Featured article: Evaluating the Cost of Longevity in Variable Annuity Living Benefits

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This is a follow-up to a previous article "Considering the Cost of Longevity Volatility on VA Guaranteed Living Benefits" that appeared in the Variable Annuity Market Update Q2 2012. In that piece, we used stochastic analysis to evaluate the risk associated with unpredictable mortality results on guaranteed living benefits when the cost of investment risk is known and fixed. Here we return to that subject, but valuing the investment volatility and longevity volatility together.

While applying significant resources to measuring and managing asset risk, insurers tend to rely upon their traditional deterministic methods to price the mortality component, often using a best estimate with some explicit or implicit margin. This article discusses a stochastic mortality methodology which allows an insurer to price for its specific risk tolerance and may even identify previously unrecognized excess embedded in its assumed deterministic mortality margins. As we explore below, employing this methodology may potentially allow the insurer to offer a more competitive product (than they could have by utilizing a deterministic mortality margin) or recognize redundancies in calculated asset requirements for existing books of business.

Guaranteed Minimum Withdrawal Benefits (GMWB's) provide a guaranteed immediate annuity benefit while providing significant liquidity making these living benefits an extremely popular feature of many VA products. Insurers have generally focused on investment risk in these products and given far less consideration to longevity risk. This article is intended to look at how insurers can identify and quantify their exposure to longevity risk as well as the impact when combined with investment risk.

ASSUMPTIONS

The objective of this analysis is to quantify the value of pricing with volatility of annuitant longevity in a simple pricing exercise on a risk-neutral basis.

Product Design: We start with a relatively simple annual model for a variable annuity (VA) with a guaranteed minimum withdrawal benefit:

- Annual policy fee of $30 waived for account values in excess of $50,000
- 7% commission rate
- $140 per policy plus 1% of premium acquisition expenses
- $110 annual maintenance expense with 3% annual inflation
- Annualized 250 bps per asset charge
- Annualized 30 bps of revenue sharing
- The GMWB provides for guaranteed lifetime withdrawals, after a 10-year waiting period, and a benefit base with 6% annual rollup for 10 years and annual ratchet through age 90. The guaranteed withdrawal rate is locked in at the date of the first withdrawal as a percentage of the GMWB benefit base. The percentage varies by attained age: 3.5% for ages below 70, 4.5% for ages 70-79, and 5.5% at ages greater than 80.
- The GMWB Fee is expressed as an annualized charge of 80 bps of the benefit base

Investment Returns: The analysis assumed premiums were allocated to a 60%/20%/20% mix of domestic equity (SPX), international equity (EAFE), and bond investment portfolios, using 1,000 risk-neutral scenarios. Selected capital markets assumptions are consistent with a long term equity volatility of about 20%. Assumed correlation between S&P and EAFE was 84%.

Other Assumptions: The analysis was limited to a 100 sample cells.

- Made up of 10 cells of each age 55, 60, 65, 70, and 75, Male and Female
- $100,000 initial deposit for each policy
- Expected mortality: A2000 Basic US Annuity Table with 1% annual improvement beginning in 2001
- Annual lapse rates of 1%, 2%, 2%, 3%, 4%, 5%, 6% and 10% in years 8+, with a 30% spike in lapses at the end of year 7, plus Dynamic lapse rate multiple of max[0, 1 - 0.75 * (GMWB/AV - 1)] if GMWB > AV, where GMWB is the GMWB face amount and AV is the account value

RISK NEUTRAL PRICING

For each scenario, we calculated the present value (discounted at the risk-free rate of interest) of the GMWB benefit base, GMWB fees and GMWB claim payments along each scenario. From these values, we can make some observations:

- The Hedge Cost is calculated as the present value of the GMWB claim payments divided by the present value of GMWB benefit base amounts. The average Hedge Cost over the 1,000 scenarios in our analysis was 99 bps.

- The excess of the Hedge Cost over the GMWB fees (approximately 19 bps) may be treated as a shortfall that will be made up by either increasing the GMWB fees or other policy charges.

Stochastic Modeling of Assets and Longevity:

The analysis thus far has assumed a static mortality curve, which was assumed to be a best estimate assumption, without an explicit margin for adverse deviation. Rather than relying on an assumed margin to cover longevity risk, we can use stochastic modeling of future mortality rates. Starting with the assumed mortality without margin (A2000 Basic with 1% Annual Mortality Improvement) and using REVEAL, a proprietary Milliman software tool[1], we applied three stochastic elements to future mortality rates:

1. ***Trend Risk:*** The initial expectation is that future mortality improvement is represented by an average 1% per year. The stochastic projection is designed such that the mean results are still in line with this expectation, but now reflects volatility in the pattern of future mortality improvement. Volatility metrics were utilized to be consistent with historical US general population mortality improvement volatility as measured over 1970-2010. The randomly projected results are designed to be consistent with the standard deviation of the historic data, as measured annually and over consecutive 10-year periods, and have the same correlation across genders and 10-year age groups.

2. ***Extreme Mortality Event Risk:*** We also reflected that future mortality rates are subject to the annual risk of a significant and permanent change by cause of death:
    1. 1% Annual Probability of 25% decrease in deaths by Neoplasm
    2. 1% Annual Probability of 25% decrease in deaths by Circulatory Disease

    The factors are intended to capture the real possibility that new treatments will be identified for cancer and/or heart disease. These factors are designed to reflect the potential for volatility in excess of historical averages[2].

    There were two reasons that we chose to test and simulate potential reductions in cancer-related deaths:

    - As of this writing, there has not been significant reduction in cancer related deaths in the period of years used to develop the historical mortality improvement trend volatility statistics.
    - Active efforts in current medical research may lead to significant advances in treating cancer. However, while there is reason to continue hoping for mortality improvement, we note that past developments have not produced large changes in mortality. This is in contrast to the recent history of measurable reductions in deaths from heart disease.

    In considering heart disease, we recognized that while there have been significant reductions in heart related disease from changes in public behavior, public policy, and medical advancements over the period measured for trend risk volatility, there is still significant research leaving a possibility we can see a further breakthrough. As such, we also test for a potential extreme reduction in heart related deaths.

3. ***Basis Risk:*** In selecting an expected mortality table (A2000 Basic in this case), an insurer is making an actuarial judgment. However, even if that selection is supported by past experience, experience may emerge that varies from that table, possibly attributable to the company characteristics and the profile of its distribution, or simply some slight skewing by region, type of employment, or other differential. Therefore, there is some risk that the "expected" table may be off. This may be seen as uncertainty that the base table is 100% appropriate for the specific population. Therefore, we assumed that the starting expected mortality table is not known with full certainty. In addition to reflecting volatility in future mortality improvement patterns, we assumed that the starting expected mortality table would be subject to a normal distribution around 100% with a standard deviation of 10.00%. As with the volatility of mortality improvement, a randomly generated value was used for each scenario which applied to the expected mortality in all years for all policies being tested in that scenario.

These are three representative sources of mortality volatility that can adversely affect annuity experience. There are additional components of mortality volatility that could impact life insurance experience that was not tested in this analysis. We assumed that each of the three sources of volatility were independent. We also note that Trend Risk and Basis Risk produce scenarios that, on average, should gravitate towards the expected mortality and improvement. However, each of the Extreme Mortality Event Risk components produces adjustments to mortality that are consistently downward at rates that reflect the distribution of deaths by cause.

Cost of Stochastic Longevity:

Stochastic longevity was captured in 1,000 stochastic scenarios that treat the volatility of asset returns and longevity as independent. However, instead of using fixed assumptions for mortality, we explicitly modeled the potential longevity volatility.

1 REVEAL (which stands for Risk and Economic Volatility Evaluation of Annuitant Longevity) is a system developed to analyze longevity risk. REVEAL generates stochastic projections on pension and annuity liabilities with volatile assumptions (i.e., baseline mortality, mortality improvement, extreme mortality and longevity events, and plan participant behavior - such as retirement dates and benefit elections). For more information about REVEAL, please see http://www.milliman.com/Solutions/Products/REVEAL/.

2 This analysis does not reflect the possibility of a pandemic or other potential spikes in mortality rates.

	Average Hedge Cost
Baseline Pricing ***(Without Margin)***	99 bps
Baseline Pricing with Longevity Volatility	102 bps

This demonstrates that the stochastic mortality model has a small but measurable impact on average over many scenarios. When we perform stochastic analysis with static assumptions, the average of the scenario liabilities (over all scenarios) will converge to the deterministic "Best Estimate Liability", which is present value of cash flows based on the deterministic expected assumption. However, if dynamic assumptions are used instead, the tail percentile values show an asymmetric dispersion, resulting in small but consistent divergence between the average of the scenario liabilities from the stochastic valuation and the deterministic Best Estimate Liability.

The average of the scenario liabilities using the stochastic longevity assumption set is higher than the deterministically calculated Best Estimate Liability. The fact that economic liability under the dynamic assumptions is more than that under static assumptions is no coincidence but rather reflects the asymmetry in the annuity payout patterns.

The average beneficiary has an equal chance of living longer than expected or dying sooner than expected. Reflecting volatility increases the range of possible values—both increasing and decreasing values. However, this asymmetry stems from the fact that there is a limit to how much sooner a beneficiary might die (i.e., on or after the valuation date), but the date to which they might survive is open-ended. Hence, the premature death can eliminate a limited number of annuity payments, but the unexpected survivor may receive a greater number of additional payments.

This average cost in excess of the best estimate is not reflected in the insurer's liability unless stochastic mortality is incorporated. An insurer investing its capital to issue annuity products that accept this risk should be compensated for this additional cost.

However, if companies are using static liability margins in all their stochastic processing, it is possible they are either understating or overstating some modeled risk. The excess levels will depend on the static margins currently being used and the liability volatility parameters chosen.

Reserving / Capitalizing For Longevity Volatility:

GMWB benefits on variable annuities consist of two separate guarantees being provided by the insurer: investment return and longevity coverage. The insurer will use an investment strategy that may include investment hedges to manage the investment risk. This is possible because there is a relatively robust marketplace for such instruments to calibrate a risk-neutral model. However, there is no universal risk-neutral assumption for future mortality trends. Furthermore, there is virtually no source for equivalent financial instruments to hedge longevity risk (other than reinsurance). Unlike participating universal life and whole life policies that have non-guaranteed elements (current cost of insurance charges and policyholder dividends) to address unanticipated adverse changes in future mortality, the GMWB does not have adjustable charges or benefits that may be modified in case of adverse longevity experience. Therefore, when considering reserving and capital levels, the prudent actuary may build an appropriate margin into their analysis to safeguard the company from this unforeseen risk. To the extent that this risk is recognized, it is commonly addressed by setting the mortality table and future improvement assumptions to reflect a margin for adverse experience.

In the absence of a rigorous stochastic mortality model, a deterministic margin may be included in the mortality assumptions. However, without testing stochastic longevity directly, one cannot measure the risk associated with the selection of the ad hoc deterministic margins. For this analysis, we consider a reserving/capital assumption based on the deterministic pricing assumption but with an additional specific margin for longevity equal to 10% of the expected mortality rates and 50% of the future annual mortality improvement. That is, the assumed mortality will equal 90% of the A2000 Basic (which approximates the A2000 valuation table) with 1.50% future annual mortality improvement which is more consistent with recent US experience. As the annuitants are assumed to live longer, this increases the calculated Hedge Costs to 114 bps.

	Average Hedge Cost
Baseline Pricing *(Without Margin)*	99 bps
Pricing with Margin for Contingencies (Reserving/Capital)	114 bps

While the static margins added may feel appropriate, this approach to measuring longevity risk fails to produces a measure of the chance or severity of adverse experience. In order to evaluate the longevity risk, we looked at the calculation of PV net GMWB cash outflows (i.e., claims less charges), not just on average, but also at various percentile rankings of the 1,000 scenarios.[3] In the following table, we compare the results under three sets of liability assumptions: 1) baseline pricing assumption without a margin, 2) baseline pricing assumption with the margin, and 3) baseline pricing without the margin but reflecting longevity volatility.

[3] While it is likely more theoretically pure to examine percentile values using a real world paradigm, we utilize the current risk neutral projections for simplicity and consistency with the above hedge cost calculations.

Present Value of GMWB Cash Outflows

Percentile of Present Value of Cash Outflows	(1) Baseline Pricing			(2) Pricing with Margin for Contingencies (Reserving / Capital)			(3) Baseline Pricing with Longevity Volatility		
	PV Claims	PV Charges	PV Outflows	PV Claims	PV Charges	PV Outflows	PV Claims	PV Charges	PV Outflows
50%	1,112,138	1,136,437	(24,298)	1,298,308	1,160,555	137,752	1,166,290	1,150,708	15,582
75%	2,027,714	1,315,651	712,063	1,857,912	904,905	953,008	2,068,468	1,298,854	769,614
90%	2,661,929	956,914	1,705,015	3,299,800	1,161,881	2,137,918	2,754,265	988,306	1,765,959
95%	3,372,525	1,012,111	2,360,413	4,011,952	1,074,505	2,937,447	3,690,432	1,101,707	2,588,725
99%	5,568,003	1,109,447	4,458,556	6,480,918	1,119,424	5,361,494	6,051,011	1,219,590	4,831,420

Column (1), which illustrates the results using the the baseline pricing deterministic mortality assumption shows the volatility in claims driven entirely by the volatility in the investment scenarios. While insurers can implement hedging strategies to offset the increase in net cash outflows, they still bear the longevity risk. Column (2) illustrates the higher present value of future net cash outflows when a margin is built into the longevity assumptions. Column (3) illustrates the present value of future net cash outflows starting with the baseline longevity assumption without the margin, but then in addition to the investment volatility, directly reflects stochastic longevity volatility in the excess of the PV of net cash outflows reflecting adverse longevity experience compared to the Baseline Pricing.

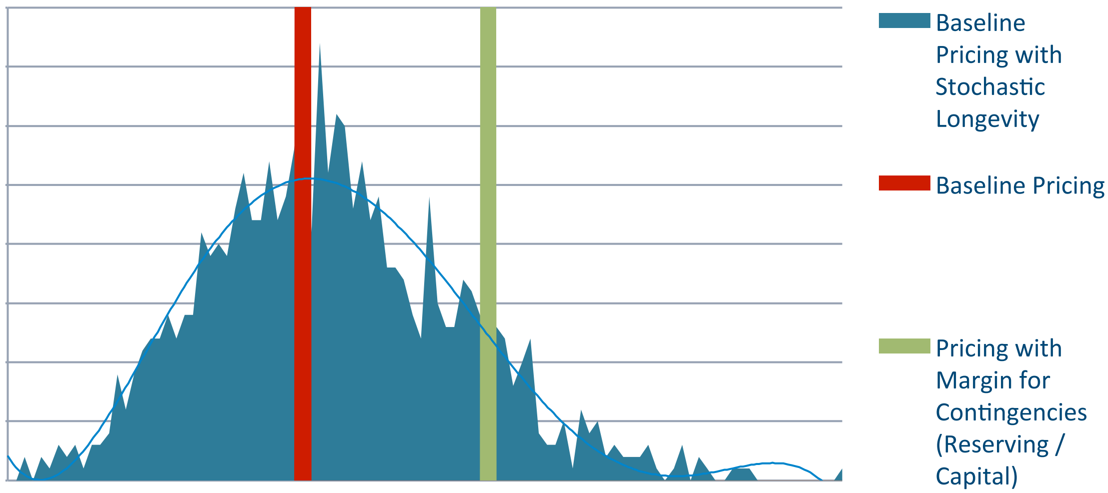
While the present value of charges are relatively stable across scenarios, the present value of claims vary significantly. As can be seen in this example from the differences in the PV of cash outflows (compared to baseline pricing), using the static margin approach to reserve or capitalize for the longevity risk may cause the insurer to be not as competitive or as profitable as it could have been if it were examining risk directly with a stochastic longevity methodology. Other situations may exist where the insurer's static margin is not adequate for the longevity risk profile it is incurring. We believe the analyzing the longevity risk directly using a scientific approach, in conjunction with deterministic stress testing, will help the insurer have a better understanding of its longevity exposure.

The results in the charts above reflect the fact that the investment returns and stochastic longevity are moving independently in the stochastic simulations. We note that if the risk neutral scenarios were real world scenarios and the insurer wasn't hedging, then the distribution described here would be indicative of the benefit of diversification between mortality variations and capital markets changes. In some scenarios, we can simulate poor investment scenarios but good longevity scenarios, In some scenarios it could be reserved. Also, some scenarios could result in good or bad simulated experience for both investment and longevity. Thus, we believe it is instructive to also examine the effect of the stochastic longevity when the investment results are held to a single scenario.

We identified the investment scenario that produced the 95th percentile results under the Baseline Pricing stochastic simulation (i.e., scenario155 of 1,000 which resulted in the present value of net cash outflows of $2,360,413), We examined how that specific investment scenario was affected by 1) adding the deterministic margin for contingencies (increasing the present value of net outlflows to $2,859,615[4]), and 2) all 1,000 stochastic longevity scenarios. The following chart demonstrates the range of results that may be attributable solely to longevity volatility.

[4] Because of the interaction of investment and longevity scenarios, scenario 155 ranks at the 95th percentile under Baseline Pricing assumption set. While close, scenario 155 does not rank at the 95th percentile under assumption set used to determine the Pricing with Margin for Contingencies (Reserving/Capital) result.

Present Value of GMWB Cash Outflows
Distribution of Scenarios - Investment Scenario at 95th Percentile



Present Value of GMWB Cash Outflows
Investment Scenario at 95th Percentile

(1) Baseline Pricing	(2) Pricing with Margin for Contingencies (Reserving / Capital)	Percentile of Present Value of Cash Outflows	(3) Baseline Pricing with Stochastic Longevity
2,360,413	2,859,615	50%	2,421,149
		75%	2,669,901
		90%	2,893,729
		95%	3,023,199
		99%	3,350,153

Note columns (1) and (2) each reflects a single investment scenario and a single longevity scenario. Thus only a single value is shown.

Under this single investment scenario, we can see that the deterministic margin provides for longevity deviation that is nearly equivalent to the 90th percentile scenario. However, using the deterministic margin approach implicitly assumes that an adverse longevity scenario will unfold along with each investment scenario. The deterministic margin approach does not reflect diversification benefit with other risks. Directly reflecting the stochastic longevity in the stochastic analysis does allow us to directly reflect diversification, which is demonstrated by the simulated lower PV of net cash outflows in the results when both the longevity and investment scenarios are volatile (compared to the results when only the longevity scenario is volatile). In this example, the PV of cash outflows at the 95th percentile when recognizing the diversification benefits of the investment and longevity risk ($2,588,725) was calculated to be less than the PV of cash outflows based on the 75th percentile longevity risk scenario around investment scenario 155 ($2,669,901).

We note that the most rigorous approach to setting a longevity margin would involve a detailed projection of hedges over stochastic scenarios for both investment returns and stochastic longevity experience. Such a projection would reflect the risk of over or under hedging due to uncertainty in the projection of mortality. We leave such quantification to a future exercise.

CONCLUSION

While static liability margins may feel tangible, they may actually be arbitrary. We believe it makes sense to consider static liability margins in context of historical levels of liability volatility. Rather than rely upon a best estimate plus a static margin, the above approach allowed us to directly quantify the cost of stochastic mortality. Further, we believe this approach will allow insurers to fine tune their risk tolerance, providing measures to balance risk management and product pricing. In fact, this stochastic methodology may identify previously unrecognized excesses embedded in the static margins, including the diversification benefit of the investment and longevity risk, allowing the insurer to recognize redundancies in calculated asset requirements for existing books of business or possibly offer more competitive products (if previously priced with deterministic mortality margins). Stochastic modeling of longevity risk can be a useful tool in the pricing and management of variable annuities with living benefits.