## An analysis of Trend-following

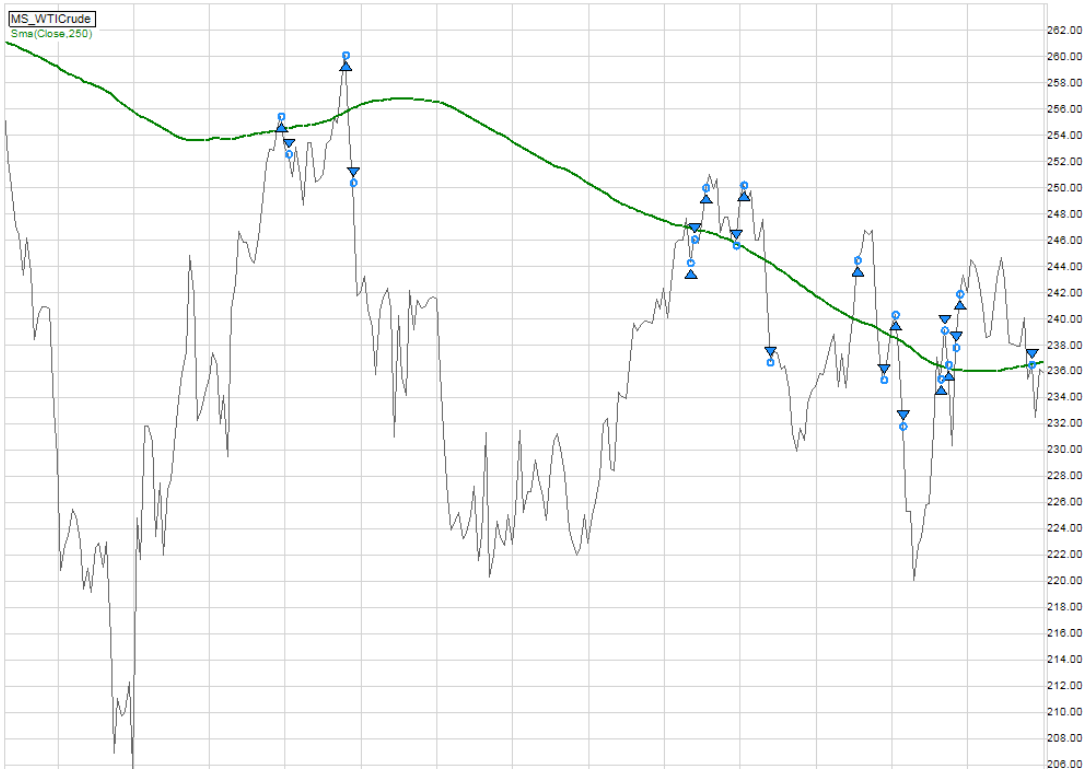
For purposes of this analysis, the baseline comparison will be the Morningstar Long/Flat product. We will use the same instruments (Morningstar Commodity Indices) as well as the same weighting scheme (Open Interest) in order to isolate the effects of different trend-following specifications.

The simplest trend-following strategy (and most commonly used by CTA's) is a moving average crossover strategy. If yesterday's closing price is greater than the average closing prices over some timeframe, then the model establishes a long position. Otherwise a short (or flat) position is taken. For reasons outside the scope of this analysis, the focus will be on long/flat models ( The majority of the "value added" of trend-following models is from the long positions; short models require higher complexity to be effective due to the higher required probability of success because of negative skew of assets).

The Morningstar L/F Index establishes a long position when the instrument's monthly closing price is above its 250 day MA and is flat otherwise. This analysis recreates this exact model using daily data (with, not surprisingly, improved results). This model, with daily data, is the baseline model for this analysis.

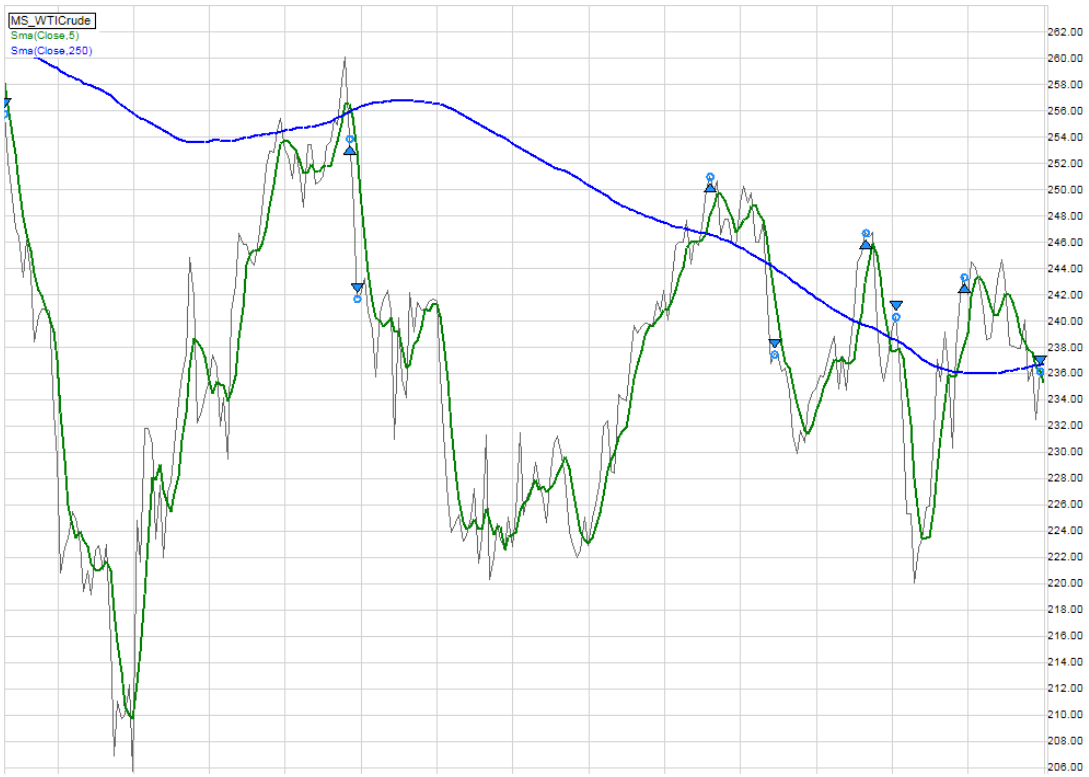
A sample of some recent trades of a simple 250 day (1 year) moving average trend following system is shown on Morningstar's West Texas Intermediate Index (WTI) below:

*WTI is always single largest component in the Morningstar Long/Flat product (at about 10% allocation):*




As can be seen, using closing price makes for a noisy signal and often results in the trend-following system getting "whipsawed" in sideways markets (as was the case recently for WTI). One intuitive (and simple) method to mitigate this effect is to smooth the closing price in order to filter some noise and thus create a more "robust" indicator signal.

For example, using the 5 day moving average (MA) instead of closing price relative to a 250 day MA would have generated the following signals:



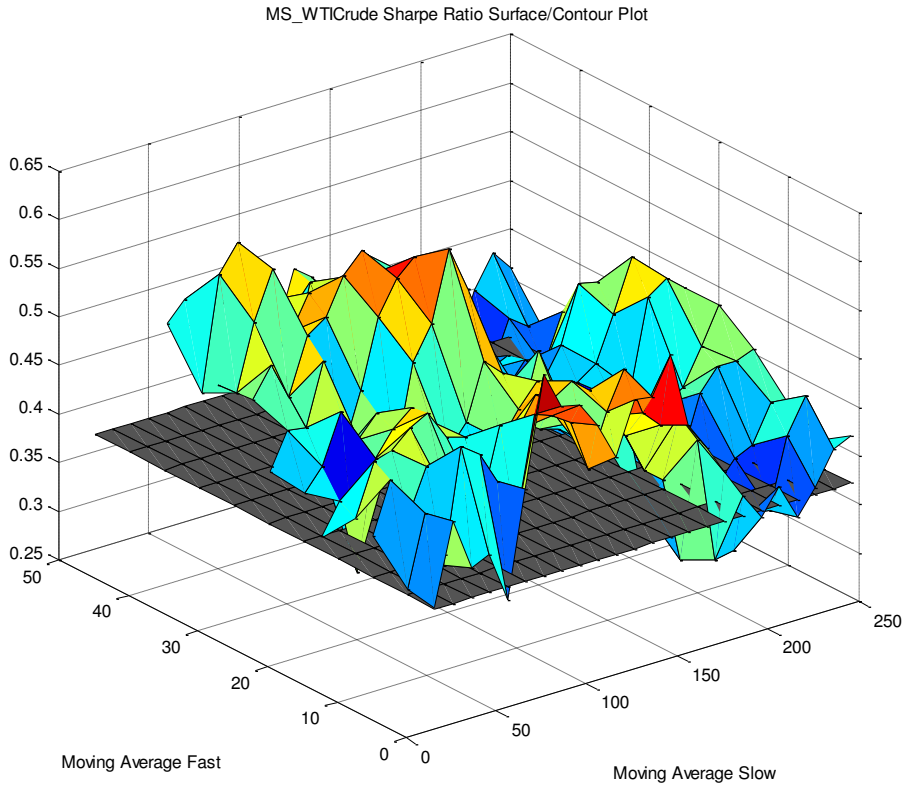

By using a moving average to smooth the closing price, we create a time series that still captures a large portion of the trends while filtering out the "noise" that result in meaningless positions.

The system shown above will be referred to as a 5x250 MA trend following system (where the 5 day MA is the "fast indicator" and the 250 day MA is the "slow indicator").

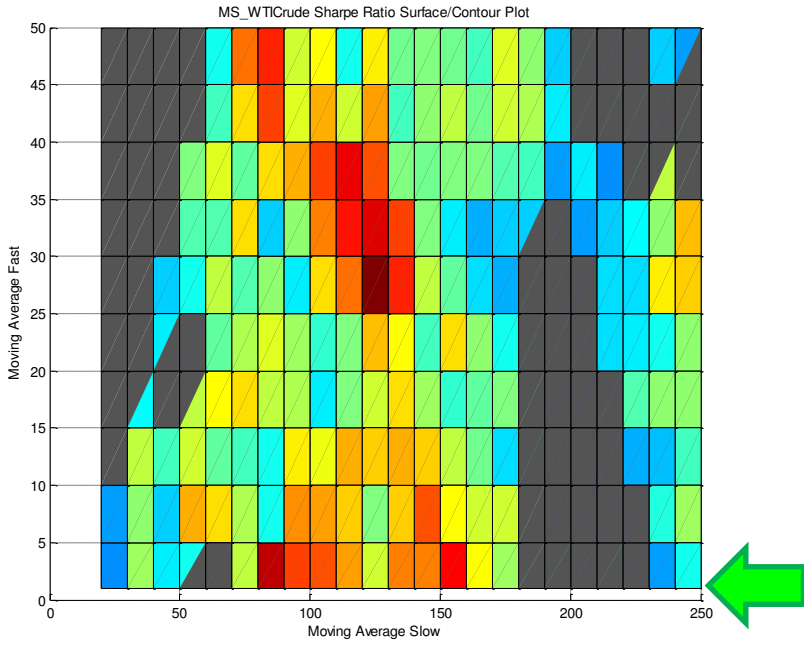
This particular system applied to WTI Crude Oil would have produced 40 long trades since 1991 at an average profit of 8.18% over an average of 86 trading days. Only 30% would've been profitable trades but the maximum drawdown would've been only 59% vs. 80% for a buy & hold strategy. The annualized return of this strategy was 6.5% vs. 6.8% for b&h. The Sharpe Ratio of this system was .37 is about the same as a b&h strategy over the same time period.

The next question is, what does the performance of different combinations of moving averages look like over this time period?

Continuing with our focus on WTI we first look at the Sharpe Ratio for every combination of “fast” & “slow” moving average compared to a b&h strategy. Specifically, we look at “fast” moving averages from 0-50 days and “slow” moving averages from 50-250 days. We calculate the sharpe ratio (since 1991) of every trend-following combination, for every Morningstar Commodity Index and plot the results below:

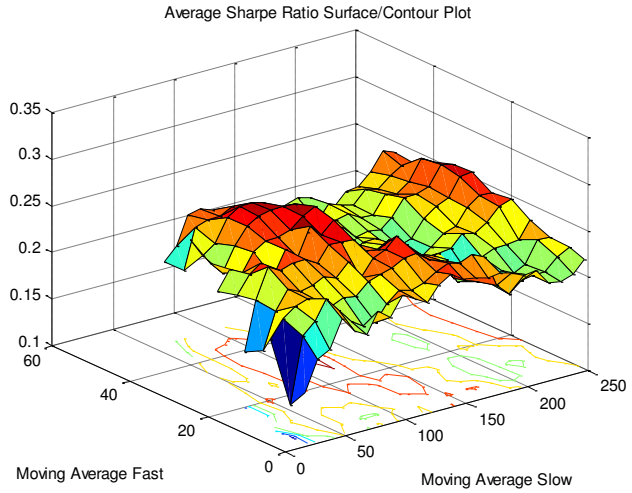


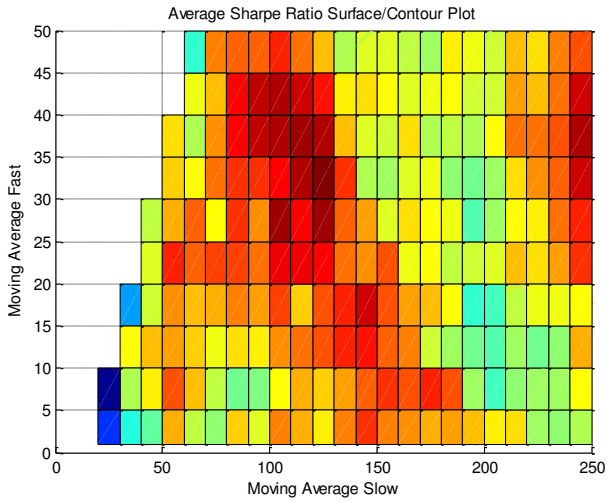

By plotting the Sharpe Ratio of each MA combination when applied to WTI (since ’91) we now have a contour plot that shows us which “areas” have yielded the best risk/return combination over time. The gray plane is the Sharpe Ratio of a b&h strategy over the same period. The baseline closing price vs. 250 day moving average is represented by the bottom right corner:



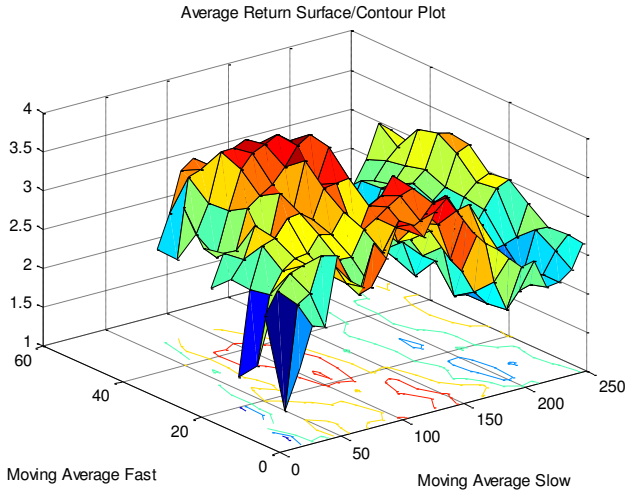
While the objective of this exercise is ***NOT*** to optimize a solution with respect to the Sharpe Ratio contour (i.e. “pick the highest point”), it is crucial to understand which smoothing parameters have done the best at separating the “signal” from the “noise” while also doing the best job at capturing meaningful trends over time. It’s also important to understand the size of the relative areas of improvement. For example, it’s quite easy to see that there are large areas of improvement over the simple 1x250 model.

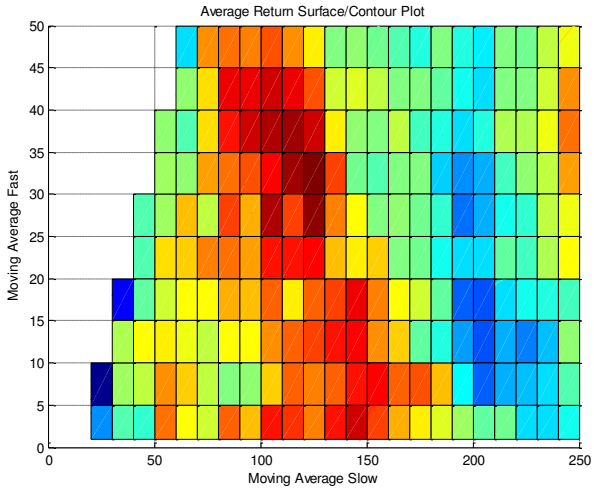
We perform the same analysis for each of the 21 Morningstar instruments and combine the contour plots to create an “average” Sharpe Ratio surface:



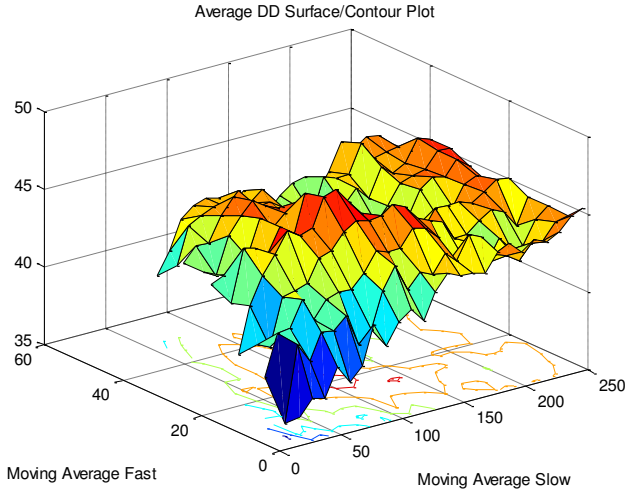



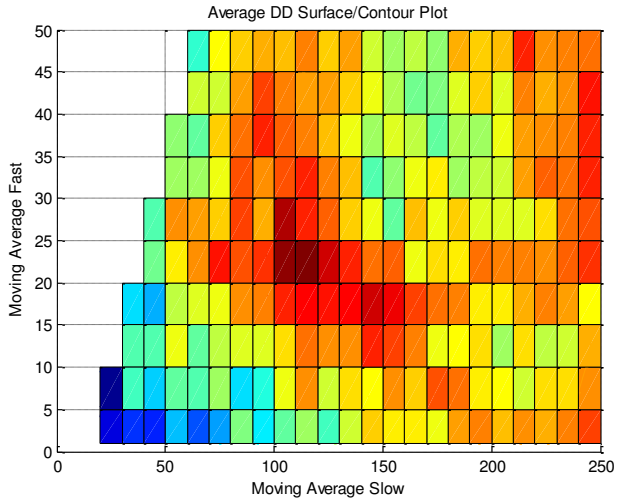

We do the same thing for annualized return:



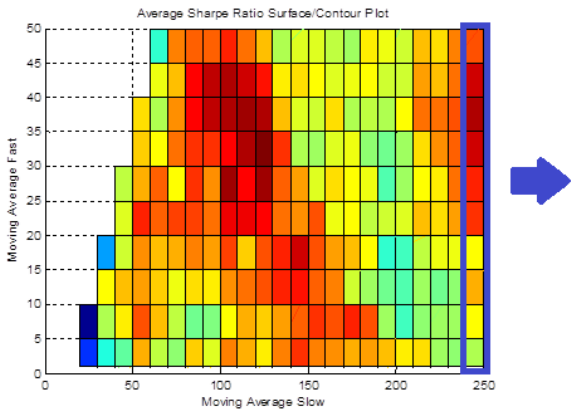



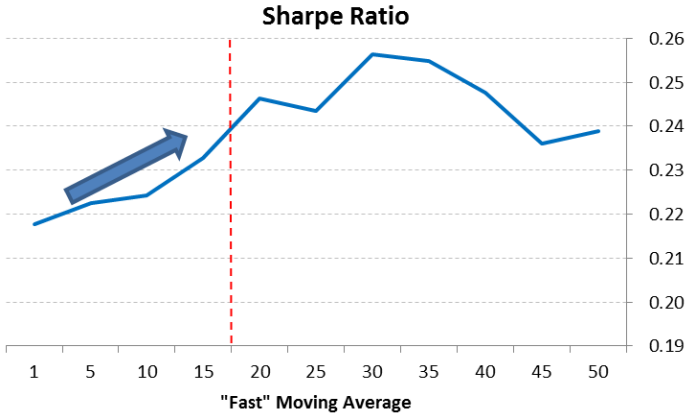
Average max Drawdown (inverse DD is shown so higher = better)



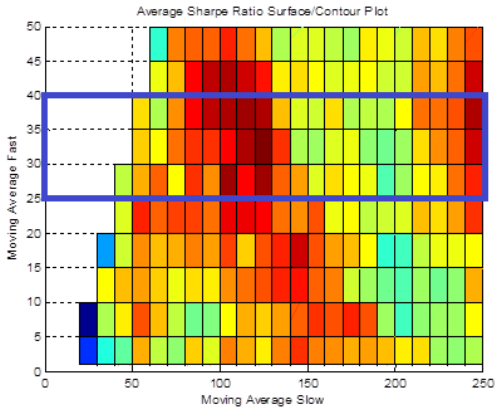

First, let's look at the benefit of smoothing the closing price when creating a "fast" indicator. As mentioned above, using an ***average*** closing price (vs. just closing price) dramatically improves the performance of a trend-following model – by reducing its tendency to get "whipsawed". If we look at the surface plot for "average" Sharpe Ratio, and focus on the very right-hand band (highlighted in blue); this shows various "fast" indicators vs a 250 day "slow" indicator. What we see is that the risk/return profile of a trend-following system dramatically improves as the "fast" signal is smoothed out to about 20 days:



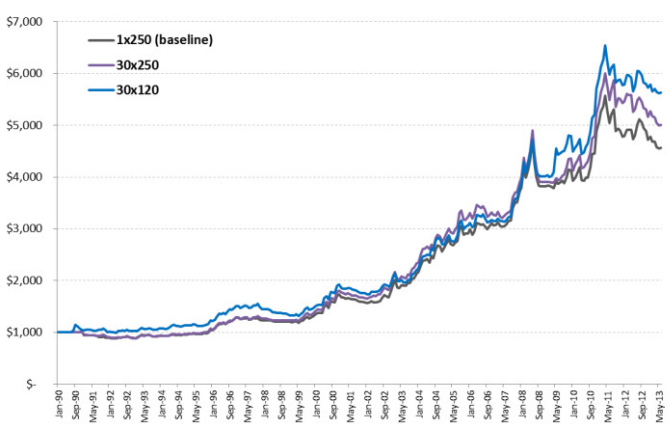



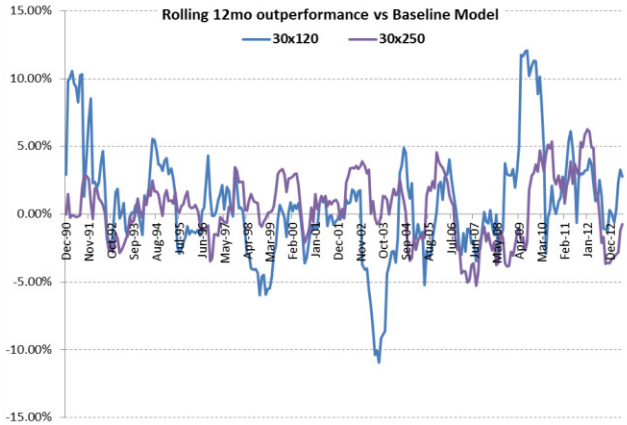

Using between 30 and 40 days to smooth the closing price has, on average, demonstrated the best performance in conjunction with a 250 day long-term signal.

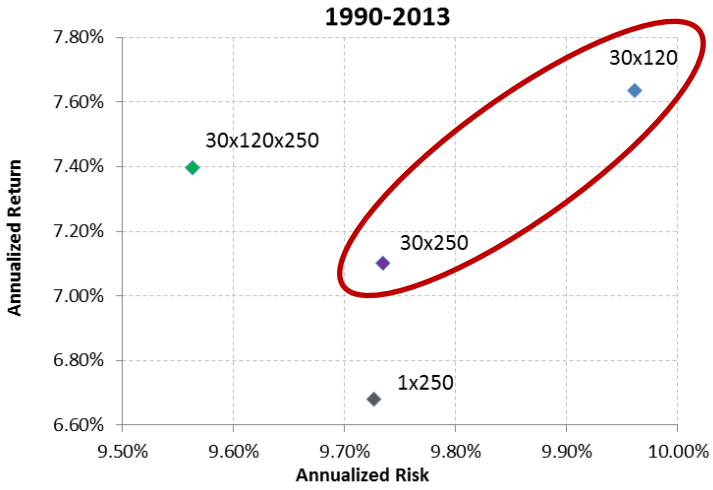
We now focus on the “fast” period between 25-40 days and create a band around the various “slow” timeframes. Within this band, we also see that several shorter “slow” signal lengths have demonstrated superior Sharpe ratios when combined with a 30-40 day “fast” signal. Specifically, the area greater than 50 days and less than 150 days:




Both **30x250** and **30x120** moving average trend-following systems are shown vs. the **1x250** “baseline” system:



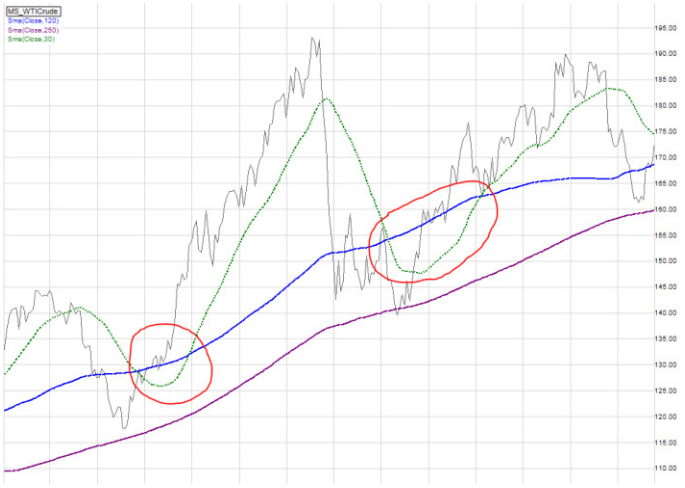



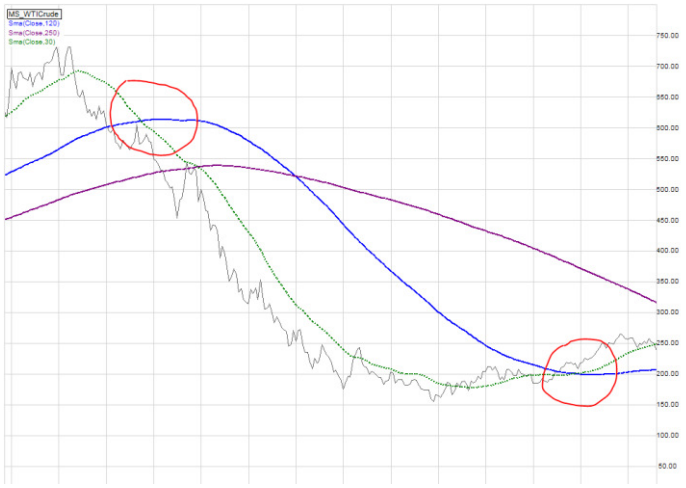

In addition to demonstrating superior risk/return characteristics relative to the “baseline” model over time, the two alternate trend-following schemes also demonstrate different periods (and magnitudes) of outperformance relative to the baseline model allowing for clear benefits of diversification.

Specifically, in a “choppy” yet up-trending market (like 2003), the **30x120** (green vs. blue) system will not participate in all of the uptrend while the simpler **1x250** (black vs. purple) system did. However in 2008, the **30x120** model exited on a downtrend sooner than the baseline model and re-established a long position quicker:

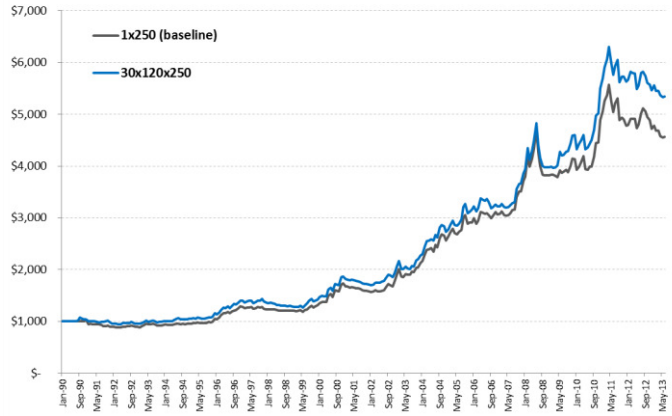
**2003**

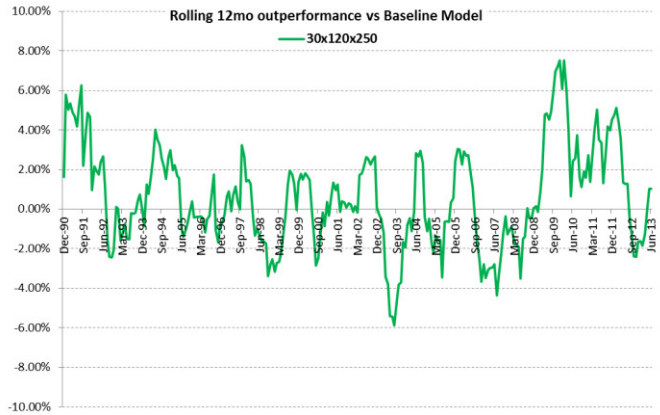


**2008**



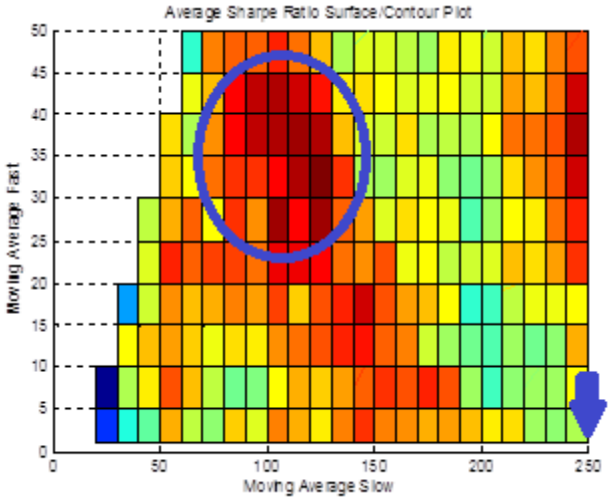
For the reasons illustrated above, many CTA’s diversify among several trend-following systems. Combining a **30x120** and a **30x250** system would have the same effect as “scaling” into positions depending on whether 1 or both of the systems are signaling long. The result is a very simple trend-following system that automatically increases its bets as an uptrend is established and decreases them as it reverses. This also leads to more consistent profitability over time:



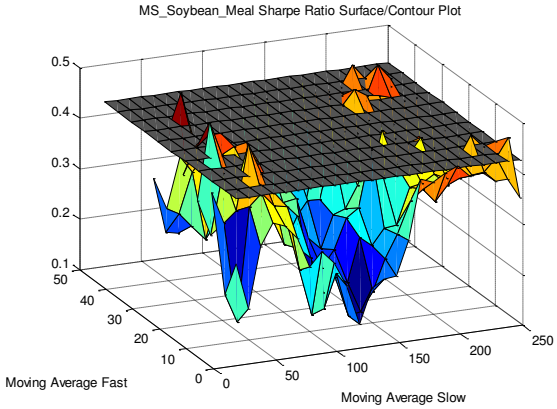

It’s important to point out that the two systems shown above (**30x120** & **30x250**) were simply chosen as examples and were not the result of an optimization process. The entire exercise of creating the surface plots is to find large “areas” of models on the surface plot that demonstrate superior performance (according to whatever metric is chosen).

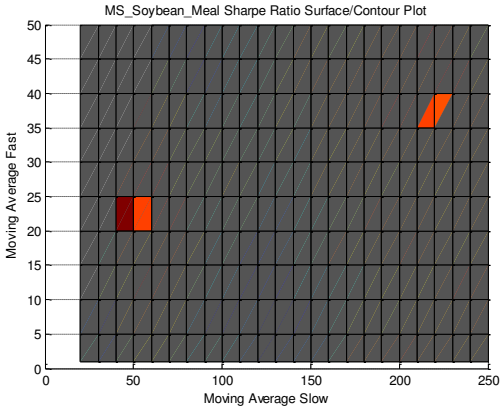
The fact that large a large, *contiguous*, area exists on the Sharpe Ratio surface plot (circled in blue) that demonstrates superior performance to the baseline **1x250** model (in the bottom right corner) suggests that simple improvements can be made to the **1x250** model that are likely to be robust & persistent going forward

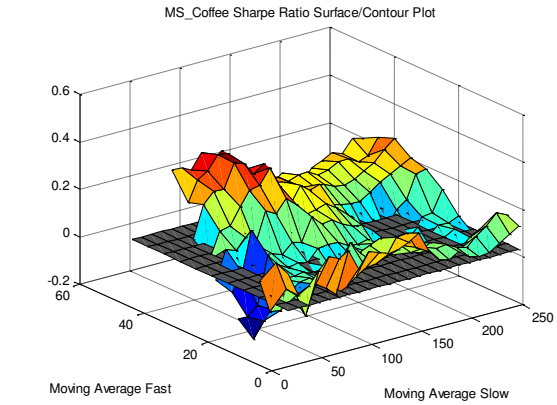


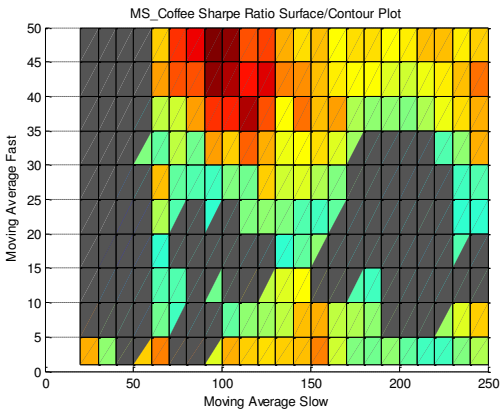
**Appendix I.**

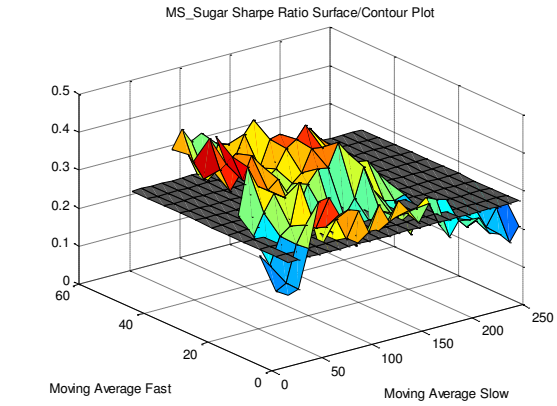
**Agriculture:**

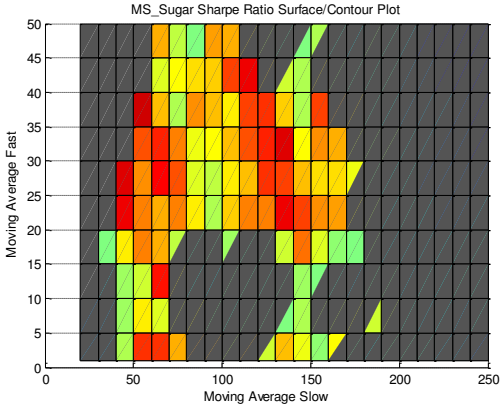


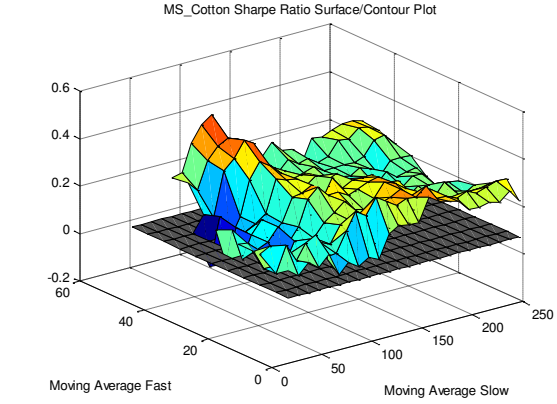



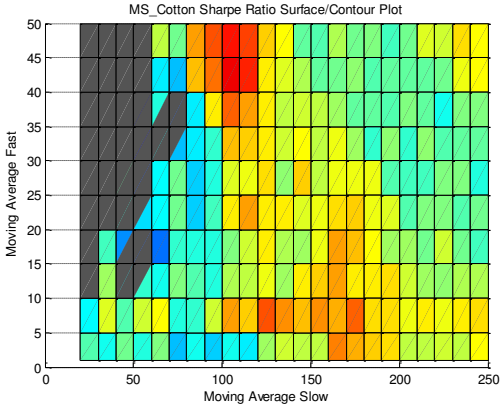



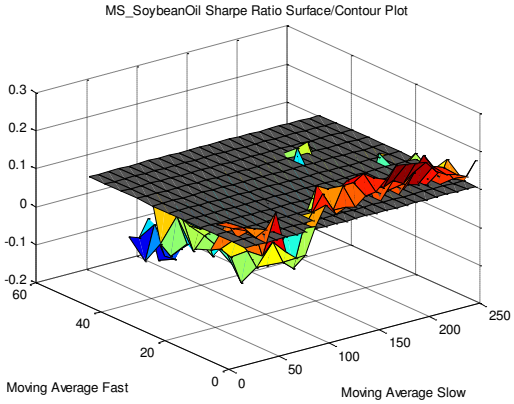



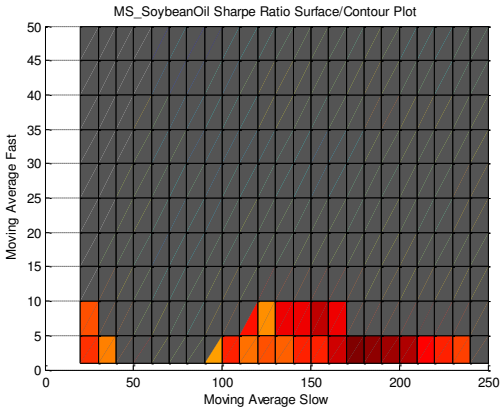



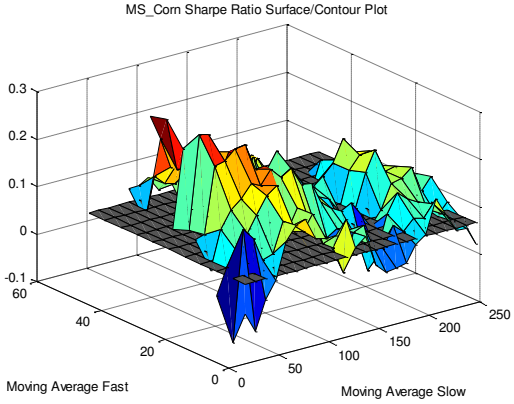



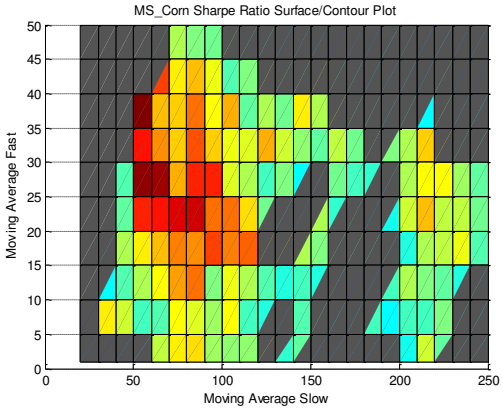



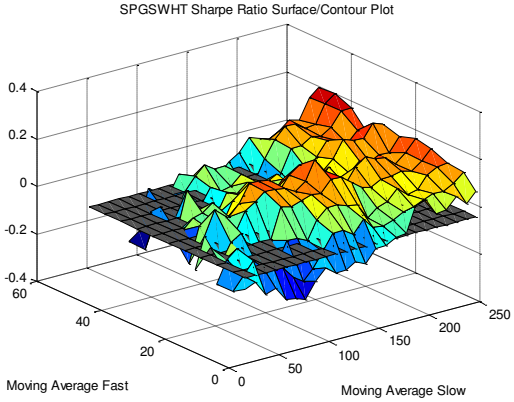



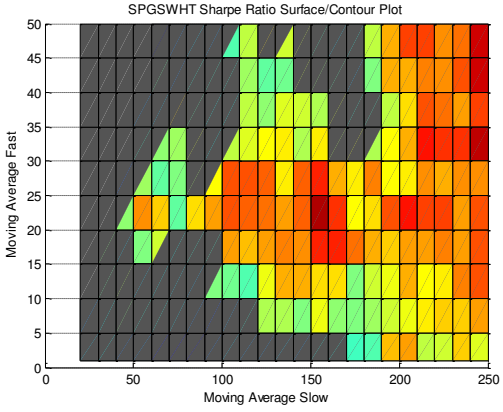

MS_SoybeanOil Sharpe Ratio Surface/Contour Plot
Moving Average Fast
Moving Average Slow

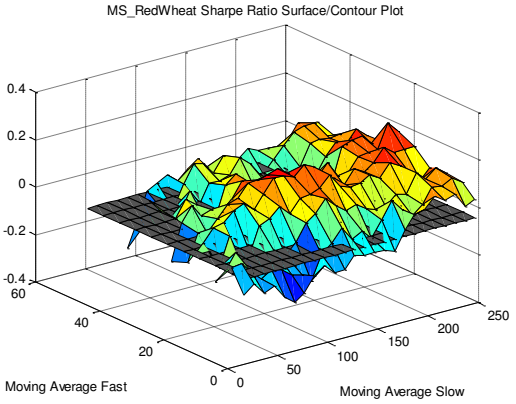

MS_SoybeanOil Sharpe Ratio Surface/Contour Plot
Moving Average Fast
Moving Average Slow

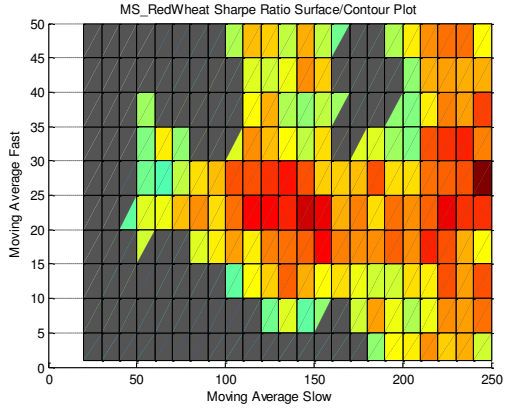

MS_Corn Sharpe Ratio Surface/Contour Plot
Moving Average Fast
Moving Average Slow

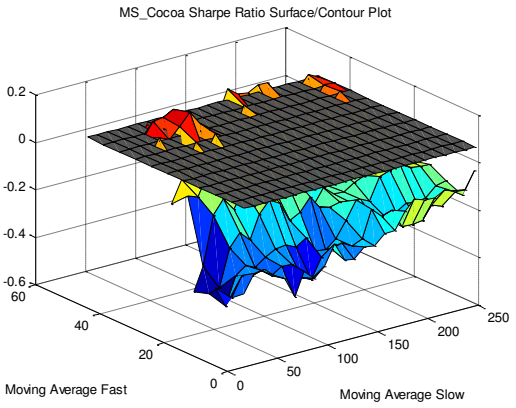

MS_Corn Sharpe Ratio Surface/Contour Plot
Moving Average Fast
Moving Average Slow

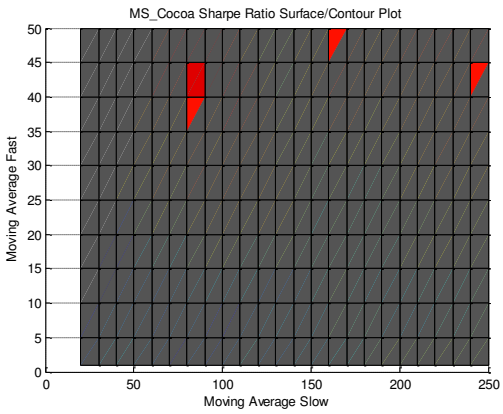

SPGSWHT Sharpe Ratio Surface/Contour Plot
Moving Average Fast
Moving Average Slow


SPGSWHT Sharpe Ratio Surface/Contour Plot
Moving Average Fast
Moving Average Slow

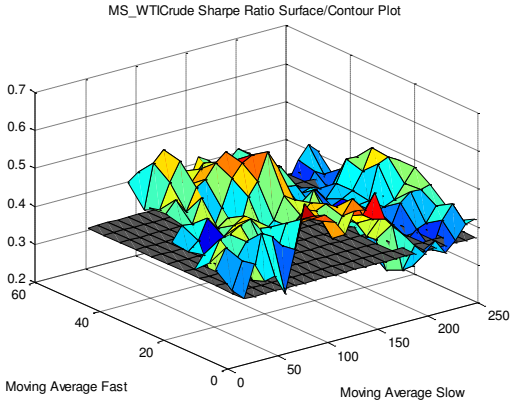

MS_RedWheat Sharpe Ratio Surface/Contour Plot
Moving Average Fast
Moving Average Slow

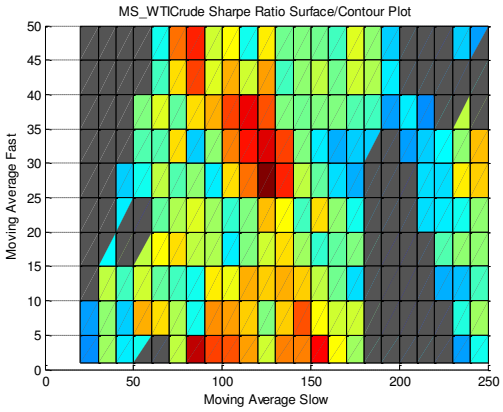

MS_RedWheat Sharpe Ratio Surface/Contour Plot
Moving Average Fast
Moving Average Slow

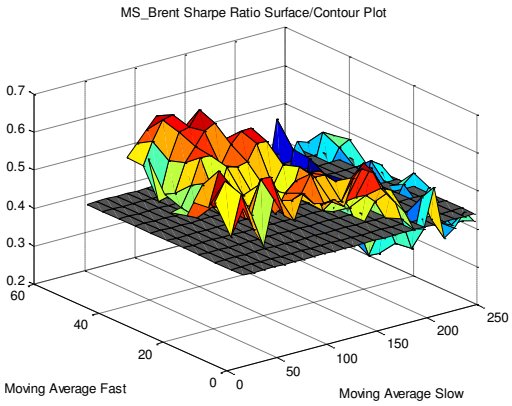

MS_Cocoa Sharpe Ratio Surface/Contour Plot
0.2
0
-0.2
-0.4
-0.6
60
40
20
0
Moving Average Fast
0
50
100
150
200
250
Moving Average Slow

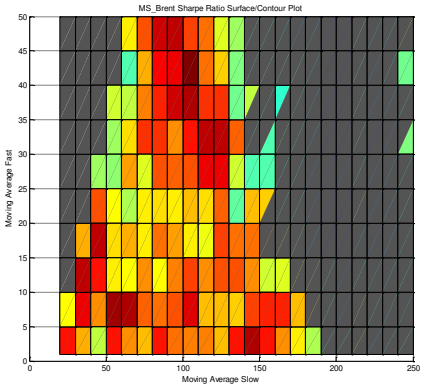

MS_Cocoa Sharpe Ratio Surface/Contour Plot
Moving Average Fast
Moving Average Slow

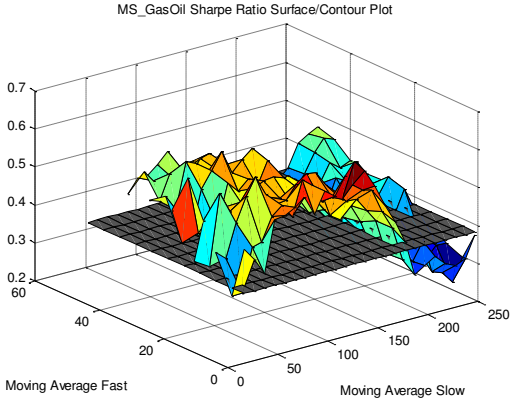
## Energy:

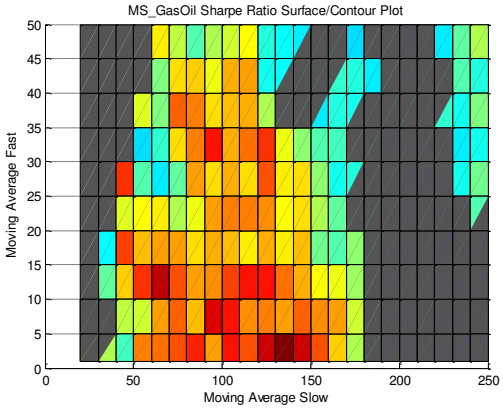

MS_WTICrude Sharpe Ratio Surface/Contour Plot
0.7
0.6
0.5
0.4
0.3
0.2
60
40
20
0
Moving Average Fast
0
50
100
150
200
250
Moving Average Slow

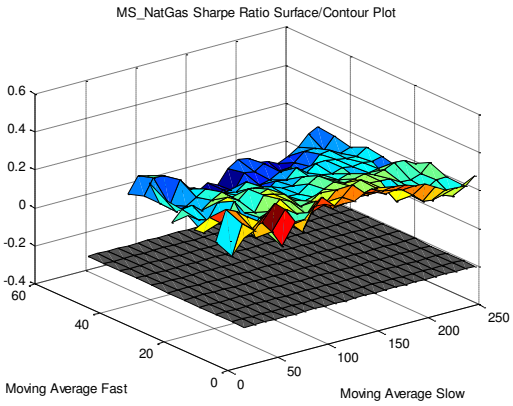

MS_WTICrude Sharpe Ratio Surface/Contour Plot
Moving Average Fast
Moving Average Slow

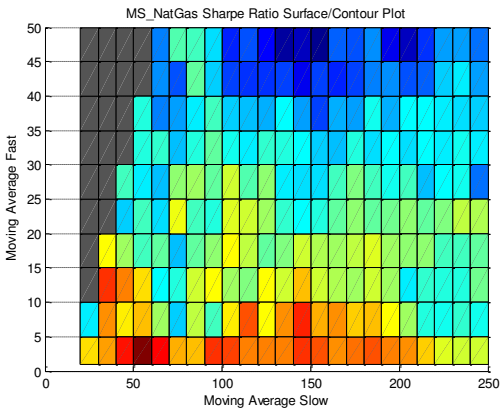

MS_Brent Sharpe Ratio Surface/Contour Plot
0.7
0.6
0.5
0.4
0.3
0.2
60
40
20
0
Moving Average Fast
0
50
100
150
200
250
Moving Average Slow

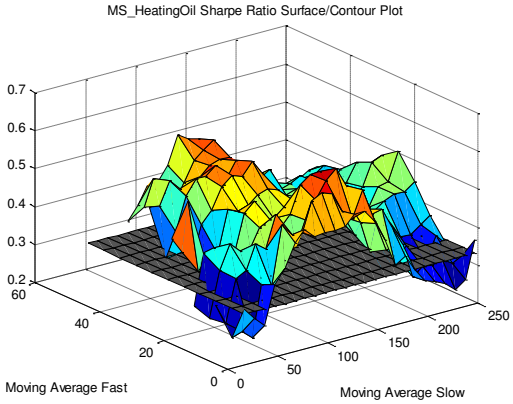

MS_Brent Sharpe Ratio Surface/Contour Plot
Moving Average Fast
Moving Average Slow

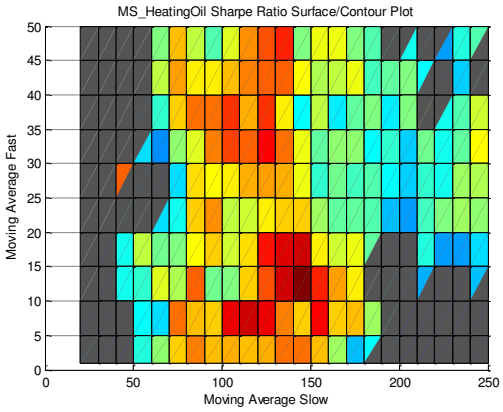

MS_GasOil Sharpe Ratio Surface/Contour Plot
0.7
0.6
0.5
0.4
0.3
0.2
60
40
20
0
Moving Average Fast
0
50
100
150
200
250
Moving Average Slow

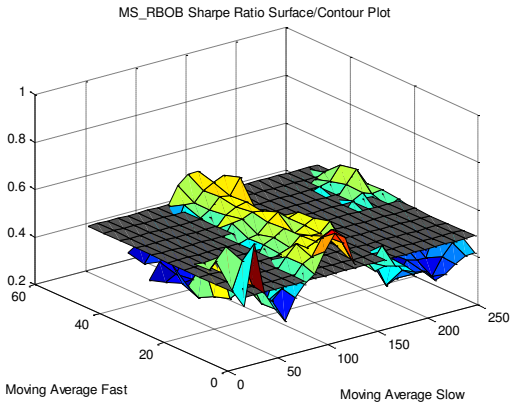

MS_GasOil Sharpe Ratio Surface/Contour Plot
Moving Average Fast
Moving Average Slow

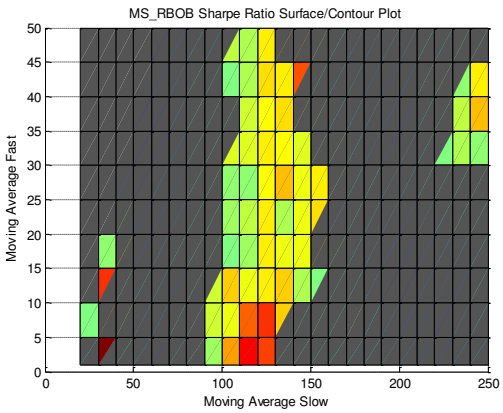

MS_NatGas Sharpe Ratio Surface/Contour Plot
0.6
0.4
0.2
0
-0.2
-0.4
60
40
20
0
Moving Average Fast
0
50
100
150
200
250
Moving Average Slow


MS_NatGas Sharpe Ratio Surface/Contour Plot
Moving Average Fast
Moving Average Slow
0
5
10
15
20
25
30
35
40
45
50
0
50
100
150
200
250

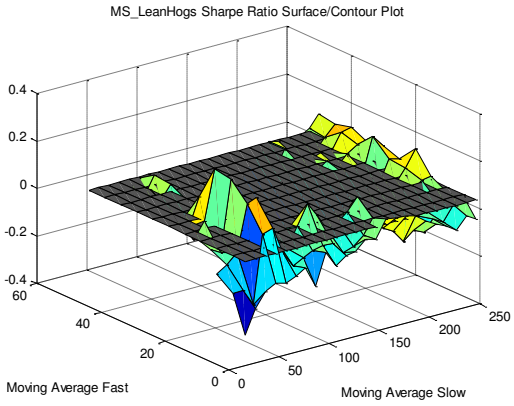

MS_HeatingOil Sharpe Ratio Surface/Contour Plot
0.7
0.6
0.5
0.4
0.3
0.2
60
40
20
0
Moving Average Fast
0
50
100
150
200
250
Moving Average Slow

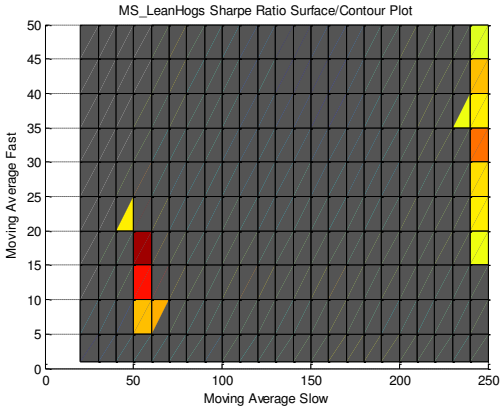

MS_HeatingOil Sharpe Ratio Surface/Contour Plot
Moving Average Fast
Moving Average Slow
0
5
10
15
20
25
30
35
40
45
50
0
50
100
150
200
250

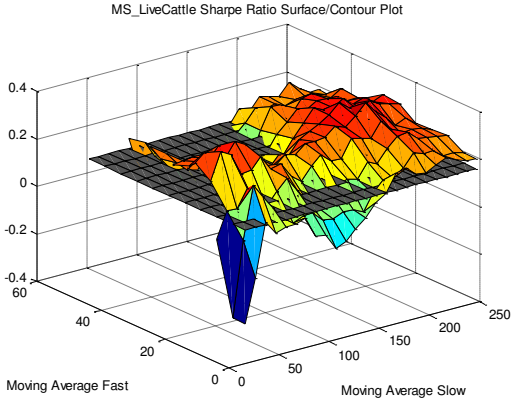

MS_RBOB Sharpe Ratio Surface/Contour Plot
1
0.8
0.6
0.4
0.2
60
40
20
0
Moving Average Fast
0
50
100
150
200
250
Moving Average Slow

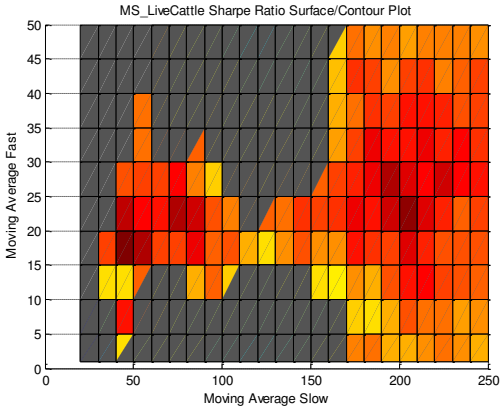

MS_RBOB Sharpe Ratio Surface/Contour Plot
Moving Average Fast
Moving Average Slow
0
5
10
15
20
25
30
35
40
45
50
0
50
100
150
200
250

## Livestock:

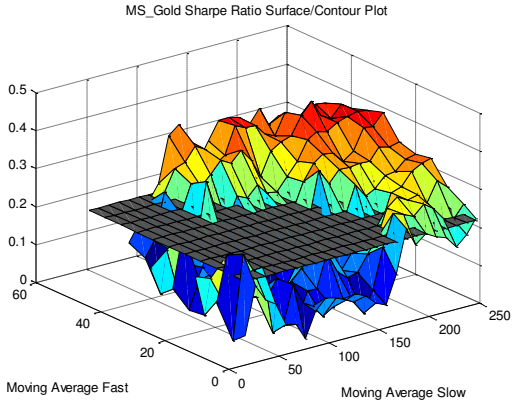


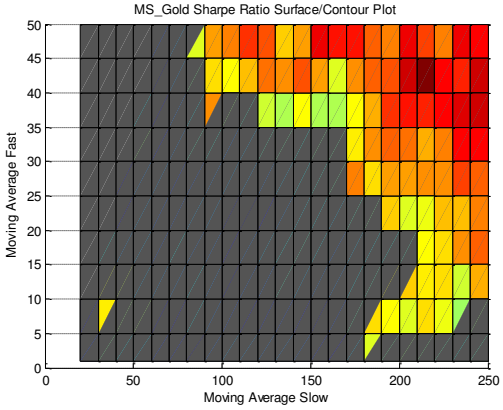



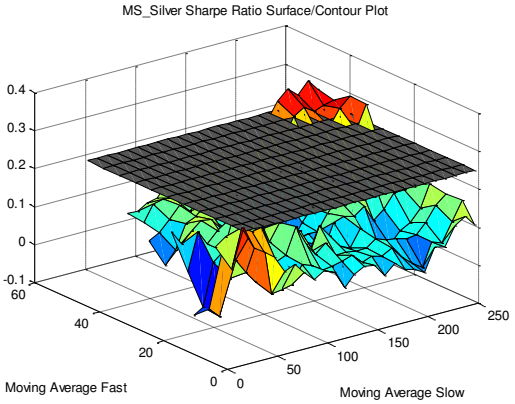



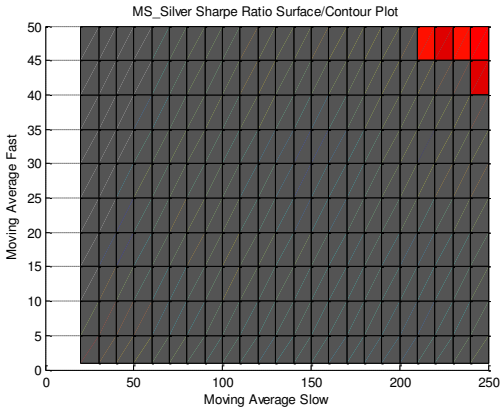



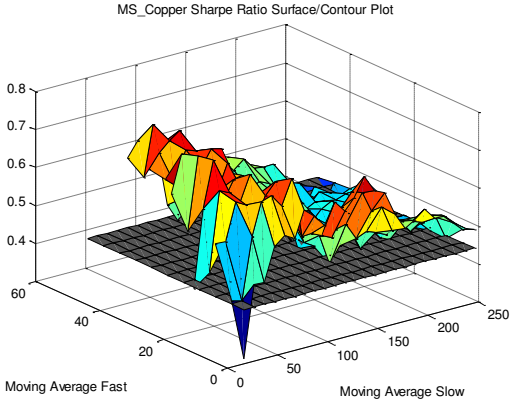

## Metals:

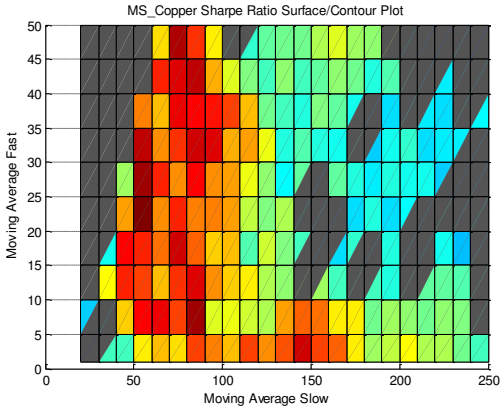



MS_Silver Sharpe Ratio Surface/Contour Plot
0.4
0.3
0.2
0.1
0
-0.1
60
40
20
0
Moving Average Fast
0
50
100
150
200
250
Moving Average Slow


MS_Silver Sharpe Ratio Surface/Contour Plot
Moving Average Fast
Moving Average Slow
0
5
10
15
20
25
30
35
40
45
50
0
50
100
150
200
250


MS_Copper Sharpe Ratio Surface/Contour Plot
0.8
0.7
0.6
0.5
0.4
60
40
20
0
Moving Average Fast
0
50
100
150
200
250
Moving Average Slow


MS_Copper Sharpe Ratio Surface/Contour Plot
Moving Average Fast
Moving Average Slow
0
5
10
15
20
25
30
35
40
45
50
0
50
100
150
200
250