Quantifying and managing extreme mortality risk of life insurers

Dale Hagstrom, Chris Lewis, Scott Mitchell and Steven Schreiber

May 2013

As insurers increasingly evaluate business decisions within the context of risk-based frameworks, such as Solvency II, the Swiss Solvency Test, and economic capital, managing tail risks has received increased focus in recent years. This short paper considers the specific area of extreme mortality risk of a life insurance portfolio.

INTRODUCTION

In recent years, the insurance industry has placed much focus on the implementation of risk-based solvency regimes, such as the EU's[1] Solvency II regime and the Swiss Solvency Test (SST), as well as risk-based frameworks of rating agencies. Additionally, certain companies have chosen to implement their own internal models within economic capital frameworks.

Such capital frameworks bring increasing focus on quantifying and managing tail risks within an insurer's portfolio. This short paper considers the specific area of extreme mortality risk of a life insurance portfolio.

EXTREME MORTALITY EVENTS

Extreme mortality events can be categorised into the following main categories:

i. Disease-related deaths
ii. War-related deaths
iii. Terrorism-related deaths
iv. Natural catastrophe-related deaths, such as earthquakes or tsunami events

Of these main categories, disease-related events typically represent the largest risk for life insurers, due to the potentially wide-spread and significant effect on the global population.[2] In particular, epidemic or pandemic[3] events are generally considered the most significant of the disease-related risks facing a life insurer. The influenza pandemic of 1918-1920 demonstrates the capacity of the influenza virus to cause a dramatic increase in deaths in a given year.

More generally, pandemic events can lead to a multitude of potential issues for life insurers, including:

- Increased mortality and morbidity claims
- Adverse impacts on the asset portfolio due to the impact on capital markets
- Issues associated with staff shortage, due to increased levels of employee illness, employee need to care for family, enforced isolation or travel bans

In the remainder of this paper, we focus on the impact on mortality experience of a life insurer in extreme events.

ALLOWING FOR PORTFOLIO CHARACTERISTICS

The financial impact of an extreme mortality event on a life insurer will depend on the specific exposure and portfolio characteristics. For example, the impact of a terrorism or natural catastrophe event will be influenced by the concentration risk of the portfolio, in particular the geographic location.

[1] European Union

[2] Wars can have an equally wide-spread global effect, but many insurers exclude claims from war-related deaths in the policy terms & conditions.

[3] Pandemics cover a much wider geographical region than epidemics, spreading beyond country borders. Pandemics are also typically caused by new strains of a virus, to which humans have little immunity.

Similarly, the age-gender mix will influence the specific risk exposure to a pandemic event, as pandemics can impact different parts of the population in a different way. Many influenza epidemics have affected children and the elderly more than those at adult ages most heavily insured for life insurance. However, the 1918-1920 influenza pandemic had particular impact on young adults at ages often covered by life insurance.

In assessing and managing the risk, it is therefore important to consider and allow for the specific characteristics of the portfolio. Furthermore, it is important to maintain awareness of any residual risk following implementation of the chosen risk mitigation strategies.

QUANTIFYING THE RISK

Insurers and reinsurers will normally want to assess the risk exposure to extreme mortality events.

Many insurers continue to adopt a relatively simple approach to risk quantification. For example, risk exposure metrics such as sum-at-risk or maximum loss (both net of reinsurance) can be used to indicate the worst-case scenario. But these metrics provide little indication about the likelihood of an extreme event, nor the possible loss in such an event.

The standard formula approach under Solvency II defines the one-in-200 year stress event to be an increase in mortality rates of 1.5 per mille over a one-year period. This prescribed stress can be used as a proxy to quantify the financial risk and associated capital requirements for the insurer at this particular quantile. However, it does not provide a full picture of the overall risk distribution, therefore limiting the conclusions that can be drawn and possible courses of action to mitigate the risk.

Some insurers apply economic capital frameworks using internal models with a different level of risk tolerance to the Solvency II framework. For example, an insurer may target a more conservative tolerance level, leading to higher target capital than that required by Solvency II.[4] In order to assess the risk distribution, an insurer must develop and/or implement a more sophisticated approach, in particular a stochastic mortality model which is appropriately calibrated to extreme events and the specific risk characteristics of the portfolio.

There are various ways to model extreme mortality risk. These typically range from actuarial approaches based on historic events,[5] to ‘complex system’ models which incorporate forward-looking aspects, such as the preparedness of governments in responding to a pandemic outbreak or the ability to rapidly develop vaccines for new strains. In the absence of a complete set of calibration data, both of these approaches have relative advantages and disadvantages. In particular, parameterisation risk increases with model complexity as the model aims to incorporate increasing levels of forward-looking forecasting of unprecedented events.

As with any risk model, it is important for users to understand the limitations of a chosen methodology.

Based on a particular demographic distribution, Milliman rank orders the severity of epidemics over the past century and fits a curve such as the one above to the experience, calibrated to characteristics of the specific portfolio or population. This allows estimates for the range of possible future severities.

Figure 1 provides illustrative output of the disease severity model, with actual severity of historic events plotted alongside. In the stochastic frequency-severity model for disease-related mortality, a random variable determines if an epidemic has occurred in any given year. Another random variable is sampled from the

[4] For example, insurers may choose to target a more conservative capital position to maintain a certain credit rating or to reflect a more conservative risk appetite. In particular, they may want to know whether they will have enough capital to remain a credible insurer even after a large loss.

[5] Milliman has made frequent use of frequency-severity models, calibrated to the age-gender profile of the underlying population.

severity curve to determine the degree of severity of the epidemic in terms of percentages of excess mortality.

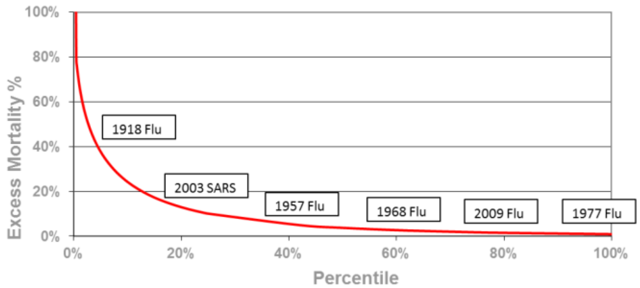

Figure 1: Disease model severity curve from Milliman model output (illustrative purposes only)

RISK TRANSFER INSTRUMENTS

The level of risk exposure to extreme mortality events may exceed the risk appetite of many insurers and reinsurers. In such cases, it will be necessary to consider risk mitigation options. The relative attractiveness of the following options will depend on a number of factors, including portfolio size, transaction price and the ability to execute certain types of transactions.

Reinsurance

Reinsurance is a natural risk mitigation option for insurers' mortality risk, and reinsurers typically have a higher appetite for extreme mortality risk than direct insurers. In many cases, stop-loss cover might be appropriate to limit the tail mortality risk for the cedant. Traditional quota-share or excess-of-loss covers can be an acceptable alternative for some insurers, especially if the ancillary reinsurance services (e.g., underwriting or pricing support) are important for the insurer, but these covers may not completely mitigate tail risk of the portfolio.

When implementing a reinsurance contract, counterparty credit risk is an important consideration. This will include consideration of the financial security of the reinsurer following an extreme event. Natural catastrophe and pandemic events are typically two of the highest ranking risk categories of large reinsurers. Both types of event can lead to significant losses for reinsurers, which naturally impacts the ability to meet claims.

Capital markets

Several insurers and reinsurers have issued mortality catastrophe (mortality cat) bonds as a way of transferring extreme mortality risks to the capital markets. These are a form of insurance-linked securities (ILS) which have increased in popularity in recent years.

Examples are listed at the end of this paper.

Of course, any transaction requires two or more willing parties and there are key reasons why such deals are also attractive to the counterparties. In particular, ILS can offer investors the opportunity to participate in uncorrelated returns, thus bringing positive diversification effects to a broader investment portfolio.

Risk exclusions

As indicated earlier, an alternative way to mitigate the effects of a particular risk is to exclude certain claims in the policy terms. For example, many insurers exclude war-related claims.

DEAL STRUCTURING

There are a variety of ways to structure reinsurance and ILS deals, and each will be tailored to the objectives of all parties involved in the transaction.

Objectivity

In general, contract terms and conditions should be prepared carefully to ensure that attachment and exhaustion points[6] are based on as objective a basis as possible, to avoid unnecessary subjectivity influencing the outcome

[6] Attachment refers to the trigger level of the contract, i.e., when the cedant/issuer can make claim recoveries from the reinsurer/counterparty. Exhaustion refers to the limit of loss for the reinsurer/counterparty, i.e., the level beyond which claims revert back to the cedant/issuer.

of future cash transfers, and also to allow full reconciliation to verifiable sources of information.

For certain events, objectivity can be increased by relying on external public bodies. For example, the World Health Organisation specifies certain levels of pandemic events, which allows the risk event to be defined using an independent external assessment.

Parametric versus indemnity basis

To bring further objectivity to the exercise of assessing the impact of an extreme mortality event, transactions are often structured on a 'parametric' basis, which involves the calculation of an index based on public and verifiable sources. For example, mortality and population data could come from government bodies, such as the Federal Statistical Office in Germany (Statistisches Bundesamt Deutschland), as specified for the German portion of the index in the Nathan cat bond of Munich Re. Attachment will be defined in relation to a certain index value, which represents a certain level of excess deaths above a pre-defined baseline level.

To the extent that the specific lives of the insurer's portfolio differ from the population upon which the index is based, the parametric basis introduces 'basis' risk for the insurer. However, the basis risk is reduced by defining the index to match as closely as possible the characteristics of the insurer's portfolio, such as age distribution. Nonetheless, the mortality experience of the overall population in an extreme event may differ from the insureds due to a number of factors, including social status, geographical location, general state of health, etc. This will result in the insurer retaining some level of residual basis risk, which should be assessed to ensure that the residual is acceptable.

In contrast, some deals are written on an 'indemnity' basis, where the insurer's underlying portfolio acts as the basis for the deal structure. While this has the advantage of reducing basis risk, it introduces a challenge when quantifying the risk – risk models will be based, at least to some extent, on historic data which will typically be based on population data, not the insurer's portfolio. The risk quantification may not, therefore, capture certain information about the risk characteristics of the portfolio. The buyer of the risk will know less than the seller of the risk about how the block was assembled and underwritten, so the buyer will want to see enough experience to validate experience assumptions for 'normal' times (i.e., in the absence of an epidemic).

Depending on the terms of the deal, the indemnity basis may also introduce some level of subjectivity into the claims assessment process (e.g., measurement of IBNR[7] claims if attachment is based on an incurred claims basis).

Aligning with risk appetite

In setting the deal terms, an insurer will aim to align the attachment level(s) with risk appetite. For example, in the context of the Solvency II standard formula, where an insurer is working under the premise of a one-in-200 risk tolerance level, then attachment should ideally occur below the one-in-200 percentile of the claims distribution. If attachment occurs above that level, then the insurer would be exposed to risk beyond its risk tolerance. It would also not obtain any capital relief from the transaction, as risk transfer occurs beyond the point upon which the Solvency Capital Requirement (SCR) is based.

Extending this example, an insurer might aim to bring some structure to the decision process, for example by optimising the Solvency II balance sheet illustrated in Figure 2 (or another equivalent economic- and risk-based metric), via the following optimisation steps:

i. Maximise balance sheet value, by minimising best estimate liability (net of reinsurance) and minimising risk margin
ii. Minimise SCR
iii. Subject to risk tolerance constraints and availability of risk transfer instruments

[7] Incurred but not reported

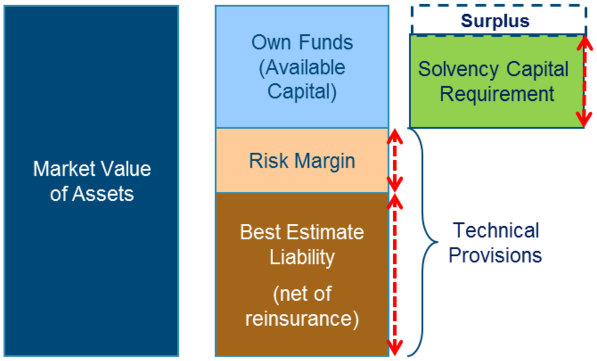

Figure 2: Using the Solvency II framework to optimise risk management decisions

While the above optimisation framework offers a neat theoretical basis, the optimisation process will, in practice, be complicated by a number of factors, such as corporate structure, local regulatory regimes which potentially restrict capital flow, lack of knowledge on reinsurance pricing for different types of coverage, etc. Nevertheless, this can be adapted into a practical and objective framework to support risk mitigation decisions.

CONCLUSIONS

Quantification and management of extreme mortality risk has increasingly become a focus for many life insurers, especially following the development of risk-based capital regimes, such as Solvency II, SST and those of rating agencies.

There are various ways to model and quantify extreme mortality risk, ranging from simple to complex. As the model methodology becomes more complex, model parameter risk increases. As with any risk model, it is important for users to understand the limitations of a chosen methodology.

Risk mitigation options include reinsurance and ILS. The relative attractiveness of each option will depend on a number of factors, including portfolio size, transaction price and the ability to execute certain types of transactions. The structure of the transaction should be tailored to the objectives of all parties involved. In general, contract terms should be as objective as possible to avoid unnecessary subjectivity influencing the outcome of future cash transfers. The terms of the transaction should also align with the risk appetite of both parties. To support the decision, an insurer will ideally assess the financial impact of the transaction within a risk quantification framework which incorporates relevant value and capital measures.

HOW MILLIMAN CAN HELP

Milliman has supported numerous reinsurance and capital market transactions covering extreme mortality and pandemic risks. We have also supported insurance clients with risk assessment for internal purposes and regulatory reporting.

Milliman's catastrophic mortality models have been used to support, among others, the following transactions:

- Swiss Re's Vita I and Vita II mortality cat bond transactions
- Axa's Osiris mortality cat bond transaction
- Scottish Re's Tartan mortality cat bond transaction
- Munich Re's Nathan mortality cat bond transaction
- Several unpublicised mortality swap transactions and reinsurance arrangements

ABOUT MILLIMAN

Milliman is among the world's largest providers of actuarial and related products and services. The firm has consulting practices in life insurance and financial services, property & casualty insurance, healthcare and employee benefits. Founded in 1947, Milliman is an independent firm with offices in major cities around the globe.

www.milliman.com

CONTACT

For more information, please contact one of the authors:

Dale Hagstrom
One Pennsylvania Plaza
38th Floor
New York, NY 10119
USA
E: dale.hagstrom@milliman.com
T: +1 646 473 3111

Chris Lewis
11 Old Jewry
London EC2R 8DU
UK
E: christopher.lewis@milliman.com
T: +44 207 847 1536

Scott Mitchell
Holbeinstrasse 31
8008 Zurich
Switzerland
E: scott.mitchell@milliman.com
T: +41 44 287 9072

Steven Schreiber
One Pennsylvania Plaza
38th Floor
New York, NY 10119
USA
E: steven.schreiber@milliman.com
T: +1 646 473 3104