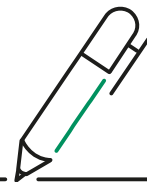


THE CASE FOR LOW-RISK EQUITY INVESTING: EVIDENCE FROM 2011-2025



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THE CASE FOR LOW-RISK EQUITY INVESTING: EVIDENCE FROM 2011-2025

Executive Summary

This paper investigates the performance of equity low-risk strategies since 2011, highlighting their ability to deliver strong risk-adjusted returns across diverse market conditions. We introduce a composite risk score that extends beyond volatility and demonstrate its effectiveness through empirical analysis. The study compares portfolio constructions, examines sector-level effects, and evaluates exposures to Fama-French factors. Results confirm the persistence of the low-risk anomaly and the presence of alpha unexplained by traditional risk premia, supporting the case for including low-risk strategies in long-term equity portfolios.

Keywords: low risk, low volatility, minimum variance, quant investing, factor investing, smart beta, equities.

JEL Classification: G11, G41

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1. INTRODUCTION

This paper explores the rationale, construction, and empirical performance of equity low-risk investment strategies, with a particular focus on their behaviour across diverse market environments since 2011 when we first launched our own strategies. In Section 1, we discuss briefly the foundations of the low-risk anomaly, tracing its origins to the work of Haugen and Heins (1972), and explaining why low-risk stocks can outperform despite traditional finance theory suggesting otherwise. We also describe how our strategies have evolved to incorporate a broader definition of risk, beyond volatility alone, by integrating balance sheet indicators such as distance to default, gearing, and external financing. Section 2 presents a comprehensive empirical analysis of these strategies, comparing different portfolio constructions, evaluating performance across market regimes, including the Covid-19 crisis, the Mag-7 rally, and the recent U.S. tariff-driven volatility, while also assessing sector-level effects. The section also includes a more academic factor-based performance attribution using the Fama-French five-factor model, highlighting the robustness of the low-risk anomaly in the period investigated and the presence of persistent positive alpha beyond some exposures to the factors proposed by the model.

1.1. The origins of Equity Low Risk Investing

In the world of investing, higher risk is typically associated with higher returns. The low-risk anomaly challenges conventional wisdom by revealing that stocks with smaller price fluctuations have historically delivered surprisingly strong returns. This was first uncovered by Haugen and Heins (1972). Analysing U.S. stock market data from 1926 to 1969, they found that portfolios invested in the least volatile stocks would have consistently outperformed expectations, delivering higher returns than their risk profiles would suggest. In contrast, portfolios invested in the most volatile stocks would have underperformed.

This counterintuitive insight laid the foundation for a new generation of investment strategies that gained popularity since the Global Financial Crisis of 2008: ones that seek to harness the power of stability of returns to drive long-term performance.

1.2. Why do low volatility stocks have higher risk-adjusted returns?

Traditional finance theory assumes that investors are rational and markets are frictionless, leading to the conclusion that higher risk should be rewarded with higher returns. But real-world investing tells a different story:

- Investors face constraints, like limits on leverage and short-selling,
- Many aim to outperform benchmarks, not maximize absolute returns,
- Costs, taxes, and liquidity are real and impactful,
- Investment horizons vary widely across individuals and institutions,
- And most importantly, behavioural biases, like overconfidence and preference for lottery-like payoffs, shape decisions in ways the theory doesn't account for.

Add real-world frictions into financial theory and the predicted relationship between risk and return flattens, or even turns negative, depending on the intensity of those frictions. A foundational example comes from Black, Jensen, and Scholes (1972), who demonstrated that increasing the cost of leverage beyond the risk-free rate is already sufficient to flatten the risk-return curve. This insight lies at the heart of what has been often referred to as the *low volatility anomaly* or *low-risk anomaly*.

1.3. Capturing the Low Vol anomaly

Low volatility equity strategies aim to deliver higher returns per unit of volatility by investing in stocks with more stable price behaviour. In equities, this approach is not only intuitive but also practical. That's because stocks that have had the lowest volatility of returns in the past tend to remain the least volatile in the future.

By systematically investing in portfolios composed of the least volatile stocks, investors can gain exposure to the low volatility anomaly, where lower-risk portfolios not only exhibit lower volatility but also tend to deliver higher risk-adjusted returns. Those same low volatility portfolios may even out-perform in the longer-term in terms of absolute returns. It's a compelling way to seek more consistent performance with lower risk.

1.4. Low Volatility Anomaly in Sectors

A key differentiator of our low-risk equity strategies is their sector-aware construction, a feature since inception in 2011. While many low-risk strategies exhibit strong sector biases, favouring traditionally defensive sectors like utilities, healthcare, and consumer staples, we demonstrated that the low volatility anomaly is not a sector effect. Empirical research prior to the launch of our strategies in 2011 that we later published in "*Low-risk anomaly everywhere: Evidence from equity sectors*", Leote de Carvalho et al. (2015), showed that the anomaly persists within every sector, including more volatile ones like information technology and industrials.

In "*The low volatility anomaly in equity sectors – 10 years later!*", Bellone and Leote de Carvalho (2020), we further confirmed these findings, showing that the anomaly remained consistently observable across sectors throughout the 2011–2020 period.

1.5. From Low Volatility to Low Risk

While volatility is perhaps the most common metric used in low-risk equity investing, it's not the only one. Alternatives like beta¹, Value-at-Risk² and others can also be used to identify low-risk stocks. However, in practice, these measures tend to pick largely the same set of stocks, i.e. switching between them adds little in terms of diversification as the ranking of low-risk stocks tends to be relatively similar no matter how risk is defined. Estrada (2025) released a recent study showing exactly that.

However, we have identified three exceptions that offer meaningful diversification. Distance to default, a metric more commonly used in corporate bond markets, captures a different dimension of risk. This metric reflects how far a firm is from breaching its debt obligations, based on the volatility of its asset value and the structure of its liabilities. Because it incorporates real-time market data, it reacts more quickly to changes in a firm's financial condition than typical credit ratings. Similarly, balance sheet-based indicators such as gearing (debt-to-equity ratio) and external financing relative to total assets can highlight companies that traditional volatility-based approaches might overlook. High gearing implies greater financial vulnerability, especially in downturns or rising rate environments, while low gearing suggests more conservative capital structures. External financing relative to total assets measures by how much a company relies on external capital markets. It reflects how much of a company's asset base is funded through new debt or equity issuance rather than retained earnings or internal cash flows.

¹ Beta is a measure of an asset's or portfolio's sensitivity to movements in the overall market. It quantifies systematic risk and was first introduced in the context of the Capital Asset Pricing Model (CAPM) by William F. Sharpe in 1964 in his seminal paper, "*Capital Asset Prices: A Theory of Market Equilibrium under Conditions of Risk*", published in the *Journal of Finance*, 19(3), 425–442.

² Value-at-Risk (VaR) is a statistical measure used to assess the potential loss in value of an asset or portfolio over a defined period for a given confidence level. It was first introduced by James Tobin in 1958 in his seminal paper, "*Liquidity Preference as Behavior Towards Risk*", published in the *Review of Economic Studies*, 25(2), 65–86, and popularized in the 1990's especially by J.P. Morgan's RiskMetrics in 1994.

Recognizing this, our low-risk equity strategies have, since Sep-2023, incorporated these additional risk indicators. Instead of relying solely on volatility, we now select stocks based on a composite risk score that includes preferring lower volatility, higher distance to default, lower gearing, and lower external financing. This broader perspective enhances diversification and strengthens our exposure to what is in effect a low-risk anomaly.

1.6. Low Risk Strategies aligned with investor needs

Minimum variance (MV) strategies aim to construct portfolios with the lowest possible ex-ante volatility, using historical estimates of stock volatilities and correlations. By design, they allocate primarily to low volatility stocks. This approach is often promoted by asset managers and index providers, motivated by empirical evidence of higher risk-adjusted returns relative to market-capitalization-weighted benchmarks. However, MV strategies come with significant drawbacks, namely, MV portfolios:

- tend to over-concentrate in defensive sectors (e.g., utilities, healthcare), ignoring the fact that the low-risk anomaly exists across all sectors, including cyclical ones,
- have very low beta and high tracking error relative to market-cap indices, making them unsuitable for investors who benchmark against those indices,
- are highly sensitive to small changes in volatility and correlation estimates, leading to excessive turnover and instability.

While imposing a myriad of portfolio constraints could help addressing these weaknesses of MV portfolios, a much more effective approach is to simply use a different approach altogether. For benchmark aware investors, one example is to:

- select the least risky stocks within each sector, rather than across the entire universe, ensuring sector diversification and avoiding overexposure to defensive sectors,
- construct portfolios that control for tracking error against the market-cap index while maintaining beta at 0.8, i.e. preserving the defensive nature of the strategy without straying too far from the benchmark.

This optimized approach offers a balanced way to capture the low volatility anomaly while staying benchmark aware. By avoiding strong sector biases, it enhances diversification and reduces the risk of underperformance during specific phases of the economic cycle. At the same time, maintaining the portfolio beta meaningfully below one while controlling for tracking error preserves the defensive nature of the strategy while keeping it aligned with benchmark expectations. The result is a strategy with lower risk than the market capitalization benchmark that delivers higher risk-adjusted returns and greater resilience across market environments, making it better suited to the practical needs of benchmark-conscious investors.

Another strategy of interest involves constructing a sector-neutral, beta-neutral long-short portfolio. This approach enables a more precise examination of the excess returns of low-risk stocks relative to high-risk ones, isolating the effects from both market-wide risk exposure and sector-specific biases. By neutralizing market beta and ensuring sector neutrality, the strategy focuses purely on the return differential between low- and high-risk stocks within each sector. This provides an effective framework for evaluating the persistence and significance of the low-risk anomaly, offering valuable insights into multi-factor equity investment strategies.

2. RESULTS

In this section, we present a series of empirical findings that underpin the design choices behind our low-risk equity strategies. We begin by comparing the effectiveness of using simple volatility versus a more diversified composite risk score in the selection of low-risk stocks. This analysis highlights the trade-offs between simplicity and robustness in identifying risk-efficient equity exposures.

Next, we examine the role of portfolio construction, and more specifically, the benefits of using optimisation techniques to better control tracking error and beta relative to market-capitalization-weighted indices. We contrast this with simpler approaches, such as equal weighting, to demonstrate the added value of a more disciplined construction process.

We then turn to the recent performance of low-risk equity strategies since 2020, a period marked by three distinct market environments:

- the challenging Covid-19 crisis, which brought unprecedented economic disruption,
- a subsequent recovery phase, dominated by the outsized performance of seven large-cap stocks designated as Magnificent 7 (Mag-7: Apple, Meta, Tesla, Microsoft, Nvidia, Amazon, and Alphabet)³,
- the presidential transition in the U.S. in 2025 with new economic uncertainty brought in mainly by a change in the U.S. trading policy with specific tariffs imposed to most countries around the World.

These contrasting regimes provide a valuable stress test for the resilience and adaptability of low-risk strategies in recent years. We complete this analysis by investigating the behaviour of the low-risk anomaly across different sectors from 2011 onward, with particular attention to its evolution in recent years.

Building on this, we explore the performance of an alternative low-risk strategy that holds particular relevance for multi-factor equity investors. This strategy constructs a beta-neutral long-short portfolio by going long on the lowest-risk stocks and short on the highest-risk stocks across all sectors.

Finally, we assess the extent to which the returns of both low-risk strategies can be explained by exposures to the factors in the Fama-French five-factor model. This analysis allows us to determine how much of the observed performance is attributable to known risk factors versus being driven by idiosyncratic alpha uncorrelated with the five-factor framework.

2.1. Evaluating Risk Measures for Low-Risk Stock Selection

Exhibit 1 presents simulated performances and risk metrics from Jan-11 to Apr-25 for various monthly rebalanced portfolio strategies based on ranking stocks by ex-ante risk. The top panel is based on stock rankings derived from a composite risk score, where historical volatility calculated over the preceding three years using weekly local currency returns contributes with 70%, and complementary balance sheet-based risk indicators (distance to default, gearing, and external financing to total assets) each contribute 10%. Each factor data is normalised using a cross-sectional z-scoring transformation so that all factors can be combined. This diversified risk score aims to capture a broader definition of risk beyond just return volatility. For comparison, the bottom panel of the table shows results based on ranking stocks solely by the stock historical volatility.

The strategy D1 invests in the lowest-risk stock decile from each sector. The screened stocks are equal weighted in each sector and sectors are equal weighted in the final decile portfolio. GICS1 sector definitions are used and, since the introduction of the Real Estate sector in Aug-16, our Financials sector is the combination of stocks from both the GICS1 Financials and GICS1 Real Estate sectors, a feature kept throughout the paper. The strategy D10 is constructed similarly to D1 but invests in the riskier stocks while D2 through D9 invest in all intermediate deciles.

³ The above mentioned securities are for illustrative purpose only and do not constitute any investment recommendation. Past performances or achievement is not indicative of current or future performance.

The empirical results reveal several key insights into the relationship between ex-ante risk measures and ex-post portfolio performance. First, the realized (ex-post) volatility of decile portfolios aligns perfectly with their ex-ante volatility rankings. The strategy composed of the lowest-risk stocks from each sector, D1, realizes the lowest volatility over the entire sample period. Conversely, the strategy invested in the riskier stocks, D10, realises the highest volatility. This confirms the effectiveness of the risk-based sorting methodology in capturing persistent differences in future stock return variability.

Jan-11 to Apr-25	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10
Deciles of stocks ranked by risk score										
Annualised return	9.7%	8.9%	8.3%	9.7%	7.2%	5.9%	5.3%	6.4%	7.1%	5.6%
Sharpe ratio	0.77	0.63	0.55	0.61	0.42	0.31	0.25	0.30	0.31	0.19
Volatility	11.3%	12.6%	13.2%	14.1%	14.8%	15.7%	17.2%	18.1%	19.9%	23.5%
Beta	0.72	0.83	0.88	0.94	0.99	1.05	1.14	1.20	1.31	1.49
Deciles of stocks ranked by volatility										
Annualised return	9.1%	8.7%	9.0%	8.1%	6.1%	6.5%	7.1%	6.7%	6.6%	6.3%
Sharpe ratio	0.69	0.61	0.59	0.51	0.33	0.34	0.35	0.32	0.28	0.22
Volatility	11.6%	12.4%	13.5%	14.0%	15.4%	15.8%	17.0%	17.6%	19.7%	23.6%
Beta	0.74	0.81	0.90	0.94	1.03	1.06	1.13	1.17	1.29	1.50

Exhibit 1: Simulation performances and risk of monthly rebalanced decile portfolios (Jan-11 to Apr-25), based on monthly USD cumulated total returns. Transaction costs, market impact and management fees have not been considered. For illustration only. Past performance is not indicative of future performance. Source: BNP Paribas Asset Management, MSCI, Worldscope, FactSet.

In addition to volatility, beta follows a similar pattern: the lowest-risk decile, D1, also has the lowest beta, while the highest-risk decile, D10, exhibits the highest beta. This reinforces the notion that the risk sorting mechanism captures both total and systematic risk dimensions.

Perhaps more remarkable, the cumulative annualized returns are higher for the lower-risk deciles compared to their higher-risk counterparts. This finding challenges the traditional risk-return trade-off, suggesting that lower-risk portfolios may offer superior long-term performance. These results are consistent with those documented in a vast number of academic papers starting with Haugen and Heins (1972) more than 50 years ago.

The Sharpe ratio, which measures the return over cash per unit of volatility, declines almost monotonically across deciles as realized volatility increases. This pattern holds regardless of whether the portfolios are ranked using a composite risk score or volatility alone. However, the dispersion in both returns and Sharpe ratios is more pronounced when using the risk score as the sorting criterion. In particular, the decile composed of the least risky stocks based on the risk score achieves a significantly higher Sharpe ratio and annualized return than the decile based solely on the lowest volatility stocks.

These findings underscore the potential advantages of incorporating broader risk metrics beyond volatility alone when constructing low-risk investment strategies.

2.2. Performance over the longer-term

In Exhibit 2 we show the simulated cumulated performance of various equity strategies over the period from Jan-11 to Apr-25. All results are based on monthly total returns in USD. The analysis contrasts these strategies with the MSCI World and MSCI World Equal Weighted indices.

The strategy D1 invests in the lowest-risk stocks within each sector, applying equal weighting to the selected lowest risk stocks in each sector and to the sector lowest risk deciles themselves. The strategy D10, is constructed using the riskiest decile of stocks, following the same equal weighting sector balanced methodology. Additionally, a third strategy, optimized low risk, selects stocks from the lowest-risk decile of each sector using our combined risk score and applies portfolio optimization to minimize tracking error relative to the MSCI World index, subject to a constraint to keep portfolio beta at or below 0.8, a constraint to fully invest in stocks and constraints to limit the absolute weight of each stock in the final portfolio to 2%. This approach aims to invest only in the least risky stocks from each sector while maintaining a constant defensive market exposure and while minimising differences in exposures to systematic risks relative to the MSCI World index portfolios.

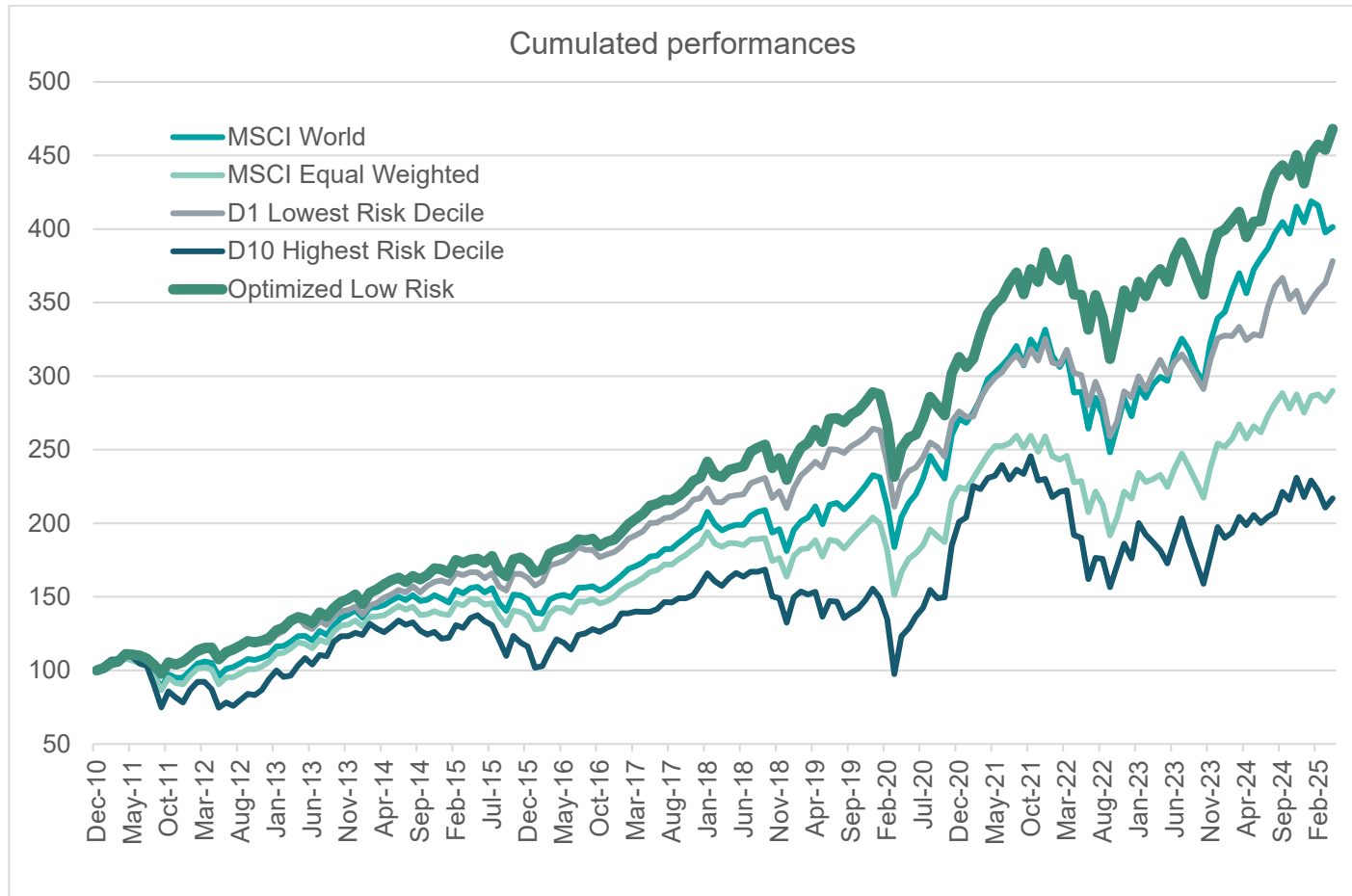


Exhibit 2: Simulated performances of low-risk strategies, based on monthly cumulated total returns in USD compared with the MSCI World and the MSCI World Equal Weighted index performances. Transaction costs, market impact and management fees have not been considered. For illustration only. Past performances or achievement is not indicative of current or future performance. As a result of currency fluctuations, returns can increase or decrease. Source: BNP Paribas Asset Management, MSCI, Worldscope, FactSet.

The results indicate that the optimized low risk strategy would have delivered the strongest performance over the period from Jan-11 to Apr-25. This strategy consistently outperformed all others, including traditional benchmarks. The MSCI World index ranked second, having lagged for most of the period but showing a significant recovery in the final years. The portfolio composed of stocks from the lowest risk decile, D1, came third: despite outperforming the MSCI World index in the early years it lost ground since 2020. In contrast, the MSCI World Equal Weighted index had disappointing performance, underperforming all other

strategies except for the highest risk decile portfolio, D10, which would have recorded the poorest performance by a significant margin. These findings underscore the potential of disciplined low-risk strategies to generate superior long-term returns while maintaining controlled exposure to the market.

2.3. Performance and risk over different periods

In Exhibit 3, we present a comparative analysis of the performance and risk characteristics of the strategies and indices introduced in Exhibit 2. Here we evaluate results across four distinct time frames: the full simulation period from Jan-11 to Apr-25, the period from Jan-20 to Dec-22 characterized by the Covid-19 crisis, the period Jan-23 to Dec-24 with the rally of the Mag-7, and the more recent period from Jan-25 to Apr-25 characterized by the changes in the U.S. trading policy. This segmentation allows for a clearer understanding of how each strategy has behaved both over the long-term and in more recent market conditions highlighting potential shifts in relative performance and risk dynamics.

2.3.1. Full period Jan-11 to Apr-25

The period from Jan-11 to Apr-25 has been rather favourable for equities, with the MSCI World index delivering an annualized cumulated total return of 10.2% in USD. This represents an excess return of 9.1% over U.S. cash rates during the same timeframe. With a realized volatility of 14.3%, the resulting Sharpe ratio of 0.64 significantly exceeds the longer-term historical Sharpe ratio for international equities at 0.3 for the period Jul-1990 to Dec-2011 calculated from return time series available at Kenneth French's website⁴. Importantly, this period does not encompass any prolonged and severe bear markets such as those experienced during the Global Financial Crisis 2008–2009 or the Dotcom Bubble of 2000–2003, making it a particularly challenging environment for low-risk strategies to outperform in absolute terms.

Despite this, the optimized low risk strategy would have outperformed the MSCI World index over this full period, at least before accounting for transaction costs and market impact, while also exhibiting lower volatility, a beta of 0.82 which is close to the beta targeted in ex-ante, and a much higher Sharpe ratio than the market-capitalization-weighted benchmark.

During the same period, even the simple low-risk decile strategy D1 would have delivered performance just 0.5% below that of the MSCI World index on an annualized basis but with significantly higher tracking error at 6.1%. This came with significantly lower volatility and beta for the decile D1 strategy, highlighting the defensive nature of the approach. By comparison, the portfolio optimization used in the optimized low-risk strategy further enhanced its effectiveness adding 0.7% to annualized returns over the lowest risk decile D1 strategy and reducing the tracking error risk to only 4.1%. This improvement came at the cost of a modest increase in volatility and beta.

Finally, a strategy that systematically invested in the riskiest stocks, D10, would have yielded an annualized cumulative return of only 5.6% and with 12.3% tracking error. This return is markedly lower than that of the MSCI World index and the low-risk strategies considered. Moreover, this underperformance would come with a volatility level more than twice as high and a beta of 1.49, underscoring the unfavourable risk-return trade-off associated with high-risk equity allocations, even during a broadly supportive market environment.

2.3.2. Covid-19 crisis

Between Jan-20 and Dec-22, global equity markets experienced heightened volatility, with the MSCI World index exhibiting an annualized volatility of 20.7% and a performance of just 5.4%, reflecting the challenging market environment shaped by the Covid-19 pandemic and subsequent macroeconomic uncertainty. In contrast, the optimized low risk strategy delivered a stronger

⁴ <http://mba.tuck.dartmouth.edu/pages/faculty/ken.french>

performance with the highest Sharpe ratio and achieving the highest annualized return with lower volatility the MSCI World indices. This outperformance was also evident relative to the D1 decile portfolio invested in the lowest-risk stocks with a more modest return of 2.6%, albeit with even lower volatility at 16.9%. Meanwhile, the high-risk D10 decile portfolio recorded a return of 4.2% but with substantially higher volatility of 34.2%.

	Benchmarks			Strategies	Decile portfolios by risk score	
	Cash	MSCI World	MSCI World EW	Optimized Low Risk	D1	D10
Jan-11 to Apr-25						
Annualised return	1.0%	10.2%	7.7%	11.4%	9.7%	5.6%
Sharpe ratio		0.64	0.44	0.84	0.77	0.19
Volatility		14.3%	15.0%	12.2%	11.3%	23.5%
Beta		1.00	1.02	0.82	0.72	1.49
Tracking Error		0.0%	3.5%	4.1%	6.1%	12.3%
Jan-20 to Dec-22						
Annualised return	0.7%	5.4%	2.0%	6.2%	2.6%	4.2%
Sharpe ratio		0.23	0.06	0.30	0.11	0.10
Volatility		20.7%	21.5%	18.4%	16.9%	34.2%
Beta		1.00	1.02	0.87	0.79	1.49
Tracking Error		0.0%	4.5%	4.2%	6.0%	17.7%
Jan-23 to Dec-24						
Annualised return	3.8%	21.8%	12.7%	11.5%	9.7%	11.2%
Sharpe ratio		1.41	0.59	0.66	0.50	0.32
Volatility		12.8%	15.0%	11.6%	11.7%	23.2%
Beta		1.00	1.11	0.85	0.77	1.58
Tracking Error		0.0%	5.2%	4.3%	6.8%	13.6%
Jan-25 to Apr-25						
Return	1.8%	-0.8%	5.4%	8.6%	10.1%	-0.3%

Exhibit 3: Simulated performances and risk of various low risk strategies, based on monthly cumulated total returns in USD and compared with the MSCI World and the MSCI World Equal Weighted indices. Transaction costs, market impact and management fees have not been considered. For illustration only. Past performance is not indicative of future performance. Source: BNP Paribas Asset Management, MSCI, Worldscope, FactSet.

The exact date marking the end of the Covid-19 crisis at global level is relatively arbitrary. Here we consider the end of the crisis in Dec-22 when the China's National Health Commission in a 10-point announcement stipulated that negative Covid-19 tests would no longer be required, apart from vulnerable areas such as nurseries, elderly care facilities and schools.

2.3.3. Mag-7 rally

The period from Jan-23 to Dec-24 was marked by exceptionally strong equity market performance, driven in large part by the sharp rally in the Mag-7 stocks. The MSCI World index delivered an impressive annualized return of 21.8% in USD accompanied by a relatively low volatility of 12.8%. This resulted in a Sharpe ratio of 1.41, well above historical. In such an environment, it

proved challenging for low-risk strategies to outperform this benchmark index. Both the optimized low risk strategy and the D1 decile portfolio delivered lower returns underperforming the MSCI World index. Interestingly, the high-risk D10 decile portfolio had similar performance to the optimized Low-Risk but with more than twice its volatility and thus, much lower Sharpe ratio.

2.3.4. The new U.S. tariffs period

The early months of 2025 were marked by heightened uncertainty in global equity markets, largely driven by the transition to a new U.S. presidential administration and a shift in trade policy. The imposition of new tariffs on imported goods followed by subsequent revisions and suspensions of those same tariffs introduced significant policy volatility. This environment contributed to increased market fluctuations, creating conditions in which low-risk strategies typically perform well.

Indeed, during this period, low-risk equity strategies regained much of the ground lost to the MSCI World index in the preceding two years. By the end of Apr-25, while the MSCI World index had declined slightly, by -0.8%, while the optimized low risk strategy had delivered a strong return of +8.6%, and the lowest-risk stocks D1 decile portfolio a return of +10.1%. To some extent, this outcome was supported by the relative outperformance of smaller-capitalization stocks compared to their larger-cap counterparts, as evidenced by the superior returns of the MSCI World Equal Weighted index relative to the MSCI World. Nevertheless, low-risk equity strategies delivered substantially stronger performance than even the MSCI Equal Weighted, underscoring their effectiveness in this period.

2.4. Dissecting the sector-level low-risk anomaly

It is instructive to examine how portfolios invested in the lowest-risk and highest-risk stocks within each sector performed over the full period, from Jan-11 to Apr-25. In Exhibit 4, we chart the cumulated performance of the D1 decile portfolio invested in the lowest-risk stocks of each sector, and the D10 decile portfolio invested in the highest-risk stocks. The results are striking: in every sector, the lowest risk decile portfolio outperformed its high-risk counterpart. In some sectors, such as Information Technology, the performance gap was substantial, while in others, like Consumer Discretionary, the difference was narrower. Nonetheless, the consistency of outperformance across sectors provides compelling evidence of a persistent low-risk anomaly at sector level.

However, there were periods when high-risk stocks delivered exceptional returns. During the Covid-19 crisis, beginning in Mar-20, the decile portfolio D10 composed of the highest-risk stocks significantly outperformed in some sectors. For Consumer Discretionary, between Mar-20 and Feb-21, this decile included standout performers such as *Tesla, Inc.*, an electric vehicle and clean energy company, which returned +545%, and *Wayfair, Inc.*, an e-commerce firm specializing in home furnishings, which gained +441%. However, these extraordinary gains were later offset by sharp declines in other high-risk names such as *Carvana Co. Class A*, a U.S.-based online used car retailer, which fell by -90%, and *Mercari, Inc.*, a Japanese e-commerce platform, which declined by -72%. A similar pattern of high-risk outperformance was observed from Jun-16 to Jun-18, when stocks like *Netflix, Inc.* (+328%) and *Fiat Chrysler Automobiles N.V.* (+209%) drove strong returns in the same sector⁵.

The Health Care sector has also experienced periods of dramatic high-risk stock outperformance, particularly during the Covid-19 crisis. Between Mar-20 and Feb-21, the highest-risk decile portfolio in this sector delivered exceptional returns, driven by companies such as *Novavax, Inc.*, a vaccine developer, which surged by +1603%, and *NovoCure Ltd.*, an oncology firm pioneering Tumor Treating Fields therapy, which gained +121%. However, these gains proved unsustainable. From Jun-21 to Jun-22, both companies saw sharp reversals, with *Novavax* declining by -76% and *NovoCure* by -69%, contributing to significant underperformance of the high-risk decile during that period⁵.

⁵ The above mentioned securities are for illustrative purpose only and do not constitute any investment recommendation. Past performances or achievement is not indicative of current or future performance.

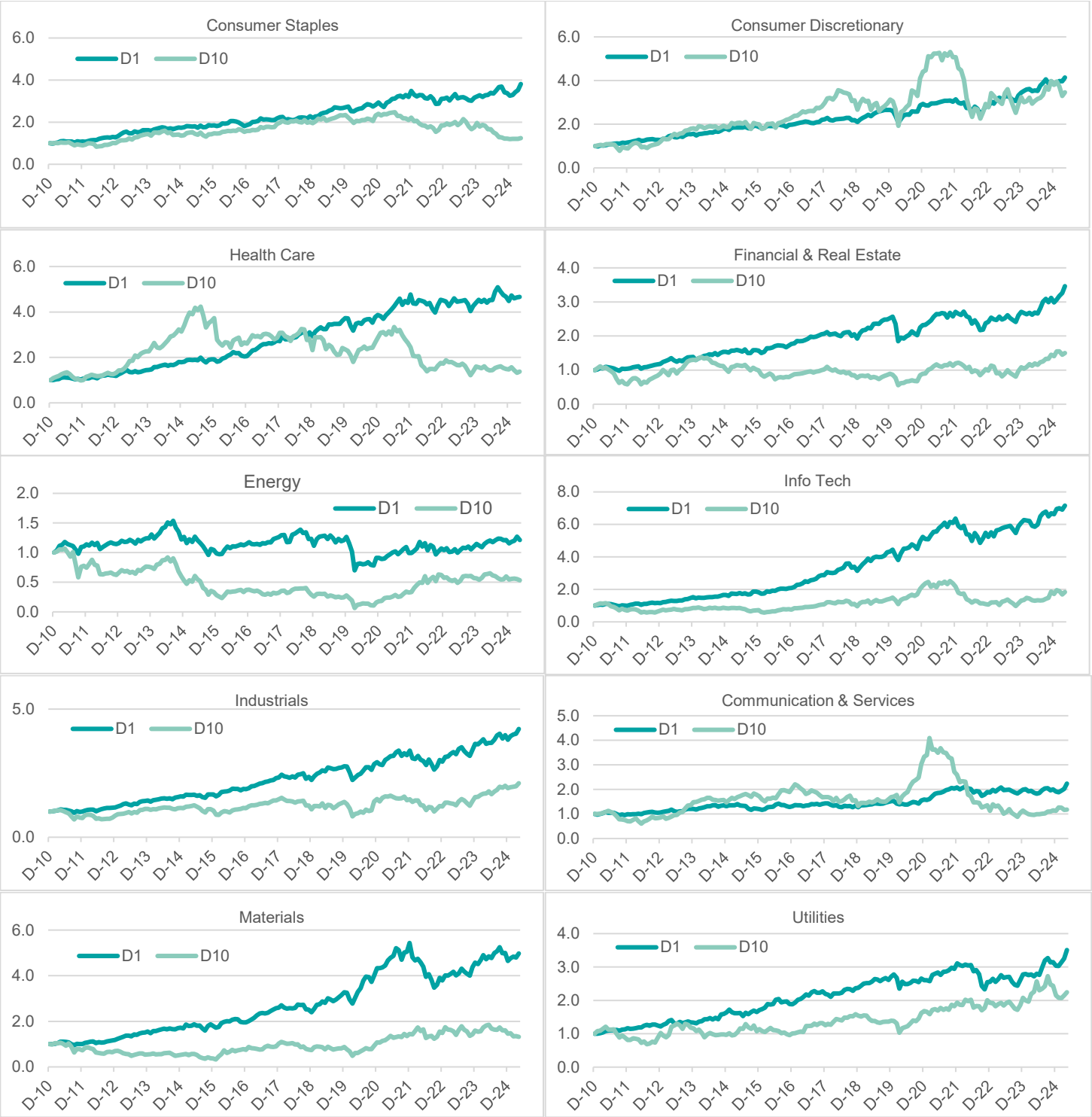


Exhibit 4: Comparison of performance of low- and high-risk decile portfolios for each sector based on simulated cumulative total returns in USD. The D1 portfolio comprising the lowest-risk stocks is compared against the D10 portfolio, which includes the highest-risk stocks. Portfolios are rebalanced monthly and constructed from ranking based on our risk score. Stocks are equally weighted. Transaction costs, market impact, and management fees are not considered. For illustration purposes only. Past performance is not indicative of future results. Source: BNP Paribas Asset Management, MSCI, Worldscope, FactSet.

A similar pattern was observed during the biotech rally from Dec-12 to Jul-15. High-risk stocks in the Life Sciences and Biotechnology space posted extraordinary gains, including *Illumina, Inc.* (+294%), a leader in genomics, and *Pharmacyclics, Inc.* (+352%), an oncology-focused biotech firm. Yet, this rally was followed by a sharp correction between Jul-15 and Mar-16, with steep losses from names such as *Bausch Health Companies Inc.* (–90%), a multinational pharmaceutical company, and *Alnylam Pharmaceuticals, Inc.* (–51%), a pioneer in RNA (Ribonucleic acid) interference therapeutics⁶.

High-risk stocks from the Communication and Services sector also experienced a remarkable surge during the Covid-19 crisis, between Mar-20 and Feb-21. During this period, the highest-risk decile portfolios captured extraordinary gains, exemplified by companies such as *Zillow Group, Inc. Class C*, a U.S.-based online real estate marketplace, which returned +400%, and *Snap, Inc. Class A*, the parent company of Snapchat, which soared by +452%. However, this momentum proved short-lived. In the subsequent period from Feb-21 to Jul-22, many of these high-flying stocks experienced sharp reversals. *Snap, Inc.* declined by –85%, while *Zillow Group* fell by –79%, erasing much of the prior gains⁶.

These boom-and-bust dynamics underscore the inherent volatility and fragility of high-risk strategies, particularly during periods of rapid market regime shifts. While such strategies can occasionally deliver outsized gains, as seen in specific episodes of speculative rallies, they are frequently accompanied by extreme volatility and substantial downside risk, highlighting the unstable nature of their performance over time.

2.5. Capturing the low-risk anomaly abnormal returns at sector level

We now turn our attention to the abnormal returns generated by low-risk equity strategies. To explore this further, we construct a long-short portfolio that aims to capture the excess returns of low-risk stocks beyond what their market sensitivity would predict, while also accounting for the underperformance of high-risk stocks relative to their expected market-driven returns.

The strategy involves taking a long position in the decile portfolios composed of the lowest-risk stocks and a short position in the decile portfolios composed of the highest-risk stocks. The long positions are invested by equally weighting the decile D1 of each sector, while the short positions are equally weighting the decile D10 of each sector. Each sector decile portfolio is based on our risk score and the selected stocks are equally weighted.

To neutralize market exposure, the net beta of this long-short portfolio is offset by investing in the MSCI World index. The beta of the long-short portfolio is estimated using the slope of a regression of its returns in excess of cash rates against the MSCI World index returns over cash, calculated over the two years preceding each monthly rebalancing.

The total size of the long-short portfolio is scaled to target a constant ex-ante volatility of 10% at the end of each month when the decile portfolios are rebalanced. The scaling factor is calculated from the two-year historical volatility of the beta neutral long-short portfolio constructed in this way.

The monthly return of this long-short portfolio strategy is:

$$\alpha(t) = 10\% \times [R_{D1}(t) - R_{D10}(t) - \beta_{D1-D10}(t-1) * R_{MSCI}(t)] / \sigma(t-1) \quad (1)$$

where the $\alpha(t)$ is the monthly return of this beta neutral long-short portfolio targeting 10% ex-ante volatility at the start of the month, $R_{MSCI}(t)$ are the MSCI returns in excess of cash rates over the same month, $R_{D1}(t)$ and $R_{D10}(t)$ are the monthly returns over cash

⁶ The above mentioned securities are for illustrative purpose only and do not constitute any investment recommendation. Past performances or achievement is not indicative of current or future performance.

of the equal weighted sector decile portfolios invested in the lowest risk (D1) and highest risk stocks (D10), $\beta_{D1-D10}(t-1)$ is the beta of the portfolio long D1 and short D10 at the start of the month, and $\sigma(t-1)$ is the volatility of the beta neutral long-short portfolio at the start of the month calculated from the prior two years of returns data. By using returns over cash, the funding costs of the beta neutral long-short portfolio are taken into account and approximated by cash rates.

Although this strategy is challenging to implement due to transaction costs and shorting constraints, it serves as a valuable proxy for assessing the potential to earn positive returns uncorrelated with market returns (MSCI World) by investing in or overweighting the lowest-risk stocks and selling short or underweighting the highest-risk stocks in each sector.

In Exhibit 5, we show the difference in ex-ante beta between the two portfolios: D1, composed of the lowest-risk stocks within each sector, and D10, similar but composed of the riskiest stocks. The result in exhibit 5 shows the amount that must be invested in the MSCI World Index to neutralize the beta of this long-short portfolio. This adjustment ensures that the overall portfolio has no net ex-ante market sensitivity.

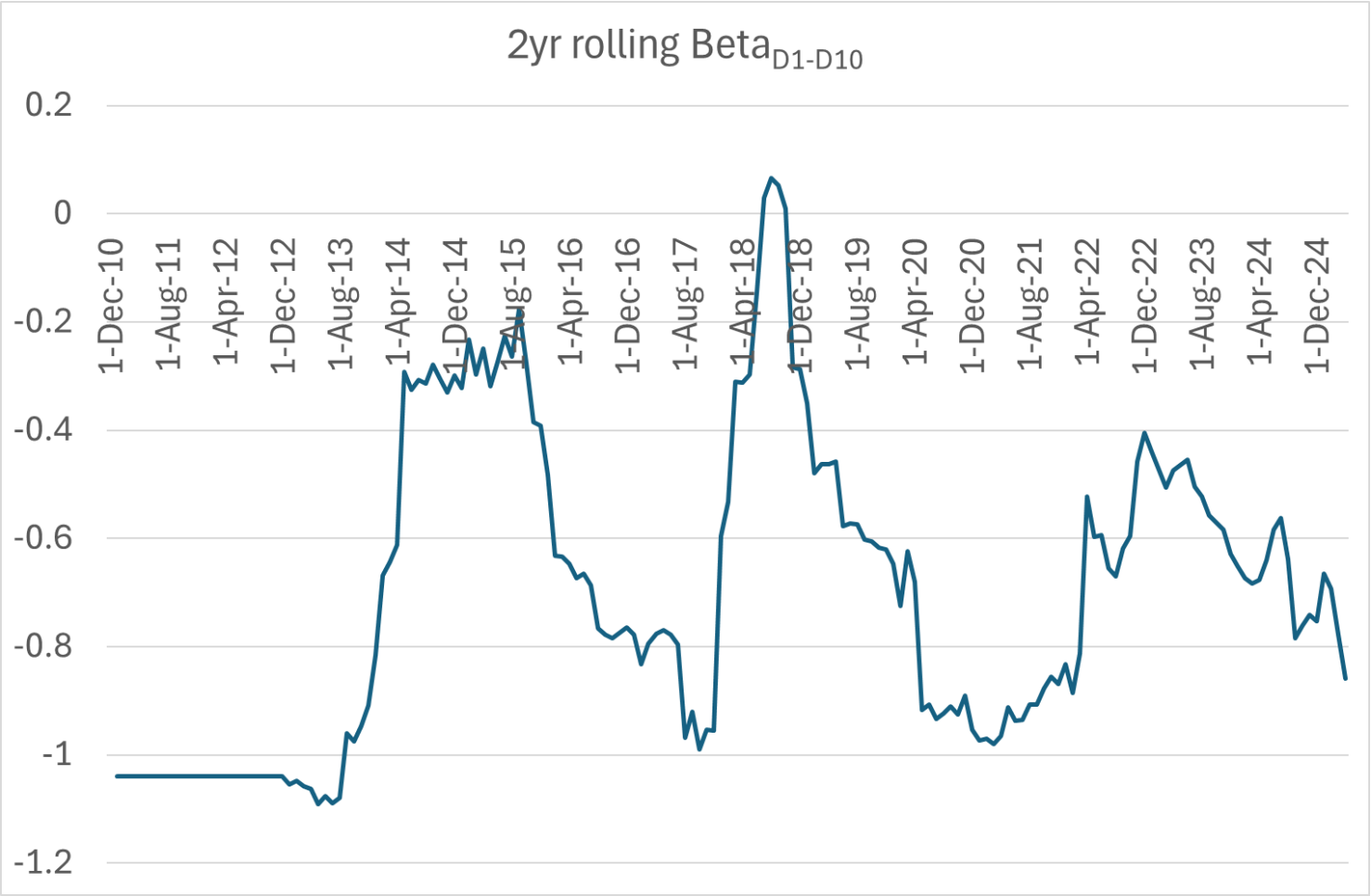


Exhibit 5: Difference between the beta of the decile portfolio D1 invested in the lowest-risk stocks of each sector and the beta of a similar portfolio invested in the riskiest stocks of each sector, D10. For illustration purposes only. Source: BNP Paribas Asset Management, MSCI, Worldscope, FactSet.

The comparison illustrates the substantial gap in market sensitivity between the two decile portfolios, with D1 consistently exhibiting much lower beta than D10. Throughout most of the sample period, the beta of the D1 portfolio has remained significantly lower than that of D10. The only notable exception occurred briefly in 2018, when the beta of the D1 portfolio temporarily converged with that of D10. It is important to note that both portfolios have a good balance of stocks from every sector which can explain why the beta of D1 is not systematically lower than that of D10.

Exhibit 6 shows the leverage coefficient required to ensure that the beta-neutral long-short portfolio, constructed by going long the lowest-risk stocks and short the highest-risk stocks within each sector, achieves a target ex-ante volatility of 10%. This leverage is applied after adjusting the portfolio's market exposure using the beta differential shown in Exhibit 5. The resulting leverage factor reflects the amount by which all positions in the entire beta neutral portfolio must be scaled to maintain a constant ex-ante target volatility of 10% over time, allowing for a fair comparison of performance across different periods and market conditions.

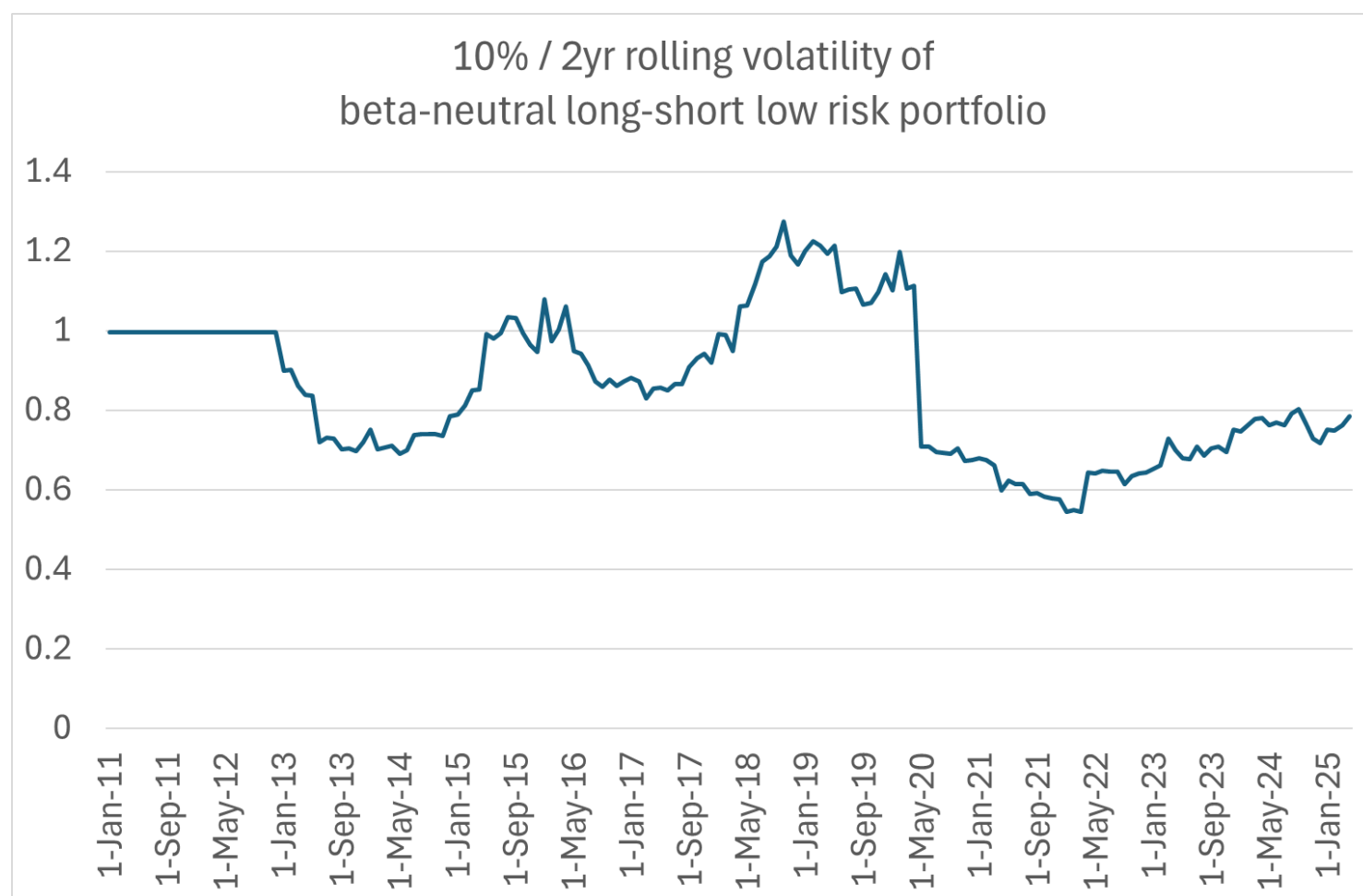


Exhibit 6: Difference between the beta of a sector-neutral portfolio invested in the lowest-risk stocks of each sector (D1) and the beta of a similar portfolio invested in the riskiest stocks of each sector (D10). For illustration purposes only. Source: BNP Paribas Asset Management, MSCI, Worldscope, FactSet.

In Exhibit 7, we show the monthly returns generated by simulating the performance of this beta neutral long-short strategy targeting 10% ex-ante volatility. The results are calculated by adding the portfolio monthly returns over time and are based on USD total

returns. Shorting high-risk stocks to fund the purchase of low-risk stocks would have generated positive and persistent performance over time after hedging the market sensitivity. The period from Oct-19 to Feb-21 offered the biggest challenge. This coincides with a period when most quantitative equity fund managers experienced difficulties with other quantitative styles commonly used by such managers, such as value, also experienced difficulties (see e.g. Bellone et al. (2021)). Nevertheless, the trend has turned positive since then.

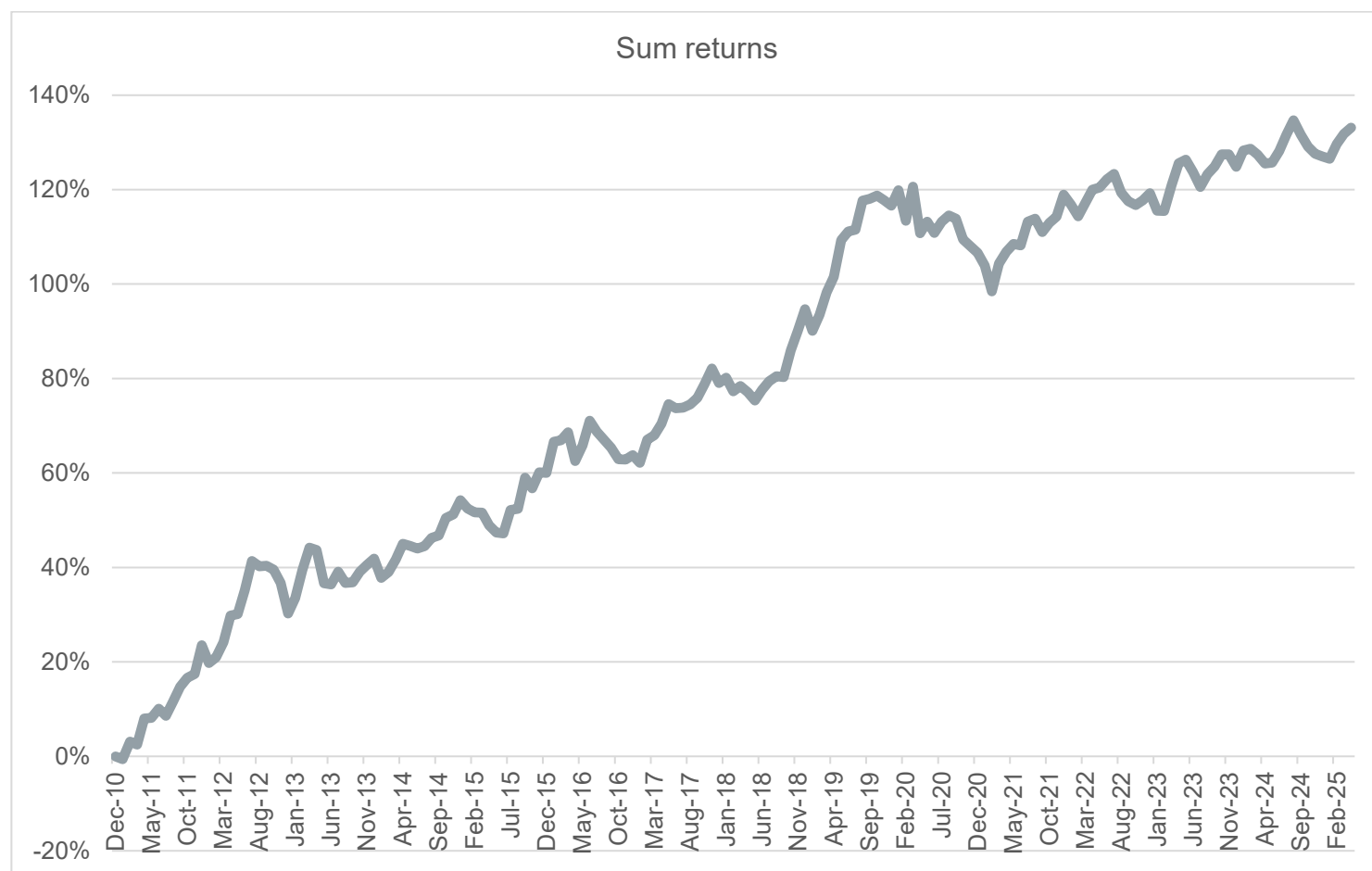


Exhibit 7: Sum of returns of a beta-neutral portfolio, long the lowest-risk decile portfolio of each sector, equal weighting them, and short the highest-risk decile portfolio of each sector, also equal weighting them. Decile portfolios are rebalanced monthly and constructed from ranking stock by our risk score. Stocks in decile portfolios are equally weighted. The beta neutral long-short portfolio is re-sized at each monthly rebalancing to target an ex-ante volatility of 10%. Based on monthly total returns over cash rates in USD. Transaction costs, market impact, management fees and possible short constraints on specific stocks and leverage constraints are not considered. For illustration purposes only. Past performance is not indicative of future results. Source: BNP Paribas Asset Management, MSCI, Worldscope, FactSet.

The results in exhibit 8 include the performance and volatility of the beta neutral long-short portfolio strategy based on the equal combination of all sectors and also based on each sector separately. The annualized average return for the aggregate version with all sectors was 9.3%. Despite the strategy's simplicity, the ex-post volatility was 10.6%, only slightly higher than the targeted 10% each month using simplified measures as the ex-ante volatility. This results in a Sharpe ratio of 0.88. The observed correlation

of the beta-neutral portfolio returns was -8%, relatively small and reasonable given the simplicity of the ex-ante beta measure used and the fact that beta is only hedged once every month at re-balancing, but not intra-month.

	Jan-11 to Apr-25			
	Annualised average return	Volatility	Sharpe ratio	Correlation with MSCI World
All Sectors	9.3%	10.6%	0.88	-7%
Utilities	2.2%	10.3%	0.21	-2%
Materials	6.0%	11.1%	0.54	-2%
Comm Services	2.8%	10.7%	0.26	-6%
Industrials	9.5%	11.0%	0.87	-2%
Info Tech	8.2%	11.2%	0.73	-2%
Energy	7.3%	12.2%	0.60	-5%
Financials	7.5%	10.8%	0.69	-5%
Health Care	5.4%	10.8%	0.50	-4%
Cons Disc	4.9%	10.4%	0.47	-9%
Cons Staples	6.9%	10.9%	0.64	-1%

Exhibit 8: Average return, volatility, Sharpe ratio, and correlation with MSCI World index returns for the beta-neutral long-short portfolio targeting 10% ex-ante volatility, calculated over the period Jan-11 to Apr-25. Also shown, the results for similar beta-neutral long-short strategies based on the decile portfolios of each sector individually, with beta measured against the MSCI World index. Results are based on monthly total returns in USD. Transaction costs, market impact, management fees and possible constraints on shorting specific stocks as well as leverage constraints are not considered. For illustration purposes only. Past performance is not indicative of future results. Source: BNP Paribas Asset Management, MSCI, Worldscope, FactSet.

The sectors where the low-risk anomaly was strongest, and thus contributed most, were Industrials, Information Technology, Energy, Financials & Real Estate, and Consumer Staples. Conversely, Utilities and Consumer Services exhibited the weakest low-risk anomaly during this period. Sector information ratios ranged from 0.21 for Utilities to 0.87 for Industrials. Ex-post volatilities were realized between 10.3% and 11.2%, with the single exception of the Energy sector, which had an ex-post volatility of 12.2%. It is important to note that not only is the measure of ex-ante volatility simple, but also the portfolios are not rebalanced intra-month to keep volatility at target.

The results in exhibit 9 show that during the Covid-19 crisis period, the beta-neutral long-short portfolio combining all sectors delivered a modestly positive average return in aggregate. However, this overall performance masked significant variation across sectors. Negative contributions from sectors such as Utilities, Energy, and to a lesser extent Financials & Real Estate, and Materials, weighed on the portfolio. In contrast, the low-risk anomaly was particularly pronounced in the Consumer Discretionary sector. The anomaly was also clearly evident in Health Care and Industrials.

The returns of the beta neutral long-short portfolio combining all sectors turned positive in the subsequent period, which was dominated by the exuberant performance of the Mag-7 stocks. During this time, the low-risk anomaly was absent only in the Industrials and Information Technology sectors. In contrast, it remained particularly strong in the Consumer Staples sector. Finally, in the first four months of 2025, annualized performances have kept the pace of the previous two years despite the fact that the low-risk anomaly remained weak in the Industrials and Information Technology sectors.

	Average annualised returns			
	Full period Jan-11 to Apr-25	Covid-19 crisis Jan-20 to Dec-22	Mag-7 rally Jan-23 to Dec-24	U.S. tariffs period Jan-25 to Apr-25
All Sectors	9.3%	0.9%	3.9%	4.6%
Utilities	2.2%	-8.0%	1.6%	3.6%
Materials	6.0%	-1.2%	6.9%	5.8%
Communication Services	2.8%	3.2%	4.5%	2.8%
Industrials	9.5%	6.4%	-4.0%	-0.4%
Information Technology	8.2%	5.9%	-4.9%	-1.0%
Energy	7.3%	-6.1%	2.7%	3.0%
Financials & Real Estate	7.5%	-3.3%	0.5%	2.5%
Health Care	5.4%	6.9%	6.5%	3.4%
Consumer Discretionary	4.9%	3.2%	4.6%	5.5%
Consumer Staples	6.9%	9.5%	16.9%	3.6%

Exhibit 9: Average return for the beta-neutral long-short portfolio targeting 10% ex-ante volatility, calculated over the periods Jan-11 to Apr-25, Covid-19 crisis, Mag-7 rally and U.S. tariffs period. Also shown the results for similar beta-neutral long-short strategies based on the decile portfolios of each sector individually, with beta measured against the MSCI World index. Results are based on monthly total returns in USD. Transaction costs, market impact, management fees and possible constraints on shorting specific stocks as well as leverage constraints are not considered. For illustration purposes only. Past performance is not indicative of future results. Source: BNP Paribas Asset Management, MSCI, Worldscope, FactSet.

2.6. The alpha of the low-risk anomaly using a Fama-French factor model

In this section, we examine the extent to which the performance of the two low risk strategies considered in the previous sections can be explained by their exposures to systematic risk factors using the Fama and French (2015) five factor model. To this end, we regressed both the returns of the beta neutral long-short low-risk strategy and the returns over cash of the optimized low risk strategy against the returns of the five Fama-French factors. We used the return data available on Kenneth French's website⁷ for the HML factor (High-minus-Low), which measures the return spread between high and low book-to-market stocks; the SMB factor (Small-minus-Big), which measures the return spread between small- and large-cap stocks; the RMW factor (Robust-minus-Weak), which measures the return spread between robust and weak operating profitability stocks; and the CMA factor (Conservative-minus-Aggressive), which measures the return spread between companies that invest aggressively and those that invest conservatively. We also used the returns over cash for the equity market (Market-RF) provided in Kenneth French's website as the additional fifth factor in the regressions.

Exhibit 10 shows the results of a factor regression for the low-risk strategies. Over the full sample period, the beta neutral long-short low risk strategy shows no significant exposure to the market factor, suggesting that the beta-neutralization approach, though simplistic, is effective over the longer term. The analysis also reveals significant positive exposures to the RMW (profitability) and CMA (investment) factors. Conversely, the strategy portfolios had negative exposures to the SMB (size) and HML (value) factors.

During the Covid-19 crisis period, Jan 2020 to Dec 2022, the strategy exhibited stronger negative exposures to the SMB factor and stronger positive exposure to the CMA factor, while the positive exposure to the RMW factor was weaker compared to the full sample period. Since January 2023, the exposure to SMB has disappeared, and the positive exposure to RMW has increased

⁷ <http://mba.tuck.dartmouth.edu/pages/faculty/ken.french>

again. Although the market factor used in the regression, sourced from Kenneth French's dataset, represents a broader equity universe than the strategy's benchmark, the MSCI World Index, the estimated beta of 0.85 closely aligns with the ex-post beta of 0.82 reported in Exhibit 3.

	Market-RF	SMB	HML	RMW	CMA	Alpha	R-squared
Jan-11 to Apr-25							
Beta neutral long-short low risk strategy	0.015	-0.380	-0.447	0.756	0.908	4.3%	38%
Optimized low risk strategy	0.853	-0.010	0.008	0.310	0.210	1.8%	94%
Jan-20 to Dec-22							
Beta neutral long-short low risk strategy	0.107	-0.927	-0.522	0.325	1.391	-3.9%	58%
Optimized low risk strategy	0.856	-0.211	0.180	0.336	0.063	-2.2%	98%
Jan-23 to Apr-25							
Beta neutral long-short low risk strategy	-0.013	0.035	-0.234	0.884	0.434	3.8%	45%
Optimized low risk strategy	0.890	0.219	-0.036	0.175	0.219	2.7%	93%

Exhibit 10: Regression of low-risk strategy returns against the Fama-French five factor returns. The table includes the regressions coefficients for both the beta neutral long-short low risk strategy and for the optimized low risk strategy in three different periods. The regression intercept has been annualized and is provided in the column Alpha. Bold font indicates statistical significance at the 5% level. Source: BNP Paribas Asset Management, MSCI, Worldscope, FactSet, Kenneth French website.

	Market-RF	SMB	HML	RMW	CMA	Sum factor contribution	Alpha
Jan-11 to Apr-25							
Beta neutral long-short low risk strategy	0.1%	1.1%	0.3%	2.8%	0.2%	4.5%	4.3%
Optimized low risk strategy	7.5%	0.0%	0.0%	1.1%	0.0%	8.7%	1.8%
Jan-20 to Dec-22							
Beta neutral long-short low risk strategy	2.0%	1.9%	5.0%	2.5%	-6.5%	5.0%	-3.9%
Optimized low risk strategy	16.0%	0.4%	-1.7%	2.6%	-0.3%	17.0%	-2.2%
Jan-23 to Apr-25							
Beta neutral long-short low risk strategy	0.0%	-0.2%	-2.0%	0.7%	2.0%	0.4%	3.8%
Optimized low risk strategy	2.1%	-1.5%	-0.3%	0.1%	1.0%	1.5%	2.7%

Exhibit 11: Contribution of the Fama-French model factor exposures to the returns of low-risk strategy returns. Source: BNP Paribas Asset Management, MSCI, Worldscope, FactSet, Kenneth French website.

As expected, a substantial portion of the returns from the optimized low-risk strategy, a fully invested long-only approach, is correlated with the market factor. The strategy also tends to show positive exposures to the RMW and CMA factors. In contrast, the regression does not indicate any significant exposure to the SMB (size) or HML (value) factors over the entire period. However, the exposure to SMB was negative during the Covid-19 period and turned positive since 2023, while the exposure to HML was positive during the Covid-19 period and negligible since 2023.

Exhibit 11 shows the contribution of factor exposures to the returns of low-risk strategy returns. These are obtained by multiplying the factors exposures in exhibit 8 by the factor annualized average returns in each period. The alpha is the annualized intercept of the regressions as in Exhibit 10.

The beta neutral long-short low risk strategy had an average return of 8.8% over the entire period of which 4.5% arise from factor contributions and 4.3% were positive alpha. RMW contributed the most to the strategy returns over the entire period. During the Covid-19 period, there was a net positive contribution from all factor exposures except for CMA. During this period the alpha was negative. Since 2023, the contribution from factor exposures was small and most performance arise from alpha which at 3.8% was close to the long-term figure.

As expected, for the optimized low-risk strategy, a fully invested long-only approach, a substantial portion of its returns is attributable to the market factor. Although the market factor used in the regression, sourced from Kenneth French's dataset, represents a broader equity universe than the strategy's benchmark, the MSCI World Index, the estimated beta of approximately 0.85 closely aligns with the ex-post beta of 0.82 reported in Exhibit 3. This market exposure explains 7.5% of the strategy's 10.5% annualized average return over cash during the full period. Additionally, RMW contributes 1.1% to the annualized return which leaves aside 1.8% in alpha. Much like before, the alpha turned negative during the Covid-19 period and has been positive since 2013.

Overall, these results show a consistent pattern where the alpha of low-risk strategies is positive since 2011 but turned negative during the two years of the Covid-19 period. We also find a positive exposure to RMW and CMA, with RMW contributing positively to returns over the entire period and sub-periods considered.

3. CONCLUSIONS

In this paper we provide robust empirical evidence supporting the effectiveness of equity low-risk strategies across a range of market environments since 2011, when we launched our low-risk equity strategies.

First, we show that equity portfolios invested in the lowest-risk stocks would have consistently delivered superior risk-adjusted returns compared to their higher-risk counterparts. The use of a composite risk measure, incorporating volatility, distance to default, gearing, and external financing, would have enhanced risk-adjusted performance relative to using volatility alone.

We also confirm that the low-risk anomaly was persistent across all sectors, not just defensive ones. Even in more volatile sectors such as Information Technology and Industrials, low-risk stocks would have outperformed their high-risk peers over the entire period considered.

We proposed an optimized low-risk strategy that controls beta and tracking error against the MSCI World index benchmark while investing in the lowest-risk stocks across all sectors. This approach proved especially effective: it not only would have outperformed simpler constructions such as equal-weighted decile portfolios but also would better align with the practical needs of benchmark-aware investors. Over the full analysis period from Jan-11 to Apr-25, a period characterized by a strong bull market, this optimized strategy would have outperformed its benchmark in absolute terms, despite facing some challenging periods such as the Covid-19 crisis, defined here as Jan-20 to Dec-22.

We also examined the performance of a beta-neutral long-short low-risk strategy that goes long low-risk stocks from all sectors and shorts high-risk stocks. While this strategy may be difficult to implement directly due to practical considerations, it provides valuable insights for incorporating a low-risk factor into multi-factor equity strategies. In particular, we show that the excess returns from this long-short strategy would have been positive and uncorrelated with broad equity market returns.

Finally, we investigated the extent to which the returns of these two strategies can be explained by systematic risk factors commonly proposed in academic literature. Regressing the returns of each strategy against the five factors proposed by Fama and French (2015) revealed that while a small part of their positive performance can be attributable to positive exposures to the RMW (profitability) and CMA (investment) factors, a significant portion remains unexplained, highlighting the presence of persistent positive alpha. And while this alpha turned negative during the Covid-19 crisis, it has now rebounded strongly since Jan-23, returning to levels consistent with its average in the full period of the analysis.

These findings reinforce the case for incorporating low-risk strategies into core equity portfolios as a means to enhance risk-adjusted returns, when such strategies are constructed with thoughtful risk definitions and benchmark-aware constraints. They can also be useful in multi-factor equity strategies and bring additional returns uncorrelated with other traditional price factors.

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