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MODERN MODELS FOR LONGEVITY RISK

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ABSTRACT

Effective risk management of a portfolio demands accurate and succinct models which explain the main risk factors. The importance of this has risen sharply in a low-interest-rate environment. We look at the various risk factors which can be found in two different portfolios in two different countries, and find a degree of commonality.

However, we also find that different portfolios have different characteristics available for modelling and risk management, and that portfolio-specific analysis is critical.

WHY CARE ABOUT LONGEVITY RISK?

"By providing financial protection against the major 18th- and 19th-century risk of dying too soon, life insurance became the biggest financial industry of that century. ... Providing financial protection against the new risk of not dying soon enough may well become the next century's major and most profitable financial industry."

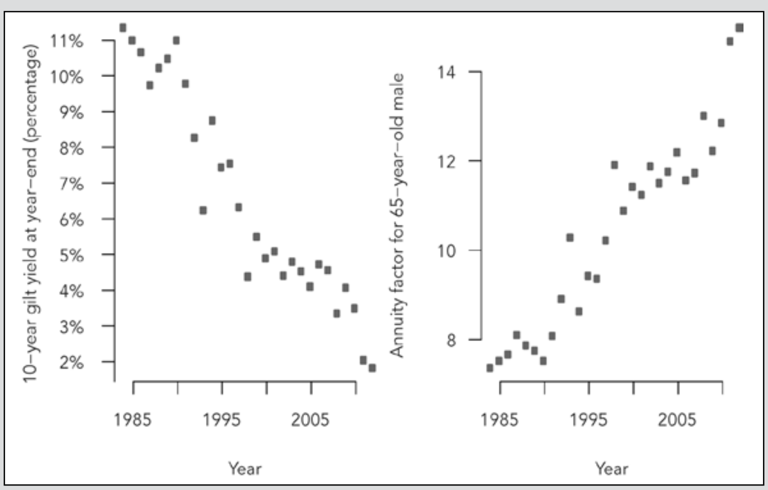
Drucker (1999)

In the July 2013 issue of *Reinsurance News*, Gavin Jones described recent developments in the market for reinsuring longevity risk in company pension plans in the United Kingdom. This market is growing in the United States as well, with well-known recent buy-out deals including General Motors and Verizon. Annuities and pension-plan restructuring are now a large part of modern life-insurance business. They have also become a lot more expensive, as shown in Figure 1.

The size of recent deals is one reason to care about longevity risk, and increased reserves due to low interest rates is another. However, a subtler point is that those increased reserves have also become a lot more sensitive to longevity assumptions. Figure 2 illustrates this. At first glance the right-hand panels of Figures 1 and 2 look near-identical. Upon closer inspection, however, you can see in Figure 2 that the sensitivity of reserves to a longevity shock has more than doubled to around 8 percent. This is highly material in the context of pricing bulk-anuity transactions, as a pricing margin is typically of the order of 5 percent. Clearly, the accurate assess-

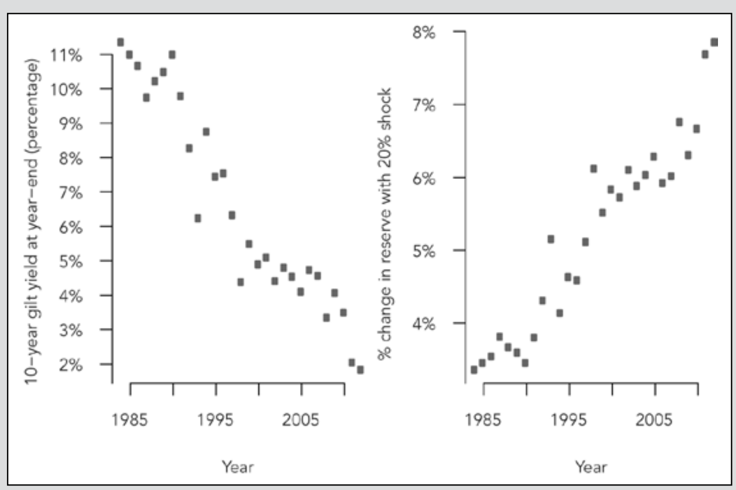
Modern Models for Longevity Risk

Figure 1: U.K. Government bond yields (left) and the corresponding cost of a level annuity to a male aged 65 (right).



Note: End-year yields from British Government Stock (10-year nominal par yield, series IUAMNPY from Bank of England) and own calculations for an immediate annuity at age 65 using S1PA (males) and same yields.

Figure 2: U.K. Government bond yields (left) and the corresponding change in reserve from a 20% mortality shock (right).



Note: End-year yields from British Government Stock (10-year nominal par yield, series IUAMNPY from Bank of England) and own calculations for an immediate annuity at age 65 using S1PA (males) and same yields.

Modern Models for Longevity Risk

Table 1: Financial impact of mortality rating factors in a U.K. annuity portfolio. Source: Richards and Jones (2004, page 39)

Factor	Step change	Reserve	Change
Base case	-	13.39	
Gender	Female->male	12.14	-9.3%
Lifestyle	Top->bottom	10.94	-9.9%
Duration	Short->long	9.88	-9.7%
Pension size	Large->small	9.36	-5.2%
Region	South->North	8.90	-4.9%
Overall			-33.6%

Table 2: Financial impact of mortality rating factors in a multi-employer pension plan in Germany. Source: Richards et al. (2013, Appendix 1)

Factor	Step change	Reserve	Change
Base case	-	16.114	
Gender	Female->male	14.529	-9.8%
Health	Normal->ill	12.974	-10.7%
Pension size	Large->small	11.717	-9.7%
Region	B->P	11.025	-5.9%
Sector type	Private->public	10.599	-3.9%
Overall			-34.2%

ment of longevity risk is far more crucial to the profitability of such business than it was in the mid-1980s.

In a low-interest environment, therefore, longevity risk plays a much bigger role than it used to. This has consequences for how actuaries perform their mortality analysis. Errors in longevity estimation have a bigger impact than they used to, so past approximations and methods may no longer be good enough. Actuaries therefore need greater sophistication in their analysis and rating of longevity risk.

PORTFOLIO-SPECIFIC ANALYSIS

Historically, actuaries analysed mortality as follows: (i) lives were grouped, (ii) a few risk factors were considered, such as age, gender and policy size, and (iii) mortality rates (qx) were compared against an industry table. In the past this was adequate, especially when interest rates were higher. However, there are a number of problems with this approach. Firstly, individuals are not all alike and have different combinations of risk factors. A mortality model for grouped data usually means that not all risk factors are being investigated, and thus that not all information is being properly extracted. Finally, portfolio mortality experience can have a very different shape from an industry table.

MODERN MODELS FOR LONGEVITY RISK

One solution to this is to construct a model using your portfolio's own experience data. You can then investigate as many risk factors as the data supports. The modern "gold standard" for this kind of analysis is a set of techniques borrowed from medical statisticians: survival models.

In our first example, a U.K. insurer found six risk factors for longevity in its annuity portfolio: age, gender, lifestyle, duration since annuity purchase, pension size and region (Richards and Jones, 2004). The importance of these risk factors for annuity reserves is demonstrated in Table 1. We start with a base case—a female of high income, high socio-economic status living in the south of the United Kingdom—and we make step-wise changes for one risk factor at a time until we reach a male of low income, low socio-economic status living in the north of the United Kingdom. Table 1 shows that each step-wise change is material relative to the typical annuity pricing margin of around 5 percent.

The phrase "lifestyle" in Table 1 refers to using so-called geodemographic profiles based on an annuitant's address or postcode. This is subtly different from a simple geographic interpretation of address, hence the term geodemographic. To illustrate this, consider two lawyers each living in the north and south of the country. They do not share a geographical region, but they are nevertheless more likely to share an education level, income and lifestyle than either would share with, say, a manual labourer living in the same city. This kind of profiling and its use in mortality modelling is described in Richards (2008), who performed a similar analysis to Table 1 for a different U.K. annuity portfolio.

Portfolios will vary as to the information they have available for modelling and analysis. These differences will be driven by industry practice and country. For example, in a recent case study Richards et al. (2013) found eight risk factors for longevity amongst pensioners in a multi-employer pension plan in Germany: age, gender, ill-health v. normal retirements, pension size, first life v. surviving spouse, sector type, region and portfolio-specific effects. Several of the risk factors are obviously shared with the previous U.K. example, but differences in available information meant that

CONTINUED ON **PAGE 12**

"LOW INTEREST RATES MEAN THAT ACTUARIES NEED TO SHARPEN THEIR MORTALITY MODELLING."

no equivalent risk factor to lifestyle was available. However, instead the German data had a reliable indicator of health status at retirement, as well as information on the sector in which each pensioner's employer operated. Table 2 shows that a similar scale of stepwise differences in reserve factors was found compared to Table 1.

We see in Tables 1 and 2 that each portfolio is unique in terms of the information it has available for assessing risk factors. The German data in Table 2 also contained a particular illustration of why portfolio-specific analysis is so important. One of the employers was a large and wealthy German city with a notably high standard of living. Even after allowing for the seven other risk factors in the mortality model, this city's pension plan had mortality around 10 percent lighter than expected. The impact of this was an extra 2 percent to 2 1/2 percent on reserves over and above what the other risk factors would have indicated. Although there were only around 11,000 surviving pensioners in the city's pension plan, the use of modern survival models enabled a formal statistical test of the significance of their lighter mortality. With a p-value of 0.0001, there was little doubt that the lower mortality was real and not a chance fluctuation.

CONCLUSIONS

Low interest rates mean that actuaries need to sharpen their mortality modelling. Each portfolio's liabilities are unique, so it is important to begin with the experience data of that portfolio. We find that survival models for individual lives make best use of all of the available information, thus allowing greater insights into the risk factors which drive the liabilities. Models should be fitted using the risk factors based on existing business practices and the data available. This way, the greatest possible insights can be gained when restructuring pension plans or designing longevity reinsurance. ■

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