



## AQR Alternative Thinking 2025 Issue 3

# Exploring Capital Efficiency

## Investment choices that help unlock the full benefits of diversification

### Portfolio Solutions Group

#### Executive Summary

“Diversification is the only free lunch in investing,” said Harry Markowitz, father of modern portfolio theory. But many investors who tried to follow this advice during the last 15 years found their diversification lunch to be rather costly. This was partly because of an exceptional market environment—a 15-year bull market in U.S. large-cap equities. It was also because Markowitz was implicitly assuming that investors can and will use leverage.

But investors don’t need to borrow money themselves to make the portfolio math work for them. They can invest in levered strategies such as private equity or hedge funds, or tilt towards higher-risk segments of a market, like small-cap stocks or high duration bonds, which may deliver more investment “bang for the buck” and allow capital savings to be deployed elsewhere. In this article we assess the benefits, costs and risks of these different sources of capital efficiency, to determine which of them offer the best route to improved portfolio diversification *and* higher long-term returns. We find that capital efficient investments can deliver substantial expected benefits at the portfolio level, especially for leverage constrained investors.

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### **About the Portfolio Solutions Group**

The Portfolio Solutions Group (PSG) provides thought leadership to the broader investment community and custom analyses to help AQR clients achieve better portfolio outcomes.

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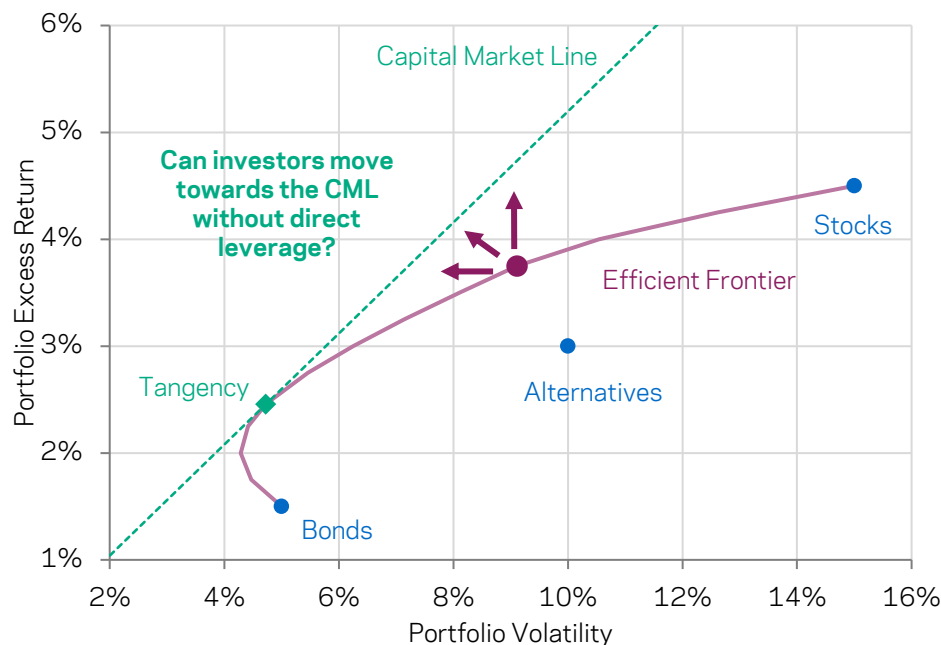
## Introduction: Modern Portfolio Theory vs. Practice

The benefit of investing in a diverse set of assets has been recognized for centuries, but it was 1950s modern portfolio theory that formalized and quantified this concept as providing a *higher return per unit of portfolio risk*. Put simply, the returns of a diverse set of investments add up over the long run, but the risks do not, because they tend to materialize at different times.<sup>1</sup>

In theory, investors can monetize this diversification by leveraging the so-called tangency portfolio according to their risk appetite (moving up the green dashed line in **Exhibit 1**). In practice, most investors can't or won't borrow to invest, so instead they choose a more concentrated unlevered mix of assets that meets their return objectives and risk constraints (red dot).

If direct leverage is off the table, then any investment that offers a *delegated* or *embedded* leverage service ("bang for the buck") is likely to be valuable. We'll show that it can help investors achieve the same effect: increase their portfolio return for a given level of risk (follow the red arrows on the chart). We'll also show that the benefit may be substantial – perhaps as large as the portfolio's total expected net alpha.

**Exhibit 1: Most Portfolios Could Be Improved with Leverage (Direct or Otherwise)**



Source: AQR. Assumes 0.3 Sharpe ratios for all three assets (gross of fees for stocks and bonds, net for alternatives), with zero correlations. Volatilities are 15% for stocks, 5% for bonds and 10% for alternatives. The tangency or maximum Sharpe ratio portfolio is 18% equities, 55% bonds and 27% alternatives. For illustrative purposes only and not representative of a portfolio AQR currently manages.

<sup>1</sup> Of course, a tendency is not a certainty: diversification does not eliminate the risk of experiencing investment losses. Rather, it makes large losses less likely.

In this article we use the terms delegated or embedded leverage to refer to any investment that delivers greater capital efficiency than other similar investments. This investment could employ leverage directly, or it could deliver a specific economic exposure (such as equity beta or rates duration) with fewer invested dollars. **Exhibit 2** lists some of the many choices available to investors. The next two sections will explore investments that offer levered exposure to *market risk* and *active risk*, respectively. We also discuss evidence that some embedded leverage is priced at a premium, offsetting any portfolio construction benefit, while other embedded or delegated leverage is available at minimal cost and so confers larger benefits.

### Exhibit 2: Investors Can Access Leverage in Many Ways (Not All Are Equal)

Direct Leverage	Embedded or Delegated Leverage	
	Mainly Market Risk	Mainly Active Risk
<ul style="list-style-type: none"> <li>• Balance sheet leverage</li> <li>• Own use of derivatives</li> </ul>	<ul style="list-style-type: none"> <li>• High beta stocks</li> <li>• Small caps &amp; EM stocks</li> <li>• Levered ETFs</li> <li>• Private equity</li> <li>• Private credit</li> <li>• High duration bonds</li> <li>• Real estate funds</li> <li>• Risk parity</li> </ul>	<ul style="list-style-type: none"> <li>• Active extension (e.g., 130/30)</li> <li>• Portable alpha</li> <li>• High-volatility liquid alternatives</li> <li>• Single-manager multi-strategy hedge funds</li> <li>• Unfunded hedge fund solutions</li> </ul>

Source: AQR. List provides main methods by which investors access leverage and is not necessarily exhaustive. For illustrative purposes only.

## Embedded or Delegated Leverage Applied to Market Risk

The classic combination of stocks and bonds (which thrive on strong and weak economic growth, respectively) is perhaps the best-known form of diversification. But investors without access to leverage cannot make full use of this diversification: super-diversified tangency portfolios like the one shown in Exhibit 1 are unlikely to meet return objectives, so investors move rightward along the efficient frontier and allow equity risk to dominate. This common practice presents an opportunity.

Any investment that provides more capital-efficient exposure to a core market risk has the potential to free up capital which can be employed to “monetize” improved diversification. For example, if an investor with 60% stocks and 40% bonds reallocates from developed large cap equities (average beta 1.0) to small caps, emerging markets and private equity (combined average beta 1.2), they can reduce their equity allocation to 50% and invest the freed 10% in more bonds. The portfolio still has 0.6 equity beta, but bond beta has increased from 0.4 to 0.5. By reallocating from lower- to higher-duration bonds, they can raise the bond beta further, further boosting

diversification, macroeconomic resilience, and expected return. In Exhibit 1, the portfolio moves above the unlevered efficient frontier, with no direct leverage in sight.

You might have noticed we made an important assumption in this allocation example. We assumed the investor is compensated for the higher equity beta and higher duration with proportionally higher excess returns – in other words, that the embedded leverage in those assets comes for free.<sup>2</sup>

**Exhibit 3** lists various more capital-efficient investments alongside their less capital-efficient counterparts, and the right-hand column reminds us that embedded leverage is not always good value. Indeed, the well-known “low beta” or “betting against beta” anomaly – that average stock returns do not increase in proportion to beta as they should – probably exists mainly because investors overpay for the **high beta stocks’** embedded leverage. The same pattern is observed in bonds, with **high duration bonds** failing to deliver proportionally higher excess returns over the long term (see **Exhibit 4**). These sources of embedded leverage should be approached with caution. Indeed, some investors may want to take the other side of the trade, with or without leverage. For example, a diversified portfolio of low beta stocks has earned market-like returns with lower volatility and smaller drawdowns.<sup>3</sup> Small caps and emerging markets may offer more promising pockets of capital efficiency within equity markets, especially considering their valuations relative to U.S. large caps in 2025.

### Exhibit 3: More Capital Efficient Ways to Access Market Risk

Less Capital Efficient	More Capital Efficient	Pricing Considerations
Low beta stocks	High beta stocks	Evidence high beta stocks are overpriced
Unlevered ETFs	Levered ETFs	Very high volatility incurs large compounding effects (a drag during choppy periods)
Public equity	Private equity	High fees mainly reflect alpha potential and “smoothing service” but may partly reflect investor demand for embedded leverage
Public credit	Private credit	
Direct real estate	Real estate funds	
Low duration bonds	High duration bonds	Evidence high duration bonds are overpriced
Investment grade credit	High yield credit	High yield bonds tend to provide more credit risk but less duration risk
Unlevered risk-balanced portfolio	Risk parity	Substantial delegated leverage available at relatively low cost

Source: AQR. See Exhibit 4 for evidence related to high beta stocks and high duration bonds.

<sup>2</sup> To be more precise, we assume that the embedded leverage is effectively financed at the risk-free rate and there is no “embedded leverage premium” in the pricing of the more capital-efficient assets. We also ignore other differences for this conceptual illustration.

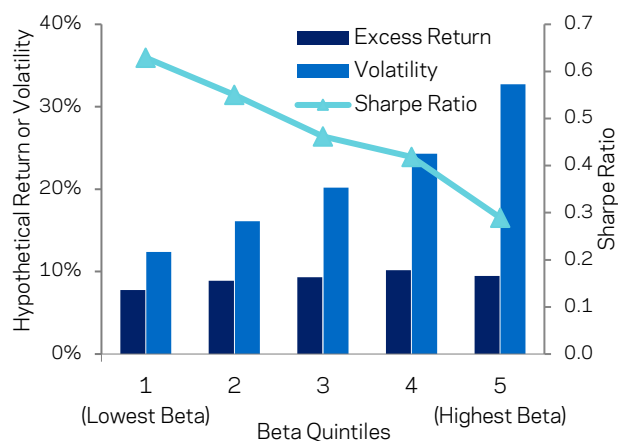
<sup>3</sup> See Frazzini and Pedersen (2014) “Betting Against Beta,” Frazzini and Pedersen (2020) “Embedded Leverage,” and Frazzini et al. (2020) “Fact and Fiction About Low-Risk Investing”.

**Levered ETFs** have become popular with tactical investors, but their high turnover and fees and very high volatility probably limit their usefulness for long-term investors.<sup>4</sup> What about **private assets**? They often come with a hefty price tag, but delegated leverage may be one of the more reliable services they can provide investors, after accounting for all-in fees. In “Broad Strategic Asset Allocation” (AQR 2024), private equity is modelled as providing a similar Sharpe ratio as public equity, net of fees, with higher expected return and risk reflecting the use of additional leverage.<sup>5</sup> Several of the optimal portfolios in that analysis reallocate from public to private equity precisely because its delegated leverage frees up capital for more diversifying assets. Funds that provide levered exposure to credit markets or real estate may fulfil a similar useful function, as long as their risks are fully understood by investors.

#### Exhibit 4: Beware: Some Embedded Leverage is Overpriced

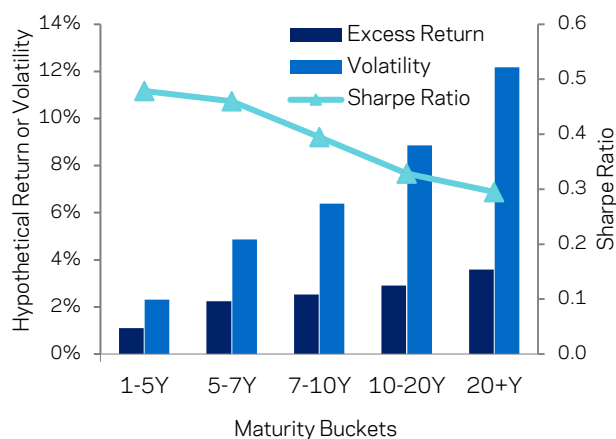
##### A. U.S. Equities Sorted by Beta

December 1, 1930 - June 30, 2025



##### B. U.S. Treasuries Sorted by Maturity

January 1, 1992 - June 30, 2025



Source: CRSP/Compustat, Bloomberg, and AQR. Chart A: U.S. Equities are the Russell 3000. Prior to 1980, U.S. Equities is represented by the CRSP U.S. Index. Return and Risk characteristics are provided excess of cash, which is the ICE BofAML 3-Month T Bill Index. Annualized risk refers to the annual volatility of each bucket. Portfolios are formed by sorting stocks on realized market beta and dividing the stocks into quintile portfolios; returns are presented gross of fees and are excess of cash. Quintile portfolio returns are value-weighted returns of the stocks in that portfolio. Chart B: US Treasuries are the Bloomberg US Treasury Total Return Indices. Past performance is not a guarantee of future performance.

Finally, we come to **risk parity**. Risk parity investing was specifically designed to use leverage to monetize diversification, with modern portfolio theory in mind. Risk parity portfolios aim to deliver risk-balanced exposures across stocks, bonds and other assets. Long-term evidence supports this approach, though risk parity funds have tended to lag behind equity-dominated approaches during

<sup>4</sup> High turnover and high fees are not necessarily bad for long-term investors, if they are associated with a unique source of returns. This is probably not the case for a levered ETF that delivers only capital-efficient exposure to a stock or index. Note that 2x and 3x levered S&P 500 ETFs have annualized volatilities of around 30% and 45% respectively, leading to large compounding effects (a.k.a. “variance drag”).

<sup>5</sup> Many studies have attempted to compare public and private equity industry long-term performance, with different results and inferences due to data challenges. See Ilmanen (2022) for a summary and literature review. AQR (2024) assumes that, over the long term and at the industry level, illiquidity premia and alpha are offset by higher fees and investor preferences for return smoothing.

the prolonged bull market of 2009-2025. If (or rather when) equity markets falter for a prolonged period, or even just slow to a more “normal” rate of return, risk parity’s superior diversification is likely to shine again.

## Delegated Leverage Applied to Active Risk (Long/Short Leverage)

Hedge funds hedge market risks – hence the name – but their second defining feature is that they *apply leverage to active risks* that would otherwise be too small to matter, such as relative value bets between highly correlated stocks, yield curve trades and corporate arbitrage. They do this via borrowing from prime brokers, trading derivatives on margin, trading securities on repo and many other mechanisms. How can investors make the most of this leverage service to harness the power of diversification in their total portfolio? This is the question to which we now turn.

Let’s start with an investor’s equity allocation. Traditional active equity portfolios face a trade-off between quantity and quality of alpha potential: the more they diversify their active bets across many stocks and sectors, the more their portfolio will behave like the market. Outperformance is likely to be more reliable but may also be smaller in magnitude.<sup>6</sup> **Active extension** strategies side-step this trade-off using leverage. By applying modest leverage to their long positions and adding some offsetting shorts to maintain 100% net market exposure, they can deliver diversified active portfolios with substantial alpha potential (see **Exhibit 5** Panel A). **Portable alpha** goes one (big) step further. By combining a full market-neutral hedge fund strategy with low-cost market beta, it delivers two strategic investments for a single capital allocation.<sup>7</sup> This allows investors to add meaningful amounts of diversifying return sources without “going underweight” market exposure (see Exhibit 5 Panel B). It provides a direct lift above the unlevered efficient frontier.<sup>8</sup>

What about the hedge fund allocation itself? Even with individual managers using leverage to magnify their bets, a well-diversified hedge fund allocation can feel decidedly low-powered.<sup>9</sup> For many investors, it fulfils a similar function to their bond allocation – providing ballast against equity market volatility, but also diluting gains on riskier investments. This limits its role in a return-seeking portfolio, leaving investors under-allocated to diversifying sources of return.

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<sup>6</sup> This is effectively the same problem we encountered with the tangency portfolio in Exhibit 1, but now in benchmark-relative space.

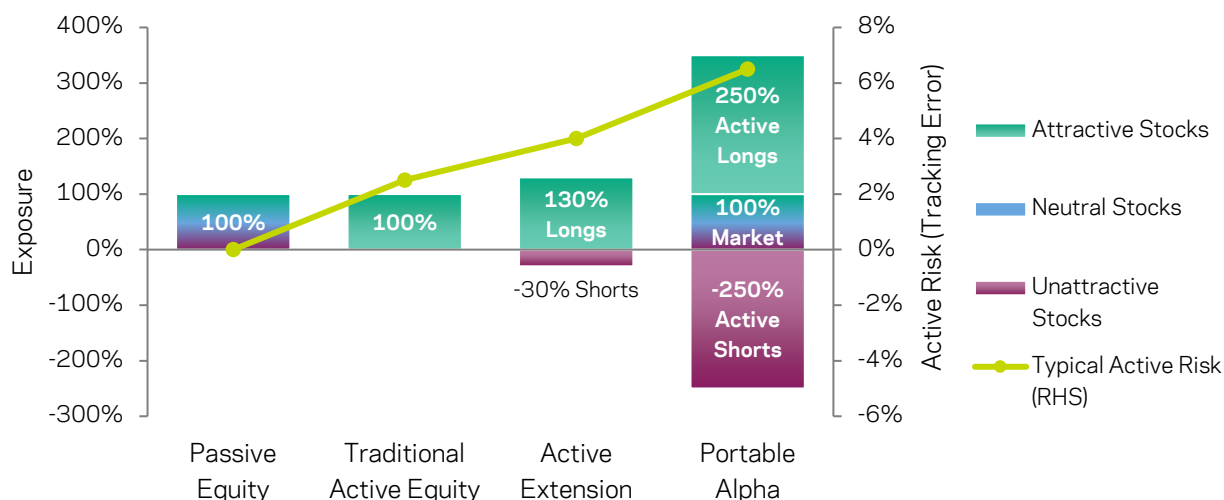
<sup>7</sup> See Asness (2025) “Should Hedge Funds Hedge? Why Some Alts Should Have a Beta of 1.0”, and Hecht and Cao (2025).

<sup>8</sup> Not all portable alpha offerings are alike. Look for uncorrelated alpha, resilient structures and fair fees – for example, any performance fees should be charged on excess-of-benchmark performance net of financing costs, rather than on gross alpha.

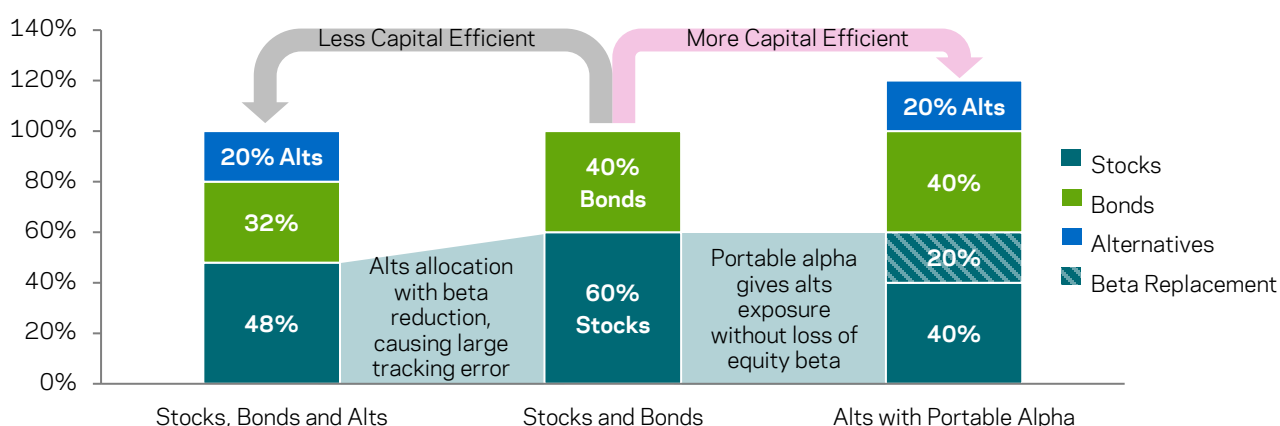
<sup>9</sup> The HFRI and Credit Suisse broad hedge fund indices have each delivered around 6% volatility since the 1990s, just a little more than a typical bond portfolio.

### Exhibit 5: Delegated Leverage in the Equity Bucket

#### A. Using Delegated Leverage to Boost Alpha Potential in Equity Investments



#### B. How Portable Alpha Addresses the “Funding Problem” via Delegated Leverage



Source: AQR. For illustrative purposes only and not representative of any AQR strategy.

Investors can make better use of hedge funds if they embrace volatility arising from prudent long/short leverage. Some hedge fund managers offer their strategies at different risk levels, while others simply offer a higher risk level than their peers. If investors choose strategies managed at higher risk levels, making proportionally smaller allocations and rebalancing regularly, the whole hedge fund portfolio becomes more capital efficient and more impactful on the total portfolio. Asness (2024) walks through a numerical example<sup>10</sup> and we have our own example in the next section. The downside of higher-volatility vehicles is that they are, yes, more volatile. They are more likely to experience larger losses on a standalone basis, and this can be problematic for some investors, even if the portfolio impact is the same (because the allocation is proportionally smaller). We return to this “line-item” challenge in the concluding section.

<sup>10</sup> See Asness (2024) “In Praise of High-Volatility Alternatives”.

Not all hedge fund strategies are offered at high target volatilities. If two competing products are equally attractive in other respects, *investors should prefer the more capital efficient strategy*. Similarly, single-manager multi-strategy hedge funds are usually more capital efficient than separate allocations to their component strategies, as managers apply some additional long/short leverage to account for diversification. Finally, some investors may have access to unfunded hedge fund solutions provided via investment bank platforms – this involves minimal upfront capital as the hedge fund return is accessed via a swap. This may be an attractive option for large institutional investors, as the financing cost will likely depend on the investor’s relationship with the bank offering the swap.

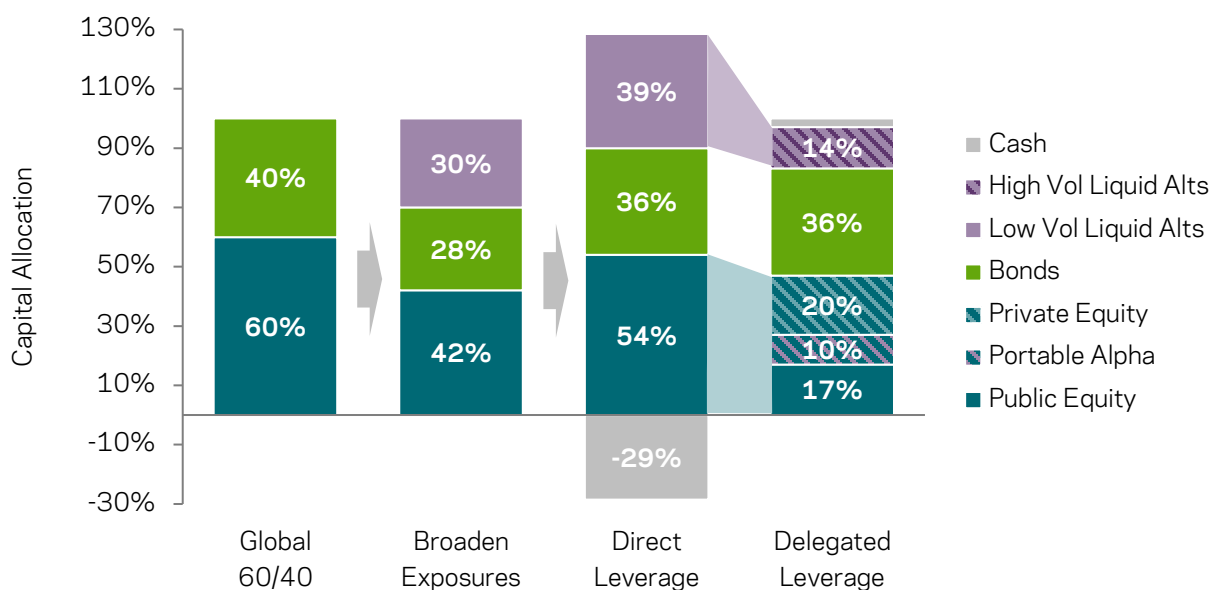
## Asset Allocation Illustrative Case Study

Can access to delegated leverage really move the needle at the portfolio level? In **Exhibit 6** we present a simple allocation example to quantify the possible impact. For the purposes of this analysis, we model private equity as 1.3x public equity. Hedge funds are available at 5% or 10% volatility, and portable alpha is passive public equity plus a 6.5% volatility hedge fund.

- **Portfolio 1** is a traditional global 60/40 portfolio, which is expected to earn around 6% total return, based on reasonable long-term assumptions listed in the Appendix. This portfolio is dominated by equity risk and is missing out on many other diversifying sources of return.
- **Portfolio 2** allocates 30% to a range of diversifying alternatives such as hedge funds, funded pro rata from stocks and bonds. The hedge fund allocation is itself well-diversified and is assumed to deliver a high Sharpe ratio and low equity correlation, but at a fairly low risk level (5% volatility). The portfolio Sharpe ratio rises, but the expected return actually falls. This is an example of a well-diversified but capital-inefficient portfolio.
- **Portfolio 3** levers Portfolio 2 back up to the original risk level to monetize the improved diversification. This requires roughly 30% leverage and delivers around 0.5% p.a. higher return than 60/40, at the same level of risk. Tracking error is reduced from 2.6% to 1.8%, as the equity beta is restored to the benchmark level.
- **Portfolio 4** uses three sources of delegated leverage to achieve the same result:
  - Reallocation from public to **private equity** provides 1.3x leverage.
  - **Portable alpha** allocation adds hedge fund exposure without reducing equity beta.
  - Low volatility hedge funds are replaced with a smaller allocation to **high volatility hedge funds**, including high volatility vehicles and capital efficient multi-strategies.

**Exhibit 6: Different Routes to the Same Destination**

	Global 60/40	Broaden Exposures	Direct Leverage	Delegated Leverage
Total Return				
GM	6.2%	6.1%	6.7%	6.7%
Volatility	9.4%	7.3%	9.4%	9.4%
Sharpe Ratio	0.34	0.39	0.39	0.39
Equity Beta	0.62	0.47	0.61	0.61
TE vs 60/40	0.0%	2.6%	1.8%	1.8%



Source: AQR. See Appendix for long-term asset class assumptions, which are gross of fees for public equity and bonds, and net of fees for private equity, liquid alts and portable alpha. GM is geometric mean. For illustrative purposes and not representative of any AQR strategy.

In this analysis, portfolios 3 and 4 are economically identical because we have made some simplifying assumptions. In practice, embedded leverage often comes with some tracking error. But in many cases investors can indeed achieve exposures that are economically almost identical to a direct levered approach – for example, investing \$5 in a higher-volatility vehicle instead of \$10 in an otherwise identical lower-volatility vehicle, or replacing separate passive equity and hedge fund allocations with a single portable alpha solution that delivers the same result.<sup>11</sup> Of course, there are operational differences between the two approaches.<sup>12</sup> Some investors will be able to access and manage direct leverage at low cost, but many will prefer to delegate this task.

<sup>11</sup> Some readers may be wondering about so-called variance drag. Leverage (whether direct or delegated) effectively reproduces the compounding effects experienced by an unlevered investment at a similar risk level. See Huss and Maloney (2017) for discussion.

<sup>12</sup> Asnes (2024) also points out that investing fewer dollars in a higher-volatility strategy can have risk benefits in extreme loss scenarios. If the investment goes to zero, you lose fewer dollars (and unlike an investor using balance sheet leverage, you can't lose more than you invested).

Portfolio 4 achieves 0.5-0.6% higher expected return than Portfolios 1 and 2, just by making use of capital efficient solutions. While the precise return impact will depend on an investor's starting portfolio and the capital efficiency gains available to them, note that this substantial improvement does not require identifying unique alpha, which probably places it among the more reliable sources of additional return available to investors.

Note that there is always a financing cost to leverage, whether it is direct, delegated, or deeply embedded in underlying investments (like indebted companies). This spread could be a few basis points or a few percentage points, depending on who is borrowing from whom. We ignore financing spreads in the above example for simplicity.<sup>13</sup> Investors should seek out the most cost-effective direct, delegated or embedded leverage for the biggest portfolio benefit.

## Concluding Thoughts: Beyond the Line-Item Mindset

Capital efficient investments address a foundational portfolio construction problem: they help investors convert diversification into higher returns, without the operational challenges of employing balance sheet leverage. This is not a completely free lunch. Some assets with embedded leverage are priced at a premium, such as high-beta stocks. Others are more attractively priced, but they are, by definition, more volatile than their less capital-efficient counterparts, creating so-called "line-item risk". Some investors shun higher-volatility vehicles because they or their stakeholders cannot stomach a large percentage loss on the investment, even if the investment only needs to be half the size.

This mindset is very common but is inherently capital inefficient, with a direct and measurable cost in the form of lower expected returns at a given level of portfolio risk. Importantly, the most diversifying investments are the most likely victims of this "line-item thinking" because their performance tends to stand out in the broader portfolio. Strategies that combine several return sources in one "line item" can help to address this challenge (multi-strategy liquid alternatives and portable alpha are two examples).

Investors who embrace a total portfolio approach to monitoring performance – maintaining focus on contributions to total portfolio risk and return – are better able to harness diversification to improve their chances of long-term investment success. Capital efficient investments are the key to translating this diversification directly into higher expected returns.

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<sup>13</sup> For private equity where financing spreads can be significant, we effectively assume spreads are offset over the long term by higher growth and/or multiple expansion. See AQR (2025) for specific estimates for these components.

## References and Further Reading

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## Appendix: Assumptions for Allocation Analysis

	Total GM Return	Volatility	Sharpe Ratio
Public Equity	6.9%	15%	0.30
Private Equity	7.5%	20%	0.30
Bonds	4.6%	4%	0.30
Low Vol Liquid Alts	5.4%	5%	0.40
High Vol Liquid Alts	7.0%	10%	0.40
Portable Alpha*	8.9%	18.5%	0.38
Cash	3.5%		

Correlations	Public Equity	Private Equity	Bonds	Low Vol Liquid Alts	High Vol Liquid Alts	Portable Alpha
Public Equity	1.00					
Private Equity	1.00	1.00				
Bonds	0.16	0.16	1.00			
Low Vol Liquid Alts	0.39	0.39	0.18	1.00		
High Vol Liquid Alts	0.39	0.39	0.18	1.00	1.00	
Portable Alpha*	0.95	0.95	0.19	0.66	0.66	1.00

\* For this analysis, portable alpha is modeled as 100% Public Equity + 65% High-Volatility Liquid Alts.

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