Invesco

Risk & Reward

Research and investment strategies

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Marty Flanagan
President and CEO
of Invesco Ltd.

Real assets define the world in which we live, and they can be an attractive portfolio addition for investors. In the emerging environment, with rising inflation and a need for greater diversification, real assets may be more interesting than ever – especially considering that a properly constructed real asset portfolio can also deliver sound ESG credentials.

Our colleagues from Invesco Real Estate have analyzed different types of real assets, from infrastructure to traditional real estate. In their article, they show that ESG leaders tend to outperform ESG laggards, making the asset class attractive even from a non-financial perspective.

ESG is also the focus of another article in this final edition of Risk & Reward for 2022: While we all know the importance of the E in ESG – particularly climate protection – there is a growing awareness of the S (social factors) in ESG investing. My colleagues have therefore constructed a social progress equity universe and show that applying a factor approach to this universe can produce a solidly performing social progress portfolio.

Continuing with more discussion of factor investing, our authors look at a risk-based factor weighting approach, presenting a base case in which factor weightings render equal contributions to portfolio risk. Read to learn why this can be used to improve a range of portfolio characteristics.

We then turn to the well-known low volatility anomaly, whereby low-risk stocks tend to yield higher risk-adjusted returns in the long run. But caution: The lower beta of the low volatility portfolio (allocation effect) can drag down returns. Our article explains how this effect might be minimized.

Finally, we take another look at tax-optimized investing in the US. This time, we construct a tax-optimized international portfolio based exclusively on US-traded securities – namely ADRs.

Wishing you all the best for 2023, we hope you enjoy this year-end edition of Risk & Reward!

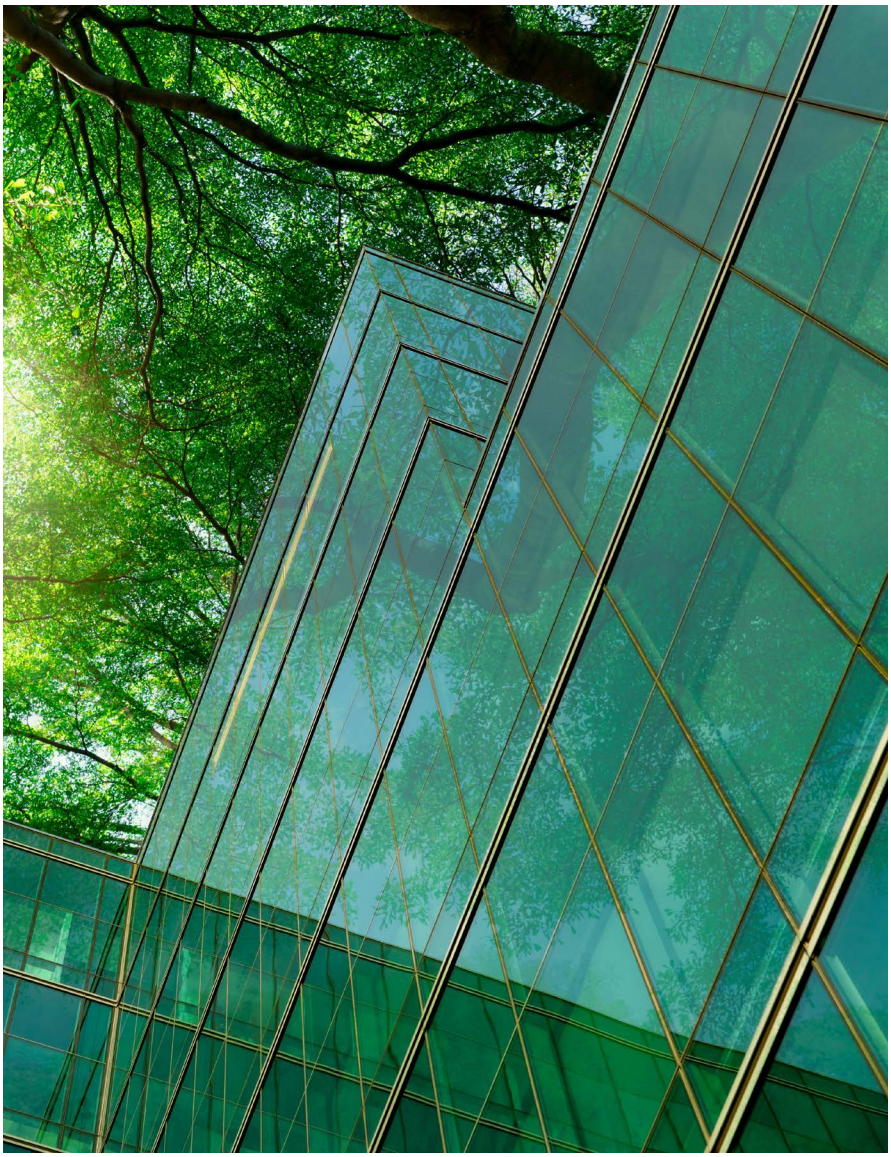
Best regards,

Marty Flanagan
President and CEO of Invesco Ltd.

Real assets: Really ESG

By Darin Turner and David Wertheim

Studies show that real assets have become one of the asset classes with the strongest links between material ESG factors and financial performance.[1] Investors can thus have confidence in the strength of ESG approaches pursued by real asset strategies – in addition to other characteristics such as yield potential, diversification and inflation protection, which may be more important than ever.



Resolving social injustices and bringing people together rest fundamentally on securing humanity's physical habitat. Capital markets, and the market for real assets in particular, have a transformative role to play in catalyzing solutions for this challenge. In this article, we briefly review different types of real assets and their ESG credentials before discussing performance differences between ESG leaders and laggards in the listed real assets space and describing our own ESG approach.

Real assets define our world. Whether infrastructure, energy and natural resources, metals & mining, agriculture or real estate – real assets are as important for economic development as they are for achieving better ESG outcomes.

Infrastructure – a long runway

Infrastructure is a cornerstone of economic development and an important investment lever for countries on the way to pandemic recovery. Roads, bridges, electrical transmission lines and other traditional assets lack the desired state of repair and modernization in the US and elsewhere – and the capital availability gap must be filled by real asset investors. Infrastructure assets are characterized by higher economic visibility, lower volatility and greater yield potential than other investments. As demand for data continues at a torrid pace, emerging opportunities in smart grids, data centers and fiber networks will be critical to power the next leg of the digital transformation.

Energy and natural resources – clean energy gains

Climate change has made the energy sector fertile ground for innovation and investment. The Paris Agreement, representing over 60% of global GDP pledged to net zero emissions by 2050,[2] calls for significant investment to decarbonize industry and transport, build smart energy systems and increase access to affordable clean energy. Concomitantly, the IEA Sustainable Development Scenario estimates spending on renewable power needs to double by the late 2030s. We have already seen an impressive adoption of low carbon energy sources over the past decade – doubling to nearly 16% of global primary energy consumption.[3] In combination with customer expectations, these trends are transforming traditional power and energy infrastructure systems, and new business models are springing up throughout the landscape.

The S&P Real Assets Equity Index (SPRAET) is a good representation of the different types of real assets available.

Metals & Mining – sustainability taking hold

Although it may seem that metals and mining would be antithetical to ESG, the sector is critical for the energy transition. Realizing the full potential of green technologies will require greater investment in minerals such as lithium, copper, cobalt, manganese, nickel and zinc. The sector has demonstrated ingenuity in developing best practices to help reduce its carbon intensity and prevent environmental disasters. Progressive rehabilitation of material extraction sites at each stage in the mining lifecycle is a notable example of prioritizing environmental risks earlier and more comprehensively than in the past. In combination with zero fatality mining safety practices and local employment, the industry is poised to benefit from greater social license to operate, lower environmental impact and enhanced mining performance.

Agriculture – carbon focus

In the US, agriculture accounts for roughly 10% of total greenhouse gas emissions, according to the EPA. However, studies indicate that enhanced agricultural practices have the potential to reduce this burden, even to the point of the sector becoming a carbon sink by offsetting more carbon emissions than it emits.[4] New technologies and production changes, such as compost, use of cover crops, reduced tillage and more precise fertilizer management, are areas of promise in the sector. Leading companies in the space have been able to reduce water use and carbon emissions while enhancing yields through such improved methods.

Real estate – raising the bar

As part of the efforts by REITs (Real Estate Investment Trusts) to identify and implement efficiency measures, best-in-class operators track and monitor property-level energy, emissions, water and waste data. Every year, these managers identify buildings as candidates for green building certification, so that a growing percentage of properties contributes toward improved ESG outcomes. For example, we have seen several top REITs reduce energy intensity by more than 20% while lowering overall energy costs by more than 10% over just a few years. Other measures include Indoor Air Quality (IAQ) audits and ensuring direct line-of-sight views in all regularly occupied buildings.

Real assets vs. the broad market

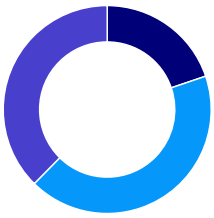
The S&P Real Assets Equity Index (SPRAET) is a good representation of the different types of real assets available. It consists of 40% global property stocks, 40% global infrastructure stocks, 15% global natural resources stocks and 5% global timber and forestry stocks. Comparing this index with the MSCI World Index (both in US dollars), reveals some significant differences between real assets and the broad equity market.

According to MSCI's ESG Reporting (figure 1), there are significant differences between the ESG risk factors of the two indices: the

Figure 1
ESG credentials in comparison

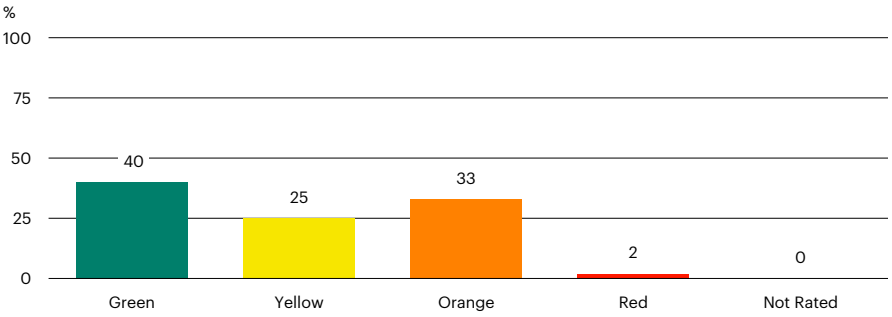
MSCI World Index

ESG weighting



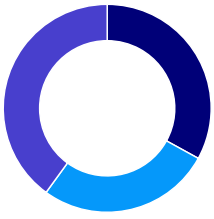
Environmental	20%
Social	43%
Governance	38%

ESG controversies flag distribution



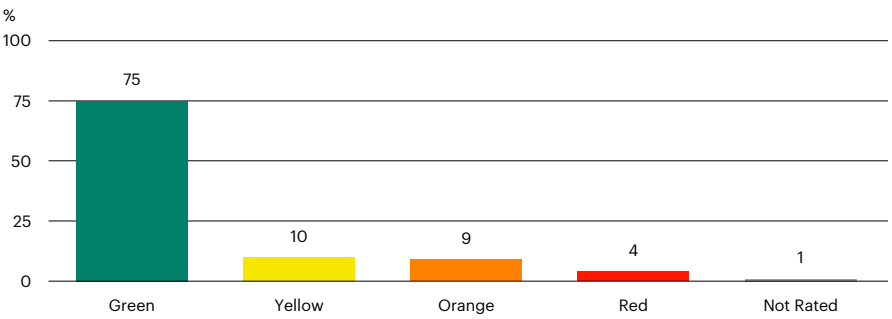
S&P Real Assets Equity Index

ESG weighting



Environmental	33%
Social	27%
Governance	40%

ESG controversies flag distribution



Source: MSCI ESG Reporting, Invesco Real Assets. Distribution of material risk factors in the two indices. Due to rounding, figures may not sum to 100%.

SPRAET contains 1.7 times as many companies with material environmental risk factors as the MSCI World Index – 33% vs. 20% – whereas companies with material social risk factors are more prevalent in the MSCI World Index – at 43% vs. 27% in the SPRAET. This is no surprise given the greater influence of human capital factors in the broad market.

For governance risks, the difference between the two indices is negligible.

Furthermore, SPRAET companies score much better in terms of controversy (75% green flags for SPRAET vs. 40% MSCI World Index for Excellence in Controversy Risk Management – indicated by the green bar). The MSCI Controversies approach is stakeholder driven and covers Environment, Human and Labor rights, Customers and Governance dimensions measured against 28 indicators. Investors can thus expect real asset companies to pay close attention to their critical ESG risks and act accordingly.

SPRAET companies score much better in terms of controversy.

Performance

Next, we turn to performance. Within the real asset space, ESG leaders outperformed laggards over a 7 year period from November 30, 2014 (the first day for which Sustainalytics ESG ratings are available) to November 30, 2021. Furthermore, the annual outperformance of 35 basis points was achieved at a considerably lower volatility of 12.68% vs. 18.16% (figure 2).[5]

During the sample period, real assets were largely out of favor whereas IT stocks were very much in demand. This may indicate that the outperformance of real asset ESG leaders is durable, in particular since the sector takes ESG risks seriously, demonstrated by their ESG credentials.

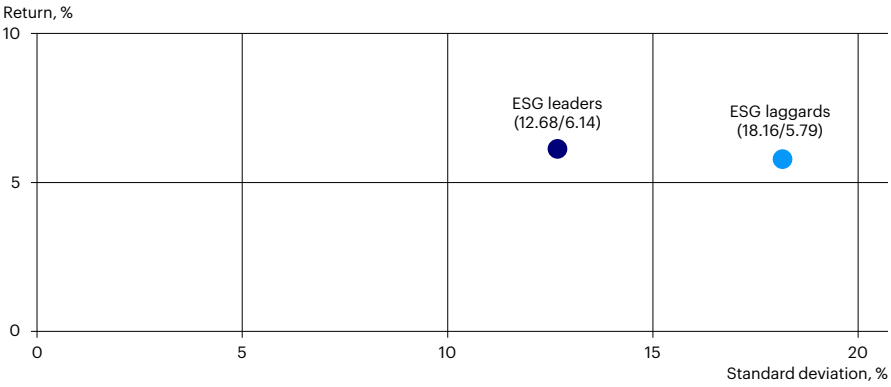
The Invesco Real Assets approach

Real asset companies live and breathe ESG. This places them in a unique position to capitalize on the epochal transformations of the physical world while meeting investor demand for responsible capital deployment. We recognize the fundamental importance of ESG principles and their potential impact on the performance of the assets clients entrust us to manage. ESG+R (environmental, social, governance and resilience) has been Invesco Real Asset's fundamental commitment for many years. Our philosophy is based on the belief that ESG has the potential to deliver competitive financial returns and opportunities for business growth and innovation.

We work together with our partners to help improve ESG performance and promote best practices.

Our commitment means we work together with our partners to help improve ESG performance and promote best practices. This enables us to respond to changing market dynamics for greater levels of engagement and transparency. We aim our ESG integration efforts at identifying and shaping better assets with broader insights, and building a more risk-resilient portfolio. We are motivated by the belief that doing what's right for the environment, our people

Figure 2
In real assets, ESG leaders have outperformed laggards
Risk and return, November 30, 2014 – November 30, 2021 (annualized)



Source : Invesco Real Estate using underlying ESG data provided by Sustainalytics. Analysis captures the return of real assets companies ranking in the top/bottom decile of Sustainalytics Historical ESG Scoring database. This does not represent any account's actual performance. Performance depicted does not factor in trading costs or effects of cash drag. Any reference to a ranking, a rating or an award provides no guarantee for future performance results and is not constant over time.
Sustainalytics did not participate in the preparation of this analysis. Performance results do not reflect the deduction of investment advisory fees. For example, an account with an assumed growth rate of 10% would realize a net-of-fees annualized return of 9.45% after three years, assuming a 0.50% management fee.
Any simulation presented here was created to consider possible results of a real assets ESG strategy (not previously managed by Invesco Real Estate for any client). These performance results are hypothetical (not real) and were achieved by using the top and bottom decile of historical Sustainalytics ESG scores. It may not be possible to replicate these results. The hypothetical results were derived by backtesting using a simulated portfolio. There can be no assurance that the simulated results can be achieved in the future. While a model using Sustainalytics historical ESG database was used to reflect the investment, this model does not factor in all the economic and market conditions that can impact results. The hypothetical performance returns shown are from November 30, 2014 through November 30, 2021.
Invesco Real Estate cannot assure that the simulated performance results shown for the strategy would be similar to the firm's experience had it actually been managing portfolios using this strategy. In addition, the results actual investors might have achieved would vary from those shown because of differences in the timing and amounts of their investments. The simulated performance results do not reflect the deduction of investment advisory fees. Returns shown for this simulation would be lower when reduced by the advisory fees and any other expenses incurred in the management of an investment advisory account. Past performance is not indicative of future results.

and the communities we serve helps us deliver the best possible experience to clients, mitigate risk and generate sustainable returns. Our approach is summarized in figure 3.

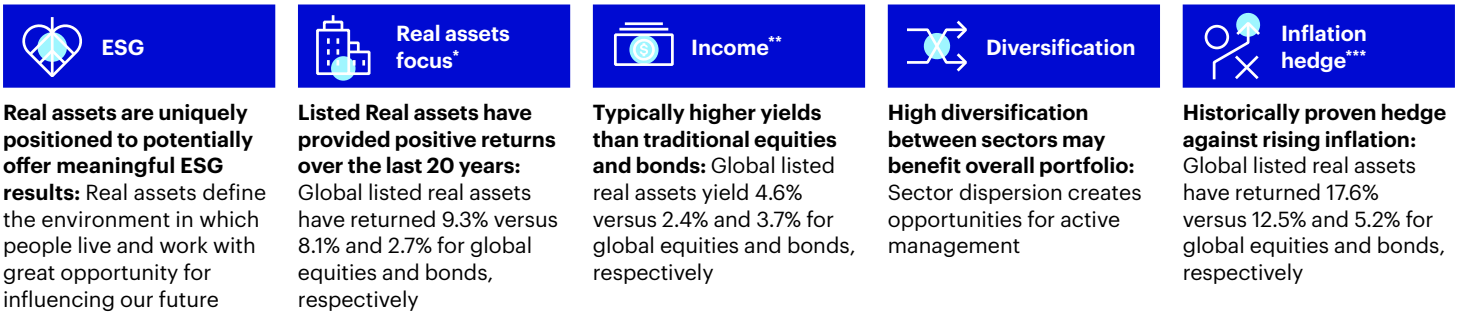
Conclusion: Why now?

Responsible real asset investing can have many advantages (figure 4) including meaningful ESG results, such as positive long-term returns, yields above those of equites and bonds, and inflation protection. The conditions present in the current and future investment environment point to real assets potentially meeting and exceeding the rigorous demands faced by investors. In combination with a disciplined ESG approach integrated within the investment process, real asset investors are equipped to build a solid economic and environmental foundation for the future.

Figure 3
An overview of the Invesco Real Assets approach

Source: Invesco Real Assets.

Figure 4
What matters in responsible real asset investing
Five considerations for investing in Responsible Real Assets



* Source: Invesco Real Estate, S&P, MSCI Bloomberg and Style ADVISOR as of September 30, 2022. Global bonds represented by Bloomberg Barclays Global Aggregate Index. Global equities represented by MSCI World Index. Global real assets is represented by the S&P Real Assets Equity Index from May 2005 – present. An equal weight custom index was used prior to the inception and the S&P Real Assets Equity index in May 2005. The custom equal weight Global Real Assets Index is made up of Real Estate, Commodities, Infrastructure and Natural Resource Equities. Real Estate represented by the FTSE Nareit Equity REIT Index. Commodities represented by the Bloomberg Commodity Total Return Index. Infrastructure represented by 50% Alerian MLP Index and 50% Dow Jones World Utilities Index. Natural Resource Equities represented by 50% Dow World Oil & Gas & 50% Dow World Basic Materials Index.
** Source: Bloomberg as of September 30, 2022. Global equities is represented by MSCI World Index; Fixed income by Bloomberg Barclays Global Aggregate Bond Index; Real assets by the S&P Real Assets Equity Index.
*** Source: Invesco Real Estate, IMF, S&P, MSCI, FTSE EPRA Nareit, Dow Jones and Bloomberg using data from January 1, 2003 – December 31, 2021. Total returns shown in USD. Annual update with latest available data. Periods of world inflation acceleration include January 1, 2004 – December 31, 2004, January 1, 2006 – December 31, 2007, January 1, 2010 – December 31, 2011 and January 1, 2016 – December 31, 2017. Rising inflation defined by the annual increase in world consumer prices (end of period) as reported by the IMF. Past performance is not indicative of future results. Global bonds represented by Bloomberg Barclays Global Aggregate Index. Global equities represented by MSCI World Index. Global real assets is represented by the S&P Real Assets Equity Index from May 2005 – present. An equal weight custom index was used prior to the inception and the S&P Real Assets Equity index in May 2005. The custom equal weight Global Real Assets Index is made up of Real Estate, Commodities, Infrastructure and Natural Resource Equities. Real Estate represented by the FTSE Nareit Equity REIT Index. Commodities represented by the Bloomberg Commodity Total Return Index. Infrastructure represented by 50% Alerian MLP Index and 50% Dow Jones World Utilities Index. Natural Resource Equities represented by 50% Dow World Oil & Gas & 50% Dow World Basic Materials Index. Source: Invesco Real Assets. Past performance is no guide to future returns.

Notes
1 See the literature review in van Heijningen, Kelly (2019): The impact of ESG factor materiality on stock performance of firms, Working Paper, Rotterdam School of Management, Erasmus University.
2 IEA (October 2021): Net Zero by 2050 – Analysis, www.iea.org/reports/net-zero-by-2050.
3 Ritchie, Hannah (March 2022): Energy Mix, Our World in Data, www.ourworldindata.org/energy-mix.
4 Mbow, C. and C. Rosenzweig (February 8th, 2021): Special Report on Climate Chance & Land – CH05 Food Security. https://www.ipcc.ch/srccl/chapter/chapter-5/
5 ESG leaders/laggards defined as top/bottom decile of the Sustainalytics ESG Risk Score. Real Assets Sectors: GICS – Energy/Industrials/Materials/Real Estate/Utilities weighted by start of period MSCI ACWI Sector Market Cap.

About the authors

Darin Turner
Chief Investment Officer, Listed Real Assets North America
Invesco Real Estate
Darin Turner is Managing Director and CIO for Invesco's Listed Real Assets team. His current duties include fundamental and securities research on real assets.

David Wertheim
Client Portfolio Manager North America
Invesco Real Estate
David Wertheim is a Client Portfolio Manager at Invesco Real Estate. David is responsible for real estate, infrastructure and real assets securities.

“More and more investors recognize the potential benefits of real assets for portfolios”

Interview with Darin Turner and David Wertheim

Darin Turner
Chief Investment Officer, Listed Real Assets North America
Invesco Real Estate

David Wertheim
Client Portfolio Manager
North America
Invesco Real Estate

Risk & Reward spoke to Darin Turner and David Wertheim from Invesco Real Estate, the authors of our study about Real Assets and ESG.

Risk & Reward
You say that, in the real asset space, there is a strong link between ESG credentials and performance. Can you elaborate?

Darin Turner
ESG considerations may benefit portfolios in two important ways: First, they help to find best-in-class companies poised to outperform and, secondly, these companies tend to exhibit lower volatility, as we show in our article. Listed real asset companies with stronger ESG scores outperformed listed real assets companies with lower ESG scores, and they did so with a lower annual volatility over the 7 years since ESG data first became available. The link between ESG, strong assets and operational strategies is becoming stronger, serving as a key pillar for real assets investment approaches.

Risk & Reward
Do companies dealing in real assets take ESG more seriously than companies from other sectors?

David Wertheim
ESG is important across all investment sectors, but not all E, S and G categories are equally important for all industries. Real assets are more impacted by environmental factors since they are intimately intertwined with the physical and built environment. For example, the transmission lines of an electric utility company need much more land than the head offices of a non-real asset company. This forces real asset companies to take environmental risks much more seriously than companies from some other sectors. We analyzed how this has been picked up through ESG-specific reporting and managed over time.

Risk & Reward
Will real assets be the hot topic in the coming years?

Darin Turner
More and more investors recognize the potential benefits of real assets for portfolios. Short as well as long term, they have been one of the few asset classes with positive inflation sensitivity. Real estate and infrastructure contain inflation-linked provisions in leasing and rate contracts, which pass through rising costs. Rising replacement costs also protect against inflation by raising the hurdle rates for new projects and existing assets. Natural resources, too, offer inflation protection. Positioned as they are at the very beginning of supply chains, they respond quickly to changing supply and demand dynamics.

David Wertheim
Real assets also offer relatively higher yields and lower correlations to traditional asset classes. For ESG minded investors, the emerging research we reference highlights their unique profile in a responsible investment strategy.

Darin Turner
After more than a decade of performance leadership from a narrow segment of the equity market – large cap technology – there is increasing recognition that the factors leading to that outperformance may be changing significantly. After decades of price stability, inflation is now a material risk for investors, and it has induced a rate hiking cycle that investors have not had to contend with for a long time. This has led to the unusual outcome whereby both stocks and bonds have fallen simultaneously for most of 2022. The lone pockets of the market that have held up this year are in real assets. Their ability to offer both cyclical and countercyclical exposure is likely to set real assets apart in the coming years.

Risk & Reward
What is so special about Invesco’s real assets approach?

Darin Turner
Our Direct Real Estate and Listed Real Assets groups have been exclusively managing real asset portfolios for 39 years; thus, this is already where our core focus lies. Our specialized approach has been strengthened and shaped over almost four decades of market cycles. The scale of our global platform, owning both direct assets and listed securities, equips us with a front-row seat to current trends, which is not necessarily available at other investment houses. We think that this combination of knowledge breadth and institutional-grade capabilities – such as real estate professionals on the ground in all key markets around the world – provides our investors with a compelling real assets advantage.

Risk & Reward
Thank you for your insight.

Shifting the focus to the S in ESG – the construction of a social progress portfolio

By Andrew Gardner, Tim Herzig, Carsten Rother and Margit Steiner

Historically, ESG investing has been centered around the 'E' – or environmental factor, due to data availability and a sense of urgency. But recently, social aspects have been discussed more prominently, pushing 'S' into the limelight. Revenues from social goods and services can be a good proxy for a firm's impact on society. A social progress portfolio can be designed to mitigate negative societal impacts through a set of strict filters and maximization of social revenue. It is designed to create positive social impact and is expected to have a sound financial profile.

Adam Smith is widely believed to have put human self-interest at the center of his theory, and in 1970, Milton Friedman wrote in the New York Times that: "The social responsibility of business is to increase its profits." We have indeed come a long way since then. In her 2017 book "Doughnut Economics", Oxford Economist Kate Raworth claims that, to think like a 21st century economist, one has to see the big picture and can no longer neglect the need to nurture society.

And this "need to nurture society" is as core to an ESG portfolio as any other consideration. Since we cannot ignore the issues that ultimately threaten not only financial stability but also society as a whole, it may be self-defeating to include companies which fail to address the need for sustainability and help solve the many socio-economic issues we face as a society.

For those truly interested in ESG investing, these 'S' factors are essential. There is a need to create decent jobs, related to

United Nations Sustainable Development Goal (SDG) 8: Decent Work and Economic Growth. We have a problem with a lack of affordable and reliable energy, which needs to be provided to billions who still rely on wood and charcoal for cooking and heating (SDG 7: Affordable and Clean Energy). Still today in the 21st century, there is discrimination and violence suffered by women and girls, who make up more than half the world's population (SDG 5: Gender Equality). For real improvements in a society, all people must have access to opportunities that allow them to grow as individuals.

Investing in these and many other goals will help foster development of societies and ensure that humans prosper. COVID-19, the war in Ukraine, soaring inflation, along with a global housing crisis (to name but a few) have only accelerated the desire to drive change and address societal shortcomings. Society itself should encourage companies actively to bring opportunities to everyone.

Common pitfalls of social data

Political theorist Robert Putnam (2000) claims that, "Social capital makes us smarter, healthier, safer, richer and better able to govern a just and stable democracy," and presents empirical evidence for this.

Nevertheless, measuring the impact of 'S'-based practices is difficult. An analysis by New York University's Stern School of Business argues that only 8% of 'S' measures reported by companies relate to the effects of their practices, whereas the remaining 92% are simply a measure of their efforts.[1] This would mean that rating agencies have looked more at the implementation of ESG policies than at their actual impact.

> Investors often gravitate to specific sectors that they deem to be social.

Given such ambiguities, investors often gravitate to specific sectors that they deem to be social.[2] It shouldn't surprise us that mutual funds in Spain tend to evaluate social organizations in the health and social services sectors more favorably than those operating in other segments of the economy.[3]

Jason Saul (2022) argues that, to overcome these issues, the measurement of 'S' factors must be modernized through several key conceptual changes, namely standardization, quantification and reporting.[4]

Standardization

Without a reliable, quantitative set of measurement standards, every company interprets, defines and measures their social impacts in a different way. According to Kotsantonis and Serafeim (2019), there are currently more than twenty ways for companies to report their employee health and safety data. Investors thus receive unreliable, incomparable and low-value data that cannot be used in financial models. To integrate social characteristics in a systematic way, schemes and standards are important, e.g., the Universal Standards for Social Performance Management and the forthcoming EU Social Taxonomy.

Quantification

In a second step, measurements must be quantified. Similar to the 'environment' characteristics, where we can measure the impact of greenhouse gas emissions, 'social' outcomes should also be quantified. Like verifying a carbon credit, 'impact developers' could report their data and have their findings verified against a standard or a benchmark. Then, ESG analysts could easily roll up and aggregate a company's total impact on society.

Reporting

Reporting is all about disclosure of material risks. In fact, however, the view that 'materiality' refers only to material risk is inconsistent with the way financial markets define the concept. Relying on a long history of existing legal precedent, the SEC defines information as 'material' if there is "a substantial likelihood that a reasonable shareholder would consider it important" in making an investment decision. There is no indication that only risks or negative factors qualify for disclosure – companies must instead focus on both positive and negative material facts.

Essentially, the appropriate assessment of social characteristics requires a shift from focusing solely on the shareholders of the company, to encompassing the stakeholders – especially employees, supply-chain relationships, the environment and the communities in which a company operates.

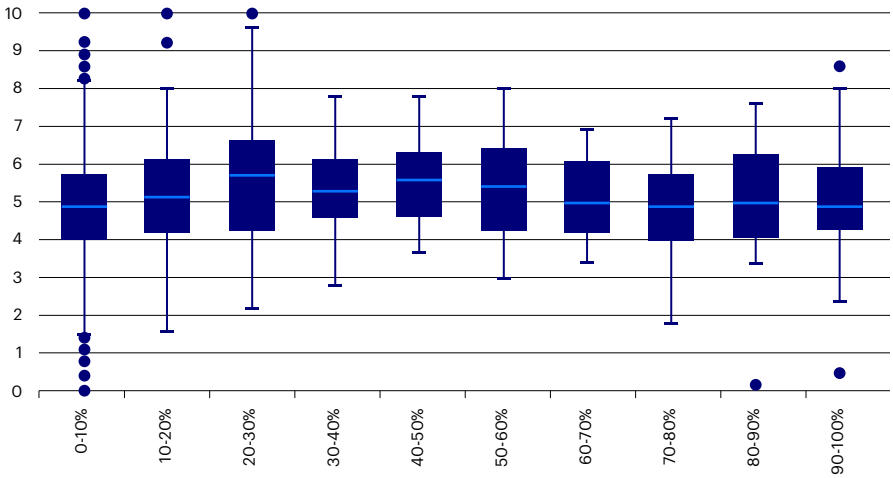
Data matters – and business activity data matters even more

There is no doubt that data is changing our lives today more than in the centuries past. And data availability has increased dramatically. But a systematic approach is key to accessing data on the societal impacts of companies' business activities. In a recent survey by ESG Investing, 51% of investors surveyed (over 356 Institutions) found the 'S' factor to be the most difficult to analyze and embed in investment strategies.[5] How, for example, can one measure things like 'meaning and joy', 'societal stability' or 'equality and human rights'?

To integrate social characteristics into a systematic investment process, we need to consider both data breadth and depth, i.e., coverage, history and consistency, as well as transparency in terms of how the data is obtained.

Recently, the ESG data market has evolved from analyzing business activities (identifying controversial involvements) to assessing positive impact based on the sustainable goods and services a firm offers. Using readily available balance sheets or sustainability reports, investors can gain insights into the social contribution of different business segments and the entire company. To this end, a company's

Figure 1
MSCI Social Pillar Scores and social revenues



Social revenues as measured by the percentage of S&P 500 companies' revenues are displayed on the x-axis and the respective MSCI S pillar scores displayed on the y-axis.
Source: Invesco. Data as of June 2022.

revenues and assets are decomposed into solutions for categories, including: health, water & sanitation, food & nutrition, capacity building, energy & climate change, access to information, infrastructure and responsible finance.

Traditional holistic scores often focus on internal company social topics, such as gender diversity or the gender pay gap. By contrast, the social goods and services (SGS) dataset focuses on the social externalities of a firm and hence its impact through the provision of social goods and services.

Given the different scopes of traditional social pillar scores and this business activity dataset, it is not surprising to observe a tenuous connection between the two. In figure 1, we plot the MSCI Social Pillar Score on the y-axis and social revenues on the x-axis. The boxplots show the distribution of social pillar scores within the respective revenue bucket. There is neither a positive nor a negative correlation.

Additionally, business activities can be linked to other common frameworks, such as the United Nations Sustainable Development Goals (UN SDGs). The social categories outlined above can be mapped to the individual SDGs. For example, revenues that fall into the category of 'health' can be linked to SDG 3: Good Health and Well-Being.

In summary, recent developments in the availability of social data provide investors with an enhanced toolkit to measure the *socialness* of a company. Such new datasets are crucial for in-depth analysis of the social profile of a company and its impact on society.

Social progress portfolio construction

We believe in a systematic approach with thoughtful integration of ESG measures rather than mere exclusions. Looking at both traditional and alternative data, we aim for a true social progress investment. Herzig et al. (2022) discuss how to consider different investor preferences in an actively managed portfolio. Following them, we integrate social characteristics and financial metrics by way of a two-step portfolio optimization.

We first target the social credentials of the investee companies by narrowing down the investment universe and maximizing of social revenue. Then, we overlay this anchor portfolio with a multi-factor model (quality, value and momentum) to take financial metrics into account. This two-step approach allows access to a broad universe of securities and a wide variety of social themes while also considering financial characteristics of the portfolio.

Narrowing down the investment universe

To fully integrate wider ESG characteristics, we start by removing a range of controversial stocks from our global equity universe of roughly 3,000 companies. These companies violate the UN Global Compact list, have revenues from controversial activities (coal, fossil fuels etc.) or are involved in controversies concerning labor rights, diversity, equal pay and many more.

In addition, the investment process uses Natural Language Processing (NLP) to help determine companies involved in controversies and potentially not covered by readily available exclusion lists.[6] A huge dictionary with adverse words captures terms associated with any state or activity considered detrimental to social considerations. This dictionary is used to filter millions of news datasets, and the process counts news hits of companies mentioned in the context of any of these adverse words.

To complete the process, a best-in-class filter is applied. This is done by utilizing a third-party data provider where the 'S' score is focused on risk mitigation. Removing the bottom 25% of the remaining

> This maximization results in a significant increase of the share of social revenues compared to a broad-based equity benchmark.

global equity universe leaves us with some 1,000 stocks that align not only with social minimum standards but also wider ESG considerations.

Thus, we have narrowed down the investment universe from roughly 3,000 to 1,000 based on three criteria:

- Exclusion of companies whose activities are considered controversial based on their revenues
- Exclusion of companies based on exclusion lists and a proprietary NLP process
- Exclusion of the bottom 25% in every sector (best-in-class) based on the 'S' score

Maximizing social revenue

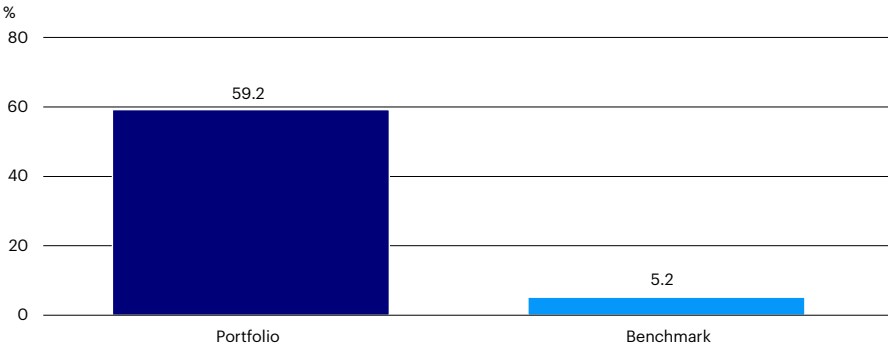
Based on the investable universe, the first step of the investment process seeks to generate positive social progress. Utilizing the SGS Revenue scores,[7] we now maximize the aggregate social revenue of the portfolio companies subject to liquidity and transaction costs and risk constraints. Furthermore, we apply active risk controls. Technically, the optimization is set up to maximize the following utility function:

$$\max U = r'h - \frac{\lambda}{2}(h - h_0)'(h - h_0)$$

where r denotes the SGS revenue scores and h_0 is defined as market capitalization weighted SGS revenue. The optimization also satisfies other constraints with respect to the sector and single-stock allocation, so that it is entirely driven by the social characteristics and does not create biases.

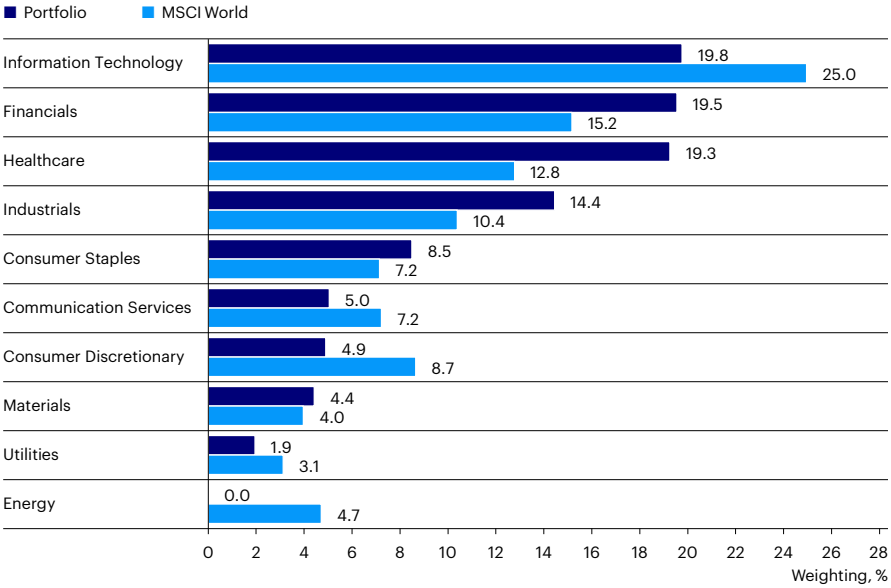
This maximization results in a significant increase of the share of social revenues compared to a broad-based equity benchmark like the MSCI World. In fact, the weighted social revenue of the resulting portfolio is close to 60% – and hence more than ten times that of the MSCI World (figure 2).

Figure 2
Total weighted social revenue in comparison



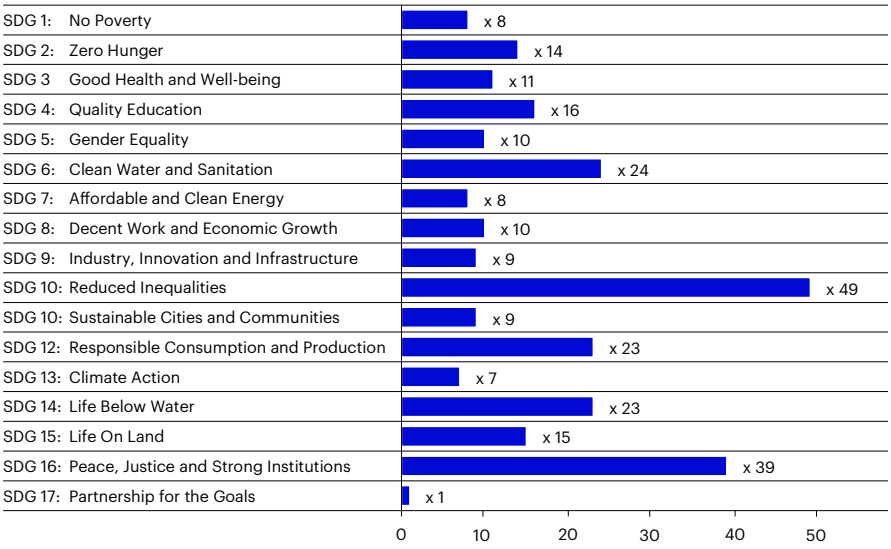
Source: Invesco. Data as of June 2022.

Figure 3
Portfolio structure



Source: Invesco. Data as of June 2022. For illustrative purposes only.

Figure 4
UN SGDs alignment: Increase of revenues relative to benchmark



Source: Invesco. Data as of June 2022.

Multi-factor overlay

As a further step, we add a multi-factor overlay to improve the financial metrics of the final portfolio. To balance S-integration with active factor investing, we apply a strict risk control to achieve a long-term tracking error of 1% vs. the anchor portfolio from step 1. The portfolio can be rebalanced monthly, with limited turnover ensuring up-to-date portfolio characteristics and limited transaction costs.

Bringing it all together

Naturally, given the strong focus on delivering positive social contributions through investment in firms with revenues derived from social activities, there are notable deviations between the model portfolio and equity indices such as the MSCI World. Most notably, relative to market capitalization weighting, the social focus results in less exposure to the IT sector and a strong overweight in healthcare (figure 4). Indeed, healthcare is a key sector in terms of social impact, with 87% of the revenues of listed healthcare firms being aligned with the UN SDGs (relative to 30% for all other sectors). On the other hand, underweights in utilities, and especially energy, are driven by strict ESG filters in the universe definition to ensure that the investment will do no significant harm (DNSH). In addition, in the model portfolio, the share of revenues aligned with the UN SDGs is significantly higher than in the benchmark (figure 5).

Conclusion

Social progress matters – and investors should be aware of this emerging reality. We have shown how to construct a social progress portfolio based not only on exclusions, but also on maximizing portfolio companies' aggregate revenue from socially desirable goods and services. Importantly, a financial overlay does not necessarily compromise the portfolio's social credentials. Indeed, chances are good that social and financial aims can be met at the same time.

“

A financial overlay does not necessarily compromise the portfolio's social credentials.

Notes
1 O'Connor, C., & Labowitz, S. (2017). Measuring human rights performance for investors. The rise of self-expression in investment, 57.).
2 Jayashankar et al. (2015), Mogapi et al. (2019).
3 Lopez-Arceizet et al. (2017).
4 Saul (2022), which is also the basis for the following section of the text.
5 BNP Paribas: The Path to ESG – No Turning Back for Asset Owners and Managers, The ESG Global Survey 2021.
6 See Roberts et al. (2021).

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About the authors

Andrew Gardner
Chief Administrative Officer
Invesco Quantitative Strategies

Andrew Gardner focuses on enhancing engagement with Invesco's global business partners. He is leading the coordination of ESG efforts within equities.

Tim Herzig
Portfolio Manager
Invesco Quantitative Strategies

Tim Herzig is responsible for managing sustainable multi-factor portfolios.

Carsten Rother
Research Analyst
Invesco Quantitative Strategies

Carsten Rother develops quantitative multi-factor models in equities and across asset classes.

Margit Steiner
Senior Quantitative Research Analyst
Invesco Quantitative Strategies

Margit Steiner conducts research on quantitative equity investment strategies. Her current work focuses on natural language processing and machine learning.

Risk-based weighting for better factor investing

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

We've developed a risk-based factor weighting methodology for systematic equity factor investing that can achieve better diversification, improved risk-adjusted return, less drawdown and lower turnover than alternative weighting schemes.

The risk and return profile of factors fluctuates over time. And, although ample empirical studies show that factors such as Quality, Momentum and Value (QMV) can deliver strong and positive risk-adjusted returns in the long run, they do not perform equally well under all market conditions. Periods of drawdowns are inevitable, which is why diversification is key.

Flexible weighting allows the overall multi-factor portfolio to take advantage of good factor performance at different times. With our risk-based factor weighting methodology, we aim to construct QMV portfolios that reflect multi-factor views while controlling for risk and incorporating client constraints.

The factors used are combinations of signals that have survived rigorous academic and practitioner research, and which capture a broad variety of aspects – for example, we use risk-adjusted and

specific momentum for Momentum, cash flow yield and earnings yield for Value, and net external financing and Piotroski's F-Score for Quality. For every factor, we employ a systematic method to group these signals into buckets, where signals in the same bucket capture the same theme. Since the signals under each factor are highly correlated, we apply equal weights to the buckets and then equal weights to signals within each bucket. In the end, the signals in the same bucket will have the same weight. This process helps to avoid domination of individual signals representing one aspect of a given factor.

Figure 1 presents an overview of our process.[1]

> We call our risk-based weighting methodology Equal Risk Contribution (ERC) weighting.

Risk-based factor weighting: ERC, EW and MVO

We call our risk-based weighting methodology Equal Risk Contribution (ERC) weighting. The concept is simple: We aim for equal risk contributions from all factors, using factor covariance as an input.

In that sense, it differs from other commonly used methods, such as Equal Weight (EW) and Mean-Variance Optimization (MVO):

In the EW model, the factors themselves (rather than their risk contributions) are weighted equally. However, since factors can have different levels of risk and correlations with each other, this does not translate into equal risk contributions. We therefore consider ERC to offer better diversification than EW.

The MVO model, on the other hand, estimates expected factor returns and the covariance matrix, and then derives a set of optimal factor weights to maximize the expected risk-adjusted return. Here again, though, we prefer ERC for three reasons:

First, ERC needs only an estimate of the factor covariance matrix (i.e., risk), whereas MVO would also require return estimates. Risk estimates have a smaller estimation error than return estimates, which suffer from well-documented problems.[2] Second, ERC is mathematically equivalent to MVO when factors have equal Sharpe ratios, which is a reasonable assumption for the long run,[3] leading to similar results. Third, under ERC weights, every factor contributes the same amount of risk, so that a factor that performs poorly in a given period will likely have a lesser weight, and thus less impact on the portfolio's volatility. As a result, we should expect a smoother multi-factor return stream with ERC than with MVO.

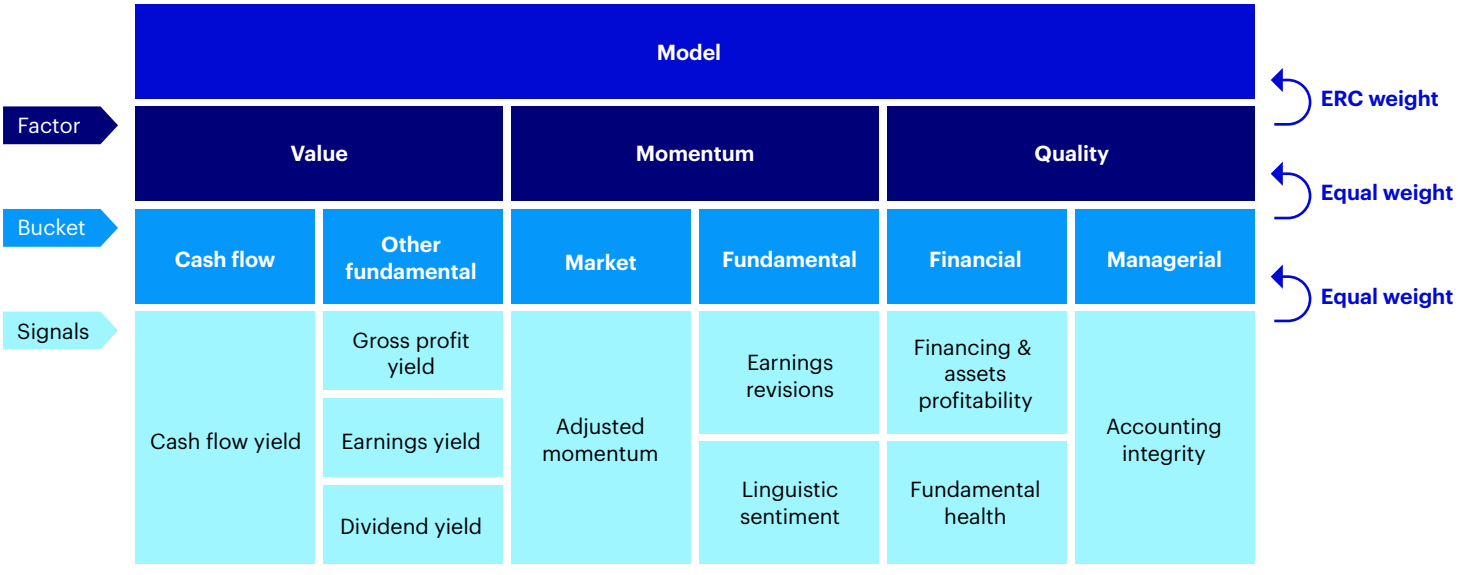
It is worth pointing out that risk-based weighting is a general framework with ERC as the base case. Deviations can be warranted for the right reasons. For example, for ERC to maximize expected risk-adjusted multi-factor returns, the factors must have similar Sharpe ratios – if one factor exhibits stronger risk-adjusted performance than the others, we should allocate more 'risk budget' to that factor. Risk-based weighting is a flexible framework that can accommodate more than just ERC, as we will show.[4]

Two examples

We now provide two examples to illustrate risk-based factor weighting and compare the results with those of the two other methods (EW and MVO).

In the first example, we combine QMV factors into multi-factor portfolios with ERC, EW and MVO weights on a sample of US large cap stocks from December 1997 to June 2022. We neutralize all factor portfolios and multi-factor portfolios by industry and market, taking a simple empirical average of the trailing 12-month returns as the estimate of expected

Figure 1
From signals to factors, and from factors to models



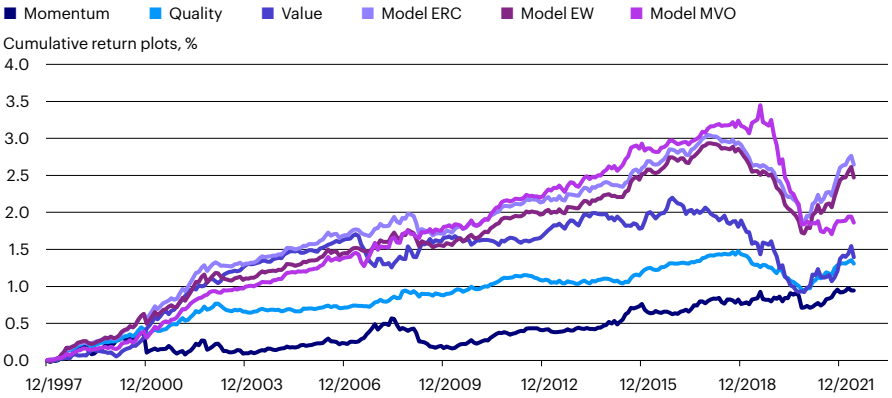
Source: Invesco.

Table 1
Simulated performance and risk metrics of a US large cap model portfolio

	Quality	Momentum	Value	ERC	EW	MVO
Return p.a. (%)	3.47	2.75	3.63	5.42	5.21	4.39
Standard Deviation p.a. (%)	4.68	8.71	7.47	5.59	6.08	6.28
Sharpe Ratio	0.74	0.32	0.49	0.97	0.86	0.70
Max. Drawdown (%)	-21.5	-25.8	-40.0	-29.0	-31.0	-39.2
Downside Deviation (MAR=0) (%)	2.79	8.30	4.98	3.72	4.27	5.56
Two-way Turnover (%)	41.5	80.8	50.0	61.6	62.0	74.2

US large caps as represented by the largest 1000 plus market capitalization stocks in the US. MAR (Minimum Accepted Return) = 0%: downside deviation is based on periods with returns below 0%.
Source: Invesco. Based on data from December 1997 to June 2022. **The figures refer to simulated past performance, which is not a reliable indicator of future performance.**

Figure 2
Simulated cumulative factor and model returns of a US large cap model portfolio



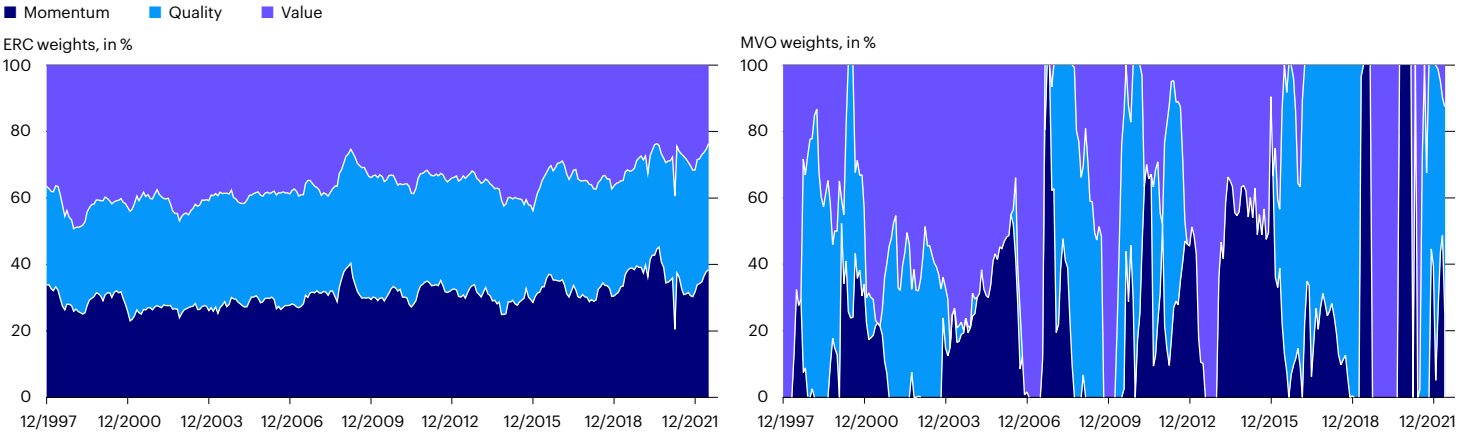
US large caps as represented by the largest 1000 plus market capitalization stocks in the US EW factor weights are not shown since they are 1/3 for every factor throughout.
Source: Invesco. Data from December 1997 to June 2022. **The figures refer to simulated past performance, which is not a reliable indicator of future performance.**

> In our example, ERC produces the highest Sharpe ratio and lowest risk, downside deviation and maximum drawdown. ERC has better diversification capabilities.

returns for MVO. Table 1 summarizes the performance and risk metrics of the factor and multi-factor portfolios; figure 2 plots their cumulative returns.

As expected, each of the three QMV factors can deliver meaningful risk-adjusted returns. When combining them into multi-factor portfolios, the diversification benefits are evident regardless of the weighting method. All versions of the multi-factor portfolio can achieve comparable, if not higher, Sharpe ratios than stand-alone factors. In our example, ERC produces the highest Sharpe ratio and lowest risk, downside deviation and maximum drawdown. This suggests that ERC has better diversification capabilities.

Figure 2
Simulated cumulative factor and model returns of a US large cap model portfolio



US Large Caps as represented by the largest 1000 plus market capitalization stocks in the US. EW factor weights are not shown since they are 1/3 for every factor throughout.
Source: Invesco. Data from December 1997 to June 2022. **The figures refer to simulated past performance, which is not a reliable indicator of future performance.**

“

The momentum-tilted risk-based weighting produces better risk-adjusted returns.

A closer look at the weights of ERC, EW and MVO could be helpful in understanding the results. Figure 3 shows the time series of ERC and MVO factor weights (in the case of EW, all weights are 1/3). We can make three observations: First, the ERC factor weights, though displaying some variation, are fairly stable over time. This means that ERC weights achieve diversification not only in the risk space (the factor risk contributions are equal by construction), but also in nominal terms – whereas the risk contributions of the constant EW factor weights can vary considerably. Second, MVO weights are much more volatile over time. This contributes to the higher turnover in table 1 (74.2% vs. 61.6% for ERC). Third, MVO weights are also much more concentrated, and in many time periods 100% of the weighting is on a single factor (e.g., 100% weight on the Value factor in December 2019). This illustrates the classic concentration problem of mean-variance optimization, resulting from noisy empirical estimates of expected return and risk. Overall, this example shows that ERC is a preferred weighting method compared to EW and MVO.

In the second example, we compare a standard ERC weighting against a modified concept that overweights the risk contribution of certain factors when this appears justified. As an example, we take the Australian ASX 300 universe from November 2000 to May 2022. As table 2 shows, the risk-adjusted return is markedly higher for the Momentum factor than for the Quality and Value factors. Thus, it may be reasonable to allocate a large part of the risk budget to Momentum. For simplicity, we allocate 50% of the risk contribution to Momentum, equally dividing the remaining risk to Quality and Value. Both table 2 and figure 4 show that, compared to ERC, the momentum-tilted risk-based weighting produces better risk-adjusted returns and comparable downside risk.

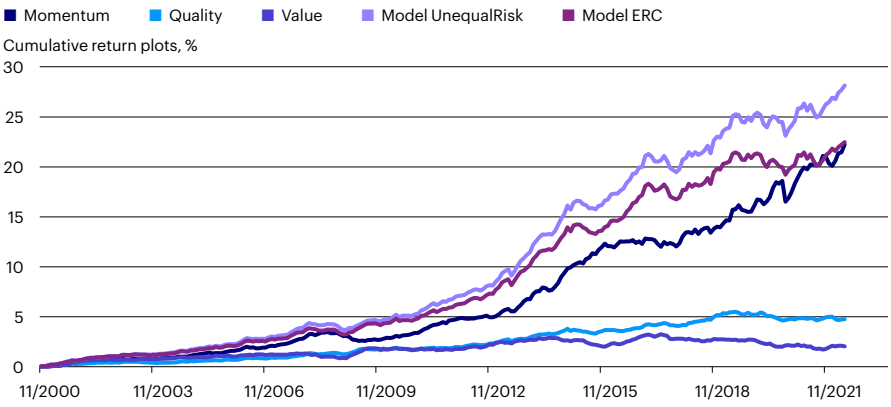
This example illustrates that our risk-based weighting is a flexible framework that can accommodate more than ERC. However, due to the difficulty in forecasting returns, it would be presumptuous to take the differences in Sharpe ratio as absolute. We should be cautious about allocating unequal risk budgets to the factors, granting exception only when there is strong conviction and empirical support.

Table 2
Performance and risk metrics of an Australian large cap model portfolio

	Quality	Momentum	Value	ERC	Unequal Risk Portfolio
Return p.a. (%)	8.44	15.69	5.29	15.74	16.91
Standard Deviation p.a. (%)	7.27	8.89	9.65	8.21	8.24
Sharpe Ratio	1.16	1.77	0.55	1.92	2.05
Max. Drawdown (%)	-13.1	-20.0	-36.3	-13.5	-12.8
Downside Deviation (MAR=0) (%)	3.85	5.98	5.65	4.31	4.43
Two-way Turnover (%)	42.6	97.6	48.7	70.7	79.0

Australian Large Caps as represented by the largest 300 market capitalization stocks traded on ASX. In the unequal risk portfolio, 50% of the risk budget is allocated to Momentum, with 25% each to Quality and Value. MAR (Minimum Accepted Return) = 0%: downside deviation is based on periods with returns below 0%.
Source: Invesco. Based on data from November 2000 to May 2022. **The figures refer to simulated past performance, which is not a reliable indicator of future performance.**

Figure 4
Simulated cumulative factor and model returns of an Australian large cap model portfolio



Australian Large Caps as represented by the ASX 300. MAR (Minimum Accepted Return) = 0%: downside deviation is based on periods with returns below 0%.
Source: Invesco. Based on data from November 2000 to May 2022. **The figures refer to simulated past performance, which is not a reliable indicator of future performance.**

Conclusion

We have explored how a risk-based weighting scheme can achieve factor diversification and harvest factor premia. In our multi-factor portfolio examples, the risk-based weighting (with ERC as the baseline case) produced better simulated performance than stand-alone factors and other weighting schemes.

Appendix: Mathematical definition of ERC and risk contribution

The risk of a portfolio can be expressed as:

$$\sigma(w) = \sqrt{w \sum w}$$

where w is the vector of portfolio asset holdings and Σ is the asset covariance matrix. In our setting, 'asset' means the QMV factors, and the overall portfolio is constructed from allocating to these three factors.

The above expression of risk can also be written as:

$$\sigma(w) = \sum_i w_i \frac{\partial \sigma(w)}{\partial w_i}$$

In other words, the total risk of a portfolio can be expressed as the sum of the components,

$$w_i \frac{\partial \sigma(w)}{\partial w_i}$$

over i. These components are called risk contributions (in our setting, 'factor risk contributions').

To explain ERC, let $w_i \frac{\partial \sigma(w)}{\partial w_i}$

ERC sets $\sigma_i = \sigma_j$ for all assets i and j, i.e., all assets (factors) contribute the same amount of risk. This can be further simplified to:

$$w_i (\sum w)_i = w_j (\sum w)_j$$

From here, different numeric algorithms can be used to solve this problem numerically.

One last note here regarding Σ: This is the factor-level covariance matrix, which can be estimated in different ways. We build this using the stock-level covariance matrix from the risk model and the factor portfolio holdings in each period; hence, this matrix is time-varying. As a result, our ERC factor weights also change from time to time, as do the factor risk contributions.

Notes

1 For details of our portfolio construction methodology, see Invesco Quantitative Strategies (2022).
2 See Merton (1980).
3 Theoretically, the mathematical equivalence also requires equal pairwise correlations between the factors, but this assumption has less impact compared to the equal IR assumption.
4 For technical background, we refer to the Appendix at the end of this article.

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.

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About the authors

Tarun Gupta, Ph.D.
Managing Director, Global Head of Research & Investment Technology

Tarun Gupta leads a team that focuses on innovative research to enhance quantitative research strategies and spearhead development of investment technology. In addition, Tarun is leading the build-out of customized and tax managed equity capabilities to advance the firm's efforts in the direct-indexing space.

Jerry Sun, Ph.D.
Senior Researcher at Invesco Systematic and Factor Investing

Jerry Sun focuses on developing quantitative models and processes to improve the performance of SFI equity strategies.

Hao Zou, Ph.D.
Research Analyst at Invesco Systematic and Factor Investing

Hao Zou conducts quantitative research on alpha factors, portfolio construction, transaction cost and risk modeling.

Dissecting the performance of low volatility investing

By Bernhard Breloer, Ph.D., Martin Kolrep, Ph.D., Thorsten Paarmann and Viorel Roscovan, Ph.D.

A low volatility portfolio aims to exploit the fact that, in the long run, low-risk stocks yield higher risk-adjusted returns than higher-risk stocks. But the low volatility portfolio's lower beta – via the allocation effect – may drag down returns at times. We dissect the performance into the low volatility anomaly and the allocation effect, analyze the relative importance of the two and show ways to minimize the allocation effect's drag on performance.

Low volatility strategies can reduce active risk and thus enhance a portfolio's risk-adjusted return. The risk reduction comes mostly through asset allocation, whereas return enhancement comes through exposure to the low volatility anomaly – both are inherent parts of low volatility investing.

Taking higher-risk stocks as the market portfolio, the return of a low volatility portfolio (following Markowitz, 1952) can be written as:

$$(1)\quad r_{LowVol} - r_f = \alpha + \beta_{LowVol} \times (r_{Mkt} - r_f) + \varepsilon$$

where r_{LowVol} is the return of the low volatility portfolio, β_{LowVol} is its beta relative to the market portfolio, r_{Mkt} is the return of the market portfolio, r_f is the risk-free rate, α is the abnormal return earned by the low volatility strategy (hence 'low volatility anomaly') and ε is a mean zero i.i.d. residual. If the return on the low volatility anomaly is greater than zero (i.e., α is economically positive and statistically significant), equation (1) can be rewritten in expectations as:

$$(2)\quad \alpha = r_{LowVol} - \beta_{LowVol} \times r_{Mkt} - (1 - \beta_{LowVol}) \times r_f$$

Equation (2) suggests that, to earn the low volatility anomaly, the market portfolio needs to be levered down to the risk level of the low volatility portfolio by allocating a portion to the risk-free rate. Looking at the active return of a low volatility portfolio, $r_{LowVol} - r_{Mkt}$, we can use (2) for the following decomposition:

$$(3)\quad r_{LowVol} - r_{Mkt} = \underbrace{r_{LowVol} - \beta_{LowVol} \times r_{Mkt} - (1 - \beta_{LowVol}) \times r_f}_{\text{Low volatility anomaly}} + \underbrace{(r_{Mkt} - r_f) \times (\beta_{LowVol} - 1)}_{\text{Allocation effect}}$$

with the first part defining the low volatility anomaly as in (2) and the last term defining the allocation effect. The low volatility anomaly is thus the excess return earned against the market, adjusted to the risk level of the low volatility portfolio. On the opposite side, the allocation effect is a pure beta effect and determined to be positive during negative excess market returns ($r_{Mkt} - r_f < 0$) – and vice versa.

Performance of low volatility portfolios

We now analyze the behavior of both sub-components of low volatility investing, the asset allocation effect and the low

volatility anomaly. We consider Global Developed, US, European and Emerging Market samples using data from January 2001 to December 2021. For each region, we calculate the monthly returns of low volatility portfolios.[1] Table 1 contains descriptive statistics of low volatility portfolios and the corresponding market portfolios.

It shows some well-documented characteristics of low volatility portfolios: lower market beta, higher Sharpe ratios and a significant drawdown reduction compared to the respective market portfolios. Note that the Global and US portfolios exhibit lower betas compared to the European and Emerging Market portfolios. This could be due to differences in the industry structure and the general breadth of the investment universe. A lower beta will have a stronger impact on the allocation component when market movements are more extreme.

In the sample period, our low volatility portfolios have outperformed the market even before risk adjustment, delivering between 100 and 300 bps of excess returns on average per year, depending on the region. However, splitting the full observation period into three 7-year sub-periods reveals that the performance of low volatility portfolios differs

Table 1
Performance characteristics of low volatility and market portfolios

	Global		US		Europe		Emerging Markets	
	LowVol	Market	LowVol	Market	LowVol	Market	LowVol	Market
Return (ann.)	8.3%	7.3%	9.2%	8.1%	6.6%	4.4%	11.6%	9.4%
Standard Deviation	10.7%	15.4%	11.1%	14.9%	12.3%	15.3%	17.0%	21.2%
Sharpe Ratio	0.63	0.37	0.69	0.44	0.41	0.19	0.59	0.37
Max Drawdown	-38.5%	-53.6%	-36.6%	-50.8%	-46.4%	-53.6%	-51.8%	-61.3%
Tracking Error	7.6%		7.0%		5.4%		6.1%	
Beta	0.62		0.66		0.76		0.78	

Source: Invesco. Sample period from January 2001 to December 2021. Net returns of Global, US and Emerging Markets are in USD. European returns are in EUR. **Past performance is not a guarantee of future results under any performance.**

Table 2
Descriptive statistics of low volatility and market portfolios (sub-periods analysis)

	Global		US		Europe		Emerging Markets	
	LowVol	Market	LowVol	Market	LowVol	Market	LowVol	Market
Panel A: January 2001 – December 2007								
Return (ann.)	9.8%	6.1%	7.8%	3.2%	6.0%	2.8%	25.3%	23.9%
Standard Deviation	9.6%	13.2%	9.7%	13.3%	12.6%	15.4%	17.0%	20.2%
Sharpe Ratio	0.70	0.23	0.48	0.01	0.23	-0.02	1.31	1.03
Max Drawdown	-22.0%	-38.7%	-20.9%	-38.8%	-38.5%	-49.7%	-29.5%	-32.7%
Tracking Error	6.5%		6.5%		5.5%		5.3%	
Beta	0.65		0.64		0.77		0.82	
Panel B: January 2008 – December 2014								
Return	5.6%	4.0%	8.9%	7.3%	5.2%	2.5%	4.9%	-0.9%
Standard Deviation	12.2%	18.3%	12.1%	16.8%	12.5%	16.2%	19.5%	25.3%
Sharpe Ratio	0.31	0.11	0.59	0.33	0.27	0.04	0.15	-0.11
Max Drawdown	-34.8%	-49.7%	-33.0%	-46.2%	-35.5%	-45.2%	-49.8%	-57.8%
Tracking Error	8.9%		7.8%		5.5%		7.6%	
Beta	0.6		0.65		0.74		0.75	
Panel C: January 2015 – December 2021								
Return	9.7%	12.2%	10.8%	14.2%	8.6%	8.2%	5.8%	6.8%
Standard Deviation	10.3%	14.3%	11.4%	14.4%	12.0%	14.5%	13.7%	16.9%
Sharpe Ratio	0.96	0.86	0.97	1.00	0.74	0.58	0.44	0.41
Max Drawdown	-16.0%	-20.9%	-18.0%	-19.6%	-18.9%	-22.4%	-24.3%	-27.7%
Tracking Error	7.2%		6.6%		5.4%		5.1%	
Beta	0.63		0.71		0.77		0.78	

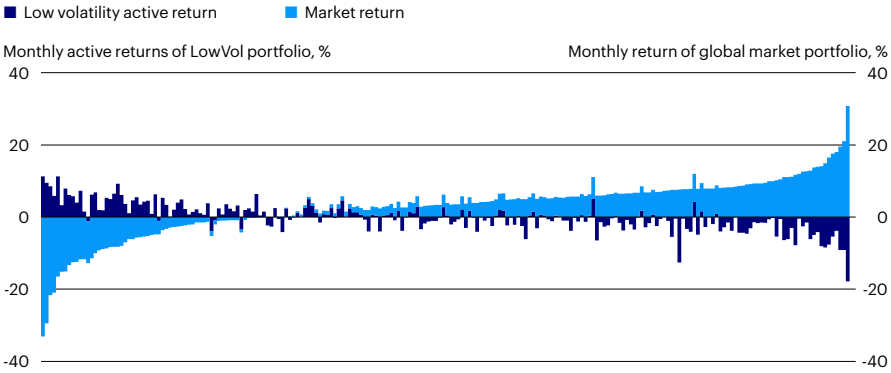
Source: Invesco. Sample period from January 2001 to December 2021. Panel A shows results for the sub-period January 2001 to December 2007. Panel B shows results for the sub-period January 2008 to December 2014. Panel C shows results for the sub-period January 2015 to December 2021. Net returns of Global, US and Emerging Markets are in USD. European returns are in EUR. **Past performance is not a guarantee of future results under any performance.**

significantly throughout the last two decades (see table 2). In the first two periods, from January 2001 to December 2007 (panel A) and January 2008 to December 2014 (panel B), low volatility portfolios delivered above market returns. Note that expecting market-like returns on average requires, by default, accepting some periods of returns below market, as we observe for the last sub-period from January 2015 to December 2021 (panel C) for most portfolios. Still, all portfolios, except for the US, show higher Sharpe ratios than the market. In summary, the performance of low volatility portfolios can vary over time. Thus, the weaker performance in recent years should be seen neither as an indicator of future returns nor as evidence for the low volatility premium having broken down.[2]

Dissecting low volatility portfolios into the low volatility anomaly and allocation effect

How does the performance pattern of a low volatility portfolio appear in up and down markets? In figure 1, we show the active 3-month return of a global low

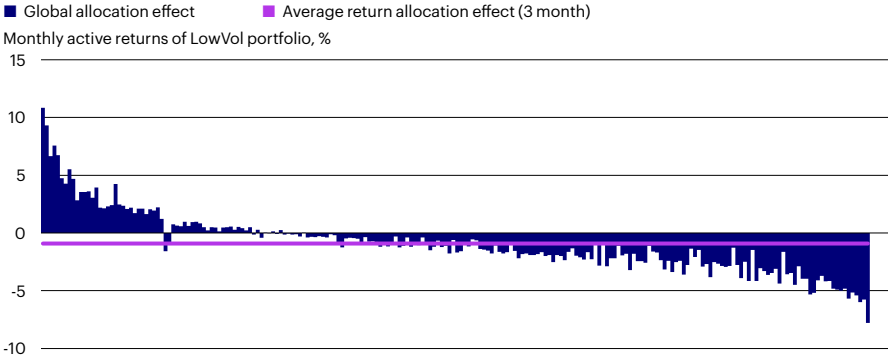
Figure 1
Active return of low volatility portfolio sorted by market portfolio performance



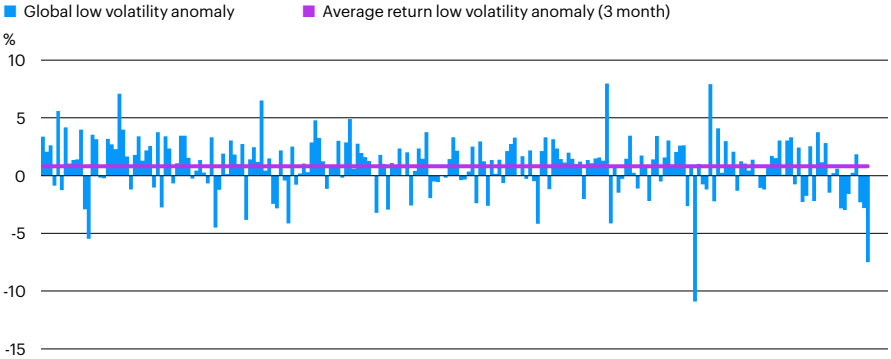
Source: Invesco. Data period: January 2001 to December 2021. The chart shows the monthly active returns of an investable low volatility portfolio, sorted by market portfolio returns from negative to positive (left to right). We use 3-month rolling returns for both the low volatility and market portfolio; net returns for global region. **Past performance is not a guarantee of future results under any performance.**

Figure 2
Global allocation effect and low volatility anomaly sorted by 3-month rolling market returns

Panel A: Global allocation effect



Panel B: Global low volatility anomaly



Source: Invesco. Period: January 2004 to December 2021. The above charts show returns of the allocation effect (panel A) and low volatility anomaly (panel B) of the global low volatility portfolio sorted by monthly market returns (negative to positive). **Past performance is not a guarantee of future results under any performance.**

volatility portfolio, sorted by market returns. We can observe a(n) (a)symmetrical performance pattern – higher active returns in downward markets, with the tendency to lag in more bullish environments.

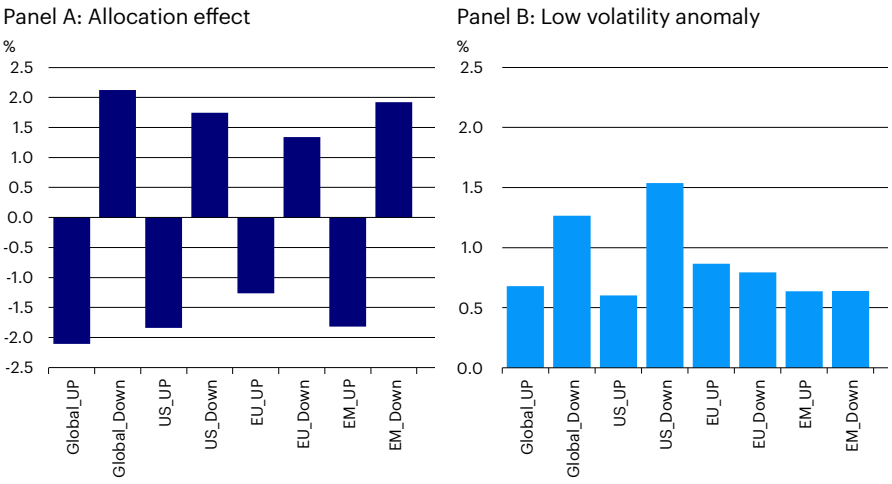
Next, we examine the allocation effect and low volatility anomaly. For estimating the β_{LowVol}, we use a 36-month rolling windows, which effectively shortens the sample period by three years.

Figure 2 shows the returns of the two return components: Clearly, the allocation effect follows a pattern (panel A), while the low volatility anomaly outperforms independent of the market environment (panel B).[3] Accordingly, the long-term return contribution of the low volatility anomaly is positive – yielding 28 bps per month.

In figure 3, we present similar results for all regional portfolios, showing the average returns of the allocation effect (panel A) and the low volatility anomaly (panel B) during positive and negative markets. Again, the allocation effect reveals a symmetrical performance pattern, while the low volatility anomaly delivers positive performance during up and down markets alike. In aggregate, the performance of the low volatility strategy is stronger during declining markets for the Global, US and Emerging Market portfolio. Interestingly, the lower beta of the Global and US portfolio goes hand in hand with a higher low volatility premium in down markets.

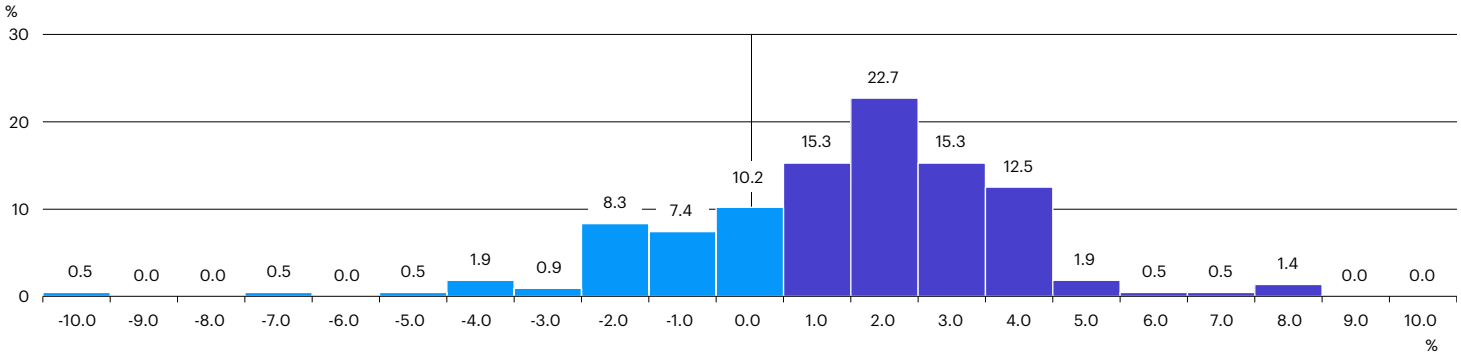
The above results imply a skewed return distribution for the low volatility anomaly. For the global portfolio, we plot the histograms based on the three-month rolling returns of the low volatility anomaly in figure 4 below. As assumed, the low volatility anomaly exhibits a clear right-skewed return pattern, i.e., the likelihood of yielding positive returns (>0) measures roughly 70%. In turn, we have to accept countervailing movements of the low volatility anomaly during both up and down markets and the very rare events of larger negative return contributions (compare panel B in figure 2).[4]

Figure 3
The allocation effect and low volatility anomaly – global evidence during up and down markets (3-month rolling returns)



Source: Invesco. Period: January 2004 to December 2021. The above charts show the monthly average returns of the allocation effect (panel A) and low volatility anomaly (panel B) of the Global, US, European and Emerging Market low volatility portfolios. "Up" ("Down") represents performance during positive (negative) returns of the respective market portfolio. **Past performance is not a guarantee of future results under any performance.**

Figure 4
Distribution of the global low volatility anomaly based on rolling 3-month returns



Source: Invesco. Sample period from January 2004 to December 2021. **Past performance is not a guarantee of future results under any performance.**

Table 3
Breakeven low volatility anomaly returns in the context of expected market premium and historic returns

	Global	US	Europe	Emerging Markets
Panel A: 2005 – 2021				
Breakeven return	3.4%	3.3%	1.7%	1.8%
Breakeven likelihood	*57.6%*	*61.0%*	*69.8%*	*48.8%*
Panel B: 2008 – 2014				
Breakeven return	1.6%	2.6%	0.7%	-0.2%
Breakeven likelihood	*71.4%*	*59.5%*	*78.6%*	*78.6%*
Panel C: 2015 – 2021				
Breakeven return	4.5%	4.2%	1.9%	1.5%
Breakeven likelihood	*39.3%*	*41.7%*	*58.3%*	*31.0%*

Source: Invesco. Period: January 2005 to December 2021. The table shows breakeven returns based on the beta of the low volatility portfolio and the market return during the respective periods. Breakeven likelihoods represent the possibility of achieving the breakeven return given the historic 12-month returns of a low volatility portfolio within the given period. **Past performance is not a guarantee of future results under any performance.**

Long-term vs. short-term performance: What to expect of the low volatility anomaly

Low volatility strategies have performed below their long-term trend in recent years. Most of the time, the low volatility anomaly did not outweigh the negative impact of the allocation effect in strongly up-trending markets. Hence, we could ask what the breakeven return is that the low volatility anomaly must achieve to cope with the market return? To answer this, we look at the historical returns of the low volatility anomaly and calculate, for each region, the required return to compensate for the allocation effect. We consider three different time periods that impose different market premiums as well as betas of the low volatility portfolios against the market.[5] Accordingly, the hurdle set by the resulting allocation effect will be higher or lower. Moreover, we calculate the likelihood of the low volatility anomaly achieving at least the breakeven return based on (overlapping) 12-month returns in each period ('breakeven likelihood').[6] In table 3, we present our results in panel A, B and C, respectively.

As we can observe for the period from January 2005 to December 2021 (panel A), the required breakeven returns for each region range between 1.7% and 3.4%. Given the historical returns of the low volatility anomaly, the likelihood of market-like returns is around 60% for the Global region and the US, 70% for Europe, and 50% for the Emerging Markets. As shown in panels B and C, the breakeven return varies with the market environment. As such, for the period with lower market returns (panel B), a low volatility strategy should have a higher likelihood of compensating the allocation effect. Thus, it is less than surprising that a pure low volatility strategy will have a more difficult time compensating a larger negative allocation effect in very bullish environments (panel C).[7, 8]

Investing in the low volatility anomaly without allocation effect

Having examined the drivers of the low volatility portfolio, the question is how to circumvent the performance drag of the allocation effect while still profiting from the low volatility anomaly? Once we are willing to give up protection and have access to leverage via equity futures, we can lever up a low volatility portfolio to the market risk level (beta = 1) and expect a higher participation in up markets. The levered low volatility portfolio is defined as:

$$(4)\quad r_{LowVol^+} = \frac{r_{LowVol}}{\beta_{LowVol}} - (\beta_{LowVol} - 1) \times r_f$$

Such a portfolio should exhibit higher expected returns at the cost of increased volatility, leverage and marketequivalent drawdowns, as shown in table 4.

Table 4
Comparison of low volatility vs. levered low volatility$^+$ portfolios

	Global			US			Europe			Emerging Markets		
	LowVol	LowVol$^+$	Market	LowVol	LowVol$^+$	Market	LowVol	LowVol$^+$	Market	LowVol	LowVol$^+$	Market
Return	9.7%	16.4%	9.3%	10.6%	17.1%	10.4%	9.2%	13.0%	7.4%	10.7%	13.2%	8.9%
Standard Deviation	10.5%	16.4%	15.0%	10.8%	15.7%	14.2%	11.4%	14.5%	14.1%	16.6%	21.2%	20.8%
Sharpe Ratio	0.81	0.93	0.54	0.87	1.01	0.65	0.70	0.81	0.44	0.58	0.56	0.37
Max Drawdown	-38.5%	-48.4%	-53.6%	-36.6%	-44.4%	-50.8%	-46.4%	-52.1%	-53.6%	-51.8%	-61.5%	-61.3%
Tracking Error	7.3%	8.0%		6.6%	7.5%		5.0%	5.0%		6.1%	5.1%	
Beta	0.63	0.96		0.68	0.97		0.76	0.97		0.77	0.99	

Source: Invesco. Sample period from January 2004 to December 2021. **Past performance is not a guarantee of future results under any performance.**

Conclusion

The active return of a low volatility portfolio can be decomposed into the low volatility anomaly and an allocation effect. The low volatility anomaly potentially delivers positive performance during bull and bear markets. On the other hand, the allocation effect is a function of market performance and will drag down performance if there is a positive market drift. In the long run, the return of the low volatility anomaly can outweigh the drag of the allocation effect with more than 60% likelihood over a one-year period. To avoid the allocation effect and purely invest in the low volatility anomaly, we can lever up a low volatility portfolio.

Notes

1 We use proprietary long-only investable minimum variance portfolios with stringent investment constraints. Stock positions are a function of the daily trading volume of individual stocks, so that we effectively exclude investments in the 30% of stocks expected to be the least liquid in any given month. The one-way turnover of the portfolio is also kept to a minimum, at 30% per year. Finally, we limit country, region, industry and sector exposures to +/-10% relative to the market portfolio and enforce diversification by capping holdings at 1%.

2 We note that, for the low volatility anomaly to dissipate, we should observe structural changes in the market that would alter the foundations of its economic rationale (be it risk-driven, rational or irrational behavior of market participants). To date, we find little evidence that this is the case. Moreover, the low volatility anomaly cannot be explained by other factors and their combinations.

3 Given the definition of both the low volatility anomaly and allocation effect, they are close to being orthogonal, i.e., independent of each other. This is also evidenced by their low correlation pattern, i.e., for the global low volatility portfolio, the correlation between the two effects measures 0.065.

4 During the observation period, the return of the low volatility anomaly was lower than -5% over a three-month period in only 1.4% of cases.

5 As shown in table 2, the market exposure of low volatility portfolios is rather stable on average, and thus of secondary order.

6 Given that we observe only one historical pathway, we run an additional bootstrap simulation resampling the historic returns to create 1,000 alternative paths. We find no significant difference between the average of the simulated series and the historic result.

7 Note that panel B and C in table 3 cover the same time periods as the respective panels in table 2.

8 Note that a given low volatility strategy can be further enhanced by adding pure return-oriented factors like value, quality and momentum to increase the likelihood of market-like returns and outperformance potential.

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About the authors

Bernhard Breloer, Ph.D.
Portfolio Manager
Invesco Quantitative Strategies
In addition to portfolio management, Dr. Breloer focuses on factor investing, portfolio construction and asset allocation, as well as investment communication. He is also involved in the development of client solutions, particularly in the area of multi-asset strategies.

Martin Kolrep, Ph.D.
Senior Portfolio Manager
Invesco Quantitative Strategies
Dr. Kolrep is involved in the development and management of factor-based multi-asset strategies, mainly for institutional clients.

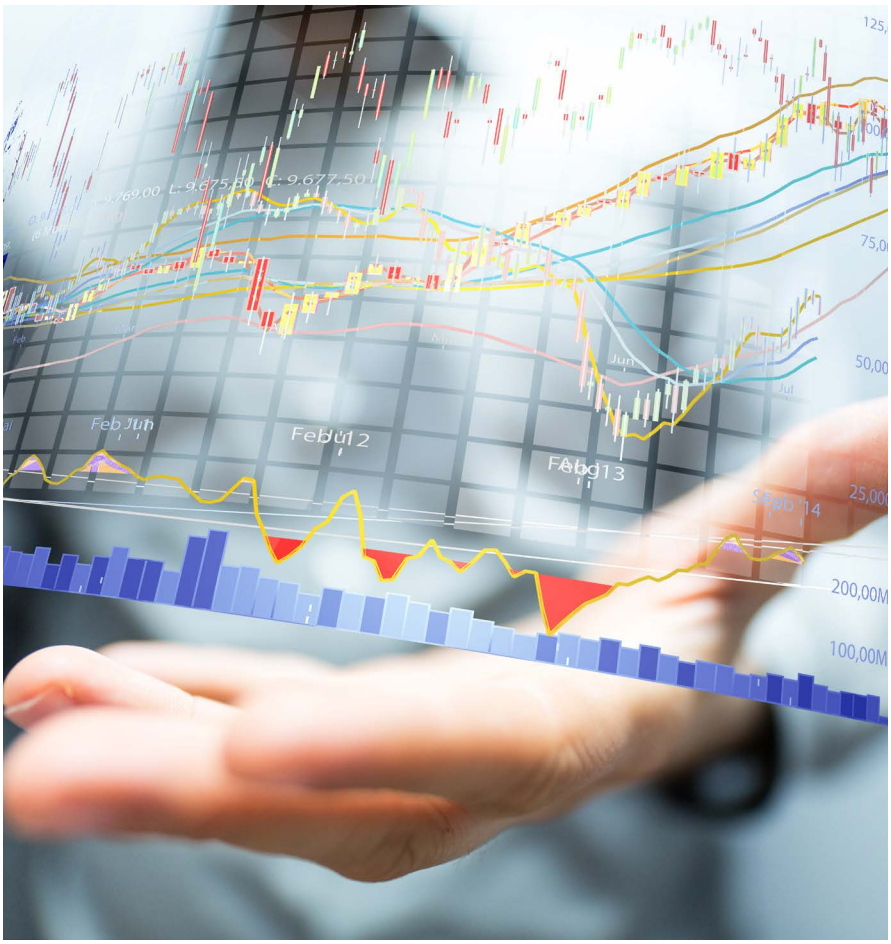
Thorsten Paarmann, CFA
Senior Portfolio Manager
Invesco Quantitative Strategies
Thorsten Paarmann is responsible for the management of European and Global equity portfolios, with a focus on low volatility strategies.

Viorel Roscovan, Ph.D.
Senior Researcher and Director
Invesco Quantitative Strategies
Dr. Roscovan specializes in factor investing research and tailored factor solutions.

Tax-optimized international equity exposure using US-traded securities

By Nikunj Agarwal, Tarun Gupta, Ph.D., and Timur Sahin

We outline a process that allows for tax-optimized international equity exposure while restricting investment to US-listed securities. The process presented produces improved after-tax performance while preserving index-like risk and return characteristics. Additional benefits include high liquidity, transparency, accessibility, and a potentially improved ability to customize portfolios to investor requirements.



A broad swath of US investors consistently lacks effective access to local market foreign equity exposure due to limitations of platforms and custodians or high costs. Moreover, onerous tax-related reporting may deter them from owning foreign ordinaries, even when feasible. The investment challenge for such investors is therefore to design portfolios that provide tax-optimized international exposure while holding only US-listed securities.

To achieve this, we've developed a two-step portfolio construction process: The first step is to create a custom benchmark that closely tracks a selected international index using only US-listed securities. The second step is to apply tax-optimization. This process results in a tax-optimized portfolio that closely tracks the custom benchmark.

Investible securities: ADRs and country ETFs

American Depositary Receipts (ADRs) represent equity shares of non-US companies that are traded in the United States and issued by US depository institutions. For US investors, ADRs provide an alternative that enables direct investment in foreign equities without the burden of currency conversion or foreign settlement procedures. Since all ADRs are traded and treated like any other US security, the commissions, fees, market impact and other transaction costs are also comparable to other US securities – which makes them an excellent, cost-effective choice over foreign holdings.

There are two types of ADRs: sponsored and unsponsored. An ADR of a foreign company is categorized as sponsored when the foreign company has a formal agreement with a depository institution to issue ADRs and provide shareholder services for US investors. However, depository institutions are also able to create unsponsored ADRs for any non-US company without seeking the approval of such company. Unsponsored or sponsored ADRs may be just as liquid as the ordinary shares they represent. Sponsored ADRs typically trade on exchanges, whereas unsponsored ADRs trade primarily over the counter. More than half (by number) of all ADRs are unsponsored, and some large foreign companies have unsponsored ADRs that trade on the OTC Bulletin Board or as 'Pink Sheets'. Yet many unsponsored

Table 1
The ADR universe vs. the MSCI ACWI ex US

	ADR universe			MSCI ACWI ex USA		
	Securities	Market Cap (tn USD)	Weight	Securities	Market Cap (tn USD)	Weight
Developed	284	22.5	47%	937	24.65	70%
Emerging	144	5.3	11%	1410	23.35	30%
Total	428	27.8	58%	2347	48.00	100%

Source: Invesco, as of December 31, 2021.

ADRs are just as liquid as sponsored ADRs that trade on exchanges like NYSE or NASDAQ. ADRs are treated in the same manner as US securities for almost all legal and administrative purposes.

For the remainder of the article, we will focus on a representative international index (MSCI ACWI ex USA) – since it comprises developed as well as emerging markets. This is a market cap weighted index covering large and midsize companies, and includes approximately 2,300 stocks from 22 developed market countries (excluding the US) along with 24 emerging market countries.

The ADR universe consists of all liquid ADRs as well as GDRs[1] that trade in the US and all securities that are dually listed in the US and a foreign country. We start by mapping all foreign securities to their US-traded counterparts. We then screen out all the mapped securities that have low liquidity. This ensures that portfolios are constructed only with liquid securities traded in the United States; table 1 compares the ADR universe with the MSCI ACWI ex US Index.

Although the coverage of ADR universe is incomplete when compared to the MSCI ACWI ex USA Index (≈58% by market cap), as we will show, it is sufficient to construct diversified portfolios with a relatively low tracking error against the underlying foreign index.

Along with ADRs, we also include single-country ETFs in our investment universe. These are also traded in the US, are highly liquid and track underlying country indices.

Portfolio construction

Step 1: Custom benchmark construction

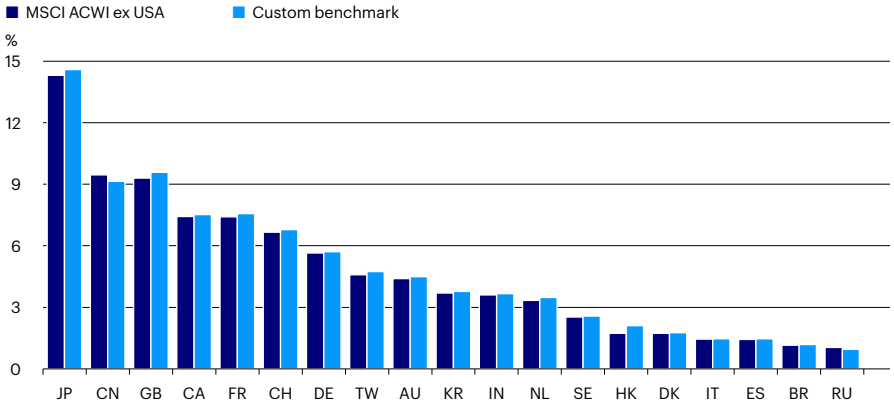
First, we create a custom benchmark. The main goal is to use liquid US-traded securities (ADRs and country ETFs) to obtain risk and return characteristics similar to the underlying index. We employ a rules-based approach rather than pure black-box optimization. Our approach preserves the benefit of low tracking error relative to the underlying index while providing greater transparency. We use liquid ADRs when available and add missing country exposure (compared with underlying index) via liquid country ETFs.

> We employ a rules-based approach rather than pure black-box optimization.

Figure 1 compares country exposures of the underlying MSCI ACWI ex USA Index with those of the custom benchmark using only ADRs and country ETFs. For simplicity, only the top 20 countries are shown. Figure 2 compares the trailing 12-month median dollar volume traded.

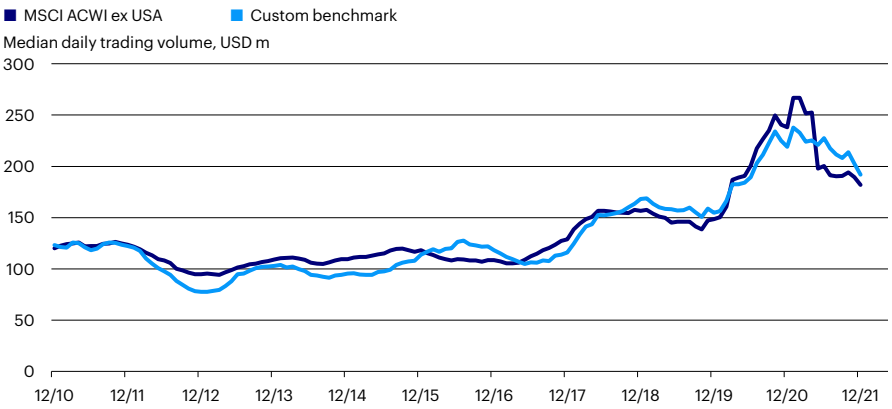
Our analysis suggests that the custom benchmark exhibits between 1.5% to 2.5% tracking error (ex post) relative to the underlying MSCI ACWI ex USA Index (table 2). For comparison: the tracking error of a MSCI ACWI ex USA ETF (using distributed market prices and dividends) exhibits a similar tracking error of between 1.5% to 2%

Figure 1
Country exposures in comparison



Country codes: JP = Japan; CN = China; GB = Great Britain; CA = Canada; FR = France; CH = Switzerland; DE = Germany; TW = Taiwan; AU = Australia; KR = South Korea; IN = India; NL = Netherlands; SE = Sweden; HK = Hong Kong; DK = Denmark; IT = Italy; ES = Spain; BR = Brasilia; RU = Russia.
Source: Invesco, as of December 31, 2021.

Figure 2
Liquidity in comparison



Source: Invesco, as of December 31, 2021.

Table 2
Tracking errors in comparison

Portfolio	Benchmark	Tracking error p.a.
MSCI ACWI ex USA ADR	MSCI ACWI ex USA	1.5% – 2.5%
MSCI ACWI ex USA ETF	MSCI ACWI ex USA	1.5% – 2.0%
MSCI ACWI ex USA ETF	MSCI ACWI ex USA ADR	1.0% – 1.5%

Source: Invesco, as of December 31, 2021.

(ex post). The results show that the custom benchmark using only liquid ADRs and country ETFs tracks the index quite well.

On the other hand, when investing only in US-traded securities, some inherent tracking error is difficult to avoid. This is due to (1) asynchronous markets across the globe – the underlying index values securities at the local market close, while the ADRs/ETFs within the custom benchmark are generally valued at the US market close – and (2) diverging dividend dates. Moreover, the country ETFs usually pay dividends only semi-annually, while that may not necessarily be true for the respective ETF constituents. Finally, there is always some variance in tracking of ADRs relative to the underlying local security due to market imperfections.

“

Some inherent tracking error is difficult to avoid.

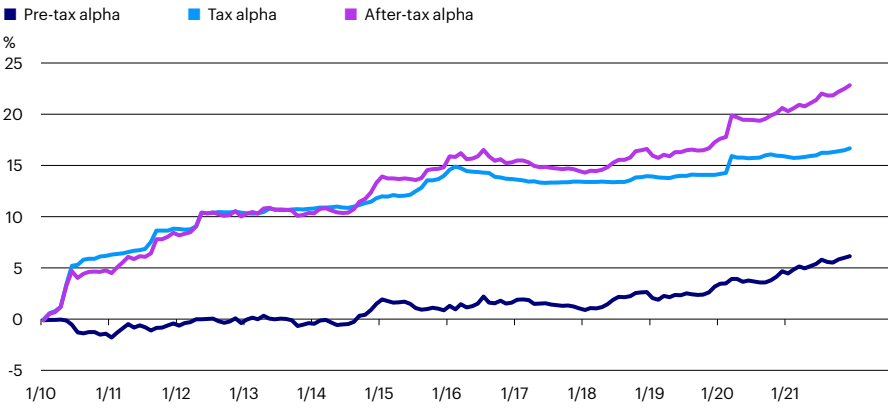
Step 2: Tax optimization

We now apply tax optimization using our custom benchmark. The final portfolio has the potential to generate tax alpha while maintaining risk and return similar to the underlying non-US index.

The objective of tax optimization is to minimize net tax gains subject to risk constraints.[2] In doing so, we observe that the optimization guides the portfolio to actively realize losses – which are tax credits that directly contribute to incremental post-tax returns – while preserving the pre-tax characteristics of the portfolio.

Figure 3 compares the pre-tax alpha, tax alpha and after-tax alpha for the tax-optimized portfolio relative to the

Figure 3
Alpha versus the custom benchmark



Source: Invesco. Data period: January 29, 2010 – December 31, 2021. There is no guarantee that the hypothetical performance will be achieved in the future.

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The tax-optimized model portfolio earns a tax alpha of 1.7% relative to the MSCI ACWI ex USA Index.

custom benchmark. Hypothetical performance shown is for the period from January 2010 to December 2021 and includes transaction costs. Portfolios are rebalanced monthly with the set objective function subject to risk constraints.

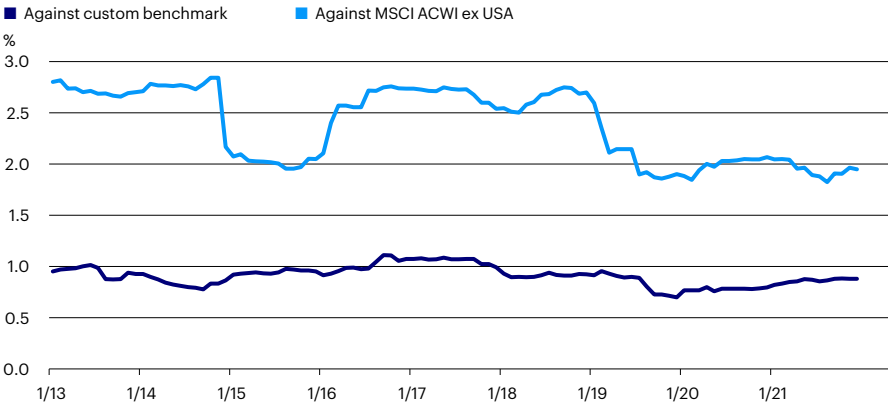
The pre-tax alpha is low (close to zero) for most of the sample period but ends up slightly positive in the end. Although this is a positive result, we do not explicitly target any pre-tax performance and expect it to moderate over time. Our ex-ante expectation for the long-term pre-tax alpha is thus zero. This is by construction, since the tax-optimized portfolio aims to track the custom benchmark (with a target tracking error of 1%) with similar expectations for pre-tax performance. However, we do observe a positive and persistent tax alpha, as expected, of 1.7% p.a. relative to the index.

The tax-optimized portfolio realizes 1% tracking error (targeted) relative to the custom benchmark. We also find that the tax-optimized portfolio has a similar tracking error to the MSCI ACWI ex USA Index as the custom benchmark – between 1.5% to 2.5%. Table 3 summarizes the performance of the tax-optimized portfolio and the MSCI ACWI ex USA Index.

The tax-optimized model portfolio earns a tax alpha of 1.7% relative to the MSCI ACWI ex USA Index. This positive tax alpha directly translates to favorable post-tax performance, exhibiting 1.7% total after-tax alpha (= tax alpha + pre-tax alpha).

Next, we compare pre-tax and post-tax returns of portfolio and index: As figure 5 shows, the portfolio performs similar to the index on a pre-tax basis. However, figure 6 reveals that the tax-optimized

Figure 4
Tracking error of the tax-optimized portfolio



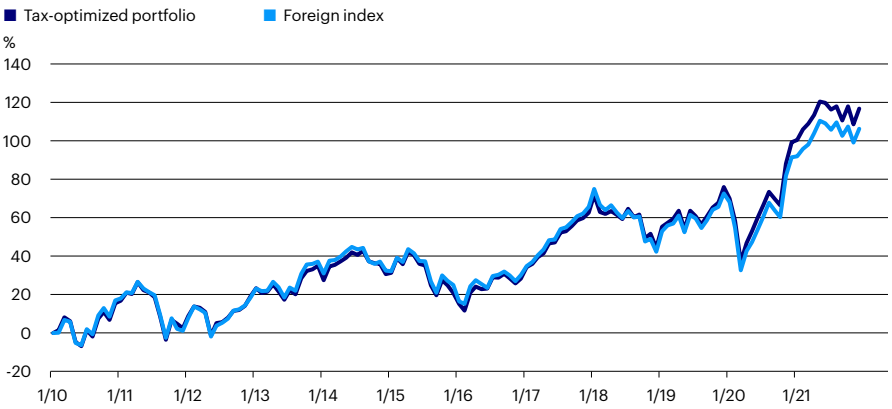
Source: Invesco, as of December 31, 2021.

Table 3
The simulated tax-optimized portfolio vs. MSCI ACWI ex USA

	Tax-optimized portfolio [Active against foreign Index]	MSCI ACWI ex USA
Capital gains	3.70%	3.50%
Dividends	3.00%	3.00%
Gross performance	**6.70% [+0.2%]**	**6.50%**
Commissions	-0.10%	0.00%
Impact	-0.10%	0.00%
Net performance	**6.50% [0.00%]**	**6.50%**
Dividend tax – unqualified	-0.20%	-1.40%
Dividend tax – qualified	-1.00%	0.00%
Capital gains tax – short term	1.80%	0.00%
Capital gains tax – long term	-0.10%	0.20%
Total tax	**0.50% [+1.7%]**	**-1.20%**
Net-of-tax performance	**7.00% [+1.7%]**	**5.30%**

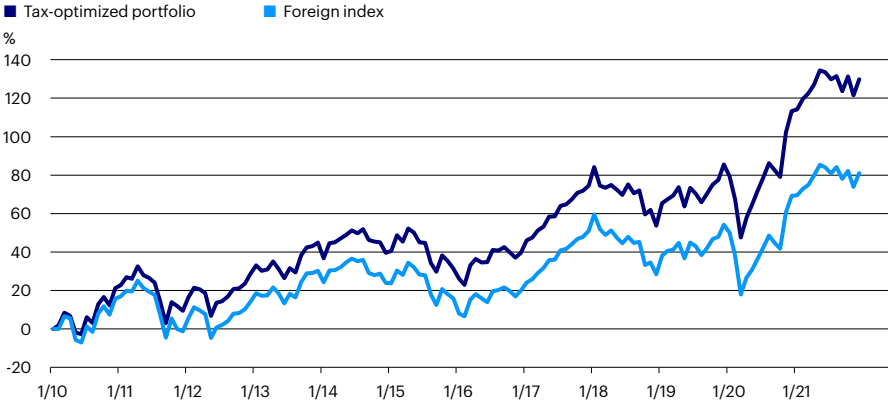
Source: Invesco, data from January 2010 to December 31, 2021. There is no guarantee that the hypothetical performance will be achieved in the future.

Figure 5
Pre-tax returns in comparison



Source: Invesco, as of December 31, 2021. There is no guarantee that the hypothetical performance will be achieved in the future.

Figure 6
Post-tax returns in comparison



Source: Invesco, as of December 31, 2021. There is no guarantee that the hypothetical performance will be achieved in the future.

portfolio outperforms on a post-tax basis due to the 1.7% p.a. tax alpha.

Summary

With ADRs, US investors can gain exposure to non-US markets. They reasonably cover investible global indices and allow simple, rules-based construction of a custom benchmark that tracks the non-US index with a relatively low tracking error. Portfolio construction is transparent and the securities invested are sufficiently liquid. We show that a tax-optimized portfolio can produce higher after-tax performance (1.7% annualized) while preserving the risk and return characteristics of the index.

Notes
1 Global Depositary Receipts
2 For a more detailed description, see Gupta and Agarwal (2022).

Performance shown is hypothetical/simulated for educational and informational purposes only. Any simulation presented here was created to consider possible results of a tax-optimized strategy (not previously managed by Invesco for any client). These performance results are hypothetical (not real) and were achieved by using a tax-optimized model. It may not be possible to replicate these results. The hypothetical results were derived by back-testing using a simulated portfolio. There can be no assurance that the simulated results can be achieved in the future. While the tax-optimized model was used to reflect the investment process for a tax-optimized strategy, this model does not factor in all the economic and market conditions that can impact results. The hypothetical performance returns shown are from January 1, 2010 through December 31, 2021.

Invesco cannot assure that the simulated performance results shown for the tax-optimized strategy would be similar to the firm's experience had it actually been managing portfolios using this strategy. In addition, the results actual investors might have achieved would vary from those shown because of differences in the timing and amounts of their investments.

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About the authors

Nikunj Agarwal
Quantitative Research Analyst
Nikunj is responsible for all aspects of Research at CTME, including developing and refining strategies and offerings, providing deliverable solutions to clients as well as supporting internal academic research.

Tarun Gupta, Ph.D.
Managing Director, Global Head of Research & Investment Technology
Tarun Gupta is a Managing Director of Research and Global Head of Investment Technology at Invesco Quantitative Strategies. He is a member of the IQS management team and leads the build-out of customized and tax-managed equity capabilities.

Timur Sahin
Senior Quantitative Portfolio Manager
Timur is in charge of implementation of CTME's strategies. He is the principal architect of CTME's portfolio management technologies and processes and oversees their daily operation.

About risk
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