Still life model

Modelling firm RMS is known for its natural catastrophe models. Here **Peter Nakada**, managing director at RMS RiskMarkets, explains why the firm ventured into the domain of traditional actuarial techniques…

In developing excess mortality models following the 2002 SARS outbreak, it became apparent to RMS that life insurers suspected that they had longevity risk – in the form of annuities and pensions – but they had no way of quantifying it accurately without underestimating future mortality improvements.

Traditional actuarial techniques estimate life expectancy in a world with no significant "regime shifts", where statistical analysis of past mortality is a good predictor of future mortality (see graph below). They are not well suited to this type of analysis. Longevity risk arises when the world changes in ways that significantly alter the patterns of mortality – for example, if a cure is found for pancreatic cancer, or the use of stem cell therapy is commercialised.

RMS recognised an opportunity to bring structural modelling – the approach used for natural catastrophe modelling – to bear on longevity risk. A structural model is developed by identifying the drivers of risk, then building a "process" model that relates the drivers of risk to the desired output.

In this case, RMS developed a process model of medical pathology – causes of death – in populations. The drivers of risk are combined with the process model to create an "event set" of potential scenarios and their probabilities. Finally, a simulation engine samples from the event set to create a distribution of potential outcomes.

RMS coined the term vitagions to represent individual sources of mortality improvement, and grouped them into six vitagion categories.

These are lifestyle trends; health environment; medical intervention; regenerative medicine – such as stem cell research, gene therapy and nanomedicine; and the retardation of ageing, including telomere shortening and caloric restriction.

For each of these categories of vitagions, RMS built a model of how longevity improvements occur. RMS then generated an event set for each vitagion category, with each event representing one way that a vitagion can create an improvement in longevity. Finally, a simulation engine sampled from all of the possible events, creating a distribution of potential longevity improvements.

Longevity model	Hurricane model
Innovation rate	Activity rate
100,000 vitagion trajectories	16,000 synthetic hurricanes
Disease reduction relationships	Vulnerability curves
Mortality rate	Mean damage ratio

RMS then modelled the likelihood and time that it could take to develop these techniques from today's pioneering proof-of-concepts to highly effective mainstream treatments. The process of getting a new treatment adopted in medical practice is complex and time-consuming, and only a fraction of new drugs and treatments make it from laboratory to the pharmacy. The US Food and Drug Administration approval process, for example, takes five to 15 years, and only 22 percent of new drugs eventually get approved.

The trajectory of a new treatment's development timeline is treated as a stochastic process – the catastrophe longevity scenarios are where a major new treatment has a strong mortality impact and arrives unusually early in the timeline outlook.

If this doesn't quite sound like a cat model, consider an analogy to RMS's hurricane model.

The development of a treatment like stem cell therapy can be thought of as an "event" that can cause an unexpected reduction in mortality – and an increase in longevity. It has a footprint of impact on certain causes of premature mortality, similar to a hurricane's wind field, and a trajectory for the vitagion's development over time can be likened to the geographical track of a hurricane. The model samples thousands of ways that these events could play out to assess the impact on mortality, in the same way that a hurricane model samples thousands of different tracks and wind fields to evaluate the impact on a portfolio of insured properties.

Know your bets, know the odds

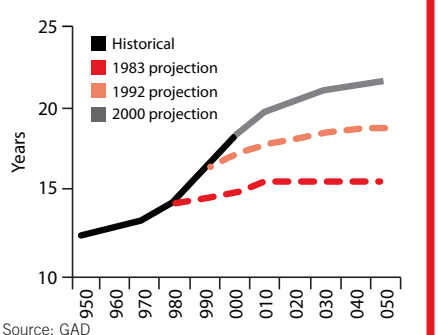
As an investor in a new asset class, one of the first things you'd like to know is "what are my bets, and what are the odds?" With a traditional actuarial analysis the answer would likely be high level: "You are betting that the reduction in premature deaths per 1,000 will be less than 2.0 over the next seven years."

The RMS longevity analysis would allow you to provide much more insight into the potential drivers of longevity risk by saying: "You are betting against a scenario where twice as many smokers quit as expected, prostate cancer mortality falls twice as much as expected, and colon cancer mortality falls 33 percent further than expected."

Pension funds are top on the list of those that should worry about catastrophic longevity risk. Defined benefit pension plans promise a predefined stream of cash flows to members for the remainder of their lives. A significant increase in longevity would create a large increase in the present value of future liabilities – creating a large decline in the pension plan's equity (or an increase in negative equity for many).

Using RMS's longevity model, we can now compare the magnitude of longevity risk in the pension market to that of natural catastrophe risk. The comparison shows that longevity risk in total is dramatically larger than natural catastrophe risk. For example, at a 1-in-100 year probability US natural catastrophe risk (all perils) is roughly $150bn, while UK pension longevity risk is over $400bn. This is even more sobering when you consider that US pension assets are roughly five times the size of UK pension assets.

Longevity projections



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