NUS INVESTMENT SOCIETY
Technical Report

Trend-following strategies in U.S. equity markets

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Introduction

We present our progress in developing trend-following strategies for the U.S. equities market. Our project began with an observation that there has been a decade-long (2009 to 2020) bull U.S. equity market since the Great Financial Crisis in 2007. However the market was not bullish consistently, with retracements in 2010, 2011, 2016 and 2018. A buy-and-hold investor would experience (unwanted) drawdowns in these years. As such we consider two questions:

1. How can we profit from the bullish runs of the market yet avoid its drawdowns?
2. How can we maximize profits from the bull run and minimize losses from the drawdowns?

To answer these, we first define what a trend is. A trend is the general direction of the price of a market over a given period of time. There are two types of trends - uptrends, downtrends. Uptrends are characterized by rising prices, such as higher highs and higher lows. Conversely, downtrends are formed by decreasing prices with lower highs and lower lows.

Our modus operandi to the former question is trend-following strategies. Such strategies assume price movements persist[1] and investors buy an asset when price is trending upwards and sell during a down trend. Common trend strategies include basic moving average rules, moving average crossovers, breakout rules.

The second question is interesting - identifying a trend is easy but to maximize profits, we need to capture most if not all of the trend. However, assuming the role of student investors, we neither have the funds nor information to “move” the markets. Consequently, we cannot with absolute certainty know when a trend starts (ends) in real time. Therefore, rather than predicting when a trend begins (ends), we want to enter the market as soon as a persistent upward trend forms and exit as soon as the direction changes; essentially following and not leading the trend. We want to avoid false signals yet enter before the uptrend changes direction and exit before excessive drawdowns. That is challenging.

In our report, we assume an initial capital of USD 10,000 and take long-only positions. Financial data (Open, High, Low, Close prices) is obtained from Yahoo Finance. We consider a daily timeframe. The primary objective of our strategies is to offer higher risk-adjusted returns than a buy-and-hold strategy over a period of time.

The rest of the report is organized as follows. In section 2, we provide a strategy involving the Parabolic SAR indicator. In section 3, we describe our findings on a strategy involving the Aroon

[1] There is a wealth of academic literature justifying the profitability of trend-following rules. See Clare et al. (2009)

indicators. In section 4, we apply machine learning techniques on the trend following strategy. Lastly, we conclude our report and point out a number of directions for future work.

Aroon

The aroon indicator attempts to determine whether a stock is trending and the strength of the trend. It measures the number of periods since the price of an asset reached a X- day high or low. There are two separate indicators, Aroon-Up and Aroon-Down. We adopt 14-day Aroon indicators.

In chart,

The X-day Aroon indicators are computed as follows:

$$Aroon\ Up\ =\ \frac{X - days\ since\ x{-}day\ High}{X} * 100$$

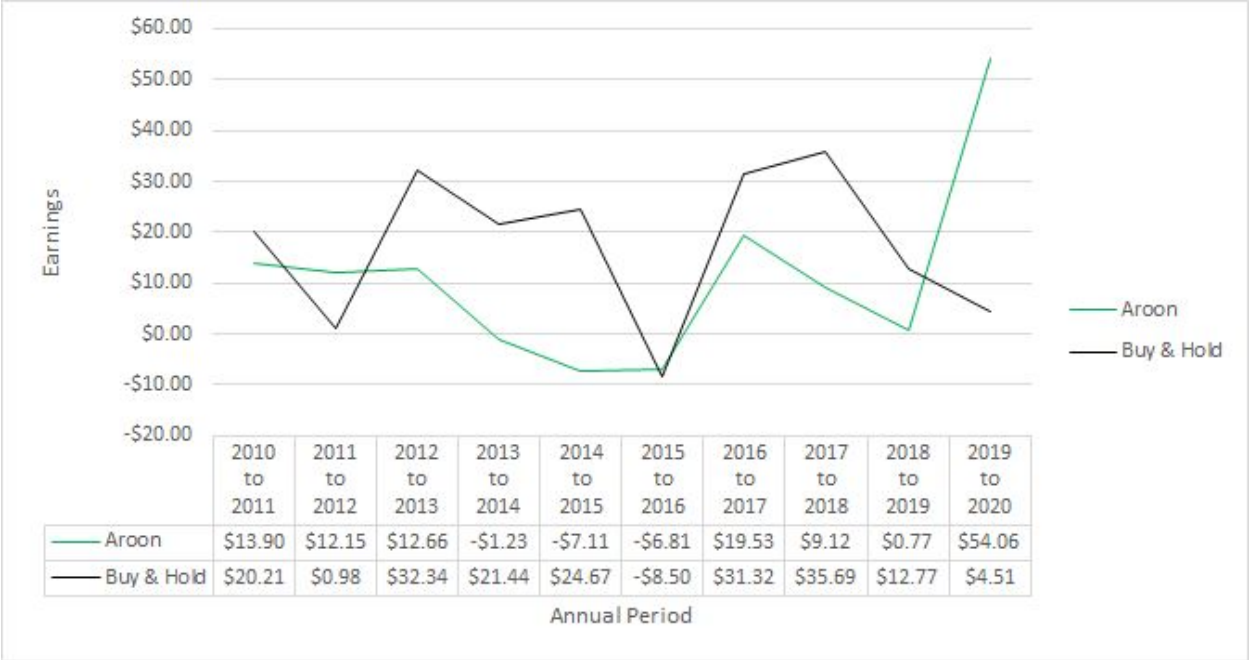
$$Aroon\ Down\ =\ \frac{X - days\ since\ X{-}day\ Low}{X} * 100$$

Our strategy is as follows:

1. Long (close market order[2]) 1 share when Aroon Up crosses up Aroon Down
2. Short (close market order) 1 share when Aroon Up crosses down Aroon Down

[2] We submit closed market orders in live trading but for analysis, we assume close prices. Hence our analysis would be a (close) estimate of the results from live trading

Results[3]:



	2010 to 2011	2011 to 2012	2012 to 2013	2013 to 2014	2014 to 2015	2015 to 2016	2016 to 2017	2017 to 2018	2018 to 2019	2019 to 2020
Aroon	$13.90	$12.15	$12.66	-$1.23	-$7.11	-$6.81	$19.53	$9.12	$0.77	$54.06
Buy & Hold	$20.21	$0.98	$32.34	$21.44	$24.67	-$8.50	$31.32	$35.69	$12.77	$4.51

The Aroon indicator, for the majority, underperformed the markets, although it outperformed over 2 periods 2011 to 2012 and 2019 to 2020.

One may observe that the Aroon indicator is a conservative trend-following strategy, as entry signals only appear much after the start of the trend. A more sensitive indicator may be better, whilst controlling the number of false signals generated.

[3] Results did not factor in transaction costs. As such, the returns from the Aroon strategy are overestimated.

Parabolic SAR

The Parabolic Stop And Reverse (SAR) is a technical indicator to determine the direction that an asset is moving. It aims to identify potential reversals in the price movement of traded assets. In particular, we use this indicator for entry and exit signals.

When plotted on a chart, the Parabolic SAR indicator is displayed as a series of dots. A bullish signal is created when the indicator appears below the current price and a bearish signal when it is above the current price.

The SAR indicator is calculated using the highest and lowest price, as well as the acceleration factor (AF) to determine where the SAR indicator dot will be displayed.

$$Uptrend\ Parabolic\ SAR\ =\ Prior\ SAR\ +\ Prior\ AF\ *\ (Prior\ EP\ -\ Prior\ SAR)$$

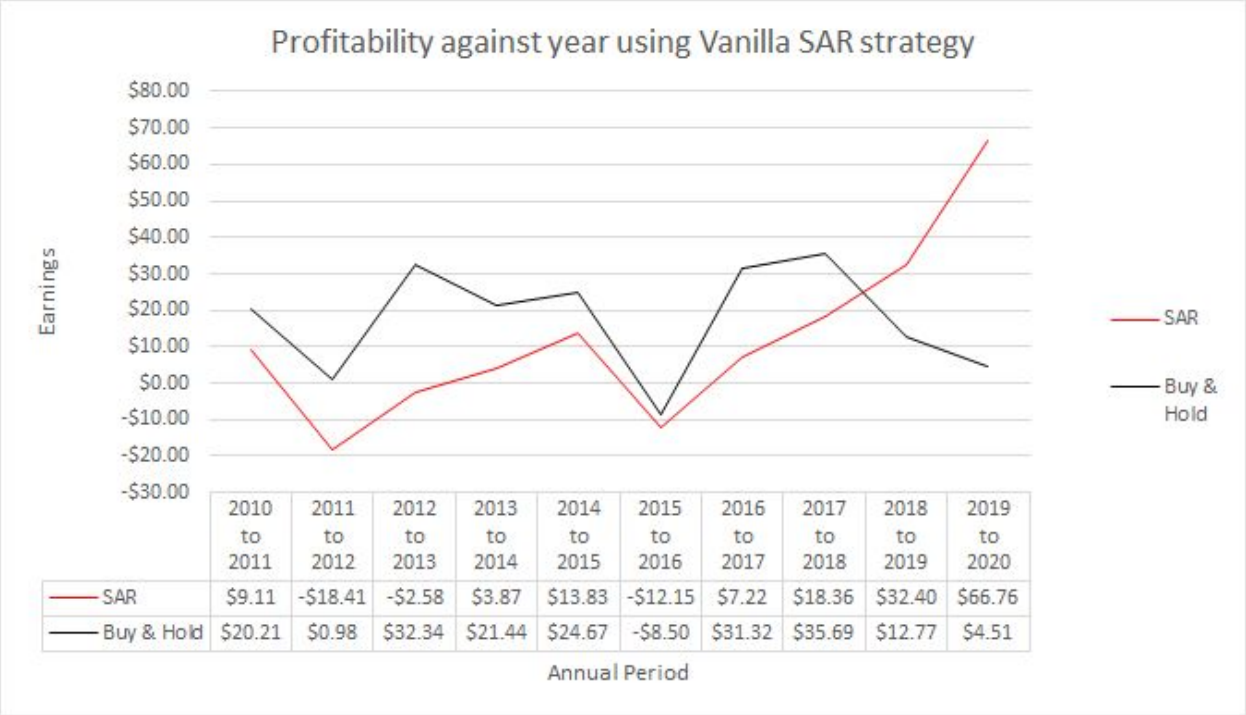
$$Downtrend\ Parabolic\ SAR\ =\ Prior\ SAR\ -\ Prior\ AF\ *\ (Prior\ SAR\ -\ Prior\ AP)$$

where EP is the extreme point in a trend (both up and down), AF is the acceleration factor starting at 0.02 and increases by 0.02 each time EP makes a new high, with maximum value of 0.2

Our strategy is as follows:

1. Long (Close market order[4]) 1 share when SAR indicator > high of previous day price changes to SAR indicator < low of current day price
2. Sell (Close market order) 1 share when SAR indicator < low of previous day price changes to SAR indicator > high of current day price.

Results[5]:



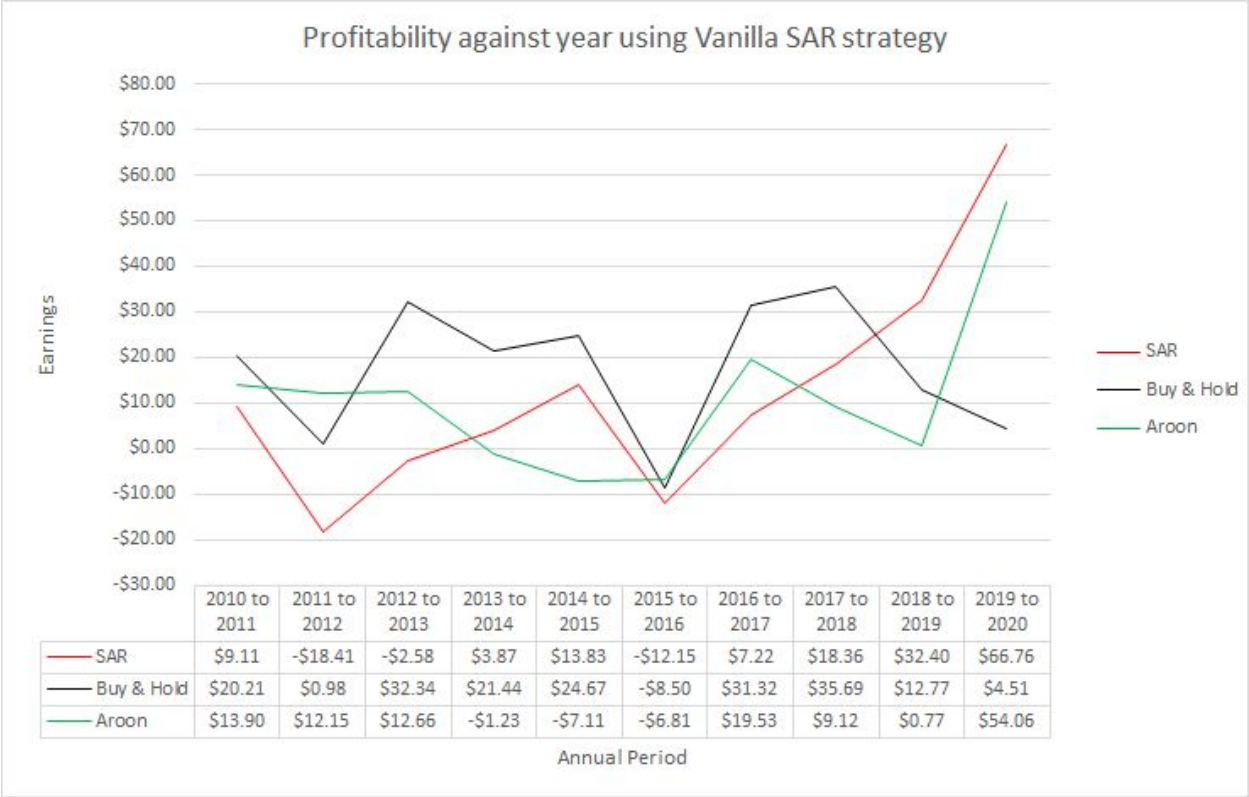
	2010 to 2011	2011 to 2012	2012 to 2013	2013 to 2014	2014 to 2015	2015 to 2016	2016 to 2017	2017 to 2018	2018 to 2019	2019 to 2020
SAR	$9.11	-$18.41	-$2.58	$3.87	$13.83	-$12.15	$7.22	$18.36	$32.40	$66.76
Buy & Hold	$20.21	$0.98	$32.34	$21.44	$24.67	-$8.50	$31.32	$35.69	$12.77	$4.51

The SAR indicator has been effective from 2018 to 2020, beating a vanilla buy-and-hold strategy. However, this strategy has drawbacks too and underperformed the market during 2010 to 2018.

The underperformance might be attributed to false signals by the indicator, leading to losses. A workaround solution to improve profitability would be to complement this indicator with moving averages and candlestick patterns to confirm the strength of the trend.

[4] See footnote 2
[5] Results did not factor in transaction costs. As such, the returns from the SAR strategy are overestimated.

Combining both Aroon and SAR indicators earnings profile, we have



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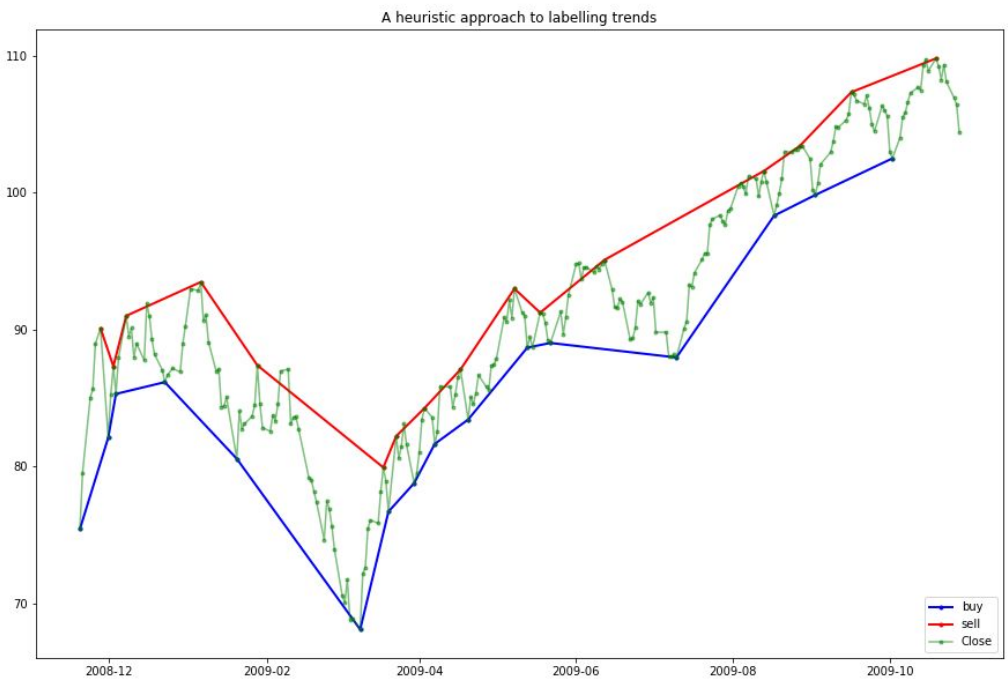
Machine Learning

We employ a heuristic approach in labelling trends. We assume that one can sell only if there is an existing long position, for simplicity.[6] The approach is as follows:

1. Set a window period of 30 days and search for the minimum close price during this duration. This will be the buy signal, b_0 at time t_{00}.
2. Next, we find the cumulative maximum of the close prices and compute the (negative) change ($\Delta = \frac{cummax(t_i) - close(t_i)}{cummax(t_i)}$). If the change at time t_x, exceeds a certain threshold k, we will restrict the time range from t_{00} until t_x.
3. Search for the maximum close price within this duration, [t_{00}, t_x]. This will be the sell signal, s_0 at time t_{01}.
4. Check if $s_0 > b_0$. If true, a trend is identified.
5. Else, continue the iteration



We then use machine learning techniques such as Random Forest, Gradient Boosting and Naive Bayes Classifier to train on the labeled dataset. The feature variables consist of Close Price, Simple Moving Average (SMA), Exponential Moving Average (EMA) and Bollinger Bands (BB) to predict if there is a signal (buy/sell) on a given day. Among all the methods, the Gradient

[6] Each transaction (buy/sell) involves 100% of capital/shares.

Boosting algorithm outperforms the rest. It has a net profit of 100% as compared to a buy-and-hold strategy which yields about 80% over a 5-year period.[7]

Although the strategy may be more profitable than a buy-and-hold strategy, due to the larger number of transactions, it may not be profitable after factoring in all the costs. Nonetheless, the idea of labelling signals should be explored further, possibly using a localised search for local minimums. More sophisticated models such as Recurrent Neural Networks (RNN) that account for seasonality trends may improve profitability as well.

[7] Results did not factor in transaction costs.

Conclusion

We present 3 different trend-following strategies in this report, Aroon indicator, SAR indicator and a machine learning approach. For the indicator strategies, it is not as profitable to a buy-and-hold strategy. However, we note that both indicator strategies have been profitable in recent years (2018 to 2020).

For future work, we can improve the back-testing model, to factor in more accurate transaction cost analysis. We may also consider if there is a difference in returns between trading on end-of-month dates and trading at the daily frequency. Clare et al. (2013) suggests there is no significant difference but their data only considered 2011 data. An updated analysis would be appreciated.

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