uninformed investors (i.e, securitize the risk) at a cost, where the cost is represented by retention of part of the exposure and/or by a risk premium. The authors use a signalling model of security issuance to show how differential information about longevity trends by holders and investors act to raise the equilibrium retention levels or the risk premia demanded by investors in a longevity risk transfer. They show how the cost of private information can be minimized by suitably tranching securitized cashflows, or, equivalently, by securitizing the exposure in exchange for an option which caps the longevity exposure of the option seller (i.e., the original holder). The seller therefore has an effective hedge against longevity risk. The intuition is that the tranching level or option strike level measures the optimal level of protection against longevity risk that the seller of the longevity exposure is willing to obtain from the market, given the costs of capital requirements and asymmetric information. The authors also investigate the benefits of pooling several longevity exposures and the impact on tranching levels.

In "Optimizing the Equity-Bond-Annuity Portfolio in Retirement: The Impact of Uncertain Health Expenses", Gaobo Pang and Mark Warshawsky derive optimal equity-bond-annuity portfolios for households who face stochastic capital market returns, differential exposures to mortality risk and uncertain uninsured health expenses, and differential social security and defined benefit pension coverage. The results show that the health-spending risk drives household portfolios to shift from risky equities to safer assets and enhances the demand for annuities due to their increasing-with-age superiority over bonds in hedging against life-contingent health-spending and longevity risks. Households with higher income have a greater incremental demand for life annuities. The annuities, in turn, provide greater leverage for equity investment in the remaining asset portfolios.

Although annuities provide longevity insurance that should be attractive to households facing an uncertain lifespan, rates of voluntary annuitization remain extremely low. In "Evaluating the Advanced Life Deferred Annuity – An Annuity People Might Actually Buy", Guan Gong and Anthony Webb evaluate the ALDA, an annuity purchased at retirement, but only providing an income once the individual has reached advanced old age. Using numerical optimization, they show that the ALDA would provide a substantial proportion of the longevity insurance available from an immediate annuity, but at much lower cost. At plausible levels of actuarial unfairness, households should prefer it both to immediate annuitization and to postponed annuitization, combined with an optimal decumulation of unannuitized wealth. Few households would suffer significant losses were it used as a 401(k) plan default.

In "Longevity Risk in Pension Annuities with Exchange Options: The Effect of Product Design", Ralph Stevens, Anja De Waegenaere and Bertrand Melenberg investigate whether the adverse effects of longevity risk on the liabilities of pension funds can be mitigated through product design. Specifically, they consider two types of pension plans that each allow their participants to choose, at the retirement date, between a single-life annuity and a joint-and-survivor annuity. In one plan, the participant builds up the right to receive a single-life annuity and can exchange that annuity for a joint-and-survivor annuity at the retirement date. In the other plan, the participant builds up the right to receive a joint-and-survivor annuity and can exchange that annuity for a single-life annuity at the retirement date. In both cases, the exchange of annuity rights is actuarially neutral at the time of exchange, which implies that the rate at which annuity rights can be exchanged is affected by longevity risk. The authors find that pension plans in which participants build up the right to receive a joint-and-survivor annuity are significantly less sensitive to longevity risk than pension plans in which participants build up the right to receive a single-life annuity.

In "On the Optimal Product Mix in Life Insurance Companies using Conditional Value at Risk", Jeffrey Tsai, Jennifer Wang and Larry Tzeng use a Conditional Value-at-Risk Minimization (CVaRM) approach to optimize the product mix for life insurance companies. Utilizing the natural hedging strategy of Cox and Lin (2007) and the Cairns–Blake–Dowd stochastic mortality model (Cairns et al., 2006), the authors calculate the optimal product mix to hedge against systematic mortality risk when there is parameter uncertainty in the stochastic mortality model. They go on to compare the hedging results using CVaRM with those produced using the duration-matching method outlined in Wang et al. (forthcoming) and show that the proposed CVaRM approach generates a narrower distribution of outcomes after hedging and thus effectively reduces systematic mortality risks for life insurance companies.

In "Mortality Risk Modeling: Applications to Insurance Securitization", Samuel H. Cox, Yijia Lin and Hal Pedersen propose a stochastic mortality model featuring both permanent longevity jump and temporary mortality jump processes. A trend reduction component describes unexpected mortality improvement over an extended period of time. The model also captures the uneven effect of mortality events on different ages and the correlations among them. The model will be useful in analyzing future mortality-dependent cash flows of life insurance portfolios, annuity portfolios and portfolios of mortality derivatives. The authors apply the model to analyze and price a longevity security.

In "Modeling Longevity Risks using a Principal Component Approach: A Comparison with Existing Stochastic Mortality Models", Sharon Yang, Jack C. Yue and Hong-Chih Huang use principal component analysis (PCA) to design a stochastic mortality model with an age shift for the purpose of projecting future mortality rates. They compare their PCA model with existing models, such as the Lee–Carter model, the Age-Period-Cohort model and the Cairns–Blake–Dowd model. Using mortality data from six countries—two each from Asia, Europe, and North America—from the Human Mortality Database over the period 1970–2005, the authors demonstrate that the PCA model produces smaller mean absolute percentage prediction errors for almost all the countries considered. To illustrate the model, it is used to estimate the premiums of whole life and deferred whole life annuities.

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*Longevity Five* took place in New York on 25–26 September 2009. The *North American Actuarial Journal* will publish a Special Issue of selected papers presented at the conference. *Longevity Six* will be hosted by the University of New South Wales in Sydney in September 2010.

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David Blake*
*Pensions Institute, Cass Business School, City University London, United Kingdom*
*E-mail address:* D.Blake@city.ac.uk.

Anja De Waegenaere
*Netspar and Tilburg University, The Netherlands*
*E-mail address:* a.m.b.dewaegenaere@uvt.nl.

Richard MacMinn
*Illinois State University, USA*
*E-mail address:* richard.macminn@ilstu.edu.

Theo Nijman
*Netspar and Tilburg University, The Netherlands*
*E-mail address:* Nyman@uvt.nl.

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* Corresponding editor.