Performance & Cost-Drag Analysis of S&P 500 Factor Portfolios: By Aled von Oppell

Abstract:

The primary research question addressed is to what extent does the implementation of "drag" negate the performance premium of a quarterly rebalanced Equal-Weight S&P 500 portfolio compared to the standard Market-Capitalization Weighted Index (SPY) from January 2018 to October 2025.

This analysis confirmed that the Artificial Equal-Weight (No Drag) portfolio outperformed across all return and risk-adjusted metrics. The analysis demonstrates that a 0.55% annual cost drag reduces the Equal-Weight premium, highlighting the strategy's sensitivity to implementation costs.

We compared the following Portfolios:

1. SPY – The standard S&P 500 Market-Cap Weighted ETF.
2. RSP – The actual S&P 500 Equal-Weight ETF – Benchmark.
3. Artificial Equal Weight with Drag – Simulated EW portfolio incorporating a realistic 0.55% annual cost drag.
4. Artificial Equal Weight with no Drag – Simulated Equal-Weight portfolio with only a minimal 0.20% expense ratio.

The actual RSP ETF was the worst performer across all metrics, delivering the lowest Total Return (1.1063) and the lowest Sharpe Ratio (0.5022), highlighting the significant real-world implementation inefficiencies.

Methodology

The Python program used Yahoo Finance to source the adjusted closing prices for current S&P 500 constituents and the Benchmarks (SPY, RSP). I then ran the four portfolios from January 2018 to October 2025. The data source was the adjusted closing price. I used S&P 500 constituents from Yahoo Finance. Survivorship bias could have been caused but due to sourcing the adjusted closing price for current S&P 500 constituents which included the historical data for these tickers even if they were not in the index for the entire period.

The comparison of two simulated equal-weight models against the RSP ETF provided a strong robustness check. The models confirmed the theoretical premium, while the RSP's failure to have the same premium showed the real-world failure of the strategy.

The portfolio was rebalanced to equal weights quarterly (every 63 trading days). The two artificial equal strategies used the annual expense ratio of 0.20%, which is applied to all simulated EW strategies. I then used an annual transaction cost (0.35%), which was applied only to the drag portfolio. The total annual drag is the sum of these two for the drag portfolio. The 0.35% transaction cost was chosen as a realistic estimate for the total cost associated with the annual portfolio turnover required for the quarterly rebalancing strategy.

The analysis assumed a 0% risk free rate for all Sharpe Ratio calculations, simplifying the measure to annualised excess return over total volatility.

Key Performance Metrics

	SPY – Market Cap	RSP (ETF)	Artificial EW (Drag)	Artificial EW (No Drag)
Total Return	1.7869	1.1063	1.9183	1.9986
Annualised Return	0.1412	0.1008	0.1480	0.1521
Volatility	0.1964	0.2007	0.2000	0.2000
Sharpe Ratio	0.7193	0.5022	0.7400	0.7601
Max Drawdown	-0.3372	-0.3904	-0.3841	-0.3839

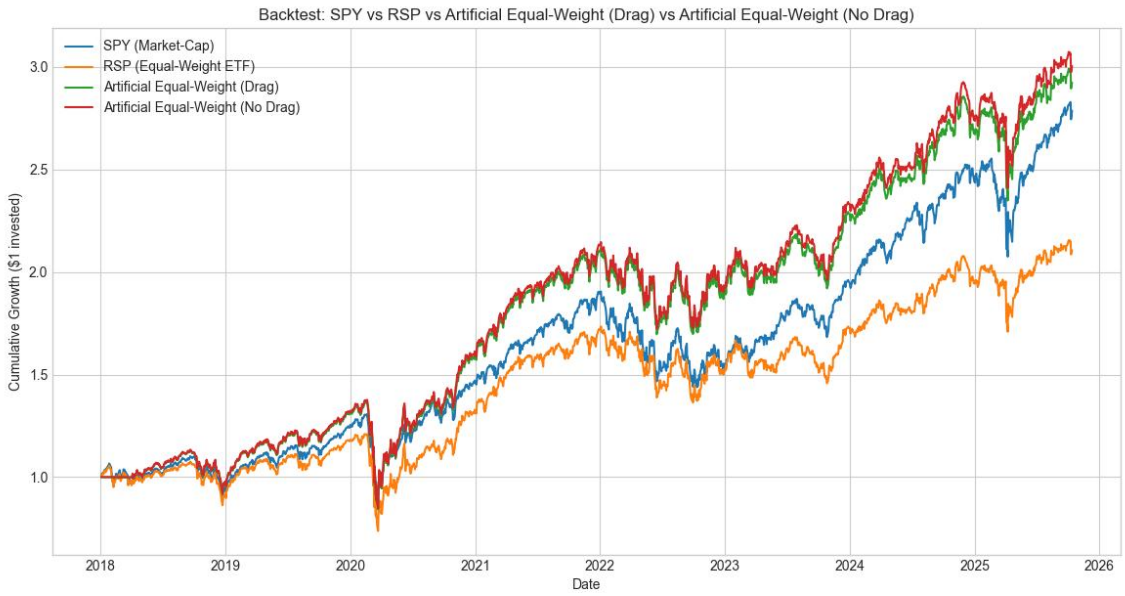
The Artificial EW (No Drag) portfolio is the best performer in the tests, generating a total return of 1.9986 and the highest Sharpe ratio, signifying the best risk adjusted return.

The difference in total return between artificial EW is 0.0803. This 8% difference in total gain over the 7.75-year period is directly proportional to the annual 0.35% trading transaction cost, demonstrating its large compounding negative impact.

The actual RSP ETF significantly underperformed all other strategies, including SPY. It has 1.1063 total return is extremely low for the period, indicating poor real-world execution or other implementation inefficiencies not captured by the simple 0.55% drag model.

Investment Growth Section

The figure below represents the cumulative growth of 1$ invested in each portfolio.



The Figure above shows that the artificial equal-weight portfolios were the clear growth leaders, generating a total return of close to $3.00 on a $1 investment from 2018. The

cumulative growth was plotted on a logarithmic scale to accurately depict proportional returns, allowing for a clearer comparison of compounding rates across the portfolios.

During 2020, all portfolios showed a decrease in cumulative returns. This was due to the COVID crash, leading to a drawdown and subsequent recovery. In 2022, we had a similar issue where all portfolios were affected by the rising interest rates and inflation.

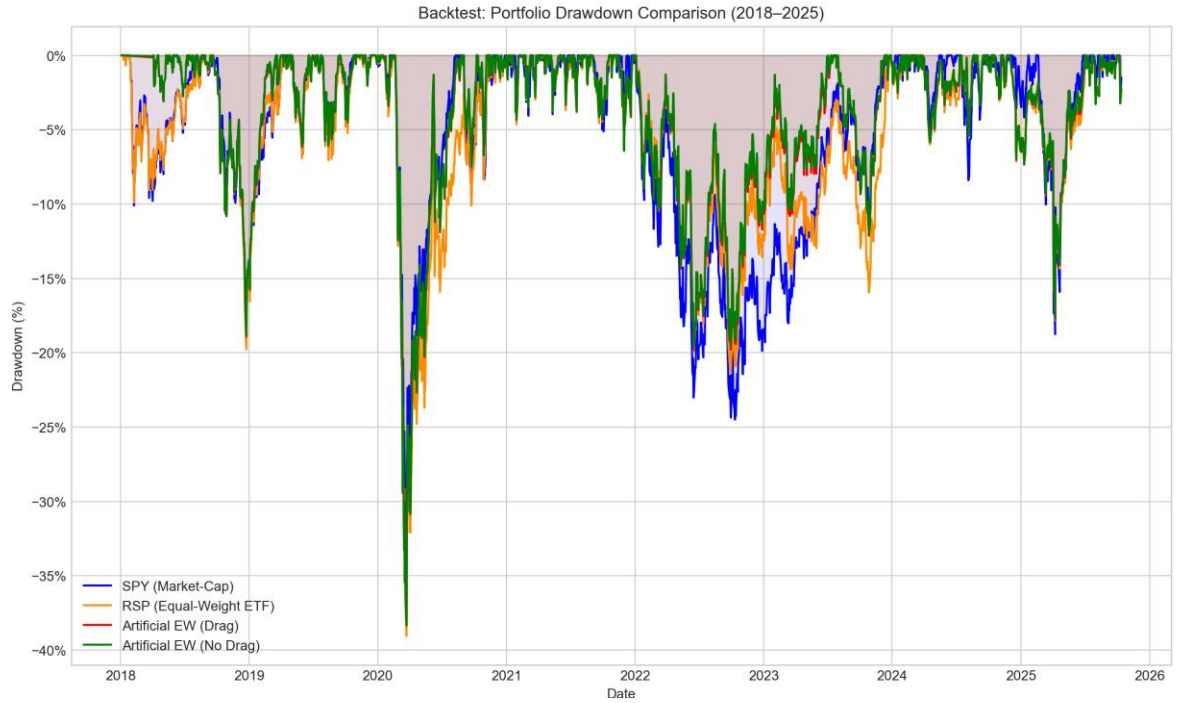
From 2023 to 2024, we saw an outperformance of the SPY, which was due to large-cap tech stock. Due to it not being equal weighted, there was more concentration on these large-cap tech stocks, leading to it pull ahead.

The Market-Cap weighted SPY was the next best performer, with an annualised return of 0.1412 and a total return of 1.7869. Throughout 2022 and 2023, there is an overlap between the RSP and the SPY, which shows the recovery after 2020 was weaker than SPY, leading to similar performance in the middle of the period before SPY pulled ahead in 2024.

The significant vertical gap between the best performer and the actual RSP visually demonstrates the substantial “real-world” inefficiency of the RSP over this period, which greatly exceeded the simple 0.55% drag assumption.

Risk Analysis:

Risk was quantified primarily using volatility and max drawdown. Volatility measures the day-to-day fluctuations around the average return, while the max drawdown measures peak to trough capital impairment. These metrics provide insight into the day-to-day fluctuations of returns and capital lost during the worst market. The figure below shows the portfolio drawdown comparison from 2018 to 2025.



The figure above showed that the market-cap weighted SPY exhibited the best risk profile in terms of capital preservation during major downturns, with the lowest max drawdown of -

0.3372. This is primarily caused to the greater concentration of less volatile stocks which fall less severely than smaller-cap stocks during corrections.

Equal-weight strategies had noticeably higher downside risk, with Max Drawdowns ranging from -0.3839 to -0.3904. This is because the approach has greater exposure to smaller-cap stocks and less financially robust companies compared to a market-cap weighted index. The volatility of these were higher than SPY, but the difference was 0.0036.

The RSP experienced the largest loss from peak to trough with a max drawdown of -0.3904, confirming its status as the worst performer.

Formulas for Performance Metrics

These were the following formulas used in the artificial equal-weight strategy.

Total Return	$\frac{Portfolio\ End}{Portfolio\ Start} - 1$	The cumulative gain or loss over the entire investment period.
Annualised Return	$(1 + Total\ Return)^{\frac{252}{Days}} - 1$	The constant annual rate of return that would yield total return
Volatility	$StDev(Daily\ Return)\ x\ \sqrt{252}$	The annualised standard deviation of daily returns (R_i)
Sharpe Ratio	$\frac{Annualised\ Return\ -\ Risk\ Free\ Rate}{Volatility}$	Measures the excess return per unit of total risk. The risk-free rate (R_f) was assumed to be 0 for model simplicity
Maximum Drawdown	$Min(\frac{Portfolio\ Value}{Highest\ Portfolio\ Value} - 1)$	Shows the maximum drawdown.

Conclusion

The artificial equal-weight (no drag) portfolio was the clear winner, achieving the highest Sharpe ratio of 0.7601. This indicates that the Equal-Weight strategy generated the best return for the level of risk taken. Crucially, the comparison between the strategies quantified the impact of transactional costs:

1. Cost-Drag Quantified: The 0.35% annual transaction cost alone, when compounded over the 7.75-year period, reduced the total gain of the strategy by 8.03%. This shows the importance of minimizing implementation costs for high-turnover strategies.
2. Implementation Inefficiency: The actual RSP's underperformance highlights the real-world inefficiencies other than annual transaction costs. The models suggest other operational costs that were not captured by the simple models which neutralize the premium for investors.

The choice of a low-cost execution platform is paramount to obtain the theoretical return premium. While equal weight offers higher potential returns, it exposes the portfolio to greater drawdown risk.

References

Yahoo Finance Risk - https://uk.finance.yahoo.com/

S&P Dow Jones Indices - https://uk.finance.yahoo.com/quote/%5EGSPC/

Invesco - https://uk.finance.yahoo.com/quote/RSP/

freeCodeCamp.org. "Algorithmic Trading Using Python - Full Course.", YouTube - https://www.youtube.com/watch?v=xfzGZB4HhEE