Step Optimization and Portfolio Design

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Introduction

- Portfolio optimization is a theoretically appealing solution to the portfolio construction problem. In practice, optimized solutions often have several shortcomings:
    - The impossibility of completely defining each investor's objective function means outcomes may overweight some objectives at the expense of others;
    - Error maximization of inputs can lead to corner solutions, leading many practitioners to modify inputs or constrain outputs; and
    - The 'black box' nature of the process can lead many investors to distrust or discount the output

- One solution Jacobi has developed to help its users overcome these shortcomings is a process of incremental Step Optimizations starting from the client's current or strategic asset allocation. The results of the Step Optimization process are returned as interactive charts depicting the incremental and aggregate change in positions as well as forecast portfolio outcomes.

- The current asset allocation is a useful starting point for the process because, assuming it has been thoughtfully constructed, it represents a good first approximation of the optimal portfolio for the investor's true objective function. Visualizing how the optimizer would then improve upon that portfolio in small step-changes provides additional insight into potential changes that could be made, and on the signals that are being provided from the asset class assumptions.

- This paper explores how multi-asset investors can use Jacobi's Step Optimization process to identify potential asset allocation trades, communicate changes to investment strategy with clients, and gain insight into the practical implications of their asset class assumptions.

1. Shortcomings of traditional portfolio optimization

Traditional portfolio optimizers seek to find the combination of asset classes that maximize some investment objective function. Quite often, the investment functions used are simplified or single dimensional approximations for what the true, multi-dimensional objective function might actually be.

A major issue with performing such optimizations is that the objectives used often don't (and perhaps can't) accurately reflect the true objective function for the fund. For instance, while a fund's stated objectives might relate to long-term real returns, stakeholders are typically also concerned with additional objectives such as risk versus peers, underperformance in down markets, costs, liquidity, and drawdown risk amongst others. Sometimes the relative importance of these objectives shifts over time or under different circumstances. Trustees or investors might be focussed on risk versus liabilities when there is a funding shortfall, but then might prefer seeking extra return when funding levels improve. These shifting preferences can make defining the true investment objective of the fund an impossible task.

The error maximizing nature of traditional portfolio optimization is a second major shortcoming. Small changes to the inputs used in an optimization (asset class return, volatility and covariance) can lead to very different optimal portfolios. These portfolios can also take the form of 'corner solutions', with large weights to few asset classes.

Finally, the 'black box' nature of the results can lead many investors to distrust or discount the output. These investors often want to know which portfolio trade-offs are most advantageous and which offer only marginal improvement. This is particularly true where clients may be put off by frequent or large changes in portfolio allocation.

2. The Step Optimization alternative

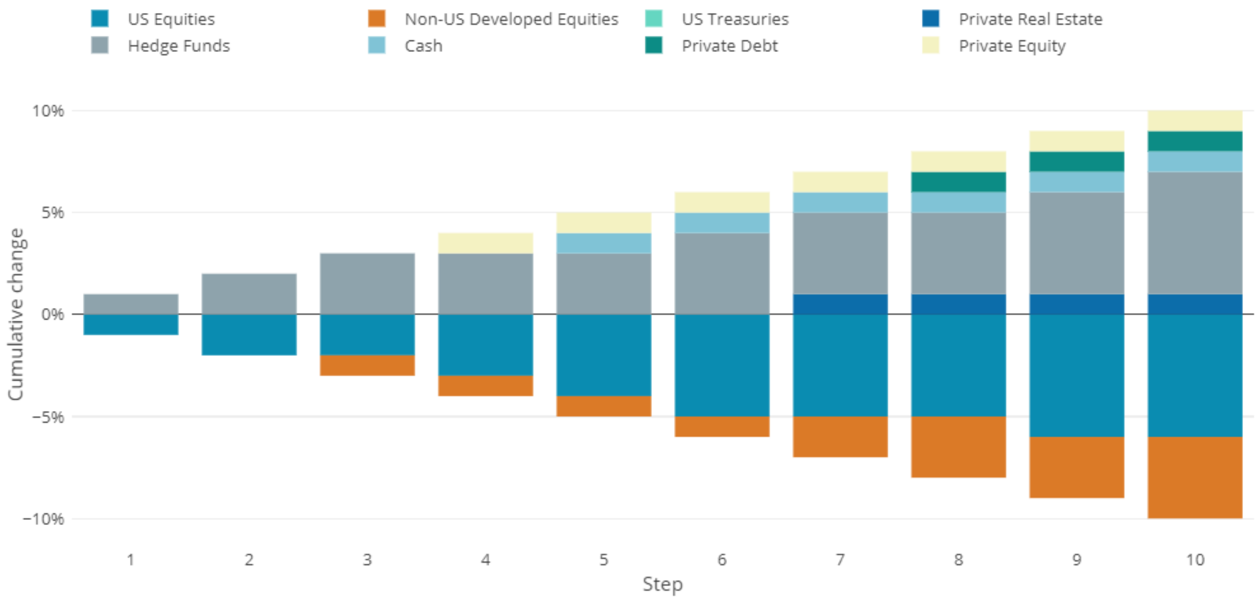
An alternative solution Jacobi has developed to help its users overcome these shortcomings is a process of incremental Step Optimizations starting from the client's current or strategic asset allocation. The current asset allocation is used because, assuming it has been thoughtfully constructed, it embodies the investment team/consultant's knowledge of the investors' and trustees' true objectives and risk tolerance, as well as their views on prospective return and risk. It is therefore a good approximation of the optimal portfolio.

The Step Optimization process then makes incremental step changes to the portfolio, the size and number of which are set by the user to align with their internal decision-making framework, to improve a given objective. At each step performed by the optimization, the system visually displays the resulting asset allocation, cumulative change in allocation, and the resulting changes in expected portfolio outcomes to understand why the asset allocation change is desirable.

3. Visualizing the outputs

To demonstrate the output of the Step Optimization process, we have created a model Growth portfolio in the Jacobi platform and run the process, first seeking to find asset allocations that would improve the portfolio's Sharpe Ratio. In our scenario, the portfolio is expected to achieve its long-term objectives but the Investment Committee wishes to know whether the current portfolio can be improved upon. We first run the optimization seeking to maximize the fund's Sharpe Ratio.

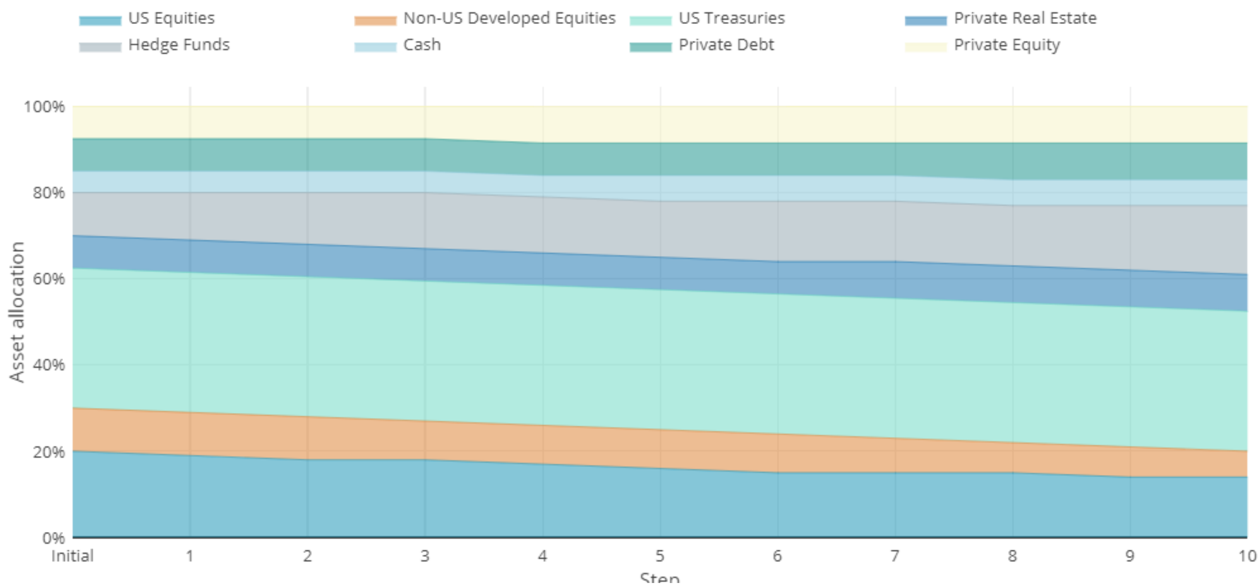
Figure 1: Changes in Allocation – Maximizing Sharpe Ratio



Source: Jacobi. Simulated results only.

Figure 1 shows the cumulative change to the fund's asset allocation over 10 steps of 1% each. The fund's Sharpe Ratio is improved by funding increased allocations to hedge funds, US equities and private real estate, funded from non-US developed equities and US equities. We can also visualize how the fund's overall asset allocation shifts across steps, as shown in Figure 2.

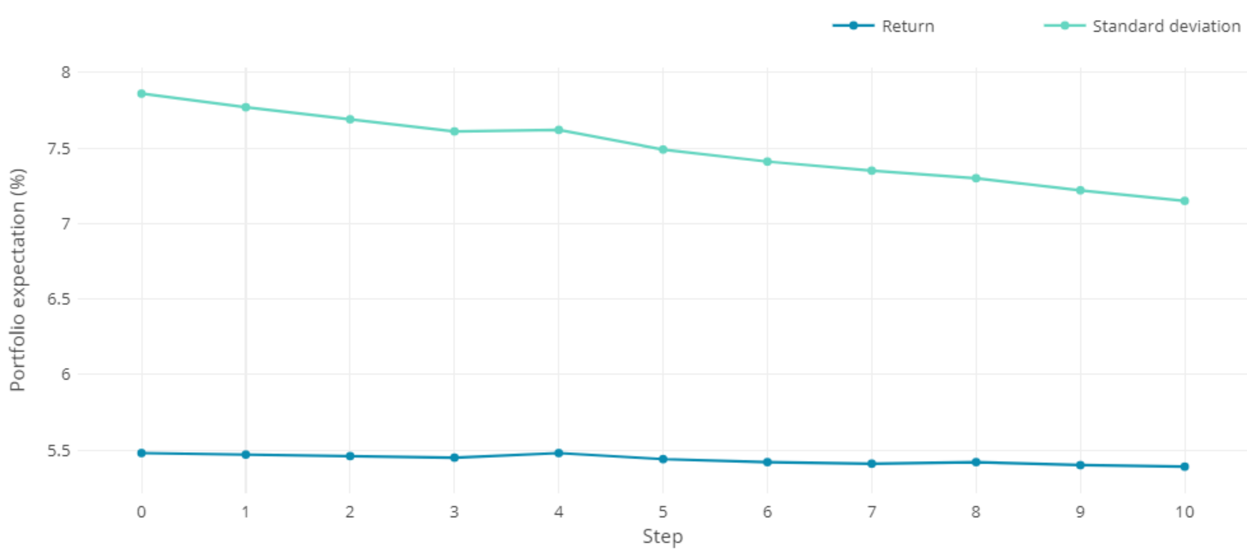
Figure 2: Asset Allocation – Maximizing Sharpe Ratio



Source: Jacobi. Simulated results only.

Figure 3 shows how the fund's return and risk is expected to change across steps. It shows that in this scenario Sharpe Ratio is maximized primarily by reducing risk from the initial asset allocation.

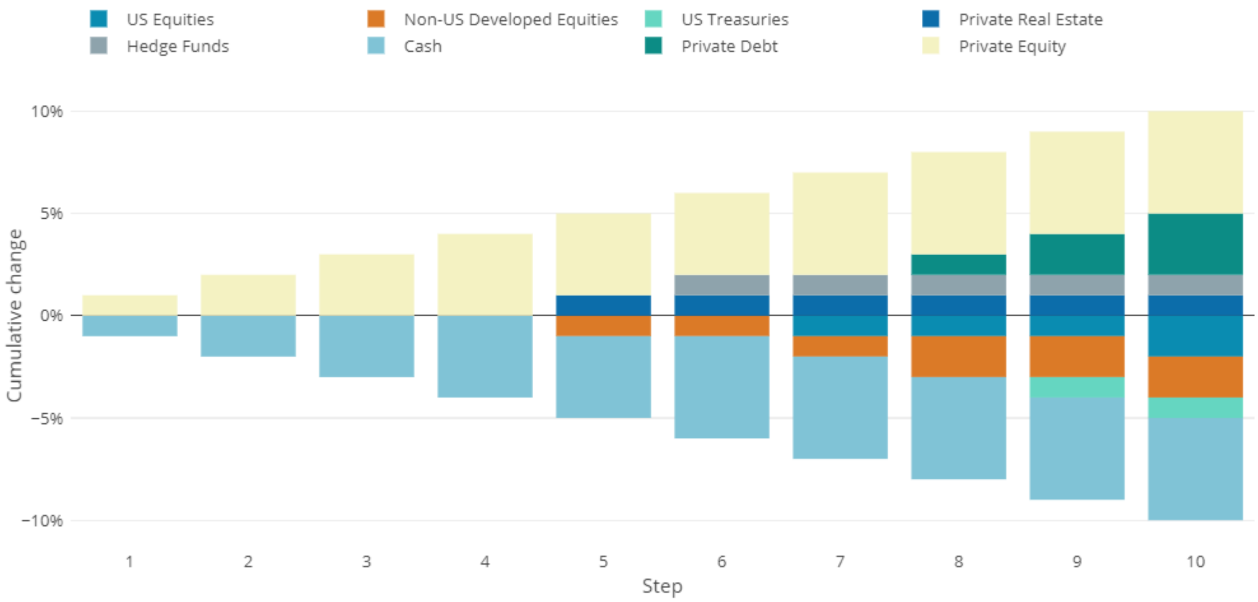
Figure 3: Expected Return and Risk – Maximizing Sharpe Ratio



Source: Jacobi. Simulated results only.

There are many scenarios where an investor may not wish to reduce risk, for instance, where they are benchmarked versus a reference portfolio or require a certain return target. We can also configure our Step Optimization for these scenarios. Figure 4 shows the asset allocation changes when we re-run the Step Optimization to maximize return for a target annual standard deviation of 8.5%.

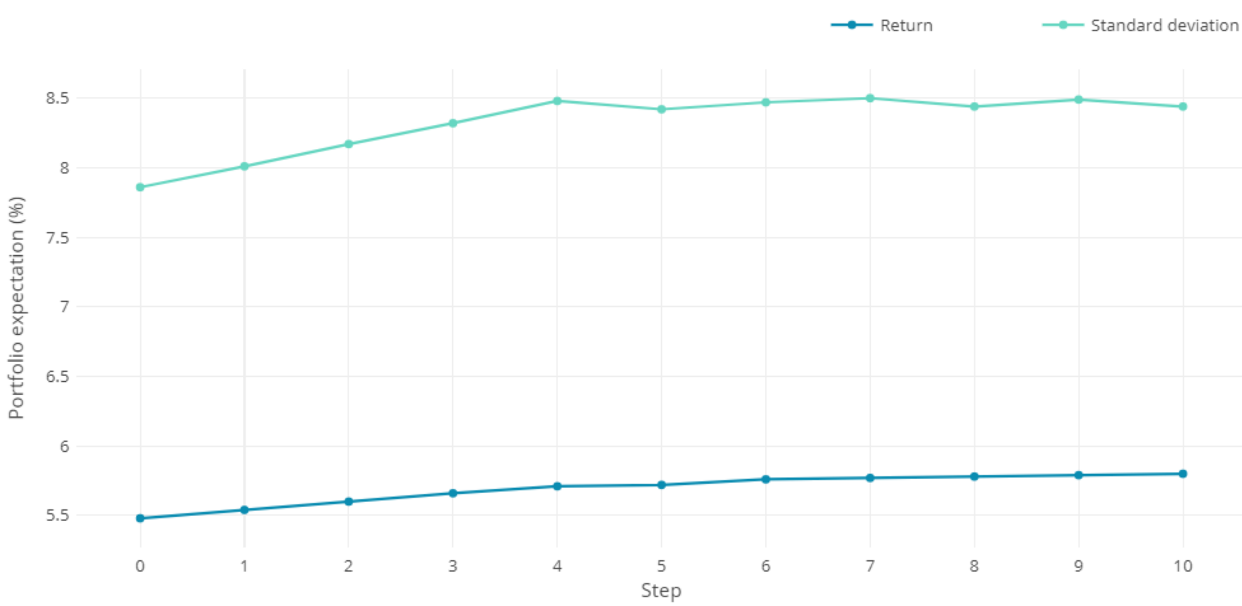
Figure 4: Changes in Allocation – Maximize Return for Risk



Source: Jacobi. Simulated results only.

Now the portfolio adds exposure to private equity, private real estate, hedge funds and private debt. The majority of these allocations are funded from cash. Figure 5 shows how the expected return of the portfolio increases across simulations while the expected volatility levels off at 8.5%.

Figure 5: Expected Return and Risk – Maximize Return for Risk



Source: Jacobi. Simulated results only.

4. Incorporating bounds and constraints

Most investors operate within the bounds of “hard” or “soft” constraints that may include asset allocation ranges, fee budgets, and tracking error constraints, amongst others. These elements can, of course, be incorporated into the optimization as part of the objective function or as bounds or constraints. Because of the path-dependent nature of the Step Optimization process, this raises the possibility that it will fail to reach the global optimal portfolio in the presence of bounds or constraints. Below, we use a trivially simple example to illustrate this clearly.

In the example depicted in Table 1, the investor has a three asset, equally-weighted portfolio and is seeking to maximize expected return subject to a fee constraint of 1.0%. Asset allocation changes are only considered in increments of +/- 1% changes in asset allocation, a level of materiality determined by the investor’s stakeholders. From the starting asset allocation there is no discrete +/- 1% asset allocation change that either increases return without exceeding the fee budget or reduces fees without reducing expected return. Therefore, the path-dependent Step Optimization process would conclude the portfolio is currently optimal.

Table 1: Example of step optimization reaching a local rather than global optimal portfolio

Asset Class	Expected Return	Fee	Starting Asset Allocation	Portfolio Asset Allocation Changes					
Asset Class 1	8.0%	1.0%	33.3%	-1.0%	-1.0%	1.0%		1.0%	
Asset Class 2	12.0%	1.5%	33.3%	1.0%		-1.0%	-1.0%		1.0%
Asset Class 3	6.0%	0.5%	33.3%		1.0%		1.0%	-1.0%	-1.0%
Portfolio Expected Return			**8.67%**	**8.71%**	**8.65%**	**8.63%**	**8.61%**	**8.69%**	**8.73%**
Portfolio Fee			**1.00%**	**1.01%**	**1.00%**	**1.00%**	**0.99%**	**1.01%**	**1.01%**

Source: Jacobi. Simulated results only.

However, if the investor had the tolerance to move +/- 2% from the starting asset allocation they could reach a portfolio with a higher expected return and the same fee by reducing the allocation to Asset Class 1 by 2% and increasing the weights to the other asset classes by 1% each.

To handle this situation, the Step Optimization can also be run to identify the optimal portfolios by making incrementally greater aggregate changes in asset allocation without assuming that each new portfolio directly follows from the one identified at the previous step. For instance, the optimal portfolio that is +/- 1% away from the starting portfolio need not be a stepping stone towards the portfolio that is +/- 2% away from the starting portfolio.

The results of this second optimization process can be contrasted with the path-dependent results to help inform investment strategy positioning and defend interim decisions that may themselves not improve expected portfolio outcomes but are necessary to achieving better long-term portfolio positioning.

5. Using the outputs

The Step Optimization outputs are useful in the portfolio management process in three main respects: identifying asset allocation changes, communicating information, and sense-checking models.

Identifying asset allocation changes: The output of the Step Optimization process naturally leads itself to identifying allocation changes that improve the expected performance of the portfolio. Many trustees/investors are unwilling to make wholesale changes to portfolios in the short term but are willing to make incremental changes over time. This type of analysis is ideally suited to such a process.

Communicating information: The Step Optimization output can be used to aid discussions with trustees/investors as to why a course of action is recommended, specifically, how specifying different objectives or including/relaxing bounds or constraints influences asset allocation. Visualizing the expected benefits arising from the optimization also helps investors make informed decisions about whether making incremental changes to the asset allocation are worthwhile, or within the realm of model error.

Sense-checking models: Finally, the results also provide insight into the model inputs and whether they accurately reflect the investment team's beliefs. For instance, if the results suggest that a portfolio dramatically increase the portfolio weight to private equity, but the investment team was bearish on the outlook for that asset class, it suggests that there is a mismatch between the team's beliefs and the assumptions used in the model. If the team is unwilling to accept the outcomes of the optimization, then it may be the case that the models are incorrectly specified.

Conclusion

Traditional portfolio optimization processes have several well-known shortcomings. To overcome these, investors often must significantly constrain the optimization such that the results add little new information.

Jacobi's Step Optimization process overcomes many these issues and could be a useful input/sense-check into multi-asset class portfolio construction. The potential benefits are three-fold: identifying trades/strategic asset allocation changes, communicating information, and sense-checking models. And because the process is contained within our interactive visualization suite, users can update return assumptions, portfolios, and available asset class at the click of a button to re-calibrate the results.

If you are a multi-asset class investor and are looking for unique tools to take your asset class modelling, portfolio construction, or communication to the next level, Jacobi has the solution for you. At Jacobi, we recognize that multi-asset investing involves a range of challenges that cannot be addressed by systems designed for equity or fixed income investing. Our cloud-based technology combines powerful modeling processes with professional visualization tools to tackle problems unique to the multi-asset class portfolio management space.

About Jacobi

Jacobi's storyboard technology has its roots in institutional investment management and brings together investment expertise and a market-leading technology platform. Headquartered in San Francisco, the company is led by a team of experienced investment professionals and engineers.

For more information on Jacobi's modeling framework or other tools available within our portfolio modeling and visualization suite, please do not hesitate to contact us.

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