Invesco Vision Case Study 4: Robust optimization

Addressing estimation error in portfolio construction

A common criticism of unconstrained mean-variance optimization is that it can result in undiversified portfolios or portfolios with large asset concentrations. This behavior is a direct result of mean-variance optimization (MVO) being sensitive to small changes in input parameters. Return forecasts are especially problematic as they are the most influential drivers while also being most likely to be erroneous. To overcome issues with estimation error, practitioners will frequently impose constraints on assets which are believed to be most problematic. While this can produce more diversified portfolios, it can also lead to the application of arbitrary limits on portfolio weights that result in portfolios that aren't necessarily optimal. To achieve more diversified MVO portfolios, we can use the Robust Mean-Variance approach introduced earlier in this paper. In this example, we consider an efficient frontier comprised of a small set of fixed income and equity indices and we compare unconstrained MVO portfolios in Figure C4a with their robust counterparts in Figure C4b. Specifically, we compare efficient portfolios with an expected return equal to that of an included existing portfolio. In both cases, we find that the same return can be achieved at lower levels of risk.

The first, and most notable, point is that the allocations produced through robust mean-variance optimization are far more diversified across assets than those produced by MVO. This is the direct result of robust optimization's explicit incorporation of uncertainty in return expectations. The return uncertainties reduce the dominance of returns in the overall optimization problem. Consequently, while mean-variance optimization allocates virtually all equity exposures to emerging markets equities (EM), robust mean-variance optimization diversifies equity allocations to also include US and developed market equities while still preserving its preference for EM. A similar pattern can be seen in the fixed income investments where corporates are added as part of the allocation at lower risk levels. It also interesting to note how the equal return portfolios produced by each approach differ. Examining the factor analyses for both examples, we see a move from equity factor exposure to more credit and rates. In the robust approach, this is achieved through a more diverse set of underlying assets.

The second point to note is that the efficient frontier is lower and shorter than its mean-variance counterpart. As we seek to diversify away from more concentrated MVO allocations, the resulting portfolios appear sub-optimal given that they include allocations to assets with less desirable characteristics in the MVO sense. However, these portfolios are expected to provide improved out-of-sample performance relative to the theoretically optimal MVO portfolios. Finally, we remark that the length of the robust mean-variance efficient frontier is less than the standard mean-variance efficient frontier. This is also to be expected as the diversification inherent to robust mean-variance optimization limits the ability of the optimal portfolio to invest in any single asset class, as is necessary in this case, to reach the risk and return delivered by the highest risk MVO portfolio which allocates 100% of assets to EM.

A final observation is that the minimum variance portfolios are identical under both optimization frameworks. In both cases, the risk, the return and the underlying asset allocations are identical. This should come as no surprise as the minimum variance portfolio is entirely based on risk and correlations with no dependency on return estimates.

Figure C4a: Unconstrained mean-variance optimization
Highlighting frontier portfolio with the same risk as the current portfolio

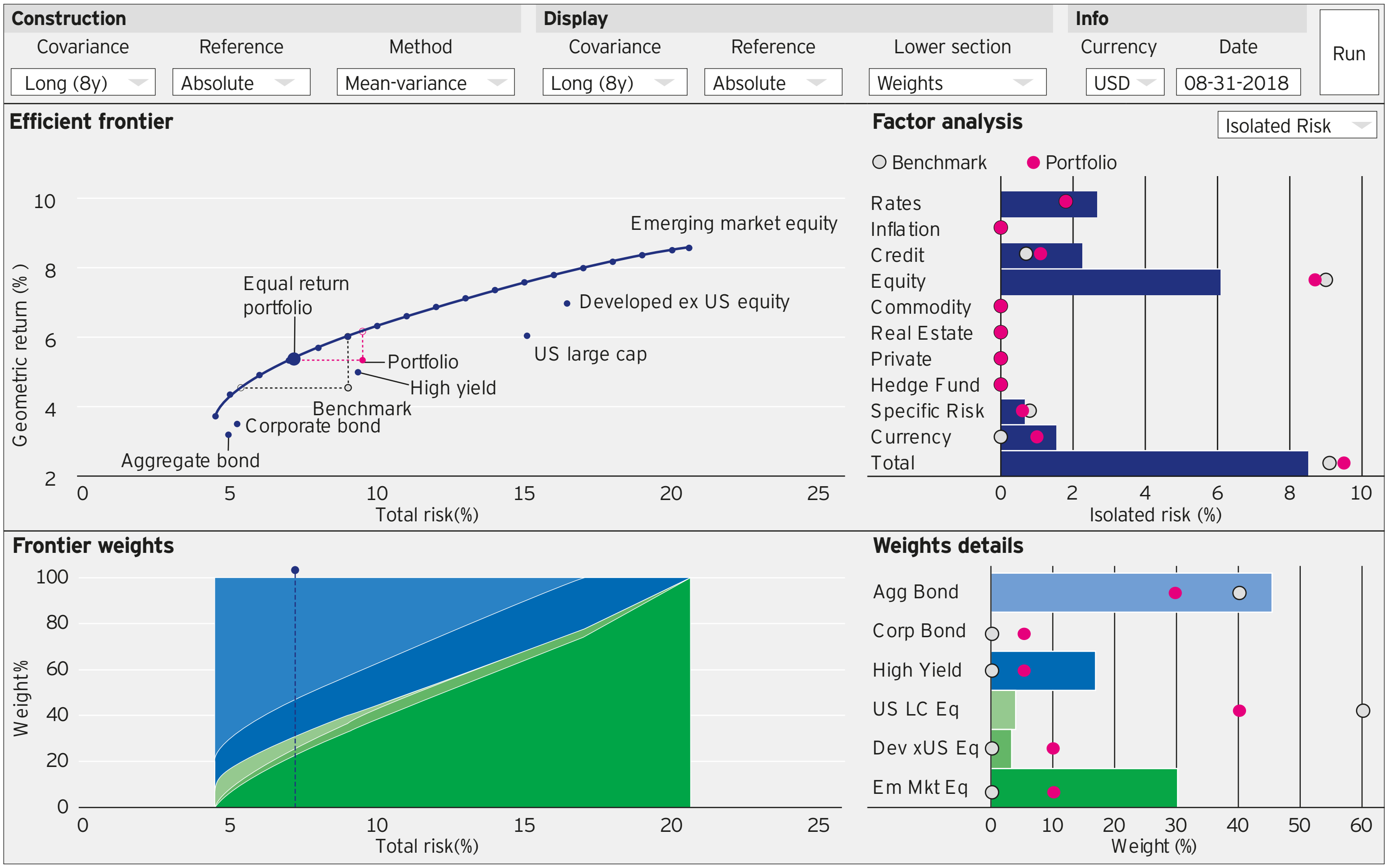
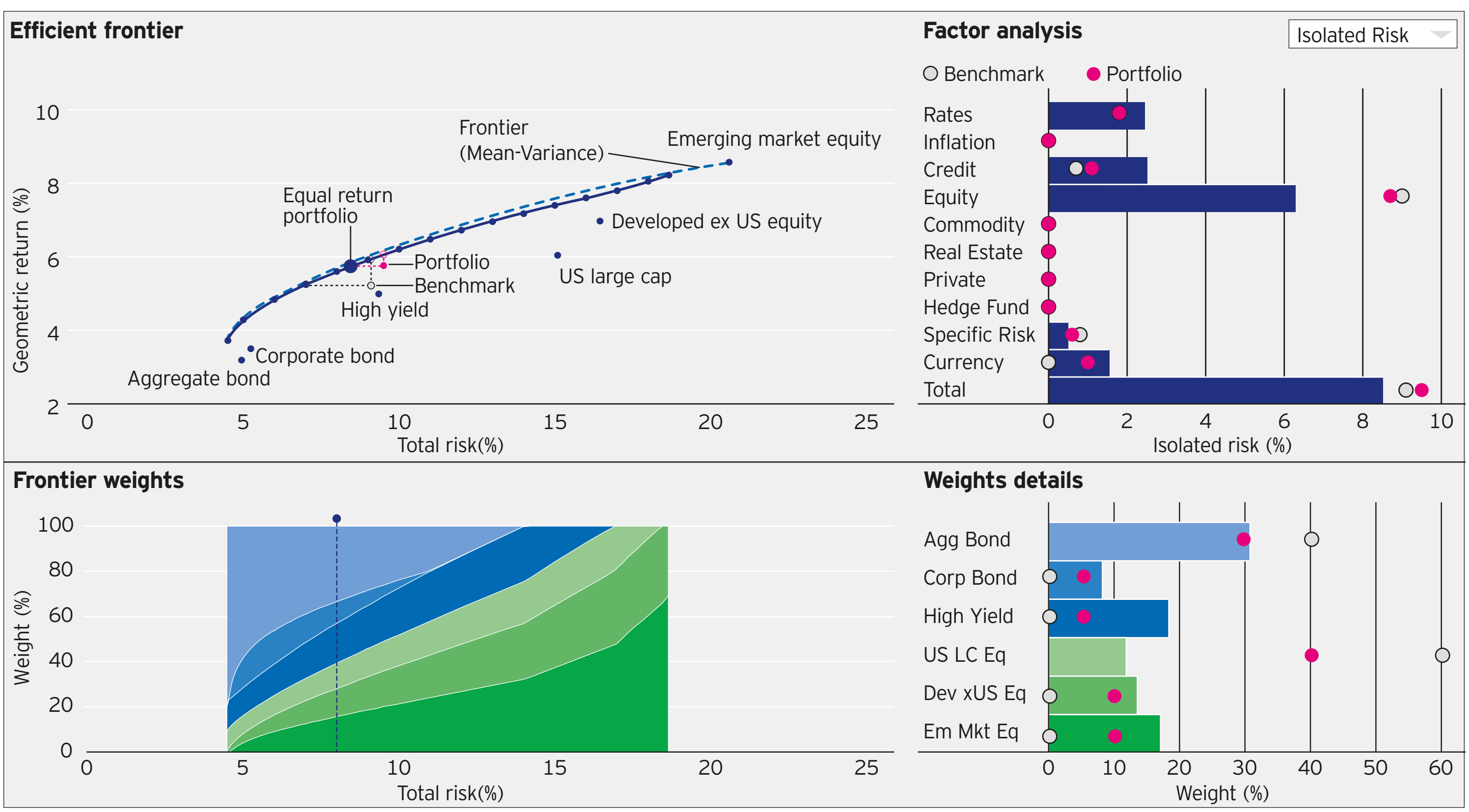


Figure C4b: Robust optimization
Highlighting frontier portfolio with the same risk as the current portfolio



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