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Advanced Financial Economics

Factor-Based Portfolio Optimization Using Market Anomalies

Abstract:

Market anomalies such as momentum, value ratios, and volatility challenge the Efficient Market Hypothesis by revealing potentially persistent return patterns. This research explores factor-based investing strategies aimed at optimizing portfolios beyond traditional market-cap-weighted approaches. Using Bloomberg market data, portfolios based on key anomalies including momentum, value ratios, and volatility will be constructed. These factors will be modeled using historical stock trends (momentum), fundamental value ratios (value), and variability in stocks (volatility). Portfolio performance will be evaluated based on returns and risk metrics, including annual returns, cumulative returns and the Sharpe ratio. By comparing these factor-driven strategies to benchmark indices like the S&P 500, the study seeks to assess whether anomalies can generate excess returns while maintaining manageable risk exposure. Two time intervals will be analyzed: 2012–2017 to observe performance in stable markets, and 2005–2024 to evaluate resilience through market downturns. Results indicate that these factor-based portfolios were profitable, providing potential insights for portfolio managers, hedge funds, and quantitative investors seeking data-driven approaches to asset allocation.

Introduction:

Despite decades of academic support, the Efficient Market Hypothesis (EMH) remains one of the most debated concepts in finance. EMH holds that asset prices fully reflect all available information, making it nearly impossible to consistently outperform the market. However, persistent patterns known as market anomalies challenge this theory. Anomalies such as momentum, value, and size suggest that certain investment strategies may consistently generate above-market returns. This paper explores whether such anomalies can be systematically exploited through factor-based portfolio construction, using historical data and quantitative analysis. By comparing the performance of these portfolios to traditional benchmarks like the S&P 500, the study evaluates whether market anomalies offer a viable alternative to market-cap-weighted investing. Both return and risk metrics will be considered to assess their practical application.

While some scholars argue that anomalies vanish quickly due to arbitrage, reinforcing EMH (Latif, 2011), others suggest these inefficiencies can be systematically exploited (Fama & French, 1993). This paper aligns with the latter perspective, emphasizing empirical evidence and real-world outcomes. The continued demand for portfolio managers and analysts further suggests that opportunities to outperform the market may persist. Among the most widely studied and persistent anomalies are momentum, value, and volatility, which have demonstrated consistent support in the literature (Yalçın, 2010; Jegadeesh, 1993). Less consistent effects, like calendar anomalies, will not be included in this study.

A strictly quantitative approach will be used to test the performance of factor-based portfolios, constructed for momentum, value, and volatility. Each portfolio will be evaluated over two periods: a stable market window (2012–2017) and a broader window including major

downturns (2005–2024). Performance will be assessed relative to the S&P 500 using return and volatility metrics such as the Sharpe ratio (measure of return relative to risk compared to risk free rate). Data will be sourced from Bloomberg, and statistical analysis will be conducted using Excel and R.

This research ultimately aims to evaluate the viability of market anomaly-based strategies in portfolio management, offering insight into whether they provide a consistent and practical edge over traditional indexing.

Literature Review:

To determine which anomalies to include in the portfolios, it is essential to evaluate the arguments challenging their effectiveness. This process helps eliminate strategies that are unlikely to outperform benchmarks, allowing focus on those with greater potential for success. A central critique of market anomalies, particularly from proponents of the Efficient Market Hypothesis (EMH), is that once an anomaly becomes public knowledge, it will be arbitraged away, effectively "invested out of the market" (Latif, 2011). According to this view, widespread use of anomaly-based strategies causes market prices to adjust, thereby eliminating any potential for abnormal returns.

However, for this to occur, two conditions must be met: the anomaly must be broadly known, and investors must have both the ability and willingness to act on it. These barriers open two potential paths for successful anomaly-based investing. The first is to identify less known or unpublished anomalies. The second is to employ strategies that, while known, are sufficiently complex or difficult to execute, limiting widespread adoption (Malyshenko, 2019). A multi-

factor portfolio that integrates such strategies, especially when it requires periodic rebalancing and is not reducible to simple buy-sell rules, can potentially maintain effectiveness despite partial awareness among investors.

Among the most discussed market anomalies are calendar effects, which propose predictable return patterns based on timing within the week, month, or year. Common examples include the weekend effect, January effect, and turn-of-the-month effect (Yalçın, 2010). The weekend effect suggests Monday returns are typically lower, the January effect posits that small-cap stocks tend to outperform in January, and the turn-of-the-month effect claims that returns are generally higher at the beginning and end of each month.

Despite extensive documentation, these anomalies are problematic for practical use. Their popularity and simplicity make them vulnerable to arbitrage. Once investors anticipate such effects, they may adjust their trades, accordingly, shifting the return pattern earlier and eventually nullifying the effect altogether. For instance, if the January effect is expected, investors may begin reallocating in December, pushing prices up prematurely and erasing the anomaly's usefulness. This feedback loop leads to a diminishing return opportunity, making timing-based anomalies particularly fragile (Rossi, 2010). Due to their broad exposure and ease of implementation, calendar effects are excluded from the factor models in this project.

Instead, this paper focuses on anomalies that are less susceptible to being arbitraged away and can be integrated into a more structured portfolio framework. The most widely studied and empirically supported factors are value, momentum, and size. A 2013 study by Cakici, Fabozzi, and Tan provides robust support for these anomalies across 18 emerging markets. Their findings show that size and value factors yielded statistically significant returns in all markets analyzed, while momentum was significant in 17 of the 18 cases (Cakici, 2013).

Each of these factors is grounded in behavioral and risk-based theories. The size effect suggests that smaller firms offer higher risk-adjusted returns, possibly due to higher perceived risk or information asymmetry. The value effect indicates that stocks with low valuation ratios (such as P/E or P/B) tend to outperform, as markets often undervalue such companies (Carhart, 1997). The momentum effect asserts that stocks with strong recent performance tend to continue performing well in the near future, likely due to investor herding and underreaction.

While Cakici's study focuses on emerging markets, its methodology and logic are still applicable in developed markets like the United States. However, because this project's portfolio will be constructed from constituents of the S&P 500, the size effect will be excluded. These stocks are large-cap by definition, making it inappropriate to assess size-related anomalies within this universe.

In addition to value and momentum, this project incorporates a volatility factor, which serves a dual role in enhancing returns and managing risk. Research by Jegadeesh (1993) and others highlights the tradeoff between volatility and return, suggesting that lower-volatility portfolios can achieve more consistent and risk-efficient performance. While not always associated with excess returns, incorporating volatility can optimize a portfolio's risk-adjusted performance, a central goal in investment management. Using high-volatility portfolios could do the opposite and capture much higher returns but increase risk. While value and momentum primarily aim to boost returns, volatility could both boost returns and/or help balance risk, offering a potentially more holistic strategy.

Regarding stock selection and factor implementation, prior studies adopt varying methodologies. There is no universally accepted procedure for applying these factors, particularly in terms of ranking, weighting, or portfolio formation. To isolate the performance of

the selected anomalies from outside influences, this study restricts the investment universe to S&P 500 stocks. This approach ensures that any outperformance can be attributed to the chosen factors rather than idiosyncratic stock selection. As a result, the three factors, value, momentum, and volatility, are the focus of the portfolio models used in this analysis.

Methodology and Data:

As briefly discussed in the introduction, the conclusions will be drawn from a numerical point of view. Each selected factor will be used to form a portfolio that will then be tracked against the benchmark, which in this case is the S&P 500. The companies included in the portfolios will be the current companies that are in the S&P 500. This will lead to a slight survivorship bias, meaning it doesn't include companies that went bankrupt or dropped out of the S&P over the time frame (Malkiel, 2003). Research suggests that to account for survivorship bias, between 1-3% must be subtracted from annual returns (Barberis, 2005). For this project, 3% will be subtracted from the annual returns to ensure the results are not overestimated. Each portfolio will be tracked over equal time periods. To analyze both market crashes and stable periods, there will be two time intervals: 2012-2017 and 2005-2024. The data used will be from Bloomberg, which will include the companies, their daily returns over the selected time periods, price ratios, and volatility measurements.

For momentum, industry norms suggest using lagged momentum rather than standard momentum. This means considering returns from t-12 through t-1 (i.e., from one year ago to one month ago) and excluding the most recent month to account for the short-term reversal effect. This effect indicates that stocks that overperform in the most recent month are likely to underperform the following month. To track momentum, two methods were considered. The first

method mirrors the value portfolio strategy by selecting the 20% of the portfolio with the highest momentum and rebalancing quarterly. The second method involves weighing each stock according to its current momentum, with stocks showing the highest returns receiving the highest weight. The first method is simpler to implement, while the second is more complex but could theoretically better capture the momentum effect. For the purposes of this research, the first method will be used, though the second method could be explored in future studies.

The value portfolio will be constructed using the P/E ratio. Companies with P/E ratios in the lowest 20% will be selected, as this is a common practice in value investing. Since P/E ratios are updated quarterly, the portfolio will be rebalanced quarterly to maintain the 20% of the portfolio that is most "undervalued" by the market, in theory ensuring higher returns compared to the benchmark.

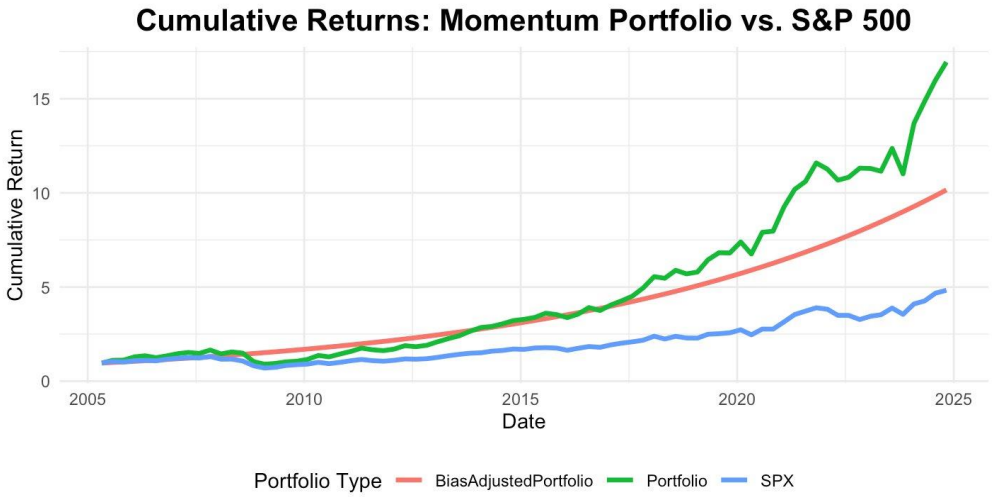
The last factor, volatility will be used by calculating each stock's volatility over the last year. Again, there are multiple implementations for this investing strategy, but the one that makes the most sense for this paper's purposes is taking the 20% of stocks with lowest volatility and adding them to the portfolio and then rebalancing each quarter. A portfolio with the 20% of stocks with the highest volatility will also be made to compare. This will be important in seeing whether volatility as an anomaly can lead to higher returns and/or lower risks than a standard index like the S&P.

Results:

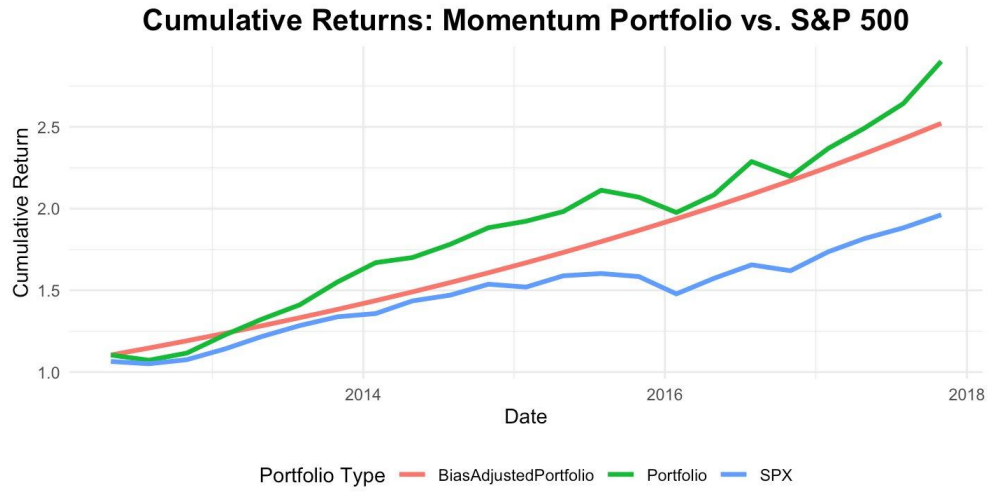
After constructing the portfolios and tracking their performance over the periods of interest, it became evident that some of the anomalies were indeed profitable compared to the S&P 500. While the low-volatility portfolio did not outperform the benchmark, the momentum,

value, and high-volatility portfolios delivered significantly better returns in both high-stability and high-volatility periods. In addition to stronger returns, these portfolios also demonstrated better relative risk, with Sharpe ratios well above that of the S&P 500. A detailed breakdown of the results for each portfolio is provided below. Graphs of returns for each portfolio and period will be inserted below the respective paragraph, the green line is the portfolio and the blue line is the S&P 500. The red line is the calculated annual returns of the portfolio minus 3% to account for Survivorship bias and then graphed over the time. It is strictly for reference to the new adjusted cumulative returns and not a reflection of the volatility of the portfolios.

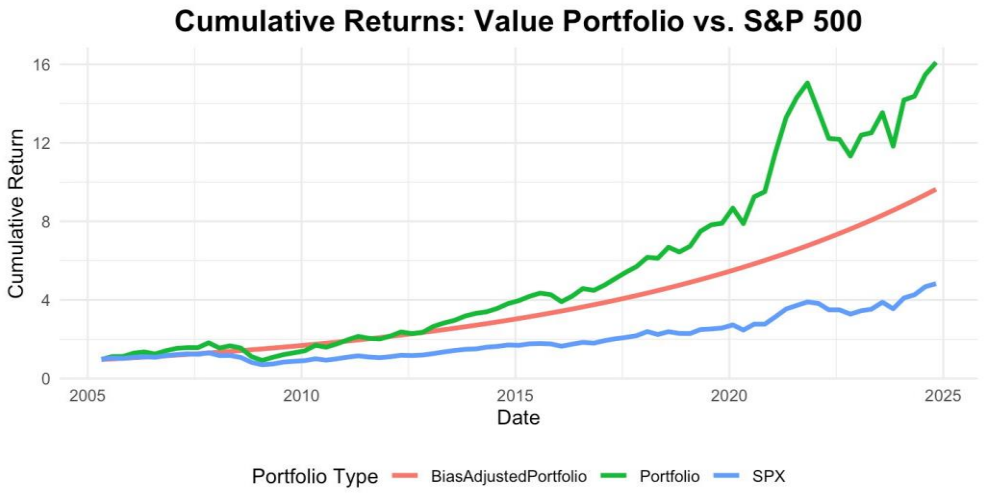
The momentum portfolio delivered consistently strong performance across both time periods. In the long-term, high-volatility period from 2005 to 2024, it achieved an annual return of 16.93%. After adjusting for survivorship bias by subtracting 3%, the return remains a robust 13.93%, compared to 9.22% for the S&P 500. Compounded over 20 years, this results in approximately a 16x return (10x with bias adjustment), whereas the S&P would yield around 5x. Despite the strong performance, risk levels were comparable: the portfolio’s volatility was 16.36%, only slightly higher than the S&P's 15.00%. However, the momentum portfolio had a significantly higher Sharpe ratio. While a Sharpe ratio above 1 is typically considered strong, it is uncommon over long time horizons. In this context, the momentum portfolio's 0.77 is quite robust, especially compared to the S&P 500's 0.33.



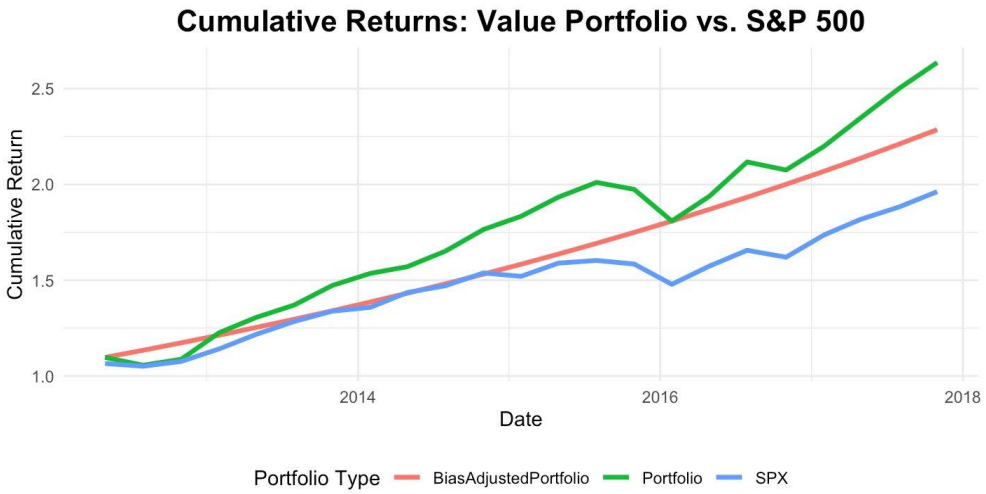
The shorter 2012-2017 period, which featured lower market volatility, showed even stronger results. The momentum portfolio returned 20.82% annually (17.82% adjusted) versus 12.53% for the S&P 500. The Sharpe ratio rose to an impressive 1.81, compared to 0.86 for the benchmark. This ratio being well above 1, highlights the portfolio's exceptional performance relative to its risk. These findings reinforce that momentum as a pricing anomaly is not only persistent but also provides superior returns without a proportionate increase in risk across both calm and turbulent markets.



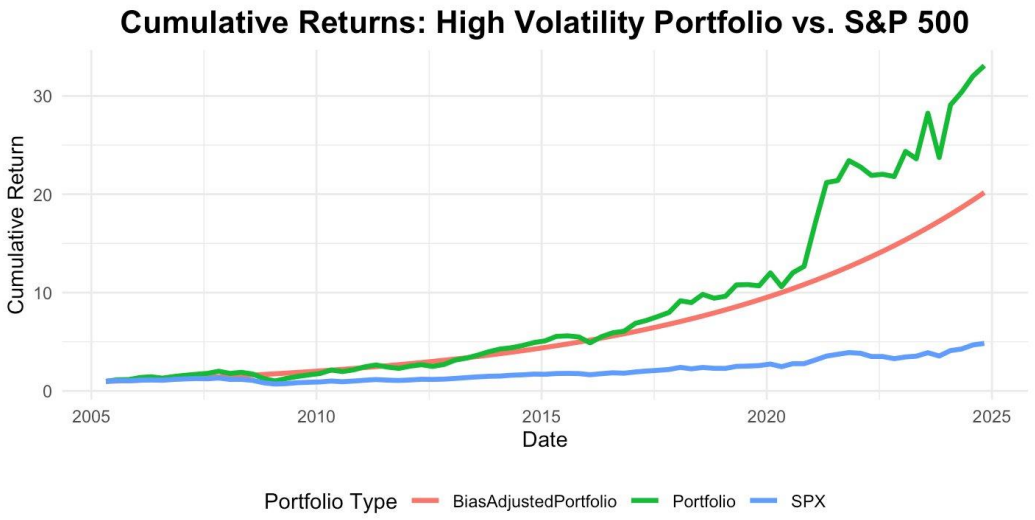
The value portfolio delivered results closely mirroring those of the momentum strategy, again significantly outperforming the benchmark. Over the 20-year high-volatility period, it achieved an annual return of 16.89%, translating to a cumulative return of approximately 16x (or 13.89% and 10x with bias adjustment). In contrast, the S&P 500 returned 9.22% annually, or about 5x cumulatively. The portfolio's volatility was slightly higher than momentum at 17.82%, yet it still achieved a strong Sharpe ratio of 0.71, more than double that of the S&P's 0.33.



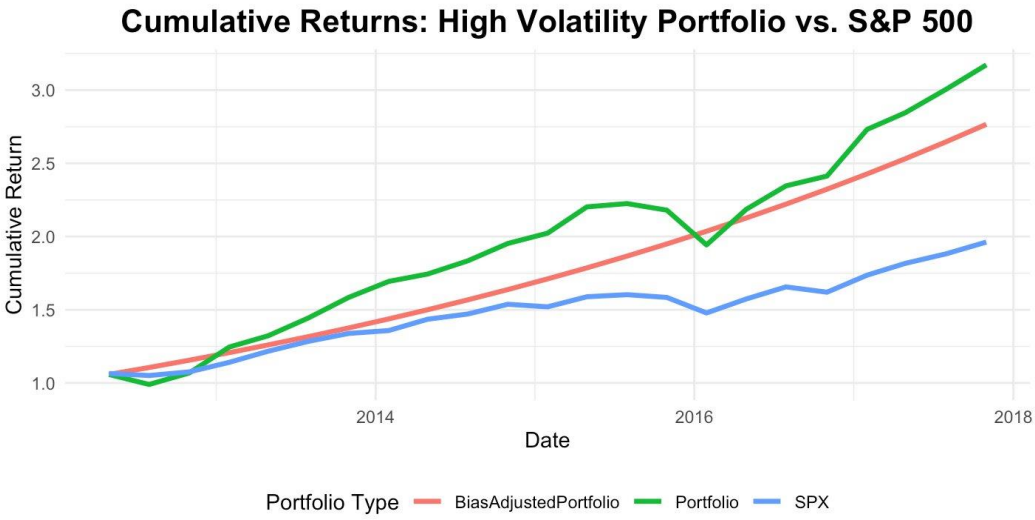
The 5-year period again saw similar results with annual returns increasing along with the Sharpe ratio. The value portfolio during this time had annual returns of 18.83% (15.83% adjusted), volatility of 9.32%, and a Sharpe ratio of 1.56. Compared with the S&Ps 12.53% annual return and 0.86 Sharpe ratio it is again clear the portfolio is far stronger than the index.



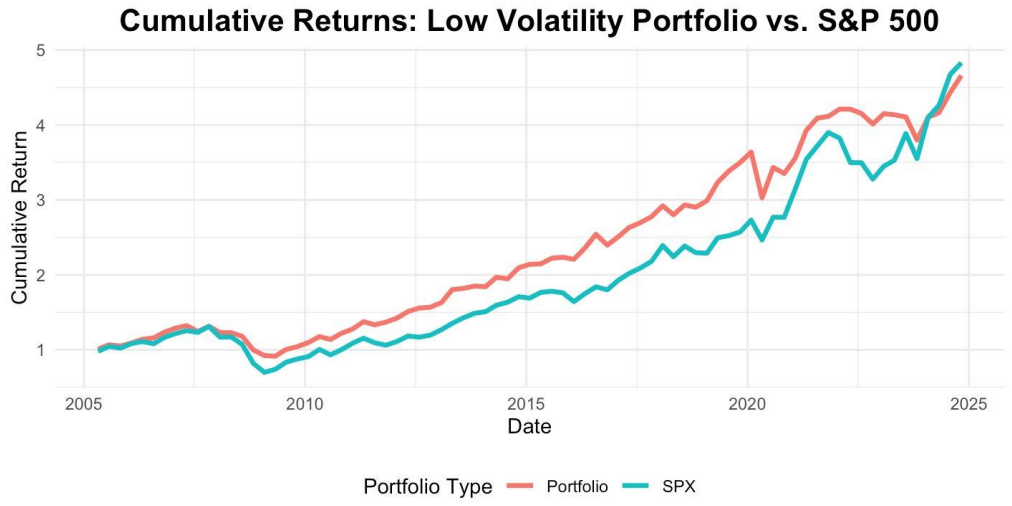
Over the 2005-2024 period, the high-volatility portfolio saw the highest returns of any of the portfolios by far. With an annual return of 21.77%, even the adjusted value of 18.77% is above the returns of all the other portfolios. Though it also had the highest volatility (20.66%), which is as expected, the Sharpe ratio was by far the best at 0.85. Again, compared to the 9.22% annual return and 0.33 Sharpe ratio the S&P is obviously inferior to the constructed portfolio. It is worth noting that this portfolio likely has the largest survivorship bias impact. All the high volatility stocks in the portfolio are long term winners who ended up in the S&P 500 in 2025. There were likely many high-volatility stocks that at times went bankrupt or crashed and dropped out of the S&P. For that reason, a portfolio like this is most likely to have this type of bias. Nevertheless, the portfolio saw such extreme returns that even accounting even more for the bias would not be able to take away from the

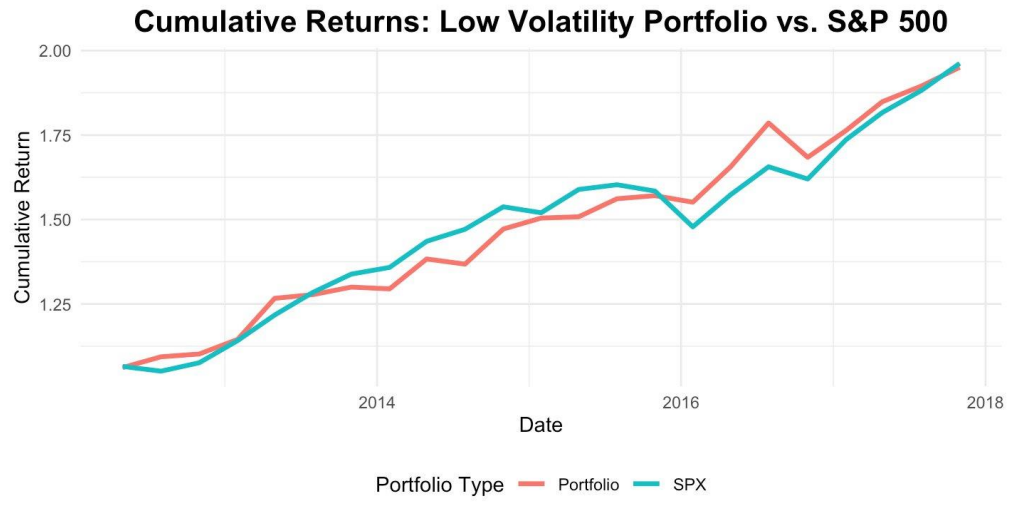


Over the 5-year period, the high-volatility portfolio delivered an annual return of 23.03%, or 20.03% when adjusted for survivorship bias, outperforming all other portfolios. Despite having the highest volatility at 12.00%, its Sharpe ratio of 1.56 was strong, indicating a solid risk-adjusted return. In comparison, the S&P 500 posted a 12.36% annual return with a Sharpe ratio of 0.86, highlighting the superior performance and risk management of the high-volatility portfolio.



The low-volatility portfolio was an outlier, closely tracking the S&P 500 in both return and volatility across both periods. While slight variations occurred, its overall performance mirrored the benchmark. A plausible explanation is that low-volatility stocks tend to be large-cap companies, which the market-cap-weighted S&P 500 already emphasizes. As a result, the portfolio may have largely overlapped with the index, naturally minimizing any divergence. This overlap also likely reduced exposure to survivorship bias, further contributing to the similarity in performance.





Limitations:

Despite the strong performance of the constructed portfolios, several limitations in the methodology should be acknowledged. The most significant is survivorship bias, which has already been discussed but remains the largest concern. Because the dataset only includes companies that have survived through 2024, it overlooks firms that failed, were delisted, or acquired during the study period. This likely had the greatest effect on the high-volatility portfolio, as such stocks tend to include more unstable and failure-prone companies. Ideally, the analysis would use data that includes all companies that were part of the S&P 500 at each rebalancing point, rather than just those still active at the end.

Second, using the S&P 500 as the benchmark presents its own limitations. The index is market-cap weighted and composed largely of low-volatility, large-cap firms, which may reduce the contrast between it and certain factor-based portfolios like the low-volatility strategy. Testing the portfolios against other benchmarks or in international markets would provide broader insight and test whether the strategies truly generalize beyond U.S. large-cap equities.

Third, the analysis relied on monthly returns, which may slightly understate true volatility. Using daily data could yield more accurate risk metrics, particularly for volatility and Sharpe ratios. While monthly data simplifies analysis and reduces noise, it may smooth over short-term risk fluctuations.

Fourth, this analysis does not incorporate transaction costs such as commissions or slippage from rebalancing trades. Given the quarterly turnover, especially in the momentum portfolio, these costs could reduce net returns and should be considered when implementing such strategies in practice. While the impact is likely modest, it may result in a slight overestimation of performance and is therefore an important limitation to acknowledge.

Lastly, all portfolios were equally weighted. Exploring alternative weighting schemes that weigh by rank within the category for the portfolio could offer deeper insights into how these strategies might behave in practice.

Conclusion and Future Work:

After constructing stock portfolios using pricing anomalies identified through academic research, this project found clear and consistent outperformance in both raw return and return relative to risk. The most prominent anomalies, momentum, value, and volatility were each used to form portfolios composed of the top 100 S&P 500 companies ranked by their respective factor at a given time, with quarterly rebalancing. The resulting portfolios significantly outperformed the benchmark S&P 500 over both the long-term (2005–2024) and shorter-term (2012–2017) periods.

Notably, this outperformance was present during both high-volatility and low-volatility market environments, suggesting that these strategies are robust across different conditions. With Sharpe ratios well above that of the benchmark, these strategies offer attractive returns for the level of risk taken and show that factor-based investing remains a viable and profitable strategy.

For future research, expanding this analysis to other indices and international markets would provide greater insight into the generalizability of these anomalies. It would also be valuable to examine whether these strategies work as effectively among small-cap stocks or in emerging markets. Incorporating alternative weighting schemes, transaction costs, and realistic rebalancing constraints would also make the findings more applicable to real-world portfolio construction.

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