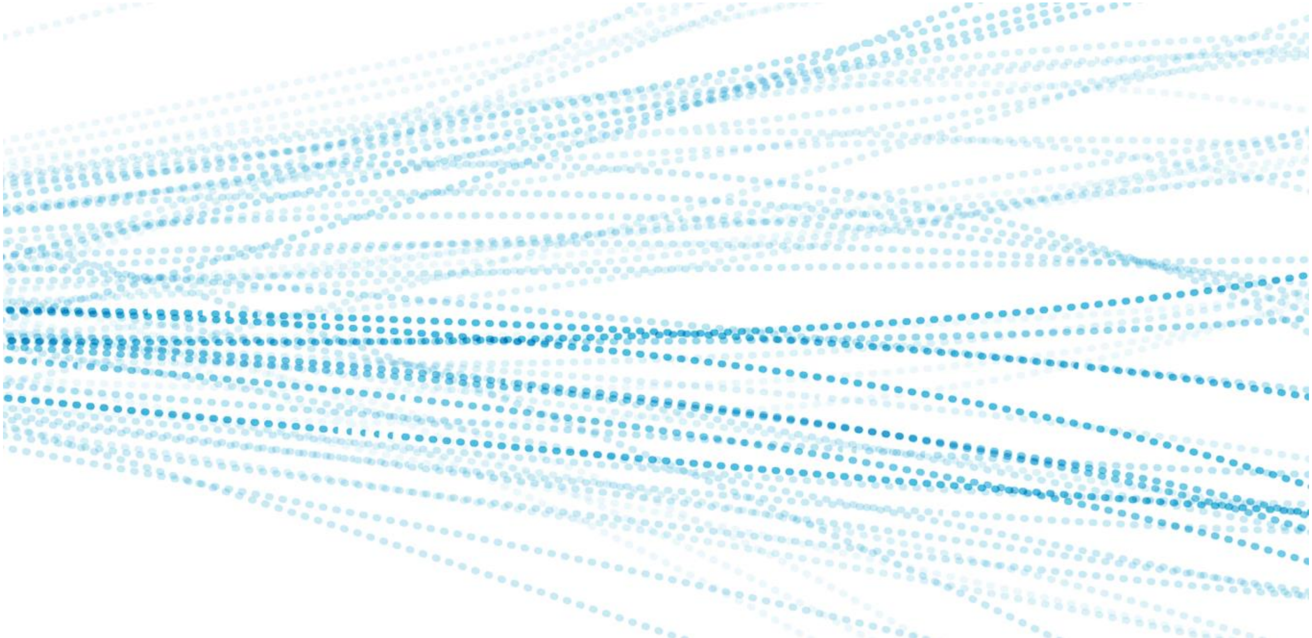

A series of practical papers on Interest Rate Risk Management under Solvency II

Part 3: Solvency II hedging

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Introduction

In the second paper in our Solvency II Rate Hedging series, we took a comprehensive look into EIOPA's Deep, Liquid, and Transparent (DLT) assessment. We updated that assessment to include market data from 2018 to 2020 and the implications for setting the Last Liquid Point (LLP), as well as the alternative methodology's extrapolation weights. We then discussed the hedging implications. Of note, trade volumes in the Euro swap markets suggest substantial liquidity past 20-year positions, with 30-year (30Y) swap trade volume already exceeding the requisite market depth and liquidity criteria. We also noted that trend past the 30Y point is towards greater liquidity and depth.

Armed with this information, we explored how changes to EIOPA's LLP/FSP (First Smoothing Point) and extrapolation weights would impact curve construction, and how that, in turn, would impact hedging. Specifically, changes to the LLP and FSP are likely to require substantial hedge portfolio rebalancing, especially around the LLP/FSP. While the impact to key rate durations appears small, that seems to be more of a function of the current yield curve levels than anything intrinsic to the methodology. It also depends substantially on the liability. Longer-duration liabilities, or ones with greater embedded optionality, will see greater key-rate duration impacts.

A limitation of the analysis in the last paper was that it reflected the dynamics of hedging at a single point in time and did not explore the intertemporal dynamics as hedged liabilities age. Any hedge program must contend with the complexity of interest rate risk (IRR) in a regulatory context. The economic view, that with no extrapolation towards an Ultimate Forward Rate (UFR), results in a picture that may deviate quite substantially from the regulatory view. Targeting economics may therefore have unfortunate regulatory implications, and vice versa.

This paper explores these issues. First, we construct a hedge program for a typical life insurance company. The hedge targets stabilising the short-term Solvency II ratio. We then examine how this hedge performs over time, as the Solvency II yield curve deviates from the market curve. After identifying the challenges facing this hedge program, we walk through several possible solutions, depending on the insurer's primary goal, and whether the capital model uses the standard formula or an internal model. We conclude with a discussion of issues still unresolved and opportunities for further research.

To motivate our analysis, consider an insurance company with the following Solvency II balance sheet:

TABLE 1: EXAMPLE SOLVENCY II BALANCE SHEET

Assets		Liabilities	
Investments	32,150	Own Funds	3,150
		Best-estimate	25,000
		Risk margin	4,000

For this company, we also posit the following initial Basic Solvency Capital Requirements (BSCR) components:

TABLE 2: BASIC SOLVENCY CAPITAL REQUIREMENTS COMPONENTS

Market risk	CPD	Life	BSCR[1]
1,604	150	936	2,100

From Tables 1 and 2, we find that our initial Solvency II ratio is 150%.

Hedge Strategy

To begin, let us further suppose that this insurer is concerned about the effects changing interest rates will have on the solvency ratio and decides to construct a hedge program to protect against adverse rate movements. That is, the hedge program seeks to stabilize the short-term Solvency II ratio of 150% due to changes in interest rates. Practically, this amounts to hedging the best estimate of the liability (BEL) and risk margin (RM), as they are the key constituent parts of the Own Funds (OF). In addition, the sensitivity of the Solvency Capital Requirements (SCR) multiplied by the current ratio is hedged as well in order to stabilize the ratio between the OF and SCR.

$$\Delta SII = SII_{t=1} - SII_{t=0} = 0$$

$$\Delta SII = \frac{OF_{t=1}}{SCR_{t=1}} - \frac{OF_{t=0}}{SCR_{t=0}} = 0$$

$$\Delta SII = \frac{A_{t=1} - L_{t=1}}{SCR_{t=1}} - \frac{A_{t=0} - L_{t=0}}{SCR_{t=0}} = 0$$

$$\frac{A_{t=1} - L_{t=1}}{SCR_{t=1}} = \frac{A_{t=0} - L_{t=0}}{SCR_{t=0}}$$

$$\frac{(A_{t=0} + \Delta A) - (L_{t=0} + \Delta L)}{SCR_{t=0} + \Delta SCR} = SII_{t=0} = SII$$

$$(A_{t=0} + \Delta A) - (L_{t=0} + \Delta L) = SII_{t=0} * (SCR_{t=0} + \Delta SCR)$$

$$\Delta A = SII_{t=0} * (SCR_{t=0} + \Delta SCR) - A_{t=0} + (L_{t=0} + \Delta L)$$

$$\Delta A = SII_{t=0} * SCR_{t=0} + SII_{t=0} * \Delta SCR - A_{t=0} + L_{t=0} + \Delta L$$

$$\Delta A = \frac{OF_{t=0}}{SCR_{t=0}} * SCR_{t=0} + SII_{t=0} * \Delta SCR - (A_{t=0} - L_{t=0}) + \Delta L$$

$$\Delta A = OF_{t=0} + SII_{t=0} * \Delta SCR - OF_{t=0} + \Delta L$$

$$\Delta A = SII_{t=0} * \Delta SCR + \Delta L$$

$$\Delta A = SII_{t=0} * \Delta SCR + \Delta BEL + \Delta RM$$

Using this knowledge, we have worked out the hedge strategy for our example insurance company. In Table 3 we show the starting balance sheet and the effect on the balance sheet when interest rates decrease parallel with 50 bps.

[1] For simplicity operational risk is not considered for this example. The marginal interest sensitivity of the operational risk SCR is limited.

TABLE 3: IMPACT ON BALANCE SHEET OF INTEREST RATE DECREASE

	2020	Rates Decrease
Assets	32.150	34.616
Liabilities	29.000	31.180
OF	3.150	3.436
SCR	2.100	2.290
Ratio	150%	150%

The goal of this hedge strategy is to ensure that you have sufficient interest rate sensitivity in the asset portfolio to maintain the target SCR ratio, which in our model is 150%. However, such hedges are never static. This is due to common issues with any insurance product hedge, in that the dynamics of the liability cannot be perfectly matched with portfolio of hedge assets. The reason for this is twofold. In general, the asset portfolio has a shorter duration than the insurance liabilities. Furthermore, because the liabilities are discounted using a not fully market-consistent yield curve, the convexity of the insurance liabilities differs from the hedge portfolio.

It is important to note that focusing on hedging Solvency II ratio has real-world implications, as we observed in our first paper of this series. When calculating SCR, the interest rate shocks apply to the entire curve, including the extrapolated, illiquid part of the curve. If the hedge target is OF-based, then the shocks apply only up to the LLP. In combination with the asymmetric effect rate shocks have on liability value, SCR ratio hedging looks like an over-hedge. This causes negative exposure to rising rates, as hedge losses exceed SCR release.

Over Time

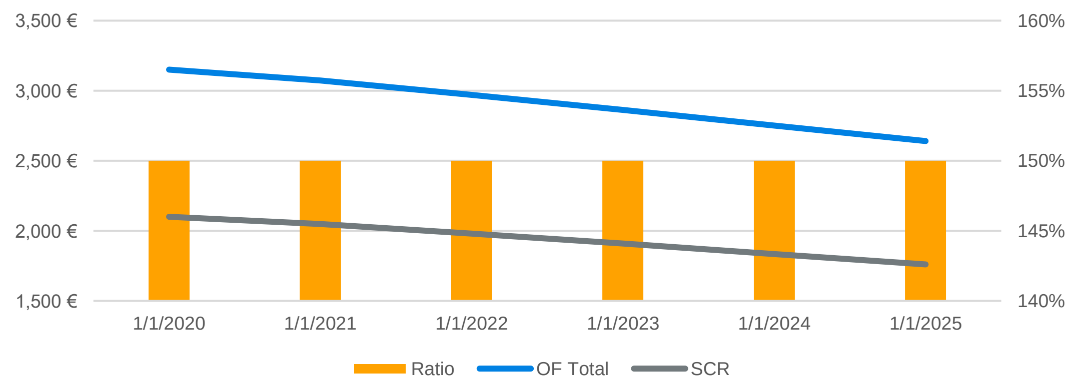
Now let's consider how the economic balance sheet evolves over time. First, let's assume that the block we are modelling is in run-off; that is, there is no new business. In the first year, claims are paid, and a portion of the risk margin is released. Table 4 illustrates these dynamics.

TABLE 4: PROJECTION OF BALANCE SHEET OVER TIME

	2020	2021	2022	2023	2024	2025
Assets	32.150	31.348	30.305	29.224	28.079	26.949
Liabilities	29.000	28.276	27.335	26.361	25.328	24.309
OF	3.150	3.072	2.970	2.864	2.751	2.641
SCR	2.100	2.048	1.980	1.909	1.834	1.761
Ratio	150%	150%	150%	150%	150%	150%

Figure 1 shows the dynamics of the ratio hedge over a five-year projection, assuming markets follow the forward rates implied by the 12/31/2020 yield curve.

FIGURE 1: HEDGE RATIO – BASE CASE: THE LEFT AXIS IS FOR SCR AND OWN FUNDS (€ MLN) AND THE RIGHT AXIS IS FOR THE HEDGE RATIO



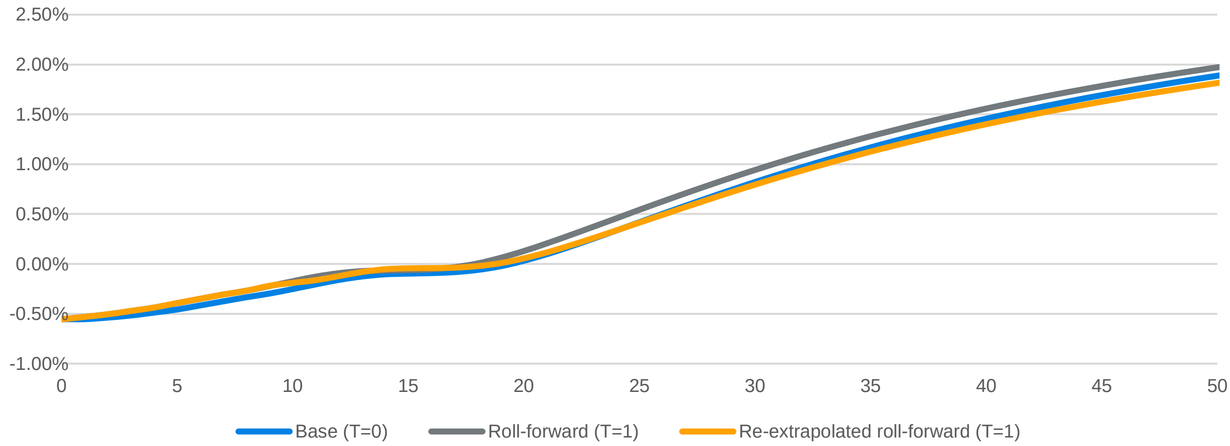
As expected, we observe a stable SCR ratio between the starting date and the end of the first year. This is because the capital generated via asset income and the release of RM and SCR compensates for the drag caused by the UFR. Understanding the nature of UFR drag is critical to understanding the time varying behavior of the ratio hedge when discount curves make use of Smith-Wilson (SW) extrapolation with an LLP and UFR. As such, we turn to exploring the UFR drag in detail in the next section.

UFR Drag

As mentioned previously, including in our prior papers, the deviation between actual and modelled forward rates will manifest over time. At present, with actual forwards below the UFR, this deviation creates a persistent drag as you roll down the curve. All other things remaining equal, this will induce a cumulative drag on OF.

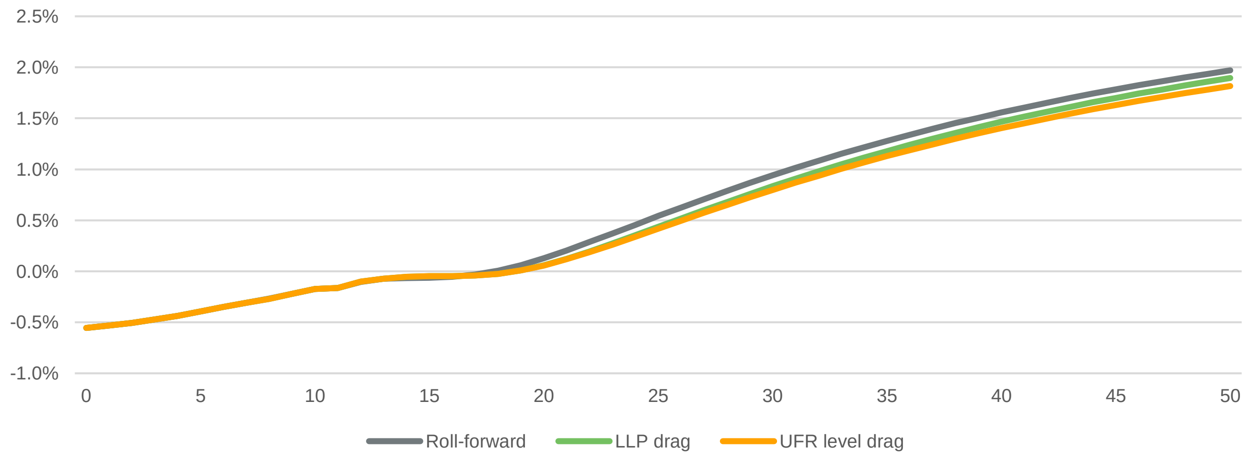
In the next three figures we aim to visualize the impact of rolling down the curve. In Figure 3 we see the expected yield curve in one year's time (grey curve), based on the roll forward rates in the valuation curve (e.g., including the extrapolation effect). Due to positive forward rates, the curve is expecting to increase, in particular on the long end of the curve where the UFR is determining the forward rates.

FIGURE 3: YIELD CURVE ROLL-FORWARD



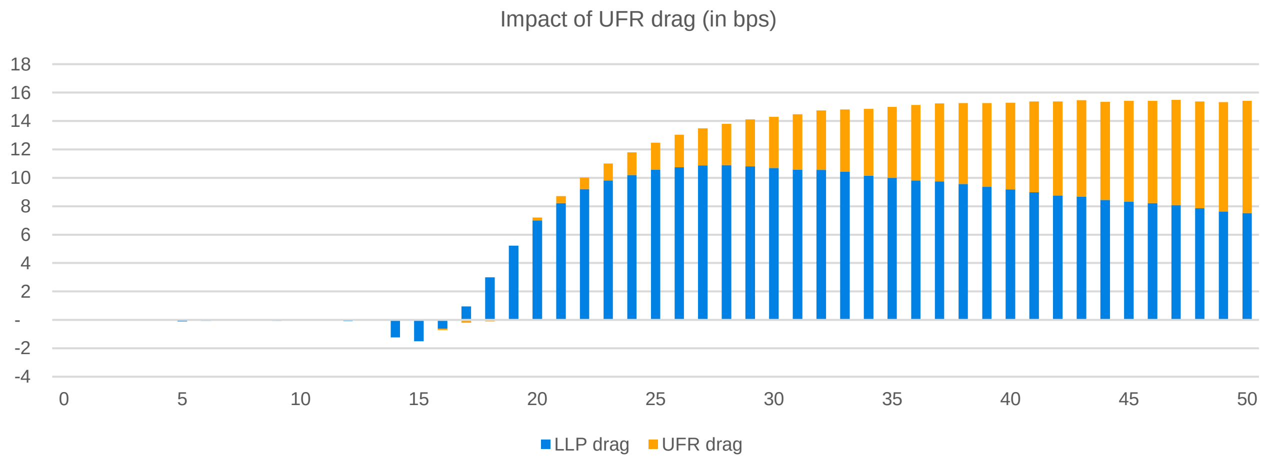
In Figure 3 we also see the hard truth, based on the roll forward rates of the market rates we generate a new base curve which is then extrapolated again. When we further decrease the UFR by another 15 bps, we see that the actual curve (based on roll forwards) at the end of 2022 will be the orange line. This curve is significantly below the expected grey line base. In Figure 4 we decompose the UFR drag into an LLP drag and an UFR-level drag.

FIGURE 4: DECOMPOSITION OF UFR DRAG



When we zoom in on the differences created by the LLP-drag and the UFR-level drag, we observe that the LLP drag is causing the majority of the pain in the first years after the extrapolation, which is illustrated in Figure 5.

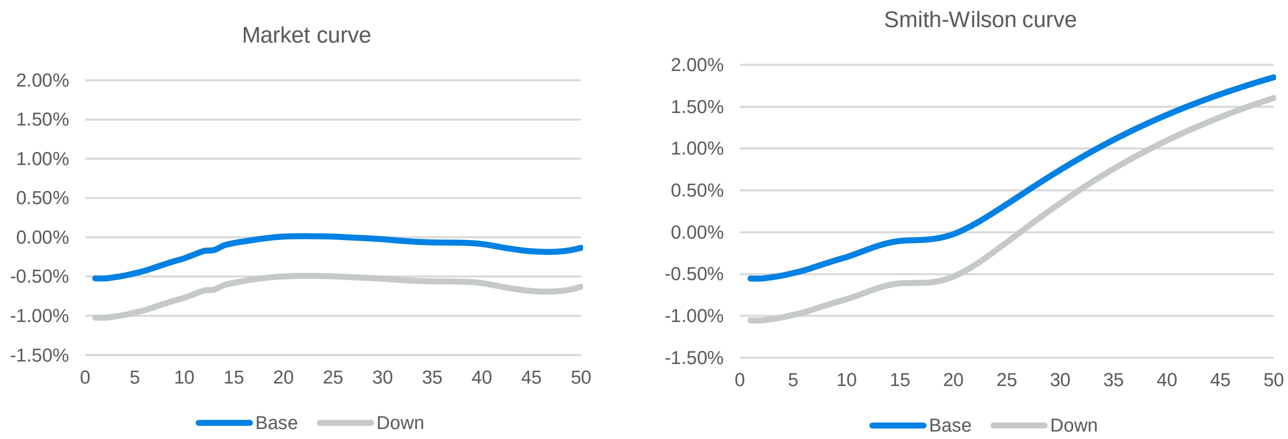
FIGURE 5: DECOMPOSITION OF UFR DRAG



Scenario with Instantaneous Rate Down Shock

Now consider a 50bp parallel shock at time zero, where the market curve will be as shown in Figure 6. The extrapolation towards the UFR will have a dampening effect on the long end of the curve, as illustrated in Figure 7.

FIGURE 6: 50BP SHOCK ON MARKET CURVE AND SMITH-WILSON CURVE



The initial impact of decreasing rates has, in our example, no impact on the actual Solvency II ratio as shown in Table 5. This follows the hedging strategy which aims to stabilize the short-term sensitivity of the Solvency II ratio.

TABLE 5: IMPACT OF LOWER RATES ON OUR BALANCE SHEET

	2020	Rates Decrease
Assets	32.150	34.616
Liabilities	29.000	31.180
OF	3.150	3.436
SCR	2.100	2.290
Ratio	150%	150%

However, when we project the balance sheet over time we observe that the lower rates will start to create additional pain. This is caused by the interest rate sensitivity of the UFR-drag itself. In Figures 7 and 8 we aim to visualize this effect.

FIGURE 7: INTEREST RATE SENSITIVITY OF THE UFR DRAG

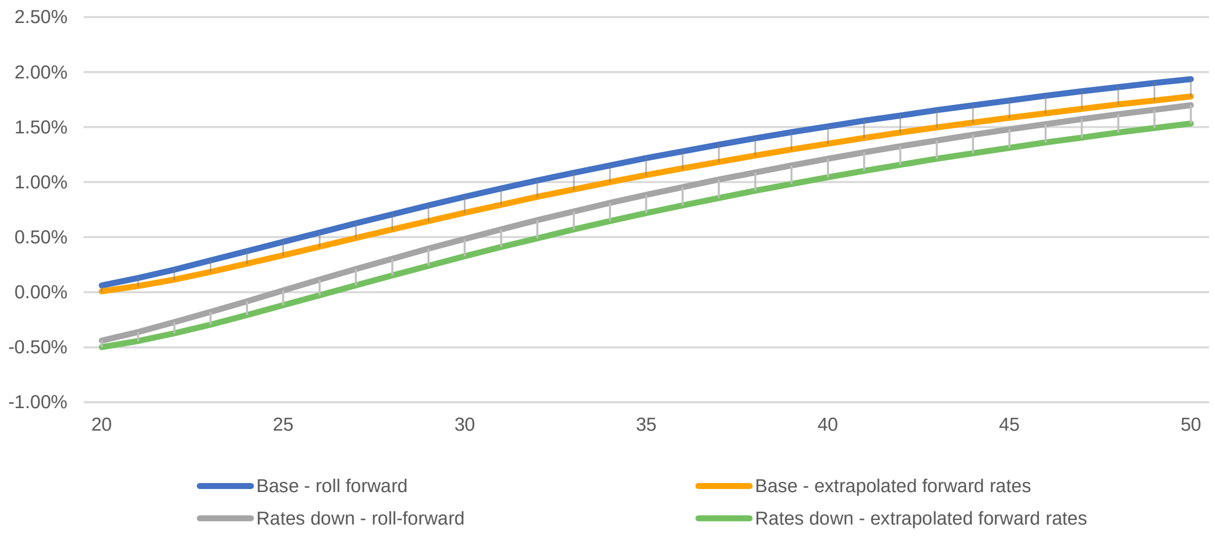
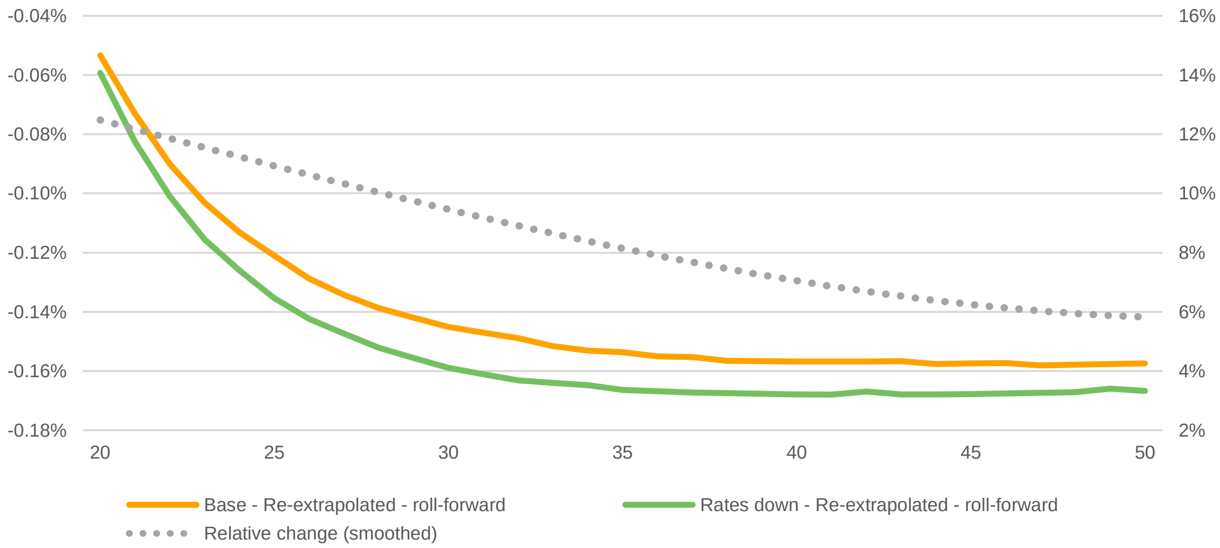
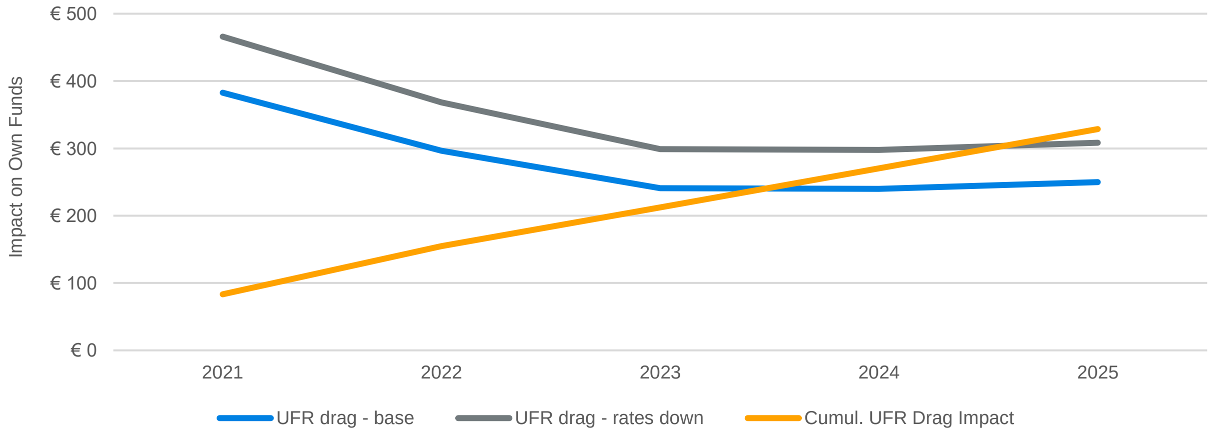


FIGURE 8: ZOOM IN ON INTEREST RATE SENSITIVITY OF THE UFR DRAG



As a consequence of this effect, the UFR drag increases in this scenario. The higher drag will create additional pain on the balance sheet and will lower the Solvency II ratio over time. This is visualized in Figure 9, where the orange line represents the cumulative impact on the OF due to a higher UFR drag.

FIGURE 9: PROJECTED UFR DRAG



In Table 6 we show the impact of the lower interest rates on the balance sheet of the example insurer. The additional cumulative drag is creating an annual reduction of the OF and consequently a decreasing Solvency II ratio through our projection period.

TABLE 6: IMPACT OF LOWER INTEREST RATES ON OUR BALANCE SHEET

	2020	2021	2022	2023	2024	2025
Assets	34.616	33.530	32.182	30.813	29.392	28.010
Liabilities	31.180	30.372	29.339	28.266	27.142	26.042
OF	3.436	3.158	2.844	2.547	2.250	1.968
SCR	2.290	2.161	1.999	1.840	1.680	1.531
Ratio	150%	146%	142%	138%	134%	129%

To manage this drag, insurers will have to increase non-hedge contributions to OF to offset. So, while the hedge is doing its job relative to the market-consistent part of the curve, the disconnect between market rates and modelled rates induces a cost which, by necessity, must be managed outside the hedge program.

It is important to note here, as well, that while we are seeing a notable UFR drag in our projection, the longer the projection, the more substantive UFR drag is likely to be. Thus, there is a clear tension between the short-term SII ratio stability, and the longer-term economics of the hedge program.

Issue

The analysis so far creates a bit of a quandary. The dynamics described in the previous section suggest that more hedging is necessary to compensate for the eroding SCR ratio from UFR drag. However, as discussed above, maintaining a stable SCR ratio under the SW extrapolation increases exposure to rising rates. Enlarging hedge positions to compensate for the UFR drag only makes this problem worse. Additionally, depending on the circumstances, the requisite larger hedge positions may also increase initial standalone IRR SCR, so the starting SCR ratio may decline as well.

Given the relatively few levers of any standard formula-based hedging program, the above trade-offs feel ineluctable. All hope is not necessarily lost, however. Ameliorative action is possible, though the suitability or effectiveness of such actions depends significantly on an insurer's preference for taking more model or operational risk in exchange for reducing IRR.

Solutions

One approach to managing this asymmetric risk is to avoid using the standard formula. By implementing an internal model, hedgers can construct a model that more accurately reflects the underlying risks of the hedged liability. An internal model may also be more flexible. By decomposing rate movements into its component parts, such as the UFR and LLP, hedgers may better manage liability movements. While this will not eliminate UFR drag, by managing hedge assets appropriately, hedgers can mitigate the economic impacts.

Alternatively, insurers can leverage option strategies instead of relying on delta-1 positions. Given the asymmetric exposure, making use of options may be a sensible alternative. Of course, such hedges come at a cost in terms of initial premium. This cost may be offset by using structured trades which combine long and short positions, but care is necessary to ensure that the risks of such positions are well understood. Alternatively, hedgers can replicate options positions, which may reduce expected hedge costs, though usually at the expense of greater gap risk and at the cost of constant rebalancing.

Regulatory carry is generally unavoidable when the reference yield curve is not completely market consistent. However, some methodologies are more market consistent than others. The alternative extrapolation, by reducing the slope of the curve between the LLP and UFR mitigates the negative carry but will not eliminate it. Additionally, by manipulating the alternative extrapolation parameters, hedgers can implement a hybrid strategy that increases ease with which to balance regulatory and economic considerations.

The above solutions do not eliminate the underlying issue that confronts each insurer seeking to hedge the SCR ratio: the trade-off between short-term and long-term risk-management. Maintenance of current SCR ratios invariably results in drag (given current rates) as the discrepancy between the regulatory yield curve and the actual curve is reflected in hedge performance. Alternatively, focusing on long-term SCR ratios will reduce the drag, but at the expense of current period SCR ratio stability. Which approach is better depends on balancing SII risk objectives against economic, accounting, and broader risk management concerns. The insurer's relative tolerance for SCR ratio volatility against other types of volatility will likely dictate which approach makes the most sense. One's view on future interest rate behavior is also likely to factor in on what strategy is more appealing, as those who believe that rates will rise significantly may be disinclined to pursue a strategy that involves *more* current rate hedging, whereas someone who believes that current rates are likely to persist into the medium term may be more comfortable with such a strategy.

Summary

In our prior papers we discussed some of the pros and cons of the alternative extrapolation methodology (AM) relative to the current approach using Smith-Wilson. While the AM is likely to increase SCR under current market conditions, it does so by moving closer to actual market rates. As such, the AM mutes some of the UFR drag illustrated above. This is especially true when alpha decreases over time, as this has the effect of bringing the AM even closer to market rates.

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