Financial Innovation and the Hedging of Longevity Risk

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Working Paper July 2007

Abstract

Longevity risk is one of the remaining frontiers challenging modern financial markets and financial engineering. Financial innovation has yet to successfully master this very significant risk facing many countries internationally. For well over a hundred years this risk has been the domain of life insurance companies, reinsurance companies and actuaries. Traditional hedging approaches to longevity risk have revolved around participating annuities and life insurance policies with guarantees, the actuarial management of an insurer's surplus (internal capital) and of policyholder expectations. A number of spectacular recent life insurance failures have cast a shadow on this approach. New accounting and regulatory requirements are changing emphasis to market consistent valuation and quantification for all risks including longevity. At the same time, the aging population around the world drives the need for new products for managing longevity risk and new markets for hedging this risk. We consider how financial markets and financial product innovations can ideally be used to hedge longevity risk and also consider lessons from the insurance linked securities market that could be used to successfully fund this risk in financial markets.

This paper was prepared for presentation at the Third International Longevity Risk and Capital Market Solutions Symposium, Taipei Taiwan July 21-22, 2007 Westin Hotel, Taipei. Support from ARC Discovery Grant DP0663090 and from the conference organizers is gratefully acknowledged. Opinions expressed herein are those of the authors alone.

1 Introduction

Longevity risk is one of the remaining frontiers challenging innovation in financial markets and products. Currently the only generally available means of hedging longevity risk for an insurer is to use capital to internally manage the risk or to purchase reinsurance. Even so, the reinsurance market has been reluctant to take this risk. It has even been referred to as a "toxic tail" risk by Blake, Cairns, Dowd and MacMinn (2006). In order for a market for hedging of longevity risk to develop there are several preconditions. These include the development of generally accepted technology and models to quantify the risk and the successful design and implementation of financial products and markets to hedge the risk. There has been a significant increase in research addressing these issues in recent years.

As noted in Mitchell, Piggott, Sherris, and Yow (2006), a major asset of individuals in many countries at retirement is the family home. Retirement savings through private pension savings and government provided social security are the other major sources. Longevity products inevitably involve financial risks related to the assets used to fund individual retirement income streams. Some recent retail products such as reverse mortgages bring together both house price risk and longevity risk. Neither of these risks currently have an active wholesale market for hedging or pricing. Financial innovation to manage longevity risk at an institutional level will inevitably require consideration of equity market, interest rate and housing price risks as well as longevity risk. This will require a comprehensive risk management and solvency framework for retail products involving longevity.

As reverse mortgages and other products based on an individual's residential property value develop, institutional markets will be increasingly providing risk transfer and other risk management products based on residential property prices. There has already been early development of residential property price indices in the USA, UK and Australia as well as derivative products based on these indices. In the retail product market there have been a number of other innovations designed to provide retirement income secured by retirement savings. Apart from the reverse mortgage, other home equity release schemes have also been available for many years but have recently increased in significance. Life annuities of various forms remain an important means of hedging longevity risk for individuals and pension plans in many countries, although the relatively low level of use by individuals remains a puzzle. Guaranteed lifetime income options in variable deferred annuities and indexed annuities, particularly in North America and Europe, are now being offered to provide longevity hedging for individuals.

In mortality risk modelling, the launch of the Credit Suisse Longevity Index based on expectation of life for US data and the more comprehensive JP Morgan LifeMetrics (JP Morgan 2007) for England/Wales and US data are innovations in publicly available indices on population longevity. JP Morgan were the developers of RiskMetrics and CreditMetrics. These are valuable tools for the quantification of risk. They can assist in the determination of capital requirements as well as in risk management for longevity risks. Even so, the underlying index suitable for longevity risk should reflect the value of future obligations allowing for expected longevity and the use of a life annuity value would provide a better measure of risk exposure.

The institutional market has been in the experimental stages of innovation in the area of longevity and mortality risk. Proposals for mortality derivatives including mortality swaps have been under development for some time. The first longevity bond, the EIB bond, was not successful and was perhaps an innovation before its time although there have been many reasons advanced for its lack of success. On the other hand, extreme mortality risk for short horizons has been successfully transferred to the financial markets through transactions such as Swiss Re Vita. The institutional market has also seen companies such as Paternoster develop comparative advantages in longevity risk management through the bulk annuity buyout market. Pension funds and other annuity providers can hedge their longevity risk into these risk warehouses.

For a number of years the insurance securitization market has been developing. Financial markets have been increasingly prepared to fund CAT and other insurance risks including mortality risk. Every year sees further innovation, including structure of product offerings and development of a secondary market providing price/spread information. Decisions about risk transfer and hedging of risks are more informed and can use more alternatives. This securitization market can provide important lessons for longevity hedging for financial institutions and ultimately the design and risk management of longevity products in the retail market. The use of tranches to “slice and dice” risk and to meet varying investor appetites for risk is an obvious approach to managing longevity risk.

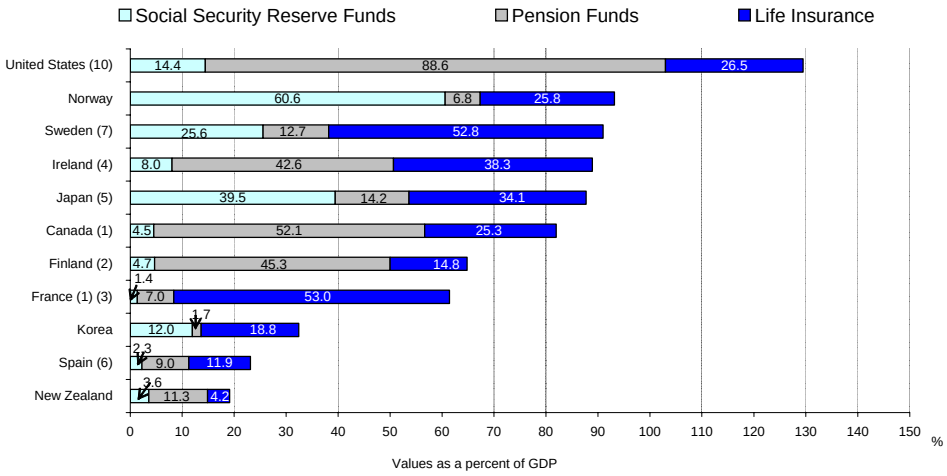
Despite these innovations, significant challenges remain for the successful hedging and management of longevity risk. These include product design issues for retail and institutional markets, pricing and risk management of guarantees offered in retail products, the integration of reinsurance and securitization markets, and further development of industry models for longevity indices and longevity risk pricing. Regulatory issues will also need consideration including the development of prudential regulations, taxation rules and other product market features that are conducive to an efficient and informed retail and wholesale market. A major issue unique to longevity risk is its very long term nature. Uncertainty in systematic trends and long run improvements in longevity also remains a major concern.

This paper considers current developments in financial innovation in both the retail and institutional markets and assesses the potential for successful innovation based on developments in the insurance linked securities market. We review developments in longevity risk models including pricing models, consider the hedging of longevity risk focusing on recent product innovations and discuss the lessons to be learned from the insurance securitization market.

2 Assets Exposed to Longevity risk

The total funds in pension plans and other retirement savings around the world is an indicator of the size of longevity risk in many countries. Figure 1 shows OECD country data for Pension and Life Insurance Assets in 2004 as a percentage of GDP. Of interest is the importance of private pension and life insurance assets compared to social security in most of these countries and the wide variation in the percentages across different countries. In Figure 2 the OECD data demonstrates the economic significance of pension funds and the potential size of longevity risk for these countries. Figure 3 shows comparable figures for pension funds in selected non-OECD countries and Figure 4 shows the 2005 assets.

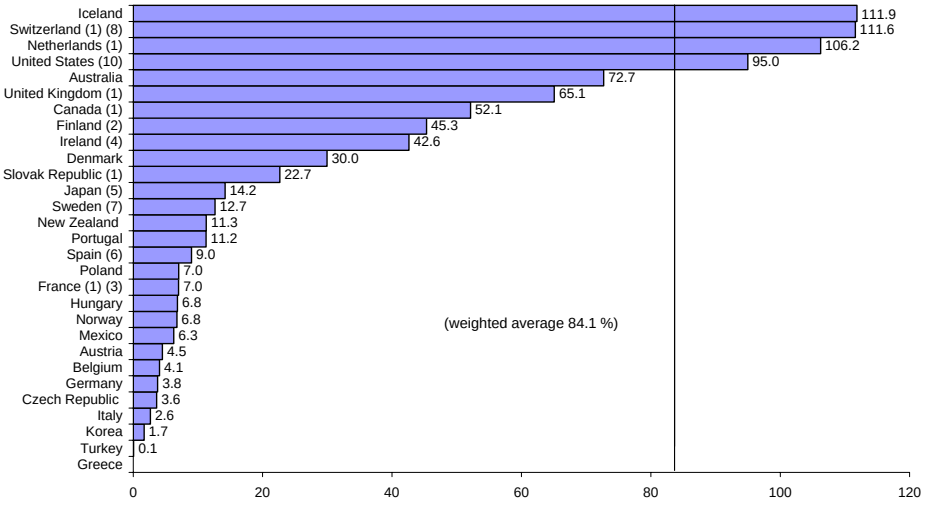
Figure 1. Consolidated Pension and Life Insurance Assets in Selected OECD countries, 2004 (as a percent of GDP).



Source: OECD Global Pension Statistics.

Figure 1 OECD Data for Pension and Life Insurance Assets in 2004: Source OECD Pension Markets in Focus, Newsletter December 2005, Number 2

Figure 2. Importance of Pension Funds in the Economy, 2004 (as a percent of GDP).



Source: OECD Global Pension Statistics.

Figure 2 OECD country data for Pension Funds in 2004. Source OECD Pension Markets in Focus, Newsletter December 2005, Number 2

Figure 5. Pension Fund Assets in Selected non-OED countries, 2004 (as a percent of GDP).

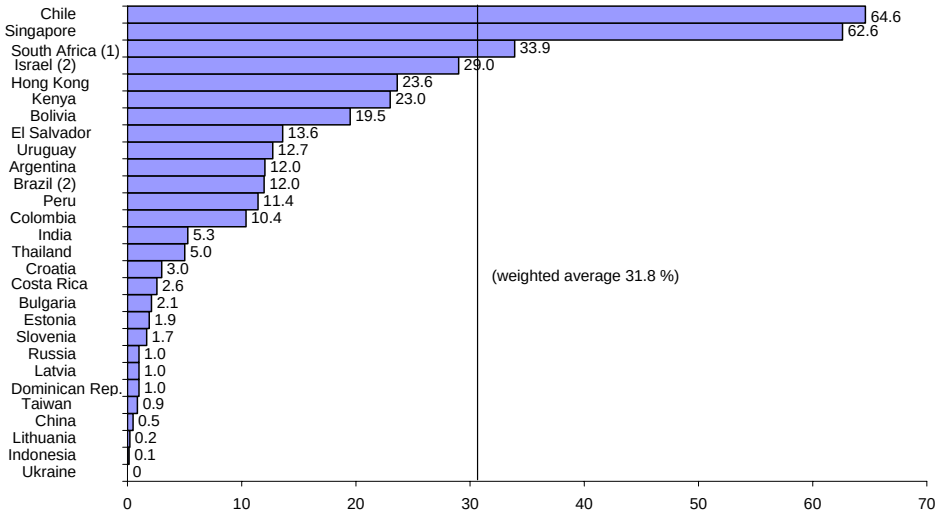


Figure 3 OECD data for Pension Funds in Selected non-OECD countries 2004. Source OECD Pension Markets in Focus, Newsletter December 2005, Number 2

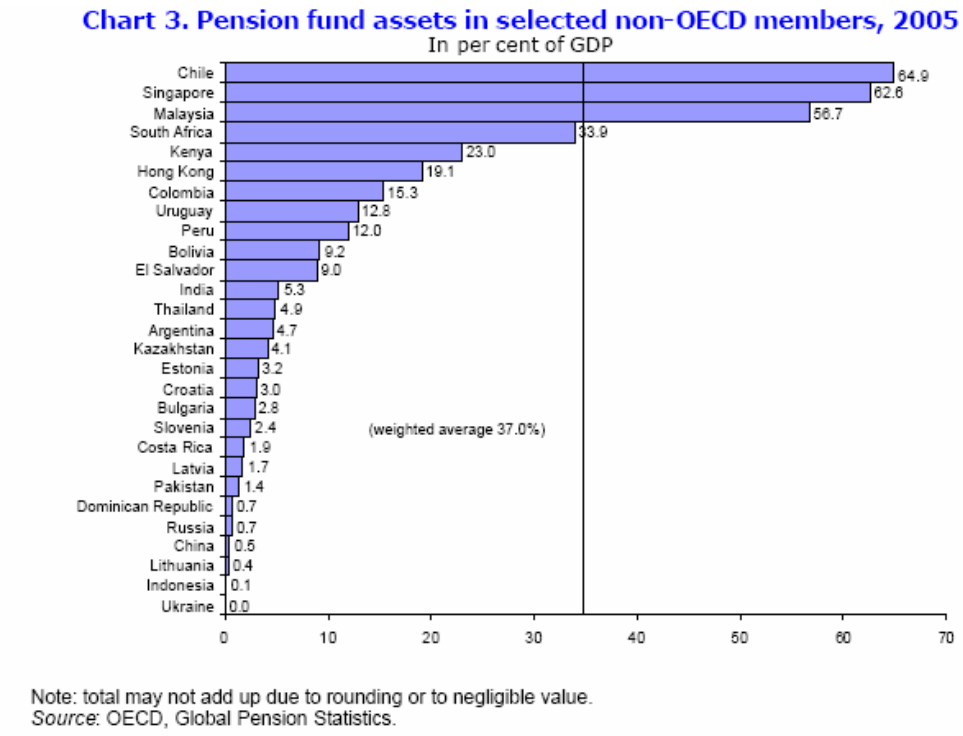


Figure 4 OECD data for Pension Funds in Selected non-OECD countries 2005. Source OECD Pension Markets in Focus, Newsletter October 2006, Number 3

Although the impact of aging will vary by country, lower fertility combined with mortality improvements will increasingly impact financial markets at an international level. Financial market innovations will need to develop in countries with larger amounts of assets in retirement savings and pension funds and at risk to increasing

longevity. Potential markets in Asia include Japan, Singapore, Hong Kong, Australia and Korea. Other solutions will be required in countries where individuals have lower levels of retirement savings. However these countries will also face long run issues of financial burden from increasing longevity.

The rapid development of derivative markets and securitization products for credit risk highlights the potential for these markets to provide financial market solutions for longevity risk management. Product innovation in the credit risk market has occurred at a rapid rate. This has included exotic structures such as CDO squared and constant proportion CDO's. Longevity risk for institutions issuing longevity products would be expected to be at least as significant as their market, credit and operational risks.

3 Longevity risk modelling

An important factor underlying innovation in longevity risk markets and hedging of longevity risk is the development of generally agreed market models for risk quantification. Risks such as equity market, interest rate, foreign currency, commodity and credit risks have well developed models for quantifying risk-based capital and market prices. Although actuarial models of mortality and life tables for pricing and projecting pension and related life product cash flows have been developed over many centuries, the technology has generally been deterministic or scenario based. Managing risks has largely been through participating product design and bonus policy and with a reliance on the law of large numbers for risk management. Tuljapurkar (1998) and Tuljapurkar and Boe (1998) provide a comprehensive review of historical patterns on mortality and longevity forecasting models. Stallard (2006) also provides a comprehensive survey of issues in longevity modelling and discusses the impact of morbidity and cause of death on longevity and longevity forecasting.

An early approach to incorporating improvement in longevity for forecasting future mortality was introduced in Lee and Carter (1992). Lee (2000) discusses the model and extensions. The model assumes age specific mortality rates that vary through time from a single factor driving mortality improvement with differential impacts by age. The mortality improvement trend is assumed to be a random walk with drift and is fitted to historical data assuming a normal distribution for the stochastic factor. The model has many parameters since it models differential age impacts of mortality improvements and each age has its own time varying mortality rate. This is an example of a single factor model with many parameters.

There have been several extensions to the Lee-Carter model including to the error assumptions and the estimation methodology. Brouhns, Denuit and Vermunt (2002) develop an extension of the Lee-Carter model allowing for Poisson error assumptions and apply the model to Belgian data. Maximum likelihood estimation is used rather than least squares. Renshaw and Haberman (2003) include additional non-linear age factors based on England and Wales data. A closer look at their analysis of residuals suggests that the Lee-Carter model, even with a non-linear age factor, does not fit the data well. Even with a Poisson error assumption, heterogeneity by age-group in mortality indicates over-dispersion of errors. Renshaw and Haberman (2006) include a cohort factor including year of birth as a factor impacting the rate of longevity improvement. This cohort factor is found to be significant in UK mortality data. These models have many parameters and can be improved through a more parsimonious model structure.

A more parsimonious model is that proposed by Cairns, Blake and Dowd (2006). They develop and apply a 2 factor model similar to the Lee-Carter model with a smoothing of age effects using a logit transformation of mortality rates. Cairns, Blake, Dowd, Coughlan, Epstein, Ong, and Balevich (2007) analyse England and Wales and US mortality data demonstrating that models that allow for an age effect, a quadratic age effect and a cohort effect fit the data best although the analysis of error distributions in these models appear unsatisfactory. Empirical studies to date suggest the need for more than a single factor to model longevity improvement. The Lee-Carter approach with a single factor and varying improvement impacts by age does not appear to capture the dynamics of longevity improvement. Pricing models can often perform reasonably well with only a single factor but hedging requires a more complete capture of the dynamics of the improvement. Multiple factor models are critical for hedging and risk assessment for longevity related financial products.

Cairns, Blake, and Dowd (2006), Biffis (2005), Dahl (2004) and Dahl and Møller (2005) develop models of mortality in the framework of financial valuation models as used in work on the term structure of interest rates. The models are based on arbitrage-free model assumptions and do not rely on market completeness since such an assumption is unlikely to hold in the longevity product market. They provide the framework for determining the price of risk and the transformation from the historical or real world probabilities, to the risk neutral, or pricing, probabilities. These models are then applied to the pricing of contracts with cash flows that depend on survival. This framework and model application provides the theoretical foundation for financial pricing of longevity dependent financial claims. These models have important implications for hedging since it is possible to derive pricing measures for use in incomplete markets based on hedging effectiveness such as mean-variance hedging approaches. Although dependence between interest rates and mortality is generally regarded as something that can be ignored, there remains the modelling of dependence between ages that does need to be considered in these models. These models have been implemented for single age cohorts. To allow for multiple ages in the modelling, dependence across ages must be modelled satisfactorily.

These arbitrage-free models currently provide the most potential as a standard modelling framework for pricing and hedging longevity risk based products. There are a number of modelling issues that need to be addressed and that are yet to be fully explored. An important modelling issue is the incorporation of morbidity and ill-health. This is particularly important for the hedging of financial products such as reverse mortgages where contract payments will often depend on date of moving into a retirement home because of ill-health. Multiple state models are required to capture these dynamics with an allowance for different illnesses as well as death. This provides a framework for also incorporating cause of death as risk factors into the modelling. These models also introduce the need to allow for dependence between competing risks.

All of the most frequently considered models are based on age and model the time dynamics of the central death rate, hazard rate, or force of mortality. Implicit in these models is the assumption that individuals with the same age have the same hazard rate. Different assumptions, or parameters, are assumed for different groups of the population where the hazard rate is known to differ. For example males and females and also population lives and selected groups such as annuitants and purchasers of life

insurance are modelled separately. Empirical evidence suggests heterogeneity exists in age groups even after assuming different parameters for different groups.

A more fundamental modelling approach that considers the physiological factors that cause aging is presented in Woodbury and Manton (1977) and developed in Yashin, Manton, and Vaupel (1985). They develop an approach where the risk factors that impact on survival probabilities need not be based on age. This modelling framework is largely unexplored mainly because of the lack of data to estimate and assess these models. They do have the potential to provide a modelling framework based on individual mortality data allowing for the impact of risk factors that do not assume hazard rates are determined only by age and time.

4 Longevity Risk Hedging

Longevity risk hedging is most concerned with the financial impact of adverse developments in the long term trend of survival probabilities. Although improvements in mortality from unexpected changes such as a cure for cancer or other serious life decreasing illnesses are the major risks of concern, mortality improvement has been a continual process over many years. Expected improvements can be modelled based on historical data and the use of expert opinions. Pricing longevity based products requires a forward market where longevity improvements should be priced. There does not currently exist a liquid forward market in longevity risk. Longevity or survivor swaps, as discussed in Dowd, Blake, Cairns, and Dawson (2006), are portfolios of forward contracts. They allow for pricing of longevity risk through a forward market for mortality. Since the extreme risks from adverse longevity development are a concern in the hedging of longevity risk, there is a need also for a financial market based solution for hedging extreme or catastrophic unexpected adverse changes.

A forward market for longevity will provide a benchmark for pricing other risk management products and provide a price discovery mechanism for expected longevity trends. Forward contracts can be considered as the fundamental product that allows the pricing of trend risk. Swaps provide for the hedging of basis risk in trends such as the basis risk between population mortality and annuitant mortality and population mortality and particular blocks of annuitant lives. Swapping population mortality for annuity portfolio mortality and a forward market in the pricing of population mortality would provide a viable market for price discovery for longevity risks. Proposals to develop a forward market on life annuities based on the UK annuity market, one of the largest in the world, would be a very valuable risk management innovation in the longevity market. We understand this has been proposed by the AFPEN, the association of French pension funds.

The major longevity risk is a systemic and unexpected change in longevity, such as a cure for cancer, which is a downside and extreme risk. Such risks are not well suited for risk management using forward contracts. Hedging adverse mortality risk requires option or reinsurance contracts. Forward markets alone are not sufficient to manage longevity risk. Reinsurance markets are designed to cover these risks but reinsurers have been reportedly unwilling to take on this risk. The reinsurance market regards longevity as “toxic”, and appears concerned about the amount of capital required to hedge large adverse unexpected mortality changes that can not be managed through

risk diversification. Securitization is a natural means to hedge these risks through accessing larger pools of capital available in financial markets.

There is concern about the extent to which there are natural hedgers of longevity risk providing both supply and demand to support a market where speculators and hedgers can trade. While there are an extensive number of parties with underlying short exposures to longevity improvements, such as governments and annuity providers, the same cannot be said for their complements. Suggestions for natural counterparties to contracts such as longevity swaps include life insurers and pharmaceutical companies, which tend to be long in longevity. However, the exact nature of the underlying mortality exposure of these businesses is not a perfect hedge for the annuity streams behind the bulk purchase annuity providers.

Younger tax payers and the current working generation will eventually be called on to meet any shortfall in retirement savings for the retired generation and potentially much of the health costs for the old aged. Not only will they have to save to provide for their own retirement, they will also be called on to fund the costs that fall on the government as financer of last resort through the social security system. This is a more significant issue for developed economies since they have more developed social security and health systems that include substantial components that are tax funded. Ultimately the next generation will bear the financial risk from longevity and there is an incentive for their retirement savings funds to earn a risk premium to bear this longevity risk.

The government also has incentives to reduce both the longer term costs of ageing and the reliance on tax revenue to fund these costs by encouraging individual provision for retirement. This can be achieved through tax favoured longevity retail products. Increases in retail providers of longevity risk products will require a focus on long term solvency and risk management. The solvency of product providers in this market is critical to its long term development. Regulation and risk management processes need to ensure these providers will survive over the long term and will be able to meet the obligations promised, regardless of adverse longevity developments.

An approach that has been used to manage longevity risk is the mutual ownership structure. This was traditionally a common corporate form for providing life insurance along with participating contracts. Actuarial management of surplus and bonuses was critical to the success of these contracts. Participating life annuities provide for the risk sharing of individual risks and a common sharing of adverse longevity risks. There are significant risk management issues for mutual companies providing participating life annuities mostly related to intergenerational equity and fairness in the treatment of policyholders. The Equitable experience demonstrated that the actuarial philosophy for surplus management and bonus policy along with the pricing and reserving for risks must take into account market risks and should take into account market consistent valuations of both assets and liabilities. An approach to using experience sharing to mitigate systemic adverse changes has also been proposed in Piggott, Valdez, and Detzel (2005). Risk sharing of extreme risks is a product feature that is potentially very valuable in the product design of life annuities.

Financial markets have increasingly developed an appetite for insurance risk through the alternative risk transfer market and insurance securitization as discussed in Lane and Beckwith (2007). Further innovations will ensure securitisation of longevity risk

becomes a successful and standard risk management technique for this market. Some of the issues relate to the structure of the securitisations as well as the term of the bonds. Financial markets, including hedge funds and other pension and insurance investment funds, should find longevity risk attractive from a pure portfolio diversification perspective given the low correlation with equity markets.

5 Retail market developments

Individuals are faced with longevity risk. Increasingly the funding of retirement for longer periods than has been expected historically is producing a demand for retail market products. These include equity release products based on residential property assets that provide either a lump sum or an income to finance retirement. The reverse mortgage is becoming increasingly popular in developed countries including the US, UK, and Australia. A major asset of most individuals in these countries is the family home. There are other equity release products based on using the residential home as security such as reversion schemes and shared appreciation mortgages.

Reverse mortgages have some appeal since they provide funding secured against the value of the family home as either a lump sum payment or as instalments. Repayment on the loan occurs on sale, death or moving out of the house, often because of ill health. There are however major risks and costs. An important risk is the negative equity risk that arises because the outstanding value of the loan including interest can exceed the market value of the home. There are also significant costs involved including mortgage insurance and administration fees. Understanding the impact of compound interest and residential property prices is a complexity that most individuals would find difficult. Combined with longevity and ill health risks, these products clearly need careful design and a high level of sophistication in their risk management. The long run solvency and integrity of the product provider is critical. These products are usually provided as a banking product whereas an important risk factor for the products is ill health and mortality. Banks are more familiar with using the securitization market for their credit and other risks and should increasingly provide a demand for longevity securitizations.

Product providers will require risk management products for residential property prices and longevity/morbidity risks in order to manage the solvency risks of these home equity based products. Residential property market indices have been recently developed. In Australia, RP Data Ltd and Rismark International launched residential property price indices, including “real-time”, “repeat sales” and “hedonic” property indices in February 2007. The global derivatives broker, GFI Group Inc, has proposed over-the-counter residential house price derivatives based on the indices. Residex has also developed residential property price indices in Australia (www.residex.com.au) based on repeat purchase data. In the US market there are the CME Housing Futures and Options based on the S&P Case/Shiller repeat sales index for 20 major metropolitan areas. In the UK the Investment Property Databank (IPD) indices include the IPD UK Residential Databank with data for about 6 years by different geographical regions including an income and capital index.

HedgeStreet, (www.hedgestreet.com) is an online internet-based market for individuals to hedge a range of risks including house price risk. It is a government regulated market subject to regulatory oversight by the Commodity Futures Trading Commission (CFTC). They offer contracts, usually binary, based on selected cities

median house prices. Although this is a derivatives market for short terms and relatively small contract sizes, it illustrates the potential for on-line markets for hedging a range of risks including residential property prices. With the development of an index reflecting the value of life annuities it would be possible for such a market to trade longevity risk over short horizons. Basis risk will always be an issue for financial market products but it is possible to develop indices that allow hedging of systemic risks in a range of insurance related risks and for risks that are not generally traded in financial markets.

In the US an increasingly popular product offered by life insurance companies is the guaranteed lifetime income annuity. These products provide a guarantee of minimum payments in Equity Indexed Annuities. There are also a range of other guarantee features including guaranteed withdrawal, death, and maturity benefits. These guarantees have recently been extended to include longevity guarantees. There are many examples of these products. Figure 5 gives an example of the guaranteed lifetime percentages offered by American Investors Life, a leading company in the indexed annuity market and recently acquired by Aviva. They illustrate the type of longevity insurance provided in conjunction with the popular tax deferred index annuity product. There are many other companies with similar products and retail products are increasingly providing longevity insurance.

These products are not without their drawbacks. As with many retail products the level of charges and fees for these products are not insignificant. They typically involve investment in equity markets and involve a range of guarantees not least of which is the longevity guarantee. They provide challenges for pricing often complex guarantees and for risk quantification, the determination of risk based capital and the assessment of solvency. The UK experience with the Equitable raised issues of risk and capital management for participating annuities with guarantees including longevity guarantees.

Guaranteed Lifetime Income Percentages

Age at Time of Election	Single Annuitant Income Percentage	Joint Annuitants Income Percentage[2]
50 - 54	4.00%	3.00%
55 - 59	4.50%	3.50%
60 - 64	5.00%	4.00%
65 - 69	5.50%	4.50%
70 - 74	6.00%	5.00%
75 - 79	6.50%	5.50%
80 - 84	7.00%	6.00%
85 - 89	7.50%	6.50%
90+	8.00%	7.00%

1. For ages over 85 - 89 the limit is 7.5%, ages 90+ is 8.0%.
2. Based on the age of the younger annuitant.

Figure 5: American Investors Life guaranteed lifetime income

The retail market is developing products designed to provide for retirement income streams. These generally come packaged with other risks such as interest rate risk, equity risk or house price risk. Life annuities have traditionally been the main form of longevity insurance available to retail investors. These products provide a hedge for both interest rate and longevity risk. Institutions that provide guarantees for annuity products must manage both interest rate and longevity risk. The Equitable experience in the UK demonstrates that together these can be significant risks even for participating annuities if not properly managed. It is not possible to rely on investment markets to hedge longevity risk. Investing in equity markets with the aim of earning higher expected returns is not a well founded strategy for hedging longevity risk.

In Europe the participating life annuity is the main form of longevity product and longevity risk around long term trends can be averaged across the pool of policyholders. Adverse longevity trends can be managed through a reduction in surplus distribution to current policyholders over time. Longevity risk has generally been emerging at a relatively slow and predictable pace compared to many other risks faced by individuals and financial institutions. Any changes from major developments such as a cure for cancer are likely to take time to have an effect on overall longevity. Participating products have the potential to provide the best approach to this risk. In the US the indexed annuity market has provided maturity, withdrawal and death benefit guarantees and increasingly provides longevity guarantees. How to price such guarantees and then to provide successful risk management is an important issue for these products.

Retail internet based derivative markets are becoming available as evidenced by HedgeStreet. Although they are simple contracts over short horizons, they indicate the potential for a hedging market even at the retail level for many of the risks that individuals face as they reach older ages. Despite this the natural and most cost effective market for hedging of these risks should be the wholesale or institutional market. Economies of scale and expertise are in the favour of financial institutions when it comes to cost effective risk management.

6 Wholesale market developments

Activity in the wholesale market has seen an increasing number and volume of issues of mortality and longevity based securities. Blake, Cairns and Dowd (2006) discuss the potential for mortality futures and options as exchange traded securities. One of the challenges in developing a market for these types of securities is to define an underlying process. While weather derivatives are not based on an underlying process, they note that it is very difficult for a futures market to survive without one. Suggestions for potential underlying longevity processes include annuity contracts, although the market for these may be too illiquid and inefficient, longevity bonds and survivor indexes. Survivor index futures would be similar to the market for CPI futures. There are a number of survival indexes now publicly available.

The first mortality bond, Swiss Re: Vita Capital, was issued in December 2003. It was designed to reduce Swiss Re's exposure to catastrophic mortality deterioration over the three year term of the bond. The issue was fully subscribed at $400 million, offering investors coupons of quarterly US dollar LIBOR + 135 basis points. Standard and Poors rated the deal A+ and Moody's A3. Vita Capital facilitated the transfer of mortality risk by providing that the principal repayment to investors at maturity was

contingent on the level of a constructed mortality index. If the index exceeded specified trigger levels the principal would begin to revert to Swiss Re. The index was designed to mirror Swiss Re's mortality exposure, minimising basis risk. The short term to maturity and the catastrophic nature of trigger events allowed lessons to be drawn from the more mature CAT bond market. In their detailed review of the issue Blake, Cairns and Dowd (2006) highlight the capacity benefits of transferring catastrophic mortality risk to the capital markets, particularly for reinsurers of Swiss Re's size. Contemporary press reports suggested that investors were pleased with the deal, laying the foundation for subsequent mortality bond issues. The first Vita Capital notes expired in January 2007 without any claims being made.

The success of the initial Vita Capital issue was followed by two more: Vita Capital II in April 2005 (USD 365 million) and Vita Capital III in January 2007 (USD 705 million). These were both modelled on their predecessor but were issued in classes characterised by different trigger levels on the underlying indexes. Vita Capital III was also issued in both USD and EUR and was designed as a shelf offering, allowing up to USD 2 billion of securities to be issued in a range of currencies.

In May 2006, Scottish Re issued USD 155 million of three year principal-at-risk mortality bonds through the SPV 'Tartan Capital'. This was designed to hedge the effect of catastrophic mortality events on the business of Scottish Annuity and Life Insurance Company Ltd (SALIC). The bonds were issued in two classes. The credit rating of the Class A notes was backed by an insurance arrangement with the Financial Guaranty Insurance Company. This guaranteed the timeliness of interest repayments and the ultimate repayment of principal at maturity. No such backing was provided for the Class B issue. SALIC was obliged to make payments to Tartan Capital comprising the interest payments on the notes, the insurance premium to be paid to Financial Guaranty Insurance Company, and the spread on an interest rate swap with Goldman Sachs International. Press reports at the time of the issue[1] suggested that the capital markets provided higher levels of coverage at a better price compared to traditional retrocession deals, despite widespread fears of a possible avian flu pandemic hitting the US at the time. Figure 6 provides a summary of recent mortality risk securitizations.

	Vita I	Vita II	Tartan	Osiris	Vita III
Sponsor	Swiss Re	Swiss Re	Scottish Re	AXA	Swiss Re
Issue	2003	2005	2006	2006	2007
Size	USD 400m	USD 365 m	USD 155 m	USD 442 m	USD 705 m
Maturity	2007	2010	2009	2010	2010-2011
Index	70% US 15% UK 7.5% France 5% Italy 2.5% Switz.	62.5% US 17.5% UK 7.5% Germany 7.5% Japan 5% Canada	100% US	60% France 25% Japan 15% US	62.5% US 17.5% UK 7.5% Germany 7.5% Japan 5% Canada
Attachment / Detachment	130 / 150%	A: 125 / 145% B: 120 / 125% C: 115 / 120% D: 110 / 115%	A: 115 / 120% B: 110 / 115%	A: 119 / 124% B: 114 / 119% C: 110 / 114% D: 106 / 110%	A: 125 / 145% B: 120 / 125% C: 115 / 120% D: 110 / 115%

Figure 6: Past mortality bond issues.

[1] May 2006, *"Scottish Re Hits Target Despite Pandemic Fears"*, Reactions, www.reactionsnet.com

The first mortality bond issue by a primary insurer was performed by AXA in November 2006 by the SPV Osiris Capital. The deal was arranged by Swiss Re following the success of their Vita Capital deals, and presented a number of firsts for the mortality securitisation market. Not only was it the first issue by a primary insurer; it also was the first deal to include offerings in both Euro and USD denominations and the first to transfer a sub-investment grade mortality risk layer to the capital markets. It was also the first mortality securitisation with its primary exposure in Europe.

The market for longevity-linked securities has not developed as quickly as the mortality bond market despite having been the subject of discussion in academic literature for a number of years (see Cox, Fairchild and Pederson, 2000; Blake and Burrows, 2001). The only transaction to date has been the proposed longevity bond issue in November 2004 by BNP Paribas and the European Investment Bank with Partner Re as the longevity risk insurer. Although it represented an innovative means of managing the longevity risk of annuity providers it was withdrawn for redesign in 2005 due to insufficient demand. Blake, Cairns and Dowd (2006) provide an analysis of the reasons behind this failure noting an insufficient term to maturity, basis, model and parameter risk, and the capital intensive upfront subscription fee as contributing factors. The recent issue of ultra-long term government bonds means that longer term longevity bonds are possible. Increasing the gearing of the risk exposure would decrease the required capital outlay of investors. Concerns with basis risk can be addressed by closer consultation with potential investors or by altering the nature of the bond to hedge the longevity risk of the issuer to allow tailored indexes.

The bulk purchase annuity market has seen rapid development in recent years. This market facilitates the transfer of longevity risk from annuity providers to specialist risk managers. Until recently the only UK firms offering this service were Prudential and Legal & General. Since the start of 2006 there has been an influx into the market of both standalone Bulk Purchase Annuity start-ups and established insurers. At present, 16 firms are offering bulk annuity buyout services in the UK ranging from specialist firms such as Paternoster and Synesis, to established insurers such as AIG, Aviva (Norwich Union) and Aegon looking to expand their operations. The competitive pressure of an increasingly crowded market has led to suggestions that these firms may be instrumental in the development of a liquid market for longevity-based securities. This is particularly true for the specialist bulk purchase annuity providers that do not have the benefit of the deep capital reserves and diversification benefits afforded to more established players. Press statements offered by the Paternoster CEO Mark Wood suggest that their approach towards managing longevity risk was based on more accurate pricing of longevity exposures through sophisticated actuarial techniques (Life and Pensions, Dec 2006). However, the firm also appears to be demonstrating some interest in moving towards risk management techniques based more on capital markets and similar in substance to securitisation programs. In January 2007, Life & Pensions reported that Paternoster was offering an alternative to traditional buy out arrangements that sees the ceded business placed in a fully funded Special Purpose Vehicle which remains subject to the same solvency capital requirements (Woolner, 2007). While this arrangement is similar in structure to a risk

transfer securitisation program, it is not identical since the obligations are not designed to be tradeable.

One of the fundamental requirements for the successful development of a derivative and securitization market in longevity is the availability of suitable mortality indices. In 2006 Credit Suisse launched its Longevity Index. The index is for expected average lifetime for the general population based on US mortality with separate indices for males and females and for different age groups. The global actuarial firm Milliman is the independent calculation agent. As well as the underlying mortality rates, the index provides projections of mortality rates for different ages and for males and females separately and updated projections will be released annually. In 2007 JP Morgan launched LifeMetrics which includes an Index for mortality rates, both crude central rates and graduated initial rates, life expectancy levels across various ages, by gender, currently for the United States and England & Wales. Software tools are provided for projecting mortality and longevity data.

Riskmetrics and Creditmetrics were developed by JP Morgan to assist in the quantification of market and credit risk. They have since been spun off by JP Morgan to be offered by the RiskMetrics Group. They provide data, software and consulting services. Much of the use of the data has focussed on capital requirements and internal risk based models for these risks. In contrast to longevity, there are active traded markets for these risks and data is extensive. They can be used to quantify the volatility of financial positions using specified model assumptions. With longevity data being available only annually, the proposed indices are unlikely to provide the basis for an active futures or other derivative market in longevity risk. In order for the longevity risk hedging market to develop, an active secondary market in longevity linked securities will be necessary. This will provide secondary market pricing and allow for the development of an active derivative market, most likely in the form of a forward market based on life annuities for a range of ages. Indices that capture fluctuations in the value of life annuities will be more useful for these markets. A forward market based on life annuities appears to be fundamental to the price discovery and trading of longevity risks.

7 Lessons from the Insurance Securitisation Market

Structuring of longevity risk through a special purpose vehicle requires consideration of how best to tranche the risk in order to meet different market demands. Even if the longevity trends are highly uncertain, it is possible to structure securities so that the more certain early cash flows are held by investors seeking lower risk investments, and the highly uncertain long term cash flows are held as equity tranches by high risk seeking investors. It is also possible to structure shorter term securities that include renewal options allowing for repricing instead of locking in prices for longer term products. The experience with quota share “sidecars” in the insurance securitization market also indicates that surplus share structures similar to XOL reinsurance structures may not be the only way to package the risk for financial market investors.

Longevity risk is a risk that does not have an established market price although financial market securitization of insurance provides indicative pricing through models such as those developed by Lane (2000). Longevity risk should be expected to trade at a multiple of expected loss and the multiple will be higher for more extreme risks. Lane and Beckwith (2007) analyse the market for catastrophe (CAT) and other

insurance risks. Over the years that the insurance linked securities market has developed the term of securitized bonds has been increasing. The preference has generally been for exposure to a single risk although multiple risk bonds have been issued. Credit risk, and other risks, is managed through the securitisation structure. There has also been the development of a more active secondary market allowing for the observation of market prices/spreads on a more regular basis for securities on issue including currently issued mortality bonds. The expected loss and type of risk are significant factors in determining the spread on insurance linked securities although probability of loss has also had an effect on spreads.

Financial markets provide a much needed home for longevity risk. The insurance linked securitization market has increasingly been developing its appetite for mortality risk. Longevity risk has yet to be successfully securitised but the requirements for a successful securitization are better understood. Longevity risk securitization products are most likely to succeed by issuing different classes of securities with exposure to losses from different ages at death and ensuring payments reflect the financial costs through the use of a life annuity index. They will need to hedge the other risks that usually accompany longevity risk, such as interest rate risk, credit risk and possibly equity market using the well developed markets for these risks. The side-car structure based on quota share for longevity risk has attractive features that may also be developed as a means of providing longevity risk coverage using financial market capital. This structure could be used to provide hedging of longer term exposures into financial markets.

There is no question that it will take time for an active market in traded longevity risk to develop. It is already taking place in the securitization market and there is a clear appetite from financial markets for alternative risk based securities. The size of the risk and its international significance will lead to innovations that will produce an active market to hedge and manage this risk.

8 Conclusions

The hedging of longevity risk has traditionally been managed by life insurance companies and reinsurance companies. Individuals can hedge their individual longevity risk through various products such as life annuity products, reverse mortgages and indexed annuity products with longevity guarantees. Life insurance companies have traditionally used actuarial solvency and risk management methods based on capital and participating policy design to manage longevity risk. Longevity risk products are usually exposed also to interest rate, credit, and equity market risks. With the exception of longevity these risks have well developed markets for hedging and risk management. Rapid increases in longevity have caught pension funds and insurance companies unawares and traditional risk management techniques have been found wanting.

The risk is significant and increasing in many countries internationally. Financial markets are developing an appetite for alternative risk including insurance linked securities. There are benefits for them to hold this risk including the risk premiums to be earned, their risk management expertise, economies of scale and potential cost savings. Many factors suggest that the longevity market will develop further. The recent development of mortality indices for use in financial product design, success of mortality securitizations and activity of the research program in the area has laid a

foundation for the wholesale market to develop to meet the needs of an increasing retail market.

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