

COMP 4971 – Independent Study (Fall 2018/19)

Development and Analysis of a Trading Strategy on ETFs
Using Multiple Technical Indicators

By

Yu Chieh CHENG

Year 3, BBA Finance & Economics

Supervised by:

Prof. David Rossiter

Department of Computer Science and Engineering

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1. Abstract

“Stoxy” is a custom python algorithm developed to extract, display, and perform simple analysis. Based on this foundation, this project developed and added new functions to Stoxy that aims to provide more insights and analysis. More specifically, the new functions show stock price patterns using multiple commonly-used technical indicators including Moving Average Convergence and Divergence (MACD), Relative Strength Index (RSI), Average True Range (ATR), and Accumulation/ Distribution Line (ADL), and tries to find the optimal parameter combination that produces the highest return during a pre-determined back-testing period. These indicators were first used to produce their own buy and sell signals, which were then aggregated to generate a consensus trading decision for the algorithm. Selected parameters for the indicators were set to be variable parameters and allow the function to test multiple parameter combinations. By testing all combinations, the function then records the best parameter combination that generates the highest return. The optimal parameter combinations across stocks were then compared and analyzed. The result proved the usefulness of our new function in finding the optimal parameter combination which generates excess return. MACD and RSI was proven to be the main driver of execution while few parameters of ADL and ATR were less important. Moreover, patterns were discovered in our testing result to help adjust and find optimal parameter combination for stocks with certain characteristics in the future.

2. Introduction

2.1 Purpose

The purpose of this project was to

- 1) Analyze stock (US sector ETFs) price patterns and generate multiple technical indicators.
- 2) Produce optimal buy and sell trading signals using selected technical indicators.
- 3) Find the optimal combination of selected parameter inputs.
- 4) Study and analyze the optimal set of parameters across different stocks.

2.2 Assumptions

- 1) All values mentioned in this report are quoted in USD.
- 2) The initial amount of investment for each scenario was set to 1 million USD.
- 3) The transaction cost was set to 0.
- 4) The back-testing only involve buying/longing stock without leverage for simplicity and to better examine the result without the effect of leverage.
- 5) When executing buy or sell in the algorithm, the algorithm enters the position by buying (selling) as much as it can with existing capital (stock).

2.3 Limitation

This study was conducted during September to November in 2018. It was designed to provide optimized algorithm parameter inputs by studying the testing result of sector ETFs in the US during the back-testing period. Therefore, the results and conclusions are based on the historical price patterns, characteristics of the underlying stock, and the corresponding market condition during the period. As a result, the conclusion and solution suggested in this project may not be equally suitable and optimal should industry/ stock characteristics and market condition changes over time.

3. Design of Study

3.1.1 Choice of Indicators

3.1.1 Moving Average Convergence/ Divergence

The Moving Average Convergence/ Divergence (hereafter referred as MACD) is a common trend and momentum indicator that shows the relationship between two moving averages of a security's price. The MACD is calculated by subtracting the 26-period Exponential Moving Average (EMA) from the 12-period EMA. The result of that calculation is the MACD line. A nine-day EMA of the MACD, called the "signal line", is then plotted on top of the MACD line which can function as a trigger for buy and sell signals. MACD is considered powerful for identifying trend and momentum. Figure 1 shows an example picture of the three MACD lines. Figure 2 is a comparison between the MACD result from Yahoo Finance (upper) and Stoxy (lower) using AAPL.US stock prices from mid-January 2018 to November 2018.

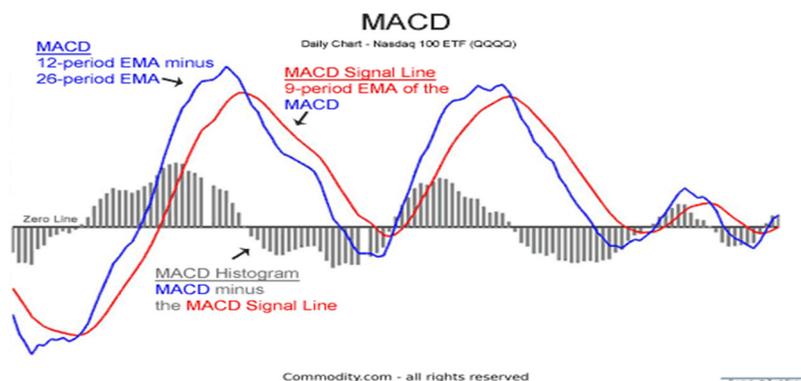


Figure 1 – MACD line example



Figure 2 – MACD comparison: public data, Stoxy

3.1.2 Relative Strength Index

The Relative Strength Index (hereafter referred as RSI) is a momentum indicator that measures the magnitude of recent price changes. It is primarily used to identify overbought or oversold conditions in the trading of an asset. Figure 3 shows a comparison between RSI result from Yahoo Finance (upper) and Stoxy (lower) using AAPL.US stock prices from January 2018 to November 2018.



Figure 3 – RSI comparison: public data, Stoxy

3.1.3 Average True Range

The Average True Range (hereafter referred as ATR) is a technical analysis indicator that measures volatility by decomposing the entire price range of an asset for that period. Specifically, ATR is a measure of volatility introduced by Welles Wilder in his book, "New Concepts in Technical Trading Systems." The true range indicator records the following value: Max (high - low, absolute value of high - previous close, absolute value of low - previous close). The average true range is a moving average, generally 14 days, of the true ranges. Picture below is a comparison between ATR result from Yahoo Finance (upper) and Stoxy (lower) using AAPL.US stock prices from January 2018 to November 2018.



Figure 4 - ATR comparison: public data, Stoxy

3.1.4 Accumulation/ Distribution Line

The Accumulation/ distribution Line (hereafter referred as ADL) is a momentum indicator that attempts to gauge supply and demand by determining whether investors are generally buying (accumulating) or selling (distributing) a certain stock. The accumulation/distribution measure seeks to identify divergences between stock price and volume flow. The accumulation/distribution of a security is calculated by first calculating the money flow multiplier and then multiplying the money flow multiplier by the period's volume. Picture below is a comparison between ADL result from Trading View (lower) and Stoxy (upper) using 1810.HK stock prices from July 2018 to November 2018.



Figure 5 - ADL comparison: public data, Stoxy

3.2 Choice of Stocks

The stocks chosen and tested in this project were the sector exchange-traded-funds (ETFs) under the SPDR fund. SPDR funds are a family of exchange-traded funds traded in the United States, Europe, and Asia-Pacific and managed by State Street Global Advisors (SSGA). It divides the stock in the S&P 500 index into eleven different industries including:

- 1) Energy (XLE)
- 2) Utility (XLU)
- 3) Technology (XLK)
- 4) Communication services (XLC)
- 5) Consumer discretionary (XLY)
- 6) Consumer staples (XLP)
- 7) Financial (XLF)
- 8) Health care (XLV)

- 9) Industrial (XLI)
- 10) Materials (XLB)
- 11) Real estate (XLRE)

However, XLC data was only available after June 19th, 2018. Therefore, we excluded XLC in our project since such insufficient data would not be interpretable. The reason we chose to use the SPDR Sector ETFs in our project are the following:

- 1) ETFs gives us exposure to a group of equities, market segment, or industries. To study the differences in optimal parameters across industries, such asset offers better efficiency comparing to hand-picking specific stocks.
- 2) Diversification is achieved through allocating our exposure to different stocks within the sector. By doing so, our result and conclusion would be less vulnerable and exposed to idiosyncratic risks arising from testing on a single stock, which may produce biased data and fail to represent the whole industry.
- 3) SPDR sector EFTs are some of the largest ETFs in the market. Having a large ETF with large trading volume translates to a smaller spread charged by market makers, allowing us to better ignore the effect of bid-ask spread.

3.3 Determination of Trading Signals

The framework of determining buy and sell signals is set by first having the four indicators (MACD, RSI, ADL, ATR) generate their own signals independently, then using those signals to conclude a final decision for the algorithm to either buy, sell or hold.

3.3.1 Moving Average Convergence / Divergence (MACD)

For MACD, a buy (sell) signal is generated if the short MACD histogram cross over 0 from negative (positive) realm, and a hold signal is generated if none of the above occurs. We chose this mechanism because the MACD is designed to identify the trend and momentum shifts in the price by looking at the crossovers of short term and long-term exponential moving averages.

3.3.2 Relative Strength Index (RSI)

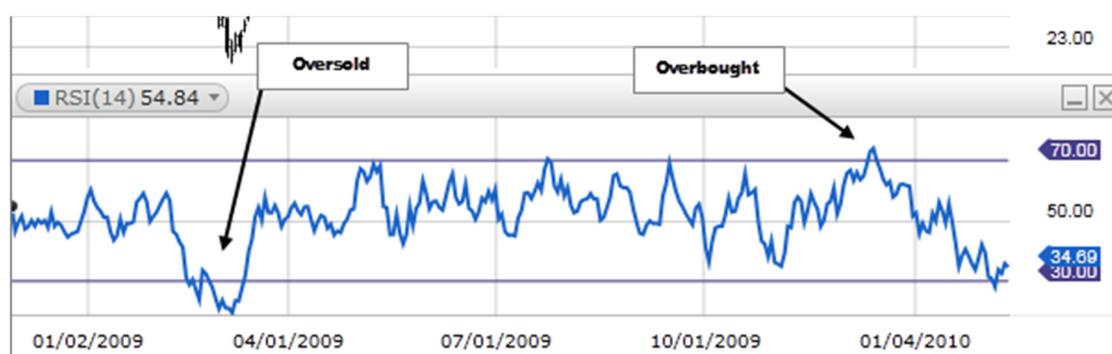


Figure 6 – RSI signal example

For RSI, a buy (sell) signal is generated if the RSI value reaches the pre-determined oversold (overbought) threshold. We chose this mechanism because RSI measures the extend of price pressure between overbought and oversold using the ratio of average gains and losses over a certain period. We believe that price should roughly follow the “mean revision” principal such that a stock with RSI entering the overbought realm should eventually reverse. Figure 6 shows an example of RSI charts, in this case, signal is generated when the RSI index crosses the overbought threshold.

3.3.3 Average True Range (ATR)

For ATR, a buy (sell) signal is generated if the ATR reaches its moving 180-day low while the stock price has been decreasing (increasing) more than a pre-determined threshold during a pre-determined time span. We chose this mechanism because ATR, unlike RSI or MACD, only measures a unique volatility that reflects the interest or disinterest in a move. Empirically, large price shifts are preceded with a period of low ATR, therefore, we first examine the relative degree of ATR comparing to past 180 days, then we examine the price overall direction during the corresponding period to anticipate a reversal. In this project, we set the price-changing period and threshold to be parameters.

3.3.4 Accumulation/ Distribution Line (ADL)

For ADL, a buy signal is generated if the ADL has been decreasing for more than $\frac{3}{4}$ of the days over a pre-determined period in the past while the stock increases more than a pre-determined percentage threshold during a per-determined period of time. We chose this mechanism because ADL identifies market’s implicit position and sentiment in aggregate by comparing the closing price with the daily high and low. ADL also measures the strength of such sentiment by integrating volume in the calculation. Therefore, we believe that a potential reversal should be anticipated if the price direction contradicts with the overall market sentiment. Due to its relative similarity to ATR mechanism, we chose to use the same price deviation threshold for ADL, which is a parameter in our experiment. The length of the period that we look back to determine market’s sentiment and the price direction was set to be a parameter.

3.4 Choice of Variable Parameters

- 1) Buy Execution’s Signal Threshold
Hereafter referred as “Buy Threshold”. This is the number of buy-signals required from the indicator to trigger a buy decision of the algorithm is set to be parameter to examine its effect on return.
- 2) Sell Execution’s Signal Threshold
Hereafter referred as “Sell Threshold”. This is the number of sell-signals required from the indicators to trigger a sell decision of the algorithm is set to be parameter to examine its effect on return.

- 3) Multiplier of original MACD and ATR parameters
Hereafter referred as “Multiplier”. This is the constant that is used to multiply and adjust the scale of the original set of period parameters in MACD and ATR without changing relative size between the parameters. We chose to hold the ratio between the original parameters constant so that we do not distort and defeat the original intention and rationale of the indicators.
- 4) Moving ADL Period Length Hereafter referred as “ADL Period”. This is the period length in which we look back and examine the market sentiment (using ADL) on a particular stock. We also use this period length to determine the price direction.
- 5) Price Deviation Period for ATR
Hereafter referred as “ATR Period”. This is the period length in which we look back and determined the price direction.
- 6) With between Neutral and Overbought/ Oversold in RSI
Hereafter referred as “RSI width”. This is While the original threshold is usually 80 and 20 (a width of 30 between neutral (50) and overbought/ oversold) for overbought and oversold respectively, we set the width to be a parameter in our project.
- 7) Price Deviation Threshold used in ADL & ATR signals
Hereafter referred as “Price Deviation”. This is the price deviation threshold in both ATR and ADL that is used to determine the price direction.

4. Result & Analysis

4.1 Result Across Different ETFs

Introduction

For all ETFs except XLRE, data period ranges from Dec 12th, 1998 to Sep 14th, 2018. Data period equals to 7,206 days, effectively, 19.73 years (assuming one year = 365.25 days on average). For XLRE, the stock price was from Oct 8th, 2015 to Sep 14th, 2018 (2.93 years under the same assumption).

To examine the effect of changes in the abovementioned parameters and its relationship under limited timeframe, we selected tested four to five inputs for each of the variable. The algorithm records all the tested combinations and finds the optimal parameter combination that yields the highest return among all. The following list shows all the inputs we tested across each parameter. All selected inputs were then cross matched as a parameter combination to tested.

- 1) Buy threshold: 1, 2, 3, 4
- 2) Sell threshold: 1, 2, 3, 4
- 3) Multiplier: 0.4, 0.8, 1, 2
- 4) ADL period: 10, 15, 20, 25, 30
- 5) ATR period: 10, 15, 20, 25, 30
- 6) RSI width: 10, 20, 30, 40
- 7) Price deviation: 2%, 4%, 6%, 8%, 10%

There may exists multiple parameter combinations that yield the same return. In such case, we list down all parameter inputs that would produce optimal result (regardless of the cross-matching method). “Any” is listed if the all tested inputs for this parameter, when cross matched with other listed inputs, produces optimal result.

We have also included the testing result for S&P 500 for reference since it is the weighted aggregation of all the industry we tested. However, we do not provide further in-depth analysis.

For every ETF we tested, we provide two 3D graph and one 2D graph to visualize the result of our test. The first graph shows the effect of different buy/ sell threshold, multiplier, RSI width on return. The execution thresholds are scaled on the x and y axis, the multiplier is scaled on the z axis, and the RSI width is represented using the color of the circle. The size of the circle indicates the return, the larger the circle is, the higher the return. Figure 7 shows an example of our first type of 3D graph.

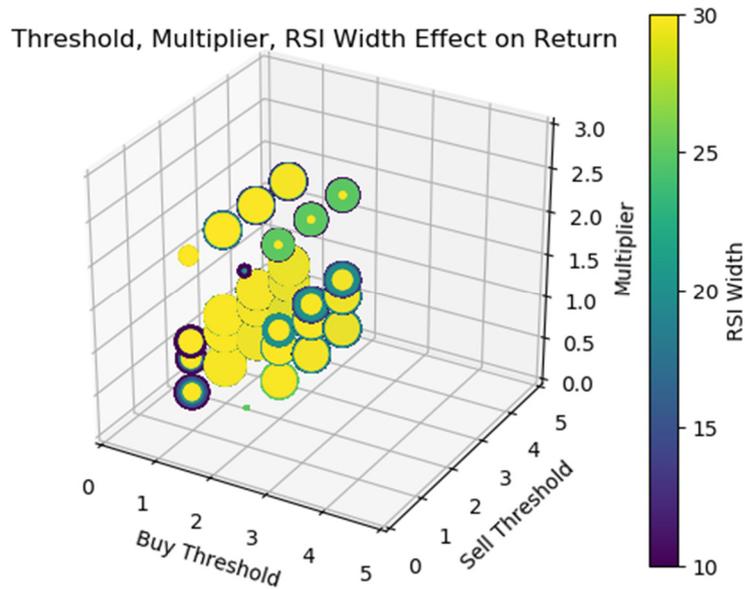


Figure 7 – First 3D graph example

Our second type of 3D graph illustrates the effect of different ADL/ ATR period, price deviation, and multiplier on the return. ADL and ATR period are scaled on the x and y axis respectively, the price deviation is scaled on the z axis, and the multiplier is represented using the color of the circle. The size of the circle indicates the return. Figure 8 shows an example of our second type of 3D graph.

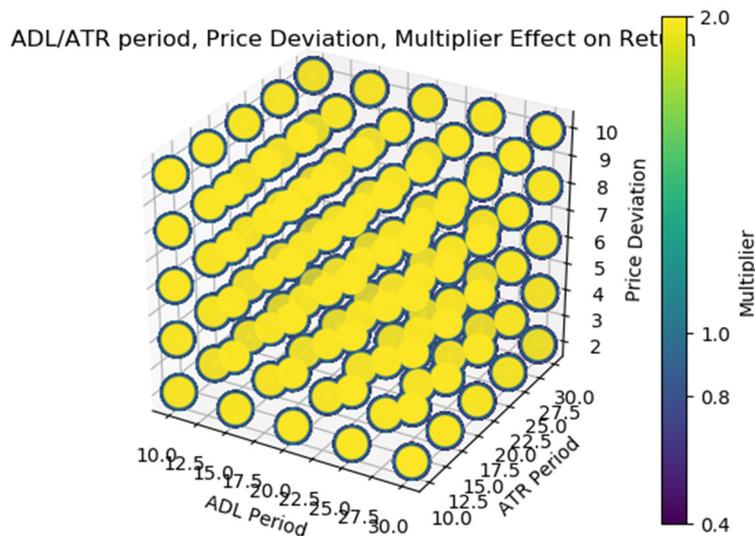


Figure 8 – Second 3D graph example

Our last type of graph shows the relationship between the buy/ sell thresholds on return. The two thresholds are scaled on the two axes while the size of the circle, again, represents the return size. Figure 9 shows an example of such type of graph.

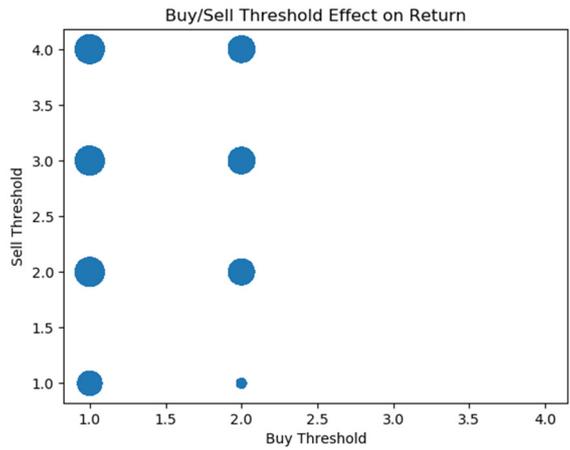


Figure 9 – 2D graph example

To better evaluate our strategy performance, the annualized stock returns over the back-testing period (19.73 years for all ETFs except XLRE and 2.93 years for XLRE) were also listed for each of the ETF. This stock return equals the return investor get if they were to buy and hold the stock on the first day and sell on the last day.

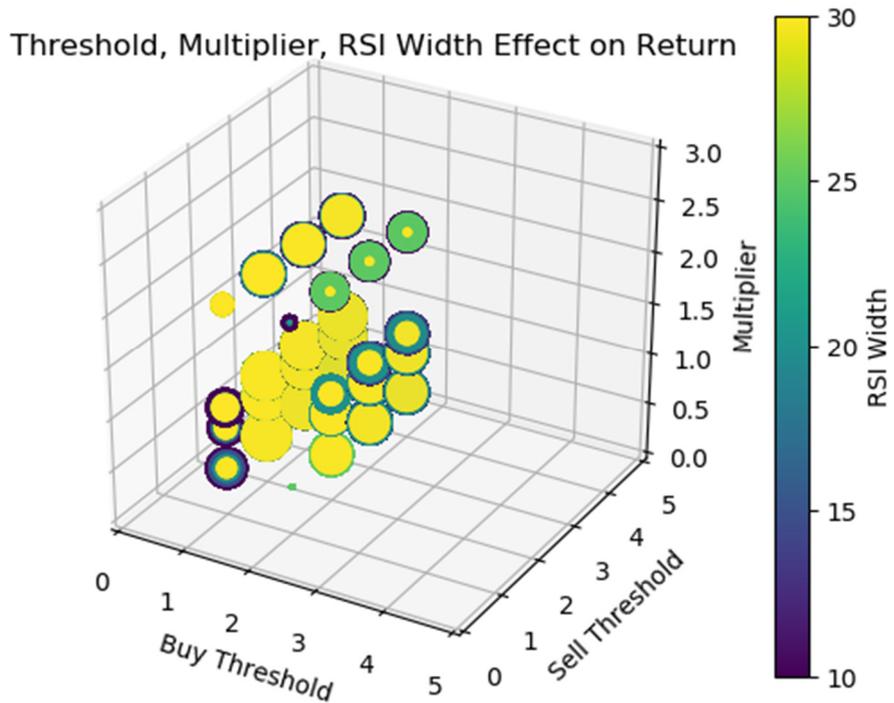
4.1.1 XLE

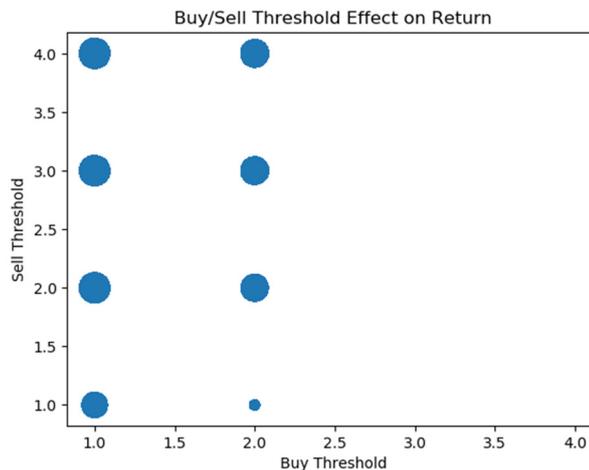
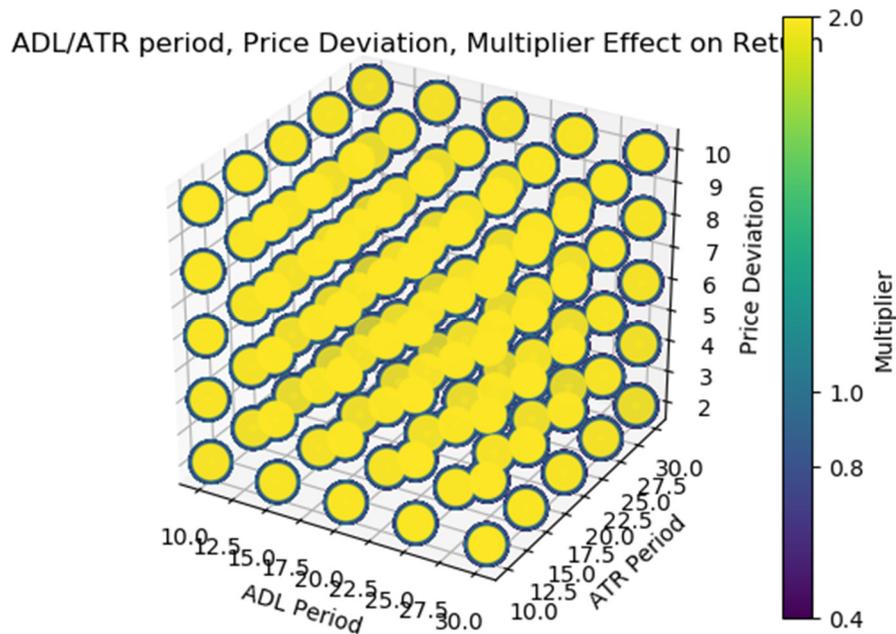
Annualized Stock Return: 8.04%

Best parameter combination:

Buy Threshold = 1 Sell Threshold= 2/3/4 Multiplier = 0.4 ADL period= any
 ATR period= any RSI width= 20 Price Deviation= any

Optimized Result: Total Return = 391.78% Annualized Return: 8.4%





Remarks

From the result, we can see that

- 1) If the buy threshold is over 2, the algorithm fails to trigger any buy execution, resulting in zero return.
- 2) Comparing to buy threshold =2, buy threshold =1 gives a better result on average.
- 3) Overall, it is better to have a smaller RSI width (except for those cases where the buy threshold=1 as we discussed earlier)
- 4) As either the multiplier or the buy threshold increases, the effect of having a smaller RSI width amplifies.
- 5) There is not much effect on changing the ADL/ ATR period and the price deviation parameter. Using a smaller multiplier produces a slightly better result in most cases.

4.1.2 XLF

Annualized Stock Return: 5.50%

Best parameter combination:

Buy Threshold= 2

Sell Threshold= 2

Multiplier= 2

ADL period= any

ATR period= any

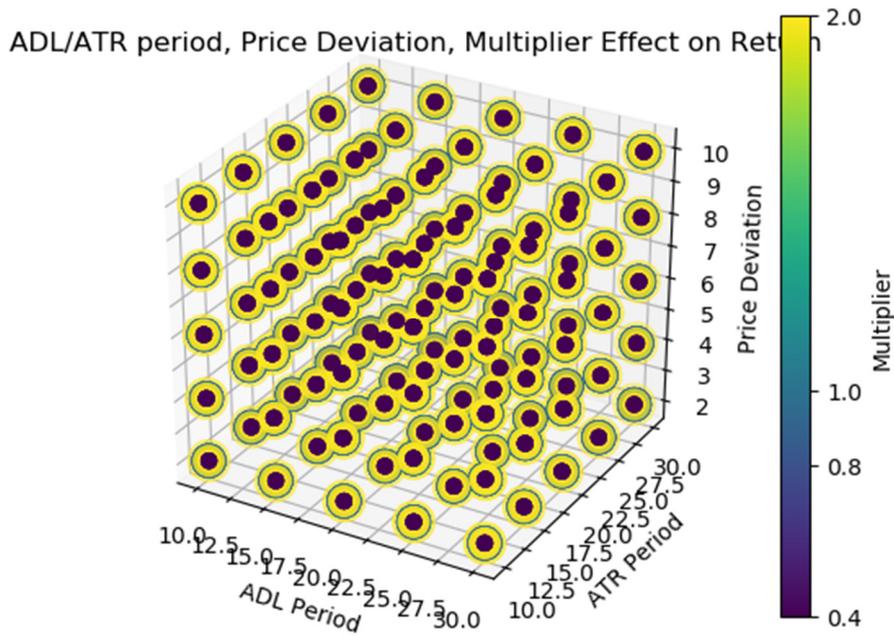
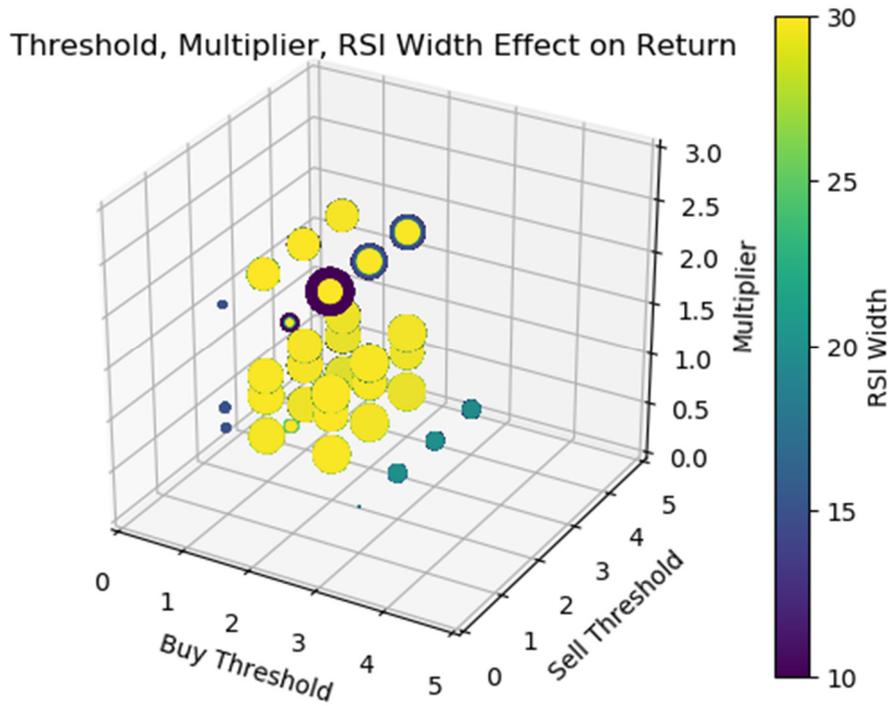
RSI width= 10

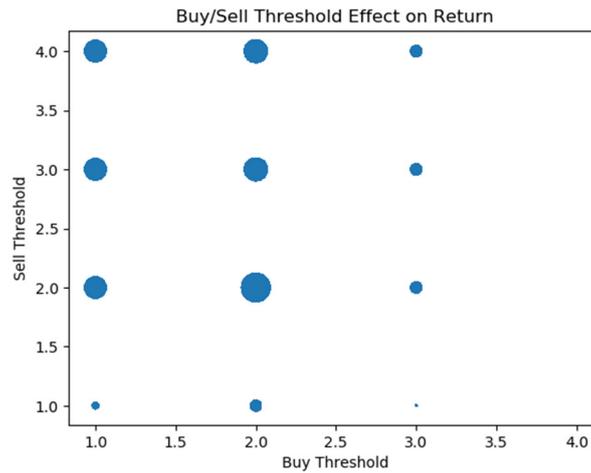
Price Deviation= any

Optimized Result:

Total Return = 348.69%

Annualized Return: 7.9%





Remarks

From the result, we can see that

- 1) It's better to have a buy threshold of two, comparing to one. However, using a buy threshold of three does not stop the algorithm from executing although the return tends to be less preferable.
- 2) It's bad to use a sell threshold of one since it dramatically reduces return in all scenarios.
- 3) In most cases, it's better to have a RSI width around 20 but when the multiplier=2, buy threshold=2, it's better to have a smaller RSI width and the effect of that gets larger as sell threshold approaches 1.
- 4) There is not much effect on changing the ADL/ ATR period and the price deviation parameter.
- 5) In most cases, it's better to have a larger multiplier.

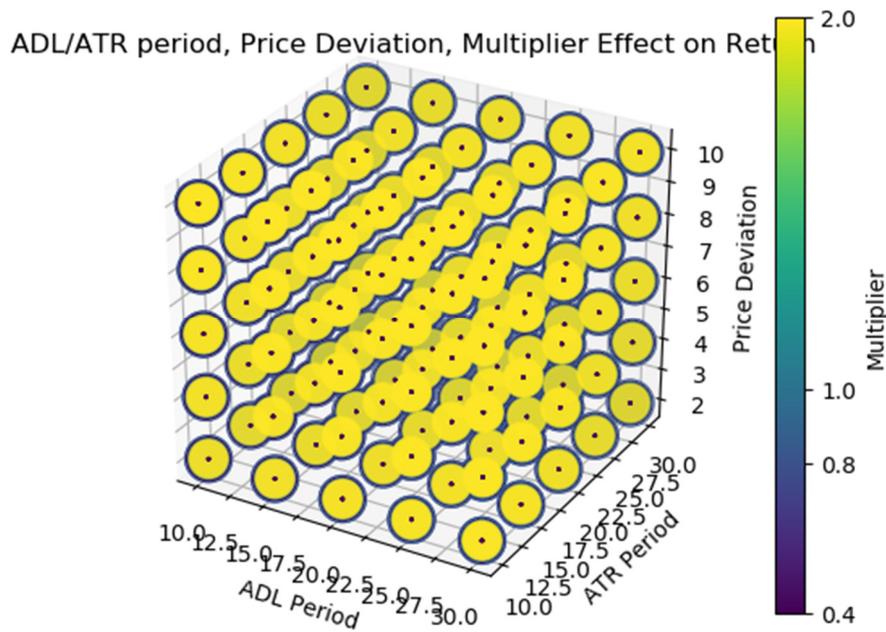
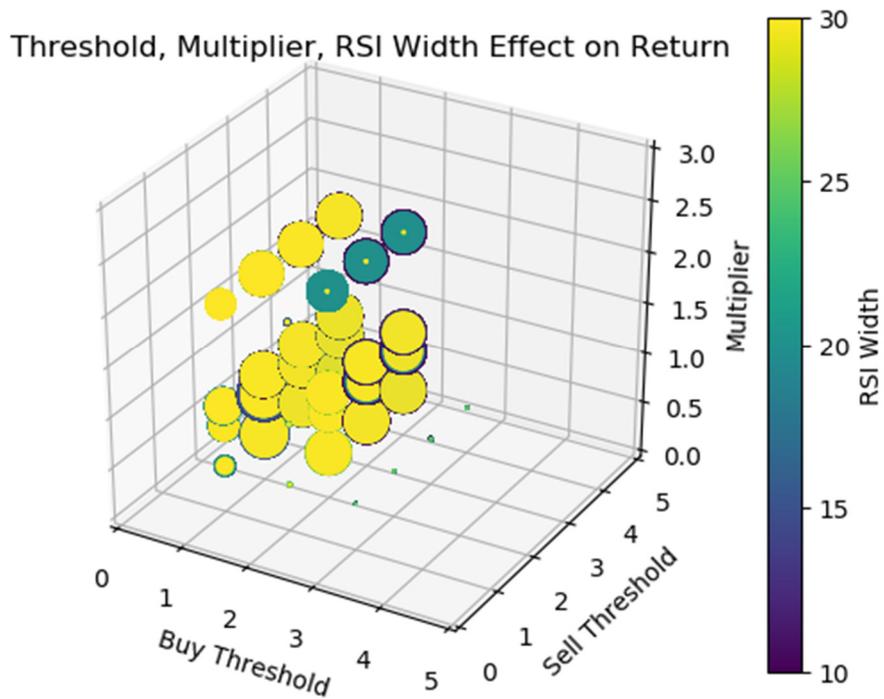
4.1.3 XLV

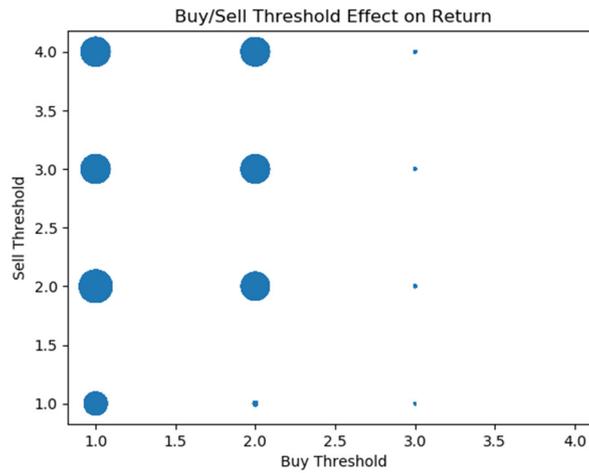
Annualized Stock Return: 8.36%

Best parameter combination:

Buy Threshold=1 Sell Threshold=2 Multiplier= 0.8 ADL period= any
ATR period= any RSI width= 15 Price Deviation= any

Optimized Result: Total Return = 458.2% Annualized Return: 9.1%





Remarks

From the result, we can see that

- 1) It's better to use a buy threshold of one instead of two. Although a buy threshold of three doesn't stop the algorithm from triggering execution, the returns were far inferior.
- 2) It is slightly better to use a sell threshold of two comparing to three and four, but there's a big reduction in return if we opt for a sell threshold of one in all scenarios.
- 3) In most cases, a smaller RSI width generates better result. When the multiplier is 2, the negative effect of using a large RSI width were significant.
- 4) Overall, it's best to use a multiplier of either 0.8 or 1. Using a multiplier of 2, although less preferable, only cause slight drop in return while using a multiplier of 0.4 dramatically causes a slump in return.
- 5) There is not much effect on changing the ADL/ ATR period and the price deviation parameter.

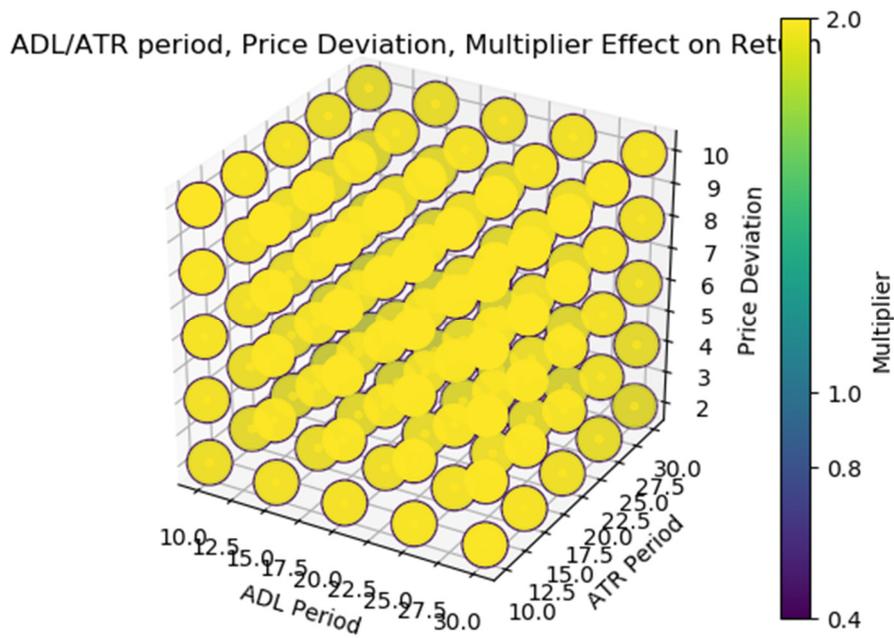
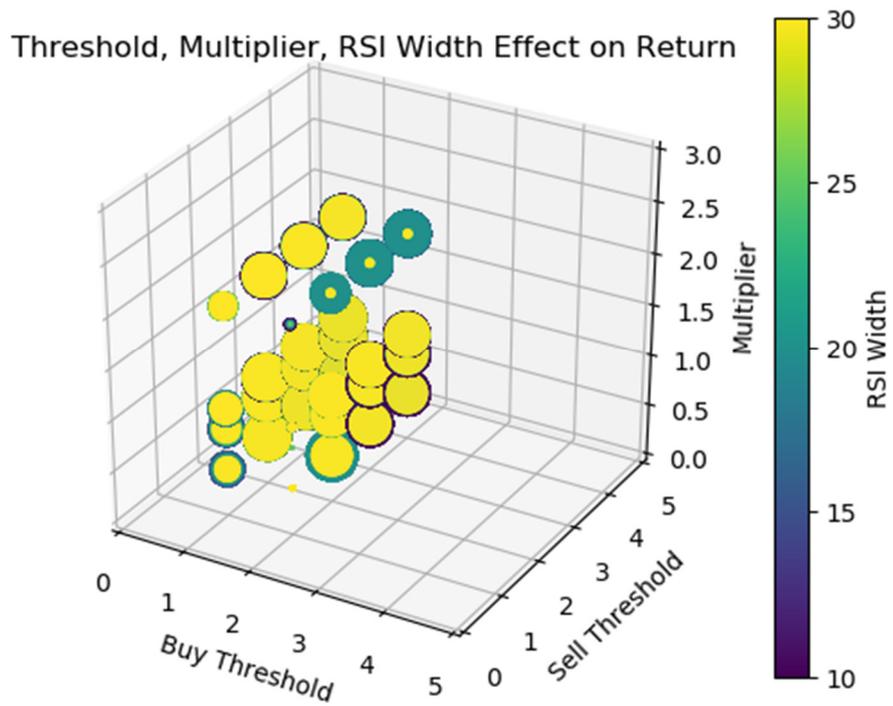
4.1.4 XLI

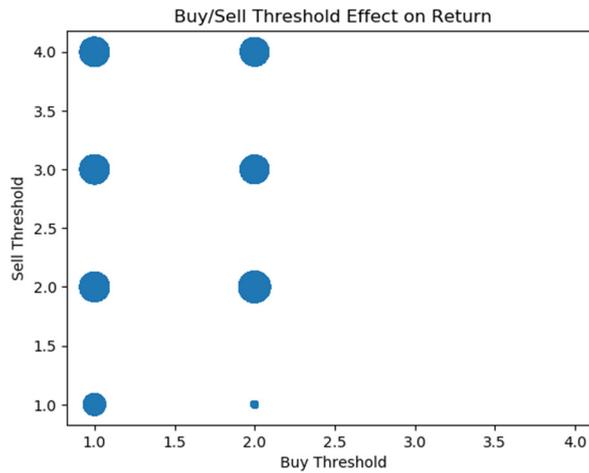
Annualized Stock Return: 8.28%

Best parameter combination:

Buy Threshold=2 Sell Threshold=2 Multiplier= 0.4 ADL period= any
ATR period= any RSI width= 20 Price Deviation= any

Optimized Result: Total Return = 424.55% Annualized Return: 8.76%





Remarks

From the results, we can see that

- 1) It's only profitable to use a buy threshold under 3.
- 2) It's better to use a sell threshold of two, with only slightly different comparing to three and four. Using a sell threshold of one, especially when the buy threshold is two, will dramatically reduce our return.
- 3) In most cases, it's slightly better to use a smaller RSI width but the difference is particularly significant when the both the multiplier and the buy threshold is two.
- 4) Overall, there's not much difference between using different multiplier, only a slight edge in using the smallest one.
- 5) There is not much effect on changing the ADL/ ATR period and the price deviation parameter.

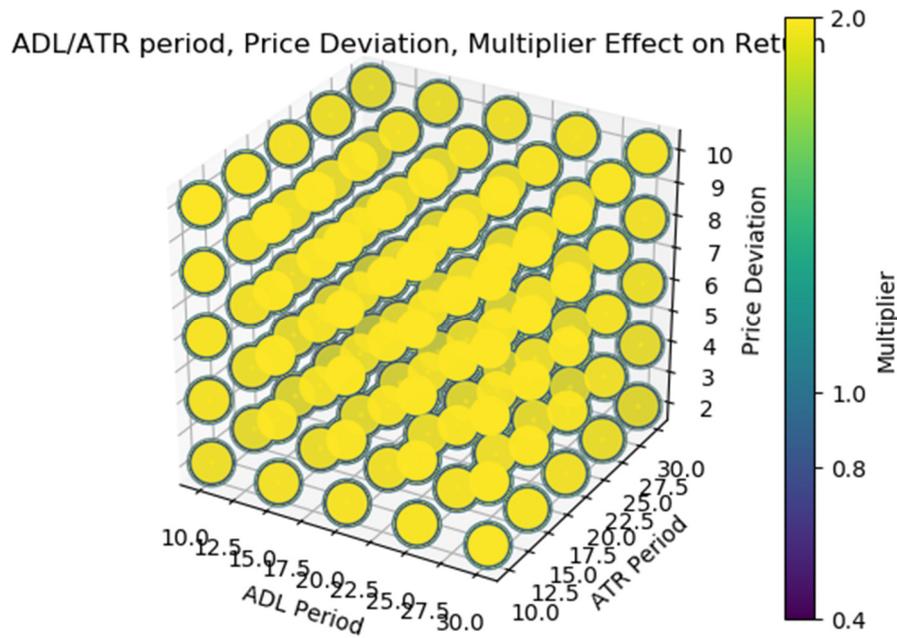
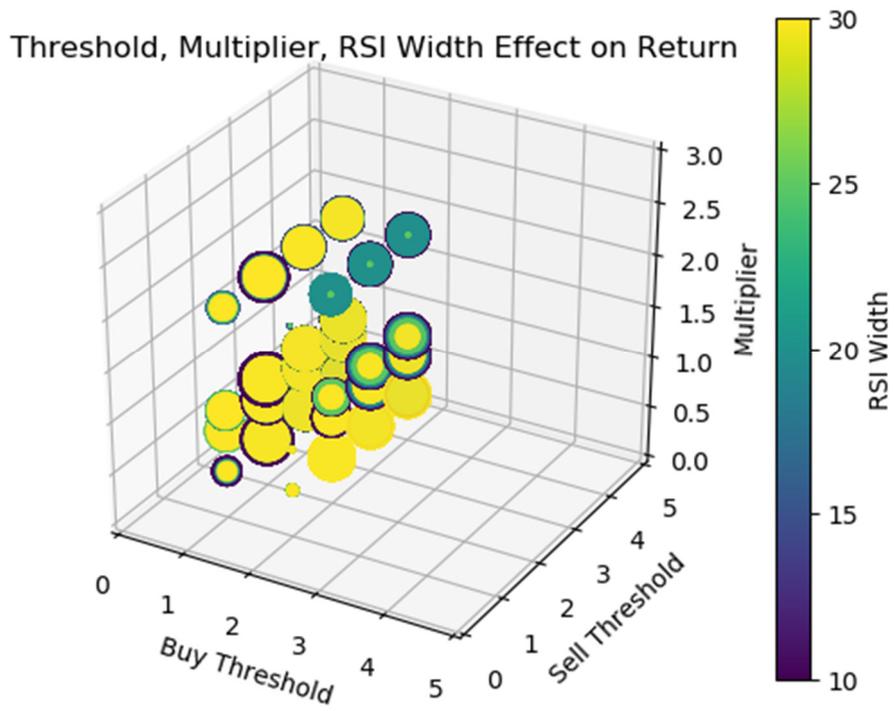
4.1.5 XLB

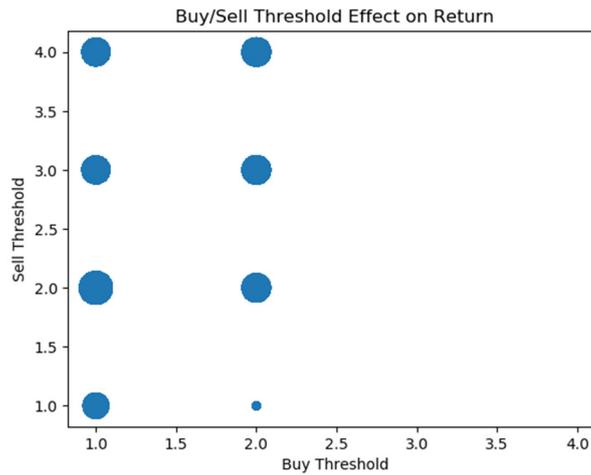
Annualized Stock Return: 7.84%

Best parameter combination:

Buy Threshold=1 Sell Threshold=2 Multiplier= 1 ADL period= any
ATR period= any RSI width= 10 Price Deviation= any

Optimized Result: Total Return = 469.65% Annualized Return: 9.21%





Remarks

From the results, we can see that

- 1) It's never profitable to use a buy threshold over three while a buy threshold of one seems to provide more consistent result comparing to that of two.
- 2) Using a sell threshold of two is slightly better. Using a sell threshold of one when the buy threshold is two dramatically reduces return.
- 3) In most cases, it's better to opt for a smaller RSI width but the difference is most significant when the buy threshold is two and the multiplier is larger.
- 4) Overall, it's slightly better to use a small multiplier.
- 5) There is not much effect on changing the ADL/ ATR period and the price deviation parameter.

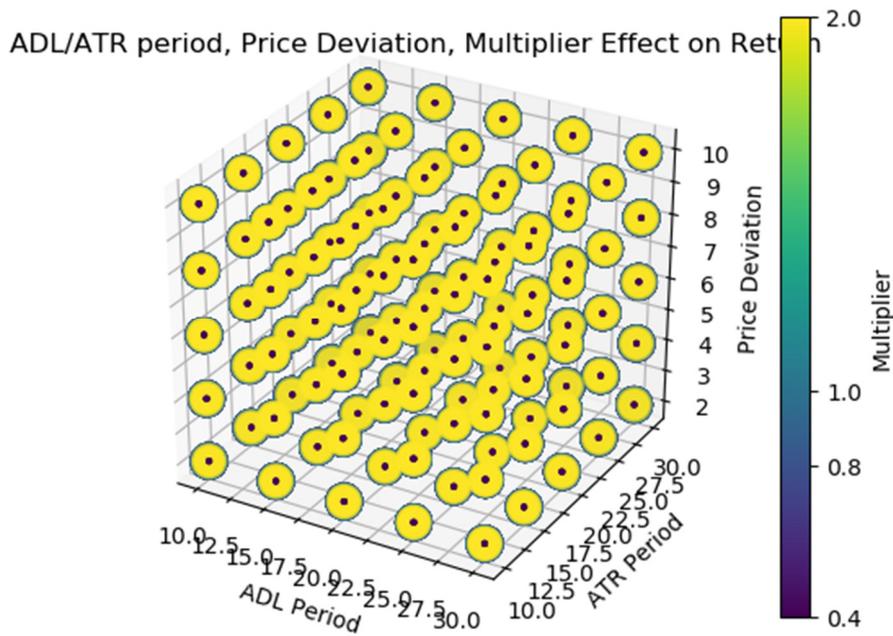
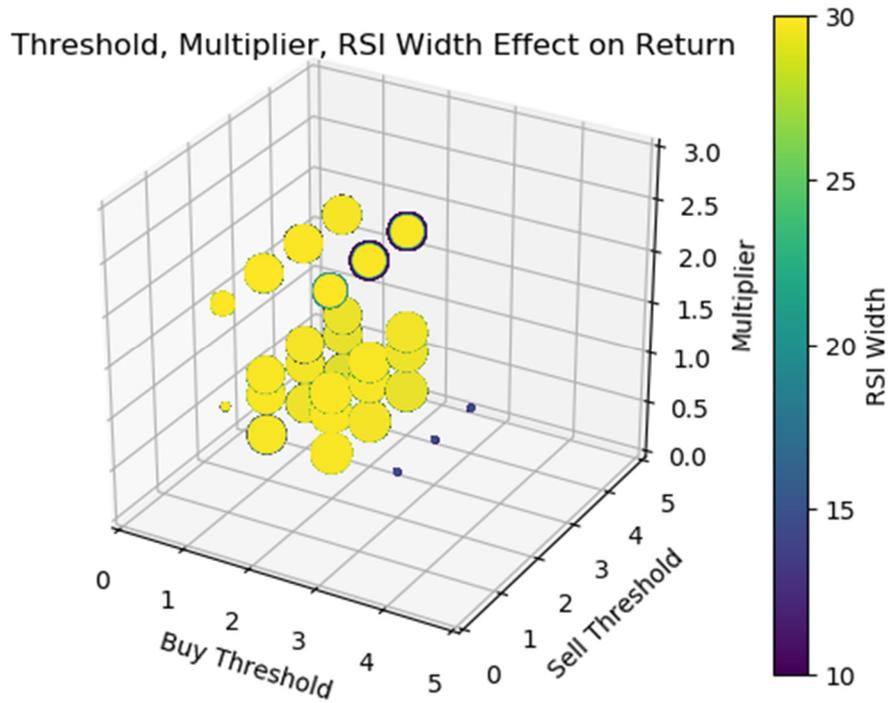
4.1.6 XLP

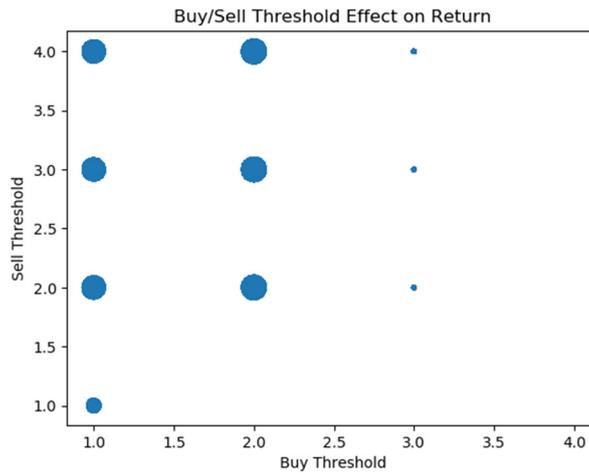
Annualized Stock Return: 6.04%

Best parameter combination:

Buy Threshold= 2 Sell Threshold= 2/3/4 Multiplier= 0.4 ADL period= any
ATR period= any RSI width= 15/20/25/30 Price Deviation= any

Optimized Result: Total Return = 262.39% Annualized Return: 6.74%





Remarks

From the results, we can see that

- 1) It's never profitable to use a buy threshold of four but using that of three gives very little return. A buy threshold of one seems to provide more consistent result comparing to that of two.
- 2) Using a sell threshold of one is only profitable when the buy threshold is one. The difference between using a sell threshold of two, three, and four were minimal.
- 3) There's not much difference if using different RSI width, but there seems to be a slight edge if we choose a smaller RSI width when both buy and sell threshold exceeds two.
- 4) In most cases, it's better to opt for a multiplier of either 1 or 0.8. While the result is only slightly worse if we use a multiplier of 2, there exists a dramatic drop in return if we choose 0.4 as our multiplier.
- 5) There is not much effect on changing the ADL/ ATR period and the price deviation parameter.

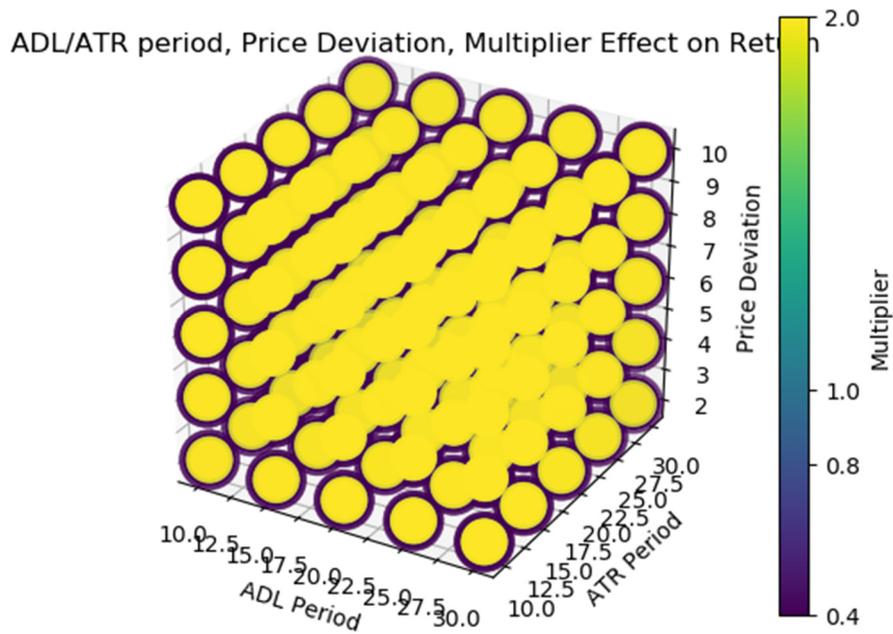
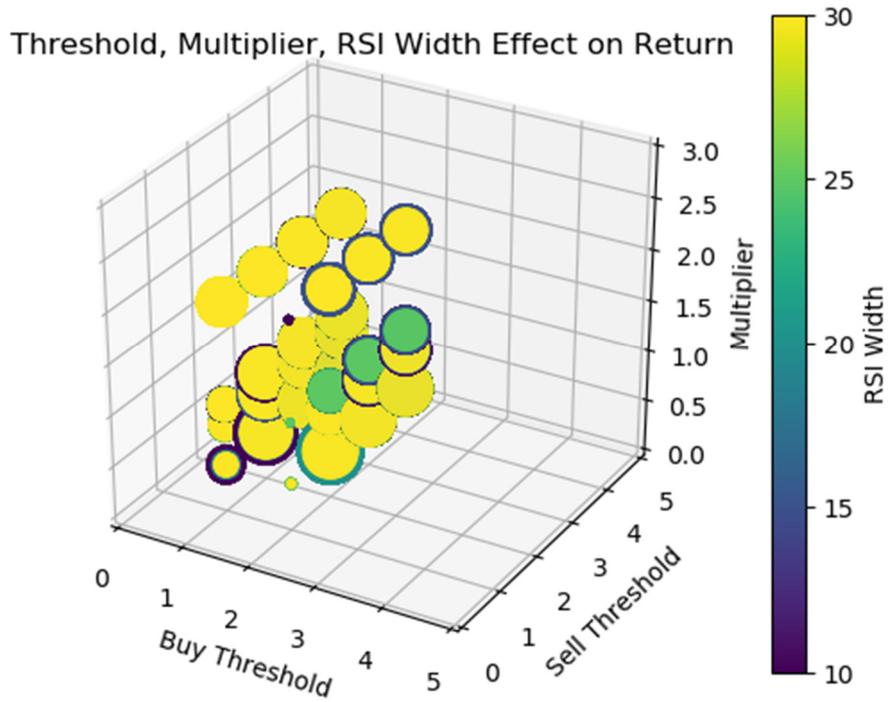
4.1.7 XLY

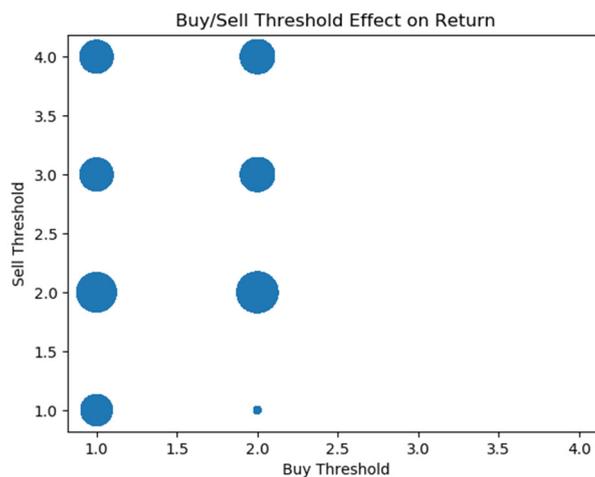
Annualized Stock Return: 9.30%

Best parameter combination:

Buy Threshold=2 Sell Threshold=2 Multiplier= 0.4 ADL period= any
ATR period= any RSI width= 20 Price Deviation= any

Optimized Result: Total Return = 713.4% Annualized Return: 11.2%





Remarks

From the results, we can see that

- 1) It's never profitable to use a buy threshold over two. A buy threshold of one seems to provide more consistent result comparing to that of two.
- 2) Using a sell threshold is dramatically worse when the buy threshold is two. The difference between using a sell threshold of two, three, and four were minimal.
- 3) When the buy threshold is one, it's better to use a smaller RSI width such as 10. When the buy threshold is two, it's better to use a smaller RSI width when the multiplier is larger and use a bigger RSI width when the multiplier is smaller.
- 4) In most cases, it's slightly better to choose a smaller multiplier.
- 5) There is not much effect on changing the ADL/ ATR period and the price deviation parameter.

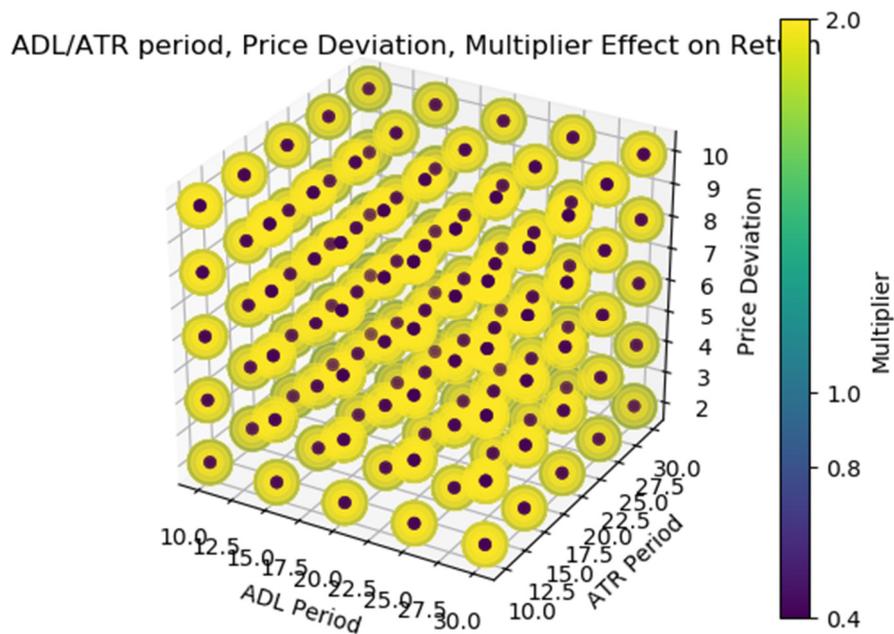
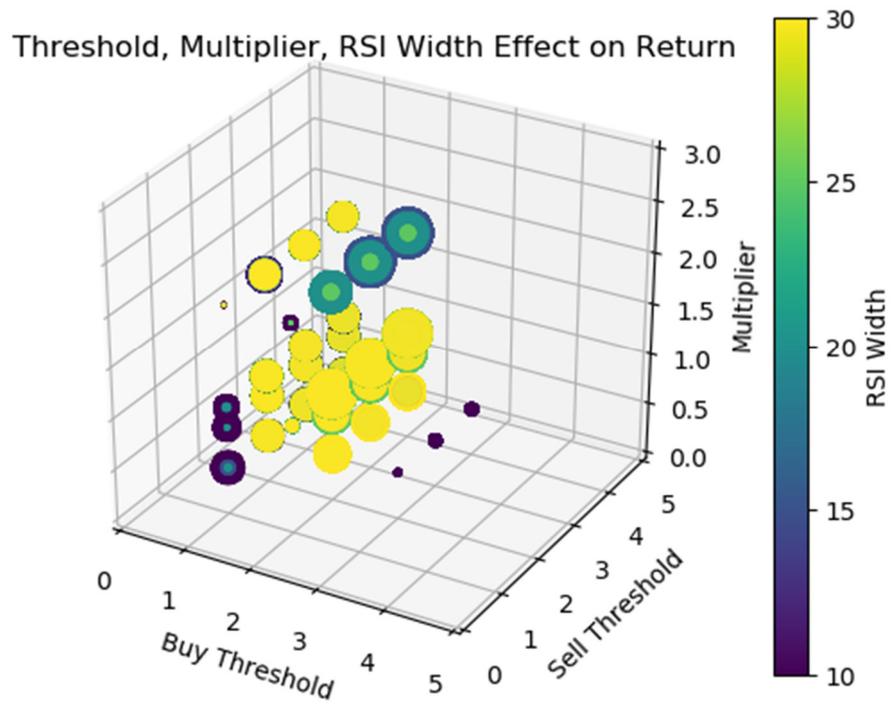
4.1.8 XLK

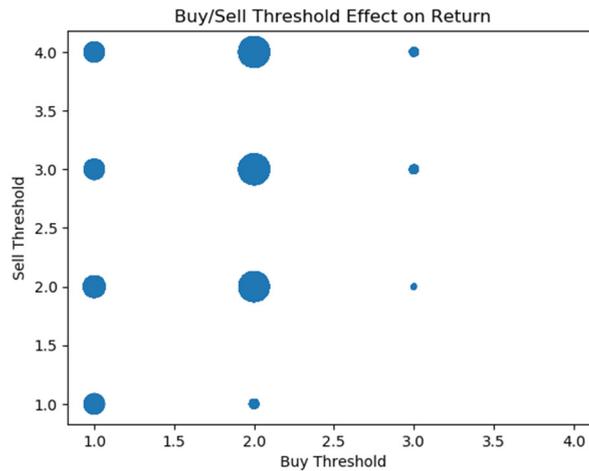
Annualized Stock Return: 5.58%

Best parameter combination:

Buy Threshold=2 Sell Threshold=3/4 Multiplier= 2 ADL period= any
ATR period= any RSI width= 15 Price Deviation= any

Optimized Result: Total Return = 412.71% Annualized Return: 8.63%





Remarks

From the results, we can see that

- 1) It's never profitable to use a buy threshold over three while using that of three produces less preferable returns. A buy threshold of one seems to provide more consistent but that of two offers more upside potential.
- 2) Using a sell threshold of one is worse when the buy threshold is two. The difference between using a sell threshold of two, three, and four were minimal.
- 3) When both buy and sell thresholds are one, using the smallest RSI width provides significant advantage. When the buy threshold is two, it becomes much worse to use a large RSI width like 30, while in other scenarios, the differences weren't noticeable. When the buy threshold is three, it's only profitable to use the smallest RSI width.
- 4) Un most cases, it's slightly better to choose a larger multiplier and choosing the smallest multiplier reduces return dramatically.
- 5) There is not much effect on changing the ADL/ ATR period and the price deviation parameter.

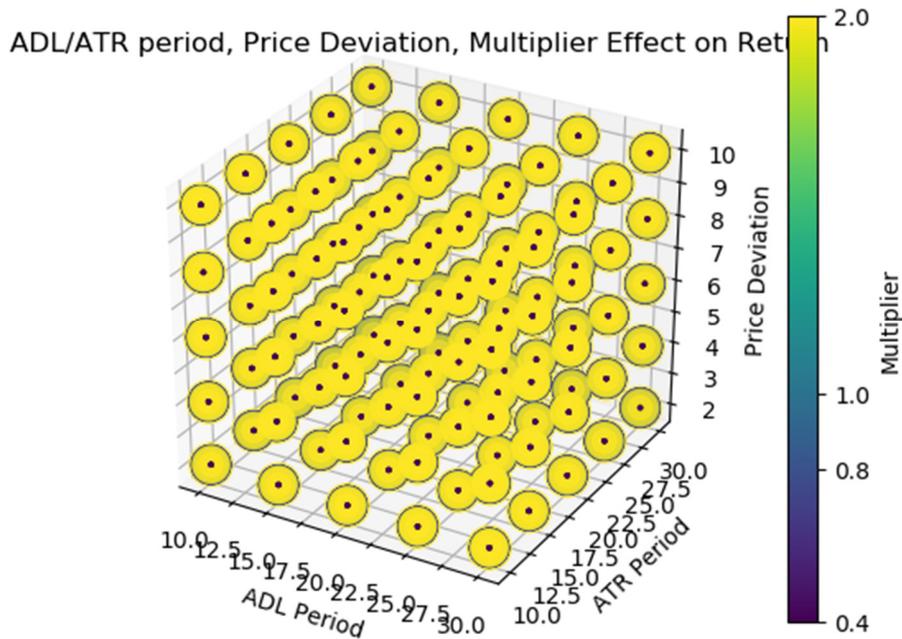
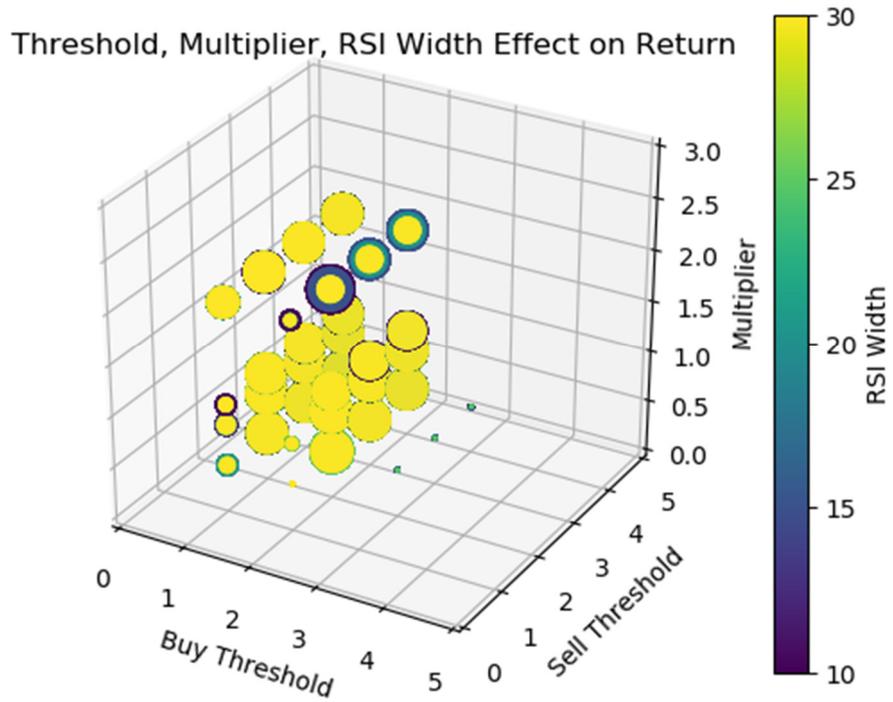
4.1.9 XLU

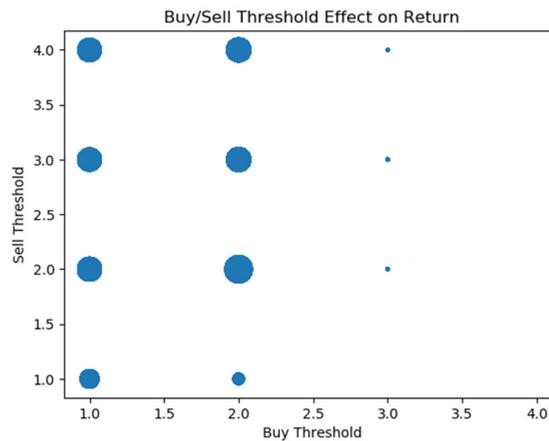
Annualized Stock Return: 6.87%

Best parameter combination:

Buy Threshold=2 Sell Threshold=2 Multiplier= 2 ADL period= any
ATR period= any RSI width= 10 Price Deviation= any

Optimized Result: Total Return = 380.64% Annualized Return: 8.28%





Remarks

From the results, we can see that

- 1) It's never profitable to use a buy threshold over three but using that of three produces a much less desirable return. A buy threshold of one seems to provide more consistent return.
- 2) Using a sell threshold of one is slightly worse.
- 3) When the buy threshold is three, it's not profitable to use a large RSI width. When the buy threshold is two and the, the advantage of using a smaller RSI width is more obvious.
- 4) In most cases, using the smallest multiplier would reduce returns dramatically.
- 5) There is not much effect on changing the ADL/ ATR period and the price deviation parameter.

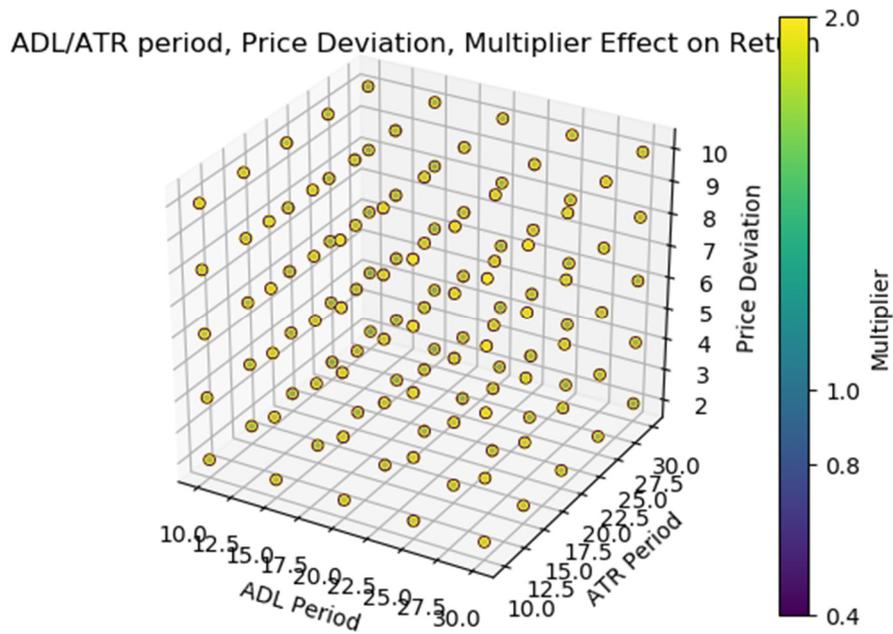
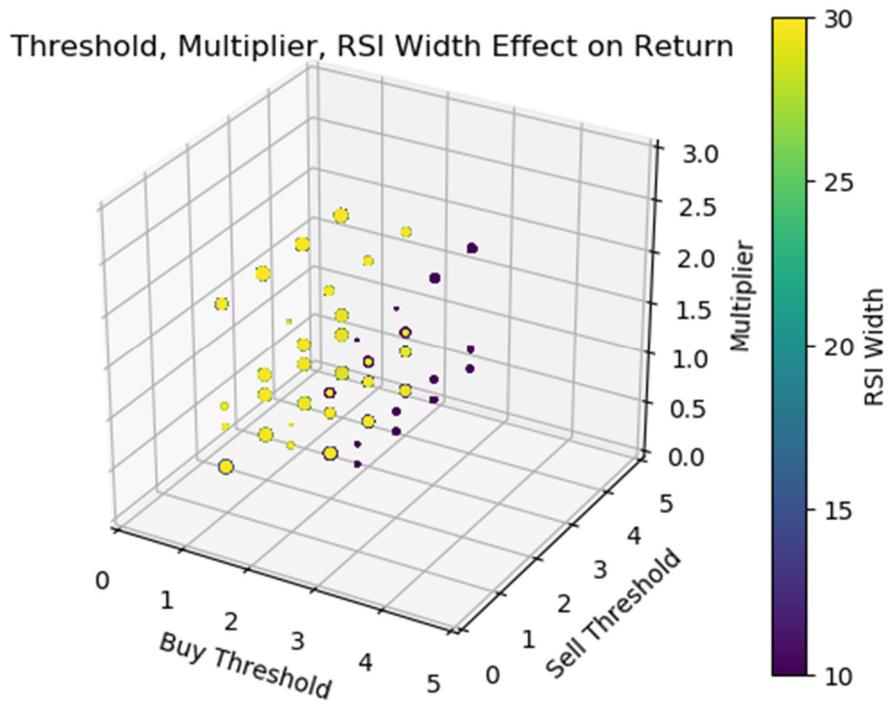
4.1.10 XLRE

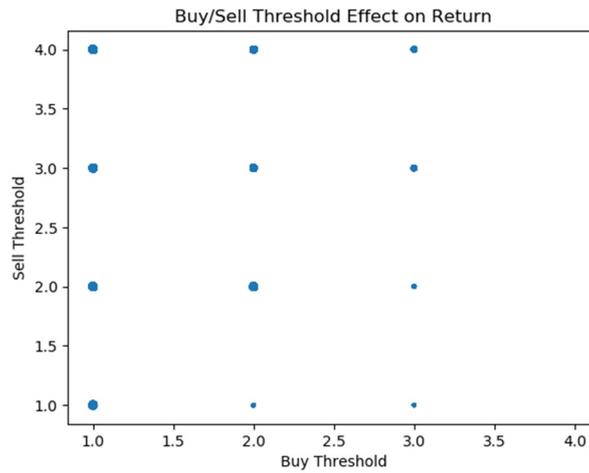
Annualized Stock Return: 7.24%

Best parameter combination:

Buy Threshold=1 Sell Threshold=1 Multiplier= 0.4 ADL period= 10/15/20/25
ATR period= 10/15/20/25 RSI width= 15 Price Deviation= any

Optimized Result: Total Return = 26.62% Annualized Return: 8.37%





Remarks

From the results, we can see that

- 1) It's never profitable to use a buy threshold over three. A buy threshold of one seems to provide more consistent return.
- 2) Using a sell threshold of one is slightly worse.
- 3) When the buy threshold is three, it's better to use the smallest RSI width.
- 4) In most cases, it's slightly better to choose a small multiplier.
- 5) There is not much effect on changing the ADL/ ATR period and the price deviation parameter.

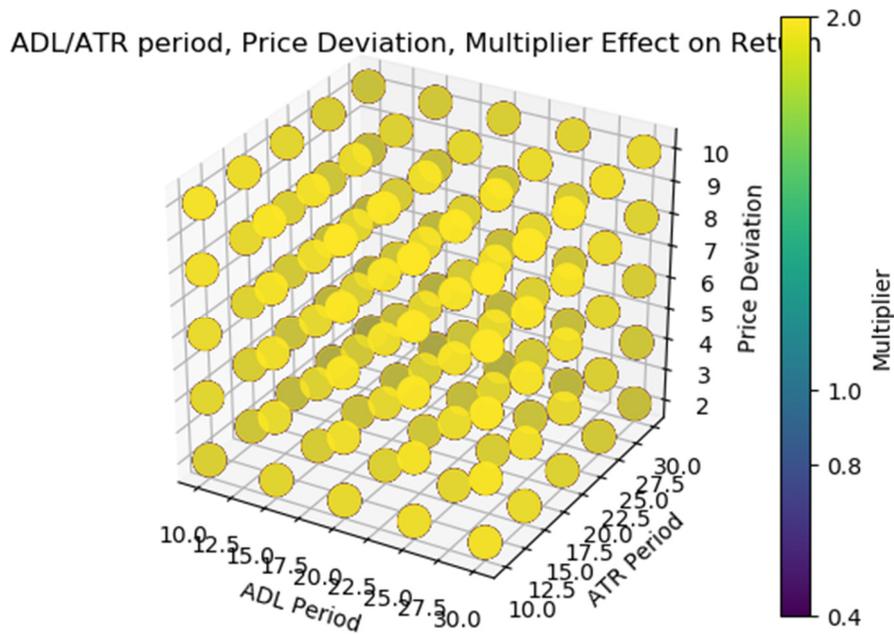
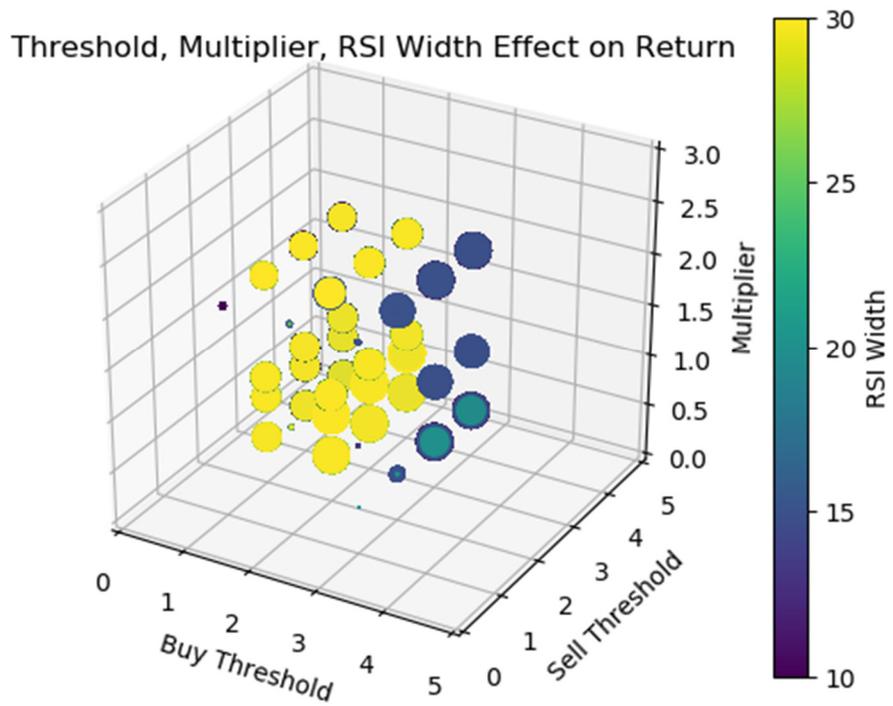
4.1.11 S&P 500

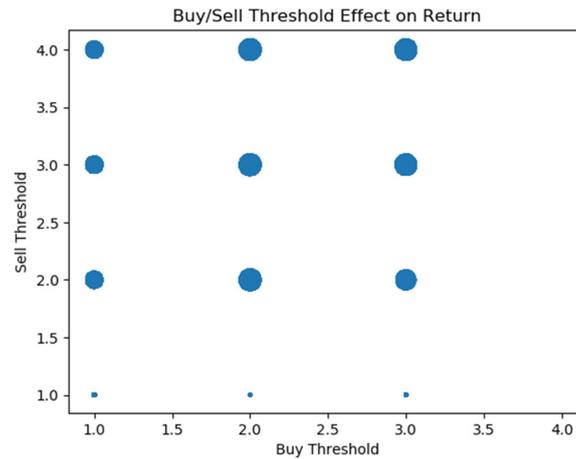
Annualized Stock Return: 4.57%

Best parameter combination:

Buy Threshold=2 Sell Threshold=2/3/4 Multiplier= 0.8 ADL period= any
ATR period= any RSI width= 30 Price Deviation= any

Optimized Result: Total Return = 214.52% Annualized Return: 5.98%





Remarks

From the results, we can see that

- 1) It's never profitable to use a buy threshold over three. A buy threshold of either two or three is preferred over that of one.
- 2) Using a sell threshold of one is worse while the difference between using a sell threshold of two, three, and four weren't drastic.
- 3) When the buy threshold is three, it's better to use the smallest RSI width.
- 4) In most cases, it's slightly better to choose a small multiplier.
- 5) There is not much effect on changing the ADL/ ATR period and the price deviation parameter.

4.2 Analysis

This graph shows a summary of all the best parameter combination for each of the tested ETFs. All stock returns and strategy returns were annualized. Excess returns were the difference between strategy returns and stock returns.

	Buy Threshold	Sell Threshold	Multiplier	ADL Period	ATR Period	RSI Width	Price Deviation	Total Transactions	Stock Return	Strategy Return
XLE	1	>=2	0.4	any	any	20	any	1	8.04%	8.40%
XLF	2	2	2	any	any	10	any	17	5.50%	7.90%
XLV	1	2	0.8	any	any	15	any	9	8.36%	9.10%
XLI	2	2	0.4	any	any	20	any	3	8.28%	8.76%
XLB	1	2	1	any	any	10	any	25	7.84%	9.21%
XLP	2	>=2	0.4	any	any	>=15	any	1	6.04%	6.74%
XLY	2	2	0.4	any	any	20	any	7	9.30%	11.20%
XLK	2	>=3	2	any	any	15	any	1	5.58%	8.63%
XLU	2	2	2	any	any	10	any	25	6.87%	8.28%
XLRE	1	1	0.4	<=25	<=25	15	any	94	7.24%	8.37%
S&P 500	2	>=2	0.8	any	any	30	any	1	4.57%	5.98%

Table 1 – Test result

Stock Code	Industry	Total Transactions	Stock Return	Strategy Return	Excessive Return per Transaction	Beta	P/E	Excess return	Volatility
XLY	Consumer Discretionary	7	9.30%	11.20%	0.3%	1	28.48	1.90%	1.4%
XLU	Utility	25	6.87%	8.28%	0.1%	0.4	22.18	1.41%	1.2%
XLRE	Real Estate	94	7.24%	8.37%	0.0%	0.59	42.22	1.13%	0.9%
XLI	Industrial	3	8.28%	8.76%	0.2%	1.03	19.90	0.48%	1.3%
XLP	Consumer Staples	1	6.04%	6.74%	0.7%	0.64	25.32	0.70%	1.0%
XLF	Financial	17	5.50%	7.90%	0.1%	1.1	0.15	2.40%	1.9%
XLK	Technology	1	5.58%	8.63%	3.1%	1.14	25.59	3.05%	1.6%
XLE	Energy	1	8.04%	8.40%	0.4%	1.12	25.60	0.36%	1.7%
XLB	Materials	25	7.84%	9.21%	0.1%	1.05	31.33	1.37%	1.5%
XLV	Health care	9	8.36%	9.10%	0.1%	0.98	29.28	0.74%	1.1%

Table 2 – Test result with stock information

From Table 1 and Table 2 above we can see our testing result alongside with some information regarding ETF's the underlying industry.

Our strategy out-performed the stock return (the return that investor would have receive if they purchase the stock on the first day and held until the end) in all cases. This result is shown on the chart above under the “Excess Return” column (Strategy return minus stock return).

Most of the optimal parameter combinations has a buy/ sell threshold of two. From our result we can see that in all cases, it is better to trigger the buy/ sell execution with a lower signal threshold. The four indicators, on their own, measures different perspective of the stock performance which makes it rare for three or all four of them to generate consensus within the moving time frame. Insisting in using a larger buy threshold, in all of our tests, results in failure on triggering execution and thus zero return.

For XLK (Technology), unlike other “stocks”, has an optimal sell threshold of “ ≥ 3 ”. This mean that the optimal strategy for this industry requires a better tolerance on the downside. Moreover, the fact that a sell threshold of three and four makes no difference indicates that the four indicators, when used on XLK, were more likely to generate “consensus” such that setting a sell threshold of four does not result in significantly less execution (Implicitly, this suggests that it is possible that the third and fourth “buy signal” were generated together). We can expect that the underlying stock tends to have clear and identifiable movements, and this is supported by the high beta (correlation with the market) and volatility of XLK we observe.

Most of the execution were triggered by signals from MACD and RSI since the change in ADL period, ATR period, and the price deviation parameter does not affect the strategy return much. We believe this is because most of optimal parameter combination has a small multiplier (≤ 1) this makes the MACD even more sensitive and more likely to trigger execution.

We found that transaction number was positively correlated to excessive return. This shows that our algorithm has the ability of identifying appropriate execution with high accuracy. While we might have missed potential entry and exit points that could have generated more upside, this result showed that most of our execution decisions were indeed helpful in achieving higher return.



Figure 10 – Comparison: Excess return of high and low beta stocks (Left)



Figure 11 – Comparison: Excess return of high and low transaction amount (Right)

For industries with higher beta (>1), we obtained better result from the algorithm (more excessive return). If we further separate the ETFs by their beta (correlation with the market, in our case, S&P 500), we observe that ETFs with a beta equal to or over 1, under our algorithm, generates more excessive return comparing to those with beta under 1 (shown on Figure 10). We suggest that this result is, again, related to the stock’s volatility and price movements. Since high beta stocks tends to fluctuate more with the market, they often have higher volatilities. Thus, the high volatilities make them more likely to generate identifiable or obvious trends that would then be captured by our indicators, creating more “reliable” execution decisions that would generate profit. As a result, EFTs with high beta underlying industries such as material, technology, consumer discretionary and financial showed higher excess returns.

From our result, we also found that cross the optimal parameter combination for each ETF, a wider RSI width is usually paired with a lower multiplier and vice versa to compensate its lack of sensitivity (shown on Figure 11). We suggest that this is because most of the executions were trigger by MACD and RSI, therefore, having a combination of wide RSI width and high multiplier would make the algorithm less sensitive to trends and therefore, miss potential entry/ exit points.

4.3 Conclusion

To sum up our result and analysis, we found the following:

- 1) Our strategy, when uses optimal parameter inputs, always generates excess return comparing to stock return (holding the stock without trading during the period) and the amount of transactions was positively correlated to the excess return we receive.
- 2) Most executions were triggered by MACD and RSI signals, changes in other parameters such as ADL/ ATR period and price deviation does not affect the result much.
- 3) High beta ETFs tend to receive higher return using our strategy with optimized parameter inputs.
- 4) The optimal buy and sell threshold is two, however, stocks with particularly high beta might require a higher sell threshold.
- 5) On average, the best multiplier input is one but it needs be adjusted to compensate if the RSI width was set to be rather high or low.
- 6) Parameters including ADL period, ATR period, and price deviation does not affect the strategy return and therefore are not relevant in finding the optimal parameter inputs for our algorithm.

5. References

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