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Liability-aware Strategic Asset Allocation

A simplified approach applied to a sample balance sheet of an average European Life-Insurer

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— The quality of a Strategic Asset Allocation heavily depends on meaningful and detailed preparation of input parameters. Next to expected returns, covariances, and other factors, the incorporation of liabilities is fundamental in order to build a suitable and robust strategic asset allocation for institutional investors such as insurance companies or pension funds.
— Based on a simplified balance sheet and key-rate durations, we propose a simple, yet effective way of modelling liabilities represented by a market-based swap benchmark in an SAA context.
— We illustrate our findings through an exemplary case study of an average European Life-Insurer showcasing the benefits of this approach in contrast to an optimization from an asset only perspective.
— The proposed framework is easy to implement and also works well for a broad range of optimization techniques from a standard mean-variance optimization as presented here to robust or simulation-based optimization approaches.

Overview

Portfolio optimization techniques are still a topic of ongoing research in academia but especially amongst practitioners. This paper seeks to introduce and illustrate a simple and straightforward framework to incorporate liabilities into the process of deriving optimized Strategic Asset Allocations (SAA) for institutional investors. This approach is flexible and enables the inclusion of various other constraints (e.g., insurance specific constraints relating to Solvency II).

Insurance companies (life and non-life) and pension funds are particularly exposed to changes in interest rates given their oftentimes long-term liabilities. The recent market developments of higher inflation and the subsequent steep rise in interest rates have led to re-valuations of balance-sheet assets and liabilities and have significantly impacted Solvency and funding ratios of insurance companies and pension funds, respectively. This has highlighted the need for a combined approach that takes into account the liability profile when developing customized strategic asset allocations.

A concept that specifically deals with the interest rate risk of insurance companies and pension funds is the so-called Asset-Liability-Management (ALM). It aims to control the impact of interest rate changes on the balance sheet from an economic, regulatory capital or accounting perspective. While managing short-term risks through tactical risk management is essential for effective ALM, constructing the strategical asset allocation is equally important. In a holistic ALM framework, the optimal configuration of assets to meet the future liabilities is determined considering the risks arising from the mismatch in asset liability structure with respect to liquidity or interest rate and – if applicable – credit spread sensitivities.

Our approach to creating holistic strategic asset allocation analyses addresses both ALM considerations and embeds our long-term asset class return forecasts to achieve a sufficient surplus return through the following steps:

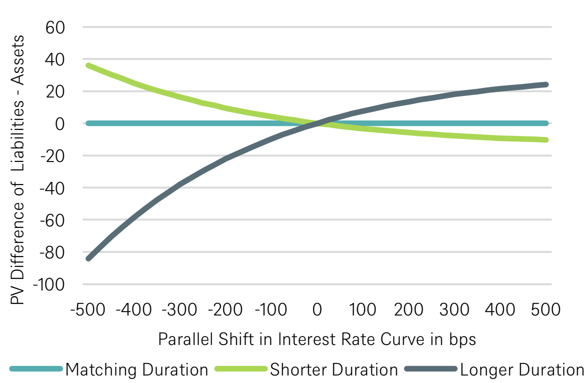
- Profiling: Asset Modelling – breaking down balance sheet assets and deriving return, volatility, correlation assumptions for the asset universe
- Profiling: Liability Modelling – analyzing liability profile and building representative benchmarks.
- Optimization – derive the efficient frontier adhering to a broad range of constraint settings based on the investor’s funding requirements/long-term targets.
- Control – risk analytics and ex-post analysis.
- Results – present findings/implementation analysis.

We want to mention that the incorporation of ESG aspects is also possible within this optimization framework. The methodology for ESG integration described in a previous publication paper[1] (ESG in Strategic Asset Allocation) can be also applied for liability-aware SAA analyses.

Making the case for a liability-aware SAA

A simple ALM framework can be established whereby one liability cashflow in a given year is matched by an investment in a single bond having only one expected cashflow of the similar amount at the same point in time (i.e. a zero-coupon bond or "ZCB"). This is an ideal scenario from an ALM perspective, as the present values of asset and liabilities move in sync, in tandem with the discount rate used in valuations. The approach can be extended to all annual liability cashflows by aligning each annual liability cashflow with an equivalent duration ZCB investment. As a result, the balance sheet is perfectly immunized against interest rate curve movements. If the assets on the balance sheet have a longer duration than the liability duration, the asset value would rise relative to the liability value when interest rates decrease. Conversely, if the assets have a shorter duration, higher interest rates would be favorable. This simple example underscores the importance of incorporating liabilities in the formulation of a meaningful strategic asset allocation. Figure 1 illustrates the potential asset-liability match that can occur with proper or improper duration matching.

Figure 1: Value of Assets and Liabilities after an interest rate shock



Source: EIOPA, DWS Investment GmbH. Data as of December 2023

Harry Markowitz, a pioneer in portfolio construction, developed Modern Portfolio Theory, which proposed that investors should receive higher returns for taking higher risks. Markowitz demonstrated that an efficient frontier of optimal portfolios exists which offers the highest expected returns for a given level of risk, quantified by the portfolio return volatility[2].

Building on the concepts of modern portfolio theory, with the aim of reducing the risk, various ALM models have been devised. By combining asset-liability matching with Modern Portfolio Theory, (surplus) return/volatility objectives can be accomplished with consideration for interest rate risk.

One such model is a single-period static model, which seeks to hedge a portfolio against interest rate changes, known as the immunization method. Redington introduced this model in 1952 with the idea of minimizing the surplus volatility (or maximizing the surplus return, or both) by matching the duration of assets and liabilities[3]. Standard immunization matches the interest rate sensitivities of assets and liabilities, which is mathematically expressed as the first order partial derivative with respect to the interest rate (linked to the concept of "Macaulay duration" and "Modified Duration"). A drawback of the standard immunization approach is that it ignores the term structure of interest rates, and assumes a single interest rate, implying that results are only valid for parallel shifts in the (flat) yield curve, whereas in reality non-parallel shifts of the (non-flat) yield curve are often observed. Key rate immunization, which resembles the standard approach, accounts for non-parallel shifts for a chosen number of maturities by segmenting the cashflows.

In this study, we will focus on an approach driven by key rates, however not with the goal to fully immunize against interest rates shifts. This paper seeks to illustrate DWS' capabilities and methods for customizing the SAA, while considering investment constraints and future liability cashflows of an institutional investor within the portfolio optimization process. We try to shine further light on our methodology by demonstrating our steps towards an optimized asset allocation for an average European life insurer as a case study. The starting point of any thorough analysis is the data collection and cleansing process. Thereafter, we will continue with the definition of a meaningful asset universe and a representative modelling of the assets and liabilities of the insurer. At the end, we explain our optimization procedure and constraints and discuss the resulting asset allocations.

Methodology Part 1 - Profiling:

We leverage our DWS proprietary research capabilities to build meaningful return and risk estimators for both the asset and liability side.

Asset Modelling

The basis for a well-balanced strategic asset allocation is the asset universe that constitutes the opportunity set for all upcoming optimizations. The asset universe covers all major asset classes across equities and fixed income both on the public and private side. We follow an index-based approach by assigning a representative index to each asset class in

[1] https://www.dws.com/insights/global-research-institute/esg-in-strategic-asset-allocation-the-2023-update/
[2] Markowitz, H. (1952). Portfolio Selection
[3] Redington, E. M. (1952). Review of the Principles of Life-Office Valuations. Journal of the Institute of Actuaries

scope. Expected return estimates for the representative indices are based on Long-Term Capital Market Assumptions (LTCMA) provided by DWS Long View and spanning a 10-year forward-looking time horizon. Assets on the investor's balance sheet are mapped to the corresponding indices within the DWS Long View's 10-year forecast coverage universe. If return estimates for certain asset classes (e.g., Real Estate Debt) are not available within the index universe of the Long View, the expected return assumptions are reflecting the long-term view of portfolio managers and investment specialists. Asset volatilities are estimated using historical monthly or quarterly returns, starting from January 2000 where available. Hence, we derive our forward-looking volatility estimate, i.e., the "expected" volatility purely from historical data and do not consider any market implied volatilities such as those embedded in option prices.

As we include both liquid public and illiquid private assets in our asset universe, we encounter some challenges. First, liquidity risk might be an issue for investors with liquidity requirements. However, investors that are able and willing to hold illiquid assets over a long-time horizon might view this liquidity issue as an opportunity to collect additional compensation ("illiquidity premium"). The illiquidity premia are reflected in our expected return assumptions. Secondly, the time series of illiquid private assets often exhibit so-called smoothed returns. This phenomenon occurs as private assets are typically valued using an appraisal-based methodology and marked-to-market less frequently than publicly traded assets, which artificially lowers the realized volatility. Not considering this effect would make illiquid assets even more attractive from a risk-adjusted return perspective and increase their relative attractiveness versus traditional liquid assets even more.

We test all illiquid asset classes in our asset universe for smoothed returns (applying a standard autocorrelation based statistical test for smoothed returns). For our case study, the returns of US and European Private Real Estate Equity asset classes appear to be smoothed. Our methodology of de-smoothing is based on the work of Meng, Zhang, and Ong (2016), and we refer to their paper for a detailed discussion. Generally, the approach is based on the assumptions that smoothed returns can be written as an exponentially weighted average of a de-smoothed return series and that the expected values of smoothed and de-smoothed returns are equivalent, which allow us to rewrite the de-smoothed returns as a function of the autocorrelation and the smoothed return. The volatilities recovered using this approach reflect the embedded economic risk of the return series of an illiquid asset more appropriately, as shown in Table 1. The volatility of the de-smoothed (EUR unhedged) returns increases significantly, and we no longer observe (significant) positive serial autocorrelation any more[4].

Table 1: Annualized Volatility of quarterly smoothed and de-smoothed returns

	Ann. Volatility of	
	Smoothed Returns	De-smoothed Returns
Private Real Estate Equity US	6.7%	12.2%
Private Real Estate Equity EUR	3.9%	8.6%

Source: DWS Investment GmbH. Data as of December 2023

Liability Modelling

In our view, a suitable Strategic Asset Allocation for institutional investors, such as insurance companies and pension funds can only be built if the interest rate risks arising from the liabilities are explicitly incorporated. Within our approach, the liabilities are modelled in terms of a market-based liability benchmark that represents the risks of the investor's income and overall balance sheet from the market risk factors of liabilities. This benchmark is constructed based on the actuarially expected future liability cashflow forecast. It can include netting of balance sheet items such as reinsurance receivables which are not part of the regular investment portfolio with respective liabilities. The (net) cashflow forecast is grouped into key-rate duration buckets and each such bucket is mapped to a representative index. These representative indices are chosen to have market-based risk characteristics substantially like those embedded in the liability forecast itself. For insurance companies, this is typically dominated by the interest rate risks within the discount curve used to calculate the present value of the liability cash-flows; choosing the index in this fashion often gives the best possible match of the interest rate risk in key rates.

As mentioned before, our SAA analysis relies on an index-based approach both on the asset and liability side. Hence, we construct customized interest rate swap indices for various swap tenors. We obtain the expected return and duration assumptions for these indices based on the DWS Long View framework. Additionally, the swap rates against the 6M EURIBOR from Bloomberg[5] are used to build historical time series, which enables us to estimate the volatility and correlations of the indices. Recall that the swap rate is the fixed interest rate that equates the present value of the future payments of both legs of the contract, implying that the interest rate swap has zero value at t=0. This allows us to model the value of a rolling position in the swap, which will

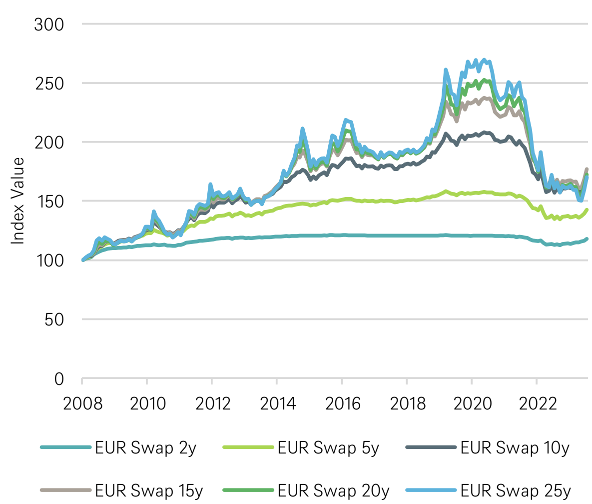
[4] Meng, Zhang, Ong. Mean–Variance Optimization with Public and Private Asset Classes (2016

[5] Bloomberg Ticker: EUSA2 BGN Curncy, EUSA5 BGN Curncy, EUSA10 BGN Curncy, EUSA15 BGN Curncy, EUSA20 BGN Curncy, EUSA23 BGN Curncy, EUSA25 BGN Curncy, EUSA50 BGN Curncy

vary inversely with the market interest rates (similar to the liabilities that they aim to replicate).

Next, these synthetically constructed swap indices are used to include the liability benchmarks in the covariance matrix and ultimately in the portfolio optimization. Figure 2 illustrates the development of multiple swap indices over time assuming a receiver swap position. It is evident that the value of the indices is driven by duration, for instance by comparing the volatility of the 2Y and 25Y Swap Index. The 25Y swap index exhibits a much larger volatility, driven by the longer duration, while the 2Y index remains almost flat over time.

Figure 2: Selected Swap Indices (Receiver Swap Position)



Source: Bloomberg, DWS Investment GmbH. Data as of December 2023

Next, we demonstrate the profiling of assets and liabilities in a case study building on an exemplary European life insurance company.

Case Study Part 1: Profiling

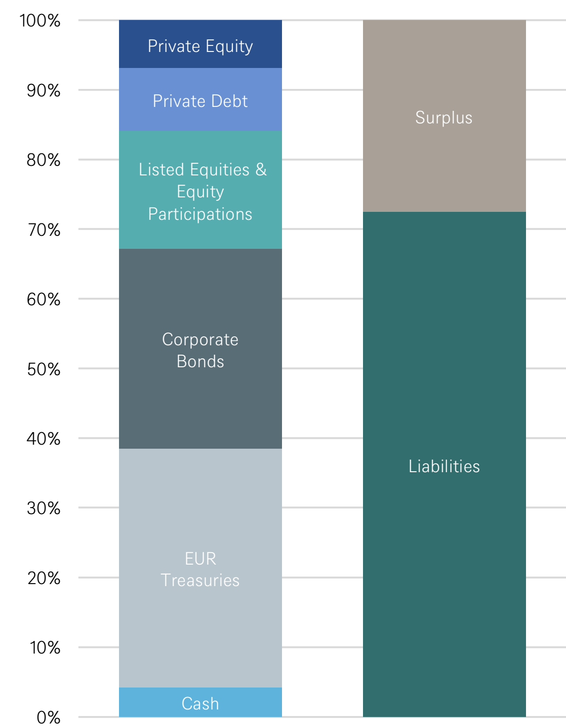
Exemplary European Life Insurer

The average asset allocation of a European life insurer is estimated using insurance statistics from European Insurance and Occupational Pensions Authority ("EIOPA").

The starting point for each SAA optimization is a thorough analysis of an investor's balance sheet. Besides constructing the liability benchmark as described in the last section, this includes modelling the asset classes of the investment portfolio. Assets and liabilities not in scope of the SAA optimization are netted in order to retrieve a simplified balance sheet. For example, reinsurance receivables are netted against the technical provisions. This simplified balance sheet then comprises the relevant asset classes of the investment portfolio and the liabilities backed by this portfolio.

For our case study, we build a (simplified) reference balance sheet of an average European life insurer, based on data from the EIOPA insurance statistics database[6]. We want to note country-specific deviations from the average allocation outlined here can be significant. All assets on the balance sheet are mapped to representative indices in the DWS Long View capital market assumptions. Please find our asset universe including the representative indices in the appendix. Figure 3 illustrates the current asset and liability breakdown of the average European life insurer. As expected, a major portion of assets is comprised of EUR Bonds, mainly used for liability matching purposes.

Figure 3: Simplified Balanced Sheet (in % of total investment assets)



Source: EIOPA, DWS Investment GmbH. Data as of September 2023

The equity part of the balance sheet contains (significant) equity participations, i.e., ownership positions in organizations or ventures taken through an investment, and hence returns on these investments are dependent on the profitability of the organization or venture. We assume that the share of these participations remains constant throughout all optimization runs.

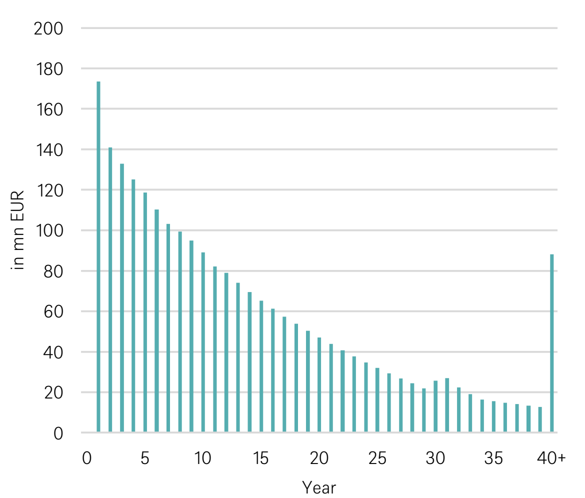
Moreover, the modelled insurer allocates a substantial share in Corporate Bonds and Private Assets and holds a Cash amount of about 4%. For simplification purposes, we split the liability side of the balance sheet into the liabilities backed by the investment portfolio and the corresponding residual as a surplus. This is broadly in line with the approach under the Solvency II regulation where we differentiate between

[6] https://www.eiopa.europa.eu/tools-and-data/insurance-statistics_en

Technical Provisions (consisting of Best Estimate Liabilities and the Risk Margin) and Own Funds representing the surplus. (Eligible) Own Funds need to cover the Solvency Capital Requirement ("SCR") and the Minimum Capital Requirement ("MCR") to ensure that the insurer has enough means to pay its policyholders, even pre-defined in worst-case scenarios. The Solvency VaR assumptions are calibrated in such way that the SCR represents the maximum loss over the next year at a confidence of 99.5% (1-in-200 years). For a detailed explanation of Solvency II, we refer to the Delegated Regulation 2015/35 from October 2014).

The exemplary liability cashflow profile is based on data sourced from EIOPA reports to approximate the future liability obligations of an average European life insurer. Figure 4 shows the distribution of discounted future liabilities[7]. It illustrates the long tenor of cashflows, which is typical for life insurers. For the purposes of this paper, we will assume an effective duration of the liabilities of 13.5 years.

Figure 4: Present Value of Estimated Future Liability Cashflows (in mn EUR)



Source: DWS Investment GmbH calculations.
*Hypothetical cashflow profile based on aggregate data sourced by DWS Investment GmbH.

It is important to emphasize that with this simplified approach we want to reflect the broader interest rate sensitivities of insurance liabilities. Hence, we do not intend to precisely model Technical Provisions under the Solvency II regulation as we neither incorporate actuarial risk factors into the Best Estimate Liabilities nor do we consider the specifics of Risk Margin calculations.

In a next step, the liabilities are divided into maturity buckets and each bucket is mapped to a respective interest rate swap index based on the key rate duration. The result of the duration matching procedure is shown in Table 2. The notional of each interest rate swap is calculated as the sum of present values of each bucket divided by the sum of present values of all liabilities. As a last step, we scale down the swap notional to account for the surplus between assets and liabilities by multiplying the swap notional by an adjustment factor smaller than one[8]. In total, we end up with a swap notional of 72.5% of the balance sheet, which can be seen in the last column of Table 2. This corresponds to the amount of liabilities in our simplified balance sheet representation.

Table 2: Duration Replication of Liabilities

Liability Bucket	Swap Contract	Liability Duration	Swap Duration	Swap Notional (adj.)
1Y-3Y	EUR Swap 2y	1.85	1.92	13.6%
4Y-6Y	EUR Swap 5y	4.82	4.60	10.8%
7Y-10Y	EUR Swap 10y	8.21	8.55	11.7%
11Y-14Y	EUR Swap 15y	12.07	11.88	9.3%
15Y-23Y	EUR Swap 23y	16.38	16.21	8.7%
24Y+	EUR Swap 50y	29.74	26.01	18.4%
Notional Weighted Average Duration		13.47	12.51	

Source: EIOPA, DWS Investment GmbH. Data as of December 2023

A side note on convexity

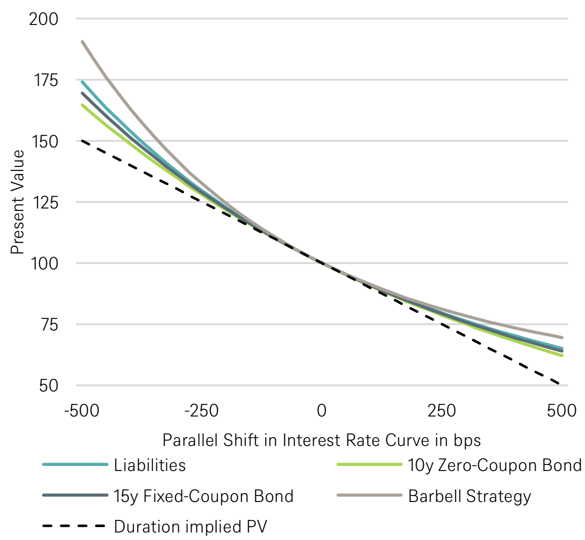
In general, Asset Liability Management has the objective of hedging interest rate risk embedded in the liabilities of a financial institution by aligning the duration of both sides of the balance sheet. A difference in the (value-weighted) duration of liabilities and assets is called a duration gap. While duration is only an approximation of interest rate sensitivity, it is fairly accurate for small interest rate changes. However, one must be aware that for more significant changes in interest rates, second order effects need to be considered, as well. The second order effect is called convexity and can be interpreted as the interest rate sensitivity of duration (and the duration gap).

Figure 5 tries to give a simple intuition about the effect of convexity and its implications. In this example, the liabilities and the three different fixed income strategies (fixed coupon, zero-coupon, and short duration/long duration barbell) are constructed to all have the same duration of 10 years. A naïve conclusion would be to assume that this translates into being perfectly hedged against parallel shifts in the interest rate curve. However, the example illustrates that the present value of assets and liabilities deviate after large interest rate changes, due to different convexity characteristics.

[7] We use the EIOPA interest rate curve for discounting.

[8] $Adjustment\ Factor = 1 - \frac{(Eligible)\ Own\ Funds}{Share\ of\ Investments\ of\ Balance\ Sheet}$

Figure 5: Convexity of Assets and Liabilities



Source: EIOPA, DWS Investment GmbH. Data as of December 2023

For longer-duration liabilities we must be acutely aware of this convexity risk with regard to asset liability management. Depending on the investor's needs and other investment constraints, additional convexity constraints can be easily incorporated into our portfolio construction framework. One such approach is to estimate the convexity of the liabilities and the asset classes that are used for duration matching. If the other assets have a positive convexity, the following inequality used as a constraint will ensure that the weighted average convexity of the asset portfolio is larger than the weighted average convexity of liabilities (represented by the duration buckets introduced earlier):

$$\sum_{k=1}^{K} \omega_k^A \, Conv(A_k) > \sum_{h=1}^{H} \omega_h^L \, Conv(L_h)$$

where

K assets are used for duration matching

H swap indices are used to reflect liability buckets

ω_k^A is the weight of asset k

ω_h^L is the weight of liability bucket h

$Conv(A_k)$ is the convexity of asset k

$Conv(L_h)$ is the convexity of liability bucket h.

If the asset universe contains asset classes with negative convexity, these assets need to be included in the K assets used for duration matching in the inequality above. Callable bonds or mortgage-backed securities are examples for asset classes with negative convexity. A second option for hedging convexity risk could be to implement an overlay strategy by using receiver swaptions, for instance, which generally exhibit high convexity (depending on tenor, strike, etc.). However, for simplicity purposes of this case study, we do not include convexity constraints in the portfolio optimization.

Methodology Part 2 - Optimization

Including liability benchmarks allows us to optimize the surplus return and surplus volatility.

Key outputs of the optimization step include an efficient frontier that graphically plots portfolios with the highest expected surplus return against the expected surplus return volatility, while all the other defined business and risk constraints are respected. The surplus return of a specific portfolio is defined as the net return of portfolio assets over liabilities considering the respective weights. The surplus return can be easily translated into a return on equity using the leverage ratio. Surplus metrics (i.e., return and volatility) reflect risk and return on equity more properly compared to asset only metrics. Hence, surplus metrics are more suitable to optimize shareholder value.

Our optimization methodology is based on a single stage (i.e., one period) portfolio search algorithm, which maximizes an objective function given a set of linear and non-linear constraints:

$$\max_{\omega^A} r(\omega^A - \omega^L) \; subject \; to$$

$$c_{lower} \leq C\omega^A \leq c_{upper}$$

$$(\omega^A - \omega^L)\Sigma(\omega^A - \omega^L)^T = \sigma_{surplus}^2$$

$$x_{lower} \leq f(x) \leq x_{upper}$$

where

ω^A is the vector of weights of indices representing the investment assets in scope

ω^L is the vector of the given weights of indices representing liabilities (notional of interest rate swaps calculated in the chapter before)

r is the vector of the expected returns

Σ is the covariance matrix

$\sigma_{surplus}^2$ is the variance of portfolio surplus returns

C is the matrix of linear constraints (Please note that the constraint $\bar{1}^T\omega^A = 1$ is also part of C, where $\bar{1}$ is the 1-vector, consisting only of ones)

$c_{lower/upper}$ is the vector of lower/upper limits for the respective row of the matrix C

$f(x)$ is a function, representing other nonlinear constraints (SCR-constraints, for instance)

$x_{lower/upper}$ are the lower/upper bounds of the nonlinear constraints.

This approach displays an extension of the classical mean-variance framework by integrating liabilities into the optimization problem. Instead of using the standard return and volatility definition, we rely on surplus return and surplus volatility. According to the definition above, expected surplus return of a portfolio is given as the difference between expected return of assets and "expected return" of liabilities considering the respective weights. The expected return of assets is conceptualized as a total return, encompassing both the capital gains from price appreciation and the income stream from dividend or interest payments.

The "expected return" of liabilities should be also interpreted as a concept representing the expected future evolution of the discount rates used to calculate the present value of the liabilities. Apart from return considerations, it is equally important to consider the volatility of surplus returns in the optimization. This ensures that optimized portfolios have similar interest rate risk characteristics as the liabilities and assets can absorb the interest rate risk in an efficient manner. However, this does not mean that the interest rate risk of assets and liabilities is always fully matched in an optimized portfolio of assets. A (potentially significant) duration gap can still exist in the optimized portfolios. The optimization procedure is rather trading off the expected return of the assets and their contribution to the volatility of the surplus return. The latter metric is of course a function of the covariance matrix of assets and liabilities. Some assets may be a good diversifier of interest rate risk of the surplus return, but less interesting from an expected return perspective while other assets can significantly enhance the expected return without good diversification properties. This may eventually lead to optimized portfolios which close the duration gap and minimize the interest rate risk of the surplus return. Solving this optimization problem for increasing volatility targets yields the portfolio weight vector ω^A, that make up the efficient frontier.

Throughout this paper we work with a mean-variance optimization framework as this is the most common framework and hence the effects of a liability incorporation become visible in the easiest way. Nevertheless, this approach can be applied in accordance with other optimization frameworks like DWS' proprietary GRIP[9], our robust optimization framework, or even simulation-based optimization frameworks.

Case Study Part 2: Optimization

Exemplary European Life Insurer

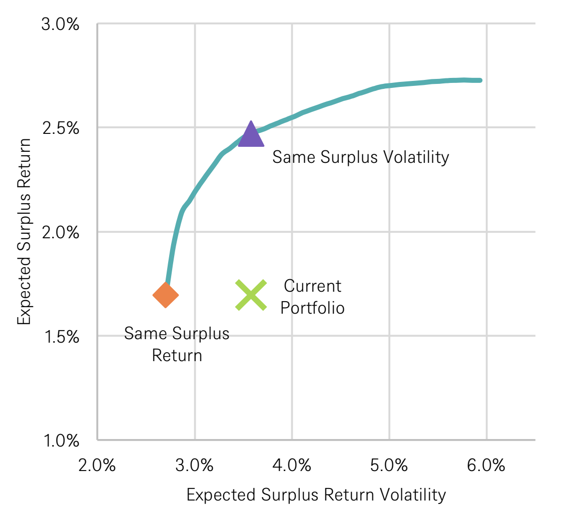
We apply the following constraints besides minimum and maximum allocations for each asset class:

1. Minimum Duration constraint (if liabilities are incorporated) imposed on EUR bonds (EUR Treasuries and EUR IG Credit) part of the portfolio.
2. Property exposure is at most 10%.
3. Private Debt has a cumulative maximum allocation of 10%.
4. EUR Corporate Bonds have a cumulative maximum allocation of 40%.
5. Maximum Market SCR set to Market SCR of current portfolio (e.g., avoiding an increase in Market SCR through optimization if liabilities are incorporated).

The solution of the optimization problem for a series of ascending surplus return volatility constraints yields a set of optimized portfolio allocations (based on our asset universe, capital market assumptions, and optimization constraints derived earlier), that deliver the maximum possible expected surplus return. Figure 6 suggests that the current allocation is inefficient as it does not provide sufficient expected surplus return for the given level of risk or equivalently the surplus volatility is too high for the current level of expected surplus return.

Figure 6: Efficient Frontier of a liability and SCR aware optimization

Figure 6



Source: DWS Investment GmbH. Data as of December 2023

The "Same Surplus Return" portfolio would provide an expected surplus return of 1.7% at an expected surplus return volatility level of roughly 2.7% compared to 3.6% of the current allocation. Alternatively, the "Same Surplus Volatility" portfolio enhances the expected surplus return from 1.7% to 2.5% at the same level of risk.

Figure 6 is based on an optimization considering both liabilities and SCR effects. In the following, we differentiate between three different ways to optimize portfolios: The basic mean-variance-optimization based on asset return/volatility and not considering liabilities ("AO"), the optimization including assets and liabilities based on expected surplus return and expected surplus return volatility ("AL"), and the "AL"-

[9] Time to get a GRIP https://www.dws.com/insights/global-research-institute/time-to-get-a-grip2/

optimization with the additional constraint that the Market Risk-SCR should not exceed the SCR of the current allocation ("AL+SCR"). We illustrate the main differences between the three procedures by calculating the average allocations to the main asset classes as well as showing average KPIs across the efficient frontier in Table 3.

Table 3: Average Allocations along the Efficient Frontier

Asset Class	Current	AO	AL	AL + SCR
Cash	4.3%	2.0%	0.1%	1.9%
EUR Treasuries	34.3%	34.3%	30.0%	34.3%
Corporate Bonds	28.6%	22.4%	25.4%	30.6%
Equities	17.0%	21.2%	24.8%	15.1%
Private Debt	9.0%	14.8%	12.0%	13.2%
Private Equity	6.9%	5.4%	7.7%	4.9%
Avg. Asset Duration	4.77	3.31	4.91	6.29
Min. Asset Duration	4.77	1.70	4.36	4.38
Max. Asset Duration	4.77	6.59	6.44	8.91
Avg. Net Duration	-4.31	-5.76	-4.16	-2.78
Avg. MSCR	11.6%	14.9%	16.9%	11.5%
Min MSCR	11.6%	5.6%	10.8%	10.8%
Max MSCR	11.6%	20.3%	20.3%	11.6%

The portfolios are average allocations along the efficient frontier:
AO: Mean-Variance-optimal portfolio
AL: Surplus Return / Surplus Volatility optimal portfolio
AL + SCR: Additionally taking the SCR-constraint into account

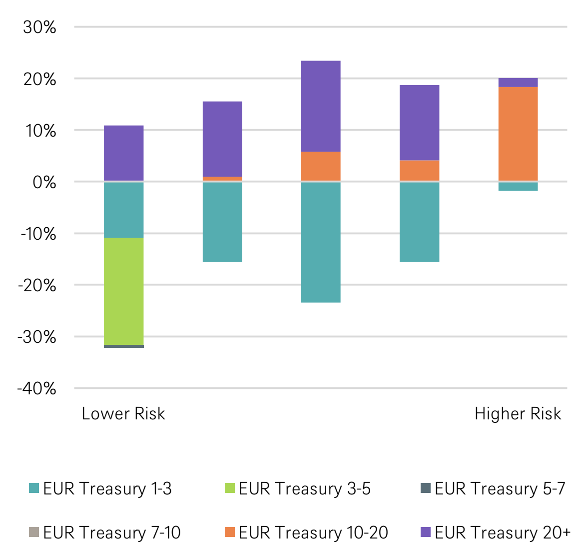
Source: DWS Investment GmbH. Data as of December 2023

The "AL+SCR"-portfolio shows how the SAA-analysis can easily be extended to also reflect investors' Solvency II objectives and constraints, i.e., consider the solvency capital requirements of the respective SAA that must be covered by Own Funds. The market stress is modelled based on the equity, interest rate, spread, currency, and property sub-modules (standard formula approach) as set out in the Delegated Regulation for Solvency II. The inclusion of liabilities serves the dual purpose of reflecting the interest rate risk arising from the liabilities in the optimization (economic perspective) and optimizing the portfolio with respect to the Market-Risk SCR (regulatory capital perspective). The liabilities are modelled to have an interest rate SCR as well, which counterbalances the interest rate SCR of the assets, as illustrated, by the fact that the allocation into EUR Treasuries/EUR Corporates further increases.

Control and Results

Without the incorporation of liabilities ("AO" portfolios) the average allocation is tilted towards shorter duration assets resulting in an average duration of 3.3 across the efficient frontier vs 6.3 in the "AL+SCR" efficient frontier. However, the minimum and maximum durations of portfolios on the efficient frontier demonstrate why an asset-only approach is misleading: Portfolio durations for the AO approach range between 1.7 and 6.6 years for higher risk portfolios mainly driven by a shift from short-dated to long-dated Treasury allocations at higher volatility targets along the efficient frontier. When including liabilities in the optimization framework the duration gap between portfolios and liabilities decreases significantly. The benefit of the inclusion of additional SCR constraints is also visible. Market Risk SCR figures vary massively along the efficient frontier for the "AO" and the "AL" portfolios (5.6.%-20.3% and 10.8% to 20.3%). The "AL+SCR" portfolios are most stable in terms of SCR as expected.

Figure 7: Differences in EUR denominated Treasury portfolio allocation of liability + SCR aware optimized portfolios vs asset only optimized

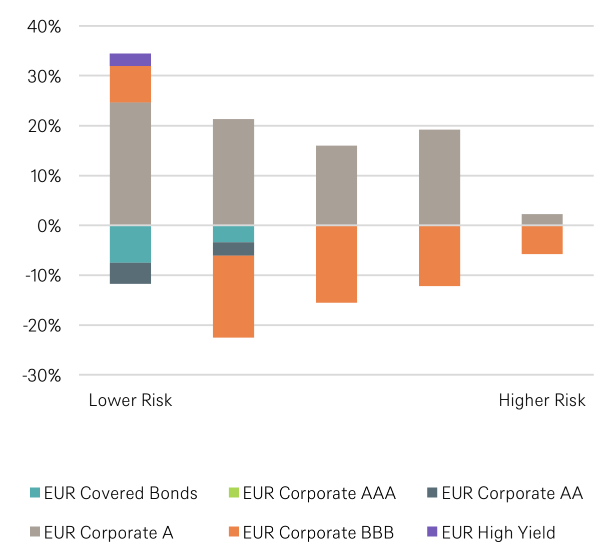


Source: DWS Investment GmbH. Data as of December 2023

It is worth taking a closer look at the allocations in the FI Treasury and Corporate bond buckets. Figure 7 illustrates the deviations for the EUR Treasury allocation across the efficient frontier. The portfolios along the efficient frontier are grouped into five groups reflecting the risk category. Next, the delta between allocations of a liability and SCR aware optimization versus an asset only procedure is displayed. It becomes apparent that, within a liability and SCR aware optimization, the allocation towards longer-dated Treasuries is significantly higher along the entire frontier. At the same time a lesser proportion is allocated to short-dated Treasuries. Alternatively, within the asset only optimization, the proportion of long-dated treasuries is quite low at low volatility targets and increases significantly at higher volatilities. For example, within our constraint set, a 30% allocation to EUR 20+ Treasuries is required to achieve a portfolio volatility of 8%.

Similar to the analysis for EUR Treasuries, the same analysis can be conducted for Corporates Bond allocations. Based on our SCR modelling (standard approach) EUR Corporate BBB comes with a spread SCR of roughly 11.1% compared to 6.6% for a EUR Corporate A index. Since the two indices have approximately the same duration their respective interest rate SCRs are approximately the same (BBB: 7.2% and A: 7.4%). The allocation resulting from optimizations including SCR considerations next to liabilities lead to a slight preference for higher credit quality on the corporate bond part of the portfolio. This is illustrated in more detail in Figure 8.

Figure 8: Differences in EUR denominated corporate bond portfolio allocation of liability + SCR aware optimized portfolios vs asset only optimized



Source: DWS Investment GmbH. Data as of December 2023

Besides comparing allocation differences, we want to focus on the comparison of certain portfolio KPIs. For this purpose, we selected the "lowest risk" portfolio on the efficient frontier for each of the different optimization settings. Since we are comparing efficient frontiers resulting from different optimization settings (i.e., expected return/ expected surplus return and expected volatility/expected surplus return volatility) these comparisons have to be taken with a grain of salt.

The view on certain portfolio KPIs further underscores the need for an integrated approach (see Table 4). The increase in Sharpe Ratio of the asset-only optimized portfolio compared to the current portfolio seems immense (0.9 vs 1.6). Additionally, the liability aware optimized portfolio is comparatively volatile with respect to asset volatility (4.9%). However, turning to the metrics that matter most for an insurance company, e.g., surplus return and surplus volatility, the story changes.

Table 4: KPIs for lowest risk portfolio

	Current	AO	AL + SCR
Expected Return	4.6%	3.7%	4.5%
Expected Volatility	5.0%	2.3%	4.9%
Asset Sharpe Ratio	0.91	1.60	0.93
Expected Surplus Return	1.7%	0.8%	1.7%
Expected Surplus Volatility	3.6%	4.0%	2.7%
Surplus Sharpe Ratio	0.47	0.21	0.62
Market SCR	11.6%	5.6%	10.8%

AO: Mean-Variance-optimal portfolio

AL + SCR: Surplus Return/Volatility optimal portfolio additionally taking SCR-constraints into account

Source: DWS Investment GmbH. Data as of December 2023

Now, the liability aware optimized portfolio has the best surplus Sharpe ratio and even comes with a lower surplus volatility compared to the asset only portfolio (4.0% vs 2.7%) illustrating why liabilities cannot be neglected when building a robust strategic asset allocation for an insurance company.

Conclusion

We have presented our methodology to derive a liability-aware strategic asset allocation combined with an application in an exemplary case study for a European life insurance company. Our approach is divided into four main steps: Profiling, Optimization, Control, and Results.

Within the profiling step, we model the assets and liabilities of the investor's balance sheet. On the asset side, we apply return estimators based on our DWS Long-View framework and estimate covariances based on historical time series data. We pay special attention to the volatility estimation for illiquid asset classes and apply a de-smoothing technique if the original time series exhibits a high degree of autocorrelation. The liability modelling is intended to represent the risk of the investor's income and overall balance sheet from the market risk factors of liabilities. It is based on the expected future liability cashflows. The cashflows are grouped into key rate duration buckets and mapped to representative market-based swap indices. The swap indices are chosen and constructed to have market-based risk characteristics substantially like those embedded in the liability forecast itself.

Our case study underscores the importance of incorporating liabilities in the formulation of a meaningful strategic asset allocation. Market-based proxies as a liability benchmark allow the inclusion of the duration gap between assets and liabilities, surplus return, and surplus volatility as part of the optimization process. Using an exemplary (average) Eurozone life-insurer we have demonstrated how the balance sheet breakdown could look like in practice and derived the replication of the liability profile with swap indices.

We have outlined a simple, mathematical formulation of the optimization problem for the inclusion of liabilities. It is based on surplus return and volatility. The framework can be easily extended to contain other (non-) linear constraints. For example, further constraints, such as Solvency II requirements, can be easily implemented for an insurance company.

Based on our asset universe and capital market assumptions we calculated an efficient frontier of optimal portfolio allocations and illustrated the deviations in allocations resulting from the different optimization settings. The liability-aware optimization framework allows for better control of the surplus volatility of the resulting SAA compared to a simple asset only approach. Hence, surplus Sharpe ratios are also improved. In particular, this is achieved by increasing the allocation into EUR Treasuries with a longer maturity. The result is a portfolio with a higher asset duration and a net asset/liability duration that is closer to zero, while keeping the Market-SCR of the portfolio constant.

The construction of market-based liability benchmarks and the derivation of suitable liability buckets lead to significantly different portfolio allocations compared to an asset only approach. Notably, our examples demonstrate that portfolios optimized solely based on asset return and asset volatility may appear low risk. However, upon revaluation using surplus metrics (surplus return and surplus volatility), these portfolios can exhibit higher-than-expected risks.

We have demonstrated how DWS incorporates liabilities in the process of deriving an optimal strategic asset allocation for our institutional clients. The intention of this approach and the case study was not to build a perfectly duration-hedged portfolio, but to rather come up with a meaningful SAA, that is a compromise between interest rate hedging and return seeking aspects, while considering other constraints, such as the Market Risk-SCR. Investors that want to further reduce their interest rate risk, could do so by setting up an overlay strategy, consisting of derivative instruments.

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Appendix

Asset Class Universe

Asset Class	Representative Index
EUR Cash	DB Euro Overnight Rate Index
EUR Treasury 1-3	Bloomberg Euro-Aggregate Treasury 1-3 Year TR Index Value Unhedged EUR
EUR Treasury 3-5	Bloomberg EuroAgg Treasury 3-5 Year TR Index Value Unhedged
EUR Treasury 5-7	Bloomberg EuroAgg Treasury 5-7 Year TR Index Value Unhedged
EUR Treasury 7-10	Bloomberg EuroAgg Treasury 7-10 Year TR Index Value Unhedged
EUR Treasury 10-20	Bloomberg Euro Treasury 10-20 Yr Total Return Index Value Unhedged EUR
EUR Treasury 20+	Bloomberg Euro-Aggregate Treasury 20+Y TR Index Value Unhedged EUR
EUR Covered Bonds	Bloomberg Euro-Aggregate Securitized - Covered TR Value Unhedged EUR
EUR Corporate AAA	Bloomberg EuroAgg Corporate Aaa Total Return Index Value Unhedged EUR
EUR Corporate AA	Bloomberg Euro-Aggregate: Corporate -- Aa TR Index Unhedged EUR
EUR Corporate A	Bloomberg EuroAgg Corporate A Total Return Index Value Unhedged EUR
EUR Corporate BBB	Bloomberg EuroAgg Corporate Baa TR Index Value Unhedged EUR
EUR High Yield	Bloomberg Pan-European High Yield (Euro) TR Index Value Unhedged EUR
US Corporates	Bloomberg US Corporate Total Return Index Value Hedged EUR
US High Yield	Bloomberg U.S. Corporate High Yield Total Return Index Hedged EUR
EM USD Sovereign IG	Bloomberg USD EM IG Sovereign
EM USD Corporate + Quasi Sov IG	Bloomberg EM USD Corp + Quasi-Sov: Investment Grade TR Index Hedged EUR
Global REITS	S&P Developed REIT USD Total Return Index
EM Equities	MSCI Emerging Markets Net Total Return USD Index
EU Equities	EURO STOXX 50 Net Return EUR
US Equities	S&P 500 Total Return Index
Equity Participations	MSCI Europe Net Total Return EUR Index
Public Infrastructure Equity	Dow Jones Brookfield Global Infrastructure Total Return Index
Public EUR Infrastructure IG	iBoxx EUR Infrastructure TRI
Private Direct Lending EUR	Morningstar European Leveraged Loan TR EUR
Private Infrastructure Equity EUR (Core)	EDHEC Infra300® EUR Index
Private Real Estate Equity US	NFI-ODCE Value Weighted Index
Private RE Pan European	MSCI Pan-European Property Index
Private Real Estate Debt EUR Senior	ICE BofA Euro Real Estate Index
Private Real Estate Debt EUR Junior	Customized Index (DWS Calculations)
Private EUR Infrastructure Debt	EDHEC Infra100® Eurozone Debt, EW EUR

Glossary

Best Estimate Liabilities
The best estimate liability is the present value of expected future cashflows, discounted using a „risk-free“ yield curve (i.e. term dependent rates).

Minimum Capital Requirement („MCR“)
The MCR is defined as a factor-based linear formula which is targeted at a Value at Risk measure over one year with 85% confidence. The MCR is floored at 25% and capped at 45% of the SCR[10].

Own funds
Own funds consist of basic own funds and free own funds. The insurer is obliged to hold own funds to cover the SCR and MCR. Own funds should absorb losses and be of sufficient quality.

Risk Margin
The risk margin is intended to increase the technical provisions to the amount that would have to be paid to another insurance company in order for them to take on the best estimate liability.

Solvency Capital Requirement („SCR“)
The SCR corresponds to the amount of own funds needed to withstand the worst annual loss expected to occur over the next 200 years (99.5% 1-year VaR).

Technical Provisions
Under Solvency II, the technical provisions are defined as the sum of best estimate liabilities and a risk margin.

For a detailed explanation of Solvency II, we refer to the Delegated Regulation 2015/35 from October 2014.

Literature Overview

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[10] https://www.eiopa.europa.eu/rulebook/solvency-ii-single-rulebook/article-2216_en

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