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Economic Capital: A Case Study to Analyze Longevity Risk

By Stuart Silverman

FOR SOME TIME NOW, INSURERS HAVE REFLECTED VOLATILITY IN ASSET RETURN ASSUMPTIONS when determining capital requirements, but have largely disregarded the impact of volatility on their liability assumptions when performing stochastic analysis. Considering the acknowledged expertise of insurance companies in managing the liability side of the balance sheet, these disparate approaches raise the question: why?

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Factor-based capital models—which ignore the inherent volatility in mortality trends—could potentially understate future economic capital needs. This shortcoming, however, can be overcome with the adoption of a principle-based approach that uses stochastic techniques and dynamic assumptions for mortality among a variety of other variables.

Over the past century, life expectancies increased significantly. But, mortality improvements occurred not in a steady upward rise but rather in fits and starts. While life insurers have largely benefited from mortality improvements that were greater than expected, the same is not likely to hold true for insurers in the longevity-protection market, based on past trends. For these companies, understanding the potential volatility embedded in future mortality rates could mean the differences between profit and loss.

Mortality volatility can come from a number of sources. Assumptions about baseline mortality tables may be inconsistent with the actual experience of an insured population. The disparity can be especially problematic in pricing the closeout of a pension plan for which generic industry mortality tables provide the main source of experience.

Lifestyle changes, medical breakthroughs, or the discovery of a blockbuster drug may also contribute to a fundamental shift in basic assumptions. Each could change the mortality curve in unprecedented ways, creating unforeseen volatility in insurers' longevity-based economic liabilities—with longevity risk not accounted for at all in current risk-based capital (RBC) formulas. The question is: how much of a capital shortfall might an insurer face because of the longevity risk embedded in its portfolio?

ISOLATING LONGEVITY BY EXAMPLE

This issue can be addressed by examining a case study that compares the capital requirement produced by the statutory RBC formula to that generated by a principle-based model using dynamic assumptions for mortality. As part of this analysis, we effectively controlled all risks other than longevity, which enabled us to identify the economic liability arising solely from longevity risk.

For the purpose of this case study, we used a block of single payment immediate annuities (SPIA), described in the table in Figure 1.

Figure 1:
Single Payment Immediate Annuity Business

Age	Annual Benefit	Lives
65	50,000	7,000
70	43,600	6,000
75	38,800	5,000
80	34,200	4,000
85	27,700	3,000

A SPIA has two risks—investment and longevity—and provides an ideal tool for a discussion of longevity risk once steps are taken to control the investment risk.

STATUTORY RESERVES AND CAPITAL

We started the comparison by calculating statutory reserves and capital for this block of business.

Statutory reserves are calculated on a deterministic basis with a prescribed mortality assumption, currently the Annuity 2000 mortality table. To build in a level of conservatism, the basic table's mortality rates are reduced by 10 percent. While this approach is well-intended, results will show that the use of a flat discount rate ignores any future improvements in mortality.

RBC requirements are developed from formula-driven charges for four risk classes: asset default (C1), mortality or insurance (C2), investment mismatch (C3), and general (C4).

Working through the statutory reserves and RBC formulas, the insurer's total asset requirement for the SPIA block is $11.04 billion (Figure 2). This amount includes a capital charge for asset default and interest rate risk but no capital charge for longevity risk. This is the case even though the level of mortality improvement that occurred in the past clearly indicates that this omission is probably an oversight in the RBC formula.

ECONOMIC RESERVES AND CAPITAL

Unlike statutory reserves and capital, whose calculation relies on a formula-based approach, economic reserves and capital are determined using a principle-based approach. For this SPIA block, we defined the economic reserves to be the present value of annuity benefits and economic capital as the additional capital needed to satisfy a predetermined risk level (at CTE 90 or the 99.5th percentile) in excess of the book's economic reserve. Under certain circumstances, margins for adverse deviation are used to determine the book's economic reserve, but this case study instead used a best estimate of valuation.

To maintain continuity with the assumptions of the statutory capital formula, economic reserves and capital assumptions were also based on the Annuity 2000 table, but without the 10 percent discount in mortality rates (i.e., the Annuity 2000 basic table). Instead of simply multiplying the basic table mortality rates by 90 percent, which may have been conservative in 2000, we reflected both past improvement from 2000 to the valuation date and projected mortality improvement after the valuation date.

To further ensure consistency with the statutory calculations, we assumed that the assets supporting the SPIA block could earn the statutory reserve discount rate. However, to control for the asset risk, for this case study we assumed that the insurer entered into a total return swap to effectively eliminate asset-related risk at a cost of 75 basis points. Other asset-management strategies could have been used to control investment risk. However, this method allowed us to identify the economic capital associated with the longevity risk and the economic capital associated with the asset-related risk.

Figure 2:
Statutory Reserves and Capital ($ in billions)

Total statutory reserve	$10.40
CAL RBC C-1 risk, asset default	0.11
CAL RBC C-2 risk, insurance risk	0.00
CAL RBC C-3 risk, interest rate mismatch	0.05
Total CAL RBC	0.16
400% CAL RBC	0.64
Total asset requirement	$11.04

Unlike the statutory deterministic approach, we calculated economic reserves and capital on a stochastic basis. When performing stochastic calculations, it is important to reflect volatility in all of your underlying assumptions. The graph in Figure 3 illustrates the economic liabilities from a stochastic calculation with static assumptions. Because there are a significant number of lives, the results converge to be the same as a deterministic calculation. That doesn't mean there isn't risk, but merely that the risk isn't reflected in the calculation. In contrast, the graph in Figure 4 illustrates the economic liabilities from a stochastic calculation now reflecting a volatile mortality assumption. The potential dispersion of risk under dynamic assumptions is further illustrated in the graph in Figure 5, which illustrates economic liabilities at various percentiles compared to the average economic liability.

In this stochastic analysis, mortality volatility was assumed to come from several sources, including:

Figure 3:
Distribution of scenarios by economic liability at each future duration

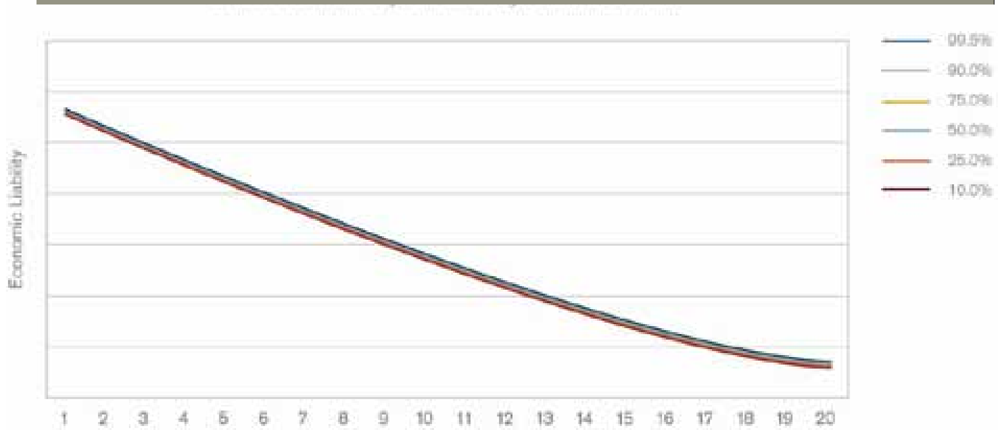

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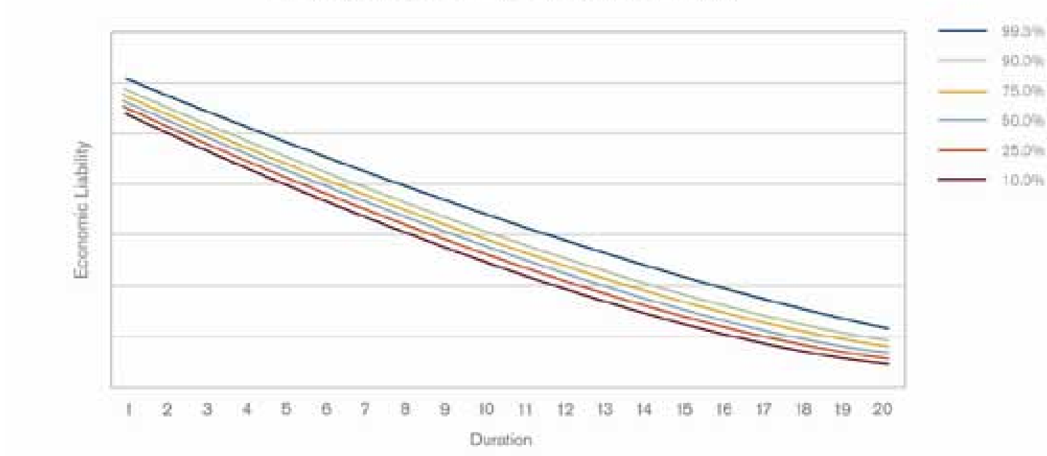
Figure 4:
Distribution of scenarios by economic liability at each future duration



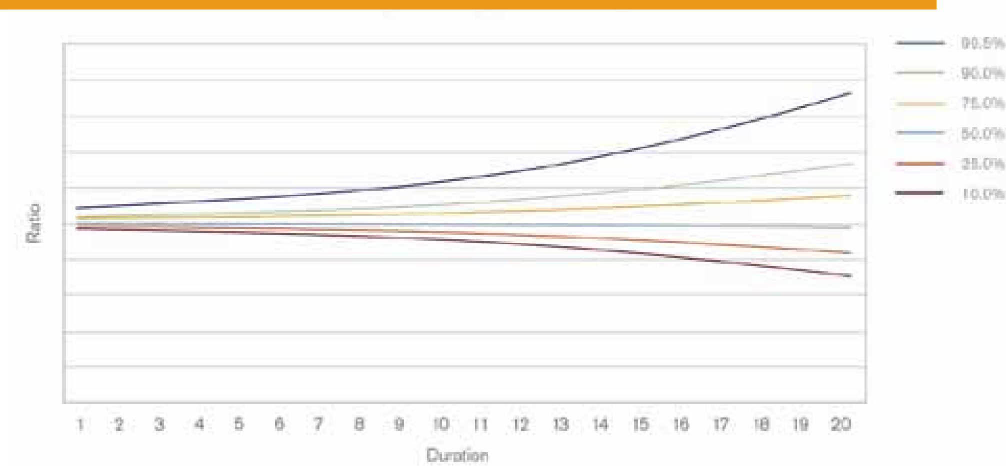
- A mismatch between the population used to generate the Annuity 2000 mortality table and the population of lives in the SPIA block.
- Volatility in future mortality improvement based on an analysis of historical levels of mortality volatility by age and gender over various time periods. Additionally, we reflected historical levels of correlation by age and genders over time periods. Then we projected volatility in future mortality improvement in manners consistent with how the factors were derived from the historical data.
- Further, our stochastic analysis reflected the possibilities of extreme longevity occurrences, such as a breakthrough in medical research.

Using the above assumptions and methodology, we focused on two economic capital measures (i.e., the 99.5th percentile and CTE 90). We calculated these capital measures at two discount rates:

- the economic liability using the 5.5 percent expected earned rate, which represents the economic capital required because of the longevity risk
- the economic liability at the 4.75 percent earned rate after entering into a total return swap rate, which represents the economic capital after reflecting longevity risk and asset risk

(Note: The economic reserve for this SPIA book is the average of all stochastic scenarios.)

Figure 5:
Ratio of scenarios economic liability to the average economic liablitity at each future duration



The difference in economic capital values at the two discount rates represents the capital required because of the asset risk.

The resulting value of $10.6 billion is fairly similar to the figure produced by the statutory reserve of $10.4 billion. To some extent this result is coincidental. This is because, at this point in time, the 10 percent reduction in mortality rates used to build conservatism in the Annuity 2000 table happens to be in line with mortality improvements that we applied to the Annuity 2000 basic table. However, if mortality improvement continues, the 10 percent reduction will become increasingly insufficient.

As shown in the table in Figure 7, the economic capital requirement for the asset risk is reasonably similar to the statutory capital requirement. However, the lack of a capital charge for longevity risk is glaringly apparent.
In fact, the main difference between the two methods can be seen in the $83 million capital needed for longevity risk under the economic model at the 99.5th percentile (or $55 million at the CTE 90 level) compared to no capital needed under the statutory formula. This figure is significant in itself, but it also highlights the shortcomings of using static assumptions to assess risk.

When static assumptions are used to calculate economic liabilities, the reserve results tend to converge around the mean, but if dynamic assumptions are used instead, the tail percentile values show a much wider dispersion, which enables us to have a better understanding of the risk profile.

The choice of assumptions has an impact not only on percentile values over time, but also on the average economic liability. In this case study, the average economic liability at 4.75 percent rate was calculated to be $11.235 billion using dynamic assumptions, compared to $11.169 billion from another stochastic analysis but in this case using static assumptions. The fact that economic liability under the dynamic assumptions is $66 million more than that under static assumptions is no coincidence but rather reflects the asymmetry in the annuity payout patterns.

This asymmetry stems from the greater likelihood that on average more beneficiaries will live longer than expected than will die sooner than expected. Think about it. Reflecting volatility increases the range of possible values—both increasing and decreasing values. But while people can live to the end of the mortality table, they can't die before the valuation date. This phenomenon therefore increases the possibility that a beneficiary will live longer rather than die earlier, creating the asymmetry. This "cost of volatility" is not reflected in the insurer's liability unless mortality volatility is introduced into the equation.

DEAL OR NO DEAL?

The additional $66 million is not an insignificant sum. For some investors, it might make or break a deal. But insurers, which have a mandate similar to other investors, often ignore mortality volatility in assessing their products, and thereby make themselves vulnerable to underperforming products.

Figure 6:
Economic Reserve and Capital ($ in billions)

1	Average economic liability value (or economic reserve) discounted at 5.50%	$10.61	
		99.5th percentile	CTE 90
2	Economic liability value discounted at 5.50%	$11.44	$11.17
3	Economic liability value discounted at 4.75%	$12.18	$11.87
	Capital for longevity risk (2) – (1)	0.83	0.55
	Capital for asset risk (3) – (2)	0.74	0.70
	Total economic capital (3) – (1)	1.57	1.26

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Figure 7:
Comparison of Statutory and Economic Approaches ($ in billion)

	(1)	(2)	(3)	(4)	(5)
	Statutory	Economic 99.5th percentile	(1) /(2)	Economic CTE 90	(1)/(4)
Reserve	$10.40	$10.61	98 %	$10.61	98 %
Capital for asset risk	$ 0.64	$ 0.74	86 %	$ 0.70	90 %
Capital for longevity risk	$ 0.00	$ 0.83	0 %	$ 0.55	0 %
Total capital	$ 0.64	$ 1.57	40 %	$ 1.25	51 %
Asset (reserve + capital)	$11.04	$12.18	91 %	$11.87	93 %

A far more realistic approach is to recognize longevity risk and identify ways to reduce the capital requirements associated with it. This task is admittedly no easy matter, and options are somewhat limited.

Diversification of risk through issuing life insurance can provide some capital relief, but negatively correlated risks are rarely perfectly matched, as the 1918 pandemic demonstrated with its comparatively higher death rates among young people but lower death rates for older people (relative to expected death rates).

An insurer also may try to reduce its capital charges by demonstrating to its rating agencies its attention to capital management and the steps it is taking to manage its capital needs.
A relatively new but increasingly popular option is the securitization of longevity risk. Markets for longevity derivatives (i.e., longevity swaps or bonds), have started to materialize. These financial instruments make payments based on a survival rate over some period of time.

To see how such an instrument might reduce an insurer's capital requirements, let us consider the case of a hypothetical 10-year longevity bond with principal of $1 billion. The bond is offered to investors with a 5.5 percent coupon, but the insurer has a 4.75 percent investment assumption, producing an annual cost of 75 basis points to the insurer. After 10 years, the principal is repaid, assuming the economic liability is below the attachment point. However, if the economic liability at the end of 10 years is above the attachment point, the insurer will not need to repay some of the principal, which ultimately offsets the higher-than-expected reserves the insurer is holding. In fact, if the economic liability reaches the exhaustion point, the insurer would not need to repay any principal.

In this hypothetical example, the probability that the insurer will reach the attachment point is 4.0 percent (or 40 out of 1,000 scenarios), while the possibility of reaching the exhaustion point is 0.2 percent (or two out of 1,000 scenarios). Over the 10-year period, investors are likely to lose 1.2 percent of their principal. In 96 percent of the scenarios the result is no loss to the investor. But the average loss of the 40 attachment scenarios is $308 million.

While this investment is an out-of-the-money risk to the investor, it can immediately reduce an insurer's economic capital. In this hypothetical example, the reduction in economic capital is as much as $230 million at the 99.5th percentile capital measure, at which point the insurer's economic liability of $12.18 billion before the hedge drops to $11.95 billion after the hedge.

Other options may be available, but before an insurer starts down the capital management road, it needs to identify its sources of risk and understand their potential volatility. Without proper analysis, insurers could find themselves increasingly vulnerable to unexpected changes in mortality. Stochastic models that incorporate volatile mortality assumptions may be a useful tool to analyze this risk. ■