Invesco

Risk & Reward

Research and investment strategies

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Chairman Emeritus

Lower for longer is over – and the traditional negative correlation between stocks and bonds has vanished, at least for the time being. This issue of Risk & Reward features two articles that analyze what this means for portfolio insurance and asset allocation. Read on to learn why it's time to rethink popular approaches, and why the times for investors may be better than many believe!

Dynamic Proportion Portfolio Insurance strategies certainly benefit from periods of higher interest rates: the cushion increases, returns go up and insurance costs go down. In our feature article, Invesco analysts describe just how this works and show how to take advantage of it.

We then demonstrate ways to make the most of positive correlations between stocks and bonds. This may be a challenge for traditional asset allocation – but who said we need to stay traditional? If one looks just a bit further, uncorrelated returns are still possible. Our innovative factor strategies provide the necessary building blocks.

Next, we turn to short sellers: They are often regarded as eternal pessimists, and sometimes they are blamed for stock market crashes. But they have an important role to play in price discovery, especially because they are usually well informed. Find out how we use shorting data to improve portfolio performance.

In the ESG category, we look at Paris alignment. Many investors seek to align their portfolios with the 2°C target for global warming – but the variety ofavailable strategies makes for a confusing landscape. In line with our factor-based investment philosophy, we've developed a process that balances climate protection with return targets.

Finally, we continue our series on tax-optimized portfolio management, this time showing how to transition a portfolio without a hefty tax bill right from the start.

We hope you enjoy this edition of Risk & Reward!

Best regards,

Marty Flanagan
Chairman Emeritus of Invesco Ltd.

Portfolio insurance in times of higher interest rates

By Alexandar Cherkezov, Carsten Becker, Moritz Brand and Bernhard Langer

Higher interest rates aid portfolio insurance (PI) strategies, as they serve to increase the size of the cushion and, hence, the size of the risk budget. This tends to translate into higher returns and Sharpe ratios, and may lead to lower implicit portfolio insurance costs. We analyze why a portfolio insurance strategy may be a viable alternative.

Portfolio insurance strategies aim to limit a portfolio risk over a specified period of time. Conventional financial theory connects risk with volatility. But for many, the expected maximum drawdown is more relevant. Broad diversification across asset classes, regions, industries and style factors can mitigate expected losses but doesn't explicitly target maximum drawdown. In this article, we analyze why a Portfolio Insurance strategy may be a viable alternative.

How portfolio insurance works

A portfolio insurance approach is an enhanced version of a conventional Constant Proportion Portfolio Insurance (CPPI) strategy. One main feature of CPPI is the so-called 'cushion' (C_t) which is the difference between the current portfolio value 'wealth' (W) and the net present value of the specified floor F_t.

(1) $C_t = W_t - NPV(F_T)$

To avoid losses in excess of the given floor over the predefined period, typically one calendar year, the maximum loss of the portfolio at time t should not exceed the cushion:

(2) $C_t \geq e_t \times W_t \times \text{MaxLoss}(\textit{risky asset})$

with e_t being the portfolio share of the risky asset and MaxLoss the risky asset's maximum loss (in %).

Defining the risk exposure $E_t = e_t \times W_t$ and rearranging formula (2), this results in:

(3) $$E_t \leq \frac{C_t}{\text{MaxLoss}(\textit{risky asset})} = m \times C_t$$

with the multiplier m:

(4) $$m := \frac{1}{\text{MaxLoss}(\textit{risky asset})}$$

The multiplier tells us how often the cushion can be invested in the risky portfolio, without losing more than the specified amount. In a CPPI strategy, this multiplier is constant over time and is usually derived from a realized maximum drawdown over a longer period. This results in lower investment exposures over time and may be regarded as extremely conservative.

A portfolio insurance strategy dynamically adjusts the exposure to risky assets based on the risk forecast.

When interest rates are higher, one can risk more than the available risk budget.

In contrast, a portfolio insurance strategy dynamically adjusts the exposure to risky assets based on the risk forecast of the portfolio, with a variable multiplier:

$$(5)\quad E_t \le \frac{C_t}{\text{MaxLoss}_t(\textit{risky asset})} = m_t \times C_t$$

with the multiplier

$$(6)\quad m_t := \frac{1}{\text{ES}_t^{99\%}(\textit{risky asset})}$$

As there is no common guideline on how to set the multiplier, most practitioners use a tail risk estimate such as a Value-at-Risk (VaR) or an Expected Shortfall (ES). Here, we use the 99% daily Expected Shortfall for the risk estimate based on a t-GARCH Copula model. This addresses multiple shortcomings of traditional risk estimation: For instance, we do not need to assume normally distributed returns and work with time-varying correlations between assets.[1]

The PI strategy thus minimizes allocation to risky assets as needed to protect the floor but also allows upside potential when the specified floor is not in danger.

The effect of higher interest rates

As can be seen in formula (1), the cushion depends on the current portfolio value and the discounted value of the floor. The discount factor can be the yield of highly rated government bonds or of risk-free cash investments. With an increase in interest rates and associated risk-free returns, the NPV of the floor decreases so that the available cushion increases.

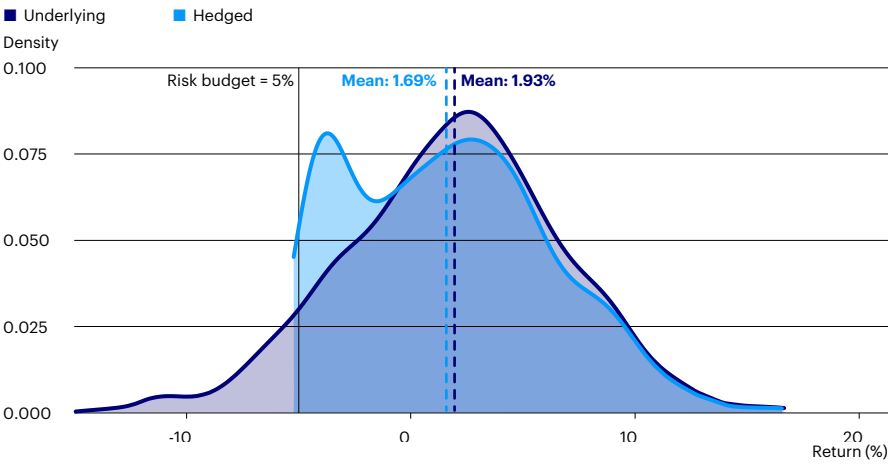
$$(7)\quad NPV = \frac{F_t}{(1+r)^t}$$

In other words: When interest rates are higher, one can risk more than the available risk budget over the year without a rising probability of breaching the year-end floor limit. In times of positive interest rates all risky positions can be liquidated to allocate the full portfolio into money market securities with interest rates lifting the portfolio up above the predefined floor. In times of negative interest rates, on the other hand, one can lose less than the defined risk budget, as negative interest rates hurt a portfolio fully invested in money market securities. Of course, the risk budget only increases if a temporary breach of the floor is accepted and the portfolio insurance is evaluated at the end of each specified period.

Simulations

We analyzed the effects of rising interest rates on a strategy by simulating 1,000 return paths with different assumptions for the discount rate. The underlying portfolio is a generic risk parity strategy, with 24% global equities, 60% 10-year global government bonds, 10% commodities and 6% money market instruments. The risk budget (i.e., the maximum loss at calendar year end) is set at 5% p.a. and the simulation – for the period from November 30, 2005 to December 31, 2022 – is based on historical returns, keeping realized correlation patterns while incorporating forward-looking capital market assumptions. The annual return assumptions are 450 bps above cash for equities, 50 bps above cash for bonds and 150 bps above cash for commodities. For the risk-free rate,

Figure 1
Simulation for a risk-free rate of -50 bps



Density chart for 1,000 simulated return paths for a portfolio with 24% global equities, 60% 10-year global government bonds, 10% commodities and 6% money market instruments. Proxy for global equities: a mixture of Eurosotxx 50 future, S&P 500 future, Topix Future and FTSE 100 Future. Government bonds: Bloomberg 10-year German government index, Bloomberg 10-year Australian government bond index, Bloomberg 10-year UK government bond and Bloomberg 10-year Canadian government bond index. Commodities: Bloomberg Copper Subindex Total Return, S&P GSCI Crude Oil Total Return CME Index, S&P GSCI Gold Index Total Return CME. Money Market: Deutsche Bank 1-month Euribor Index. November 30, 2005 to December 31, 2022. PI risk budget of 5% p.a.
Source: Invesco calculations. **There is no guarantee that the simulated results will be achieved in the future.**

Higher interest rates not only reduce portfolio insurance costs, but also enhance the total return of the strategy.

we have iterated 5 variants: -50 bps, 0 bps, 100 bps, 200 bps and 300 bps p.a.

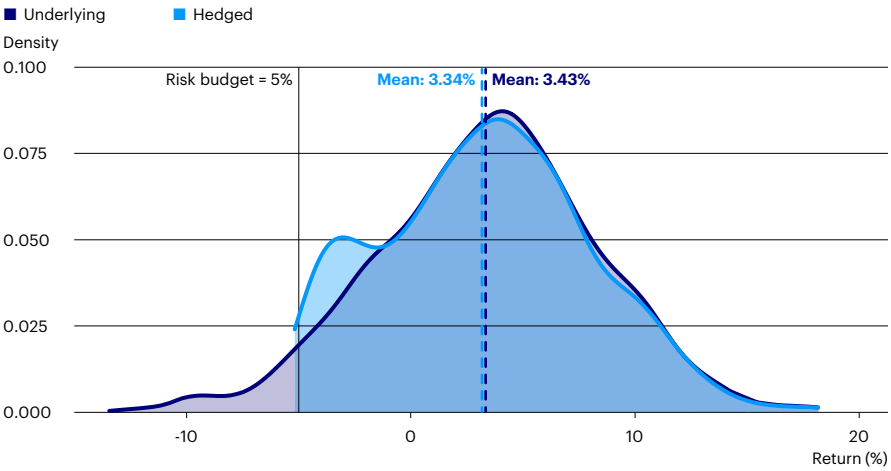
Table 1 shows the results for the -50 bps (figure 1), 100 bps (figure 2) and 300 bps (figure 3) and presents the result for all five iterations.

For a risk-free rate of -50 bps (figure 1), the portfolio return without PI is 1.93% p.a.; measured as the annualized return differential between the strategies with and without PI, the implicit insurance cost amounts to 24 bps p.a. Also, there are quite a few paths with a loss close to (but still above) the floor – as the blue hump in the distribution on the left-hand side shows. These observations result from the so-called 'cash-lock' situation. A cash-lock occurs when the portfolio value moves close to the floor, effectively reducing the cushion to almost zero and not allowing the strategy to build up any new exposure to risky assets.

As expected, some return potential may be forfeited, but this may be limited to the defined drawdown limit, offering an insurance-like payout profile.

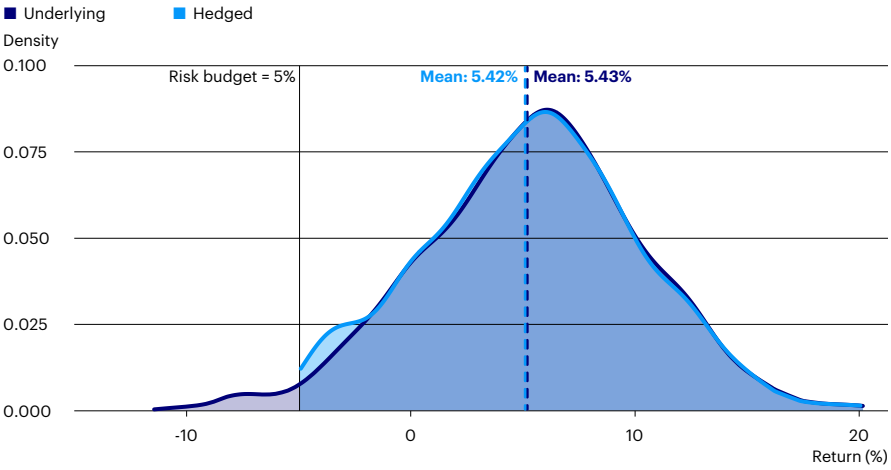
For a higher risk-free rate of 100 bps, the picture changes somewhat (figure 2). The hump on the left-hand side is much smaller, and the implicit portfolio insurance cost amounts to just 9 bps (3.34% minus 3.43%). The overall return increases significantly due to the higher risk-free rate. In addition, the increase in volatility is offset by a higher return, leading to a better Sharpe ratio.

Figure 2
Simulation for a risk-free rate of 100 bps



Density chart for simulated return paths for a portfolio with 24% global equities, 60% 10-year global government bonds, 10% commodities and 6% money market instruments, November 30, 2005 to December 31, 2022. PI risk budget of 5% p.a.
Source: Invesco calculations. **There is no guarantee that the simulated results will be achieved in the future.**

Figure 3
Simulation for a risk-free rate of 300 bps



Density chart for 1,000 simulated return paths for a portfolio with 24% global equities, 60% 10-year global government bonds, 10% commodities and 6% money market instruments, November 30, 2005 to December 31, 2022. PI risk budget of 5% p.a.
Source: Invesco calculations. **There is no guarantee that the simulated results will be achieved in the future.**

Table 1
Simulation results in full

Risk-free interest rate		-50 bps	0 bps	100 bps	200 bps	300 bps	300 bps (scaled-up)
Portfolio insurance cost		24 bps	17 bps	9 bps	4 bps	1 bps	7 bps
Return p.a.	**without PI**	1.93%	2.43%	3.43%	4.43%	5.43%	5.90%
	with PI	1.69%	2.26%	3.34%	4.39%	5.42%	5.83%
Volatility p.a.	**without PI**	4.51%	4.51%	4.51%	4.51%	4.51%	5.41%
	with PI	3.90%	4.01%	4.15%	4.26%	4.33%	5.07%
Sharpe ratio	**without PI**	0.59	0.59	0.59	0.59	0.59	0.59
	with PI	0.44	0.47	0.51	0.54	0.56	0.53
Maximum drawdown (average over simulation period p.a.)	**without PI**	-4.86%	-4.72%	-4.47%	-4.26%	-4.07%	-4.98%
	with PI	-4.14%	-4.09%	-3.99%	-3.90%	-3.80%	-4.50%

Average results for 1,000 simulated return paths for a portfolio with 24% global equities, 60% 10-year global government bonds, 10% commodities and 6% money market instruments, November 30, 2005 to December 31, 2022. PI risk budget of 5% p.a.
Source: Invesco calculations. There is no guarantee that the simulated results will be achieved in the future.

Finally, at a rate close to the current cash market rate of 300 bps, there are almost no portfolio insurance costs (figure 3). The return without DPPI is 5.43%, whereas an insured strategy yielded 5.42%.

Table 1 summarizes the results for all five interest rate assumptions (and the 'scaled-up' version, which we will discuss later). Higher interest rates not only reduce portfolio insurance costs, but also enhance the total return of the strategy more or less linearly (since we assumed constant risk premia for all asset classes). As for the maximum drawdown, a similar observation can be made: With a higher yielding risk free investment, the drawdowns for the DPPI strategies are reduced. As expected, our risk-managed version additionally reduces the average yearly drawdown compared to a non-risk-managed strategy.

Do higher interest rates enable higher risk exposures?

Next, we examine whether it is possible to increase overall portfolio risk when interest rates rise and still achieve satisfactory results after PI. To this end, we have scaled up the portfolio by 20% so that portfolio shares become: 29% for equities, 72% for bonds and 12% for commodities, introducing a small degree of leverage. Figure 4 shows the results for a risk-free rate of 300 bps.

As expected, the implicit portfolio insurance costs have risen – in this case from 1 bp to 7 bps, but the total return has also increased – to 5.90% without and 5.83% with PI. For a less risk-averse appoach, the higher insurance fee may seem appropriate; it is expected to remain in the single digits while the total return increases by more than 40 bps.

Are bonds an alternative?

It is prudent to frequently weigh the benefits and drawbacks of a diversified, risk-budgeted multi-asset strategy against an allocation to bonds. Figure 5 compares the maximum drawdown of US 10-year Treasuries without PI to the theoretical

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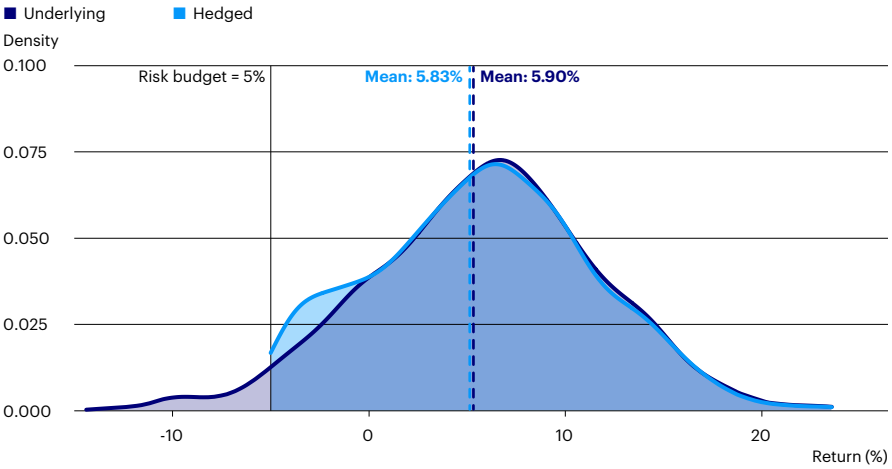
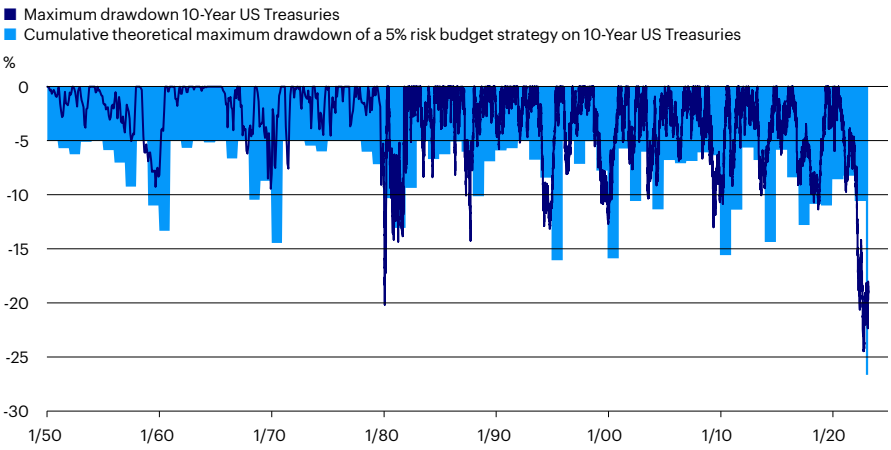
> US Treasuries have frequently experienced significant drawdowns.

Figure 4
Simulation for a risk-free rate of 300 bps (scaled-up)



Density chart for 1,000 simulated return paths for a portfolio with 29% global equities, 72% 10-year global government bonds, and 12% commodities, November 30, 2005 to December 31, 2022. PI risk budget of 5% p.a.
Source: Invesco calculations. **There is no guarantee that the simulated results will be achieved in the future.**

Figure 5
Maximum drawdowns of US Treasuries – with and without PI



Source: Invesco. Data from January 31, 1950 to March 21, 2023. DPPI risk budget of 5% p.a. **There is no guarantee that the simulated results will be achieved in the future.** Backtested data.

maximum drawdowns of a PI-based US Treasury allocation with 5% annual risk budget.

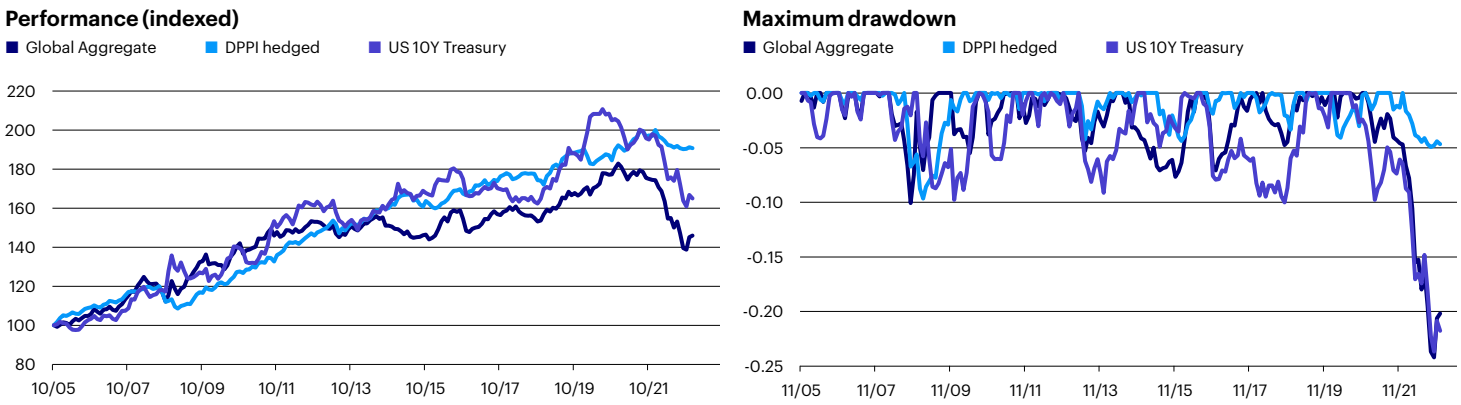
Despite their safe-haven characteristics and extremely low default probability, US Treasuries have frequently experienced significant drawdowns. The most severe episodes, exceeding 20%, occurred in 1980 and 2022, when the Fed swiftly raised interest rates to bring down inflation. This highlights a potential pitfall of a pure bond allocation – its lack of diversification. Bonds suffer during periods of growth and inflation.[2] An annual risk budget of 5%, as

Table 2
Return patterns of PI and US Treasury strategies in comparison

	Return			Return comparison		Maximum drawdown per calendar year end		
	PI	US 10Y Treasury	Global Aggregate	Difference (PI vs US Treasury)	Difference (PI vs Global Agg)	PI	US 10Y Treasury	Global Aggregate
2005*	3.7%	1.8%	0.3%	2.0%	3.4%	-0.2%	-0.3%	-0.7%
2006	5.5%	1.3%	6.6%	4.1%	-1.2%	-1.0%	-1.8%	-1.8%
2007	7.3%	9.7%	9.5%	-2.4%	-2.2%	-0.4%	-1.0%	-1.4%
2008	-3.4%	20.1%	4.8%	-23.5%	-8.2%	-6.5%	-1.4%	-2.4%
2009	4.5%	-9.8%	6.9%	14.2%	-2.5%	-1.3%	-10.2%	-3.9%
2010	8.6%	8.0%	5.5%	0.6%	3.1%	-0.6%	-6.7%	-3.7%
2011	7.5%	17.2%	5.6%	-9.7%	1.8%	0.0%	-0.6%	-2.8%
2012	7.3%	4.1%	4.3%	3.1%	2.9%	0.0%	-1.7%	-0.7%
2013	2.1%	-7.8%	-2.6%	9.9%	4.7%	-2.0%	-9.5%	-2.6%
2014	6.8%	10.7%	0.6%	-3.9%	6.3%	-0.5%	-0.8%	-4.1%
2015	-0.8%	0.9%	-3.2%	-1.7%	2.4%	-5.2%	-3.6%	-3.7%
2016	5.0%	-0.2%	2.1%	5.2%	2.9%	-0.9%	-8.6%	-7.8%
2017	5.6%	2.1%	7.4%	3.5%	-1.8%	-0.1%	-2.4%	-0.9%
2018	-3.3%	0.0%	-1.2%	-3.3%	-2.1%	-3.7%	0.0%	-2.8%
2019	10.0%	8.9%	6.8%	1.1%	3.2%	-0.6%	-3.6%	-0.8%
2020	1.6%	10.6%	9.2%	-9.0%	-7.6%	-0.1%	-3.2%	0.0%
2021	4.1%	-3.6%	-4.7%	7.6%	8.8%	-0.2%	-3.6%	-4.9%
2022	-4.7%	-16.3%	-16.2%	11.7%	11.6%	-4.6%	-15.2%	-15.9%
Total simulation period (11/30/05 – 12/31/22)								
Return (p.a.)	3.83%	2.96%	2.23%					
Volatility	3.81%	7.21%	5.83%					
Sharpe Ratio	0.71	0.26	0.19					

Data from November 30, 2005 to December 31, 2022; return for 2005 since November 30. Drawdown is defined as the drawdown during the specified year based on year-end prices. 'PI' refers to the multi-asset strategy, a risk budget of 5% p.a and a risk free rate of 5% p.a and actual historical risk-free rates.
Source: Invesco, Bloomberg. **There is no guarantee that the simulated results will be achieved in the future.**

Figure 6
Performance and maximum drawdown over time



Data from November 2, 2005 to December 31, 2022. **Past performance is not a guarantee of future results.**
Sources: Invesco, Bloomberg.

in our PI-based simulations, is exceeded numerous times.

For comparison: Over the historical backtest period from November 30, 2005 to December 31, 2022, using historical interest rates, the multi-asset strategy experienced maximum drawdowns of 14.4% without and 11.0% with PI (table 2), whereas US Treasuries saw maximum drawdowns of 25.1% (even with PI) at a much higher level of volatility.

Increasing diversification by using a broader Global Aggregate Bond index that invests in multi-currency investment grade debt from treasuries, government-related or corporates, volatility can be reduced, while providing a nearly identical drawdown profile compared to US Treasuries. Contrasting those drawdown figures, it becomes apparent that both diversification and the portfolio insurance mechanism can help mitigating drawdowns.

As table 2 and figure 5 show, the multi-asset PI approach produced overall higher returns and lower volatility than US Treasuries – and consequently much better risk-adjusted performance. Especially in times of rising rates, the US Treasury strategy is prone to substantial negative returns. (For completeness, we have also calculated result for a Global Aggregate strategy, which essentially show a similar pattern.)

By its multi-asset nature, the underlying portfolio looks well-equipped to deliver a diversified return in different economic environments. Equities help in times of non-inflationary growth, bonds work as a safe haven asset in recessionary environments and commodities constitute a viable hedge against unexpected inflation.

Conclusion

In an environment of higher interest rates, a balanced multi-asset strategy with different macro sources of return looks well positioned to harvest these successfully through its underlying strategic allocation. Coupled with a drawdown-limiting mechanism, a second line of defense is introduced which controls the maximum possible loss over a calendar year. Higher short-term rates function like a backwind for those strategies, providing it with the opportunity to bear higher risks without increasing the likelihood of breaching the predefined floor. A multi-asset strategy may provide a stable stream of returns compared to a pure fixed income allocation, as it has more diversified sources of return compared to traditional options.

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> The portfolio looks well-equipped to deliver a diversified return in different economic environments.

Notes
1 e.g., Happersberger, Lohre and Nolte (2020); Pfaff (2010); Kolrep, Lohre and Happersberger (2017).
2 cf. Lohre, Hixon, Raol et al. (2020).

Simulated performance: Performance shown is hypothetical/simulated for educational and informational purposes only. The simulation presented here was created to consider possible results of a strategy not previously managed by Invesco for any client. It does not reflect trading in actual accounts and is provided for informational purposes only to illustrate the factor results during specific periods. There is no guarantee the model/ hypothetical results will be realized in the future. Invesco cannot assure the simulated performance results shown for these strategies would be similar to the firm's experience had it actually been managing portfolios using these strategies. In addition, the results actual investors might have achieved would vary because of differences in the timing and amounts of their investments. Simulated performance results have certain limitations. Such results do not represent the impact of material economic and market factors might have on an investment advisor's decision-making process if the advisor were actually managing client money. Simulated performance also differs from actual performance because it is achieved through retroactive application of a model investment methodology and may be designed with the benefit of hindsight.

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Liquidity and diversification: Absolute return strategies for asset allocation

By Bernhard Langer, Carsten Rother and Dr. David Happersberger

Over the last 20 years, the correlation between equities and fixed income has been predominantly negative. But, with the emergence of inflation, this relationship has changed, leaving a need to add uncorrelated and liquid building blocks to investment portfolios. Using hedged equity factors, fixed income factors, FX overlays and stand-alone tactical asset allocation signals, we have researched an absolute return approach that may serve as an uncorrelated portfolio component.

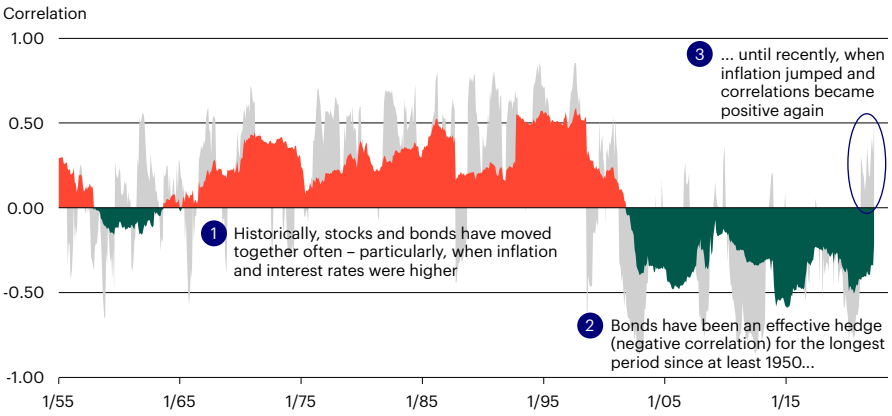
For more than 20 years, the negative correlation between equites and bonds was taken for granted, making these two asset classes the main ingredients of balanced, well-diversified portfolios.

But this correlation has not always predominated. In fact, the correlation between equities and bonds has varied quite drastically over time.[1] Figure 1 shows positive 5-year correlations between 10-year US Treasuries and the S&P 500 in red and negative correlations in green.

As we can see, long periods of negative 5-year correlations are a fairly recent phenomenon. From 1963 to 2000, stocks and bonds generally moved in the same direction. The 1-year correlation, shown in gray, is more volatile – but its recent return into positive territory signals that the current period of negative 5-year correlations may soon be over. This means a well-diversified portfolio may require more than just stocks and bonds, and absolute return strategies may be more interesting than ever.

In fact, the correlation between equities and bonds has varied quite drastically over time.

Figure 1
Correlations between equities and bonds



Source: Bloomberg, Invesco. 5-year correlations between 10-year US Treasury bonds and the S&P 500 in red (positive) and green (negative); 1-year correlations in gray. Data from January 1955 to August 2022.

How uncorrelated are "uncorrelated" portfolio components?

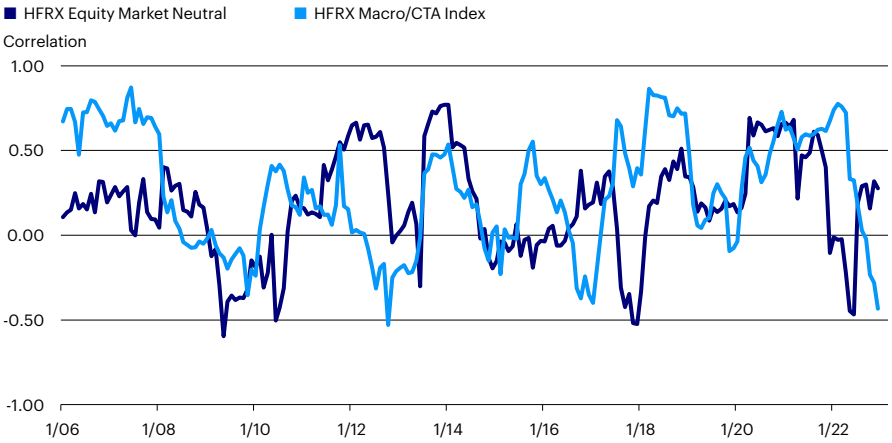
Absolute return strategies have a long history: Initially, fairly illiquid offshore hedge funds dominated. But since the global financial crisis in 2008, more and more strategies with daily liquidity have appeared in the market, some managed by hedge funds, others by traditional asset managers. Numerous alternative indices have also emerged over the years, and fund rating providers have introduced various new investment categories. Some of these have recently changed, proving how dynamic the market is – Morningstar, for example, restructured its categories in 2021.[2]

Still, the right indices can be a valuable source for analysis, and we'll look at the Hedge Fund Research (HFRX) indices for the categories Equity Market Neutral and Macro/CTA, which are well known and have a long history. Equity Market Neutral represents equity-based strategies with a net market exposure close to zero. The Macro/CTA Index consists of macro strategies with long and short positions mostly in bond, equity, commodity and currency indices. As expected, both indices have, on average, low correlations with equities over the long term.

While long-term diversification is important, adequate diversification over shorter periods is necessary, too. Figure 2 shows the historical correlations between the two alternative indices and global equities. The long-term pattern looks favorable, with average correlations close to zero. But intermediate deviations are also visible and can persist for periods longer than expected.

Particularly interesting are the 18 months from January 2020 until June 2021 – encompassing periods before and after the COVID outbreak. Both indices experienced a rolling 12-month correlation with equities of more than 0.5, which may have been a good thing when equities were rising. But there was obvious disappointment when equities declined. The COVID period was unusual, even though similarly high correlations between alternatives and equity markets were observable previously.

Figure 2
Rolling 12-month correlation of hedge fund strategies and global equities



Sources: Bloomberg, Invesco. Hedge fund strategies as measured by the HFRD Equity Market Neutral and the HFRX Macro/CTA Index, global equities as measured by the MSCI World. Data from January 2006 to December 2022.

A possible solution may be an absolute return strategy with well-known building blocks.

Combining all four building blocks into an absolute return strategy shows the potential of diversification.

The question is when this will happen again, and what could then be an appropriate portfolio positioning.

An absolute return strategy with diversified building blocks

A possible solution may be an absolute return strategy with well-known building blocks, namely: equity factors, fixed income factors and FX factors, as well as a tactical asset allocation component.

Equity factors are derived from the well-established risk and return drivers quality, momentum, value and low volatility. Drawing from a global universe, we construct beta-neutral factor exposures by building a global equity portfolio that represents these factors. Additionally, we hedge risk-adjusted equity market exposure using index futures. The result is a liquid equity multi-factor investment without counterparty risk.

Fixed income factors overweight bonds in the portfolio with positive value, carry and low volatility characteristics. Starting with an appropriate investment grade universe, three portfolios are formed. Low volatility targets bonds with higher credit ratings and lower duration. Value targets bonds with higher spreads or yields in excess of maturity-matched Treasuries (relative to bonds with similar industry characteristics, credit rating and maturity). Carry targets the bonds with the highest overall spread. These three portfolios are combined such that each component contributes equally to risk. A final optimization controls for other risk factors such as capital structure and issuer concentration.

FX factors are formed for two separate universes: ten major developed market currencies (G10) and emerging market currencies (EM). For each universe, we form long-short portfolios targeting carry, value and momentum. For carry, we go long (short) the currencies with the highest (lowest) forward yield. Value is formed by going long (short) the currencies with both the highest (lowest) discount to their PPP[3]-implied fair value and a large decrease (increase) in their fair value. Momentum is formed by going long (short) the currencies with the highest trailing 12-month return and a strong dollar-beta exposure, i.e., a strong correlation to the US dollar.

The ***tactical asset allocation (TAA)*** building block consists of a portfolio that invests in the S&P 500, EuroStoxx 50, FTSE 100 and TOPIX. Investments are based on a set of tactical signals comprising three different concepts: Trend following captures the overall risk aversion and price trends in capital markets. Valuation compares the standardized relationship between current and fundamental prices. Economics measures the economic outlook given that equity market performance is sensitive to shifts in underlying macroeconomic trends. In implementing the tactical signals, we assign a fixed pre-defined tracking error budget to the TAA (in this case: 1%) such that the risk contribution of the four equity markets can be controlled effectively.

Table 1 compares the simulated performance of the MSCI World absolute return strategy and its four building blocks. An equity factor investment would have delivered significantly higher risk-adjusted returns than the MSCI World (Sharpe ratio of 0.66 vs 0.35). In periods with equity market losses, it would have delivered a positive return 61.28% of the time and an aggregate return of 11.70%, confirming its diversification capabilities. As the fixed income factor, the FX factor and TAA component target a risk of 1%, their return contribution is lower. Still, they helped to diversify since they performed well in equity downturns and had low equity betas overall.

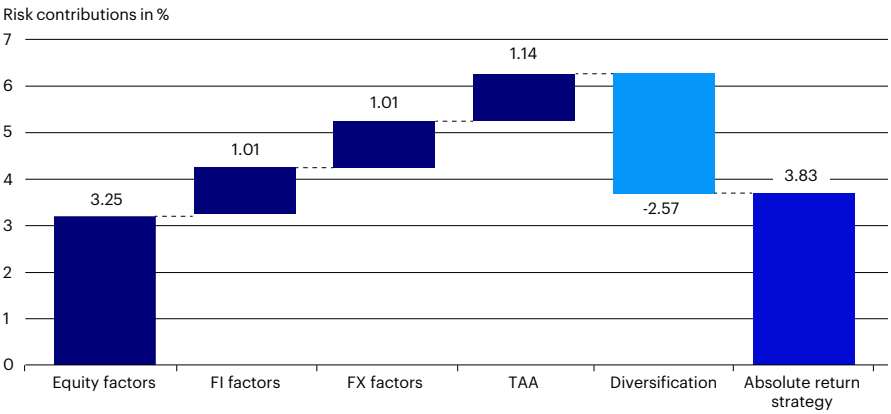
Combining all four building blocks into an absolute return strategy shows the potential of diversification. Over the sample period, this combination would have returned 5.36% p.a. at 3.83% annualized volatility, translating to a Sharpe ratio of 0.97. Beta-hedged, i.e., adjusted with the aim of reaching an equity

Table 1
Simulated performance in comparison

		MSCI World	Equity factors	FI factors	FX factors	TAA	Absolute return strategy	Absolute return strategy (beta-hedged)
All period	Return p.a	7.32%	3.80%	0.48%	0.51%	0.51%	5.36%	5.76%
	Standard deviation p.a.	16.21%	3.25%	1.01%	1.01%	1.14%	3.83%	3.26%
	Sharpe ratio	0.35	0.66	-1.17	-1.13	-1.00	0.97	1.26
	Beta (ex post)	1.00	-0.02	0.00	0.02	0.02	0.03	0.01
Periods with equity market drawdowns only	Total return	-82.97%	11.70%	0.91%	-3.63%	-6.86%	1.16%	3.52%
	Average return	-0.70%	0.04%	0.00%	-0.01%	-0.03%	0.00%	0.01%
	Periods with positive return	0.00%	61.28%	52.99%	42.86%	21.17%	50.92%	51.40%

Sources: Bloomberg, Invesco. Data from January 2005 to December 2022. **Past performance does not predict future returns.** There is no guarantee the simulated results will be realized in the future.

Figure 3
Risk decomposition of the absolute return strategy



Sources: Bloomberg, Invesco. Data from January 2005 to December 2022.

market beta near zero, the results would have been even better, with a Sharpe ratio of 1.26; we will discuss this in more detail later. Hence, in risk-adjusted terms, the absolute return strategy would have outperformed a pure equity market investment as well as investments in the four building blocks.

Figure 3 shows the risk decomposition of the strategy. While, at 3.25%, the equity factors were responsible for the largest proportion of risk, the FX, fixed income and the TAA components are constructed to reach around 1% risk ex post. As the four building blocks diversify one another, the final strategy would have had a risk of 3.83% – only slightly above the equity factor on its own.

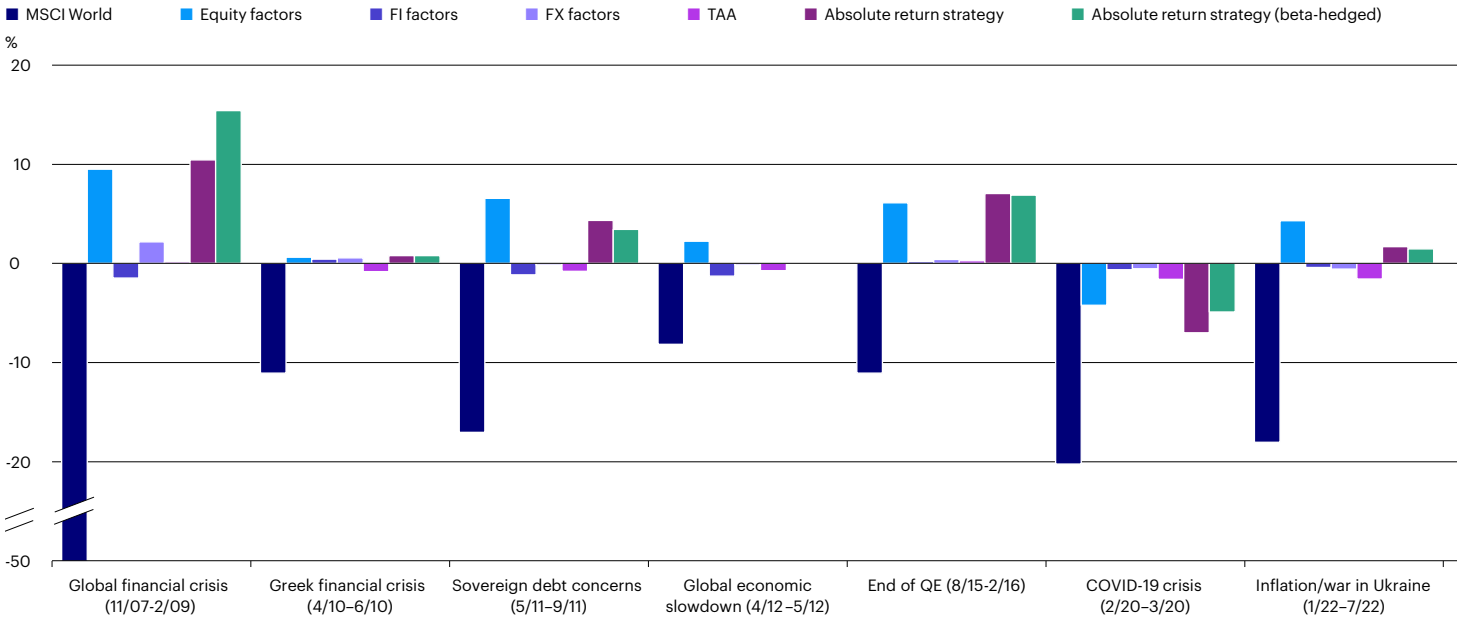
Protection is key, especially when equities experience elevated drawdowns. Figure 4 shows the performance of the absolute return strategy and its building blocks in different bear markets.

During most bear markets, the strategy would have held up nicely, reporting positive or at least flat returns. The only exception is during the COVID pandemic with its sharp and rapid drawdown followed by a very fast recovery.[4] Actively managing the beta of the absolute return strategy would have led to even better results. While equity factors were the main driver of outperformance, the other components helped as well by adding diversification to the strategy.

Adding diversity

As discussed, hedge fund indices proxy the ability to engage in uncorrelated portfolio components. Table 2 shows low correlations between the indices, the four building blocks and the resulting absolute return strategy. While the Equity Market Neutral Index has an average correlation of 0.22 with equites, and the Macro/CTA Index has one of 0.12, the absolute return strategy would have been relatively uncorrelated, at 0.08 – and only 0.06 if beta were managed actively.

Figure 4
Performance of the absolute return strategy and its building blocks in selected bear markets



Sources: Bloomberg, Invesco. Data from January 2005 to December 2022. **Past performance does not predict future return.**

Table 2
Correlations

	MSCI World	Equity factors	FX factors	FI factors	TAA	Absolute return strategy	Absolute return strategy (beta-hedged)	HFRX Equity Hedge Market Neutral Index	HFRX Macro/ CTA Index
MSCI World	1								
Equity factors	-0.17	1							
FX factors	0.43	-0.12	1						
FI factors	0.04	0.24	0.10	1					
TAA	0.52	-0.06	0.17	-0.07	1				
Absolute return strategy	0.08	0.91	0.19	0.43	0.21	1			
Absolute Return strategy (beta-hedged)	0.06	0.90	0.17	0.42	0.20	0.98	1		
HFRX Equity Hedge Market Neutral Index	0.22	-0.01	0.22	-0.07	0.26	0.10	0.08	1	
HFRX Macro/CTA Index	0.12	0.04	0.08	0.04	0.17	0.11	0.12	0.07	1

Sources: Bloomberg, Invesco. Based on data from January 2005 to December 2022.

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When striving for diversification, it is crucial to control a strategy’s major risk drivers.

Actively controlling beta

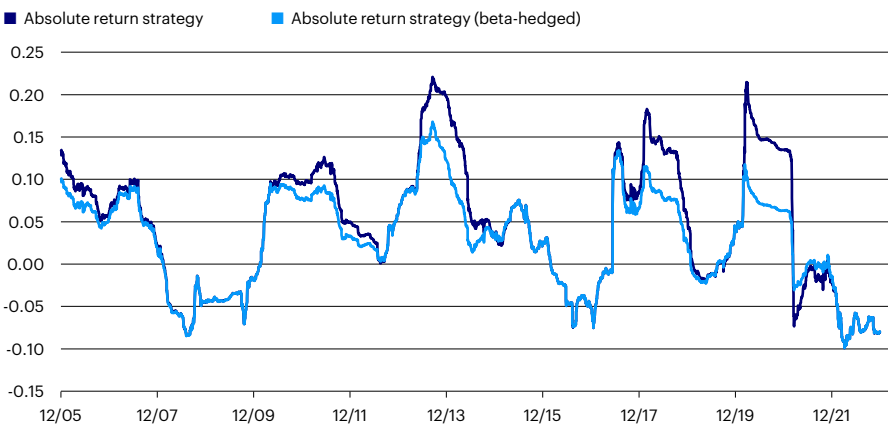
When striving for diversification, it is crucial to control a strategy’s major risk drivers. As illustrated in figure 3, equity risk is the main risk factor of the absolute return strategy. Nevertheless, over the sample period, the beta relative to the MSCI World was 0.03, providing overall diversification with respect to the equity market.

As the correlations between financial markets vary over time, we need to examine the development of their betas to equities. Figure 5 shows that the beta of the absolute return strategy relative to the MSCI World would have been very volatile over the sample period, with a maximum of 0.23. Thus, especially in periods of high correlation, we can further increase diversification by controlling for beta relative to the equity market.

To this end, we apply a dynamic asset allocation strategy that invests in the risky (absolute return) portfolio and a non-risky asset so that the risk target will not be violated. Specifically, systematically adjusting exposure to the portfolio conditioned on its current beta (forecast) maintains a pre-specified beta target of, in this case, 7.5%. If the portfolio’s current beta is above target level, we would reduce the investment exposure by shifting towards the risk-free asset, and vice versa. To rule out leverage and short positions, we restrict the total investment exposure to between 0% and 100%. Since we do not know the ex-ante beta of the underlying risky portfolio, we estimate it using a rolling 252-day window.[5]

Figure 5 shows that the beta-hedged strategy indeed mitigated the correlation to the equity market in periods of high correlation, providing diversification when needed most. As table 1 shows, beta hedging would have further reduced equity beta (to 0.01) and portfolio risk (to 3.26) and increased the portfolio return (5.76%) compared to the pure absolute return strategy. This would have led to a 29 bps improvement in the Sharpe ratio.

Figure 5
12-months rolling beta relative to MSCI World



Sources: Bloomberg, Invesco. Data from January 2006 to December 2022.

Table 3
Simulated performance in comparison

		60% equities 40% bonds	Blended 90/10	Blended 80/20	Blended 70/30	Blended 60/40	Blended 50/50
All period	Return p.a	5.92%	5.95%	5.97%	5.98%	5.98%	5.97%
	Standard deviation p.a.	9.58%	8.64%	7.72%	6.83%	5.96%	5.14%
	Sharpe ratio	0.45	0.50	0.56	0.63	0.73	0.84
	Beta (ex post)	0.59	0.53	0.47	0.41	0.36	0.30
Periods with equity market drawdowns only	Total return	-63.81%	-59.78%	-55.31%	-50.34%	-44.82%	-38.70%
	Average return	-0.40%	-0.36%	-0.32%	-0.28%	-0.24%	-0.19%
	Periods with positive return	6.08%	6.99%	8.34%	10.61%	13.89%	18.18%

Sources: Bloomberg, Invesco. Blended 90/10: 90% traditional 60/40 portfolio (60% equities, 40% bonds), 10% beta-hedged absolute return strategy etc. Data from January 2005 to December 2022. There is no guarantee the simulated results will be realized in the future.

The new normal: Adding absolute return strategies to a traditional 60/40 portfolio

Finally, we analyzed the effects of adding the beta-hedged absolute return strategy to a traditional 60/40 portfolio, consisting of 60% equities and 40% bonds. Table 3 shows different allocations – from 90% 60/40 and 10% absolute return to 50% 60/40 and 50% absolute return. While the annualized return would have risen only marginally, volatility could have been reduced significantly, by up to 4.44 percentage points (for the 50/50 variant), resulting in a Sharpe ratio increase from 0.45 to 0.84.

In equity market downturns, the 60/40 portfolio lost 63.81% in total, as opposed to a loss of 82.97% for the MSCI World. Obviously, the bond component's ability to mitigate losses is limited. But with the beta-hedged absolute return strategy, losses would have been almost halved, to 38.70% (using a mixing ratio of 50/50).

Conclusion

While simple multi-asset allocations struggle with positive correlations between equities and bonds, uncorrelated absolute return strategies may fare much better. We have researched such a strategy using well-known drivers of risk and return, i.e., style factors, as well as tactical signals. Results can be further improved by hedging equity market beta to near zero. This is confirmed by comparing the simulated performance of a traditional 60/40 portfolio with the performance of various combinations of 60/40 and/or beta-hedged absolute return strategy.

Notes
1 cf. Campbell et al. (2017).
2 See Introducing the New Alternative Morningstar Categories | Morningstar.
3 Purchasing Power Parity.
4 cf. Gormsen and Koijen (2022).
5 Hollstein and Prokopczuk (2016) show that regressing a portfolio's return on the market return delivers reasonably good forecasts, even outperforming various more sophisticated methods.

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Simulated performance: Simulated performance is not an indication of or guarantee of future results. Actual performance may vary significantly from any hypothetical or historical performance shown for the index. Charts and graphs herein may reflect hypothetical historical performance. All information is provided for informational purposes to illustrate the effects of a strategy while applying various measures. Simulated performance is not actual performance, but is hypothetical and are based on criteria applied retroactively with the benefit of hind-sight and knowledge of factors that may have positively affected its performance, and cannot account for all financial risks that may affect the actual performance. Back-tested data calculations are based on the same methodology that was in effect when the index(es) was officially incepted. Back-tested performance results have certain limitations. Such results do not represent the impact of material economic and market factors might have on an investment advisor's decision making process if the advisor were actually managing client money. There is no assurance that the future performance of any specific investment strategy presented herein will be profitable or equal to past hypothetical performance levels. It is not possible to invest directly in an index.

Performance shown is hypothetical/simulated for educational and informational purposes only. The simulation presented here was created to consider possible results of a strategy not previously managed by Invesco for any client. It does not reflect trading in actual accounts and is provided for informational purposes only to illustrate the factor results during specific periods. There is no guarantee the model/hypothetical results will be realized in the future.

Invesco cannot assure the simulated performance results shown for these strategies would be similar to the firm's experience had it actually been managing portfolios using these strategies. In addition, the results actual investors might have achieved would vary because of differences in the timing and amounts of their investments. Simulated performance results have certain limitations. Such results do not represent the impact of material economic and market factors might have on an investment advisor's decision-making process if the advisor were actually managing client money. Simulated performance also differs from actual performance because it is achieved through retroactive application of a model investment methodology and may be designed with the benefit of hindsight

Alpha in shorts: Shorting activities and the cross-section of stock returns around the world

By Hao Zou, Ph.D., and Jerry Sun, Ph.D.

Short sellers convey information through their bearish view on the securities they short. Using various metrics, we've constructed a 'shorting signal' to reflect in a timely manner and measure shorting activities which could unlock robust return premiums across regions and market capitalization group.

Short sellers are important for price discovery: Because short selling is riskier (theoretically, the downside potential is unlimited) and more costly (due to additional borrowing costs), their trading activities are often perceived to convey greater conviction, and short sellers are often believed to be more informed than long investors.

Academics have argued that short selling theoretically improves price discovery and market liquidity.[1] Empirical studies have found that heavily shorted stocks tend to underperform, and stocks with minimal shorting tend to outperform. This is consistent with the notion that short sellers express a bearish view that is informative with respect to the stocks they short. One potential issue with many of these empirical studies is that they rely on data reported by stock exchanges, which can be heavily delayed,[2] are only available in a small number of countries (such as the US and Canada) and do not account for the supply side of the shorting market. In this study, we use data from the securities

lending market, which captures shorting activities more comprehensively and in a timelier manner than exchange data.

Data from the securities lending market

Short selling normally involves a short seller borrowing a security, selling it and eventually buying back the security to 'cover the short' position. Consequently, there exists a securities lending market, where the owner of a stock or bond transfers ownership temporarily to a borrower. To mitigate the counterparty risk faced by the lender, a cash or non-cash collateral[3] is required. The borrower is also charged a fee for borrowing the security.

Data from the securities lending market is provided by IHS Markit, which sources daily shorting activities data from market participants, including custodians, prime brokers, asset managers and other financial intermediaries. More than 3 million intraday transactions encompassing USD 12 trillion in securities are covered.[4] Compared to the data from stock exchanges, IHS Markit data has the following advantages: (1) It is timelier, because the data is recorded daily and delivered with only a two-day lag; (2) it provides broader coverage over many different regions and countries; (3) it captures information not only from the demand side (e.g., short interest), but also from the supply side (e.g., available inventory for lending), plus shorting costs. In this research, we aggregate the daily data to monthly and perform analysis at monthly frequency.

Four variables form the shorting signal

After reviewing and analyzing the IHS Markit securities lending market dataset, we focus on four variables to capture different facets of shorting:

(1) short interest ratio,
(2) days to cover ratio,
(3) utilization and
(4) active utilization by quantity.

Table 1 provides a description.

The selection of these variables is based on their underlying economic rationale, data coverage[5] and univariate return predictability. They collectively capture both the supply and demand sides of the shorting market and are calculated based either on quantity of shares or value of shares. This selection provides more diversified exposure to the shorting market than a single-variable construct.

The eventual shorting signal is constructed as a combo signal of these four variables. Specifically, we follow our standard signal construction process and first standardize the raw value of each variable into industry-neutral z-scores. After combining the four z-scores by taking their simple average, we then neutralize the average score by market. These steps are done so that the efficacy of the shorting signal is not impacted by taking unintentional market or industry bets. Finally, we form a unit leverage signal portfolio based on the negated scores such that the signal takes long positions in stocks with low shorting activity and short positions in stocks with high shorting activity. The results here presented are based on this combo shorting signal.

Empirical results

We conduct empirical tests for various regions – Australia, Emerging Markets, Continental Europe, Japan, the UK and the US. With the exception of Australia, where our test is based on the all cap universe,[6] we look at large-mid and small caps separately. The testing period is from January 2007 (when the shorting data became available) to October 2022, based on monthly data.

We start with the coverage analysis. Table 2 shows the time series average coverage by number of names and coverage by market cap,[7] along with the average universe sizes for the large-mid and small caps. Not surprisingly, the US is the largest universe for both the large-mid and small caps, whereas Australia and the UK are among the smallest. In terms of signal coverage, all are satisfactory except the Emerging Markets, where coverage is about 50%. This low coverage is not surprising due to regulations prohibiting short selling in some countries and/or inadequate reporting.[8]

Next, we analyze signal performance: Table 3 shows the performance statistics of the shorting signal, including the annualized returns, risk and information ratios (IR), as well as market betas. We can see that, in all regions and market cap groups, IRs are quite strong and can go as high as 1.7. Risk is on average a little above 5%, with slightly higher in Australia (all

Table 1
Shorting signal variables for our analysis

Type	Tested variable	Definition and data used
Demand	**Short interest ratio**	Number of shares borrowed / shares outstanding
Demand	**Days to cover ratio**	Value of shares borrowed / trading volume
Demand + supply	**Utilization**	Value of shares lent out divided by share available for lending
Demand + supply	**Active utilization by quantity**	Quantity of shares lent out divided by shares actively available for lending

Source: Invesco.

Table 2
Data coverage (averages over time)

		Names in the universe	Observations	Coverage (by names)	Coverage (by market cap)
Panel A: Large-mid caps	Australia (all cap)	290	273	94.0%	97.2%
	Emerging Markets	1162	582	51.7%	51.4%
	Continental Europe	525	484	92.1%	94.2%
	Japan	704	661	93.9%	96.4%
	UK	263	228	86.7%	88.7%
	US	1217	1140	93.7%	95.6%
Panel B: Small caps	Emerging Markets	2040	1043	50.3%	49.6%
	Continental Europe	850	759	89.4%	90.3%
	Japan	1026	969	94.4%	93.7%
	UK	431	370	86.1%	86.1%
	US	2454	2219	90.4%	92.1%

The large/mid and small cap universes in each region are defined according to commonly used research universes. Based on monthly data from January 2007 to October 2022.
Source: Invesco.

> There is some evidence that the signal performs even better for small caps than for large to mid caps.

cap), as well as the United Kingdom and US (small cap). Since the shorting signal is constructed to be industry and market neutral, the signal betas[9] are very close to zero, suggesting that signal performance is not driven by the market. This beta-neutral construction is consistent with our portfolio construction process.

There is also some evidence that the signal performs even better for small caps than for large to mid caps. For example, the IR for US large to mid caps is 0.77, but for US small caps it is almost double, at 1.50. One explanation is that there is more need to borrow small caps in the wholesale securities lending market, whereas there are generally sufficient large-mid caps available to be borrowed through rehypothecation.[10] In this regard, the shorting data for small caps is likely more complete and accurate. Nevertheless, the large cap results are still solid in our view – and they demonstrate the signal's efficacy.

Figure 1 shows the cumulative returns of the signals for all regions and both market cap groups. Generally, they are trending upwards without large drawdowns, and the small cap performance appears stronger over time.

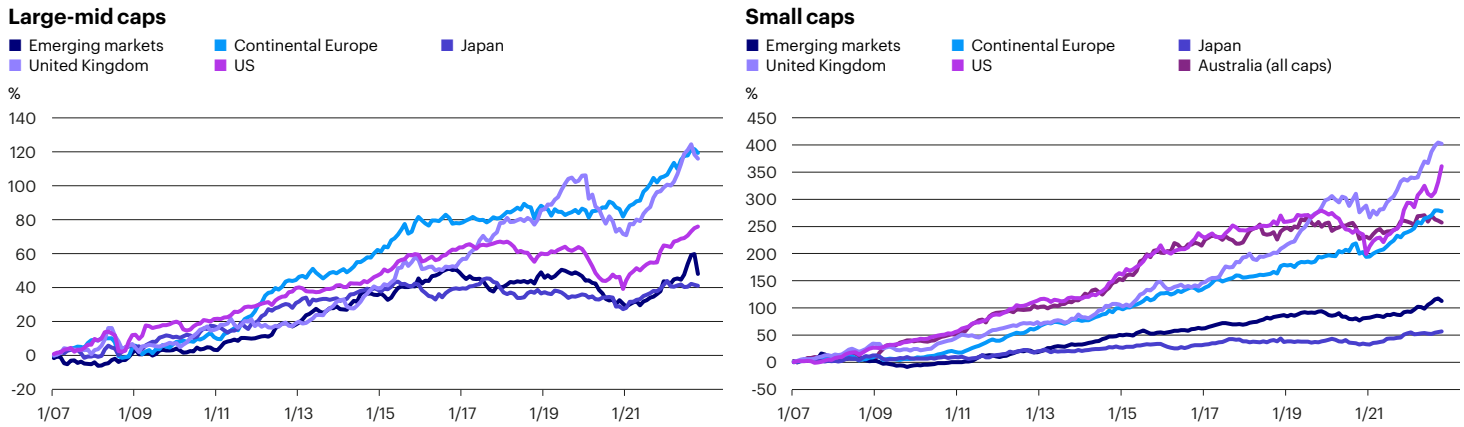
But how much does the shorting signal improve performance? We analyzed its effect on the market portfolio, three factor portfolios (momentum, quality, value) and a risk-weighted multi-factor portfolio. We regressed the returns of the shorting signal portfolio against the respective portfolio returns. Significantly positive intercepts indicate that the shorting signal adds value.

Table 3
Signal performance

		Return p.a.	Risk p.a.	Information ratio	Beta
Panel A: Large-mid caps	Australia (all cap)	8.37%	7.76%	1.08	0.05
	Emerging Markets	2.42%	4.96%	0.49	-0.06
	Continental Europe	5.08%	4.98%	1.02	-0.02
	Japan	2.24%	4.24%	0.53	-0.00
	UK	4.98%	5.95%	0.84	0.04
	US	3.84%	5.01%	0.77	0.01
Panel B: Small caps	Emerging Markets	4.80%	5.18%	0.93	-0.04
	Continental Europe	8.91%	5.31%	1.68	-0.10
	Japan	2.98%	5.04%	0.59	-0.07
	UK	10.70%	6.95%	1.54	-0.13
	US	10.72%	7.17%	1.50	-0.09

The large-mid and small cap universes in each region are defined according to commonly used research universes. Based on monthly data from January 2007 to October 2022.
Source: Invesco.

Figure 1
Cumulative returns



The large/mid and small cap universes in each region are defined according to commonly used research universes. Based on monthly data from January 2007 to October 2022.
Source: Invesco. **Past performance does not guarantee future results.**

> In many cases, the shorting signal generates significantly positive intercepts.

> Our empirical results suggest that shorting signal performance is solid.

Table 4 shows the results, with the t-statistics in parentheses. Intercepts that are statistically significant at 5% have their t-statistics in bold. In many cases, the shorting signal generates significantly positive intercepts, even on the multi-factor model returns. This pattern is even stronger in small caps.

A closer look at long and short legs of the signal

Our last set of empirical results breaks down the effect of the shorting signal on the long and the short leg. In principle, a signal's efficacy could come from both its long and short legs. Figure 2 shows the IRs for each, as well as the overall signal.[11] We see that both the long and short legs contribute to performance in most regions and market cap groups and that the overall IRs are usually higher than the standalone IRs of both the long and short legs.

The signal portfolio is constructed such that stocks on the long leg are those experiencing minimal shorting and stocks on the short leg are those with a high level of shorting activity. In other words, stocks in the short leg indicate a more bearish view, whereas those in the long leg could be more neutral and not necessarily positive. Accordingly, one would expect the short leg to carry more information content and hence have greater efficacy compared to the long leg. And the results we observe are consistent with this hypothesis in a number of markets, such as the US, the UK and Australia.

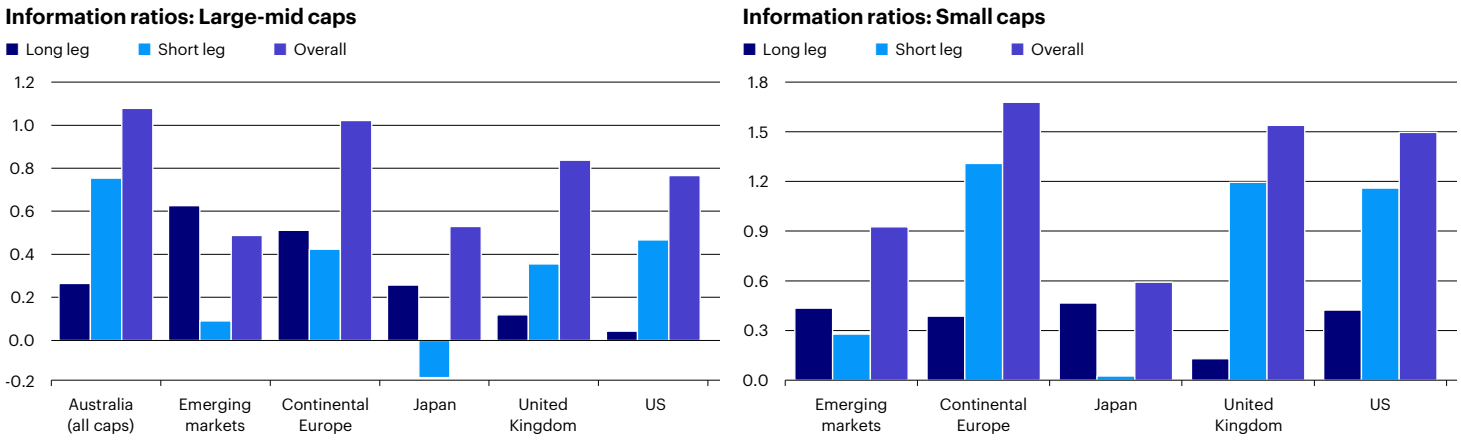
Overall, our empirical results suggest that shorting signal performance is solid and not dominated by either the long or the short leg.

Table 4
Spanning test results

		Market portfolio	Momentum	Quality	Value	Multi-factor portfolio
Panel A: Large-mid caps	Australia (all cap)	8.33% **(4.09)**	4.82% **(2.32)**	7.07% **(3.39)**	7.97% **(3.93)**	3.62% (1.74)
	Emerging Markets	3.02% **(2.42)**	1.31% (1.03)	2.46% (1.88)	2.59% **(2.03)**	0.17% (0.13)
	Continental Europe	5.32% **(4.13)**	3.79% **(3.17)**	5.35% **(4.12)**	5.46% **(4.20)**	3.89% **(3.21)**
	Japan	2.36% **(2.18)**	2.03% (1.94)	1.87% (1.73)	2.05% (1.92)	1.23% (1.19)
	UK	4.92% **(3.19)**	1.88% (1.32)	3.82% **(2.35)**	4.87% **(3.16)**	1.31% (0.90)
	US	3.86% **(2.98)**	3.09% **(2.44)**	4.01% **(3.03)**	3.95% **(3.10)**	3.63% **(3.08)**
Panel B: Small caps	Emerging Markets	5.34% **(4.00)**	3.03% **(2.23)**	4.66% **(3.45)**	5.39% **(3.92)**	2.42% (1.72)
	Continental Europe	9.73% **(7.39)**	8.26% **(7.15)**	9.61% **(7.18)**	9.92% **(7.51)**	8.16% **(6.90)**
	Japan	3.51% **(2.78)**	2.92% **(2.37)**	3.57% **(2.79)**	3.45% **(2.73)**	2.96% **(2.37)**
	UK	12.03% **(6.84)**	11.42% **(6.61)**	11.98% **(6.72)**	11.75% **(6.72)**	11.20% **(6.38)**
	US	11.83% **(6.38)**	10.74% **(5.79)**	11.45% **(6.19)**	11.68% **(6.46)**	10.27% **(5.73)**

The large/mid and small cap universes in each region are defined according to commonly used research universes. Based on monthly data from January 2007 to October 2022.
T-statistics in brackets (bolded if significant at the 5% level).
Source: Invesco.

Figure 2
Comparison of long and short leg performance



The large/mid and small cap universes in each region are defined according to commonly used research universes. Based on monthly data from January 2007 to October 2022. Source: Invesco. **Past performance does not guarantee future results.**

Short squeeze

A 'short squeeze' occurs when a significant number of short sellers scramble to cover their positions, which leads to surging demand-side pressure and a sharp rise in stock prices. This, in turn, triggers even more margin calls and short covering. Although an unusual occurrence, short squeeze events have happened in the past, most notably as a result of a gaming stock frenzy in early 2021.

We did not specifically control for short squeeze situations in the construction of our shorting signal because we believe it is not a systemic phenomenon that needs to be priced into a factor – a short squeeze usually affects an individual stock and its short-term price dynamics, whereas factor investing relies on harvesting long-term factor premia and diversifying idiosyncratic risk. We did, however, examine the potential impacts from a short squeeze and explored whether controlling for variables that are likely indicative of a short squeeze (such as a spike in shorting cost) can improve performance. We found nothing significant, which reinforces our assertion that short squeeze events would likely have limited impact on our shorting signal.

Conclusion

We have developed a shorting signal based on market theories of price discovery and build it out on a set of variables that capture the array of short selling activities. Our empirical results indicate that using the shorting signal could possibly improve portfolio performance in all regions around the world. The alpha potential in the signal is stronger among small cap stocks, exists in both long and short legs and is not significantly impacted by short squeeze events. We further find that this signal adds alpha to our multi-factor model based on quality, momentum and value.

Notes
1 see: Miller (1977).
2 e.g., the data reported by Compustat in the US suffers from a 14-day delay.
3 Can be other securities of similar value.
4 see: "Shining the Light on Short Interest", Markit Factor Insights.
5 e.g., we did not use fee-related variables because their coverage is less ideal in regions outside the US.
6 Australia is a relatively small market, and we want to ensure enough breadth in constructing the shorting signal.
7 Coverage by market cap is calculated by the total market cap of stocks covered by the shorting signal, divided by the total market cap of stocks in the universe.
8 Our Emerging Market universe contains a large percentage of Chinese A shares, which have limited shorting capacity (and hence limited shorting data) due to regulations. This further contributes to the relatively low data coverage.
9 These can be called "ex-post" betas, which differ from "ex-ante" betas that we use to neutralize the shorting signals. In practice, ex-post betas can almost never be completely turned to zero – this just reflects the discrepancy between prediction (ex-ante) and what actually happens (ex-post).
10 A practice that occurs where a bank or other broker-dealer reuses the collateral pledged by its clients. It may be cheaper to borrow from its own long book than pay a higher rate to borrow from the wholesale market.
11 The IRs for the long and short legs are calculated using market adjustment. For example, we subtract the market return from the long leg returns, so what remains is attributable to the long leg signal itself.

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Don’t be blind just because a benchmark is Paris-aligned

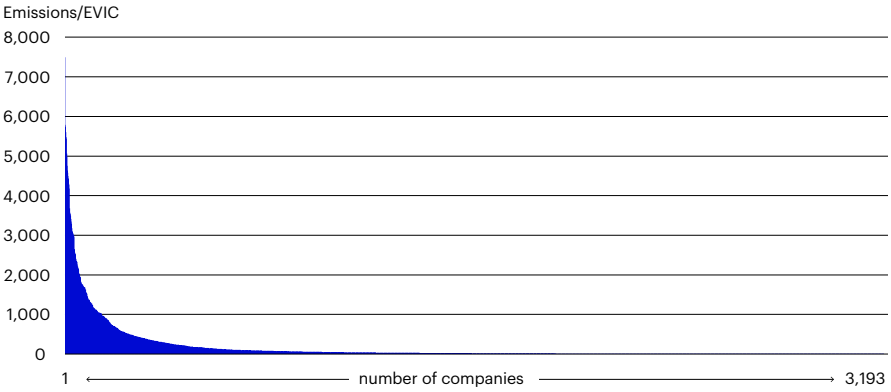
By Joshua Kothe, Erhard Radatz, Andre Roberts and Carsten Rother

Limiting global warming to “well below” 2°C – preferably below 1.5°C – as agreed in Paris in 2016 is one of the main challenges of our generation. And as more portfolios align with the Paris targets, confusion may arise from the diversity of available strategies. To overcome the noise, we research Paris-aligned objectives to better understand the sources of risk in low tracking error portfolios using a two-step factor-based process that balances Paris goals with return objectives.

In 2020, the EU set out minimum standards for Paris-aligned benchmarks and climate transition benchmarks. They combine exclusions with self-decarbonization and demand greenhouse gas emissions below those of the investable universe. Furthermore, so-called ‘high-impact sectors’ should not be underweighted relative to a standard equity benchmark.[1]

An EU Paris-Aligned Benchmark (PAB) requires GHG emissions to be 50% below those of the benchmark, whereas a difference of 30% is sufficient for an EU Climate Transition Benchmark (CTB). The main goal of both benchmark types are lower greenhouse gas (GHG) emissions. In addition, both require an annual decarbonization of 7% p.a. (geometric)[2] as well as some exclusions: For CTBs, companies involved in controversial weapons or tobacco production must be excluded, as well as companies violating the UN Global Compact, the OECD guidelines for multinational enterprises or the EU environmental objectives. PABs add further restrictions in the field of fossil energies – in terms of both exploration and power generation.

Figure 1
Distribution of the GHG footprint



Distribution of CO_2 emissions/EVIC in a global equity universe (3,193 companies), as of December 2021.
Source: Invesco, ISS.

> Divesting from a handful of companies can significantly reduce the carbon intensity of the portfolio.

Paris-aligned investments: Where do we stand?

A key component of the guidelines is the decarbonization pathway. Due to the skewed distribution of the carbon footprint, as shown in figure 1, divesting from a handful of companies can significantly reduce the carbon intensity of the portfolio. Therefore, only a small active risk budget is needed.[3] As for exclusions, simple ones could lead to significant biases,[4] but most Paris-aligned portfolios are optimized to avoid sector and country tilts without harming their ESG characteristics.[5]

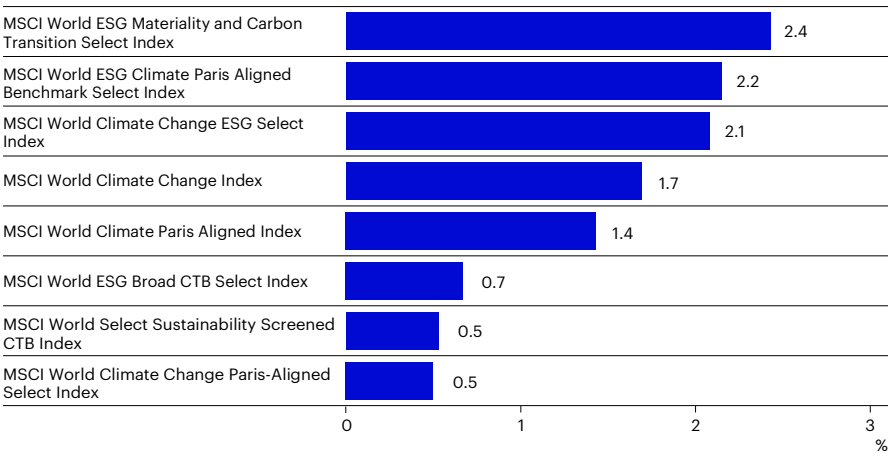
However, none of the EU standards is forward-looking, which leads to a debate about their effectiveness.[6] While investments into already green companies probably don't further reduce carbon emissions (as they are already low for these companies), investing in companies on a transformation trajectory could do so. However, such an approach might produce a portfolio overweighting high emitters and would require regular checks to ensure they are really changing. To strike a balance between a green portfolio and supporting climate transition, Paris-aligned portfolios require minimum investments in certain sectors.

Decomposing the impact of guidelines

There are many different Paris-aligned benchmarks, whose index constituents are selected and weighted to be aligned with the global warming targets of the Paris Agreement. These readily available benchmarks are convenient to allocate capital towards a low-carbon, climate-resilient economy. However, they come with a significant degree of active risk. Figure 2 shows the ex-ante tracking error of various Paris-aligned benchmarks relative to their parent indices. Active risk varies considerably, ranging between 0.5% and 2.4%. While certain indices, such as the MSCI World Climate Change Paris-Aligned Select Index, aim to fulfill only the minimum requirements, others surpass them in order to fully align with the Paris Agreement and reduce exposure to climate risks.

The specific sustainability goals and their effects on active risk can be difficult to discern due to the multitude of available

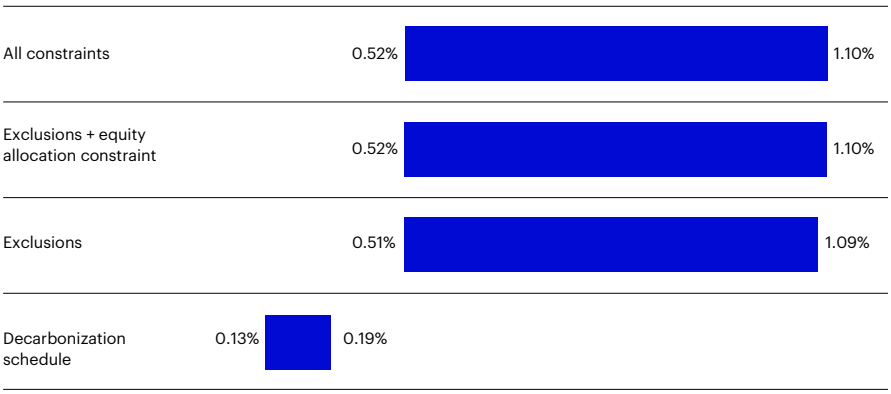
Figure 2
Active risk of Paris-aligned benchmark indices



Data as of March 2023. Active risk relative to the underlying parent indices.
Source: Invesco, MSCI.

The specific sustainability goals and their effects on active risk can be difficult to discern.

Figure 3
Tracking error of Paris-aligned portfolios relative to the MSCI World
(95% confidence intervals)



Simulations based on monthly optimizations from December 2019 to December 2022.
Source: Invesco.

options. To address this, we have grouped possible index requirements into three categories:

1. **Decarbonization schedule:** 50% reduction in GHG emissions relative to the parent index as of 2019, plus an additional 7% year-on-year reduction in GHG emission intensity.

2. **Exclusions:** Eligible companies have to adhere to the EU Taxonomy's "Do No Significant Harm", cannot be involved in controversial weapons, tobacco production or violate the UN Global Compact guidelines. There are also limits for revenue from fossil fuel exploration, extraction and distribution.

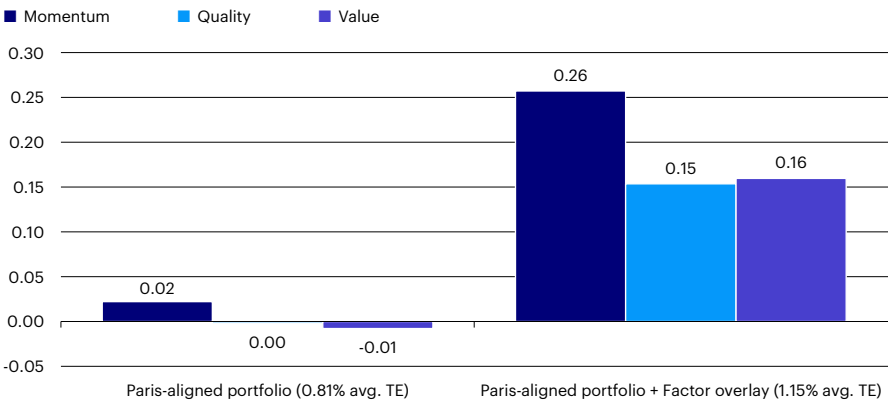
3. **Equity allocation constraint:** EU Paris-Aligned Benchmarks must contain certain basic sectors, primarily ones with a strong impact that are high-emitting but crucial for the overall health of the economy. This ensures capital allocation into these industries while focusing on the cleaner names to finance the transition.

To untangle the influence of these requirements on active portfolio risk, we constructed index portfolios for each of the sub-requirements. Specifically, these minimize the expected tracking error relative to the MSCI World Index while taking into account the specific Paris constraints. We placed stringent limits on exposures to other variables as well as individual positions to ensure that the portfolios avoid industry-specific bets or covariance-induced trades. This decomposition offers flexibility to address the most important investing preference.

Figure 3 shows the 95% confidence intervals for ex-ante tracking error; according to the simulations, a Paris-aligned decarbonization schedule can be achieved with an average tracking error of 16 bp.[7] The elimination of certain companies has the greatest impact, resulting in a tracking error of 80 bp on average. Adding the equity allocation constraint or the decarbonization schedule does not have much of an impact, resulting in an addition tracking error of approximately 81 bp for all Paris alignment constraints.

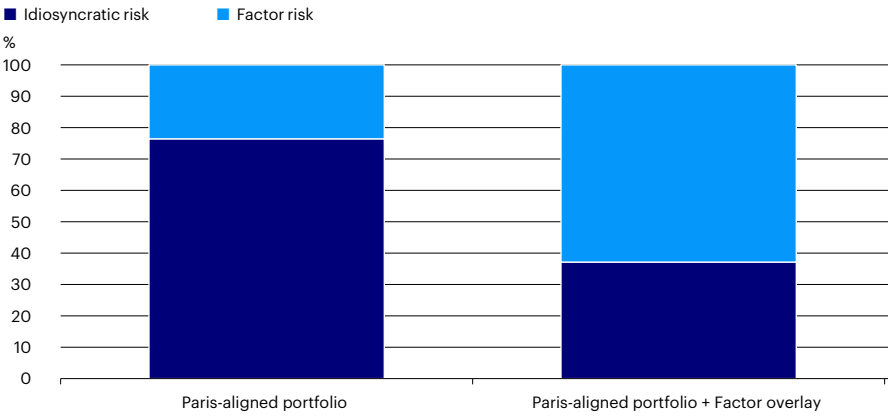
It appears that the main elements of Paris alignment can be implemented with modest levels of active risk.

Figure 4
Average active factor exposures vs. the MSCI World



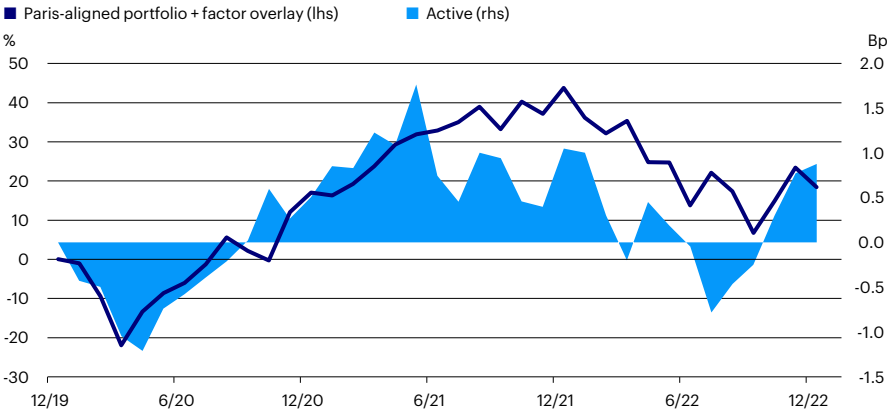
Factor exposes measures in standard deviations. Simulation period: December 2019 to December 2022.
Source: Invesco.

Figure 5
Decomposition of tracking error vs. the MSCI World



Simulation period: December 2019 to December 2022.
Source: Invesco.

Figure 6
Cumulated portfolio performance and active return



Simulation period: December 2019 to December 2022.
Source: Invesco. **Past performance does not predict future returns. There is no guarantee that the simulated results will be achieved in the future.**

Above and beyond: Paris alignment and factor investing

It appears that the main elements of Paris alignment can be implemented with modest levels of active risk. This leaves room for the inclusion of return-seeking elements, using key factors: Quality, Momentum and Value.

To enhance the active return of the strategy, we followed a two-step procedure. First, we constructed a reference portfolio applying the minimum standards used by Paris-aligned benchmarks with a minimal tracking error verses the MSCI World. Then we applied an active multi-factor investment process. This layered approach has several benefits: It distinguishes between the effects of the Paris alignment criteria and the multi-factor management on the risk budget, prevents distortion of the optimal portfolio and bases the factor-focused optimization on a benchmark that already incorporates the climate-related constraints.

The resulting portfolio is entirely Paris-aligned, with a beta of 1 to the MSCI World Index and an active risk between 0.6% and 1.3% throughout the simulation history. As figure 5 shows, almost two-thirds of its tracking error can be attributed to style factors, whereas factors do not contribute significantly to the tracking error of the simple Paris-aligned portfolio.

In our simulations, the combined portfolio delivered attractive outperformance of 90 bp – on par with the active risk taken and despite an overall challenging investment environment for systematic equity strategies. Overall, this approach appears to strike a balance between climate-conscious investing and factor enhancement, providing an interesting concept for Paris-aligned investing.

Conclusion

Paris alignment requires any array of portfolio characteristics. The decarbonization path, exclusions and minimum sector positions are meant to reward low-emitting companies and support companies on their climate transition journey.

Paris alignment can be made compatible with financial objectives to produce

> “Paris alignment can be made compatible with financial objectives to produce portfolios that fulfil the key criteria of the Paris Agreement without compromising on investment return.

portfolios that fulfil the key criteria of the Paris Agreement without compromising on investment return. A layered approach to portfolio construction may balance sustainability preferences with return objectives, providing a flexible and dynamic solution that can be adapted to different investment strategies and asset classes.

Notes

1 Commission Delegated Regulation (EU) 2020/1818, available under https://eur-lex.europa.eu/legal-content/en/txt/pdf/?uri=CELEX:32020R1818&rid=1
2 To be comparable, emissions are divided by company size, leading to the so-called 'GHG footprint'. Company size can be measured either by sales or by enterprise value including cash (EVIC), as used by the EU. As the inflation of asset values can lead to a reduction in the GHG footprint merely by increase of the denominator, the regulations prescribe disinflating it via the average change in EVIC of the index constituents.
3 cf. Anderson et al. (2016).
4 cf. Alessandrini & Jondeau (2020).
5 cf. Alessandrini & Jondeau (2021).
6 cf. Blitz & Swinkels (2020). Kolle et al. (2022) describe how to incorporate a scenario-based temperature alignment which goes beyond standard Paris alignment characteristics.
7 Andersson et al. (2016) have argued that a 50% reduction in carbon can be achieved with little to no tracking error.

Simulated performance: Performance shown is hypothetical/simulated for educational and informational purposes only. The simulation presented here was created to consider possible results of a strategy not previously managed by Invesco for any client. It does not reflect trading in actual accounts and is provided for informational purposes only to illustrate the factor results during specific periods. There is no guarantee the model/hypothetical results will be realized in the future.

Invesco cannot assure the simulated performance results shown for these strategies would be similar to the firm's experience had it actually been managing portfolios using these strategies. In addition, the results actual investors might have achieved would vary because of differences in the timing and amounts of their investments. Simulated performance results have certain limitations. Such results do not represent the impact of material economic and market factors might have on an investment advisor's decision-making process if the advisor were actually managing client money.

Simulated performance also differs from actual performance because it is achieved through retroactive application of a model investment methodology and may be designed with the benefit of hindsight.

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Tax optimal equity portfolio transition

By Nikunj Agarwal, Tarun Gupta, Ph.D., Jacob Guan and Josh Rogers

The possibility of a hefty tax bill can be a heavy burden for a portfolio with considerable gains. In the United States, realized gains are taxed and unrealized gains are not. Investors may defer or even forgo a necessary portfolio adjustment to manage tax charges. To address this issue, we outline a framework for transitioning a legacy portfolio towards a more diversified target portfolio with a given annual tax budget.

Portfolio needs and preferences often change over time. For instance, asset owners may want to reduce portfolio risk when they get older, incorporate ESG criteria or re-establish portfolio diversification when outsized gains of certain positions lead to significant concentration. All of these activities involve realizing gains and, depending on the tax system, may result in a substantial tax bill. A nuanced transition approach is therefore required, which incorporates both the need for portfolio adjustment and the desire to limit its tax impact.

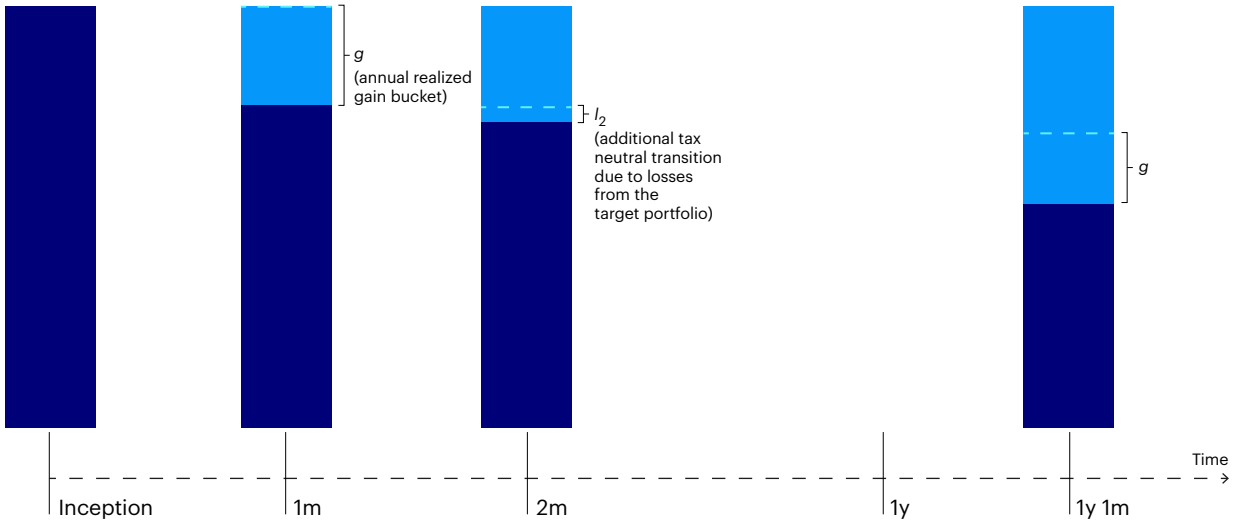
We begin by calculating the total tax burden incurred to fully transition a legacy portfolio into a target portfolio. This tax bill can then be split into annual tax budgets, i.e., maximum yearly taxation totals until the transition is complete. At the beginning of each year, the annual tax budget is utilized fully by realizing gains, after which the portfolio is managed on a tax-neutral basis for the rest of the year – matching any realized gains with realized losses until the budget is refreshed at the beginning of the following year. This disciplined and gradual build-up of the desired target portfolio can avoid the substantial one-time tax bill that could come with a portfolio replacement all at once.

Long-term transition strategy

To start, we create a simple long-term transition strategy to convert a legacy portfolio into a better-diversified target portfolio. We first set a yearly tax budget, which equals the annual realized gain budget (g) multiplied by the individual tax rate (r). In January of every year of the transition period, we sell as many assets from the legacy portfolio – which typically has meaningful embedded gains – until the annual tax budget is fully utilized and invest the pre-tax proceeds of the sale into the target portfolio (this assumes that there are enough funds to meet the tax bill without selling part of the investment altogether). We repeat this process each year until the transition is complete.

By using the entire annual tax budget at the beginning of each year, we speed up the transition. And we can speed it up even further by using losses from the target portfolio over the following eleven months to convert an additional part of the legacy portfolio without additional tax cost. Figure 1 illustrates the process.

Figure 1
Overview of the transition process
We assume taxes are paid from funds outside the portfolio and do not reduce the money invested



■ Legacy portfolio	V	$V - g$	$V - g - l_2$	...	$V - g - \sum_{i=2}^{12} l_i$	$V - g - \sum_{i=2}^{12} l_i - g$ ...
■ Target portfolio	0	g	$g + l_2$	...	$g + \sum_{i=2}^{12} l_i$	$g + \sum_{i=2}^{12} l_i + g$ ...
Tax paid	0	$g \times r$	0	...	0	$g \times r$ ...

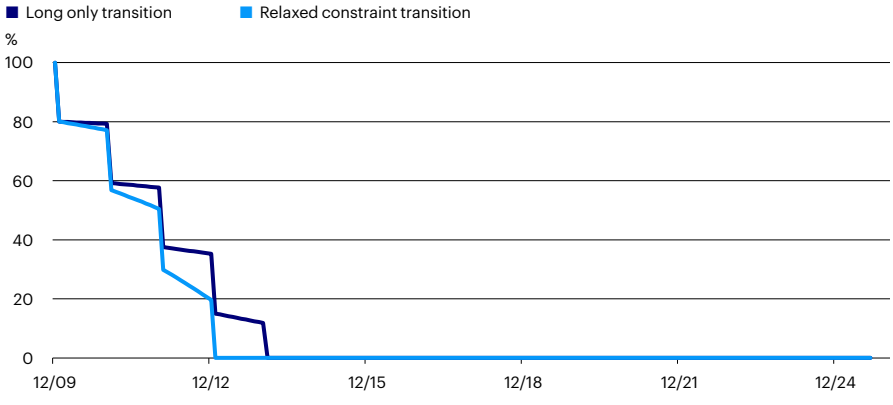
Source: Invesco.

Importantly, the annual tax budget is always respected – regardless of market moves. For example, when equities are strong, the target portfolio is unlikely to suffer meaningful losses throughout the year, resulting in minimal additional transition opportunities. On the other hand, if equities are weak, there may be significant losses that can be harvested, allowing a faster transition without additional tax payments.

Case study: Transitioning a highly concentrated portfolio

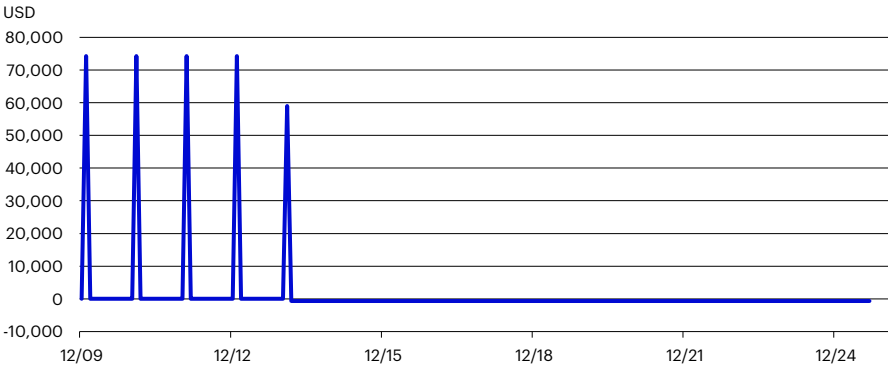
In this example, we seek to transition USD 1,000,000 of a single stock.[1] Assuming that all gains are long term, under US tax law the initial tax liability would be USD 371,000 (= 0.371 × USD 1,000,000) if we were to completely liquidate the portfolio and reallocate to a new portfolio. So instead of incurring that entire tax bill immediately, it would be interesting to transition this concentrated portfolio into an index-oriented diversified portfolio over time. To accomplish this, we consider two potential target portfolios: a long-only S&P 500 portfolio and a relaxed constraint tax-optimized S&P 500 strategy that can employ modest amounts of shorting and leverage. Figure 2 shows how the transition would take place (assuming no market movements) and how both transition portfolios would evolve over time.

Figure 2
Evolution of the legacy portfolio during the transition



Source: Invesco. For illustrative purposes only.

Figure 3
Tax paid

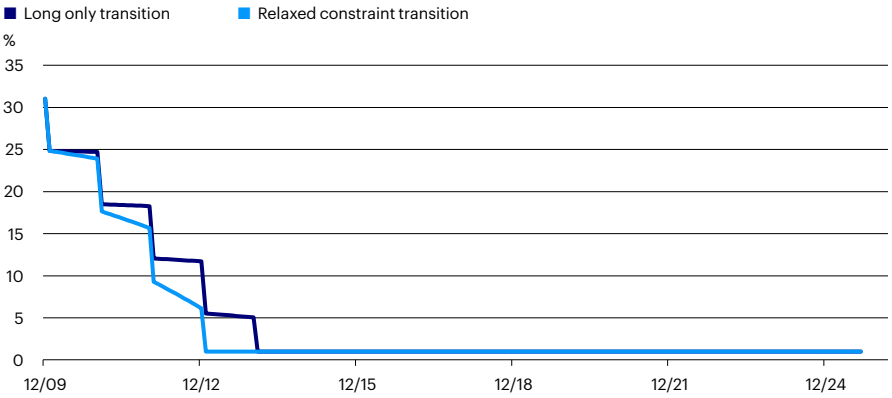


Source: Invesco.

We can see that the transition happens gradually, with the majority occurring at the beginning of each year and incremental shifts occurring during the remaining months. As stated previously, the annual tax budget is fully spent in the first month of the year (figure 3). After the first month, there are no more tax payments, but the transition continues, as gains from the legacy portfolio can be offset by losses harvested from the target portfolio. The relaxed constraint portfolio employs enhanced tax loss harvesting techniques, thereby allowing more tax-neutral transitioning and resulting in a faster transition.

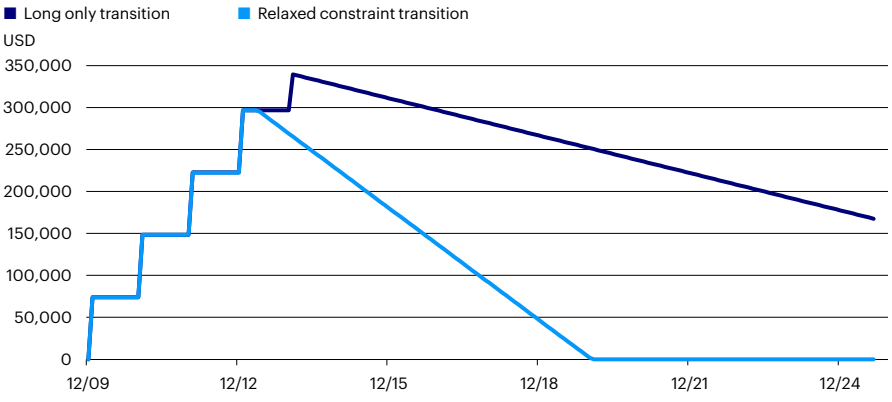
In figure 4, we look at the tracking error during the transition between the client portfolio – which contains both legacy assets and newly invested assets in the target portfolio – and the benchmark. We can see that tracking error gradually declines from 30% (when the portfolio is highly concentrated and contains only 1 stock) to 1% (when the desired

Figure 4
Tracking error against target benchmark



Source: Invesco.

Figure 5
Cumulative taxes paid



Source: Invesco.

diversification and investment objective is achieved). Mirroring the stepwise transition of the legacy portfolio, the tracking error also declines gradually. At the beginning of each year, when most of the gains are realized, the tracking error declines meaningfully, while we observe marginal decreases during the calendar year due to further tax-neutral transitions.

Once the portfolio's tracking error relative to the benchmark has reached 1%, we deem the portfolio fully transitioned – from then on, it can be managed in a standard, tax-optimal way, subject to risk controls.[2]

Finally, it is worth highlighting the potential benefits of a relaxed constraint transition over a long-only transition. Firstly, the planned transition tends to happen much faster so that the investment objective is achieved more quickly. The more significant losses harvested from the target portfolio result in a faster transition. So even for the same annual tax budget, the relaxed constraint process is more efficient at achieving its transition objective. Secondly, a relaxed constraint transition strategy can continue to generate significant tax alpha after the transition is complete. Thus, investors can completely transition from a highly concentrated portfolio with considerable gains into a diversified portfolio with meaningful ongoing tax savings post transition (figure 5).

> The more significant the losses harvested from the target portfolio, the faster the transition will occur.

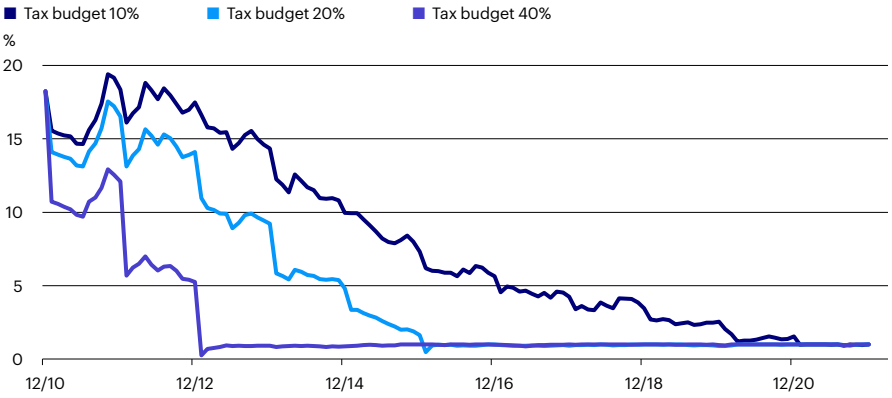
Suitability-based tax and risk preferences

To test how the proposed transition framework functions in practice, we produce a simulation using historical market data with settings in line with the model above. The objective is to transition a highly concentrated portfolio with considerable unrealized gains into a long-only diversified portfolio with a risk target similar to the S&P 500. Again, the legacy portfolio contains only one stock with a $1,000,000 market valuemade up entirely of long-term gains. We start the analysis in December 2010 and continue it for 10 years based on our previous assumptions.

To illustrate different preferences and journeys, we compare three different annual tax budgets – 10%, 20% and 40% of the total tax liability at transition (or strategy) inception. A higher tax budget leads to a quicker transition with more diversification and a higher tax bill upfront.

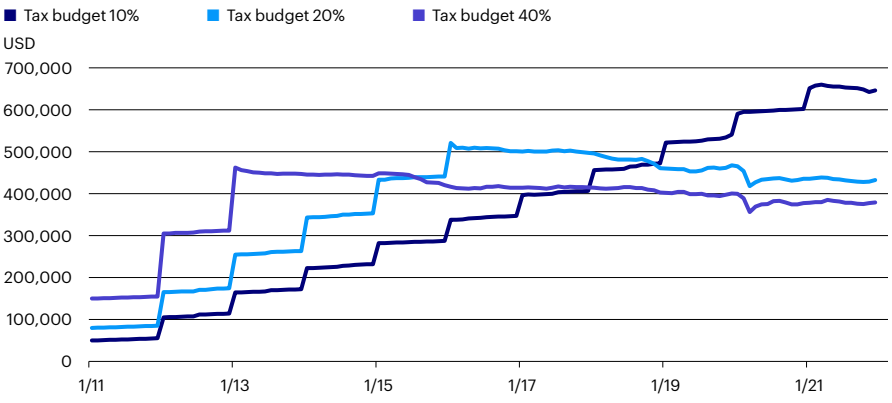
Interestingly, for all three tax budgets, the transition pattern is very similar but, as expected, results in varying timeframes for full transition. As figure 6 shows, the full

Figure 6
Tracking error against target benchmark



Source: Invesco.

Figure 7
Cumulative tax paid



Source: Invesco. Transition analysis shown utilizes the long-only construction methodology.

transition (hitting the desired target portfolio and diversification) is achieved more quickly with a higher tax budget. In our backtest, it takes approximately two years for an investor with a tax budget of 40% to complete the transition, while it takes roughly 10 years for a tax budget of 10%.

In the long run, we find that the portfolio with a higher tax budget pays the least taxes. While this may at first seem counterintuitive, figure 7 illustrates the dynamic. The portfolio with a higher tax budget transitions sooner to the tax-optimal strategy, thereby enabling more loss harvesting. Those harvested losses are valuable, as they can be used to offset future gains elsewhere in the portfolio (or some other account held by the same investor). Thus, in many instances, it is more favorable from a tax perspective to transition faster. A higher tax budget early on allows more losses to be harvested from the desired portfolio later down the line, which can enhance long-term after-tax wealth.

Although the above case study considers an extreme example of a concentrated portfolio with high unrealized gains, this long-term transition framework can also handle other types of portfolios – even when they are broadly diversified and hold depreciated assets. The framework can also incorporate pooled vehicles like ETFs and, in some instances, mutual funds as well.

Conclusion

Tax-efficient portfolio transitions can substantially limit investor's tax burden while still allowing the desired diversification and portfolio exposures. Whether a faster or a slower transition is more appropriate may depend on the asset owner's individual circumstances. Nevertheless, a faster transition will often be more favorable in the long run, despite the likelihood of higher tax payments upfront. This kind of approach allows more losses to be harvested from the target portfolio once the transition is complete, which can enhance total after-tax wealth over time.

Notes
1 For simplification, transaction costs are assumed to be zero.
2 More about tax optimization and tax-optimal index tracking strategies can be found in Gupta et. al. (2022).

Important Information: Invesco does not provide legal or tax advice and we encourage you to consult your own lawyer, accountant or other advisor before making an investment. "Pre-tax returns," "earnings before taxes," and similar terms refer to gains made before liquidation and other taxes incurred when gains are realized. Nothing in this document should be construed as encouraging or seeking unlawful tax avoidance. Note that all examples and strategies described in this paper are based on the US tax code.

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Jacob Guan is a quantitative researcher for Custom Equities. He is responsible for developing tax-optimized investment strategies and building innovative research technologies with advanced customization capabilities. Jacob also provides quantitative analysis and support for the portfolio management team.

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Client Portfolio Manager
Josh Rogers is Lead Client Portfolio Manager for Custom Equities. He is focused on commercialization efforts and serves as an expert on the firm's platform of systematically implemented separately managed accounts (SMAs), which provide both tax optimization and customization capabilities.

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