Analysis of Historical Profitability:

Moving Average Strategies on ES Futures

Reese McDonald

Glossary

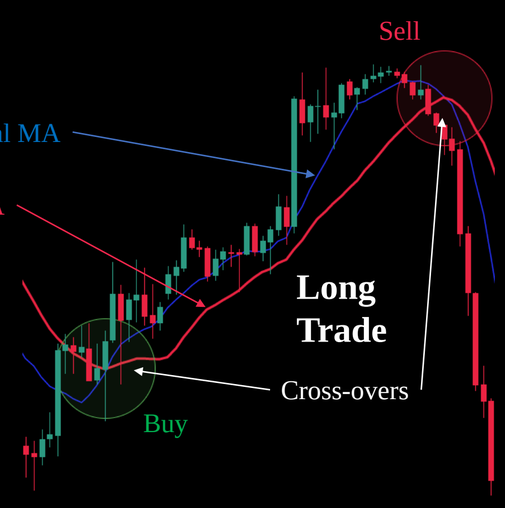
- Signal – The MA that typically has the shorter period length in a cross-over strategy
- Control – The MA that typically has the longer period length in a cross-over strategy
- Buy and Hold – Purchasing an asset and holding it long term
- Back-testing – Programmatically testing a strategy's performance on historical price data
- Trading Rules – The elements of a strategy that interact to provide trading signals
- Ticker – The letter symbol for a financial instrument or asset
- ES Data – Historical price data of S&P 500 futures
- MA Cross-Over Strategy – Trading strategy that takes trading signals from moments when MAs of different period lengths cross each other. A short trade is signaled when the signal MA crosses the control MA to the downside and a long trade when the signal crosses the control to the upside (9 period signal < 20 period control)
- Inverse Cross-Over – Doing the opposite of a given conventional cross-over (20 period signal > 9 period control)

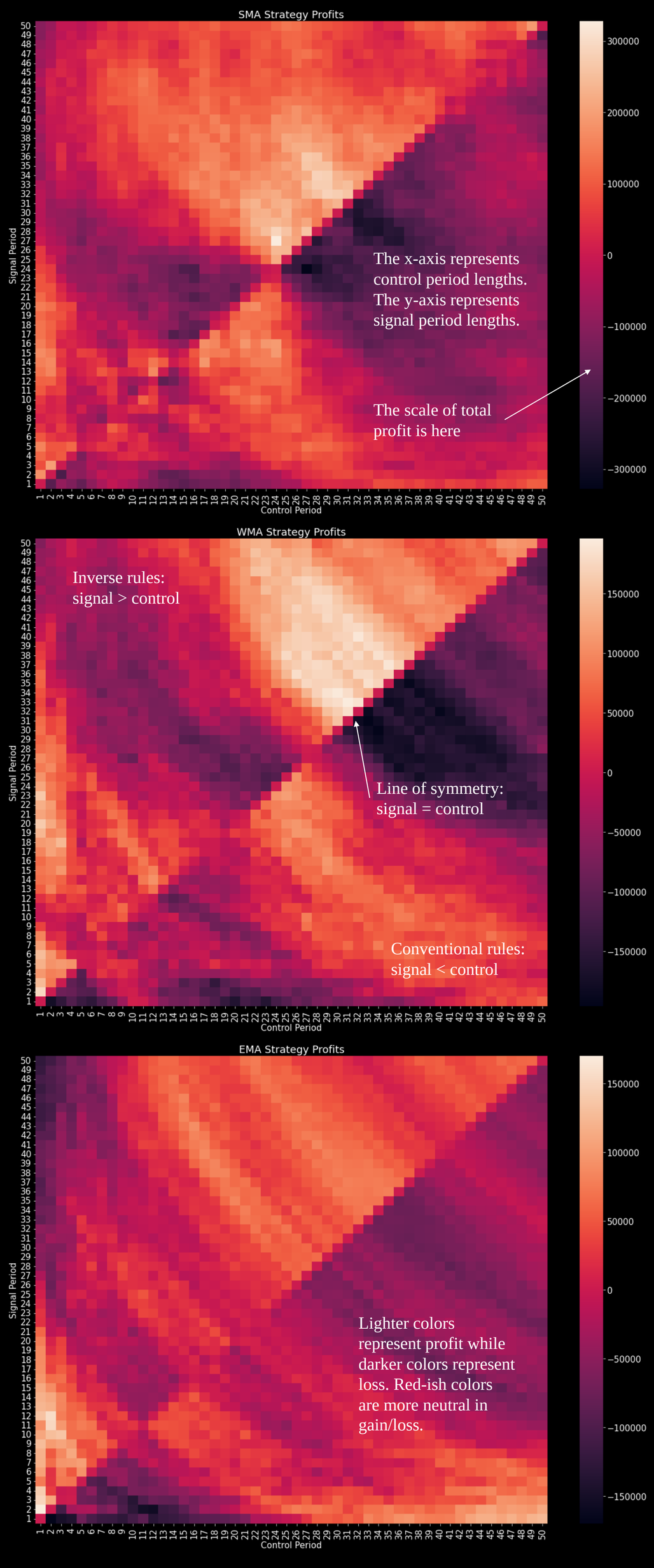
Background & Purpose

This work and analysis was done for several reasons:

1. To discover if any configuration of trading rule of a basic moving average (MA) cross-over trading strategy would have earned more than a buy and hold strategy over the span of the data.
2. To visualize the back-testing of any trading rule configuration in action.
3. To create an analytical tool for measuring moving average strategy profitability on any ticker, any time frame, and any range of MA period lengths.
4. To serve as necessary first steps in the exploration of price data that are foundational to the beginning algorithmic trader.

The short and long trade examples to the upper-right show how a moving average cross-over strategy directs an algorithm to enter and exit positions in both directions. A short trade (a bet that price will fall) begins with the sale of an asset to enter, and a buy to exit. A long trade (a bet that price rises) is opened by buying an asset and closed by selling it. See the glossary for an explanation of an MA cross-over strategy, which is the focus of this project.





Methodology

- Simple, weighted, and exponential signal and control MAs, along with directional trading signal and price movement columns for each MA style, were created from raw ES hourly price data with Python as the programming language.
- Profit columns were calculated by multiplying the signal value (-1 for a short position or 1 for a long position) by the associated movement in price.
- Profit columns were then summed to give the total amount each moving average strategy would have made over the span of the data for comparison against a buy and hold strategy (price of last hour – price of first hour).
- This process was repeated for every signal and control period length combination within the range of (1, 50) and profit totals were visualized in heat maps for each MA style.

Outcome

- The four visualizations seen to the left and below constitute the primary work product that resulted from this project. With them, it is possible to see how each strategy performs over the length of a set of price data, and where and why a given strategy wins or loses on an hourly basis.
- A buy and hold strategy would have made $143,325.
- The SMA had 217/2500 pairs beat the market (buy/hold strategy), WMA had 135/2500, and EMA had only 4/2500.
- The most profitable strategy at $327,437 had an SMA signal of period 27 and an SMA control of period 24.

Limitations

- This system does not make predictions based on sentiment or fundamental indicators, but rather on the assumption that price trends persist more often than they change direction on any timeframe. There is a whole world of causation to price behavior that has not been considered in this work.
- Running price data that is more granular than a `1min` timeframe through the Python script may result in extremely high demand on memory storage and processing.

Moving Average Style Calculations

- The visualization above shows how MA styles behave differently. The color- matched equations below show how these moving averages were calculated.

$$SMA = (A_1 + A_2 + \dots + A_n) / n$$

Where:
A_n = the price at period n
n = number of total periods or the "period length"

$$WMA = (A_1*1 / s + A_2*2 / s + \dots + A_n*n / s) / n$$

Where:
A_n = the price at period n
n = number of total periods or the "period length"
$s = (1 + 2 + \dots + n)$

$$EMA_c = P_c*a + EMA_p*(1-a)$$

Where:
EMA_c = current EMA value
P_c = current price
$a = 2 / (1+n)$
n = length of period
EMA_p = EMA value of the prior period

Recommendations

- The data spans over seventeen years and four months and includes 104,439 hours of open, high, low, and close (OHLC) prices. Over this amount of time, it is reasonable to assume that this algorithm would encounter, and account for, a comprehensive variation of technical situations which would be expressed in the performances of these MA strategies.
- As such, it may also be reasonable to assume that the strategies that did well within this span of time might continue to do so over any span of time that is similar in length.
- Some of the most profitable strategies were the inverses of failing strategies. A willingness to utilize a counter-intuitive application of MA cross-over based on these findings may result in an algorithm that outperforms the market in the long-run.