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**Longevity Risk and Capital
Markets: The 2014-15 update.**

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Longevity Risk and Capital Markets: The 2014-15 Update

David Blake
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This Special Issue of the *Journal of Risk and Insurance* contains 11 contributions to the academic literature all dealing with longevity risk and capital markets. Draft versions of the papers were presented at *Longevity 10: The Tenth International Longevity Risk and Capital Markets Solutions Conference* that was held in Santiago, Chile on 3-4 September 2014. It was hosted by the Universidad Diego Portales, the International Federation of Pension Fund Administrators (FIAP), the Chilean Securities and Insurance Supervisor (Superintendencia de Valores y Seguros - SVS) and the Pensions Institute, Cass Business School, City University of London, UK. It was sponsored by AFP Habitat, Principal Financial Group, Prudential Financial, Inc., Société Générale Corporate and Investment Banking, the Society of Actuaries (SOA), and the Insurers Association of Chile.

Longevity risk and related capital market solutions have grown increasingly important in recent years, both in academic research and in the markets we refer to as the new Life Market, i.e., the capital market that trades longevity-linked assets and liabilities.¹ 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 and transfer the risk from those unwilling or unable to manage it to those willing to invest in this risk in exchange for appropriate risk-adjusted returns or to those who have a counterpoising risk that longevity risk can hedge, e.g., life offices and reinsurers with mortality risk on their books. 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.

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¹ Blake et al. (2013).

The conferences have closely followed the developments in the market. The first conference (*L1*) 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 (*L2*) was held in April 2006 in Chicago and hosted by the Katie School at Illinois State University.² Since *L1*, there have been further issues of mortality catastrophe bonds, as well as the release of the Credit Suisse Longevity Index. 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 (Rothesay Life) because the issue of pension liabilities was beginning to impede its mergers and acquisitions activities. It decided that the best way of dealing with pension liabilities was to remove them altogether from the balance sheets of takeover targets. So there was firm evidence that a new global market in longevity risk transference had been established. 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. A great deal, however, was learned from this failed issue about the conditions and requirements needed to launch a successful capital market instrument.

The third conference (*L3*) was held in Taipei, Taiwan on 20-21 July 2007. It was hosted by National Chengchi University.³ It was decided to hold *L3* in the Far East, not only to reflect the growing importance of Asia in the global economy, but also to recognize 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.⁴ Since the Chicago conference, there had been a number of new developments, including: the release of the LifeMetrics Indices covering England & Wales, the US, Holland and Germany in March 2007 by J.P. Morgan, the Pensions Institute and Towers Watson;⁵ 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 or indemnification contract rather than a capital market transaction).

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.⁶ The index, QxX.LS, was 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

² The conference proceedings for *L2* were published in the December 2006 issue of the *Journal of Risk and Insurance*.

³ The conference proceedings for *L3* were published in the Fall 2008 issue of the *Asia-Pacific Journal of Risk and Insurance*.

⁴ In fact, Asia has the world's largest and fastest growing ageing population (United Nations, 2007).

⁵ www.lifemetrics.com

⁶ 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.

AVS. In 2008, Institutional Life Services (ILS) and Institutional Life Administration (ILA), a life settlements trading platform and clearing house, were launched by Goldman Sachs, Genworth Financial, and National Financial Partners. ILS and ILA were designed to modernize dealing in life settlements and meet the needs of consumers by ensuring permanent anonymity of the insured and of the capital markets by providing a central clearing house for onward distribution of life settlement assets, whether individually or in structured form.⁷

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 its regions, Holland and England & Wales.

The world's first capital market derivative transaction, a q -forward contract⁸ between J. P. 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 £500m 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 (ILS) funds. J. P. Morgan acted as the intermediary and assumes counter-party credit risk. Forty five longevity swaps were completed in the United Kingdom between 2007 and 2015, valued at £73bn and covering 13 insurance companies' annuity and buy-out⁹ books, 21 private sector pension funds, and one local authority pension fund (some of which executed more than one swap).¹⁰ In August 2011, ITV, the UK's largest commercial TV producer, completed a £1.7bn bespoke longevity swap with Credit Suisse for its £2.2bn pension plan: the cost of the swap is reported as £50m (3% of the swap value). The largest to date, covering £16bn of pension liabilities, was the longevity swap for the British Telecom Pension Scheme, arranged by the Prudential Insurance Co of America in July 2014. In February 2010, Mercer launched a pension buy-out index for the UK to track the cost charged by insurance companies to buy out corporate pension liabilities: at the time of launch, the cost was some 44% higher than the accounting value of the liabilities which highlighted the attraction of using cheaper alternatives, such as longevity swaps.

The fourth conference ($L4$) was held in Amsterdam on 25-26 September 2008. It was hosted by Netspar and the Pensions Institute.¹¹ In 2008, Credit Suisse initiated a longevity

⁷ In 2010, National Financial Partners became the sole owner of ILS/ILA.

⁸ Coughlan et al. (2007).

⁹ With a buy-out, an insurance company buys out the liabilities of a pension scheme which is paid for with the pension scheme assets and a loan if the scheme is in deficit at the time. Both the pension scheme assets and liabilities are removed from the corporate sponsor's balance sheet. Each member has a personal annuity from the insurer who takes over responsibility for paying the pensions. This contrasts with a buy-in, where the liabilities remain on the sponsor's balance sheet, but the scheme buys a bulk purchase annuity (BPA) from an insurance company and pays members' pensions from the annuity payments it receives from the insurer. The BPA is an asset of the scheme, not the members.

¹⁰ www.artemis.bm/library/longevity_swaps_risk_transfers.html

¹¹ The conference proceedings for $L4$ were published in the February 2010 issue of *Insurance: Mathematics and Economics*.

swap with Centurion Fund Managers, whereby Centurion acquired a portfolio of synthetic (i.e., simulated) life policies, based on a longevity index built by Credit Suisse. In 2009, survivor swaps began to be offered to the market based on Deutsche Börse's Xpect Cohort Indices.

The fifth conference (*L5*) was held in New York on 25-26 September 2009.¹² On 1 February 2010, the Life and Longevity Markets Association (LLMA)¹³ was established in London. Its current members are Aviva, AXA, Deutsche Bank, J.P. Morgan, Morgan Stanley, Prudential PLC, and Swiss Re. LLMA was formed to promote the development of a liquid market in longevity- and mortality-related risks. This market is related to the ILS market and is also similar to other markets with trend risks, e.g., the market in inflation-linked securities and derivatives. LLMA aims to support the development of consistent standards, methodologies and benchmarks to help build a liquid trading market needed to support the future demand for longevity protection by insurers and pension funds. In April 2011, the LifeMetrics indices were transferred to LLMA with the aim of establishing a global benchmark for trading longevity and mortality risk.

The sixth conference (*L6*) was held in Sydney on 9-10 September 2010.¹⁴ In December 2010, building on its successful mortality catastrophe bonds and taking into account the lessons learned from the EIB bond, Swiss Re launched a series of eight-year longevity-based ILS notes valued at \$50 million. To do this, it used a special purpose vehicle, Kortis Capital, based in the Cayman Islands. As with the mortality bonds, the longevity notes are designed to hedge Swiss Re's own exposure to mortality and longevity risk. In particular, holders of the notes are exposed to an increase in the spread between mortality improvements in 75-85-year-old English & Welsh males and 55-65-year-old US males, indicating that Swiss Re has life insurance (mortality risk) exposure in the US and pension (longevity risk) exposure in the UK.

In January 2011, the Irish government announced that it would issue bonds that allow the creation of sovereign annuities. This followed a request from the Irish Association of Pension Funds and the Society of Actuaries in Ireland. If the bonds are purchased by Irish pension funds, this will have a beneficial effect on the way in which the Irish funding standard values pension liabilities. On account of a statutory deadline to submit a deficit repair plan, 2013 was a record year for bulk annuity transactions in Ireland with sovereign annuities being used in a significant number of transactions.

The world's first longevity swap for non-pensioners (i.e., for active and deferred members of a pension plan) took place in January 2011, when J. P. Morgan executed a £70m 10-year *q*-forward contract with the Pall (UK) pension fund. This was a value swap designed to hedge the longevity risk in the value of Pall's pension liabilities, rather than the longevity risk in its pension payments as in the case of cash flow swaps which have been the majority

¹² The conference proceedings for *L5* were published in the *North American Actuarial Journal* (Volume 15, Number 2, 2011).

¹³ www.llma.org

¹⁴ The conference proceedings for *L6* were published in the October 2011 issue of *Geneva Papers on Risk and Insurance - Issues and Practice*.

of the swaps that have so far taken place. Longevity risk prior to retirement is all valuation risk: there is no cash flow risk and most of the risk lies in the forecasts of mortality improvements. Further, the longevity exposure of deferreds is not well defined as a result of the options that plan members have, e.g., lump sum commutation options, early retirement options, and the options to increase spouses' benefits at the expense of members' benefits.

In April 2011, the International Society of Life Settlement Professionals (ISLSP)¹⁵ formed a life settlement and derivatives committee and announced that it was developing a life settlement index. The purpose of the index is to benchmark net asset values in life settlements trading. Investors need a reliable benchmark to measure performance and the index will help turn US life insurance policies into a tradable asset class according to ISLSP. The calculation agent for the index is AA Partners.

The first pension risk transfers deals outside the UK took place in 2009-11. The first buy-in deal (i.e., bulk annuity purchase to hedge the longevity risk of pensions in payment) outside the UK took place in 2009 in Canada; it was arranged by Sun Life Financial and valued at C\$50 million. The first buy-in deal in Europe took place in December 2010 between the Dutch food manufacturer Hero and the Dutch insurer Aegon (€44 million). The first buy-in deal in the US took place in May 2011 between Hickory Springs Manufacturing Company and Prudential (US) (\$75 million). The first buy-out deal outside the UK was announced in May 2011 and involved the C\$2.5bn Nortel pension plan in Canada. In September 2011, CAMRADATA Analytical Services launched a new pension risk transfer (PRT) database for US pension plans. The database provides insurance company organisational information, pension buy-in and buy-out product fact sheets and screening tools, pricing data, up-to-date information on each PRT provider's financial strength and relevant industry research. Users can request pension buy-in and buy-out quotes directly from providers, including American General Life Companies, MetLife, Pacific Life, Principal Financial Group, Prudential (US), Transamerica and United of Omaha.

The first international longevity reinsurance transaction took place in June 2011 between Rothesay Life (UK) and Prudential (US) and was valued at £100m. The first life book reinsurance swap since the Global Financial Crisis took place in June 2011 between Atlanticlux and institutional investors and was valued at €60m.

The seventh conference (*L7*) was held at the House of Finance, Goethe University, Frankfurt, Germany on 8-9 September 2011.¹⁶

In February 2012, Deutsche Bank executed a massive €12 billion index-based longevity solution for Aegon in the Netherlands. This solution was based on Dutch population data and enabled Aegon to hedge the liabilities associated with a portion of its annuity book.

¹⁵ www.islsp.org

¹⁶ The conference proceedings for *L7* were published in the September 2013 issue of the *Journal of Risk and Insurance*.

Because the swap is out of the money, the amount of longevity risk actually transferred is far less than that suggested by the €12 billion notional amount. Nonetheless, the key driver for this transaction from Aegon's point of view was the reduction in economic capital it achieved. Most of the longevity risk has been passed to investors in the form of private bonds and swaps.

In June 2012, General Motors Co. (GM) announced a huge deal to transfer up to \$26 billion of pension obligations to Prudential (US). This is by far the largest ever longevity risk transfer deal globally. The transaction is effectively a partial pension buy-out involving the purchase of a group annuity contract for GM's salaried retirees who retired before December 1, 2011 and refused a lump sum offer in 2012. To the extent retirees accepted a lump sum payment in lieu of future pension payments, the longevity risk was transferred directly to the retiree.¹⁷ The deal was classified as a partial buy-out rather than a buy-in because it involved the settlement of the obligation. In other words, the portion of the liabilities associated with the annuity contract will no longer be GM's obligation. Moreover, in contrast to a buy-in, the annuity contract will not be an asset of the pension plan, but instead an asset of the retirees. In October 2012, GM did a \$3.6 billion buy-out of the pension obligations of its white-collar retirees. Also in October 2012, Verizon Communications executed a \$7.5 billion bulk annuity buy-in with Prudential (US). The buy-out deals in the U.S. in 2012 amounted to \$36 billion.

The eighth conference (L8) was held at the University of Waterloo, Ontario, Canada on 7-8 September 2012.¹⁸

In February 2013, the first medically underwritten bulk annuity transaction was executed in the UK by the UK insurer Partnership.¹⁹ This involved each member filling in a medical questionnaire in order to get a more accurate assessment of their life expectancy based on their medical history or lifestyle. This was particularly useful in the case of "top slicing", where scheme trustees insure the pensioners (who will typically be the company directors) with the largest liabilities and who therefore represent a disproportionate risk concentration for the scheme. In December 2014, Partnership executed a £206 million medically underwritten bulk annuity transaction with a "top slicing" arrangement for the £2bn Taylor Wimpey pension scheme. Legal & General transacted a £230m medically-underwritten buy-in in December 2015. The process of collecting medical information has been streamlined in recent years using third-party medical data collectors, such as MorganAsh, Age Partnership and Aon's AHEAD platform. It is expected that the share of medically underwritten de-risking deals will increase significantly over the next few years in the UK.²⁰

In April 2013, Legal & General reported its first non-UK deal, the buy-out of a €136 million annuity book from New Ireland Life. In June 2013, the Canadian Wheat Board executed a

¹⁷ In fact, the lump sum is only being offered to limited cohorts of plan members.

¹⁸ The conference proceedings for L8 were published in the *North American Actuarial Journal* (Volume 18(1), 2014).

¹⁹ Harrison and Blake (2013).

²⁰ For more details about medically underwritten buy-ins, see Hunt and Blake (2016).

C\$150 million pension buy-in from Sun Life of Canada, involving inflation-linked annuities, while in March 2014, an unnamed Canadian company purchased C\$500m of annuities from an insurer reported to be Industrial Alliance, making it the largest ever Canadian pension risk transfer deal to date.

In August 2013, Numerix, a risk management and derivatives valuation company, introduced a new asset class called ‘life’ on its risk modeling platform (in addition to equities, bonds and commodities). In November 2013, SPX Corp. of Charlotte, NC, purchased a buy-out contract with Massachusetts Mutual Life Insurance Co as part of a deal that moved \$800 million in pension obligations off SPX’s balance sheet.

The ninth conference (*L9*) was held in Beijing, China on 6-7 September 2013.²¹

In September 2013, UK consultant Barnett Waddingham launched an insurer financial strength review service which provides information on an insurer’s structure, solvency position, credit rating, and key risk’s in their business model. This service was introduced in response to concerns about the financial strength of some buy-out insurers.

In November 2013, Deutsche Bank introduced the Longevity Experience Option (LEO). It is structured as an out-of-the-money call option spread on 10-year forward survival rates and has a 10-year maturity. The survival rates will be based on males and females in five-year age cohorts (between 50 to 79) derived from the England & Wales and Netherlands Life and Longevity Markets Association longevity indices. LEOs will be traded over-the-counter under a standard ISDA contract. They allow longevity risk to be transferred between pension funds, insurance companies and investors. They are intended to provide a cheaper and more liquid alternative to bespoke longevity swaps which are generally costly and time consuming to implement. Purchasers of the option spread, such as a pension fund, will gain if realised survival rates are higher than the forward rates, but the gains will be limited, thereby providing some comfort to the investors providing the longevity hedge. The 10-year maturity is the maximum that Deutsche Bank believes investors will tolerate in the current stage in the development of a market in longevity risk transfers. It was reported that Deutsche Bank executed its first LEO transaction with an ILS fund in January 2014.

In December 2013, Aegon executed a second longevity risk transfer to capital markets investors and reinsurers, including SCOR. Société Générale was the intermediary in the €1.4 billion deal and Risk Management Solutions (RMS) was the modelling agent.

Also in December 2013, the Joint Forum reported on the results of its consultation on the longevity risk transfer market. It concluded that this market is not yet big enough to raise systemic concerns, but “their massive potential size and growing interest from investment banks to mobilize this risk make it important to ensure that these markets are safe, both on a prudential and systemic level” (Joint Forum (2013, p.2)).

²¹ The conference proceedings for *L9* were published in *Insurance: Mathematics and Economics* (Volume 63 (July), 2015).

In February 2014, the Mercer Global Pension Buy-out Index was introduced. It shows the benchmark prices of 18 independent third-party insurers in the four countries with the greatest interest in buying out defined benefit liabilities: UK, US, Canada and Ireland. Costs were highest in the UK where the cost of insuring £100 million of pension liabilities was 123% of the accounting value of the liabilities – equivalent to £32 per £1 p.a. of pension.²² The comparable costs in Ireland, the U.S. and Canada were 117%, 108.5% and 105%, respectively. The higher cost in the UK is in part due to the greater degree of inflation uprating in the UK compared with the other countries. The difference between the US and Canada is explained by the use of different mortality tables. Rising interest rates and equity markets will lower funding deficits and hence lead to lower buy-out costs in future, especially in the US.

In July 2014, Mercer and Zurich launched Streamlined Longevity Solution, a longevity swap hedge for smaller pension schemes with liabilities above £50m. This is part of a new Mercer SmartDB service which provides bespoke longevity de-risking solutions and involves a panel of reinsurers led by Zurich. It reduces the costs by having standardized processes for quantifying the longevity risk in each pension scheme. The first deal, valued at £90m, was transacted with an unnamed UK pension scheme in December 2015.

In December 2014, Towers Watson launched Longevity Direct, an off-shore longevity swap hedging service that gives medium-sized pension schemes with liabilities between £1-3bn direct access to the reinsurance market, via its own cell (or captive) insurance company. This allows schemes to bypass insurers and investment banks, the traditional de-risking intermediaries, and significantly reduces transactions costs and completion times, while still getting the best possible reinsurance pricing. The first reported transaction on the Longevity Direct platform was the £1.5bn longevity swap executed by the Merchant Navy Officers Pension Fund (MNOF) in January 2015 which was insured by MNOF IC, a newly established cell insurance company based in Guernsey, and then reinsured with Pacific Life Re. In February 2015, PwC launched a similar off-shore longevity swap service for pension schemes as small as £250m. It uses a Guernsey-based incorporated cell company called Iccaria, established by Artex Risk Solutions, to pass longevity risk directly on to reinsurers. The arrangement is fully collateralized and each scheme owns a cell within Iccaria which again avoids the costs of dealing with insurer and investment bank intermediaries.

There is evidence of increasing demand from reinsurance companies for exposure to large books of pension annuity business to offset the risk in their books of life insurance.²³ For example, in 2014, Warren Buffett's Berkshire Hathaway agreed to a £780 million quota-reinsurance deal with the Pension Corporation, a specialist UK buy-out insurer.²⁴

²² Towers Watson (2015) *Corporate Briefing*, April.

²³ The biggest buyers of longevity risk at the present time are global reinsurers. Nevertheless, according to Hannover Re: "The number of risk-takers is limited and there is no unlimited capacity in the market for taking on longevity risk. The increasing worldwide demand for longevity cover will challenge the capacity for securing longevity risk" (quoted in Punter Southall (2015) *De-risking Bulletin*, March).

²⁴ Reported in *Financial News*, 14 July 2014.

Similarly, in August 2014, AXA France executed a €750m longevity swap with Hannover Re.

In March 2014, the UK insurer Legal & General announced the biggest single buy-out in the UK to date when it took on £3bn of assets and liabilities from ICI's pension fund, a subsidiary of AkzoNobel. In December 2014, Legal & General announced the largest ever UK buy-in valued at £2.5bn with US manufacturer TRW. Around £13bn of bulk annuity deals were executed in the UK in 2014, the largest volume of business since the de-risking market began in 2006 and beating the previous best year of 2008, just before the Global Financial Crisis, when £7.9bn of deals were completed. The total volume of de-risking deals in the UK in 2014 (covering buy-outs, buy-ins and longevity swaps) was £35bn, a significant proportion of which is accounted for by the £16bn BT longevity swap. In response to the announcement by the UK finance minister (George Osborne) in his Budget Speech on 19 April 2014, that UK pension scheme members no longer needed to buy annuities when they retired (which resulted in an immediate fall in annuity sales of more than 50%), a number of traditional annuity providers, such as Friends Life and Scottish Widows, are considering entering the bulk annuity market.

In November 2014, the Longevity Basis Risk Working Group (2014) of the Institute & Faculty of Actuaries (IFoA) and the Life and Longevity Markets Association (LLMA) published "Longevity Basis Risk: A Methodology for Assessing Basis Risk". This study develops a new framework for insurers and pension schemes to assess longevity basis risk. This, in turn, will enable simpler, more standardized and easier to execute index-based longevity swaps to be implemented. Index-based longevity swaps allow insurers and pension schemes to offset the systemic risk of increased liabilities resulting from members living longer than expected. It had hitherto been difficult to assess how effectively an index-based longevity swap could reduce the longevity risk in a particular insurance book or pension scheme. The methodology developed in the report is applicable to both large schemes (which are able to use their own data in their models) and smaller schemes (by capturing demographic differences such as socio-economic class and deprivation).

In March 2015, the UK government announced that it would introduce a new competitive corporate tax structure to allow Insurance Linked Securities to be domiciled in the UK. In May 2015, Rothesay Life, the insurance company owned by Goldman Sachs, bought out the liabilities of Lehman Brothers' UK pension scheme for £675m, thereby securing the pensions of former employees of the company associated with the beginning of the Global Financial Crisis.

An innovation in the UK buy-out market has been the buy-out combined with a longevity hedge. An example of this was the Philips Pension Fund which in 2015 completed a full buy-out valued at £2.4bn with the Pension Insurance Corporation. The longevity risk was simultaneously reinsured with Hannover Re. Another interesting feature of this deal was that it covered both retired and deferred members. A similar innovation is the bringing together of liability management solutions (such as interest rate and inflation swaps) and bulk annuities in a buy-out – so instead of completing liability management before considering a buy-out, schemes do this in a single exercise. Other innovations include

insuring the tail of the liabilities – whereby a closed scheme that cannot afford a full buy-out insures only the liabilities after a certain point in time, say, 10 years’ ahead – and deferred premium buy-ins and buy-outs – where schemes that cannot afford the upfront cost of a de-risking solution pay for it in instalments over a number of years.

In 2015, the UK insurer Legal & General entered both the US and European pension risk transfer markets. It executed a \$450m transaction with the US subsidiary of Royal Philips covering 7,000 scheme members in October and a €200m deal with ASR Nederland NV, a Dutch insurer in December. The pension obligations were transferred to L&G Re in cooperation with Hannover Re. L&G said: ‘The pension risk transfer market has become a global business... The potential market for pension risk transfer in the US, UK and Europe is huge, and will play out over many decades’. Two US insurers were also involved in the Royal Philips deal: Prudential Financial also acquired \$450m of scheme liabilities covering another 7,000 members, while American United Life Insurance Company issued annuity contracts to 3,000 deferred scheme members, valued at \$200m.

In June 2015, the Mercer Pension Risk Exchange was launched. It gives clients in the US, UK and Canada up to date buy-in and buy-out pricing based on their scheme’s data. It collects prices provided monthly by insurers in the bulk market, based on scheme benefit structures and member data. Mercer said: “Many companies have the appetite to transfer pension risk off their balance sheet but they face barriers: lack of clear information about the true cost of a buy-in or buy-out, limited transparency, the fluctuation of market rates and scheme economics to name but a few. [The exchange will enable] sponsoring employers and trustees to be more strategic and sophisticated in their approach and to know that they are executing a buy-in or a buy-out at the best time for them and at a competitive price”.

In January 2015, the Bell Canada Pension Plan executed a C\$5bn longevity swap with Sun Life Financial,²⁵ SCOR, and RGA Re; it was SCOR’s first transaction in North America. In June 2015, Delta Lloyd did a €12 billion longevity swap with RGA Re. In July 2015, Aegon did one valued at €6 billion with Canada Life Re.

As mentioned before, not all paths to progress are smooth. In recent years, this has been particularly true currently in the largest market dealing with micro-longevity risk, namely life settlements.²⁶ The life settlements market has been dogged by systematic underestimates of policy holders’ life expectancies by certain medical underwriters, issues concerning premium financing, frauds, and ethical issues associated with ‘profiting’ from individuals dying and policies maturing. In December 2009, Goldman Sachs announced it

²⁵ Sun Life Financial uses the RMS Longevity Risk Model, which RMS describes as a ‘structural meta-model of geroscience advancement’.

²⁶ The market for micro-longevity risk trades assets involving a small number of lives. In the case of life settlements, for example, the products involve individual lives and hence are subject to a significant degree of idiosyncratic mortality risk. This contrasts with the market for macro-longevity risk which deals with pension plans and annuity books and hence involves a large number of lives: here idiosyncratic mortality risk is much less important than systematic mortality risk which is essentially the trend risk of getting life expectancy projections wrong.

was closing down its Q_xX.LS index. This was partly because of the reputational issues associated with life settlements, but mainly because of insufficient commercial activity in the index. While the ethical issues are no different in substance from those relating to the macro-longevity market (see, e.g., Blake and Harrison, 2008), the micro-longevity market needs to learn some important lessons from the macro-longevity market. The macro-longevity market has been very successful at promoting good basic research on the analysis of the stochastic mortality forecasting models it uses and putting these models into the public domain and has also been much more transparent with the data it uses. This suggests a way forward for the life settlements micro-longevity market.

Another setback, this time to the macro-longevity market, occurred in April 2012 when a number of investment banks – Credit Suisse, Nomura and UBS – pulled out of the longevity risk transfer market as a result of additional capital requirements under Basel III. Investment banks had already been disadvantaged in this market by the US Dodd-Frank (Restoring American Financial Stability) Act 2010 which prevented US banks and their affiliates from entering longevity swaps and synthetic trades in life settlements. At around the same time, however, a number of insurers and reinsurers entered the market, i.e., Prudential (US), SCOR and Munich Re. Despite these new entrants, the following year witnessed the start of a process of consolidation in the insurance industry. In August 2013, Lucida was purchased by Legal & General for £150m; at that time, it had 31,000 pensioners on its books and £1.4 billion in pension assets. In February 2014, the buy-out business of MetLife, which entered the market in 2007 and acquired the pension assets of 20,000 pensioners worth £3 billion, was sold to Rothesay Life for an undisclosed sum, bringing its total assets to £10 billion.

In December 2013, Goldman Sachs sold the majority of its stake in Rothesay Life to Blackstone (28.5%), Government of Singapore Investment Corporation (GIC) (28.5%), and MassMutual (7%), due to the new regulatory capital requirements faced by banks and insurers.

As with the previous conferences, *Longevity 10* consisted of both academic papers and more practical and policy-oriented presentations. The conference was addressed by the following keynote speakers:

- Professor Alan Fine (Boston University) gave a presentation on "Strategies and Prospects for Organ Regeneration in Aging". After a review of the background on aging and organ function, he went on to discuss the relationship between senescence and aging-related diseases, emphasizing the importance of stem cells in organ regeneration. He then discussed strategies and limitations for organ regeneration and ended with some thoughts on future prospects.
- Professor Angus Macdonald (Heriot Watt University) talked about "Mortality Table Graduation and Unisex Mortality Tables". He showed how all graduations involve the estimation of mortality rates at individual ages mortality rates at occurrence/exposure (O/R) rate, defined as the ratio of number of deaths at age x to the person-years exposed to risk at age x . He then reviewed the different methods for fitting the mortality rates to a parametric function (such as a Gompertz-

- Makeham or Perks function) to generate a smooth mortality curve. Mortality curves can also be stratified between, say, males and females, or smokers and non-smokers. He ended by discussing the issues involved in developing unisex mortality tables. Studies have found that the proportion of males in insurers' books of business vary by every risk factor considered: company, age at entry, age attained, sum insured, distribution channel, duration, and postcode. This means that unisex premium rates had to be tailored to every company and line of business.
- Brent Walder (Chief Actuary, Prudential Retirement) gave a presentation on "Future Capital Requirements that Should be Imposed on Annuity Writers". He showed that the reason why capital is needed is because of the three primary risks annuity writers face: longevity risk, asset default risk and asset-liability mismatch (interest rate) risk. The key issue is to focus on longevity improvement in order to maintain a stable and robust annuity market. The required capital will include "margins in reserves" through "best estimate liability" calculation and the amount of capital will depend on a consistent valuation of liabilities and assets.
 - Professor Moshe Milevsky (York University) discussed "Market Development of Deferred Annuities". The principal product is the Advanced Life Deferred Annuity (ALDA) (also known as a Deferred Income Annuity (DIA), Longevity Insurance, or a Qualified Longevity Annuity Contract (QLAC)). He showed that with ALDAs, late life mortality models are extremely important for getting more accurate estimates of time of death. He ended by showing the importance of ALDAs in post-retirement investment portfolios along with stocks and bonds.
 - Jeff Mullholland (Managing Director and Head of Insurance and Pension Solutions Americas for Societe Generale) presented "Time to Go into Production Mode: The Beginnings of a Standardized Replicable Capital Market in Longevity Risk Transfers". He discussed how to develop an index-based hedge with minimal basis risk that involves an option collar with a lower strike (attachment point) at the 95% estimate of the liability and a higher strike (exhaustion point) at the 99% estimate of the liability. He showed that in this region, there is considerable scope for capital reduction by using the hedge. He believes that capital market investors will be interested in assuming the risk exposure in this region because they avoid assuming the extreme tail risk above 99%.
 - Amy Kessler (Prudential Retirement) gave a presentation on "Longevity Risk and Reinsurance: Strategies for Managing Annuity Blocks". She showed that inflation-linked and deferred annuities are the most risky types of products for an annuity writer. This is because interest rate risk, longevity risk and inflation risk compound each other in the liability. Hence leaving longevity risk out of the analysis will underestimate total risk, especially in respect of inflation-linked annuities and deferred annuities, because their longer durations make them significantly more sensitive to adverse outcomes. She showed how longevity reinsurance can be used by annuity writers to manage longevity risk. The annuity writer's asset strategy can then combine liquid and illiquid fixed income bonds selected for duration, yield, or inflation protection. Duration is matched to the liability as closely as possible and swaps may be used to improve the match.
 - Guy Coughlan (Pacific Global Advisors) talked about "Market Products for Longevity Risk Hedging". The longevity market involves two distinct channels.

- One involving insurance markets and the other involving capital markets. The traditional products for managing longevity risk are buy-outs and buy-ins offered by insurance companies. The new products are (the first two can be offered by both the insurance and capital markets, while the rest are offered only by the capital markets):
- longevity swaps which exchange actual liability payments (based on realized *longevity*) for a fixed set of payments
 - out-of-the-money longevity swaps which are out-of-the-money options on a longevity swap, with attachment and detachment points.
 - q-forwards (“mortality forwards”) which exchange a payment based on a realized *mortality* rate for a fixed payment
 - S-forwards (“survivor forwards”) which exchange a payment based on a realized *survival* rate for a fixed payment
 - LEOs (“Longevity Experience Options”) which are out-of-the-money options on an S-Forward, with attachment and detachment points.
- John Kiff (IMF) discussed the Joint Forum Report on the Longevity Risk Transfer Market. In December 2013, the Joint Forum of the Basel Committee on Banking Supervision, International Organization of Securities Commissions, and International Association of Insurance Supervisors released its final report on “Longevity Risk Transfer Markets: Market Structure, Growth Drivers and Impediments, and Potential Risks”. Its key recommendations to policymakers are:
 - Communicate and cooperate
 - Understand longevity risk exposures
 - Assess relevant policies
 - Review longevity risk rules and regulations
 - Ensure adequate risk-bearing capacity
 - Monitor market developments
 - Pay attention to tail risk
 - Collect adequate data.
 - Alejandro Bezanilla (AFP Habitat) gave a presentation on "Longevity Risk Pooling" in a Chilean context. He discussed the characteristics of programmed withdrawal in Chile, the problem of inheritance, and the pooling of programmed withdrawals in order to hedge longevity risk.
 - Patricio Espinoza (Regulation Department Head, the Chilean Securities and Insurance Supervisor) gave a presentation on “Longevity Risk and its Coverage: The Vision of the Regulator”. He argued that the key issue was to determine the release of capital to insurers that is acceptable given the extent to which the insurer has effectively covered or hedged its exposure to longevity risk, including basis risk. The regulator’s challenge was to develop a methodology for determining the relationship between hedge effectiveness and release of capital. He said that such a methodology is not currently available.
 - Michael Garvin (Chief Financial Officer, Latin America Region, Principal Financial Group) talked about "Deferred Annuities in Latin America". He argued that the deferral periods were currently too short in Latin America, typically less than four years, with very few companies offering longer periods of deferral. He put this down to a combination of insufficient demand (annuities are sold not

- bought), on the one hand, and a scarcity of long-duration matching assets, on the other hand.
- Jonathan Callund (Managing Director of Callund y Compañía Ltda) chaired a panel discussion on the “Lessons from the failed World Bank Longevity Bond” with Patricio Espinoza (SVS), Guy Coughlan (Pacific Global Advisors), Amy Kessler (Prudential Financial) and John Kiff (IMF). The issues discussed were:
 - To assess after a period of 5 years the reasons for the failure in take-up of the longevity bond in Chile in 2009.
 - Was the initiative mistake and, if so, why?
 - What lessons have been learned?
 - What key risks remain un-hedged?
 - How can we improve on the design of the longevity bond to make it more attractive to local annuity providers?
 - Are alternative vehicles more appropriate?
 - What are the next steps to putting in place a solution that works, i.e. to provide appropriate risk-hedging that is “attractive” to all parties?
 - Finally, there was a panel on annuities and longevity risk management with Moshe Milevsky, Michael Garvin, Pablo Antolin (Head of the Private Pension Unit at the OECD) and Solange Berstein (Former Head of the Chilean Pension Regulator).

The academic papers that were selected by us as the editors of this Special Issue went through a refereeing process subject to the usual high standards of the *Journal of Risk and Insurance*. They cover the following themes: the conditions for the success or failure of longevity-linked markets, the impact of health status on optimal annuity decisions, pension risk management, pricing longevity-linked products, longevity risk hedging, and longevity risk modelling in a multi-country context. We briefly discuss each of the 11 papers selected.

In “On the failure (success) of the markets for longevity risk transfer”, Richard D. Macminn and Patrick L. Brockett note that potential increases in life expectancy expose insurers and pension funds to the risk of not having sufficient funds to pay a longer stream of annuity benefits than promised. Longevity bonds and forwards provide insurers and pension funds with financial market instruments designed to hedge the longevity risk that these organization face. The European Investment Bank and World Bank have both discussed longevity bond issues, but those issues have failed due to insufficient demand. Forward contracts have also been created, but that market remains dormant. The extant literature suggests that these failures may be due to design or pricing problems. In this paper, the authors show that the market failure is instead due to a moral hazard problem. It is insolvency risk that introduces the moral hazard problem for corporate management. Although hedging with the longevity linked securities makes the annuity books of business more valuable and hence makes annuity holders better off, that same hedging reduces the value of the current shareholders’ stake in the firm. Hence, corporate management acting in the interests of shareholders (and not the annuity holders) succumbs to the moral hazard problem and does not hedge.

In “Health state transitions and longevity effects on retirees’ optimal annuitization”, Jing Ai, Patrick L. Brockett, Linda L. Golden and Wei Zhu investigate the interplay between longevity risk and health state transitions for retirees’ optimal annuitization decisions. Using a life-cycle framework incorporating wealth levels, bequest motives and consumption floors created by government subsidies, the authors examine how increased longevity in conjunction with an individual’s health state transition process impacts annuity purchase decisions. Health state transition matrices are estimated from the Health and Retirement Survey (HRS) data. The effects of increased longevity on annuitization decisions are considered both when longevity is accompanied with increased time spent in healthier states (morbidity compression) or experienced by more time in unhealthy states (morbidity expansion). The authors find that retirees’ annuity demand is affected by wealth, initial health status and expansion or compression of morbidity. Wealthier retirees have higher annuity demand when health shocks are considered, and increased longevity increases demand even more when retirees expect an expansion or slight morbidity compression. With health shocks and expectations of severe morbidity compression considered, the opposite effect might occur. Thus, an annuity can help retirees hedge health shock costs when slight compression or expansion of morbidity occurs. For retirees with lower wealth, the consumption floor provided by governmental subsidies will create a decreased propensity to annuitize.

In “Pension risk management in the enterprise risk management framework”, Yijia Lin, Richard D. Macminn, Ruilin Tian and Jifeng Yu present an enterprise risk management (ERM) model for a firm that is composed of a portfolio of capital investment projects and a defined benefit (DB) plan for its workforce. The firm faces the project, operational and hazard risks from its investment projects as well as the financial and longevity risks from its DB plan. The firm maximizes its capital market value net of pension contributions subject to constraints that control project, operational, hazard, financial and longevity risks as well as an overall risk. The analysis illustrates the importance of integrating pension risk into the firm’s ERM program by comparing firm value with and without managing pension risk with other risks in an ERM program. An ERM program considering pension effect integrates the risks of the operation and pension divisions and thus achieves diversification benefits between and within these two divisions. The authors also show how pension hedging strategies can impact the firm’s net value under the ERM framework. While the existing literature suggests that a longevity swap is less expensive than a pension buy-out because the latter is more capital intensive, the analysis in this paper shows that the buy-out is more effective in increasing firm value.

In “Pricing buy-ins and buy-outs”, Yijia Lin, Tianxiang Shi and Ayşe Arik show that pension buy-ins and buy-outs have become an important aspect of managing pension risk in recent years. As a step towards understanding these pension de-risking instruments, the authors develop models for pricing the investment risk and longevity risk embedded in them. They also use a contingent-claims framework to price the credit risk in buy-in bulk annuities.

In “Mortality dependence and longevity bond pricing: A dynamic factor copula mortality model with the GAS structure”, Hua Chen, Richard D. MacMinn and Tao Sun point out that modeling mortality dependence for multiple populations has significant implications for mortality/longevity risk management. A natural way to assess multivariate dependence is to use copula models. The application of copula models in the multi-population mortality analysis, however, is still in its infancy. In this paper, the authors present a dynamic multi-population mortality model based on a two-factor copula and capture the time-varying dependence using the generalized autoregressive score (GAS) framework. The model is simple and flexible in terms of model specification and is widely applicable to high dimension data. Using the Swiss Re Kortis longevity trend bond as an example, the authors use the model to estimate the probability distribution of principal reduction and some risk measures such as probability of first loss, conditional expected loss and expected loss. Due to the similarity in the structure and design of CAT bonds and mortality/longevity bonds, the authors borrow CAT bond pricing techniques for mortality/longevity bond pricing. They find that their pricing model generates par spreads that are close to the actual spreads of previously issued mortality/longevity bonds.

In “Dynamic longevity hedging in the presence of population basis risk: A feasibility analysis from technical and economic perspectives”, Kenneth Q. Zhou and Johnny Siu-Hang Li study the feasibility of dynamic longevity hedging with standardized securities that are linked to broad-based mortality indexes. They generalize the dynamic ‘delta’ hedging strategy developed by Cairns (2011) to incorporate the situation when population basis risk exists. They then discuss the potential financial benefits of an index-based hedge over a bespoke risk transfer. By considering data from a large group of national populations, the authors find evidence supporting the diversifiability of population basis risk. They go on to propose a customized surplus swap—executed between a hedger and reinsurer—to utilize this diversifiability. As standardized instruments demand less illiquidity premium, a combination of a dynamic index-based hedge and the proposed customized surplus swap may possibly be a more economical (and equally effective) alternative to a bespoke risk transfer.

In “Hedging longevity risk in life settlements using biomedical research-backed obligations”, Richard D. MacMinn and Nan Zhu discuss how in the settlement market mortality risk is transferred from life insurance policyholders to third party life settlement firms. This risk transfer occurs in conjunction with an information transfer that is relevant not only for pricing but also for risk management. The authors compare the efficiency of two different hedging instruments in managing the mortality risk of the life settlement firm. First, they demonstrate that conventional longevity-linked securities do not perform as effectively in the secondary life market, i.e., life settlement market, as in the annuity and pension markets due to the basis risk that exists between the general population and the life settlement subgroup. Second, they show that the unique risk exposure of the life settlement firm can be specifically targeted using a new instrument—biomedical research-backed obligations. This finding connects two seemingly independent markets and can promote the healthy development of both.

In “Robust mean-variance hedging of longevity risk”, Hong Li, Anja De Waegenaere and Bertrand Melenberg argue that parameter uncertainty and model misspecification can have a significant impact on the performance of hedging strategies for longevity risk. To mitigate this lack of robustness, the authors propose an approach in which the optimal hedge is determined by optimizing the worst-case value of the objective function with respect to a set of plausible probability distributions. They consider an insurer who hedges longevity risk using a longevity bond, and compare the worst case (robust) optimal hedges with the classical optimal hedges in which parameter uncertainty and model misspecification are ignored. They find that unless the risk premium on the bond is close to zero, the robust optimal hedge is significantly less sensitive to variations in the underlying probability distribution. Moreover, the robust optimal hedge on average outperforms the nominal optimal hedge unless the probability distribution used by the nominal hedger is close to the true distribution.

In “Modeling multi-country longevity risk with mortality dependence: A Lévy subordinated hierarchical Archimedean copulas approach”, Ken Seng Tan, Chou-Wen Wang and Wenjun Zhu propose a new copula model known as the Lévy subordinated hierarchical Archimedean copula (LSHAC) for multi-country mortality dependence modeling. Through an extensive empirical analysis of the mortality experiences of 13 countries, the authors demonstrate that the LSHAC model, which has the advantage of capturing the geographical structure of mortality data, yields a better fit and more accurate and robust out-of-sample forecasting, when compared to other benchmark copula models. The LSHAC model also confirms that there is an association between geographical location and the dependence of the overall mortality improvement. The results yield new insights into future longevity risk management. Finally, the model is used to price a hypothetical survival index swap written on a weighted mortality index. The results highlight the importance of dependence modeling in managing longevity risk and reducing population basis risk.

In “Mortality leads and lags”, Andreas Milidonis and Maria Efthymiou show that mortality risk varies geographically, especially in the Asia-Pacific (APAC) region, where economic development is quite diverse. The authors present a newly collected data set on aggregate population mortality from 11 countries in APAC, which they rank based on their economic development. Using lead–lag analysis, they identify short-term predictability in mortality risk across countries. Mortality improvements appear to be faster in more developed than less developed countries. Such predictability is useful for longevity risk management and in producing cross-country mortality indices. The authors propose ways in which their results can help institutions manage their exposure to APAC mortality and longevity risk.

Finally, in “The cross-section of Asia-Pacific mortality dynamics: Implications for longevity risk sharing”, Enrico Biffis, Yijia Lin and Andreas Milidonis study the dynamics of longevity risk across a subset of countries in the Asia-Pacific (APAC) region. They use new and existing data on age-specific mortality rates from emerging and developed economies to understand how secular changes in mortality vary within and across APAC countries. The findings help to identify cross-hedging opportunities among longevity risk exposures in the APAC region. The authors also introduce k -forward contracts, which offer

natural risk-sharing opportunities to hedgers in different countries.²⁷ They consider the example of Korea and Japan as a case study.

Longevity 11 took place in Lyon, France, on September 8–9, 2015. *Insurance: Mathematics and Economics* will publish a Special Issue of selected papers presented at this conference. *Longevity 12* took place in Chicago on September 29–30, 2016; and *Longevity 13* will take place in Taipei, Taiwan on September 21–22, 2017. The *North American Actuarial Journal* will publish a Special Issue of selected papers presented at both conferences.

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²⁷ Chan et al. (2014) and Tan et al. (2014) previously introduced a standardized longevity security called a K-forward. This was also based on a time-varying parameter in a stochastic mortality, although a different model was used in this case.

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