Portfolio Construction and Backtesting Analysis

A Comparative Study of Eight Investment Strategies

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Abstract

This report presents an analysis of eight portfolio construction and investment strategies tested over an 11-year period. The study evaluates various approaches including factor-based strategies (value, momentum, quality), risk-based weighting schemes (equal-weighted, market capitalization, inverse volatility, risk parity), and ESG integration. Each strategy was rigorously tested with transaction costs to provide realistic performance expectations. The analysis reveals significant performance differences across strategies, with the Quality Strategy delivering the highest total return of 869.74% and a Sharpe ratio of 0.99, while the Value Strategy underperformed with only 72.09% total return and a Sharpe ratio of 0.16. These findings provide a practical view of the risk-return characteristics of different portfolio construction methodologies and demonstrate the importance of balancing return objectives with transaction costs and risk management considerations.

1 Introduction

Portfolio construction is a fundamental aspect of investment management that seeks to optimize the balance between risk and return. Modern portfolio theory establishes the framework for understanding how diversification can reduce portfolio risk without necessarily reducing expected returns.Numerous strategies have been developed to construct portfolios based on different underlying principles, ranging from simple equal-weighting schemes to complex multi-factor approaches. This project examines eight different portfolio construction approaches, each representing different investment philosophies. These strategies include factor investing approaches (value, momentum, quality), alternative weighting schemes (equal-weighted, market capitalization-weighted), risk-based allocation methods (inverse volatility, risk parity), and sustainable investing (ESG integration). By comparing these strategies under consistent backtesting conditions, we can better understand their relative merits and potential applications in real-world portfolio management.

2 Methodology

2.1 Investment Strategies Tested

Eight distinct portfolio strategies were implemented and backtested to evaluate their performance characteristics:

2.1.1 Equal-Weighted Portfolio

This strategy assigns equal weights to all securities in the portfolio, providing maximum diversification across holdings. The portfolio is rebalanced periodically to maintain equal weights. When securities outperform, they are sold down to equal weight; when they underperform, additional shares are purchased. This approach tries to eliminate concentration risk from any single position.

2.1.2 Market Capitalization-Weighted Portfolio

Securities are weighted proportionally to their market capitalization, similar to major market indices like the S&P 500 or FTSE 100. This approach naturally overweights larger, more established companies and requires minimal rebalancing as weights adjust automatically with price movements. The strategy tries to capture the return of the overall market.

2.1.3 Value Strategy

This factor-based strategy selects and overweights stocks with low price-to-earnings ratios, low price-to-book ratios, or other favorable valuation metrics. The strategy is based on the assumption that undervalued securities will eventually be recognized by the market and generate returns. Value investing has a well-established academic lineage, supported by various research demonstrating that value stocks historically outperformed growth stocks.

2.1.4 Momentum Strategy

The momentum strategy focuses on investing in securities that have performed well recently, based on the observed tendency of winning stocks to keep outperforming over the short to medium term. This strategy typically ranks securities by their trailing returns over periods such as 6-12 months and overweights top performers. Momentum is well-documented in academic literature and exploits behavioral biases such as herding and under-reaction to news.

2.1.5 Quality Strategy

This approach focuses on companies with strong fundamentals including high profitability, low leverage, stable earnings growth, and strong management. Quality metrics include return on equity (ROE), return on assets (ROA), earnings stability, and balance sheet strength. The rationale is that high-quality companies can sustain competitive advantages and deliver consistent returns with lower downside risk during market stress.

2.1.6 Risk Parity

Risk parity allocates capital such that each asset contributes equally to the portfolio's overall risk, rather than allocating equal capital amounts. This approach typically results in larger allocations to lower-volatility assets and smaller allocations to higher-volatility assets. The strategy aims to achieve better diversification by balancing risk contributions rather than capital contributions, potentially improving risk-adjusted returns.

2.1.7 Inverse Volatility

This strategy weights securities inversely proportional to their historical volatility, assigning larger weights to more stable securities and smaller weights to volatile ones. The approach is based on observations that suggest lower-volatility stocks often deliver superior risk-adjusted returns compared to their higher-volatility counterparts, a phenomenon known as the low-volatility anomaly.

2.1.8 ESG Integration

Environmental, Social, and Governance (ESG) integration incorporates sustainability criteria into the investment process. This can include screening out companies with poor ESG profiles, tilting weights toward higher ESG-rated securities, or selecting best-inclass companies within each sector based on ESG metrics. The strategy reflects growing investor interest in sustainable and responsible investing.

2.2 Backtesting Framework

The backtesting framework was designed to simulate actual trading conditions as realistically as possible:

- Initial Investment: $1,000,000 allocated at the start of the backtesting period
- Transaction Costs: All trades include realistic transaction costs including brokerage fees and market impact
- Daily Valuation: Portfolio values and returns are calculated daily based on closing prices
- Periodic Rebalancing: Each strategy rebalances according to its specific requirements (monthly, quarterly, or signal-based)
- Survivorship Bias Mitigation: Historical composition includes delisted securities to avoid survivorship bias
- Dividend Reinvestment: All dividends are automatically reinvested in the portfolio

2.3 Performance Metric

Multiple performance metrics were calculated to provide a comprehensive evaluation of each strategy:

- Total Return: Cumulative percentage return over the entire backtesting period
- Annualized Return: Compound annual growth rate (CAGR) of the portfolio
- Volatility: Annualized standard deviation of daily returns, measuring total risk
- Sharpe Ratio: Excess return per unit of total risk, calculated as (return - risk-free rate) / volatility
- Sortino Ratio: Downside risk-adjusted return, using downside deviation instead of total volatility
- Calmar Ratio: Return divided by maximum drawdown, measuring return per unit of worst-case loss
- Maximum Drawdown: Largest peak-to-trough decline in portfolio value
- Win Rate: Percentage of days with positive returns
- Value at Risk (VaR): Expected loss at the 95% confidence level
- Conditional VaR (CVaR): Average loss beyond the VaR threshold, capturing tail risk

- Skewness: Measure of return distribution asymmetry
- Kurtosis: Measure of tail thickness in the return distribution 8

2.4 Data and Implementation

The backtesting utilized historical price data, fundamental metrics, and market capitalization data for a diversified universe of securities. All calculations were performed on a daily basis, and portfolios were marked to market using closing prices. Transaction costs were estimated based on typical institutional trading costs including commissions, bid-ask spreads, and estimated market impact.

3 Results and Analysis

3.1 Summary Performance Comparison

Table 1 presents the performance metrics for all eight strategies. The results reveal the differences in both absolute returns and risk-adjusted performance across the various portfolio construction approaches.

Table 1: Comprehensive Performance Metrics for All Strategies

Strategy	Total Return	Ann. Return	Vol.	Sharpe	Sortino	Max DD	Final Value
Quality	869.74%	23.00%	21.14%	0.99	1.31	-30.25%	$9,697,400
Market Cap	591.99%	19.27%	19.96%	0.87	1.10	-30.25%	$6,919,929
ESG	591.99%	19.27%	19.96%	0.87	1.10	-30.25%	$6,919,929
Equal Wtd	398.02%	15.75%	17.79%	0.77	0.93	-36.57%	$4,980,167
Risk Parity	361.61%	14.95%	20.90%	0.62	0.78	-36.13%	$4,616,149
Inv. Vol.	314.23%	13.82%	16.45%	0.72	0.84	-35.27%	$4,142,279
Momentum	285.61%	13.08%	21.71%	0.51	0.61	-37.82%	$3,856,123
Value	72.09%	5.07%	18.76%	0.16	0.20	-47.84%	$1,720,903

Figure 1 provides a side-by-side comparison of key performance metrics across all strategies.

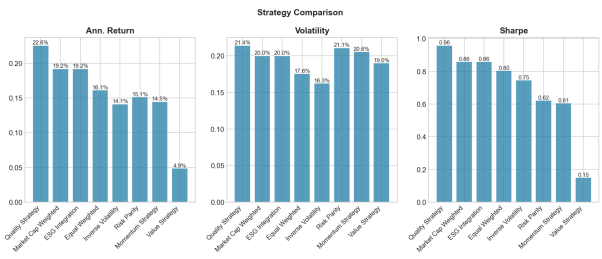

Figure 1: Strategy Performance Comparison: Annualized Return, Volatility, and Sharpe Ratio

3.2 Key Findings

3.2.1 Top Performers

The Quality Strategy emerged as the clear winner with an impressive total return of 869.74% over the backtesting period, translating to an annualized return of 23.00%. This strategy demonstrated superior risk-adjusted performance with a Sharpe ratio of 0.99 and a Sortino ratio of 1.31, indicating strong returns relative to both total and downside risk. The Quality Strategy achieved this exceptional performance while maintaining a relatively moderate maximum drawdown of -30.25%, the joint-lowest among all strategies tested.
Figure 2 presents the complete performance tearsheet for the Quality Strategy with its cumulative returns, drawdown profile, monthly returns heatmap, and return distribution.

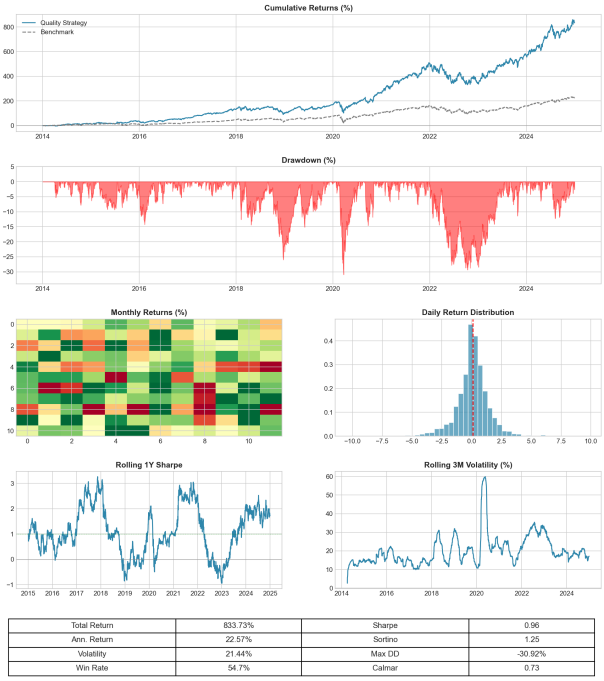

Figure 2: Quality Strategy Performance Tearsheet

The Market Cap Weighted and ESG Integration strategies performed identically with total returns of 591.99% and annualized returns of 19.27%. Both strategies showed strong risk-adjusted performance with Sharpe ratios of 0.87 and identical risk characteristics. This finding is particularly noteworthy as it suggests that ESG screening, when implemented alongside market cap weighting, did not significantly detract from performance during this period. The identical performance likely reflects identical underlying holdings between the two strategies.

3.2.2 Middle-Tier Strategies

The Equal-Weighted strategy delivered a total return of 398.02% with an annualized return of 15.75% and a Sharpe ratio of 0.77. While this approach underperformed the market cap-weighted benchmark, it demonstrated the potential benefits

of systematic rebalancing and equal diversification across holdings. The strategy exhibited the highest win rate at 55.42%, indicating more consistent positive daily returns. However, this came at a significant cost, with transaction expenses totaling $118,098 due to the frequent rebalancing required to maintain equal weights. Risk-based strategies, including Risk Parity (361.61% total return) and Inverse Volatility (314.23% total return), showed modest performance relative to the top performers. These strategies prioritize risk management over maximum return generation, as evidenced by their design to reduce portfolio volatility. The Inverse Volatility strategy successfully achieved the lowest annualized volatility at 16.45%, demonstrating effective risk reduction. However, this risk reduction came at the cost of lower absolute returns.

3.2.3 Underperformers

The Momentum Strategy generated a total return of 285.61% with an annualized return of 13.08% and a Sharpe ratio of only 0.51, indicating relatively poor risk-adjusted returns. This strategy experienced the highest transaction costs at $317,182 due to frequent portfolio turnover of 35.53 times over the period. The high turnover reflects the strategy's need to continuously rotate into recent winners, which significantly eroded gross returns. Additionally, the Momentum Strategy exhibited high volatility at 21.71% and suffered a substantial maximum drawdown of -37.82%. The Value Strategy was by far the worst performer with only 72.09% total return over the entire period, translating to a mere 5.07% annualized return. With a Sharpe ratio of just 0.16 and the largest maximum drawdown of -47.84%, this strategy struggled to deliver positive risk-adjusted returns. Figure 4 illustrates the severe drawdowns experienced by the Value Strategy, particularly during the 2020 market crisis.

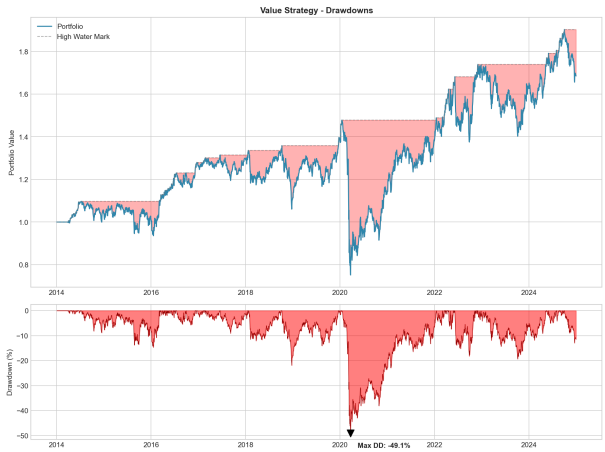

Figure 3: Value Strategy Drawdown Analysis: Maximum Drawdown of -47.84%

3.3 Risk Analysis

3.3.1 Volatility Comparison

Annualized volatility across the eight strategies ranged from 16.45% (Inverse Volatility) to 21.71% (Momentum Strategy). The Quality Strategy achieved its exceptional returns with moderate volatility of 21.14%, demonstrating efficient return generation. As expected, risk-focused strategies successfully reduced volatility, with the Inverse Volatility strategy showing the lowest annualized volatility at 16.45%, followed by Equal-Weighted at 17.79The Market Cap Weighted and ESG Integration strategies exhibited identical volatility of 19.96%, slightly lower than the Quality Strategy's 21.14%. This similarity in volatility, combined with identical returns, suggests highly correlated portfolio compositions. The Momentum Strategy exhibited the highest volatility at 21.71%, consistent with its high-turnover approach of continuously rotating into recent winners.

3.3.2 Maximum Drawdown Analysis

Maximum drawdowns varied significantly across strategies, ranging from -30.25% (Quality, Market Cap, ESG) to -47.84% (Value). The Quality, Market Cap Weighted, and ESG Integration strategies demonstrated fairly good downside protection, all experiencing identical maximum drawdowns of -30.25%. This level of drawdown, while significant, remained manageable and below the psychological threshold of -40% that often triggers investor capitulation.

In contrast, the Value Strategy experienced severe drawdowns exceeding 47%, highlighting the strategy's vulnerability during adverse market conditions. The Momentum Strategy also suffered a substantial drawdown of -37.82%, reflecting its exposure to momentum crashes when market conditions reverse suddenly. The Equal-Weighted strategy experienced a -36.57% drawdown, larger than the market cap-weighted benchmark, suggesting that equal weighting may amplify drawdowns when smaller companies suffer disproportionately.

Figures 4 and 5 compare the drawdown profiles of the quality and value strategies, highlighting the differences in downside risk.

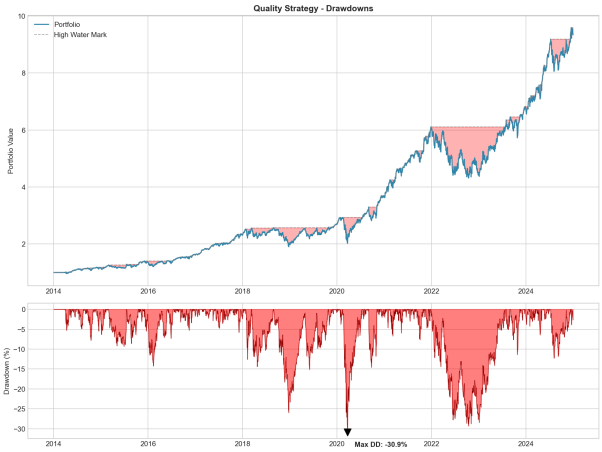

Figure 4: Quality Strategy

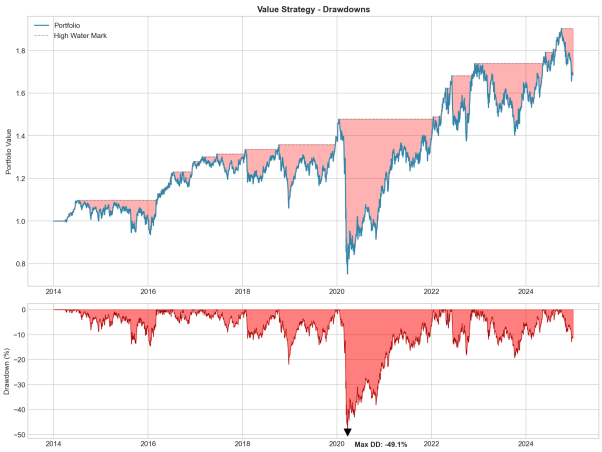

Figure 5: Value Strategy

3.3.3 Risk-Adjusted Performance Metrics

The Sharpe ratios provide insight into risk-adjusted performance, with the Quality Strategy leading at 0.99, nearly achieving a Sharpe ratio of 1.0, which is considered good. Market Cap Weighted and ESG Integration followed with Sharpe ratios of 0.87, indicating strong risk-adjusted returns. The Equal-Weighted strategy achieved a respectable 0.77 Sharpe ratio, while the Inverse Volatility and Risk Parity strategies delivered Sharpe ratios of 0.72 and 0.62, respectively. The Sortino ratios, which focus on downside risk rather than total volatility, show a similar pattern but with higher values across all strategies. The Quality Strategy's Sortino ratio of 1.31 significantly exceeds its Sharpe ratio, indicating that upside volatility contributes substantially to its total volatility while downside volatility remains controlled. This characteristic is highly desirable for investors who are primarily concerned with downside protection. The Calmar ratios, which measure annualized return divided by maximum drawdown, provide another perspective on risk-adjusted returns. The Quality Strategy leads with a Calmar ratio of 0.76, followed by Market Cap Weighted and ESG Integration at 0.64. These ratios indicate how much return was generated per unit of worst-case loss experienced.

3.3.4 Win Rate and Consistency

Win rates (percentage of profitable trading days) ranged from 50.47% (Momentum) to 55.42% (EqualWeighted). The Equal-Weighted strategy's high win rate of 55.42% reflects the benefits of broad diversification and systematic rebalancing, which tends to capture small gains consistently. The Quality, Market Cap, and ESG strategies all exhibited similar win rates around 54-55%, indicating consistent positive daily returns. However, it is important to note that a high win rate does not necessarily translate to superior overall returns, as evidenced by the Equal-Weighted strategy's high win rate combined with moderate total returns. Conversely, the Quality Strategy achieved exceptional returns despite a moderate win rate of 54.66%, demonstrating that the magnitude of winning days is more important than their frequency.

3.4 Return Distribution Analysis

Figures 6 and 7 present the return distribution characteristics for the quality and the value strategies, illustrating the differences in their statistical properties.

Figure 6: Quality Strategy

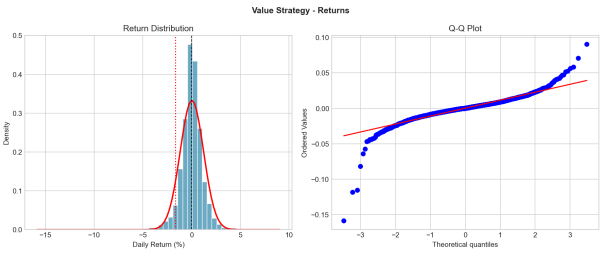

Figure 7: Value Strategy

3.5 Transaction Cost Impact

Transaction costs varied dramatically across strategies, directly correlating with portfolio turnover and significantly impacting net returns. Table 2 presents the transaction cost analysis for all strategies.

Table 2: Comprehensive Performance Metrics for All Strategies

Strategy	Total Trades	Turnover	Total Costs
Momentum	854	35.53x	$317,182
Risk Parity	2,749	25.99x	$278,803
Inverse Volatility	3,275	12.59x	$123,598
Equal Weighted	3,123	10.70x	$118,098
Quality	250	4.61x	$58,479
Value	265	5.82x	$34,928
Market Cap	514	1.89x	$20,429
ESG	514	1.89x	$20,429

The Momentum Strategy incurred the highest transaction costs at $317,182 with a portfolio turnover of 35.53 times over the backtesting period. This extremely high turnover reflects the strategy's inherent need to continuously rotate capital into recent winners and out of laggards, with positions being held for relatively short periods. These substantial costs significantly diminished the strategy's gross returns, contributing to its poor risk-adjusted performance. Risk Parity also faced substantial transaction costs of $278,803 due to frequent rebalancing requirements (25.99x turnover). The strategy's objective of maintaining equal risk contributions from each asset necessitates continuous rebalancing as volatilities and correlations change over time. The Equal-Weighted and Inverse Volatility strategies similarly incurred high costs ($118,098 and $123,598, respectively) due to their systematic rebalancing requirements. In contrast, the Market Cap Weighted and ESG Integration strategies maintained low turnover of 1.89x and minimal transaction costs of only $20,429 each. These passive approaches benefit from the fact that portfolio weights adjust naturally with price movements, requiring rebalancing only when constituents are added or removed or when weights drift significantly. This cost efficiency contributed to their strong net returns. The Quality Strategy achieved an optimal balance, generating strong returns while keeping transaction costs moderate at $58,479 with 4.61x turnover. This demonstrates that selective active management can add value while maintaining reasonable implementation costs, avoiding the cost drag that plagued the Momentum and Risk Parity strategies.

3.6 Rolling Performance Analysis

Figures 7 and 8 present the rolling performance metrics for the quality and the market cap weighted strategies, illustrating how their risk-adjusted performance evolved over time.

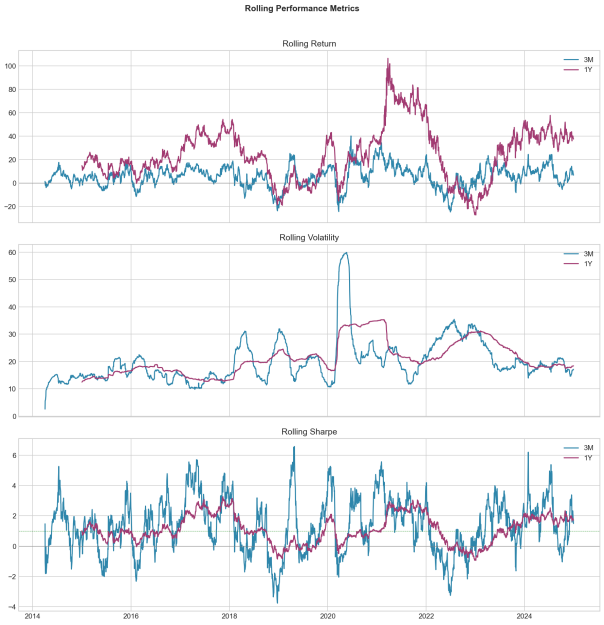

Figure 8: Quality strategy

Figure 9: Market cap weighted strategy

3.7 Distribution Characteristics

Analysis of return distribution characteristics provides additional insights into strategy behavior:

3.7.1 Skewness

All strategies exhibited negative skewness, indicating return distributions with fatter left tails (larger negative returns are more likely than symmetry would suggest). The Value Strategy showed the most extreme negative skewness at -1.39, reflecting its vulnerability to sharp drawdowns. The Quality Strategy exhibited the least negative skewness at -0.20, suggesting more symmetric returns and better

tail risk management.

3.7.2 Kurtosis

Kurtosis values, which measure tail thickness varied considerably across strategies. The Value Strategy showed the highest kurtosis at 20.05, indicating extremely fat tails and proneness to extreme events. The Inverse Volatility strategy exhibited very high kurtosis at 17.21, while the Equal-Weighted strategy showed 14.56. These high kurtosis values suggest that returns occasionally deviated far from the mean, creating challenges for risk management based solely on standard deviation measures. The Quality Strategy demonstrated relatively moderate kurtosis at 3.81, closer to the normal distribution's kurtosis of 3.0. This suggests more predictable return behavior with fewer extreme outliers, a characteristic that enhances the strategy's appeal for risk management purposes.

4 Discussion

4.1 Factor Performance

The Quality Strategy performed best, consistent with research showing that companies with strong fundamentals high profitability, stable earnings, low leverage tend to offer steady, risk-adjusted returns. Their stable cash flows, competitive advantages, and pricing power help them resist downturns and capture rallies.

The Value Strategy underperformed, reflecting a long-term trend since 2007. Factors include the rise of intangible assets in tech, growth-oriented business models, low interest rates favoring growth stocks, and widely known value metrics being arbitraged away.

Momentum showed moderate returns but high costs. While academically supported, momentum requires frequent trading and is vulnerable to sharp market reversals, as shown by its high drawdown.

4.2 Risk-Based Allocation

Risk Parity and Inverse Volatility effectively reduced portfolio volatility and controlled downside risk. However, this came at the expense of lower absolute returns compared to factor-based strategies like Quality. High transaction costs, especially for Risk Parity, highlight practical limitations. These strategies suit risk-averse investors or those prioritizing volatility reduction.

4.3 Passive vs Active

Market Cap Weighted investing performed well, supporting passive strategies with low costs and efficient market exposure. However, the Quality Strategy outperformed, demonstrating that well-designed active, factor-based strategies can add value despite higher costs.

4.4 Implementation Insights

Transaction costs, risk-adjusted returns, and drawdowns are crucial for portfolio decisions. Strategies with frequent rebalancing or severe drawdowns can harm net performance and investor persistence. Factor timing is challenging, as shown by Value's extended underperformance.

4.5 Limitations

Key limitations include period dependency, survivorship and look-ahead biases, transaction cost estimation, market impact for large portfolios, factor cycles, and the uncertainty of out-of-sample performance. Strategy implementation choices, like rebalancing frequency and factor definitions, also affect results.

5 Conclusion

This backtesting study of eight portfolio strategies highlights substantial differences in performance, both in absolute and risk-adjusted terms, offering practical insights for portfolio construction while emphasizing that results vary across market conditions.

5.1 Key Findings

The Quality Strategy was the top performer, with 869.74% total return (23.00% annualized) and a Sharpe ratio of 0.99, showing the value of investing in fundamentally strong companies. It combined high returns with moderate costs ($58,479) and reasonable drawdowns (-30.25%).

Momentum delivered positive returns (285.61%) but suffered from high turnover (35.53x) and costs ($317,182), resulting in a low Sharpe ratio (0.51).

Risk-based approaches, like Risk Parity and Inverse Volatility, effectively reduced volatility but produced lower absolute returns, making them suitable for risk-averse investors or as part of a diversified strategy.

The Value Strategy performed poorly (72.09% total return, Sharpe 0.16) with large drawdowns (-47.84%) and high tail risk, illustrating the cyclical nature of factor performance.

5.2 Practical Implications

- Quality Focus: Incorporate quality factors into portfolio design.
- Cost Management: Monitor turnover and transaction costs.

- Diversification: Combine multiple strategies to reduce factor-specific risks.
- Long-Term Perspective: Maintain discipline during underperformance.
- ESG Integration: Can be implemented without sacrificing returns.
- Risk Management: Consider drawdowns and tail risk alongside volatility.

5.3 Final Remarks

Portfolio construction requires balancing methodology, costs, risk, and investor behavior. Historical performance shows the potential for large differences between strategies (e.g., Quality vs. Value), but successful investing depends on consistent implementation, effective risk management, and behavioral discipline.

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