Enhancing SAA outcomes with derivatives: Insights from a RILA case study

Alfred Au, FSA, MAAA
Vincent Embser, FSA, MAAA
Ken Qian, FSA, MAAA

Milliman

Executive summary

Reserve and capital requirements for registered index-linked annuities (RILA) under VM-21 and non-variable annuities under VM-22 are heavily driven by asset-liability mismatch. Duration mismatch can drive losses in tail scenarios, and liquidity mismatch can result in forgone profits (from an overly conservative asset portfolio) or punitive illiquidity cost (from high sales cost under forced sale of illiquid assets). This paper provides a case study on a block of RILA new business to illustrate how derivatives can play a key co-optimization role in strategic asset allocation (SAA). This paper also presents an analytical framework to quantify the drivers of the VM-21 reserve requirements, including the costs of asset-liability management (ALM) mismatch and liquidity, and to facilitate comparisons of candidate SAA portfolios.

We compare three different asset portfolios, with two of them allocated to higher-yielding assets at the cost of larger duration mismatch:

1. Baseline cash flow and well-duration matched portfolio with typical industry asset allocations
2. Higher allocation to floating rate asset classes, such as collateralized loan obligations (CLOs) at the cost of lower asset duration. Structured assets like CLOs tend to earn higher spreads than corporate bonds with the same credit rating.
3. Higher allocation to longer-tenor corporate bonds at the cost of higher asset duration to earn additional term premium

For each of the portfolios, we used interest rate derivatives to manage ALM risk, thereby preserving a larger portion of the asset yield in the tail scenarios and showcasing their use as a SAA co-optimization tool. While more dynamic reinvestment and disinvestment strategies are common alternatives to improve SAA outcomes, they are not in the scope of this paper.

While this paper focuses on RILA under VM-21, many similar takeaways can be applied to other asset-intensive, non-variable annuities such as fixed-indexed annuities (FIA) under the recently adopted VM-22 principles-based reserving (PBR) framework[1]. Like VM-21, VM-22 PBR requires insurers to model assets and liabilities under stochastic economic scenarios. Both methodologies allow for the reflection of hedging, and this paper establishes a framework for understanding the costs and benefits of different hedging strategies to improve ALM outcomes. With the increased use of complex, illiquid assets, insurers must understand the ALM challenges these investments introduce and how thoughtful hedging strategies can mitigate these risks while preserving the targeted yield profile.

Liability summary

The modeled RILA liability is $1 billion notional of new business with a mix of one-year, three-year, and six-year segments indexed to the S&P 500. The surrender charge period of the product is six years, and typical product features and industry assumptions are reflected in this analysis. Additional details are documented in the Appendix.

[1] Effective January 1, 2026, the National Association of Insurance Commissioners (NAIC) has adopted a principle-based reserving (PBR) statutory framework for non-variable annuities under VM-22, to be applied prospectively to new business.

Asset portfolio summary

This analysis constructed three different asset portfolios of similar average credit rating to support the RILA liability. More details of each portfolio can be found in Figure 1:

- **Baseline portfolio:** This portfolio consists of a mix of corporate bonds, CMBS, CLOs, and private credit, with most bonds maturing in six years. The intent of this portfolio is to cashflow match the liability along a best estimate forward rate path scenario, as well as closely match the initial liability effective duration, which is approximately ~4.25.
- **CLO-heavy portfolio:** This portfolio reallocates 15% of the Baseline portfolio from fixed rate corporate bonds into BBB CLOs to pick up higher yield from CLOs at the cost of larger duration mismatch, since CLOs traditionally pay floating rate coupons and have close to zero duration. CLOs are considered less liquid than corporate bonds, and are assumed to have a higher sale cost in this analysis.
- **Long-duration portfolio:** This portfolio reallocates the Baseline portfolio from six-year to twenty-year corporate bonds to pick up higher yield from term premium, at the cost of larger duration mismatch.

The alternative portfolios illustrate two common strategies to attain higher asset yields with similar U.S. risk-based capital (RBC) C-1 charges:

1. In recent years companies have increased their allocations to private and structured credit (like CLOs) that typically earn higher spreads than corporate bonds for the same credit ratings[2].
2. Insurers have historically been willing to take longer duration risk to earn higher yields. However, duration mismatch now directly results in higher reserve requirements under VM-21 and VM-22 PBR. Our analysis explores how duration mismatch can be managed to effectively realize higher asset yields for such strategies.

FIGURE 1: ASSET PORTFOLIO COMPOSITION

ASSET CLASS	RATING	TENOR	LIQUIDITY TIER (1-HIGHEST; 3-LOWEST)	NET SPREAD	BASELINE PORTFOLIO WEIGHTS	CLO-HEAVY PORTFOLIO WEIGHTS	LONG-DURATION PORTFOLIO WEIGHTS
Public corporate bonds	A	6	1	0.24%	20%	20%	0%
Public corporate bonds	A	20	1	1.13%	0%	0%	20%
Public corporate bonds	BBB	6	1	0.50%	20%	10%	0%
Public corporate bonds	BBB	20	1	1.39%	0%	0%	20%
CMBS	AA, A	6	2	1.40%	15%	15%	15%
CLO	AAA, AA, A	6	2	1.49%	20%	20%	20%
CLO	BBB	6	2	2.96%	5%	20%	5%
Other fixed bonds (e.g. private-placements)	A, BBB	5 to 10	3	1.38%	15%	10%	15%
Private credit	A, BBB, BB	5 to 10	3	4.67%	5%	5%	5%
Portfolio effective duration					3.77	2.99	6.50
Portfolio net spread					1.29%	1.63%	1.65%
Time zero portfolio earned rate					5.52%	5.86%	5.88%
RBC C-1 charge					0.81%	0.82%	0.81%

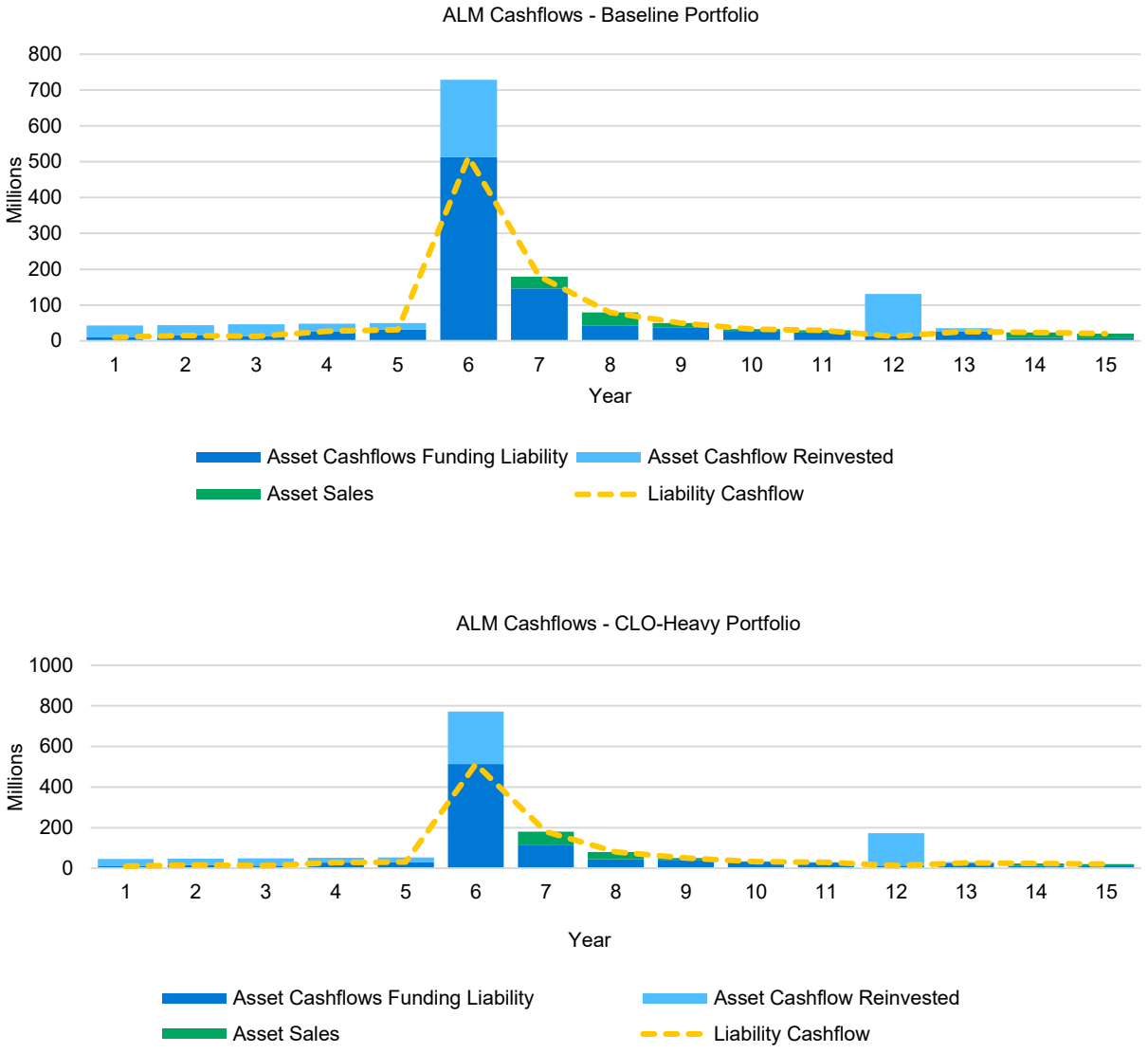
[2] Historically NAIC capital charges have not varied between different fixed income investments with the same credit rating, so a BBB public corporate bond would have the same C-1 charge as a BBB-tranche CLO. As of publication of this paper, NAIC has been reviewing potential changes to C-1 capital charges for lower rated tranches of CLOs. If implemented the risk-return trade-off of the portfolio allocation changes analyzed in this paper will be different.

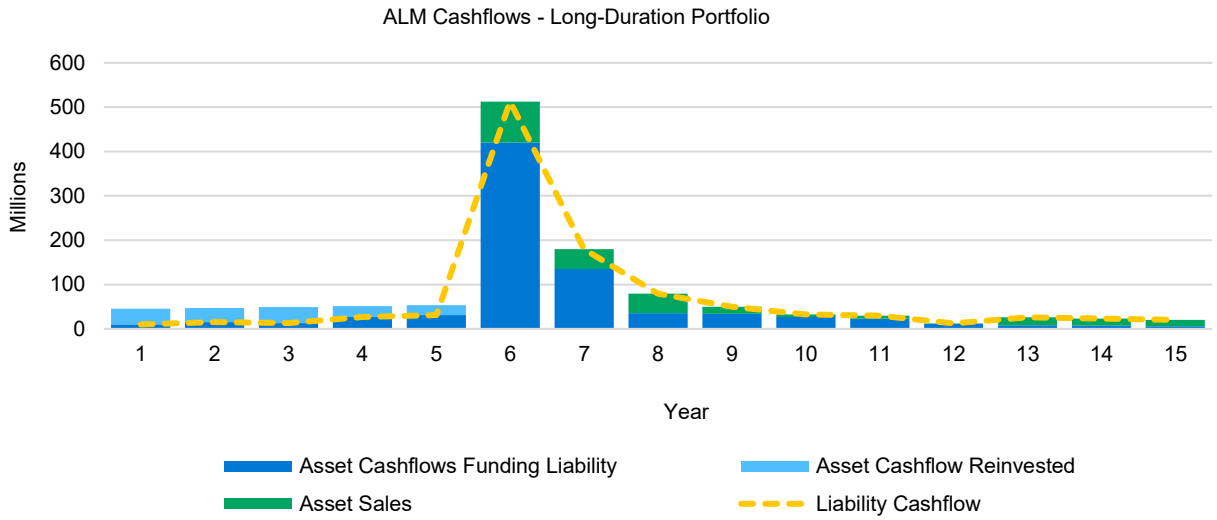
Asset and liability cashflows along deterministic forward-rate path

To illustrate the asset and liability cashflows, the charts in Figure 2 below show the annual cashflows under a deterministic scenario, where rates follow the expected forward path.

- The **Baseline portfolio** has excess cashflows over the first six years that are reinvested. The principal payments from 6-year bonds are more than sufficient to cover the liability outflow in year 6, which is driven primarily by the sizable shock lapse following end of the surrender charge period. Some assets are sold in the following years as the lapse-driven outflows are greater than the coupon payments from the reinvested assets.
- The **CLO-heavy portfolio** has a similar cashflow pattern, because its assets have the same maturity as the baseline portfolio. However, under an alternative low rate scenario, the CLO floating-rate investment income will be reduced.
- The **Long-duration portfolio** has a cashflow shortfall in year 6, which requires selling some of the 20-year corporate bonds to fund the shock lapse. Although capital gains/losses are minimal under this deterministic, forward-rate scenario, they could be significant under scenarios with large rate increases during the shock lapse year.

FIGURE 2: ASSET AND LIABILITY CASHFLOWS ALONG DETERMINISTIC FORWARD-RATE PATH SCENARIO





Interest rate hedging

Based on the asset-liability cash flow match shown in the section above, we would expect some cost of ALM mismatch to be captured in the VM-21 reserve requirement. To mitigate the ALM risk, we used interest rate swaps to manage the duration mismatch.

We calculated key rate rho for assets and the economic liability. Interest rate swaps are sized at time 0 based on the residual key rate rho between the assets and the hedge target, which is defined as a function of the economic liability, and rebalanced every year based on the projected asset and hedge target rho.

Figure 3 below plots the evolution of the parallel rho of the liability and the three asset portfolios along the deterministic forward path scenario. The spike in liability and asset rho at the end of year six is driven by the renewal of the six-year segment and reinvestment of the six-year assets, respectively.

FIGURE 3: PARALLEL RHO ALONG DETERMINISTIC SCENARIO

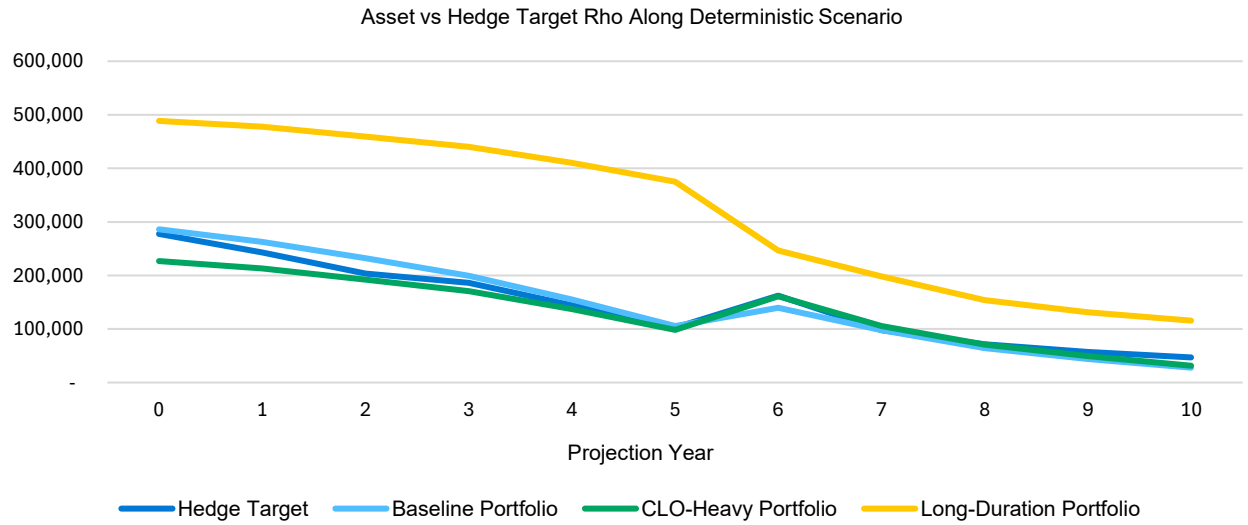


Figure 4 below summarizes the initial hedge target key rate rho and the residual key rate rho (KRR) of each asset portfolio that is hedged with swaps.

FIGURE 4: INITIAL HEDGE TARGET RHO AND HEDGED RHO BY ASSET PORTFOLIOS

	RESIDUAL KRR TO BE HEDGED WITH SWAPS			
KRR TENOR	**HEDGE TARGET KRR**	**BASELINE PORTFOLIO**	**CLO-HEAVY PORTFOLIO**	**LONG-DURATION PORTFOLIO**
1	-18,928	-9,578	-7,238	-9,011
2	-1,701	2,725	1,634	3,073
3	-24,661	-12,679	-15,319	-11,774
5	-109,905	14,908	-6,352	-50,551
7	-102,054	33,517	-3,128	-15,382
10	18,318	18,318	18,318	59,909
15	-23,735	-23,735	-23,735	32,262
20	-10,725	-10,725	-10,725	206,669
30	-4,161	-4,161	-4,161	-4,161
Total	-277,553	8,590	-50,707	211,033

An analytical framework for understanding VM-21 requirements

For purposes of this paper, VM-21 is used as the basis for understanding the risk-return profile of the candidate portfolios. The VM-21 stochastic scenario framework provides a large number of data points to identify and study scenarios where a given candidate portfolio is sub-optimal.

We reflected typical assumptions for the VM-21 calculations with back-to-back index credit hedging, and modeled collateral needs for derivatives and asset sale costs that vary by asset class. Additional details are documented in the Appendix.

To attribute the drivers of the VM-21 requirements, we developed an analytical framework to explain the walk from the starting asset portfolio yield to the effective reserve discount rate. The results of this attribution are shown in Figure 5. The yield impacts quantify the reserve margins associated with the corresponding assumptions and risk factors, relative to the forward path deterministic scenario. By establishing a clear connection between asset yield and liability yield, the risk-return trade off from changes in asset allocation/investment strategy can be easily assessed.

FIGURE 5: CTE70/CTE98 YIELD WATERFALL

	CTE70 YIELD			CTE98 YIELD		
ATTRIBUTION STEPS	**BASELINE PORTFOLIO**	**CLO-HEAVY PORTFOLIO**	**LONG-DURATION PORTFOLIO**	**BASELINE PORTFOLIO**	**CLO-HEAVY PORTFOLIO**	**LONG-DURATION PORTFOLIO**
1. Starting assets	**5.47%**	**5.76%**	**5.72%**	**5.47%**	**5.76%**	**5.72%**
Impact on yield						
2. Portfolio turnover	0.10%	0.11%	-0.13%	0.10%	0.11%	-0.13%
3. VM-21 assumption and reinvestment PADs	-0.27%	-0.37%	-0.16%	-0.27%	-0.37%	-0.16%
4. ALM mismatch	-0.23%	-0.28%	-0.90%	-0.57%	-0.50%	-1.96%
5. Equity risk	-0.12%	-0.14%	-0.07%	-0.09%	-0.13%	-0.05%
6. Liquidity cost from collateral needs	-0.02%	-0.01%	0.00%	-0.04%	-0.12%	0.00%
No rate hedging	**4.93%**	**5.07%**	**4.46%**	**4.59%**	**4.75%**	**3.41%**
Impact of rate hedging	0.07%	0.12%	0.63%	0.24%	0.28%	1.44%
7. Rate hedging	**5.00%**	**5.19%**	**5.09%**	**4.84%**	**5.03%**	**4.86%**

For reference, Figure 6 shows the resulting VM-21 CTE70/CTE98 requirements in excess of cash surrender value (CSV), expressed as a percentage of initial premium.

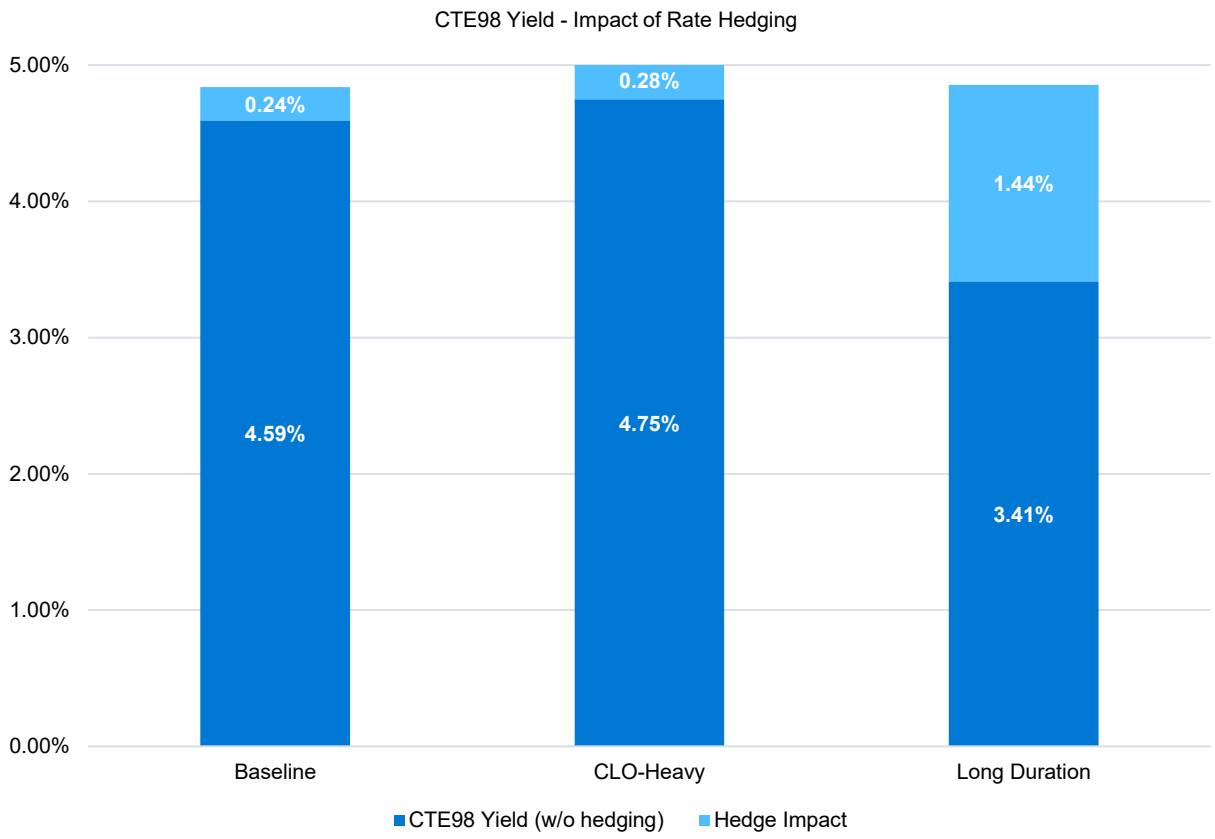
FIGURE 6: CTE70/CTE98 REQUIREMENTS

	CTE70			CTE98		
VM-21 REQUIREMENT IN EXCESS OF CSV (AS PERCENTAGE OF INITIAL PREMIUM)	**BASELINE PORTFOLIO**	**CLO-HEAVY PORTFOLIO**	**LONG-DURATION PORTFOLIO**	**BASELINE PORTFOLIO**	**CLO-HEAVY PORTFOLIO**	**LONG-DURATION PORTFOLIO**
No rate hedging	1.17%	0.47%	4.09%	3.24%	2.29%	11.10%
With rate hedging	0.76%	0.06%	0.35%	1.75%	0.58%	1.64%

Our analysis shows that for a traditional RILA block with full back-to-back index credit hedging, VM-21 requirements are heavily driven by ALM interest rate risks. Figure 7 shows that interest rate hedging improves the CTE98 yield for the Baseline and CLO-heavy portfolios, and drastically improves the yield for the Long-duration portfolio. The CTE70 improvements, while smaller in magnitude, are comparable and support applicability for such an interest rate hedging strategy to VM-22.

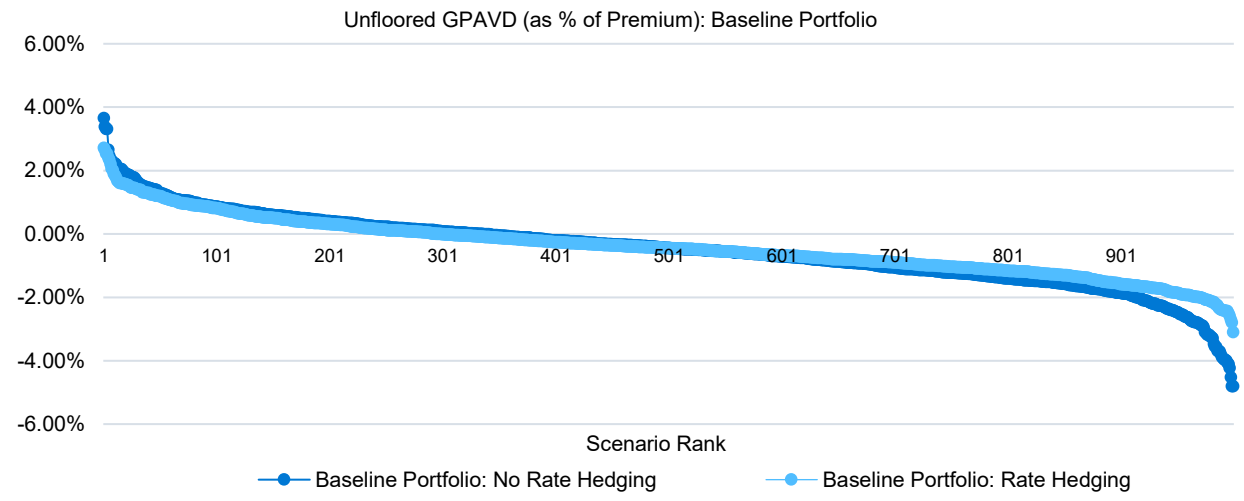
This validates that interest rate hedging can be used as a SAA co-optimization tool to capture higher asset yield and mitigate the ALM mismatch risk introduced by alternative portfolios.

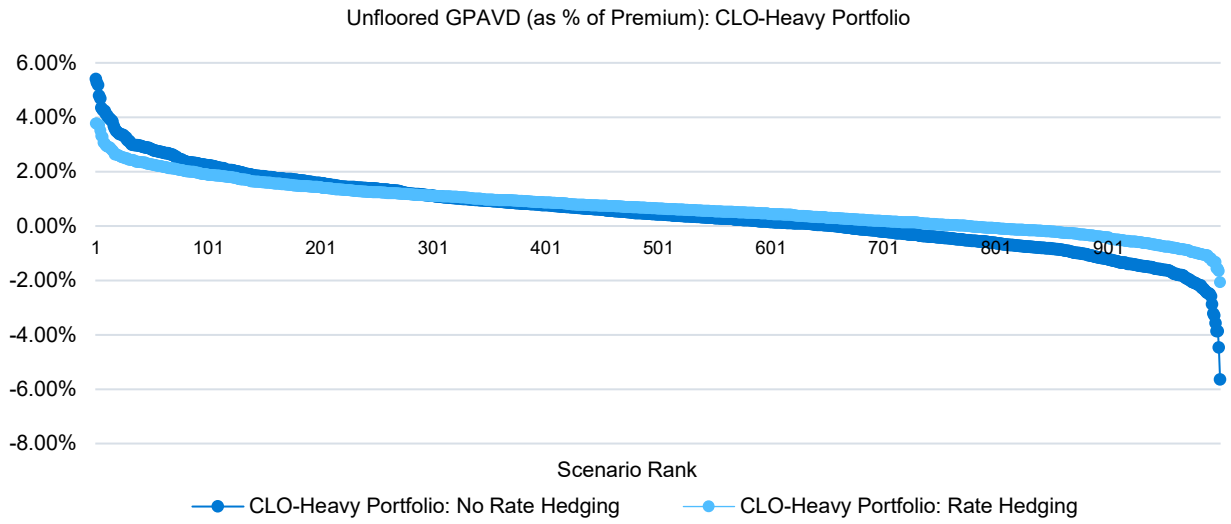
FIGURE 7: CTE98 YIELD – IMPACT OF RATE HEDGING

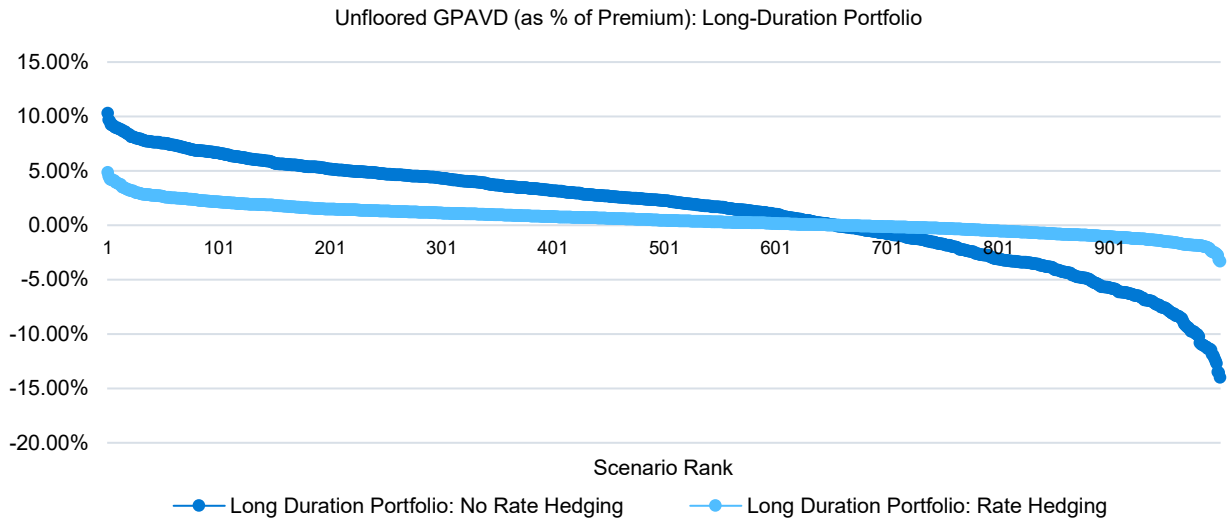


To further understand the impact of rate hedging across the distribution, a comparison of the full set of scenario-level greatest present value of accumulated deficiencies (GPVAD), represented as a percentage of initial premium, is shown below in Figure 8. Based on the observed flattening of the GPVAD distribution, rate hedging noticeably reduces the volatility of the scenario requirement for the CLO-heavy and Long-duration portfolios, while the Baseline portfolio shows modest improvement.

FIGURE 8: DISTRIBUTION OF UNFLOORED GPAVD AS PERCENTAGE OF INITIAL PREMIUM



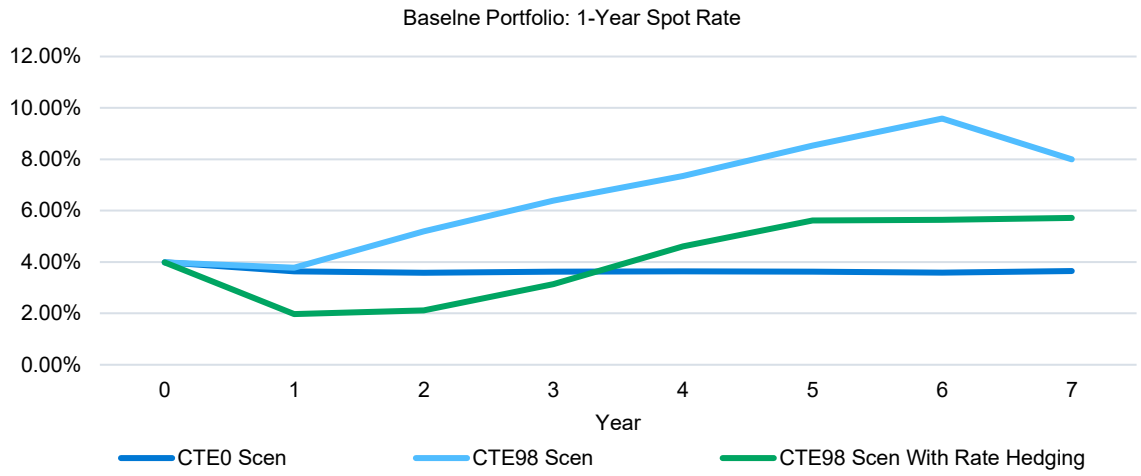


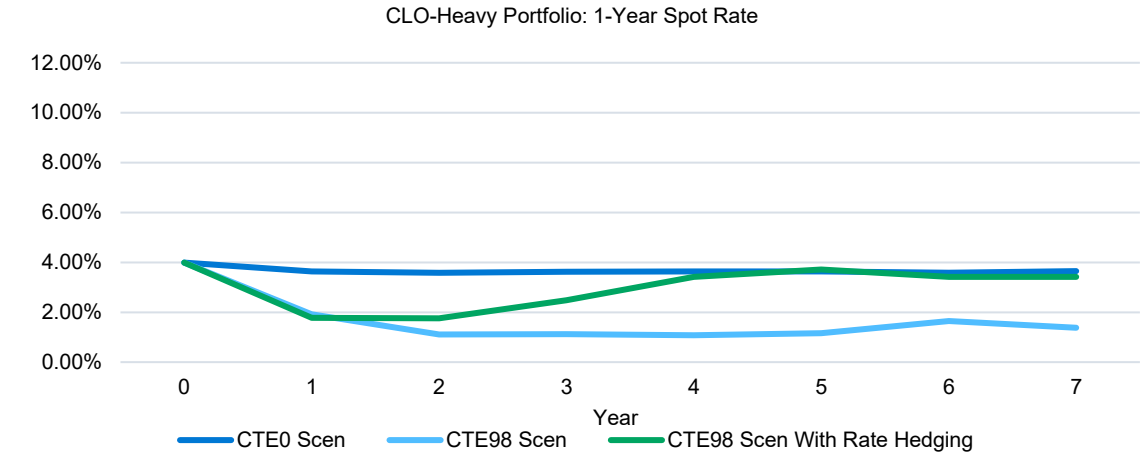


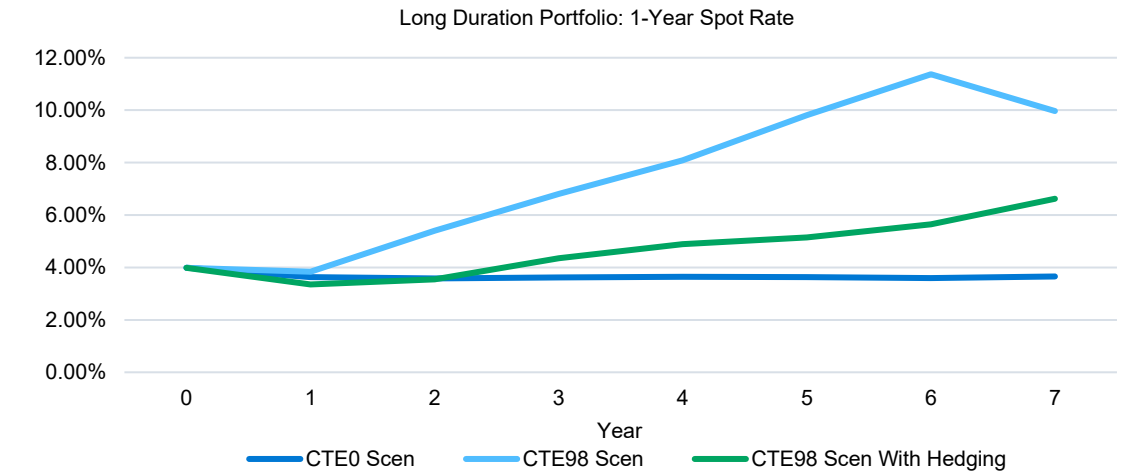
We can drill down further into the average interest rate path across the CTE98 tail scenarios (shown in Figure 9), which helps to illustrate the impact of hedging.

- The CTE98 average rate path for the Baseline portfolio is higher than the average rate scenario (i.e. CTE0). Minor net hedge positions of interest rate payer swaps are layered onto the Baseline portfolio to improve the exposure to high rate scenarios where higher shock lapses reduce spread profits post-surrender charge period.
- The CLO-heavy portfolio is exposed to persistent low rate scenarios, which reduces investment income on the floating rate assets. With hedging, the interest rate receiver swaps mitigate the reduced income, thereby raising the average rate path.
- The Long-duration portfolio is exposed to high interest rate environment throughout the projection where assets need to be sold with substantial capital losses. With hedging, the pay-fixed swaps provide gains in the high rate scenarios and as a result materially flatten the average CTE98 rate path.

FIGURE 9: AVERAGE PATH OF ONE-YEAR SPOT RATE







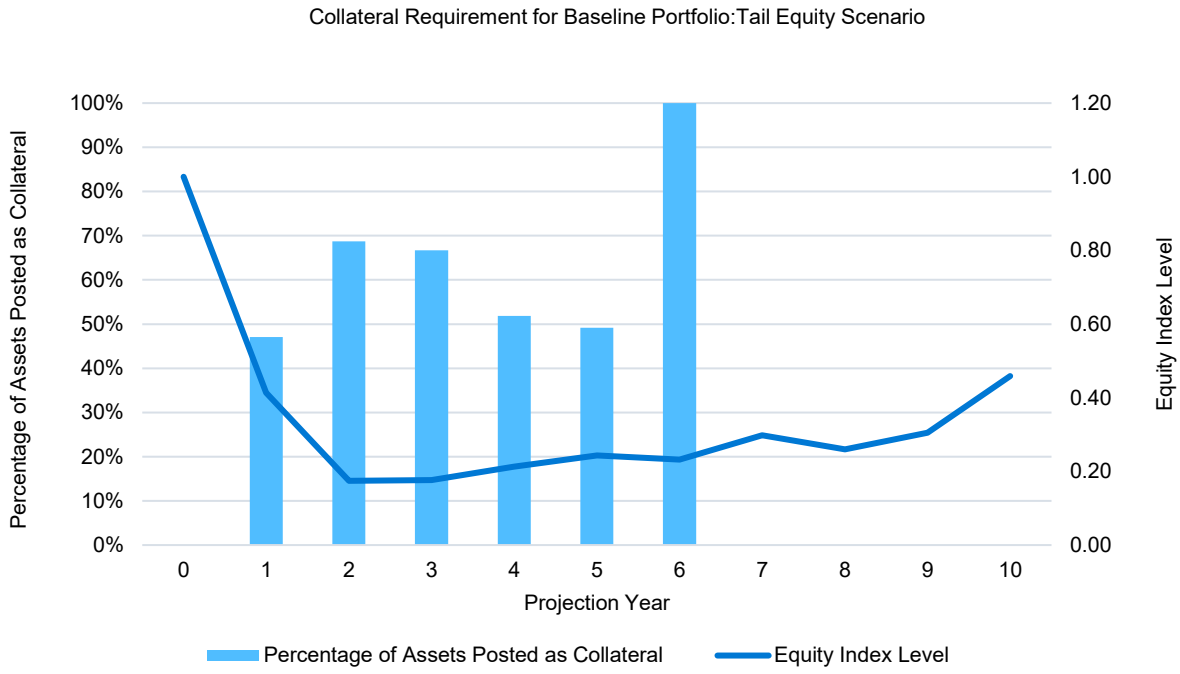
Modeling collateral

Although the yield attribution analysis indicates collateral modeling has modest impact on VM-21 results, it is still a meaningful risk to consider when evaluating specific scenarios. For instance, **Figure 10** shows a scenario with large negative equity returns in the first two years that causes the market value of the static option hedge to be negative, resulting in large collateral requirements that persist until the 6-year RILA renews into the next segment. In this analysis, the model assumes the insurer would have to sell large portions of its asset portfolio to fund the collateral requirement in cash, resulting in lost spread investment income and incurring higher transaction costs on less liquid assets.

One mitigating factor could be the insurer's ability to negotiate a "dirty" credit support annex (CSA), which would allow the insurer to post corporate bonds (with a haircut) in addition to cash and treasuries as acceptable collateral. This would allow the insurer to retain some spread investment income in lieu of selling corporate bonds to raise cash.

The implications of selling assets to raise cash for collateral needs could be even more severe if rates drastically increase during the same period, resulting in large capital losses. Although these types of scenarios are not common in the prescribed stochastic scenario set, proper modeling of collateral with derivatives and the associated liquidity risks is an important SAA consideration.

FIGURE 10: COLLATERAL REQUIREMENT FOR TAIL EQUITY SCENARIO

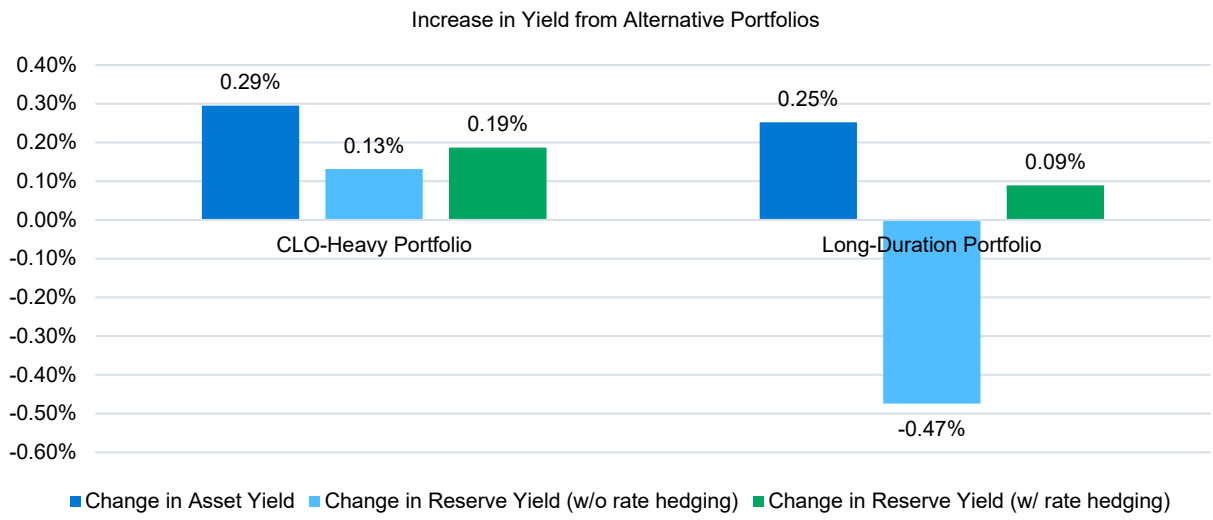


Conclusion

This paper presents a case study that explores how derivatives can be used to enhance SAA outcomes. The stochastic, principles-based framework that applies to RILA and other asset-intensive annuity business is a proven metric to evaluate the complex trade-offs between yield and duration. As shown in **Figure 11,** robust interest rate hedging preserves a larger proportion of the asset yield pickup in the alternative portfolios, reducing reserves and capital while maintaining strong ALM and risk management practices.

As the insurance asset landscape continues to evolve, insurers that can effectively incorporate derivatives in their SAA will be best positioned to capitalize on attractive investment opportunities.

FIGURE 11: INCREASE IN YIELD FROM ALTERNATIVE PORTFOLIOS



If you have any questions about the content of this report or other RILA hedging topics, the authors can be reached at alfred.au@milliman.com, vincent.embser@milliman.com, or ken.qian@milliman.com.

Acknowledgments

The authors thank the following Milliman colleagues for their input and assistance with the production of this paper: Collin Davidson, Cameron Kassam, Jieming Li, Jacob Rahn, and Ricardo Trachtman.

Appendix

LIABILITY ASSUMPTIONS

The allocations by segment are shown in the table below:

SEGMENT DURATION	AV ALLOCATION
1	25%
3	10%
6	65%

A base shock lapse of 65%, with interest rate-sensitive dynamic lapse, is assumed when the surrender charge period ends at year six. 80% of the shock lapse is assumed to occur immediately after the end of year six and is not renewed into a new segment.

VM-21 ASSUMPTIONS

The index credit is hedged back-to-back with equity options, with a 2% hedge ineffectiveness assumption.

The reinvestment strategy has a 50/50 allocation split between AA and A six-year corporate bonds. The six-year tenor is determined based on the projected Macaulay duration of the liability cash flows after the shock lapse year along the forward path, which is close to five years.

Disclaimers

The information, products, or services described or referenced herein are intended to be for informational purposes only. This material is not intended to be a recommendation, offer, solicitation or advertisement to buy or sell any securities, securities related product or service, or investment strategy, nor is it intended to be to be relied upon as a forecast, research or investment advice.

The products or services described or referenced herein may not be suitable or appropriate for the recipient. Many of the products and services described or referenced herein involve significant risks, and the recipient should not make any decision or enter into any transaction unless the recipient has fully understood all such risks and has independently determined that such decisions or transactions are appropriate for the recipient. Investment involves risks. Any discussion of risks contained herein with respect to any product or service should not be considered to be a disclosure of all risks or a complete discussion of the risks involved.

The recipient should not construe any of the material contained herein as investment, hedging, trading, legal, regulatory, tax, accounting or other advice. The recipient should not act on any information in this document without consulting its investment, hedging, trading, legal, regulatory, tax, accounting and other advisors. Information herein has been obtained from sources we believe to be reliable but neither Milliman Financial Risk Management LLC ("Milliman FRM") nor its parents, subsidiaries or affiliates warrant its completeness or accuracy. No responsibility can be accepted for errors of facts obtained from third parties.

The materials in this document represent the opinion of the authors at the time of authorship; they may change and are not representative of the views of Milliman FRM or its parents, subsidiaries, or affiliates. Milliman FRM does not certify the information, nor does it guarantee the accuracy and completeness of such information. Use of such information is voluntary and should not be relied upon unless an independent review of its accuracy and completeness has been performed. Materials may not be reproduced without the express consent of Milliman FRM. Milliman Financial Risk Management LLC is an SEC-registered investment advisor and subsidiary of Milliman, Inc.

Solutions for a world at risk™

Milliman is an independent consulting, benefits and technology firm. Our expert guidance and advanced analytical solutions empower leading insurers, healthcare companies and employers to protect the health and financial well-being of people everywhere. Every day, in countries across the globe, we collaborate with clients to improve healthcare systems, manage risk, and advance financial security, so millions of people can live for today and plan for tomorrow with greater confidence.

milliman.com

CONTACT

Alfred Au
Alfred.Au@milliman.com

Vincent Embser
vincent.embser@milliman.com

Ken Qian
Ken.Qian@milliman.com

Milliman

© 2026 Milliman, Inc. All Rights Reserved. The materials in this document represent the opinion of the authors and are not representative of the views of Milliman, Inc. Milliman does not certify the information, nor does it guarantee the accuracy and completeness of such information. Use of such information is voluntary and should not be relied upon unless an independent review of its accuracy and completeness has been performed. Materials may not be reproduced without the express consent of Milliman.