Better Sector Rotation Performance Through Signal Processing and Problem Segmentation
by Scott Juds

The founder of SumGrowth Strategies explains how to use his SectorSurfer service to build a sector rotation strategy that is optimized for both bull and bear markets.

Sector rotation, as an investment strategy, is rooted in the economic cycle data produced by the National Bureau of Economic Research (NBER) dating back to 1854. However, achieving satisfactory sector rotation investment performance has long been difficult or elusive. For example, Figure 1 illustrates how a sector rotation strategy employing the original nine Select Sector SPDR ETFs (exchange-traded funds) and a popular momentum algorithm (purple line, detailed later) barely outperforms a simple equal-weight portfolio of the same ETFs (red line). This article shows how performance similar to that of the “Desired Sector Rotation Strategy” (light blue line in Figure 1) can be achieved by utilizing advanced signal processing methods and employing problem segmentation to treat bull and bear markets as separate problems.
Market Character

The conventional theory underlying sector rotation strategies is that markets predict the state of the economy typically three to six months in advance and that different sectors naturally perform better during particular portions of the economic cycle, as suggested by Figure 2. Although this model implies there’s an orderly sequence of market sectors and economic phases, sector performance has clearly been strongly affected by the introduction of new technologies that don’t wait their turn in the cycle to shine.
It’s doubtful that Steve Jobs waited for this chart to tell him it was his turn before saying “And one more thing—this is an iPhone.” Punctuated events such as elections, wars, political/monetary policy and natural disasters don’t wait their turn either to change the direction or focus of the economy. Furthermore, the 2008–2009 financial crisis demonstrated that all sectors can suddenly become correlated, simultaneously crashing and later rising together, as illustrated in Figure 3. Performing well during this period clearly requires something other than ordinary sector rotation.

**Figure 3. Correlated Market Sectors During the 2008–2009 Financial Crisis**

Compounding the problem further, bear market volatility is typically twice that of a bull market—a matter not addressed by ordinary momentum algorithms that often results in spurious trade alerts. Finally, even though it’s well understood that other asset classes perform better during a market crash, it is difficult to employ that knowledge well in a sector rotation strategy. In the process of addressing these shortcomings of ordinary sector rotation here, we build on the principles presented in the January 2017 CI article entitled “Using Asset Class Rotation to Reduce Risk and Increase Return.”
A Holistic Solution

When the first motorized carriage was designed, it was thought to be wonderful—at least until we decided it also needed to run well in rain and snow, have tougher tires, air conditioning, locks and a radio. Attaching a simple engine to a frame with wagon wheels left much to be desired. Similarly, the most common and rudimentary of trend filters, the rectangular 12-month SMA (simple moving average), is far from optimum for determining which of a set of sector funds should be owned.

Stepping back for a moment to review the nature of the problem as depicted by the sector trend chart of Figure 4, a few interesting things are observed:

1. The S&P 500 (bold white line), is always flanked by sectors doing better or doing worse, as should be expected because the S&P 500 is composed of all sectors.
2. The waves generally have much in common—with the exception of bond and Treasury funds which typically have a mind of their own.
3. There are funds on the left with high trends that a decade later have low trends, and vice versa, but there is no observable pattern of a grand, gradual rotation.

![Figure 4. Trends (Smoothed Monthly Return) for S&P 500, Sectors, Bonds & Treasuries](image)

It’s clear that to “win the game” of sector rotation, one must first and foremost do an excellent job of owning the trend leader. However, because bear markets have quite a different character, attempting to treat bull and bear markets as one homogeneous problem results in disappointing performance, with periods of underperformance that can easily last longer than one’s patience. A holistic sector rotation solution requires solving three problems:

1. optimizing bull market sector rotation,
2. employing a market direction indicator to determine when it is a bull or bear market, and
3. integrating a separate bear market strategy.
None of these are trivial when better performance is the objective. After examining these three topics, we employ them in a strategy using the original nine Select Sector SPDR ETFs.

**Improving Momentum Indicators**

Sector rotation performance depends on extracting the momentum signal buried in noisy market data. In signal processing science, everything except for the desired signal is considered noise because in some form it degrades signal detection. For example, if the object is to find ETFs with momentum better than the S&P 500, then the process requires subtracting the S&P 500 daily returns from the ETF’s daily returns to remove the “common mode market noise,” and then subsequently apply a moving average filter to reduce remnant short-term noise. In this example, the S&P 500 itself is considered baseline market noise that must be removed. Although momentum in market data was formally **found in 1993** and **confirmed in 2008**, practitioners have long struggled to build satisfying momentum strategies. In this author’s opinion, satisfaction is proportional to the probability of making an outstanding investment decision.

National Medal of Science recipient **Claude Shannon’s 1948 theorem** proved that the probability of a signal leading to a correct decision is directly proportional to its signal-to-noise ratio. An excellent analogy is the probability of correctly hearing your honey-do list from a soft-spoken spouse in a noisy café. Rewards are definitely better when you get it right. **Figure 5** provides a visual illustration of high, medium and low signal-to-noise ratio (S/N). The size of the sine wave signal is constant in all three, but the size of the noise changes. The signal and noise RMS values (root mean square—like standard deviation) are used to calculate the ratio. It is common to state the ratio in decibels (dB), which is given by:

\[
S/N_{(dB)} = 20 \log_{10}(\text{RMS(Signal)}/\text{RMS(Noise)})
\]

When the signal and noise are the same sizes, the ratio is 1.00, which translates to 0.0dB. When the signal is 3.16 times larger than the noise it is +10dB, and when 3.16 times smaller it is −10dB. It’s pretty easy to see that the sine wave becomes reasonably discernable when the S/N = 0dB or better and easily becomes unrecognizable when buried in noise larger than itself.
Thus, optimizing sector rotation performance requires pulling out all the stops to improve the signal-to-noise ratio of the momentum (trend) signal. When the signal and noise are similar in size, a 30% reduction in noise produces about a 30% improvement in the probability of buying the best fund—and that is significant when your IRA is at stake! In the field of signal processing, the two most important means of improving the signal-to-noise ratio are 1977 Nobel laureate J. H. Van Vleck’s matched filter theory, and 1833 Royal Society fellow Samuel H. Christie’s differential signal processing method. Let’s examine each of these.

Van Vleck’s matched filter theory can be used to optimize the momentum filter shape and duration to improve the signal-to-noise ratio. The shape and duration of a filter determine what portions of the noise spectrum pass through the filter and what portions are blocked. It is referred to as a matched filter because in the frequency domain the optimum noise filter matches the signal’s frequency spectrum—the same principle used for tuning in a radio station. The frequency domain shape of the filter can be translated to the time domain via the Laplace transform to instead show us the filter’s impulse response, which is what we are more accustomed to viewing when charting an SMA (simple moving average) or EMA (exponential moving average) filter.
**Figure 6** illustrates a broad array of candidate momentum filters having different shapes and durations. The popular SMA-252 filter (green) averages 252 market days (one year) of equally weighted daily return data over the period. The EMA-125 filter (top red) has an exponentially declining weight for data the older it gets. Its 125-day time constant causes the weighting at day 125 (one-half year) to be $1/e = 36.8\%$ (where $e$ is the base of the natural logarithm and has a value of 2.71828). A DEMA filter (blue, double exponential moving average) is sometimes referred to as a second-order EMA filter because the data is doubly smoothed by passing it through the EMA filter twice.

Remarkably, the most common filter utilized in academic momentum research papers is the simplistic SMA-252 (although variations such as six months of duration, or skipping the most recent month are occasionally employed). They have apparently never asked, “what are the chances that nature would hand us such a simple equally weighted (rectangular shape), exactly one-year duration filter as the optimum solution?” I would suggest that the chances are about the same as the boxy Model-T Ford turning out to be the lowest wind resistance body design for efficient freeway driving. The SMA may be an intellectually easy place to start, but matched filter theory shows us that the optimum filter shape is neither the SMA, nor the EMA, but is actually more like the DEMA filter, as confirmed by strategy design performance.

Unfortunately, there is no single answer to the question of which DEMA filter duration is best. When considering the differences in character of diverse sets of asset classes (such as Treasuries, bonds,
utilities, REITs, commodities, sectors, regions and countries), it should not be surprising that the optimum filter shape and duration depend not only on the asset class but also on the mix of asset classes the strategy is tasked with considering. Although a broad range of filter shapes and durations is required for broad functionality, the SMA shape is not among them. The reason the SMA turns out to be a poor momentum filter choice can be best understood by considering the basic idea behind matched filters. What it tells us is that on balance the SMA is including more noise than is necessary for the momentum information it is extracting from the data.

Consider that the momentum signal is actually a predictor of near future performance (i.e., the expected return next month). We want all the little hints we can get, but know that some hints are more valuable than others. For example, when stated this way, everyone can probably agree that a hint provided by performance two months ago is likely more relevant than a hint provided by performance 12 months ago, and very much more relevant than a hint provided from 24 months ago. However, the one-year SMA erroneously values the contribution of information from 12 months ago exactly the same as information from two months ago, and then sharply drops to zero value for contributions from 13 months ago or more. I must agree with my attorney friend who says using the SMA for a momentum filter is quite “arbitrary and capricious.” Although the mix of asset classes included in a strategy can profoundly complicate the process of determining the optimum shape and duration of its momentum filter, fortunately, the optimization process has been automated by our SectorSurfer service for use by anyone (whether a free or paying subscriber), and is detailed in this white paper entitled “Automated Polymorphic Momentum.”

The value of Samuel H. Christie’s method of making differential measurements to remove noise common to multiple signals is easily appreciated in Figure 7 where 11 mutual funds having significant common mode noise (common short-term wiggles) eventually diverge from one another. Differential signal processing has profound implications on the entire framework of technical analysis: It is no longer an analysis of one equity at a time to determine investment suitability, but rather a comparative analysis of a set of candidate funds that further reduces noise in the decision process and results in the selection of investments most likely to do well in the near future.
The filtered momentum signals produced from the original nine Select Sector SPDR ETFs are plotted in Figure 8 over a two-year period, illustrating that a significant amount of common mode undulation (moving like a herd) remains after momentum filtering. These momentum signals are not judged individually according to some threshold, but rather are judged relative to their peers (the candidate funds being considered by the momentum strategy). Comparing one against another to determine which one is better is called “differential signal processing.” The question is not “did the fund do better than some threshold,” but rather “did this fund do better than the other funds?” The one with the highest momentum signal is the trend leader and is most likely to do well next month. New monthly trend leaders are marked in Figure 8 by a vertical yellow hash line. It’s worth noting that restricted month-end trading is actually superior to allowing trades to occur on any day a new trend leader emerges. The two primary causes of this effect are (1) funding retirement plans monthly, and (2) reporting fund performance monthly. Both of these induce large investment sums to start trading near the end of the month. Such large sums can only be traded over a period of many days and results in a higher quality momentum signal around month end. Consequently, the performance of month-end traded strategies is generally higher. Stocks underlie both mutual funds and ETFs, thus moving any one of them inherently moves the other two. Although many investors have an itchy trigger finger, it’s actually better to be right than to be early.
The summary block diagram of Figure 9 illustrates how daily market data for each candidate fund is first passed through a momentum filter to eliminate as much extraneous market noise as possible, then compared with other momentum signals to remove remnant common mode noise, and the fund with the highest momentum signal is finally designated as the trend leader. A BUY signal is generated for newly identified trend leaders at the end of each month. A typical sector rotation strategy averages three to five trades per year.

In the quest for improving the signal-noise ratio, the value of ordinary diversification must always be considered. While individual stocks are susceptible to catastrophic failure, quarterly earnings debacles, trader manipulation and many other ailments, a mutual fund or ETF virtually eliminates those risks through ordinary diversification by holding shares in many dozens of companies. Thus, noise reduction afforded by diversification significantly improves the behavior of funds in a sector rotation strategy. Conversely, momentum strategies selecting individual stocks are not afforded these noise reduction benefits and are likely to have trouble reliably passing leadership from one stock to another because of...
their much higher noise between individual stocks. Most investors prefer trading stocks to trading ETFs because of their higher return potential and the special situation stories that can be told about stocks that cannot be told about sectors or funds. However, sectors make up for their lower return potential by offering momentum strategies with a higher probability of making better investment choices, and by having much lower overall volatility.

An often misunderstood characteristic of market noise is that it is not consistent over time. Black swan events (extraordinary outliers), such as the 1987 market crash, show up more often than would normally be expected. While weather can cause short-term black swan events, political policy change or the introduction of a new technology can often lead to new trends that produce new sets of winners and losers. The point is simply to understand and acknowledge that momentum is not always with us and can change on a dime, even though it works in our favor most of the time.

One of the more interesting measures of momentum in market data is provided by the Hurst exponent, as illustrated in Figure 10. A value of 0.5 indicates randomness, whereas a value of 1.0 indicates a straight line. The Hurst exponent for the S&P 500 market index occasionally dips to 0.5 and confirms our instincts that momentum is not always with us. It is notable that in 2015 when the Hurst exponent charted the longest complete loss of momentum in 20 years, hedge fund closures reached a record high, most often blaming their closures on momentum models that were no longer working. Although many speculated in 2016 that it was different this time because the algorithms were in charge, Figure 10 shows that momentum was clearly neither dead nor exhibiting any character that it had not before.

**Figure 10. The Hurst Exponent for the S&P 500: A Measure of Trending in the Market**
Improving Market Direction Indicators

Even a casual observer quickly ascertains that bull and bear markets are neither symmetrical in shape nor similar in volatility. Thus, it should be expected that the best performing algorithmic solutions for them would be different, and determining when to switch from one to the other might be critically important. This is the purpose of market direction indicators. While numerous market indicators are documented on the web, it is hard to find test data documenting their efficacy. However, comparative performance for seven of the better ones can be found here.

The recent performance of the well-known Death Cross market direction indicator (S&P 500 50-day SMA crosses its 200-day SMA) is illustrated in Figure 11. Like other simplistic market direction indicators, it monitors only a single source of data with a single time period designed to ignore short-term drops but triggers if the drop lasts long enough to suggest the start of a serious bear market. Unfortunately, these simplistic indicators are vulnerable to locking in whipsaw losses during medium-term drops lasting long enough to trigger the indicator, but then rebounding shortly thereafter. While such medium-term drops had not occurred in the prior 25 years, two of them recently appeared within six months of one another (Figure 11), much to the dismay of many investors. Clearly, such simple market direction indicators are too simplistic and calls for improvements were justified.

Figure 11. Performance Failure of the Simplistic Death Cross Indicator in 2015 and 2016
However, simply tweaking the algorithm’s time constant (duration) only moves the problem elsewhere to slightly shorter or slightly longer events. Better bear market protection requires additional market information. Metaphorically, if watching one knee of an elephant helps determine if it’s going to take a step, then watching three knees will likely provide earlier detection and reduce false positives. StormGuard-Armor (SectorSurfer’s market direction indicator) was specifically designed to incorporate three distinct views of the market, including price trend, market momentum and value sentiment. Together they indicate behavioral changes in both high volume and value investors prior to serious price movement. When either of them stops participating, it is a sign they are standing at the door waiting to run at the next sign of trouble. That’s an indication that the market is no longer safe—downside risk far outweighs upside potential.

The chart on the left in Figure 12 illustrates that during the market’s rough patch in 2010 it was only the market momentum signal that indicated the market was in trouble. In 2011 during the run-up to the August 1 sell-off (triggered by S&P downgrading U.S. debt), the market momentum signal again indicated trouble ahead of the event. However, in the chart on the right in Figure 12, it is the value sentiment indicator that indicated trouble long before the August 2015 market drop triggered by a Chinese market sell-off.

Figure 12. Components of StormGuard-Armor During 2011 and 2015

Twelve separate measures taken from the price trend, market momentum and value sentiment signals are combined using the principles of fuzzy logic to produce the final StormGuard-Armor indicator. The green equity curve and statistics table of Figure 13 illustrates the performance improvement provided by StormGuard-Armor over simply owning the dividend adjusted S&P 500 (gray) or using the Death
Cross (red) to exit the S&P 500 to cash. StormGuard-Armor is published daily as a free service along with other well-known market direction indicators. The importance of a good market direction indicator is corroborated by Warren Buffett’s primary rules for investing: “Rule No. 1: Never lose money. Rule No. 2: Never forget rule No. 1.” There is no reason to ever ride to the bottom of a market crash again.

**Figure 13. StormGuard-Armor and StormGuard-Std as Applied to the S&P 500**

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### Integrating Bear Market Strategies

After implementing a proficient market direction indicator, one must determine what investment to hold, if any, while the market crash plays out. Sitting snug in cash may be the simple answer, but anyone employing sector rotation will likely be interested in doing something a bit more sophisticated that offers the possibility of better returns. Fortunately, there are a variety of bonds and Treasuries that are worthy alternatives to cash. The chart on the left in **Figure 14**, however, shows that bonds have not been reliably negatively correlated with stocks over time. The chart on the right in **Figure 14** shows that gold at times...
may be a helpful alternative, but again, certainly not reliable. Furthermore, as might be suggested by
the chart’s strong swings, gold’s volatility is difficult to deal with. Thus, the best solution is to create a
bear market strategy that selects the trend leader from a set of such alternative funds.

**Figure 14. Correlation of 5-Year Treasury Bond and Gold to U.S.**

An excellent list of potential bear market strategy ETFs is shown in **Figure 15** and includes U.S.
Treasuries of different maturities, bonds of different types, inverse market ETFs and a gold bullion ETF.
The bear market strategy integrated into the sector rotation strategy described in the next section of this
article is simply referenced as BMS-2 within SectorSurfer and has these candidates to select from:
iShares 10-20 Year Treasury Bond (TLH), iShares 7-10 Year Treasury Bond ETF (IEF), Vanguard Total Bond Market ETF (BND), SPDR Mortgage Backed Bond ETF (MBG), and PIMCO Investment Grade Corporate Bond ETF (CORP). Other ETFs listed in **Figure 15** were rejected as candidates for use with this bear market strategy because their volatility during a market crash is higher than desired.

**Figure 15. Possible Candidate Bear Strategy ETFs**

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Name</th>
<th>Symbol</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>SHY</td>
<td>Treasury, 1-3 Year</td>
<td>BND</td>
<td>Vanguard Total Bond Market</td>
</tr>
<tr>
<td>IEF</td>
<td>Treasury, 3-7 Year</td>
<td>CORP</td>
<td>PIMCO Inv. Grade Corp. Bonds</td>
</tr>
<tr>
<td>IEF</td>
<td>Treasury, 7-10 Year</td>
<td>MUB</td>
<td>iShares National Municipal Bond</td>
</tr>
<tr>
<td>TLH</td>
<td>Treasury, 10-20 Year</td>
<td>MBG</td>
<td>SPDR Mortgage Backed Bond</td>
</tr>
<tr>
<td>TLT</td>
<td>Treasury, 20+ Year</td>
<td>HYG</td>
<td>High Yield Corporate Bond</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>PSQ</td>
<td>Short QQQ NASDAQ 100</td>
</tr>
<tr>
<td>SH</td>
<td>Short S&amp;P 500</td>
</tr>
<tr>
<td>GLD</td>
<td>State St. ETF SPDR Gold</td>
</tr>
</tbody>
</table>
Figure 16 illustrates the equity curve (strategy performance curve) for the BMS-2 bear market strategy, where each of its color segments indicates which of the ETFs was the trend leader at that time. The white reference curve is the iShares Core US Aggregate Bond ETF (AGG). Performance of the entire equity curve of a bear market strategy is unimportant because only performance during bear markets (as determined by StormGuard-Armor) matters. Only the periods marked with gray vertical bars matter because they are the only times that its parent strategy calls on it to perform. Otherwise, it is ignored. Information about other bear market strategy variations, performance measures and design tips can be found here.

Figure 16. Bear Market Strategy BMS-2

Setting the Stage: Ordinary Sector Rotation

Fund managers and market analysts typically describe being slightly overweight or underweight in various sectors, leading to performance that is barely distinguishable from the S&P 500. However, as used herein, sector rotation will mean owning the one, and only one, trend leader from among a set of candidates. The original nine Select Sector SPDR ETFs of Figure 17 were developed to match the
primary market sectors composing the S&P 500. This set of candidate ETFs will be used in the example strategies that follow.

**Figure 17. The Nine Original Select Sector SPDR ETFs**

<table>
<thead>
<tr>
<th>ETF Description</th>
<th>Symbol</th>
</tr>
</thead>
<tbody>
<tr>
<td>StateSt ETF Financial Select Sector</td>
<td>XLF</td>
</tr>
<tr>
<td>StateSt ETF Industrial Sel Sector</td>
<td>XLI</td>
</tr>
<tr>
<td>StateSt ETF Materials Select Sector</td>
<td>XLB</td>
</tr>
<tr>
<td>StateSt ETF Energy Select Sector</td>
<td>XLE</td>
</tr>
<tr>
<td>StateSt ETF Consumer Discretionry</td>
<td>XLY</td>
</tr>
<tr>
<td>StateSt ETF Tech Select Sector</td>
<td>XLK</td>
</tr>
<tr>
<td>StateSt ETF Health Care Sel Sector</td>
<td>XLV</td>
</tr>
<tr>
<td>StateSt ETF Utilities Select Sector</td>
<td>XLU</td>
</tr>
<tr>
<td>StateSt ETF Consumer Staples</td>
<td>XLP</td>
</tr>
</tbody>
</table>

The starting point for examining the benefits of better sector rotation algorithms, proficiently knowing when it is a bull or bear market and employing integrating bear market strategies begins with examining the performance of a sector rotation strategy employing the classic 12-month SMA momentum indicator for the nine original Select Sector SPDR ETFs illustrated in the chart on the left side of Figure 18. Each of the colors on the strategy’s equity curve indicates the particular ETF of Figure 17 that was held at that time. The white reference curve is the S&P 500. Over the 18-year period of this strategy, the 12-month SMA momentum indicator failed to improve upon simply holding the S&P 500 index. When further employing the well-known Death Cross indicator (shown in the chart on the right side of Figure 18), performance measurably improves by exiting the Select Sector SPDR ETFs to cash (a money market fund—white) during bear markets. Still, performance during many periods would lead most investors to abandon the strategy in favor of simply holding the S&P 500 index.

**Figure 18. Sector Rotation Strategy Employing 12-Month SMA**

(a) 12mo SMA Rotation No Bear Market Exit

(b) 12mo SMA Rotation Death Cross → Cash
Month-end sector rotation of the nine original Select Sector SPDR ETFs using the classic 12-month SMA as a momentum indicator and optionally using the Death Cross to exit the market to cash during a bear market.

Two additional popular momentum indicators worth examining are the three-month SMA (chart a in Figure 19) and the six-month EMA (chart c in Figure 19), both of which have no bear market strategy. Their counterparts (charts b and d in Figure 19) both further include the Death Cross indicator to exit the strategy to cash during a bear market. The three-month SMA strategies, with and without the Death Cross, are only slightly different from their 12-month SMA counterparts of Figure 18. The six-month EMA strategy without the Death Cross (chart c in Figure 19) is barely distinguishable from the S&P 500, making it clear that the entire performance improvement observed in chart d in Figure 19 is credited entirely to the addition of the Death Cross market direction indicator.

In summary, the three popular momentum indicators (12-month SMA, three-month SMA and six-month EMA) of Figures 18 and 19 failed to provide sector rotation algorithmic value for these strategies without the additional aid of a bear market strategy.

Figure 19. Strategies Employing 3-Month SMA and 6-Month EMA, With & Without Death Cross
Month-end sector rotation of the nine original SPDR ETFs contrasting (a) the three-month SMA momentum indicator with (c) the six-month EMA momentum indicator and additionally using (b and d) the Death Cross indicator to exit the market to cash.

The comparative performance of the above momentum strategies are further plotted in Figure 20 alongside the industry reference standard asset class funds and portfolios (detailed in the January 21, 2017, Computerized Investing article entitled “Using Asset Class Rotation to Reduce Risk and Increase Return”). The value of treating bear markets as a separate problem is self-evident—the addition of the Death Cross effectively reduced risk by half and doubled the annualized return.

Comparative risk/return performance for month-end sector rotation of the nine original Select Sector SPDR ETFs using three common momentum indicators and optionally using the Death Cross to exit the market to cash during bear markets.
Better Sector Rotation: Putting it All Together

An improved sector rotation strategy utilizing a momentum indicator based on matched filter theory, a market direction indicator employing three market views and an integrated bear market strategy will now be examined.

As previously suggested and illustrated by Figure 6, a wide range of DEMA filters is required to handle the differing characteristics of many asset classes through an automated filter selection process. In SectorSurfer, the process is called Forward-Walk Progressive Tuning (FWPT). The yellow dots along the horizontal axis of the plots in charts b, c and d in Figure 21 are indicative of this process. The left-most yellow dot represents the boundary between pure backtesting (to determine initial tuning: momentum filter shape and duration) and the start of forward-walk through out-of-sample data. The initial tuning was performed with in-sample data, which means that its tuning was selected based on performance for that specific set of data by definition, it should be able to do well with that. The set of data that follows the date of initial tuning is called out-of-sample data because it was not part of the sample data used for the initial tuning. If a strategy can perform well walking forward in time through out-of-sample data then it is likely that the initial tuning was related to some stable character of the data, as opposed to some lucky pops and drops that were strategically included or excluded in hindsight (curve fit) as the strategy was tuned. Each of the subsequent yellow dots on the horizontal axis indicates a six-month interval when the algorithm re-evaluates the tuning profile in view of the additional six-months of historical data. In this manner, the algorithm adaptively tunes itself to accommodate changing market conditions or the impact of candidate funds with starting dates that occur sometime after the initial tuning date. FWPT is considered the gold standard for algorithmic performance evaluation.

Chart a in Figure 21 is simply a repeat of chart a in Figure 18 for convenient comparison with the FWPT strategies of charts b, c and d in Figure 21. Even without a bear market exit method, the matched filter and FWPT strategy design of chart b in Figure 21 substantially outperform the S&P 500 and other ordinary momentum strategies, confirming that a better momentum indicator signal-to-noise ratio improves the probability of making better investment choices. Chart c in Figure 21 illustrates the further benefit provided by StormGuard-Armor’s triple evaluation of market safety to determine when to exit the market to the safety of a money market fund (white portion of the strategy’s equity curve). Chart d in Figure 21 illustrates the final benefit of utilizing an integrated bear market strategy (designated BMS-
2) to produce moderate investment returns during the bear market (white) by selecting the trend leader among these bond and Treasury ETFs: iShares 10-20 Year Treasury Bond (TLH), iShares 10-20 Year Treasury Bond (IEF), Vanguard Total Bond Market (BND), SPDR Bloomberg Barclays Mortgage Backed Bond (MBG) and PIMCO Investment Grade Corporate Bond (CORP).

**Figure 21. Adding Filters to the Sector Rotation Strategies**

Month-end sector rotation of the nine original Select Sector SPDR ETFs contrasting (a) the classic 12-month SMA as a momentum indicator with (b) using Forward-Walk Progressive Tuning and optionally employing StormGuard-Armor to (c) exit the market to cash or (d) exit the market to bear market strategy BMS-2.

The performance of the four strategies of Figure 21 is plotted in Figure 22 alongside the industry reference standard asset class funds and portfolios for perspective. The beneficial contribution achieved by separately addressing problems associated with sector rotation, market direction and bear market strategies speak for themselves.
Figure 22. Comparative Risk/Return Performance of Strategies With Filters

Comparative risk/return performance for month-end sector rotation of the nine original Select Sector SPDR ETFs and incorporating FWPT, SG-Armor and BMS-2.

Conclusion

Substantially improving sector rotation performance requires solving three problems:

1. optimizing bull market sector rotation,
2. employing a market direction indicator to determine when it is a bull or bear market, and
3. incorporating an integrated bear market strategy.

The cross-disciplinary sciences of matched filter theory and differential signal processing from the field of electronic signal processing improve the probability of owning the trend leader. Utilizing three distinct views of the market (price trend, market momentum and value sentiment) does a much better job of determining when to exit to safety. Finally, employing an integrated bear market strategy provides substantial additional return during bear markets by selecting from a variety of bonds, Treasuries and other fixed-income funds. Together, these three improvements make a substantial difference in both risk...
and return that is hard to ignore when compared to the performance achieved by a classic buy-and-hold moderate risk portfolio.

→ Scott Juds is founder and CEO of SumGrowth Strategies and a founder and chief science officer of AlphaDroid Strategies.