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Kirkland, September 15th, 2022

Hello Travis,

Please find our research regarding strategies for momentum-trading individual stocks.

Thank you,
Best regards.

Felix Bertram

Introduction

When we started developing momentum strategies, we noticed that the lookback period for measuring momentum is of critical importance: the results of a strategy change significantly, based on the lookback period used, and no single lookback period works for all markets.

We developed the multi-period momentum indicator to overcome this issue, and progress toward a scheme where the strategy can, within limits, self-adapt to use the best-suited lookback period. And while we have seen some success with this approach, the report #13 has also shown the limitations.

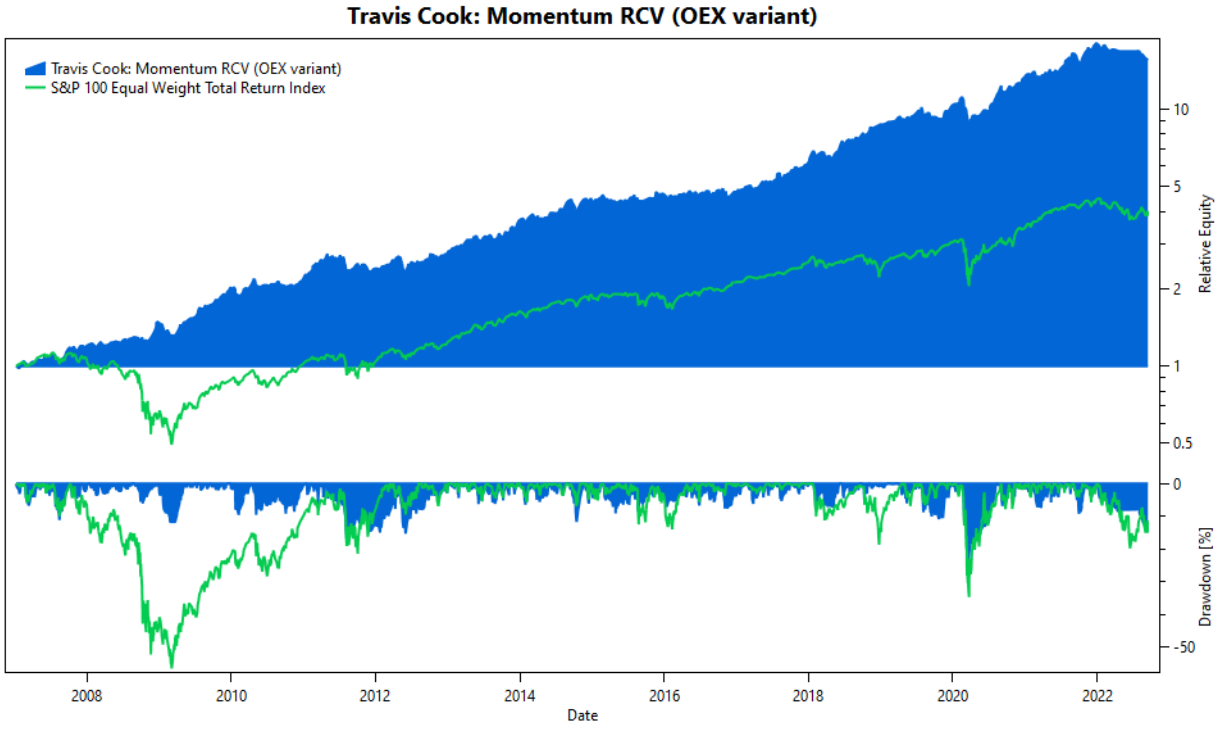
Mr. Cook is looking to trade individual stocks using momentum. Because of the limitations we noticed with the multi-momentum approach, we decided that basing such a strategy on the same algorithm core was likely not the best approach. Further, the algorithm core would have required significant updating to support universes in which constituents change over time, such as typical stock indices including SPX, OEX, and NDX.

Consequently, we decided to develop a new algorithm core from scratch. Here is the main concept:

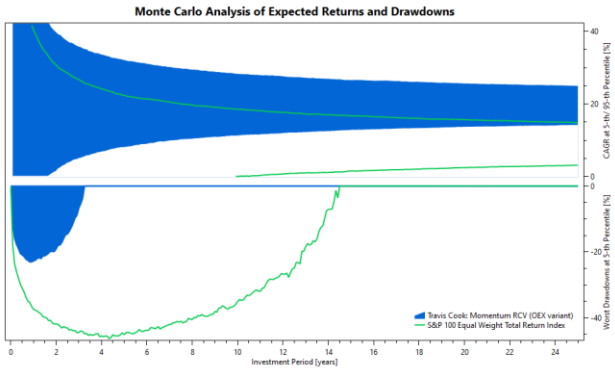
- Ultimately, any momentum strategy is more interested in the ranking of assets than the calculated momentum. Consequently, we focus more on improving the ranking of assets than improving the momentum calculation.
- As a compromise between fast response and holding a reasonably steady course, we settled on a weekly trading schedule.
- As a precursor to ranking assets, we determine asset candidates. We use a simple moving-average crossover trend-following mechanism to do so.
- We begin with calculating momentum over a number of lookback periods. Here, we chose 10 intervals, ranking from 3 to 12 months.
- For each lookback interval we create one ballot. On each ballot, we rank all asset candidates by their momentum over the respective interval.
- We select the winning assets using the multi-winner ranked choice method (see MULTI-WINNER RCV - Ranked Choice Voting). In particular, we are using a method were surplus votes are transferred to the next-ranked asset as fractions (Minneapolis method).
- We then allocate capital to the winning assets. We use a fixed-fraction approach here, where we aim to allocate capital such that the daily risk is a fixed fraction of the account value. Further, we limit the maximum position size to ensure a minimum level of diversification.
- We allocate unused capital to a safe asset.
- As an additional twist, we use a market-regime filter. This filter has a trend-following and a breadth component. The trend-following aspect uses a simple moving-average crossover over an equal-weighted index of the tradable assets. The breath component is a simple cutoff, based on the number of assets in a downtrend. If the market-regime filter indicates bearish conditions, we no longer allow buying any shares of the main universe. Consequently, we can neither open new positions, nor increase existing positions. However, we do not exit positions based on the market regime.

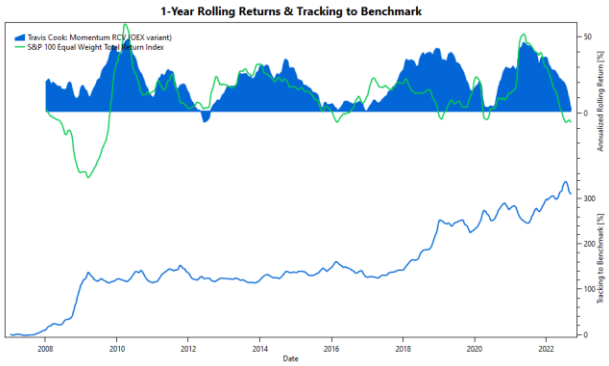
Trading S&P-100

As an initial test, we traded stocks from the S&P-100 (OEX) between 2007 and 2022. As a safe-asset, we use our bond-rotation strategy. Here are the results after optimizing the strategy parameters:



Metric		Travis Cook: Momentum RCV (OEX variant)	S&P 100 Equal Weight Total Return Index
Simulation Start	01/08/2007	$1,000.00	$1,000.00
Simulation End	09/14/2022	$15,757.81	$3,849.35
Simulation Period	15.7 years		
Compound Annual Growth Rate		19.22%	8.98%
Stdev of Returns (Monthly, Annualized)		13.76%	16.44%
Maximum Drawdown (Daily)		26.19%	56.99%
Maximum Flat Days		522.00 days	1605.00 days
Sharpe Ratio (Rf=T-Bill, Monthly, Annualizec		1.23	0.47
Beta (To Benchmark, Monthly)		0.42	- benchmark -
Ulcer Index		5.24%	13.48%
Ulcer Performance Index (Martin Ratio)		3.67	0.67





All of these charts and metrics look very encouraging. We make the following observations:

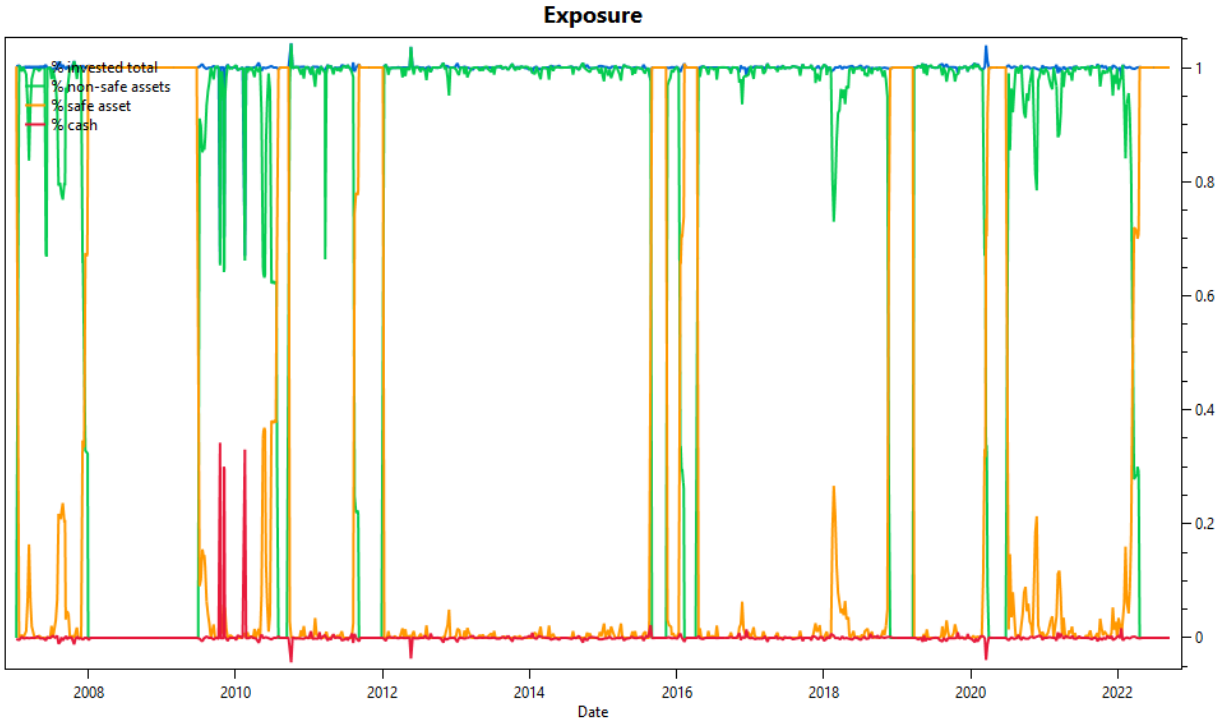
- The strategy has a massive upside over its benchmark. Especially during recessions and after 2018, the strategy gained over the equal-weighted OEX index.
- The strategy has rarely produced negative 12-months rolling returns. 2012 is a notable exception here.
- The strategy offers high risk-adjusted returns. Namely, the Sharpe Ratio exceed 1.2 and the Martin Ratio exceeds 3.6.
- The strategy suffers a bit from the recent drawdowns in the bond rotation component. As discussed previously, this drawdown is caused by a suboptimal market-regime filter.

In the following, we want to discuss some of the observations we made during the implementation of the strategy. The first parameter is the list of periods to observe momentum over. We found that a list with 10 entries, representing 3 to 12 months is sufficient. Adding more periods, e.g. going to weekly observations did not change results. However, changing the shortest period from 3 months to 1 or two month did have a negative effect on the results.

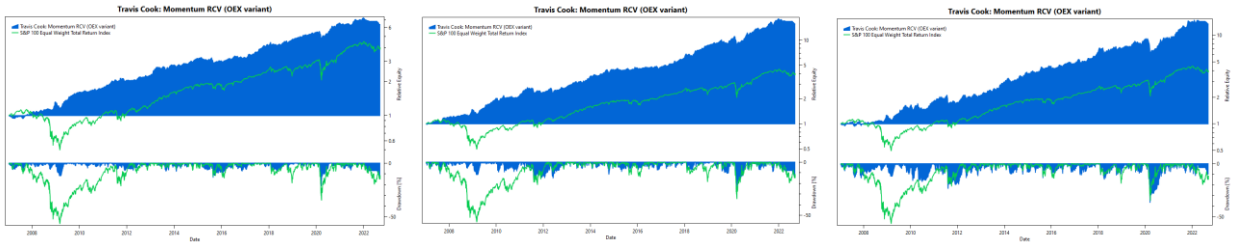
The strategy uses trend filters to disqualify individual stocks, and as one component of the market-regime filter. In the former case, the trend filter runs on the stock price, in the latter it runs on an internal equal-weighted index across all assets in the universe. All filters use the same parameters for a simple moving-average crossover mechanism. We found that the strategy is relatively immune to changes in these parameters.

The chart above shows the market breadth, and the market-regime filter in action. We see some whipsaws here, which might be worth improving. However, the strategy is much less sensitive to these

whipsaws, the market-regime filter does not force an exit to safety. Instead, it only inhibits buying shares from the universe, which is a much less aggressive approach.



To determine its position sizes, the strategy uses a fixed-fraction approach, where the daily risk exposure is kept below a threshold level. Because smaller position sizes also affect the strategy's total returns, reduced exposure due to higher volatility needs to be taken into account when ranking the assets. The chart above shows how position sizes are reduced to control risk. We are looking to adjust risk level such that the strategy runs close to the threshold, but rarely exceeds it.



There are two parameters controlling this mechanism. For once, there is the risk level, which controls position size and with that directly affects the asset's momentum. Further, there is an additional penalty factor, which increases the weight of the exposure during the initial ranking of the assets. This parameter controls how much to push assets with higher volatility down in the ranking. We've been able to come up with good results, but tweaking these parameters is finicky. The charts above show the results at 1.50%, 2.75%, and 5.00% risk setting. Further research needs to be done to improve this mechanism.

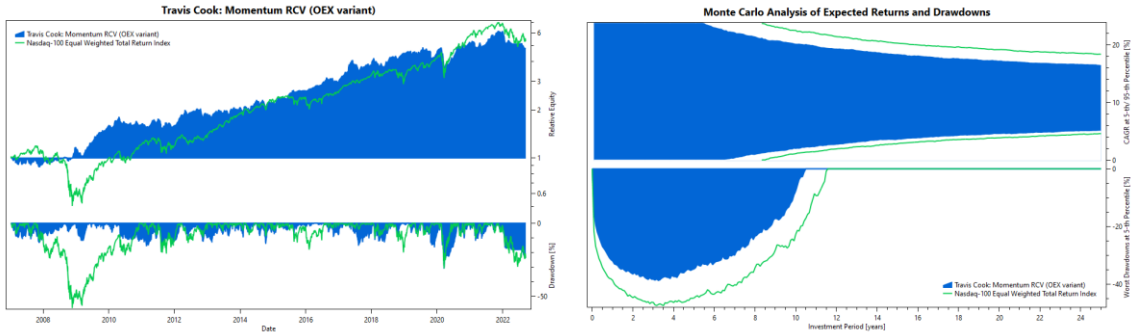
It is possible, that we've been attempting to be overly precise when adjusting the asset momentum for position size. It might be better to take some liberties here and make sure that the ranking order is always independent from the strategy's risk setting. Further research would be required to come to a final conclusion.

As we can see, risk assessment is an important part of the strategy. There are many different ways of measuring risk, including volatility, average trading range, drawdown, ulcer index, and many more. We noticed that the formula should include some means to detect peaks, and hold them for some time. This type of mechanism makes sure that we can use relatively short time constants, without inducing too much noise into the asset ranking.

Another important set of parameters concerns the number of positions to hold, and the maximum position size in case not all positions can be filled. As a general rule of thumb, less positions will lead to higher returns but also higher volatility. In bearish times, the number of candidate assets might not be enough to fill all positions. Under these circumstances, there is more capital available for each position. We want to limit the maximum capital assigned to a single asset, to enforce a minimum level of diversification. We achieved excellent results with only three positions, and imposing a limit of 34% of capital for a single stock.

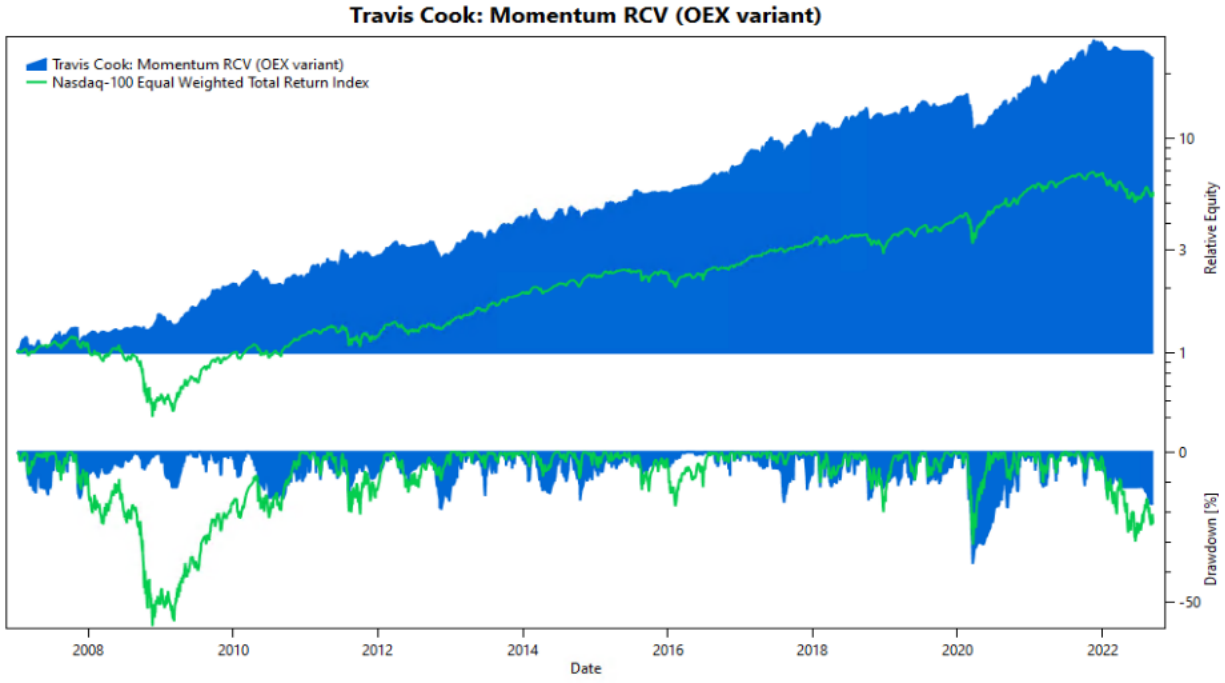
Trading Nasdaq-100

To prove the strategy's validity, we like to trade it with other universes. As a first experiment, we replace OEX with NDX, the Nasdaq-100 index. All of the strategy's parameters remain unchanged.

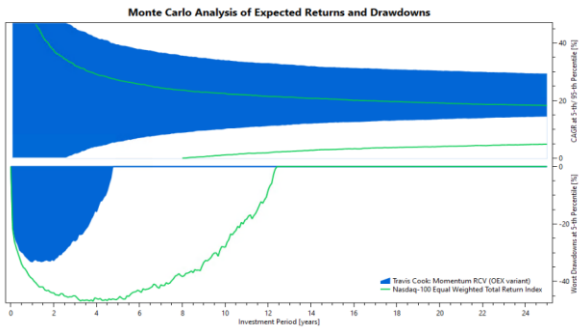


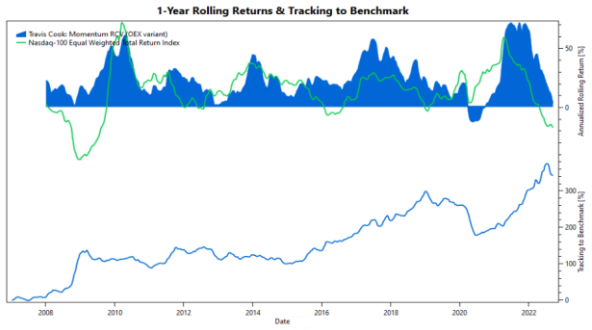
This result is disappointing. While the strategy does provide some steady returns and somewhat limits drawdowns, the Monte Carlo simulation shows that the reduction in volatility is not enough to justify the effort.

Based on the observations above, we tuned the strategy's overall risk threshold, and the penalty factor for reduced position sizes. By just tuning these two parameters, we've been able to achieve outstanding results:



Metric		Travis Cook: Momentum RCV (OEX variant)	Nasdaq-100 Equal Weighted Total Returr
Simulation Start	01/08/2007	$1,000.00	$1,000.00
Simulation End	09/14/2022	$23,761.92	$5,347.03
Simulation Period	15.7 years		
Compound Annual Growth Rate		22.39%	11.28%
Stdev of Returns (Monthly, Annualized)		18.63%	18.67%
Maximum Drawdown (Daily)		37.29%	58.01%
Maximum Flat Days		314.00 days	1155.00 days
Sharpe Ratio (Rf=T-Bill, Monthly, Annualizec		1.01	0.53
Beta (To Benchmark, Monthly)		0.55	- benchmark -
Ulcer Index		7.87%	13.76%
Ulcer Performance Index (Martin Ratio)		2.84	0.82

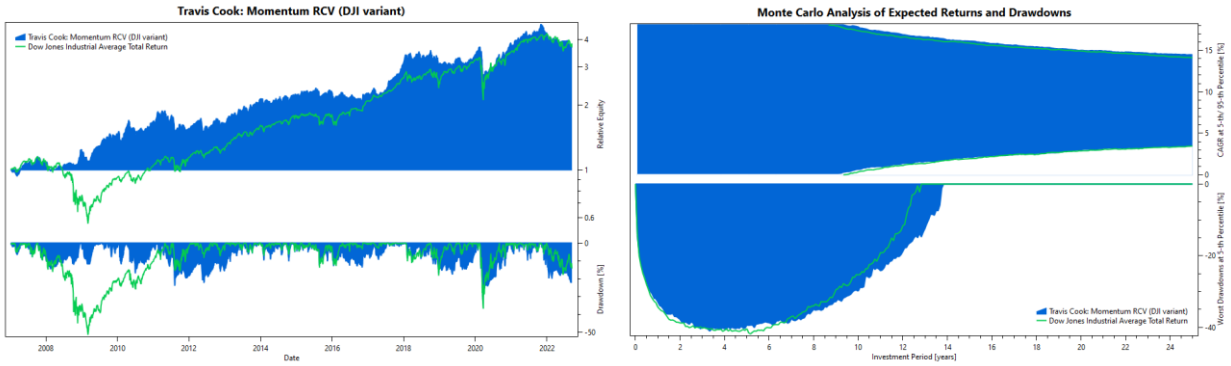




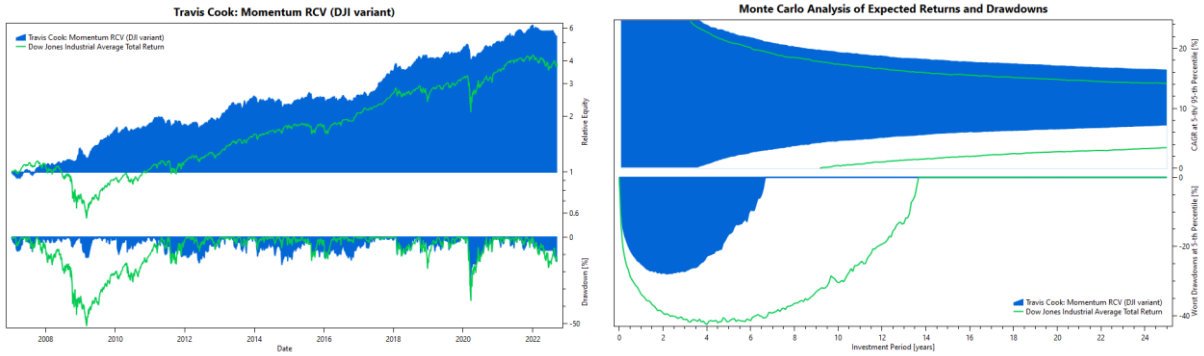
The strategy outperforms its benchmark since 2015, while at the same time offering lower drawdowns, faster recovery and approximately the same volatility.

Trading Dow Jones Industrial Average

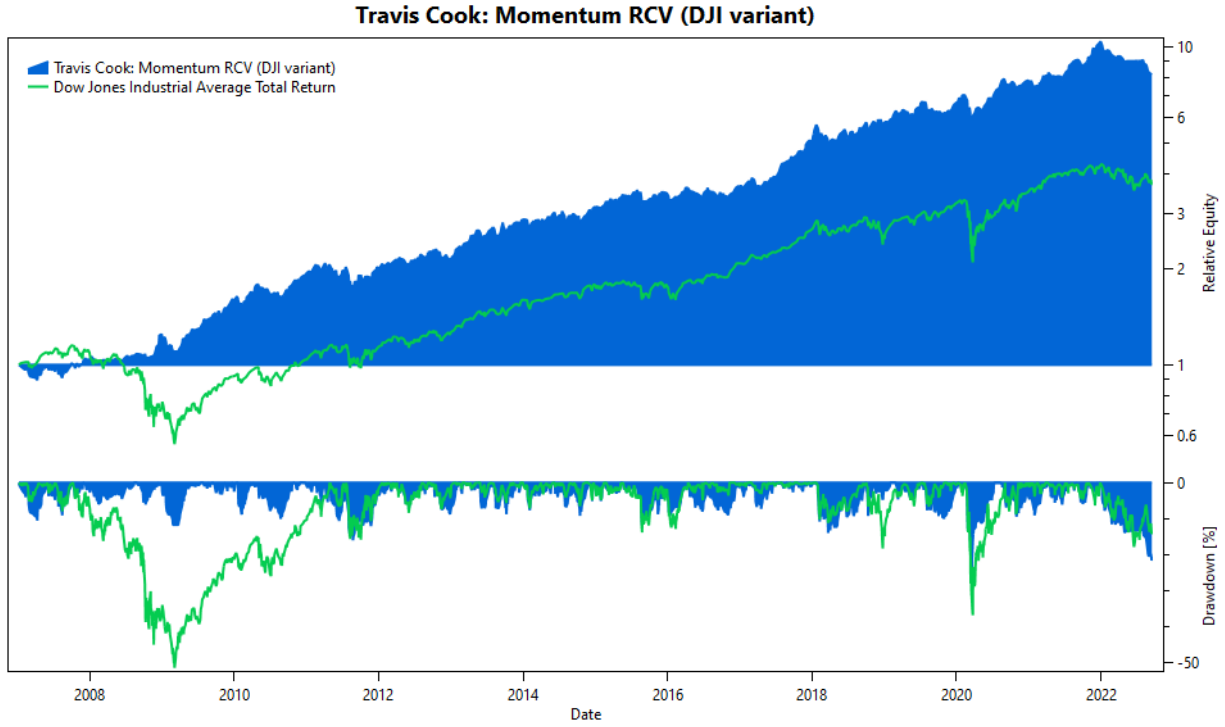
Similar to before, we try the strategy on the Dow Jones Industrial Average, DJI.



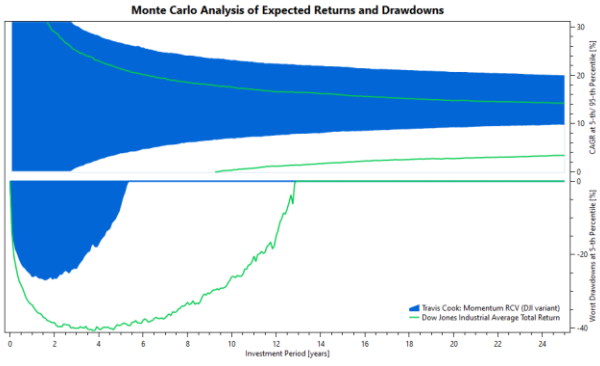
And as before, the strategy backtest shows reduced drawdowns in the 2008 recession, but the Monte Carlo simulation shows no benefit over buy-and-hold. Next, we optimize the two parameters for the strategy's risk threshold and excess risk penalty.

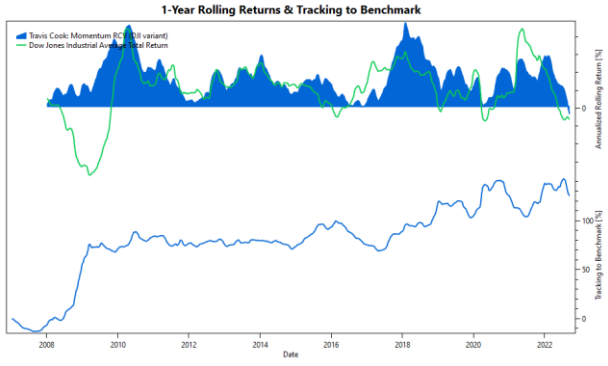


With these parameters tweaked, the Monte Carlo chart shows some improvements. However, this is likely still not enough to satisfy investors. We suspect that the small and skewed universe might be part of the issue. Therefore, we adjusted the breadth threshold for the market regime filter, but saw only minor improvements from doing so. More meaningful improvements came from adjusting the time constants used in the trend-following filters. Ultimately, we went adjusted all of the strategy's parameters to achieve the desired performance.



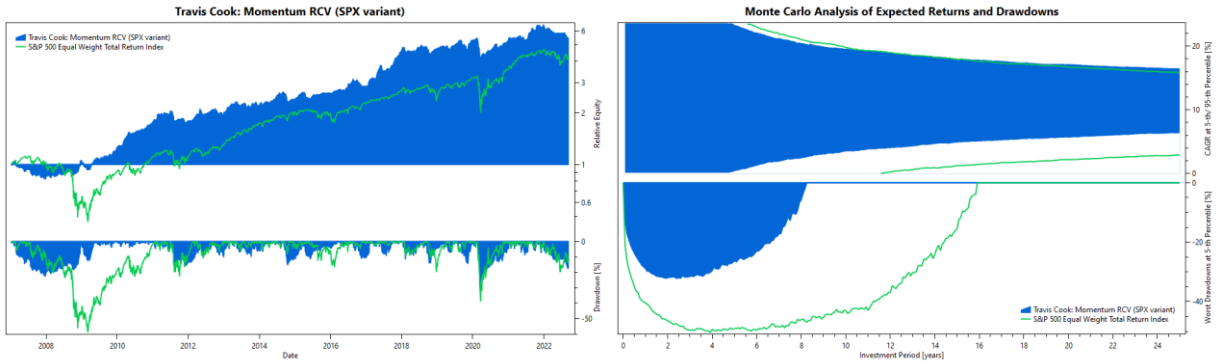
Metric		Travis Cook: Momentum RCV (DJI variant)	Dow Jones Industrial Average Total Return
Simulation Start	01/08/2007	$1,000.00	$1,000.00
Simulation End	09/14/2022	$8,190.76	$3,702.66
Simulation Period	15.7 years		
Compound Annual Growth Rate		14.35%	8.71%
Stdev of Returns (Monthly, Annualized)		13.59%	15.04%
Maximum Drawdown (Daily)		24.21%	51.78%
Maximum Flat Days		290.00 days	1298.00 days
Sharpe Ratio (Rf=T-Bill, Monthly, Annualizec		0.95	0.50
Beta (To Benchmark, Monthly)		0.55	- benchmark -
Ulcer Index		5.45%	12.40%
Ulcer Performance Index (Martin Ratio)		2.63	0.70





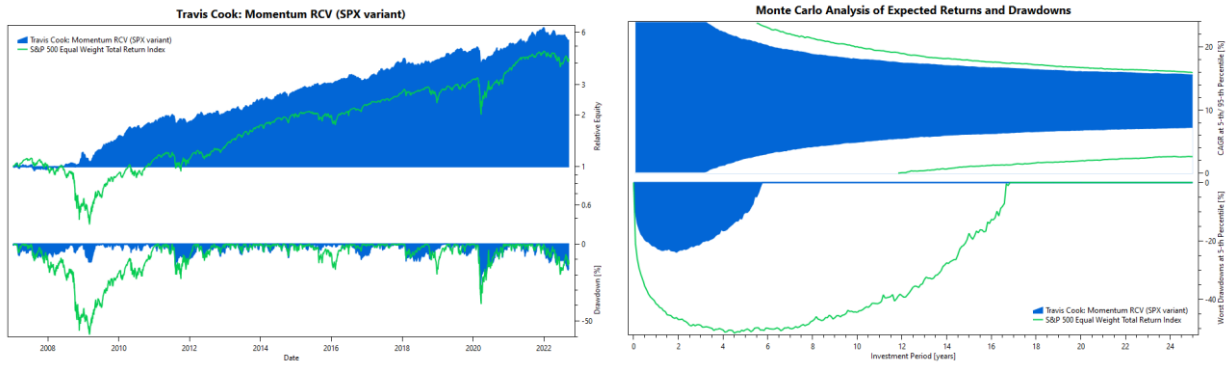
Trading S&P-500

Finally, we wanted to try trading the S&P-500, SPX. The universe is rather large, including almost 2000 stocks over the backtest period. This creates a significant burden, due to the massive CPU and memory requirements, leading to because backtests running very slow and making parameter optimization difficult.



When using the same parameters as we used for OEX, the performance is underwhelming. However, we do see that the strategy nonetheless adds some value, even if it is not as much as we would like to see. In a first attempt to improve the behavior, we set the number of stocks to hold to 10, and the maximum allocation per stock to 25%.

While not improving returns, this step did narrow the range of outcomes somewhat, and slightly improved the depth and duration of drawdowns. We spent a few more hours tweaking parameters but ultimately, we abandoned this work, because the progress did not seem to justify the effort. However, we firmly believe that a deeper understanding of the issues related to changing the trading universe is required to make the strategy self-adjusting. Here are the last results we achieved:



Conclusions

From the tests outlined above, we conclude that the strategy has a lot of potential trading various stock markets. Its performance, especially with the OEX and NDX universes, is very good while at the same time docile and even-keeled. With these properties, the strategy can rival TuringTrader's Stocks on the Loose, which is a great result. Our main complaint with the strategy are the drawdowns in 2022 that are caused by the bond-rotation strategy. We believe that the culprit for these drawdowns lies in the component's market-regime filter and that this can flaw is fixable with minimal effort.

While the strategy performed nicely across multiple universes, we had to adjust various parameters to achieve these results. Here are the parameters we used for the various universes:

	OEX (baseline)	**NDX**	**DJI**	**SPX**
Number of positions held	3	3	3	10
Period used for risk evaluation	10	10	5	10
Breadth threshold for bear-market regime	33	33	5	33
Maximum daily risk (in bpts)	275	400	225	275
Penalty factor for higher-risk assets	600	300	450	550
Maximum capital assigned to single asset (in bpts)	3400	3400	3400	2500
Period of fast MA used by trend filter	50	50	5	50
Period of slow MA used by trend filter	126	126	252	168

Looking at this table, we make the following observations:

- For large universes, the number of assets to hold should likely be higher. Doing so will help avoid some of the churn that results from noisy momentum rankings. The maximum capital parameter needs to decrease at the same time to reflect this change. It might be possible to auto-adjust this parameter automatically with the size of the universe.
- The threshold risk level seems dependent on the universes' long-term volatility. This likely opens an opportunity to adjust this parameter automatically on the fly.
- With the DJI and SPX universes, we needed to adjust the trend-following filter, but we have no good explanation why this was required. Possibly this is an indication that a more sophisticated trend-filter would be preferable.