Spring Valley
Asset Management

Research Series

Rebalancing Luck

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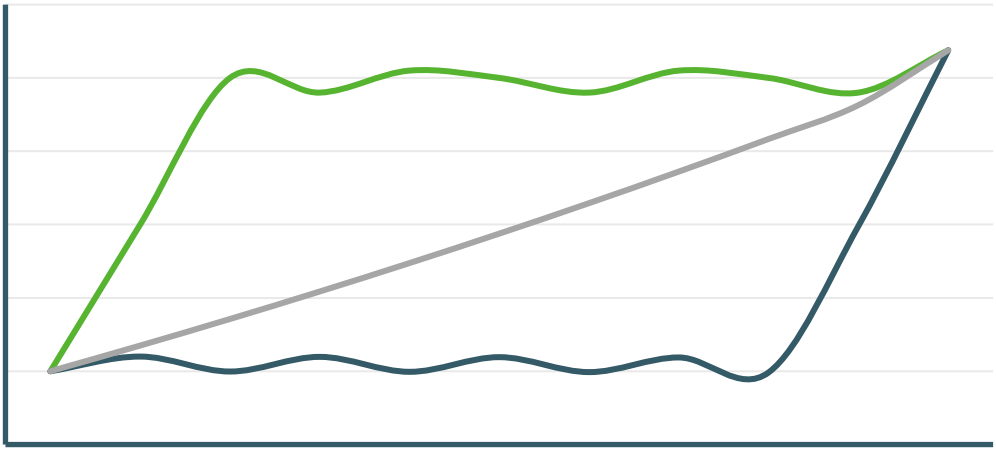
Rebalancing is an essential piece of the portfolio management process. It allows us to evaluate new information and align the portfolio with our target allocations. The frequency of rebalancing is generally well informed. It reflects several critical factors, including alpha decay, transaction costs, and taxes. However, *when* the portfolio rebalances often goes overlooked. As demonstrated in [1, 2, 3], this can have a profound impact on realized performance. The dispersion in outcomes across portfolios using identical strategies but rebalanced on different dates is the result of path dependency. For our application, we call it rebalancing luck.

Exhibit 1

Path dependency illustration



Source: Spring Valley Asset Management. For illustrative purposes only.

Path dependency describes how initial conditions impact the future path of events. For example, consider the arrangement of letters on a keyboard. In the early 1870s, typewriters had a mechanical issue. When neighboring keys were hit in rapid succession, the hammers would collide. To mitigate the problem, they separated the most common pairs of letters. The result became known as QWERTY, the first six letters on the top alphabetic line. Over time, typists became proficient with QWERTY. This created a barrier to change, even as technology improved. We no longer use typewriters, and more efficient designs exist, yet we still use this layout today.

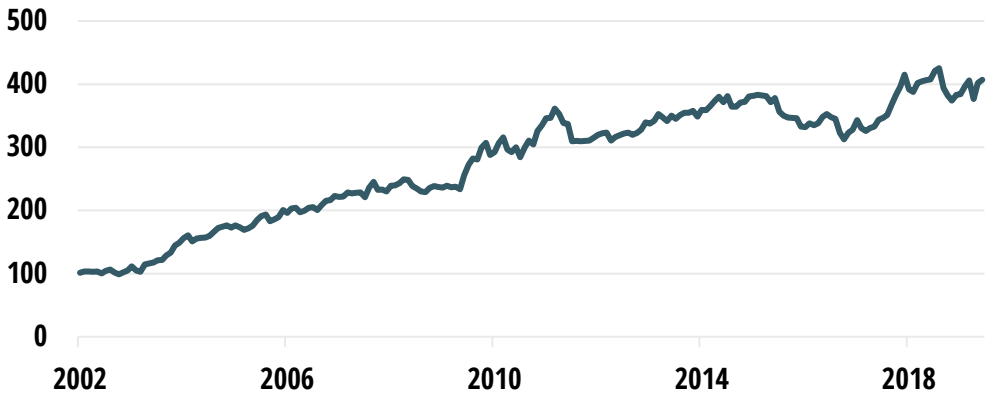
Exhibit 2

QWERTY keyboard layout

To investigate the significance of path dependency, we will use a simple strategy developed in Faber [4]. If the current price is above the 10-month moving average, the investor goes long the asset class. If the current price is below the 10-month moving average, the investor goes to cash. We apply this logic to the total return indices of the S&P 500, MSCI EAFE, S&P GSCI, U.S. 10-year note, and FTSE NAREIT. We then combine them into a portfolio with equal weights and rebalance every 21 days. Also, we target 10% volatility using the prior 36 months of returns with a 200% cap on gross exposure.

Exhibit 3

Cumulative returns



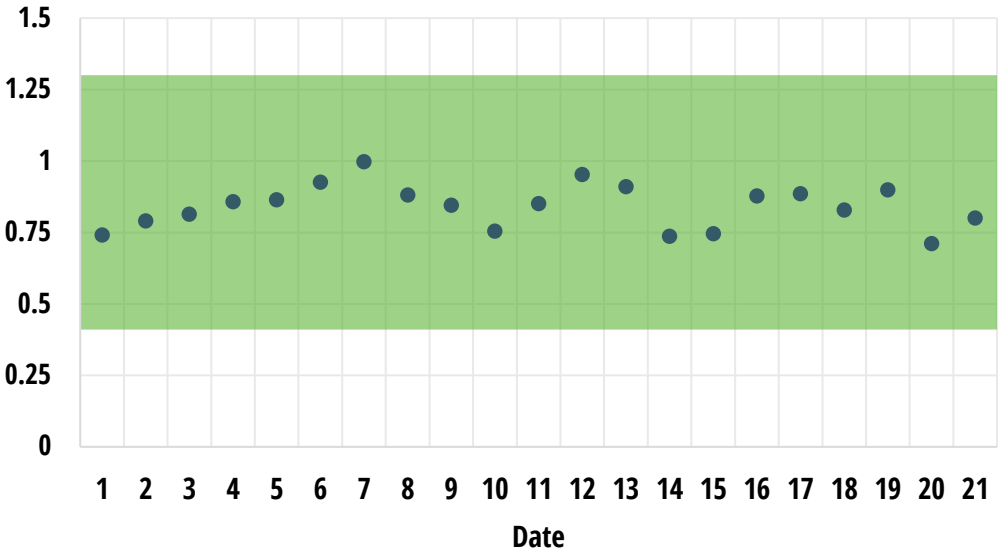
Source: Spring Valley Asset Management, Bloomberg

	Strategy
Ann. Return	8.35%
Ann. Volatility	10.77%
Sharpe	0.80

Exhibit 3 displays the results using this approach. While the performance is attractive, this is only one representation of the strategy. For example, consider non-overlapping periods of 21 days. We can rebalance on the first day of each period, the last day of each period, or any day in between. With a 21-day rebalance frequency, there are 21 dates on which we can choose to rebalance. Portfolio managers generally anchor rebalancing around transitions in the calendar. For example, the first or last day of each month. This choice introduces path dependency.

Exhibit 4

Sharpe ratios for each rebalance date and 95% confidence interval

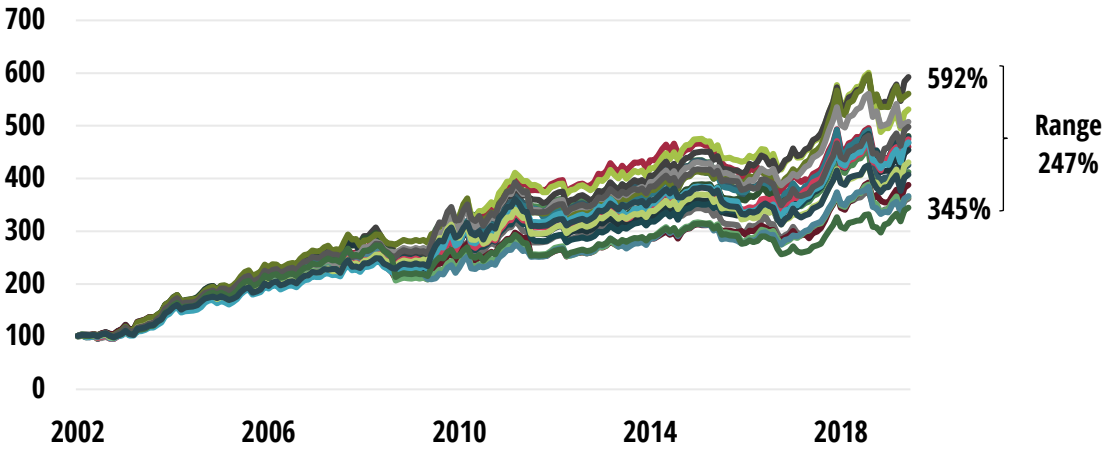


Source: Spring Valley Asset Management, Bloomberg

We begin by creating 21 portfolios. Each portfolio uses the same strategy but rebalances on different dates. Exhibit 4 plots the Sharpe ratios for each date and the 95% confidence interval using the approach in Lo [5]. While we observe a wide range of outcomes, the Sharpe ratios are statistically indistinguishable from one another. In other words, differences in performance are likely due to random noise. However, as we can see in Exhibit 5, there is a large amount of dispersion in total returns. The total return spread between the best and worst-performing dates was 247% over our sample.

Exhibit 5

Cumulative returns across rebalance dates



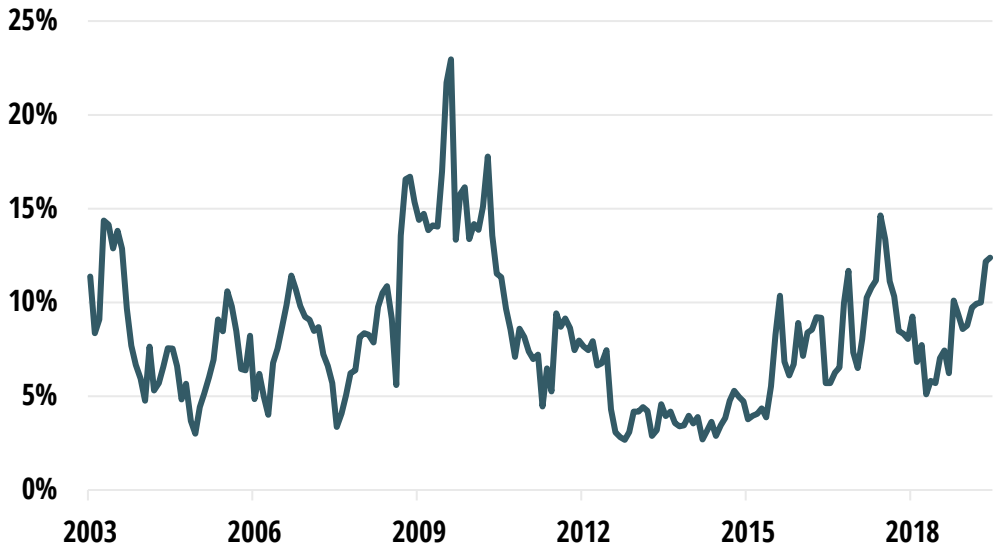
Source: Spring Valley Asset Management, Bloomberg

Day	Ann. Return	Ann. Volatility	Sharpe
1	7.63%	10.71%	0.74
2	8.43%	11.03%	0.79
3	8.62%	10.93%	0.81
4	9.12%	10.90%	0.86
5	9.21%	10.91%	0.86
6	10.01%	10.99%	0.93
7	10.70%	10.81%	1.00
8	9.39%	10.88%	0.88
9	9.03%	10.97%	0.85
10	8.06%	11.11%	0.76
11	9.36%	11.29%	0.85
12	10.36%	11.02%	0.95
13	9.72%	10.88%	0.91
14	7.68%	10.87%	0.74
15	7.71%	10.75%	0.75
16	9.30%	10.84%	0.88
17	9.23%	10.63%	0.89
18	8.70%	10.80%	0.83
19	9.61%	10.90%	0.90
20	7.33%	10.80%	0.71
21	8.35%	10.77%	0.80

In addition, short-term differences in performance can be substantial. Exhibit 6 plots the total return spread between the best and worst-performing dates over rolling 12-month periods. We can see that differentials can reach up to 23% over 12 months. These spreads are entirely explained by when each portfolio rebalanced.

Exhibit 6

Rolling 12-month return differential between the best and worst performing date

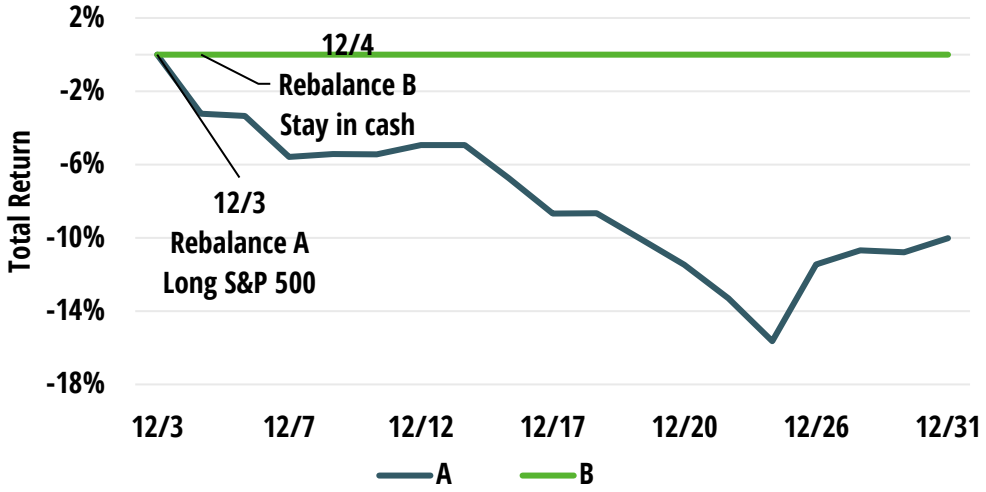


Source: Spring Valley Asset Management, Bloomberg

Exhibit 7 shows a specific example of the strategy applied to the S&P 500 in December 2018. If the portfolio rebalanced on December 3rd, we would have gone from cash to long the S&P 500. However, if the portfolio rebalanced on the 4th, our signal would have kept us in cash. Despite being only one day apart, the difference in performance approached 16% during the month.

Exhibit 7

Example of different results for neighboring rebalance dates applied to the S&P 500

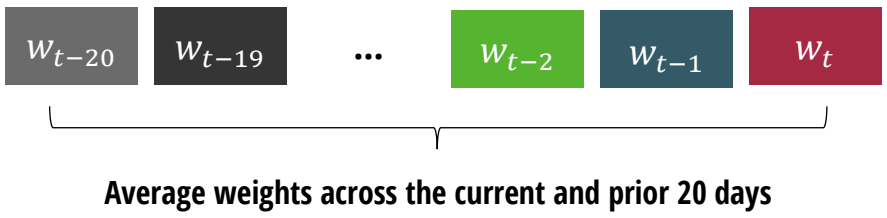


Source: Spring Valley Asset Management, Bloomberg

We have shown that path dependency can result in a substantial amount of variability over time. Also, we have determined that differences in performance across dates are statistically insignificant. Therefore, our best estimate for the future Sharpe ratio of any date is the average across all dates. Any deviation from that average is an uncompensated source of risk. As studied in [1, 2], we reduce this risk using a novel approach called partitioning. Each day, we take the average of the weights over the current and prior 20 days. In other words, we equally weight 21 overlapping sub-portfolios. Each sub-portfolio uses the same methodology and frequency but rebalances on a different date.

Exhibit 8

Partitioning illustration

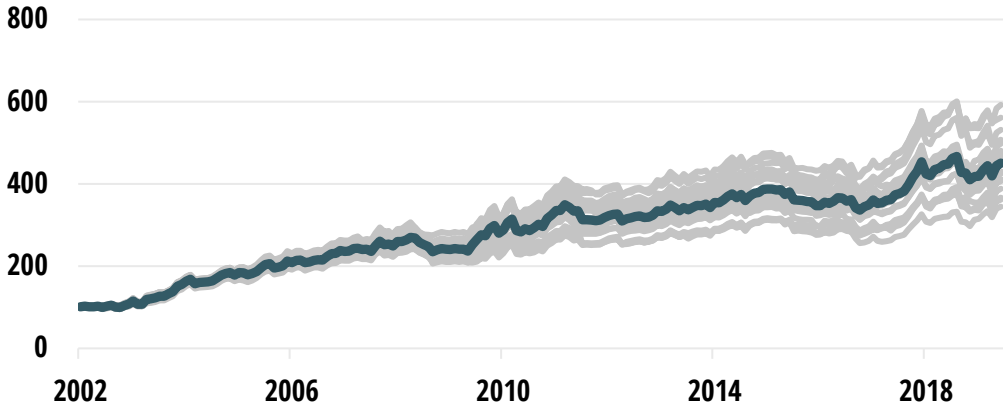


Source: Spring Valley Asset Management. For illustrative purposes only

Exhibit 9 displays the results of the partitioned portfolio in the context of all dates. We see that it tracks the average very closely. Also, the average Sharpe ratio across each rebalance date is .84. Whereas the Sharpe ratio for the partitioned portfolio is .88. Since the signals across dates are imperfectly correlated, we realize a diversification benefit.

Exhibit 9

Cumulative returns to partitioned portfolio

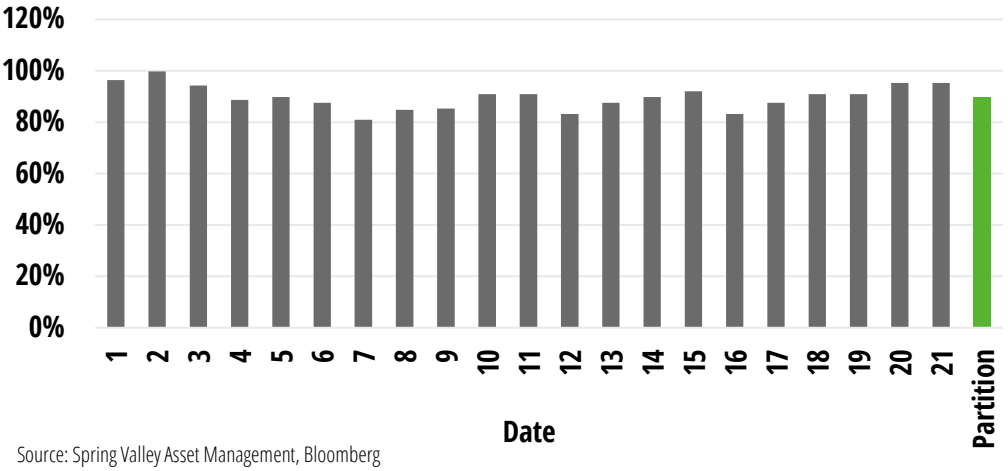


Source: Spring Valley Asset Management, Bloomberg

Since we rebalance every day as opposed to every 21 days, it might be natural to assume turnover would increase. However, as shown in Exhibit 10, it does not. Since we are averaging weights across time, the weights become smoothed. Also, because of disagreement across dates, there are offsetting positions.

Exhibit 10

Average annual one-way turnover by rebalancing date and partitioning



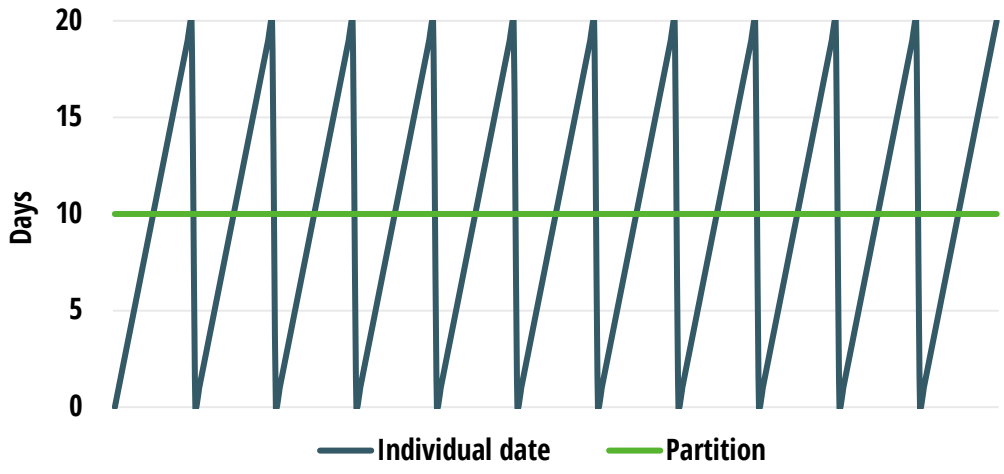
Source: Spring Valley Asset Management, Bloomberg

Partitioning can reduce slippage and market impact as well. For example, instead of rebalancing the entire portfolio in one day each month, we only need to adjust about 5% of the portfolio every day. Also, large portfolios are generally unable to rebalance over the course of a single day. They are forced to delay the trades. Depending on the nature of the signals, there can be a substantial degradation in performance.

We have also seen that partitioning minimizes the deviation from the average portfolio. One way to understand this result is by observing the age of our signals. Exhibit 11 displays the age of a portfolio rebalanced every 21 days and one that uses partitions. The age of signals rebalanced every 21 days is variable over time. For example, when we rebalance, our positions reflect the most recent signals. Whereas the day before rebalancing, our signals are 20 days old. The average age over time is 10 days. However, using the partitioned approach, the average age across the portfolio at any point is 10 days. It is constant across time. Also, almost 5% of the portfolio always represents the most up-to-date signals while preserving our choice of holding period.

Exhibit 11

Age of signals calculated as days since rebalance



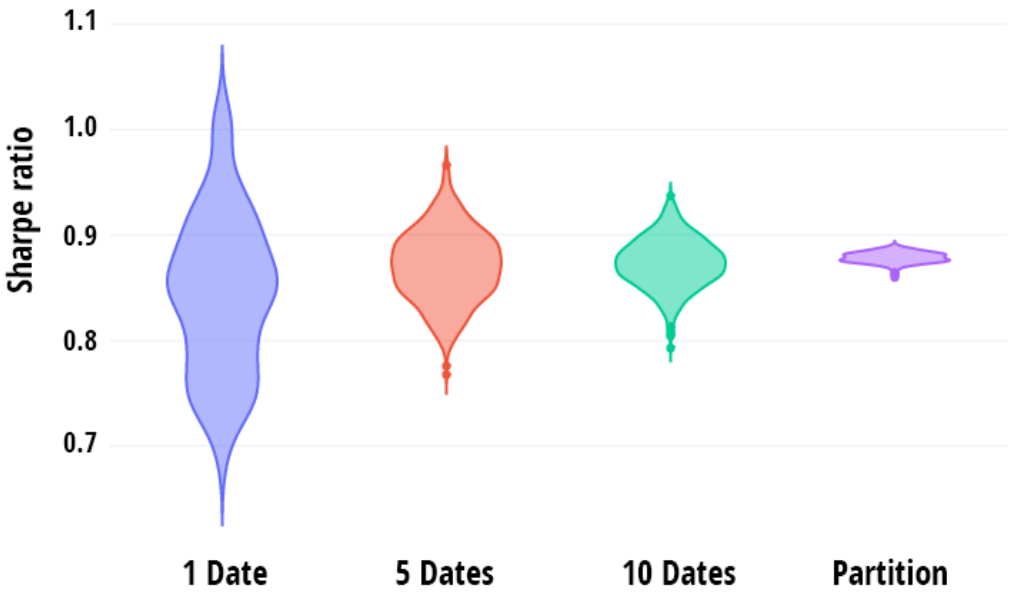
Source: Spring Valley Asset Management, Bloomberg

To prove the robustness of partitioning, we will introduce a small amount of random noise. As in [6], we will add a series of random numbers drawn from a normal distribution with a mean of 0% and a standard deviation of

.025% to the daily returns of each asset class. For U.S. 10-year notes, we use a standard deviation of .01%. We then run the strategy on our slightly modified history. The returns from a specified number of dates are chosen at random and combined into a portfolio. We repeat this process 1000 times for each random combination of 1, 5, and 10 dates. We will apply this process to a partitioned portfolio as well. Exhibit 12 plots the distribution of Sharpe ratios. We see that the distributions contract as the number of dates increases. Also, the partitioned approach yields the narrowest distribution of Sharpe ratios.

Exhibit 12

Distribution of Sharpe ratios for randomly sampled date combinations with noise

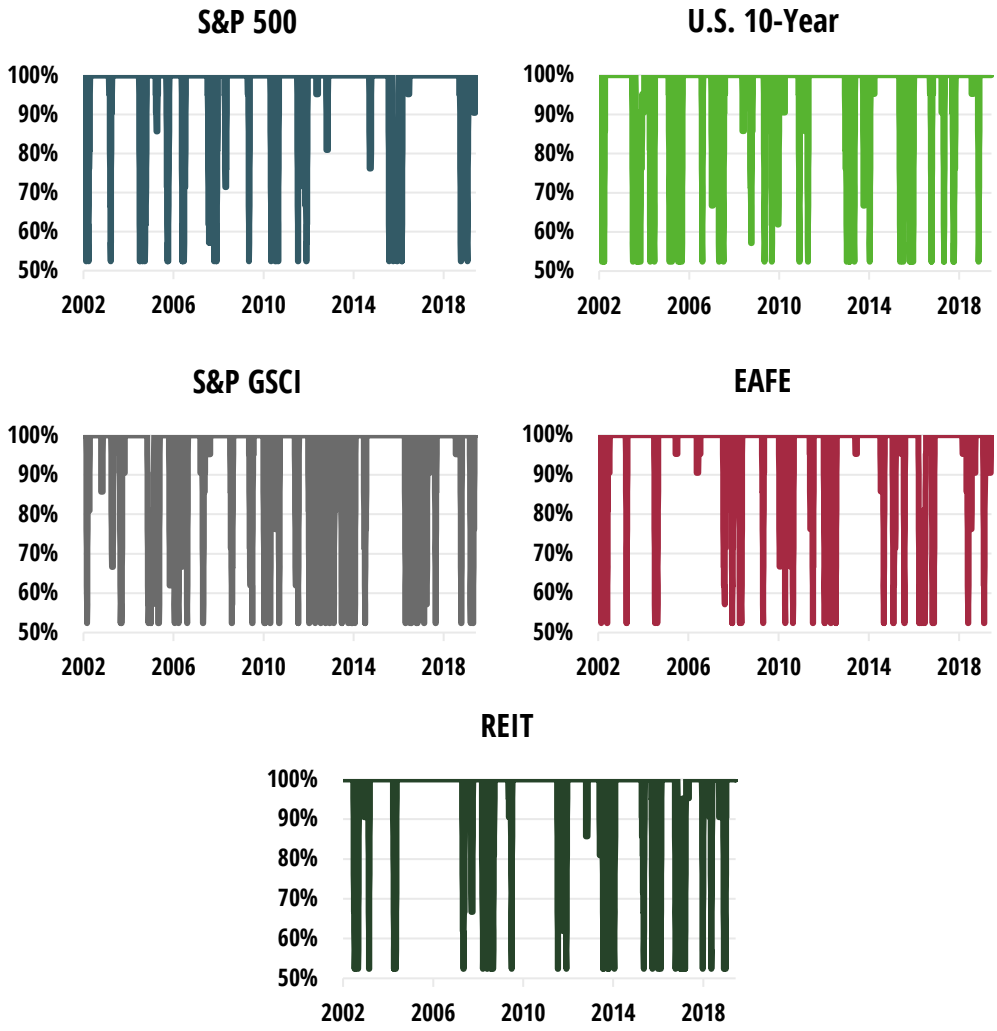


Source: Spring Valley Asset Management, Bloomberg

One explanation for this result is that partitioning scales in and out of positions across time. The amount of agreement across sub-portfolios acts as a level of conviction. As agreement increases, we can be more confident that we are not capturing short-term noise. This is important considering the most significant technical risk to a trend following system is whipsaws. A partitioned portfolio is less susceptible to whipsaws and random noise.

Exhibit 13

Percentage of signal agreement between rebalance dates



Source: Spring Valley Asset Management,

The implications of path dependency are tremendous. Two managers using the same investment process but rebalancing on different dates can realize substantially different results. For example, when we injected a small amount of noise, the distribution of Sharpe ratios ranged from .67 to 1.04 across individual dates. With a 10% volatility target, one manager can realize annualized returns of approximately 6.7% and the other 10.4%. This differential is significant, and as we have seen, can reach up to over 20% over short time frames. However, it is entirely the result of rebalancing luck,

not investment skill. As stated in Hoffstein et al. [2], it can be "the difference between hired and fired." Therefore, since differences in performance are likely due to randomness, our goal should be to minimize this risk. Our solution is portfolio partitioning. We have demonstrated that it can diminish path dependency and achieve greater stability of outcomes.

References

[1] D. Blitz, B. van der Grient, P. van Vliet, 2010, *Fundamental Indexation: Rebalancing Assumptions and Performance*, Journal of Index Investing, Vol.1, No. 2, 82-88.

[2] C. Hoffstein, J. Sibears, N. Faber, 2019, *Rebalance Timing Luck: The Difference Between Hired and Fired*, Available at SSRN: https://ssrn.com/abstract=3319045

[3] ReSolve Asset Management, 2018, *Same Same But Different*, https://investresolve.com/blog/same-same-but-different/

[4] M. Faber, 2007, *A Quantitative Approach to Tactical Asset Allocation*, Available at SSRN: https://ssrn.com/abstract=962461

[5] A. W. Lo, 2002, *The Statistics of Sharpe Ratios*, Financial Analysts Journal 58(4), 36-52.

[6] C. Hoffstein, 2018, *What do portfolios and teacups have in common?*, https://blog.thinknewfound.com/2018/12/what-do-portfolios-and-teacups-have-in-common/

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