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Longevity risk management for life and variable annuities: The effectiveness of static hedging using longevity bonds and derivatives

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ABSTRACT

For many years, the longevity risk of individuals has been underestimated, as survival probabilities have improved across the developed world. The uncertainty and volatility of future longevity has posed significant risk issues for both individuals and product providers of annuities and pensions. This paper investigates the effectiveness of static hedging strategies for longevity risk management using longevity bonds and derivatives (*q*-forwards) for the retail products: life annuity, deferred life annuity, indexed life annuity, and variable annuity with guaranteed lifetime benefits. Improved market and mortality models are developed for the underlying risks in annuities. The market model is a regime-switching vector error correction model for GDP, inflation, interest rates, and share prices. The mortality model is a discrete-time logit model for mortality rates with age dependence. Models were estimated using Australian data. The basis risk between annuitant portfolios and population mortality was based on UK experience. Results show that static hedging using *q*-forwards or longevity bonds reduces the longevity risk substantially for life annuities, but significantly less for deferred annuities. For inflation-indexed annuities, static hedging of longevity is less effective because of the inflation risk. Variable annuities provide limited longevity protection compared to life annuities and indexed annuities, and as a result longevity risk hedging adds little value for these products.

1. Introduction

Retirement systems around the world are increasingly relying on individuals to accumulate personal savings for retirement through defined contribution accumulation schemes. On retirement, these accumulated funds will need to finance an increasing and uncertain lifetime. Fig. 1 shows the rapid mortality improvements in the late 20th century in Australia. Government support through social security and aged pensions will be under pressure as more individuals will be expected to finance their longevity risk with retirement products that include longevity insurance.

The traditional longevity insurance products have included life annuities, indexed annuities, and deferred annuities offered by life insurers. Annuity markets have not developed, except in a few countries, typically where there has been an element of compulsion to annuitize retirement savings. A product innovation recently introduced into Australia, popular in the US, Japan, and Europe, is the variable annuity with a guaranteed lifetime withdrawal benefit (GLWB) rider. The GLWB is designed to cover insurance against longevity and market risks while allowing individuals more flexibility and liquidity as compared to life annuities (Ledlie et al., 2008). The recent global financial crisis has drawn attention to the risks for variable annuity writers, resulting in insurers increasing fees, reducing benefits, or withdrawing from selling variable annuities altogether (Burns, 2009; Lankford, 2009).

The annuity markets in the US and UK are relatively well developed, with US annuity sales amounting to US$255b in 2007 (Source: Morningstar, Inc. and LIMRA). Table 1 shows how the US fixed annuity market (including both term and life annuities) has been relatively stable while the variable annuity market has been growing rapidly until recently. Variable annuities have proved to be attractive, addressing consumer concerns over issues such as bequests, early death, and income flexibility (HM Treasury, 2006). In the US, the proportion of variable annuities sold with a GLWB has increased from 24% in 2004 to 43% in 2006, the highest election rate among all the variable annuity guarantees offered (Source: NAVA).

A range of annuities has been offered in Australia, including fixed-term, fixed-life, and inflation-indexed products. Table 2 shows recent sales. Annuity demand has been low and falling, with sales of A$3.04b in 2004 decreasing to A$0.82b by 2007. Most annuities sold in Australia are term-certain annuities, with life annuities accounting for only 2% of annuity sales in 2006 (Source: IFSA). The decline in annuity demand is partly due to changes in

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Table 1
US annuity sales (US$b).
Source: Morningstar, Inc. and LIMRA International.

Annuity market	2001	2002	2003	2004	2005	2006	2007
Life and term annuities	74.3	103.3	89.4	87.9	79.5	78.3	72.8
Indexed annuities	6.8	11.8	14.4	23.1	27.2	25.4	24.8
Variable annuities	113.3	115.0	126.4	129.7	133.1	157.3	182.2

Table 2
Australian annuity sales (A$m).
Source: Plan for life research.

Annuity market	2001	2002	2003	2004	2005	2006	2007
Life annuities	166	154	200	281	27	29	36
Term annuities	794	1096	1357	2758	548	530	787

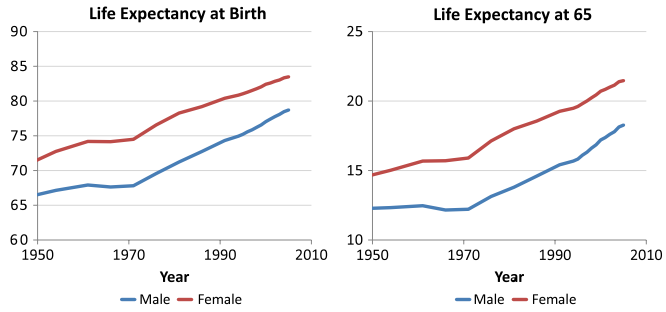

Fig. 1. Australian life expectancies, 1950–2005.
Source: ABS.

taxation and regulation in 2004 and 2007, when the Australian Government reduced the assets test exemption for complying income streams and made superannuation benefits tax free for those aged 60 or over (Ganegoda, 2007). Both of these changes have decreased the attractiveness of life annuities, and the effect of the first change can be seen by the 90% fall in life annuity sales from 2004 to 2005.

A viable life annuity market requires that life insurers be able to effectively manage the risks of retail products without holding excessive levels of capital. The longevity risk can be managed using a variety of techniques, including reinsurance and hedging in financial markets (Blake et al., 2006a). As reinsurers have been unwilling to accept substantial amounts of longevity risk (Wadsworth, 2005), insurers are increasingly considering hedging and securitization. Financial market hedging requires mortality/longevity-linked securities and derivatives. Pooling longevity risk and natural hedging are not effective for systematic longevity improvement. This impacts all ages, and can only be hedged in financial markets or by reinsurers through diversification with relatively uncorrelated risks (Loeys et al., 2007).

Mortality-linked securities were first proposed by Blake and Burrows (2001), who suggested a survivor bond as a method of hedging the longevity risk, and suggested that the government should issue survivor bonds based on population mortality. Dowd (2003) proposed other methods of hedging the longevity risk, including survivor options, futures, and swaps. Blake et al. (2006b) and Dowd et al. (2006a) discuss longevity bonds and survivor swaps, respectively, including construction and use in hedging the longevity risk. Brown and Orszag (2006) provide a detailed discussion of the advantages and disadvantages of government involvement in longevity bonds, such as the ability of the government to spread the longevity risk across generations.

There have been innovations to transfer the longevity risk to the capital markets, including mortality-linked securities (MLSs), longevity derivatives such as q-forwards (Coughlan et al., 2007), and longevity swaps. There is also a potential role for government to issue longevity bonds (Blake et al., 2009a) to provide the hedging. At the same time, regulatory capital requirements for European insurers under Solvency II and risk-based capital requirements in other countries need to be allowed for in the successful provision of longevity insurance to individuals (Blake et al., 2009a). Although securitization of extreme mortality risk has been successful, there has yet to be a successful securitization of the longevity risk (Biffis and Blake, 2009). Lin and Cox (2005) proposed a longevity bond with payments based on the insurer's loss experience eliminating the basis risk while Wills and Sherris (2010) analysed tranching in a longevity bond structure, showing how age dependence is a critical factor in the design and pricing of a securitization.

In 2007, JPMorgan launched the LifeMetrics mortality index, initially based on US and UK data (Blake et al., 2008). By disclosing the data and the methodology, LifeMetrics provided a transparent mortality index on which survivor derivatives can be traded. In 2008, the first transaction based on this index took place, a q-forward transaction between JPMorgan and Lucida, a UK buyout firm. The first longevity swap in the capital markets soon followed, with JPMorgan facilitating the swap between Canada Life and a group of investors including ILS and hedge funds (Blake et al., 2009b). Several further transactions between life insurers and investors have since occurred (Ribeiro and di Pietro, 2009).

There is relatively little analysis of annuities and longevity risk from an insurer's perspective. Bauer and Weber (2008) assess the risk of annuities for a single-premium immediate life annuity using relatively simple stochastic models to describe the market and mortality processes. Dowd et al. (2006b) analyse the risks of various mortality-dependent positions, including an annuity book with a longevity bond hedge. The longevity bond involves coupons based on survival probabilities, and is structured to match a typical life annuity book for a given cohort. A range of risk measures such as expected shortfall and spectral measures are used to quantify the risk in the portfolios. More recently, Plat (2009) assesses the longevity risk and q-forward hedge effectiveness for a sample insurance portfolio with a stochastic factor model to describe portfolio-specific mortality in relation to population mortality.

Most techniques available to hedge the longevity risk involve illiquid or developing markets. It is not practical to dynamically hedge the longevity risk. Against this background, it is important to assess the effectiveness of static hedging strategies using currently available and proposed hedging instruments for retail longevity risk management products including life annuities and variable annuities. In this paper, market and mortality models are applied to assess the static hedging of the mortality risk in an Australian context. A range of hedging strategies for annuity portfolios is assessed, extending Dowd et al. (2006b) and other studies. Techniques for hedging the longevity risk must be assessed in a rigorous framework to support the development of retail annuity