Liability-Relative Optimization:
Focusing on True Risk

The investment management process traditionally has focused on the risk and return characteristics of investors’ assets. In many cases, the asset-centric approach may not be ideal because the purpose of most asset portfolios is to fund a specified future cash flow stream—a liability. Optimal solutions should consider investors’ total financial situation by focusing on the risk and return characteristics of the investor’s net portfolio, which contains both assets and liabilities. After all, it is the investor’s total financial health that matters; not the risk and return of the assets in isolation. The true risk for the portfolio is not the standard deviation of the assets or the performance of the assets relative to that of peers; the true risk is not being able to fund the future liability.

Liability-relative optimization, or surplus optimization, is not a new concept. Some of the biggest names in finance including Jack Treynor, Martin Leibowitz, John Mulvey, Roger Ibbotson, Edwin Elton, and Martin Gruber have worked on this methodology at one time or another. The creators of Modern Portfolio Theory, like Bill Sharpe, have contributed tools and techniques to create optimal strategic asset allocation while considering both assets and liabilities. Following perfect storms in the early 2000s and 2008 credit crisis that saw the funding status of many plans plummet, pension plan sponsors rediscovered the need for liability-driven investments (LDI). Today, the use of LDI techniques is quickly spreading beyond traditional users to those designing target maturity and retirement income strategies.

Liability-based approaches have typically applied within a defined pension context where there is a legal liability, but they are relevant for everyone with a portfolio of assets that exists to fund a liability. This includes individual investors funding their future retirement income, foundations and endowments seeking to preserve real purchasing power, or insurance companies managing pay-outs in conjunction with a pool of assets.

The historical approach to asset-liability modeling has actually been asset-only mean-variance optimization followed by a series of Monte Carlo simulations. The resulting return, wealth, and income distributions are then analyzed. This is an inferior tactic because asset-only optimization fails to consider the liability and focuses on the wrong definition of risk. The true risk is that of a mismatch between the assets and the liabilities preventing the portfolio from paying for the liability.

Conceptually, liability-relative optimization is an extension of the traditional Markowitz asset-only approach to determining an optimal asset allocation in which the mean-variance optimizer is constrained to hold an asset class (or combination of asset classes) representing the liability short. Liabilities are typically modeled as a combination of TIPS, long-term nominal bonds, and perhaps a small allocation to equities or real estate. The liability model attempts to capture the systematic characteristics of the liabilities.

Institutional investors are now anxiously adopting these techniques. Robust tools are available for building portfolios that exist to pay for liabilities. Liability-relative optimization helps redefine risk around what truly matters, maximizing the health of an investor’s total portfolio and taking advantage of a natural hedge that may exist between the portfolio’s assets and the systematic risk factors that influence the value of liabilities. Investment professionals have the opportunity to make conscious decisions to find risk-return balances for the entire portfolio when building optimal asset allocation strategies.

References


Case Study
Construction of a Liability Model using Surplus Optimization in Morningstar® Direct®

Liabilities are typically a series of outgoing payments. The systematic characteristics of liabilities vary. In most cases, the cash flow series is expected to last for a significant period of time. In this sample case for a pension plan, we will use the LT Gvt Bond to represent our pension liability due to its long-term nature (20 years in this case). However, Direct Asset Allocation allows practitioners to choose any assets, or combination of assets, to model the systematic characteristics of the liabilities.

The funding ratio compares a plan’s total assets to its liabilities, and is defined as:

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\text{Funding Ratio} = \frac{\text{Assets}}{\text{Liabilities}}
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If the initial funding ratio < 1, then the portfolio fund is underfunded; if the initial funding ratio > 1, then the portfolio fund is overfunded; if the initial funding ratio = 1, then the portfolio fund is fully funded.

Ultimately, the better a plan’s funding is, the smaller the effect of liabilities on the asset allocation and the lower the impact of a switch from an asset-only to a full surplus optimization.1

When running an optimization case that includes liabilities, Direct Asset Allocation can generate three “expected return” measures: Expected Surplus, Expected Surplus Ratio, and Expected Funding Ratio. The default measure is Expected Surplus Ratio, which is a forecast of future net worth. It is the excess of the asset return over the liability return, expressed as a percentage of the initial value of the fund’s assets. Direct Asset Allocation also produces a “surplus standard deviation,” which mathematically is the square root of the surplus variance.

Figure 1. Surplus Optimization: Efficient Frontier and Allocation Spectrum

In this sample case, we will assume the Investment Policy Statement permits investment in Large Stocks, Small Stocks, IT Govt Bond, and 30 Day TBill.

Instructions

- Open Direct Asset Allocation
- Click on + New Input from the main window
- Add the following asset and liability asset classes: Large Stocks (Ibbotson SBBI US Large Stock TR USD), Small Stocks (IA SBBI US Small Stock TR USD), IT Govt Bond (IA SBBI US IT Govt TR USD), 30 Day TBill (IA SBBI US 30 Day TBill TR USD) and LT Govt Bond (IA SBBI LT Govt TR USD). Click OK
- A new Asset Allocation window will appear.

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We will assume a fully funded pension fund. (The Direct Asset Allocation also enables you to run a surplus optimization on funds that are overfunded or underfunded.)

To select asset and liability asset classes, and assign an asset value of $25,000,000 and initial funding ratio for the pension plan:

Instructions

1. In the new Asset Allocation window, go to Optimizer Workspace. Click on Optimization button and activate the Surplus Optimization button at the top.
2. Click on Select Assets to select the following asset classes as your Assets: Large Stocks, Small Stocks, IT Govt Bond, and 30 Day TBill
3. Enter 25,000,000 as the Initial Assets value.
4. Click on Select Liabilities to select the LT Govt Bond as your Liability
5. Enter 25,000,000 as the value for LT Govt Bond.
6. Click the OK button

The Efficient Frontier and the other linked windows appear in the Optimizer Workspace. Select “Position 50”, which is close to the midpoint portfolio amongst the 100 portfolios created on the efficient frontier. By including the portfolio liability into the optimization process, the portfolios generated along the efficient frontier from the surplus optimization (Figure 1) are constrained to hold the liability short. This calculates more realistic portfolio risk-return expectations than from an asset-only optimization as the surplus optimization favor asset classes that hedge the liability. In this study, we notice a reduced allocation to the short-term cash component in the surplus portfolio allocations (Figure 2).

The Asset Mix Statistics window displays the portfolio data (expected surplus, expected surplus ratio, expected funding ratio, surplus standard deviation, asset arithmetic mean (refined), and asset standard deviation (refined), etc.) for the portfolio at “Position 50” (Figure 3).

Notice that the Expected Surplus Ratio, the Surplus Standard Deviation, and the Expected Funding Ratio are 5.19%, 17.23%, and 1.05, respectively. The asset expected return is 10.98%. Recall from the Input Workspace, that the return for the liability, LT Govt Bond is 5.79%.
Since the fund is fully funded, the fund’s assets and liability obligation both have a present value of $25,000,000. In other words, the fund’s net worth or initial surplus is 0 (assets minus liabilities), but given the Expected Surplus Ratio of 5.19%, you can calculate next year’s net worth, or Expected Surplus. Since the expected surplus ratio is a forecast of future net worth, next year’s expected surplus is $1,297,500. We arrive at this figure by multiplying this year’s assets by the Expected Surplus Ratio, or: $25,000,000 \times 5.19\% = $1,297,500.

Also, we can forecast next year’s total assets (not accounting for the liability obligation) and the present value of the liability a year from now. The forecasted total assets a year from now are this year’s assets multiplied by $1 + \text{E(R}_A\text{)}, the asset expected return for a given point on the efficient frontier line, or: $25,000,000 \times (1 + 10.98\%) = $27,745,000.

The forecasted present value of the liability a year from now is simply this year’s present value of the liability obligation multiplied by $1 + \text{E(R}_L\text{)}, the return on liabilities, or: $25,000,000 \times (1 + 5.79\%) = $26,447,500.

From here, we can calculate the expected funding ratio one year from now to be 1.05, or $27,745,000 / $26,447,500 = 1.05.

Monte Carlo simulation can provide more detailed insight on whether the pension plan portfolio we select here can satisfy the long term return and risk objectives.

**Instructions**

- Click on **Forecasting Workspace**
- Click the **Forecasting** button at the top
- Go to the **Display** tab, add or remove simulation **Percentiles, Project Year, Target Return** and **Target Value**, if needed.
- Enter additional cash flows to the asset portfolio and liability portfolio, if any
- Click the **OK** button

The simulated results are reported on wealth, return, and funding ratio basis. For example, we can view the forecasting of Wealth Percentiles, Target Returns, Cumulative Probability of Loss, and Funding Level.

For the wide range of simulation graph and tables, there are usually three views available: the asset-only portfolio, the liability-only portfolio, and the surplus portfolio. The liability-only portfolio functions just as they do with an asset-only portfolio mix. All graphs and tables that are normally available for simulated asset portfolios are available for the liability portfolio.

The surplus portfolio is created by taking the wealth value of the assets for each simulation and subtracting the wealth value of the liability for the simulation. Since this can lead to negative wealth values for the surplus portfolio, it is meaningless to generate return numbers for the surplus portfolio. Thus, some of the forecasting graphs and tables may not be applicable.