Mean Reversion Algorithm

'Can't Lose Til' You Sell'

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A Project Completed by the Trading Team in conjunction with
The University of Western Australia
April 2022 Quantitative Finance UWA

Contents

1 Introduction

“Mean reversion, or reversion to the mean, is a theory used in finance that suggests that asset price volatility and historical returns eventually will revert to the long-run mean or average level of the entire dataset.” - Investopedia

The mean or average price of a stock in finance is usually calculated on a rolling basis, for example, the mean price of a stock over a two-week period is the price of the stock on each of those days, summed and divided by the number of days. This can be used as a good indication of the value of a stock.

Mean reversion states that stocks should eventually return to a long-term mean price over time, therefore any anomalies in either price direction would eventually correct themselves. In this correction period, is where money can be made.

2 Algorithm Selection

2.1 Overview

We chose to test a wide range of different technical indicators to identify the most consistently performing ones, on which we ran wide parameter sweeps to further hone the performance of the algorithms. The indicators that we focused on were Bollinger Bands, Relative Strength Index (RSI), Stochastic Oscillator, and Internal Bar Range (IBR). These were selected and combined to produce many algorithms, of which we tested to determine the best.

2.2 Bollinger Bands

Bollinger bands are lines plotted on a stock price graph an equal distance above and below a rolling average. For example, a common Bollinger band plot would be 2 standard deviations above and below the 14 day moving average of a stock. Performing Mean Reversion trading using Bollinger bands involves trading when the price of a stock crosses over one of the Bollinger bands. If the price of the stock breaches the upper Bollinger band, the stock has had an anomalous upwards swing, and will likely return to its long-term mean price, therefore the stock should be shorted.

2.3 Relative Strength Index (RSI)

Relative Strength Index is a momentum oscillator that evaluates overbought or oversold conditions by measuring the speed and change of the price movement. It oscillates between 0 to 100, where anything above 70 represents overbought and anything below 30 represents oversold. We may use it to find the price point where the trend reverses. The threshold values can be adjusted depending on the stocks that you have. You should keep in mind that the sum of the threshold values must be equal to 100 and the overbought threshold must be larger than the oversold threshold.

$$RSI = 100 - \frac{100}{1 + \frac{Average\ Gain}{Average\ Loss}}$$

Another way of using RSI is to compare it against the stock price or against another technical indicator. If the price is making a higher high and RSI is making a lower high or the price is making a lower low and RSI is making a higher low, then we have a regular divergence. A regular divergence indicates a trend reversal and may have lesser false alarms than just using the thresholds alone. A lower high price

and a higher high RSI or a higher low price and a lower low RSI indicate a hidden divergence which signals a possible trend continuation.

2.4 Stochastic Oscillator

The Stochastic Oscillator is an oscillating indicator that fluctuates between 0 to 100. It uses a formula which tracks the closing prices of stock against the highs and lows over a certain period. It is described as a momentum indicator that attempts to illustrate how oversold or overbought a certain stock is. When used in a mean reversion trading strategy context, a low reading would indicate that the stock is oversold and will likely revert to a buy momentum, thus driving up the price. Conversely, if the indicator shows a high reading, it is suggested that the stock is overbought and momentum will likely revert to sell, driving down the price.

There are two line that are used in Stochastics – K% and D%. The K% line is known as the fast Stochastic indicator and has the following formula: $\frac{close(today)-low(n\ days)}{high(n\ days)-low(n\ days)} \times 100$. The D% line is created by smoothing out the K% line with a n day simple moving average (SMA) of itself. A crossover between the K% and D% signals a buy or sell depending on whether the crossover occurred above the overbought threshold or below the oversold threshold.

2.5 Internal Bar Strength

Internal Bar Strength (IBS) is an oscillator that positions the period's close in relation to the period's range. IBS ranges from 0 to 1, where 0 means that the close was at the lowest price of the range, and 1 if the closing price is at the high of the range. The essence of the idea is based on mean reversion, where if the IBS value closes in the lowest part of the range, the value will revert closer to 0.5 the following period. The formula for IBS is similar to the formula for the Stochastic Oscillator but differs in the periods included in the calculation.

$$IBS = \frac{close(today) - low(today)}{high(today) - low(today)}$$

While using IBS as an oscillator by itself can be profitable, an alternative approach can be applied by using IBS as a filter on other mean reversion trading strategies. This approach allows for trades to be applied on a longer timescale, compared to IBS alone. A common example is using Internal Bar Strength with Relative Strength Index, mentioned below. A weakness regarding IBS is the fact that trades need to be entered near the close if not at the close. However, in a market setting this is not extremely realistic, as it adds another layer of difficulty in making the trades.

3 Algorithm Optimization

3.1 Overview

For the project, teams were provided with an API in which they can pull stock data from many different markets across the world. We were told that our algorithms will be tested on S&P 500 stocks with 1 minute price intervals. The data includes the last 24 months of data and will be tested on such. Our goal is to optimize a mean reversion strategy to maximise profit on the back-tested prices but will also not be over-fitted to this data and should therefore work effectively in future data sets and in live trading. Our strategy for optimizing these algorithms was to test different combinations of the above indicators and see how they performed when back-testing. Each indicator was also tested extensively to

identify which combination of parameters worked to produce the most consistent results across several stocks. We ensured to test each algorithm on a range of stocks over different time periods to avoid overfitting our algorithms to the data.

3.2 Bollinger Bands

We found that using Bollinger Bands to trade alone had very poor performance in mean reversion strategies. However, after testing 2500 combinations of long and short moving averages, we found that a training period of 2 and a band size of 2 standard deviations produced the best results across the stocks, however this "best result" still produced a net loss. Bollinger Bands are much better suited when combined with other indicators, as opposed to trading by themselves.

3.3 Stochastic Oscillator

The Stochastic Oscillator did not perform very well by itself. Initially, we tested this indicator with technology stocks with large amounts of rapid growth such as Tesla and Apple. We found that the Stochastic Oscillator gave many short/sell signals that performed poorly and resulted in losses. We hypothesised that this may be due to the general increase in the stock prices resulting in less profitable short opportunities. Thus, the Stochastic Oscillator may perform better with a stock trading sideways compared to a growth stock. This hypothesis was back tested against stocks such as Amazon, which exhibited prices with less volatility.

3.4 Relative Strength Index

RSI is not usually used as a standalone strategy, and this was proven by the consistently poor results of back testing the data whilst only using RSI to generate trading signals. We quickly abandoned this method and resorted to only adding RSI to existing algorithms to make improvements, rather than using RSI as the main decision-making indicator.

3.5 Internal Bar Strength and Relative Strength Index

Like RSI, IBS is also not used standalone and using it alone does not produce promising results. Using IBS in conjunction with RSI displayed the efficiency of using IBS as a filter, through removing trades that should have resulted in losses. Throughout our project, we back tested 3 different methods from our control regarding using IBS as a filter on RSI. Unfortunately, however, we did not see any profits come from utilising IBS with RSI on our back tests, but the results still display the ability of IBS as a filter.

1. Only Longs Trades
2. Maintain Trade if within Boundaries
3. Maintain Trade until Opposite Entry Conditions Met

For our control method, trades were entered at close if conditions were met, and were exited the following close. A quick summary showed that: tightening the IBS threshold from 0.5 to 0.1 reduced loss by around ~ 11%, whilst not averaged across different equities. However, at times through having such tight margins, potential gains were ignored and as such, some tests with lower margins outperformed tighter margins.

Several articles have mentioned that IBS performs better in bear markets, and as such, for one of the methodologies we tested long only trades. As a result, percentage losses were improved by more than half on average. While it may be because shorts were not entered half the "losses" from the algorithm were not included. From the fact that losses were improved more than half, shows that longs 'typically' did perform better than having both shorts and longs.

Maintaining the trade while it was still within the boundaries showed minute improvements compared to selling at the next close, at ~0.5%. This could be because, potential gains were removed by leaving the trade as soon as possible in addition to the fees that come into play from having a higher frequency of trades that come with leaving trades immediately and entering trades soon after.

Finally, maintaining trades until the opposite entry conditions are met is based around the idea that, for example, when a stock is oversold and is expected to rise in price (due to central concept of mean reversion), the stock is held until the stock is then conversely overbought (which should be at a higher price) before taking profit. While in theory, this too should bring profits, results were lower by ~1-2%.

4 Algorithm Performance

After testing many different combinations of indicators and trading strategies, we found that the strategy that performed the most consistently was a combination of Bollinger Bands, RSI and Stochastic Oscillator. The combination of indicators greatly reduced the volume of stocks traded, which was necessary as with a higher trade volume, fees would quickly eat into our equity. Our algorithm does not enter any short positions, as during a mostly upwards moving market, shorts were consistently losing us money. Likely this is due to insufficient time spent on optimizing and tweaking the short implementation, as standard mean reversion algorithms utilize shorts effectively. Below are some of the results from testing our final algorithm.

```
------------- Results ----------------

AAPL_2020-04-18_2022-03-09_1min_Processed_bb_rsi_stoch
Buy and Hold : 147.05%
Net Profit   : 7352.4
Strategy     : 109.99%
Net Profit   : 5499.3
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Longs        : 112
Sells        : 111
Shorts       : 0
Covers       : 0
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Total Trades : 223
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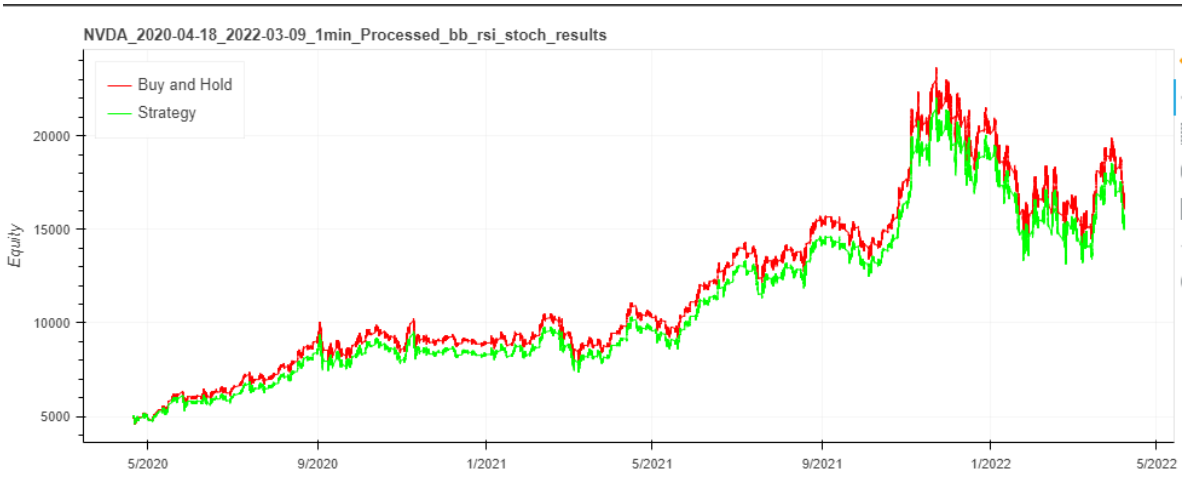


```
------------- Results ----------------

NVDA_2020-04-18_2022-03-09_1min_Processed_bb_rsi_stoch
Buy and Hold : 232.08%
Net Profit   : 11604.23
Strategy     : 209.33%
Net Profit   : 10466.48
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Longs        : 56
Sells        : 55
Shorts       : 0
Covers       : 0
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Total Trades : 111
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The final algorithm used a training period of 30 periods, RSI thresholds of 80 and 20, Bollinger Bands 3 standard deviations from the rolling average, and a k period of 20 for the Stochastic Oscillator.

5 Summary and Findings

Compared to trading strategies used in previous projects, we found that overall, the Mean Reversion trading strategy performed worse than strategies such as Momentum and Pairs Trading. Initially, we experienced difficulties maintaining an equity that would not dropped significantly in value rapidly, due to our algorithms making large volumes of trades with low profit margins. This results in fees accumulating and poor trades eroding our equity. However, after combining our individually developed indicators and optimising them, we found that the frequency of trade decreased significantly and resulted in much better returns.

As we only had access to price data over the last 2 years, more testing should be done to ensure that the strategies are not overfitted to the data. We also concluded that Mean Reversion strategies don't perform particularly well in very bullish markets and would likely perform better on more sideways travelling markets. If the price of a stock is not oscillating up and down, the strategy has little opportunity to make a profit, as repeatedly placing shorts on an upward moving market will not yield profitable results. In conclusion, we believe that mean reversion strategies should be used on fairly price stagnant stocks and in periods of low market movement in order to return the best results.

If we were to complete this project again, I think that more time should be spent on investigating how to incorporate short positions, and the proper usage of stop losses in our algorithms. A larger time range of price data would be preferable too.

6 References

https://www.investopedia.com/terms/m/meanreversion.asp

https://www.quantifiedstrategies.com/the-stochastic-indicator-does-it-work/