Fibonacci Retracement Trading Strategy and Backtesting

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Abstract

Traders often use the Fibonacci numbers for technical analysis. Historically, stock prices tend to obey the Fibonacci retracements as levels of support and resistance, but there does not seem to be any prove why this is so. This study aims to test the validity of using Fibonacci as a technical analysis tool and optimise the Fibonacci trading strategy by combining the strategy with other indicators, using US-based Vanguard ETFs as a test subject. The results of this study prove that trading using Fibonacci retracements might lead to unprofitable results, significantly underperforming the passive trading strategy.

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1. Introduction

1.1. Fibonacci numbers and retracement levels

In 1202, an Italian mathematician Leonardo Bonacci (also known as Fibonacci) wrote a book called *Liber Abaci* ("The Book of Calculation"), where he introduced the Fibonacci sequence:

0, 1, 1, 2, 3, 5, 8, 13, 21, 34, 55, 89, 144, 233, 377, 610, 987… to infinity.

where:
$S_0 = 0$, $S_1 = 1$, and $S_n = S_{n-1} + S_{n-2}$, for $n > 1$[1].

When we divide any number in the sequence with the preceding number, the ratio converges to 1.618 (for example, 610/377 = 1.618), making it a mathematically significant number. This is known as the Golden Ratio φ (also known as the Golden Mean or Divine Proportion) [2]:

$$\varphi = \lim_{n\to\infty} \frac{S_n}{S_{n-1}} \quad (1)$$

The Fibonacci sequence is widely applicable in nature. For example, the number of flower petals is equal to a number in a Fibonacci sequence, and equiangular spirals (which are found in snail shells or seashells) can be created through the Fibonacci numbers. The widespread application of the Fibonacci made it often referred to as the "numbers of nature".

Today, many technical traders use the Fibonacci Ratios to identify key levels of support and resistance to determine entry and exit opportunities. The commonly used ratios for analysis are: 0, 0.236, 0.382, 0.5, 0.618, 0.786, 1.0, -0.236, -0.382, -0.618 and -0.786 levels[3]. These numbers are mathematically related to one another[4]:

$$1.0 - 0.618 = 0.382$$

$$0.618 \times 0.618 = 0.382$$

$$\frac{1.0}{2} = 0.50$$

$$\sqrt{0.618} = 0.786$$

[1] Fibonacci number. (2020, July 26). Retrieved from https://en.wikipedia.org/wiki/Fibonacci_number

[2] Fiorenza, A., & Vincenzi, G. (2013, March 18). From Fibonacci Sequence to the Golden Ratio. Retrieved from https://www.hindawi.com/journals/jmath/2013/204674/

[3] Mitchell, C. (2020, August 01). Fibonacci Retracement Levels. Retrieved from https://www.investopedia.com/terms/f/fibonacciretracement.asp

[4] Boroden, C. (2008). *Fibonacci trading: How to master the time and price advantage*. New York: McGraw-Hill.

$$\frac{1}{0.618} = 1.618$$

$$0.618 - 0.382 = 0.236$$

$$0.382 \times 0.618 = 0.236$$

The 0, 0.236, 0.382, 0.5, 0.618, 0.786, and 1.0 levels are known as Fibonacci retracement levels, which are levels of support and resistance in trading. The -0.236, -0.382, -0.618 and -0.786 levels are known as the profit targets or projection levels, as it predicts the future price levels.

1.2. Fibonacci application in trading

To set up the Fibonacci retracement manually, analysts first need to identify the general trend in the time period. Then, the Fibonacci retracement tool is dragged from a low point to a high point in an uptrend, or from a high point to a low point in a downtrend. The retracement levels will then be shown automatically based on low and high points.

In an uptrend, traders will enter a trade after the price passes through the support level and will exit once the stock price passes through the target profit level (-0.236, -0.382, -0.618 or -0.786). Conversely, in a downtrend, short sellers will enter the trade after the price passes through the resistance level and will exit the market once the price passes through the target profit level. Based on Figures 1 and 2, the Fibonacci retracements seem to act as levels of support and resistance, albeit failing to capture all of the key levels.

Depending on the type of investors, different target profit levels are used. For example, risk-averse investors would take profit at the -0.236 level, while risk-loving investors would do so at the -0.786 level. There is a greater chance that prices will reach the -0.236 level, but it yields lower profits than the -0.786 level. This study will investigate the performances of each target profit level.

Another application of Fibonacci in trading is the Fibonacci extensions, which take into account the pullback (in addition to the low point and the high point of the prices) to predict future prices. Similar to the projection levels, the extension levels are usually regarded as profit targets. However, Fibonacci extensions will be outside of the scope of this study.

Figure 1

Fibonacci Retracement Setup in an Uptrend

*of the period under assessment

Figure 2

Fibonacci Retracement Setup in a Downtrend

*of the period under assessment

2. Methodology

2.1. Exchange-Traded Fund (ETF) selection

3 ETFs were used in this study:

1. Vanguard Large-Cap ETF (VV)
2. Vanguard Mid-Cap ETF (VO)
3. Vanguard Small-Cap ETF (VB)

These ETFs track the Center for Research in Security Prices (CRSP) Large Cap, Mid Cap, and Small Cap index, respectively. Vanguard ETFs were used to measure the performance of the Fibonacci trading strategies as it contains a diversified group of US-based companies, which would reflect the market conditions better than simply measuring the performance of strategies on individual stocks.

2.2. Initial capital and commissions

In this study, the initial capital will be US$10,000. The cost of purchase (i.e. trade commissions) is assumed to be zero throughout the study.

2.3. Source of data and software

All historical data used in this study is retrieved from TradingView. The strategies are backtested using TradingView's Pine Script. The backtest results are exported into Comma Separated Values format using Autoview, which is a Chrome extension. The results are then displayed in Microsoft Excel.

2.4. Result analysis

To analyse the backtest results, the following indicators were chosen.

2.4.1. Profit factor

The profit factor is the ratio of the gross profit to the gross loss. A profit factor above 1 is considered desirable as it shows that the strategy makes a profit.

$$\text{Profit Factor} = \frac{\text{Gross Profit}}{\text{Gross Loss}} \tag{2}$$

2.4.2. Net profit

In this study, the net profit is measured by the ratio of the gains or losses from the investment to the initial capital. The net profit is calculated by:

$$\text{Net Profit} = \frac{\text{Gross Profit} - \text{Commission}}{\text{Initial Capital}} \tag{3}$$

2.4.3. Sharpe ratio

The Sharpe ratio is used to calculate the return of the strategies while taking into account the risk (i.e. volatility or price fluctuations). A higher Sharpe ratio is desirable as there is higher return and/or lower risk. The Sharpe Ratio is calculated by:

$$\text{Sharpe Ratio} = \frac{R_p - R_f}{\sigma_p} \tag{4}$$

where:
R_p = portfolio return
R_f = risk-free rate
σ_p = standard deviation of portfolio excess return

2.4.4. Maximum Drawdown (MDD)

An MDD is the maximum observed loss of the trade. A lower MDD is better as it shows that there is a lower downside risk. The MDD is calculated by:

$$\text{MDD} = \frac{V_P - V_T}{V_p} \tag{5}$$

where:
V_P = peak value
V_T = trough value

2.4.5. Compound Annual Growth Rate (CAGR)

The CAGR is the "smoothed" growth rate of an investment over a time period longer than one year. A higher CAGR is better as it signals a high return of investment. The CAGR is calculated by:

$$\text{CAGR} = \left(\frac{V_{\text{final}}}{V_{\text{beginning}}}\right)^{\frac{1}{t}} - 1 \tag{6}$$

where:
V_{final} = final value of the investment
$V_{beginning}$ = beginning value of investment / initial capital
t = time in years

2.4.6. Buy and Hold

Buy and hold refers to when all funds (initial capital) were used to buy the security when the first trade is entered, and the position was held for the duration of the test period[5]. In other words, this is a passive trading strategy. In this study, the buy and hold strategy is measured in terms of the returns and CAGR.

(i) **Returns.** The buy and hold return will be compared with the net profit to check if an active trading strategy brings greater returns compared to a passive strategy. This is calculated by:

[5] How are Strategy Tester Report values calculated and what do they mean? (n.d.). Retrieved from https://www.tradingview.com/support/solutions/43000561856-how-are-strategy-tester-report-values-calculated-and-what-do-they-mean/

$$\text{Buy and Hold Return} = \frac{V_{final} - V_{beginning}}{V_{beginning}} \quad (7)$$

where:
V_{final} = final value of the investment (as of 24 July 2020)
$V_{beginning}$ = beginning value of investment / initial capital

(ii) **CAGR.** The buy and hold CAGR will be compared with the CAGR of the active trading strategy. The formula would be the same as Equation (6). The beginning value would be the first price of the ETF when it was launched (VV, VO, and VB were launched on 30 January 2004), and the ending value would be the final price of the ETF as of 24 July 2020.

3. Strategy Development

3.1. Moving Fibonacci

In this study, the 1-Day time period is used, as it is a medium time frame. Thus, it captures the general trend of the market but eliminates the market noise from a shorter time period.

To start this study, a "Moving Fibonacci", which is the historical retracement and projection levels, is plotted. This is done by looking back at a certain number of candlesticks as a time frame and determining the highest and lowest point within the specified time frame. This study looks back 100 candlesticks (in other words, the previous 100 trading days). Also, since Fibonacci trading relies on long term trends, the 100-time period would be able to capture that trend[6]. The time frame and Fibonacci levels will be adjusted as new candlesticks are formed over time.

The "Moving Fibonacci" considers whether the chart is uptrend and downtrend. The initial condition for an uptrend is that if the Exponential Moving Average of the previous 50 candlesticks is higher than the previous 100 candlesticks (i.e. 50EMA $\geq$ 100EMA). The condition for a downtrend is when 50EMA is less than 100EMA (i.e. 50EMA < 100EMA)[7]. This condition will change in the latter part of the study. In an uptrend, the profit targets will be above the highest point, as this provides an opportunity for a long entry. In a downtrend, the profit targets will be below the lowest point, as this provides a shorting opportunity.

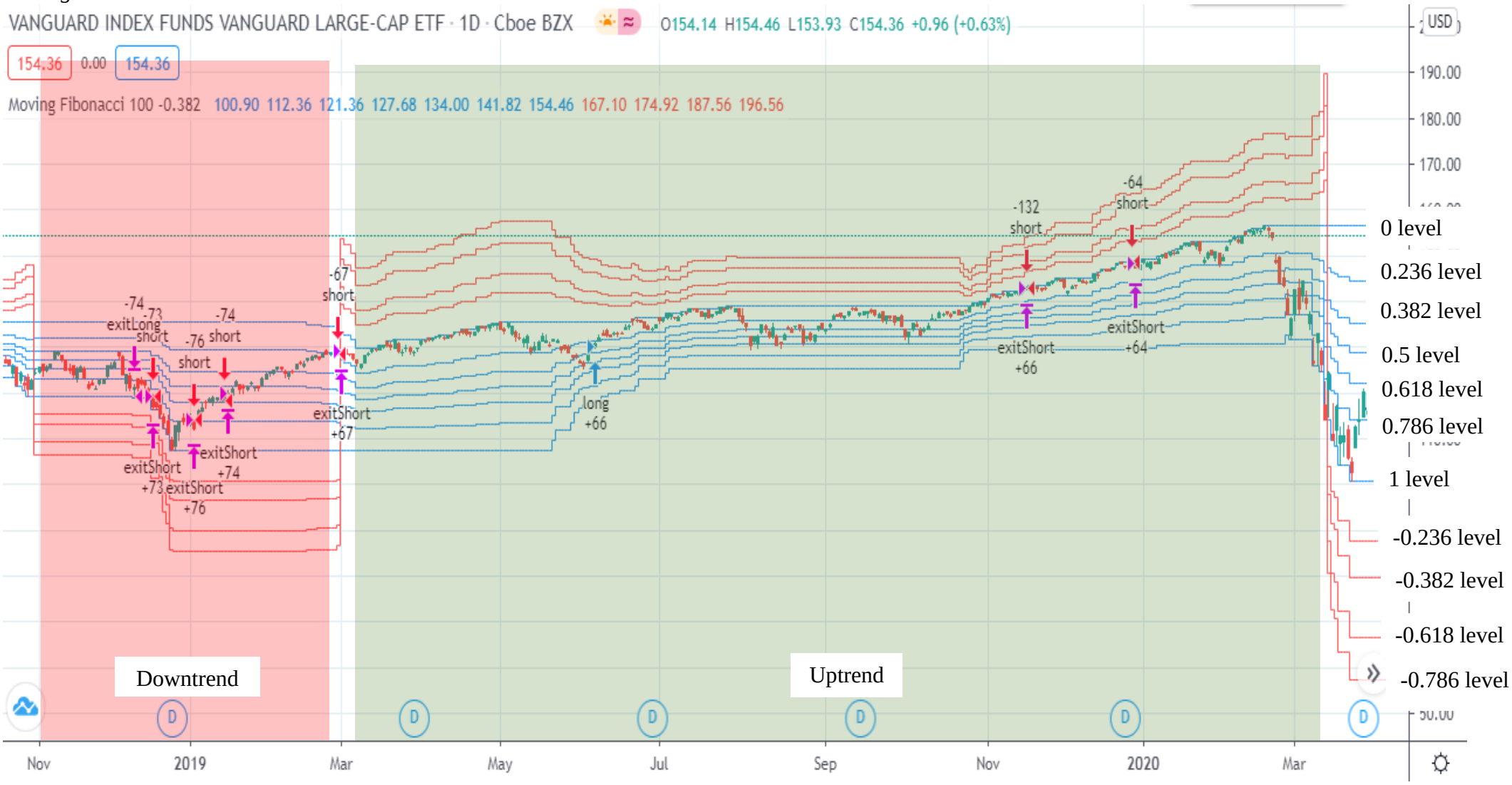
The diagram below shows the Moving Fibonacci. The blue lines are the retracement levels and the red lines are the profit targets.

[6] Lee, R. (2020, April 30). Top 4 Fibonacci Retracement Mistakes to Avoid. Retrieved from https://www.investopedia.com/articles/forex/11/fibonacci-rules.asp

[7] Rolf, Romz, Fred, Nkosinathi, Saba, Romy, . . . Rao, S. (2019, October 23). How To Use Moving Averages - Moving Average Trading 101. Retrieved from https://www.tradeciety.com/how-to-use-moving-averages/

Figure 3

Moving Fibonacci

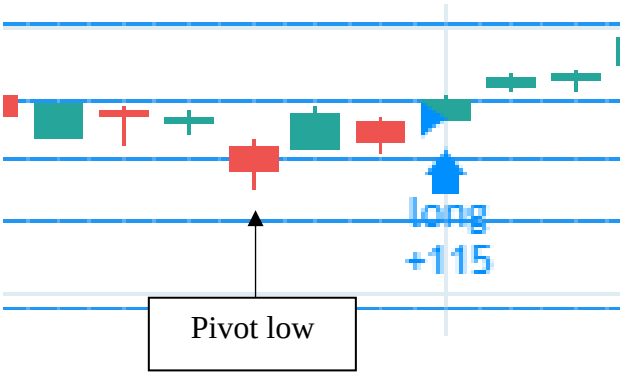


3.2. Conditions for a long entry

3.2.1. Pivot low

A pivot point with a period of 2 will be used. A minimum of 2 candlesticks before and after the pivot low point will have higher lows for this condition to be fulfilled. The illustration can be found in the figure below.

Figure 4
Pivot Low



3.2.2. Fibonacci retracement as a support level

The pivot low candlestick body crosses a Fibonacci retracement level. The retracement level would be regarded as a level of support.

3.2.3. Uptrend

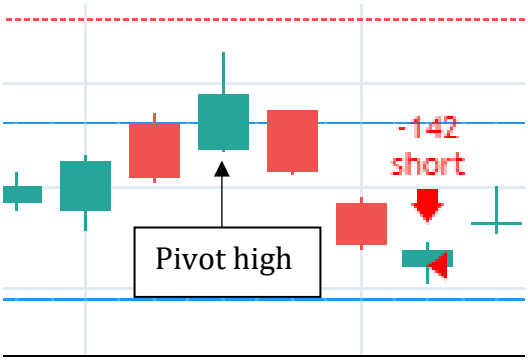
The conditions for an uptrend will be 50EMA ≥ 100EMA in Part 1 of the study, positive 100HMA gradient for Part 2, and positive 89HMA gradient for Part 3.

3.3. Conditions for a short entry

3.3.1. Pivot high

A pivot point with a period of 2 will be used. A minimum of 2 candlesticks before and after the pivot high point will have lower highs for this condition to be fulfilled. The illustration can be found in the figure below.

Figure 5
Pivot High



3.3.2. Fibonacci retracement as a resistance level

The pivot high candlestick body crosses a Fibonacci retracement level. The retracement level would be regarded as a level of resistance.

3.3.3. Downtrend

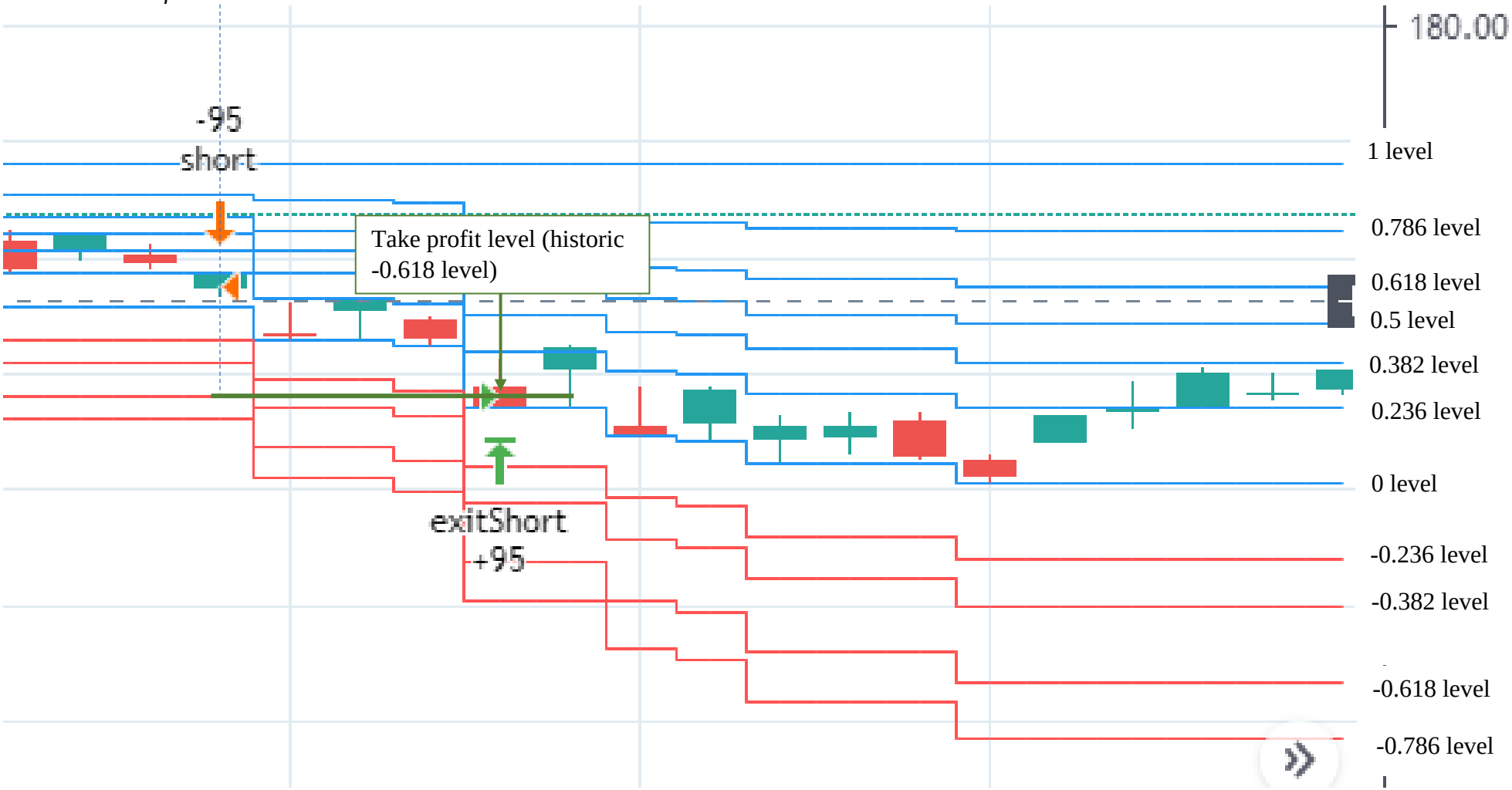
The conditions for an uptrend will be 50EMA < 100EMA in Part 1 of the study, negative 100HMA gradient for Part 2, and negative 89HMA gradient for Part 3.

3.4. Conditions for exit

The strategies will exit when prices reach the -0.236, -0.382, -0.618 or -0.786 projection levels at the time the trade is entered. Each of the strategies tested in this study will track the performances of the 4 projection levels. The figure below shows the short entry and exit for a historic -0.618 level.

Figure 6

-0.618 Take Profit Level



3.5. Stop-loss

A stop-loss is added to ensure that the position is not held for too long. In this study, 3 different types of stop-losses will be tested.

3.5.1. Fibonacci Stop-loss

The stop-loss for a long entry is placed on the retracement level below the support level. The stop-loss for a short entry is placed on the retracement level above the resistance level. The illustration can be seen in Figures 7 and 8 below.

Figure 7
Fibonacci Stop-Loss – Long Entry

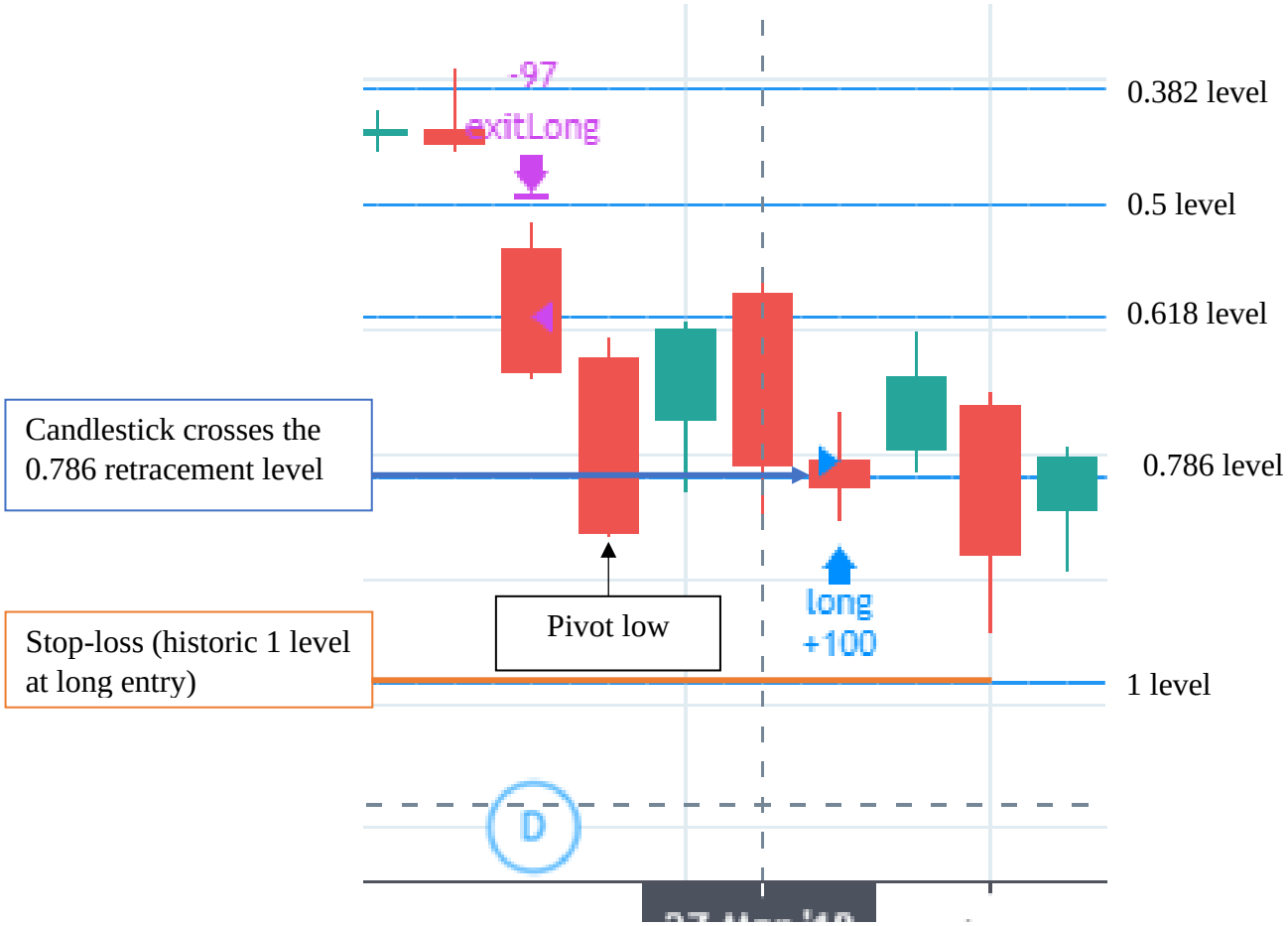
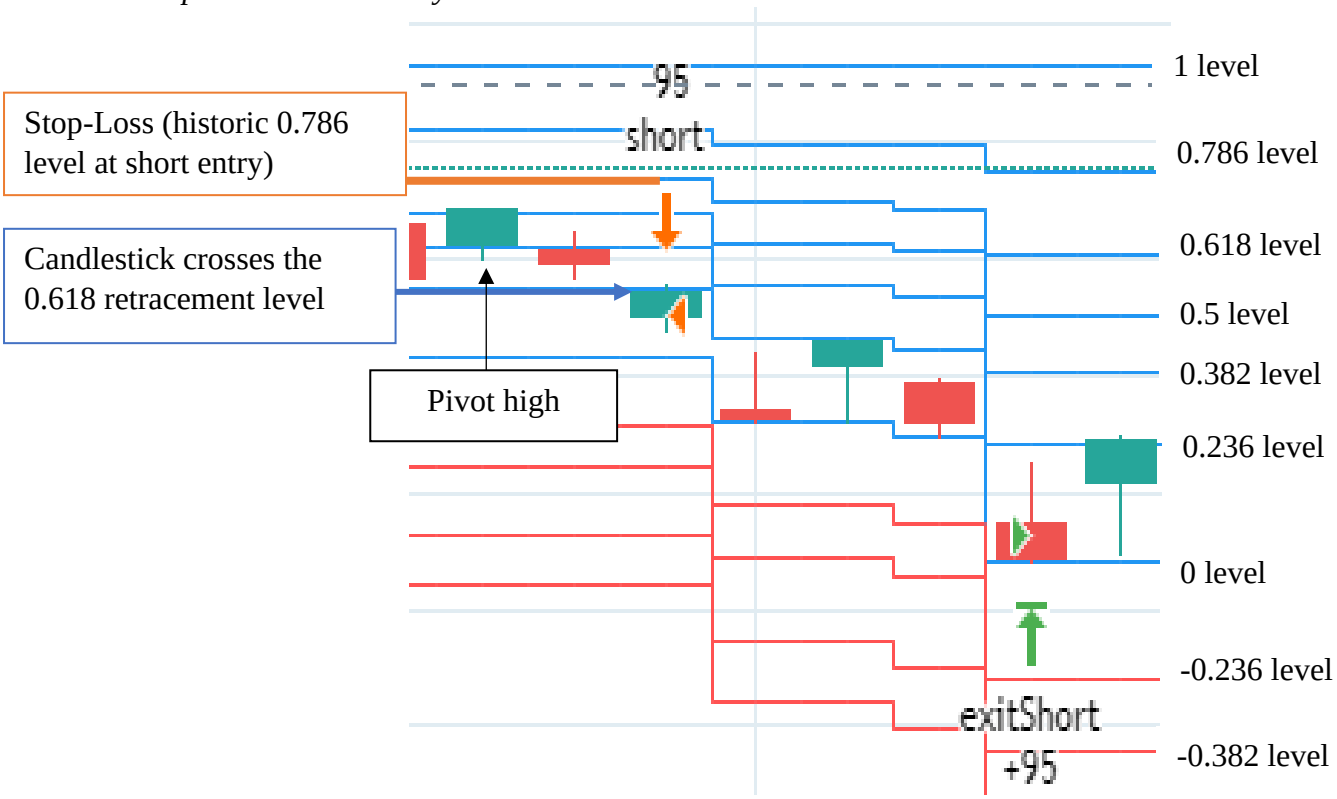


Figure 8

Fibonacci Stop-Loss – Short Entry

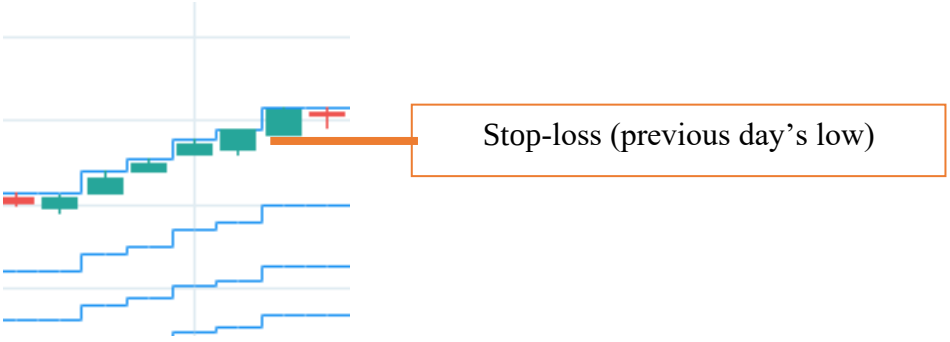


3.5.2. Trailing stop-loss

The stop-loss for a long entry would be the lowest point of the previous candlestick, and the stop-loss for a short entry would be the highest point of the previous candlestick. If the stop-loss condition is met, it may signal a trend reversal[8], meaning that it would be a good exit point. The illustration can be seen in Figures 9 and 10 below.

Figure 9

Trailing Stop-Loss – Long Entry



[8] Investopedia. (2020, May 29). Determining Where to Set Your Stop-Loss. Retrieved from https://www.investopedia.com/ask/answers/030915/how-do-i-determine-where-set-my-stop-loss.asp

Figure 10

Trend Reversal – Short Entry

3.5.3. Average True Range (ATR)

The ATR measures volatility, and it can be used to determine the stop-loss. In this study, the stop-loss will be placed 1 ATR below the long entry price, and 1 ATR above the short entry price. An ATR with a period of 14 days will be used, as this is the standard. As a reference, the ATR is calculated in 2 steps by:

$$TR = \text{Max}\left[(H - L), \left|(H - C_P)\right|, \left|(L - C_P)\right|\right] \quad (8)$$

$$ATR = \frac{1}{n}\sum_{i=1}^{n} TR_i \quad (9)$$

4. Strategy Testing (Part 1)

In this part of the strategy testing, the strategy focuses on the use of 50EMA ≥ 100EMA as an uptrend indicator, and 50EMA < 100EMA as a downtrend indicator. The strategy results show the average performances of VV, VO, and VB.

4.1. EMA Benchmark Strategy

This strategy randomly enters and exits the market purely based on the Fibonacci retracement levels, with the conditions outlined in the setup. A Fibonacci stop-loss is placed.

4.1.1. Results: EMA Benchmark Strategy

Table 1

EMA Benchmark Strategy Results

Profit Targets	Profit Factor	Net Profit	Sharpe Ratio	Max Drawdown	CAGR	Closed Trades
-0.236	1.35	41.02%	0.02	34.61%	1.92%	49
-0.382	1.52	78.06%	0.04	37.19%	3.41%	39
-0.618	1.35	63.23%	0.03	54.16%	0.80%	40
-0.786	1.17	44.86%	0.02	52.07%	1.05%	31
Average	1.35	56.79%	0.03	44.51%	1.79%	40

Start Year – End Year: 2004 – 2020

Buy and hold return: 224.30% (CAGR: 7.50%)

The results show that for each profit targets, the net profit and CAGR is significantly below the buy and hold return and CAGR, respectively. This is expected, as the trades are done without verifying whether the trend is actually bullish or bearish.

4.2. Trend Reversal Indicator Strategy

The strategy has the same entry points as the setup. A trailing stop-loss is placed.

4.2.1. Results: Trend Reversal Indicator Strategy

Table 2

Trend Reversal Indicator Strategy Results

Profit Targets	Profit Factor	Net Profit	Sharpe Ratio	Max Drawdown	CAGR	Closed Trades
-0.236	0.94	-5.25%	-0.01	39.10%	0.69%	63
-0.382	1.17	23.12%	0.03	37.57%	0.95%	57
-0.618	1.19	23.24%	0.03	37.45%	2.13%	55
-0.786	1.20	22.40%	0.03	35.35%	1.85%	54
Average	1.13	15.83%	0.02	37.37%	1.62%	57

Start Year – End Year: 2004 – 2020
Buy and hold return: 231.63% (CAGR: 7.50%)

The results are worse than the EMA Benchmark Strategy in terms of the profit factor, net profit, Sharpe ratio, and CAGR, but better in terms of MDD. A lower MDD was achieved due to the conservative stop-loss, which led to a significantly higher number of closed trades compared to the benchmark strategy. This shows that a conservative stop-loss would work against the investor in terms of profitability but achieves lower volatility.

4.3. EMA Crossover Strategy

In addition to the entry requirements stated in the setup, this strategy checks whether the trend shows a bullish or a bearish pattern using the EMA crossover. The trend is considered bullish if the EMA of the previous 50 candlesticks is greater than or equal to the EMA of the previous 200 candlesticks (i.e. 50EMA ≥ 200EMA). Conversely, the trend is bearish if 50EMA < 200EMA, and the strategy will enter a short trade. A Fibonacci stop-loss will be placed.

4.3.1. Results: EMA Crossover Strategy

Table 3

EMA Crossover Strategy Results

Profit Targets	Profit Factor	Net Profit	Sharpe Ratio	Max Drawdown	CAGR	Closed Trades
-0.236	1.43	52.41%	0.02	27.90%	2.29%	42
-0.382	1.63	91.64%	0.04	32.15%	3.78%	33
-0.618	1.10	19.86%	0.01	53.08%	0.66%	30
-0.786	1.16	33.60%	0.02	51.53%	0.94%	27
Average	1.33	49.38%	0.02	41.16%	1.92%	33

Start Year – End Year: 2004 – 2020
Buy and hold return: 188.54% (CAGR: 7.50%)

The results show a worse profit factor, net profit, and Sharpe ratio, but a slightly better MDD and CAGR compared to the EMA Benchmark Strategy. In general, it performs worse than the benchmark, showing that checking the longer-term trend (i.e. 200 EMA) may not necessary, as it can be too limiting.

4.4. Trend Reversal Indicator + EMA Crossover Strategy

This strategy combines the Trend Reversal Indicator and EMA Crossover strategies. Trades will be executed when both the EMA crossover conditions (i.e. 50EMA ≥ 200EMA for an uptrend, and 50EMA < 200EMA for a downtrend) and the setup conditions are met. The trailing stop-loss is placed.

4.4.1. Results: Trend Reversal Indicator + EMA Crossover Strategy

Table 4

Trend Reversal Indicator + EMA Crossover Strategy Results

Profit Targets	Profit Factor	Net Profit	Sharpe Ratio	Max Drawdown	CAGR	Closed Trades
-0.236	1.18	12.40%	-0.04	16.67%	0.73%	49
-0.382	1.31	21.98%	-0.02	17.20%	1.24%	65
-0.618	1.48	36.06%	0.01	17.80%	1.81%	62
-0.786	1.68	48.62%	0.03	15.80%	2.35%	58
Average	1.41	29.77%	-0.01	16.87%	1.53%	59

Start Year – End Year: 2004 – 2020
Buy and hold return: 188.54% (CAGR: 7.50%)

The results show a better profit factor and MDD compared to the EMA Benchmark Strategy. However, the net profit, Sharpe ratio, and CAGR are much worse. Overall, this strategy performs poorly in terms of profitability, and this was due to the lower volatility of the trades from a conservative stop-loss.

4.5. Relative Strength Index (RSI) Strategy

This strategy checks whether the ETF is overbought or oversold based on the RSI of 14 periods, which is the standard time period. A long trade will be placed either when the RSI is oversold (RSI < 30), or when the

entry conditions are met. A short trade will be placed either when the RSI is overbought (RSI > 70)[9], or when the entry conditions stated in the setup is met. Unlike the previous strategies, which looks at the historical prices and assumes that the trend will be the same in the future, the RSI looks more into the future based on the present demand or strength of the buyers relative to the supply. As a reference, the RSI is calculated as follows:

$$\text{RSI} = 100 - \frac{100}{1 + \frac{\text{Avg. upward price change}}{\text{Avg. downward price change}}} \quad (8)$$

The Fibonacci stop-loss is also placed in this strategy.

4.5.1. Results: RSI Strategy

Table 5

RSI Strategy Results

Profit Targets	Profit Factor	Net Profit	Sharpe Ratio	Max Drawdown	CAGR	Closed Trades
-0.236	0.94	-5.25%	-0.01	39.10%	0.69%	63
-0.382	1.17	23.12%	0.03	37.57%	0.95%	57
-0.618	1.19	23.24%	0.03	37.45%	2.13%	55
-0.786	1.20	22.40%	0.03	35.35%	1.85%	54
Average	1.13	15.83%	0.02	37.37%	1.62%	57

Start Year – End Year: 2004 – 2020
Buy and hold return: 231.63% (CAGR: 7.50%)

The results perform very poorly in all indicators compared to the EMA Benchmark Strategy, except for the MDD. This shows that Fibonacci retracements might not work very well with RSI.

4.6. Hull Moving Average (HMA) Strategy

The HMA computes the average prices with less lag compared to the EMA or Simple Moving Average (SMA)[10]. This strategy enters a long trade when the gradient of the 100HMA is positive (this shows that prices are in the uptrend direction, which is a bullish pattern), and when the setup conditions are met. Conversely, the strategy enters a short trade when the gradient of the 100HMA is negative, and when the setup conditions are met. As a reference, the HMA is calculated as follows:

1. Calculate a Weighted Moving Average (WMA) with period $\frac{n}{2}$ and multiply it by 2
2. Calculate a WMA for period n and subtract it from step 1

[9] Blystone, D. (2020, April 06). Overbought or Oversold? Use the Relative Strength Index to Find Out. Retrieved from https://www.investopedia.com/articles/active-trading/042114/overbought-or-oversold-use-relative-strength-index-find-out.asp

[10] How to reduce lag in a moving average. (n.d.). Retrieved from https://alanhull.com/hull-moving-average

3. Calculate a WMA with the period $\sqrt{n}$

$$HMA=WMA\left(2 \times WMA\left(\frac{n}{2}\right) - WMA(n)), \sqrt{n}\right)^{11} \quad (9)$$

where:
n = number of periods (in this study, 100 periods is used)

The Fibonacci stop-loss is placed in this strategy.

4.6.1. Results: HMA Strategy

Table 6
HMA Strategy Results

Profit Targets	Profit Factor	Net Profit	Sharpe Ratio	Max Drawdown	CAGR	Closed Trades
-0.236	1.34	45.45%	0.00	37.24%	-0.36%	43
-0.382	1.14	9.46%	-0.03	35.04%	0.18%	31
-0.618	0.94	-19.08%	-0.04	52.24%	-1.69%	29
-0.786	0.98	-15.85%	-0.03	49.68%	-1.96%	28
Average	1.10	5.00%	-0.03	43.55%	-0.96%	33

Start Year – End Year: 2004 – 2020
Buy and hold return: 231.15% (CAGR: 7.50%)

The results show a poor strategy with a lower profit factor, net profit, Sharpe ratio, and CAGR compared to the benchmark strategy. However, the strategy yielded a slightly lower MDD compared to the benchmark. This was due to the overly restrictive HMA strategy which reduced the number of trade entries, while the Fibonacci stop-losses were met too often.

4.7. Results: Average – Strategy Testing (Part 1)

Table 7
Average Results from Strategy Testing (Part 1)

Profit Targets	Profit Factor	Net Profit	Sharpe Ratio	Max Drawdown	CAGR	Closed Trades
-0.236	1.25	27.85%	-0.01	29.43%	1.08%	55
-0.382	1.33	38.68%	0.00	30.16%	1.63%	50
-0.618	1.23	24.38%	0.00	39.55%	0.92%	48
-0.786	1.30	35.57%	0.02	36.99%	1.45%	44
Average	1.27	31.62%	0.00	34.03%	1.27%	49

Start Year – End Year: 2004 – 2020
Buy and hold return: 218.32% (CAGR: 7.50%)

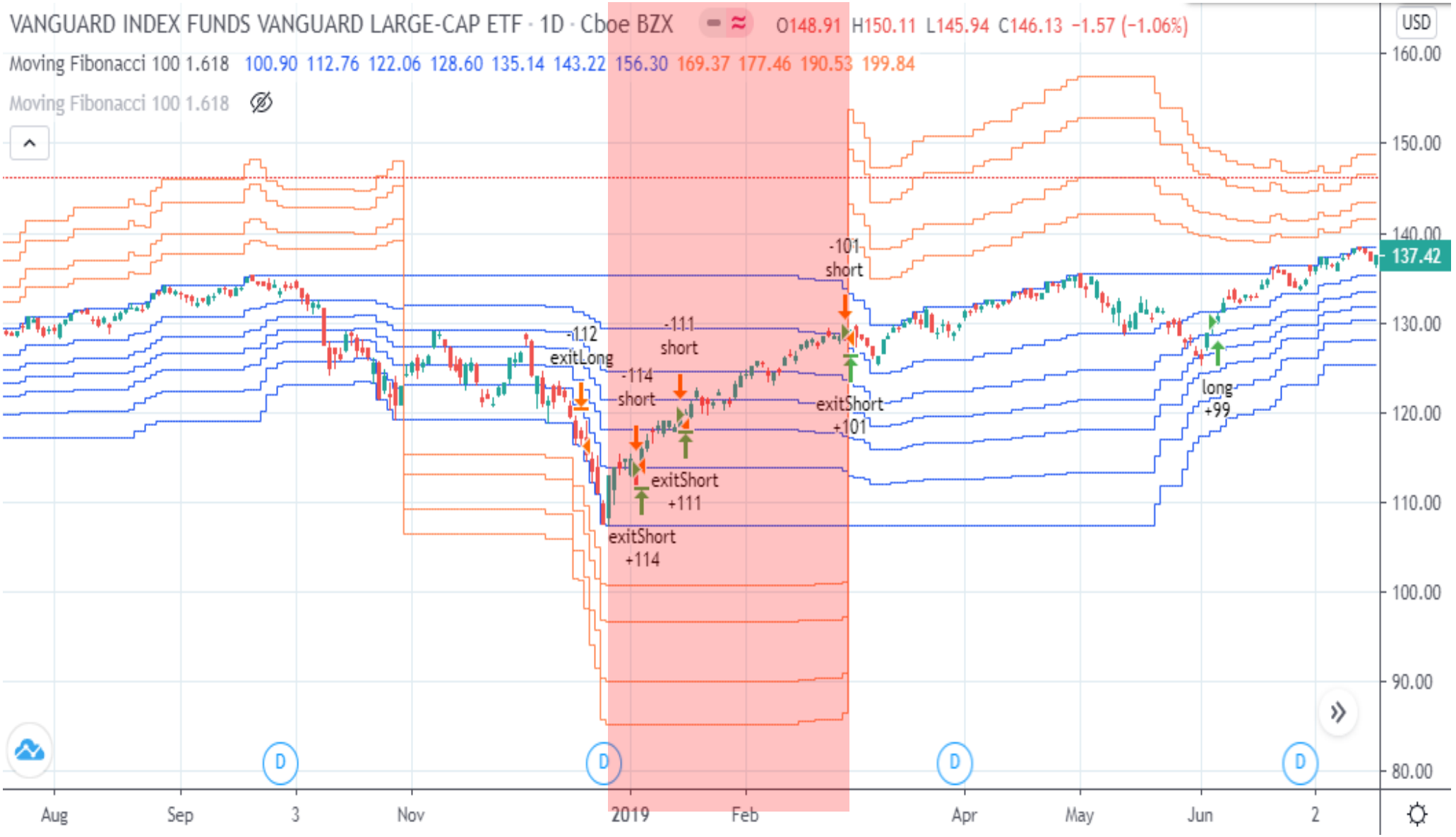
On average, the strategies are not optimal. Even though the profit factor and CAGR is acceptable, the Sharpe ratio is 0.00, meaning that the strategy is as good as not investing. The MDD is also quite high, showing that there is a high risk. Based on the observations from the Moving Fibonacci, the main problem with this strategy

[11] Hull Moving Average. (n.d.). Retrieved from https://www.fidelity.com/learning-center/trading-investing/technical-analysis/technical-indicator-guide/hull-moving-average

is that there is a lag in detecting the trend. This signals that using the 50EMA and 100EMA crossover is not a very good trend detector. This may result in placing trades against the trend, leading to highly unprofitable trades. Refer to Figure 11 for an illustration of the time-lag. The red area shows that the crossover detected a bearish price movement when it is actually bullish. This led to unprofitable short trades that immediately hits the stop-loss levels.

Figure 11

Time-Lag with the 50EMA and 100EMA Crossover



5. Strategy Testing (Part 2)

Considering the significant reduction in the time-lag when using the HMA in detecting the trend, this part of the trading strategies uses a positive 100HMA gradient as an uptrend condition and a negative 100HMA gradient as a downtrend. Figure 12 shows an improvement in the trend detection, for the same time frame as Figure 11. This led to fewer errors in trading against the trend.

Other entry and exit conditions will be the same as the setup.

Figure 12

Trend Detection Using 100HMA Gradient

5.1. HMA Benchmark Strategy

This strategy randomly enters and exits the trades when the setup conditions are met. A Fibonacci stop-loss is placed.

5.1.1. Results: HMA Benchmark Strategy

Table 8

HMA Benchmark Strategy Results

Profit Targets	Profit Factor	Net Profit	Sharpe Ratio	Max Drawdown	CAGR	Closed Trades
-0.236	1.46	44.94%	0.03	27.66%	2.33%	49
-0.382	1.39	62.66%	0.03	31.98%	2.94%	44
-0.618	1.19	41.06%	0.02	44.06%	0.60%	39
-0.786	1.38	71.22%	0.03	46.71%	1.91%	38
Average	1.35	54.97%	0.03	37.60%	1.94%	42

Start Year – End Year: 2004 – 2020
Buy and hold return: 227.38% (CAGR: 7.50%)

The results show the same profit factor, slightly lower net profit, same Sharpe ratio, lower MDD, and a higher CAGR compared to the EMA Benchmark Strategy. In general, the HMA Benchmark Strategy seems to be promising in terms of growth prospects and reducing volatility.

5.2. EMA Crossover Indicator

In addition to meeting the setup conditions, the strategy places a long trade if 50EMA ≥ 200EMA, and short if 50EMA < 200EMA. A Fibonacci stop-loss is also placed.

5.2.1. Results: EMA Crossover Strategy

Table 9

EMA Crossover Strategy Results

Profit Targets	Profit Factor	Net Profit	Sharpe Ratio	Max Drawdown	CAGR	Closed Trades
-0.236	1.51	29.06%	0.00	28.46%	0.97%	29
-0.382	1.42	36.93%	0.01	26.38%	1.58%	25
-0.618	1.15	-0.25%	-0.01	46.49%	-0.82%	23
-0.786	1.22	-0.30%	-0.01	50.59%	-0.97%	22
Average	1.32	16.36%	0.00	37.98%	0.19%	25

Start Year – End Year: 2004 – 2020
Buy and hold return: 183.95% (CAGR: 7.50%)

Consistent with the results from the first part of the trading strategy, the EMA Crossover Strategy does not perform well with the use of Fibonacci retracements. The results show that the strategy performs worse than the HMA Benchmark Strategy in all indicators.

5.3. RSI Strategy

This strategy places a long trade either when the RSI is oversold, or when the entry conditions are met. A short trade will be entered either when the RSI is overbought, or when the entry conditions stated in the setup is met. A Fibonacci stop-loss will be placed.

5.3.1. Results: RSI Strategy

Table 10

RSI Strategy Results

Profit Targets	Profit Factor	Net Profit	Sharpe Ratio	Max Drawdown	CAGR	Closed Trades
-0.236	0.91	-10.39%	-0.06	37.87%	-0.77%	94
-0.382	1.05	3.59%	-0.03	34.85%	0.09%	91
-0.618	1.19	20.96%	0.00	33.64%	0.99%	84
-0.786	1.39	36.01%	0.01	31.88%	1.37%	77
Average	1.13	12.54%	-0.02	34.56%	0.42%	86

Start Year – End Year: 2004 – 2020
Buy and hold return: 189.67% (CAGR: 7.50%)

Consistent with the first part of the strategy testing, the RSI performs poorly. This was evidenced by the lower profit factor, net profit, Sharpe ratio, and CAGR compared to the HMA Benchmark Strategy, and the relatively high MDD. This confirms that the RSI does not perform well with Fibonacci retracements.

5.4. ATR Stop-Loss Strategy

This strategy places trade orders when the conditions in the setup are fulfilled. An ATR stop-loss is placed.

5.4.1. Results: ATR Stop-Loss Strategy

Table 11

ATR Stop-Loss Strategy Results

Profit Targets	Profit Factor	Net Profit	Sharpe Ratio	Max Drawdown	CAGR	Closed Trades
-0.236	1.37	37.15%	0.05	29.10%	1.95%	59
-0.382	1.50	66.99%	0.05	29.02%	2.42%	51
-0.618	1.45	63.79%	0.05	29.59%	2.40%	50
-0.786	1.45	68.21%	0.05	29.41%	2.52%	50
Average	1.44	59.03%	0.05	29.28%	2.32%	53

Start Year – End Year: 2004 – 2020
Buy and hold return: 227.38% (CAGR: 7.50%)

The ATR stop-loss has improved the profit factor, net profit, Sharpe ratio, MDD, and CAGR. This shows that the ATR is a better stop-loss compared to the Fibonacci stop-loss. This makes the ATR Stop-Loss Strategy promising.

5.5. Results: Average – Strategy Testing (Part 2)

Table 12

Average Results from Strategy Testing (Part 2)

Profit Targets	Profit Factor	Net Profit	Sharpe Ratio	Max Drawdown	CAGR	Closed Trades
-0.236	1.37	37.15%	0.05	29.10%	1.95%	59
-0.382	1.50	66.99%	0.05	29.02%	2.42%	51
-0.618	1.45	63.79%	0.05	29.59%	2.40%	50
-0.786	1.45	68.21%	0.05	29.41%	2.52%	50
Average	1.44	59.03%	0.05	29.28%	2.32%	53

Start Year – End Year: 2004 – 2020
Buy and hold return: 227.38% (CAGR: 7.50%)

Overall, the strategies in Part 2 has improved profitability and reduced the volatility compared to Part 1. This confirms that HMA is a good indicator of trends, reducing the errors in the trades.

6. Strategy Testing (Part 3)

This part of the study aims to optimise the use of HMA and Fibonacci retracements, by using a "long-only" strategy. In the previous strategies, most of the short strategies were not profitable, while the long entries were significantly more profitable. Besides, a short entry will be riskier than a long entry as there will be a risk that investors will be unable to cover their short position, thereby magnifying the losses.

Another change in this part of the study will be the time period. Studies have shown that 55HMA and 89HMA are most often used as a long-term trend detector[12]. The table below shows the result of an "HMA Long Only" strategy which enters a long trade when the gradient of the HMA is positive for 2 consecutive candlesticks, and exits when the gradient is negative for 2 consecutive candlesticks. 2 candlesticks were used to ensure that the trend is confirmed.

Table 13

HMA Long Only Strategy Results

Time Period	Profit Factor	Net Profit	Sharpe Ratio	Max Drawdown	CAGR	Closed Trades
55	1.53	96.11%	0.07	32.01%	4.28%	96
89	1.68	114.47%	0.09	16.56%	4.87%	75

Start Year – End Year: 2004 – 2020
Buy and hold return (55): 196.53%; Buy and hold return (89): 216.78% (CAGR: 7.50%)

Based on the results above, the 89HMA time frame outperforms 55HMA. Thus, Part 3 of this study will look back at 89 candlesticks.

[12] Hull Moving Average (HMA). (n.d.). Retrieved from https://s2analytics.com/blog/hull-moving-average-hma/

6.1. 89HMA Benchmark

This strategy enters a long trade when the gradient of 89HMA is positive for 2 consecutive candlesticks, and when the setup conditions are met. The strategy exits the trades when the Fibonacci projection level is crossed. A Fibonacci stop-loss is placed.

6.1.1. Results: 89HMA Benchmark

Table 14
89HMA Benchmark

Profit Targets	Profit Factor	Net Profit	Sharpe Ratio	Max Drawdown	CAGR	Closed Trades
-0.236	1.94	59.04%	0.04	17.74%	2.85%	23
-0.382	1.96	76.66%	0.05	17.45%	3.40%	22
-0.618	2.11	103.32%	0.07	17.15%	4.42%	20
-0.786	2.38	134.13%	0.08	15.79%	5.43%	19
Average	2.10	93.29%	0.06	17.03%	4.02%	21

Start Year – End Year: 2004 – 2020
Buy and hold return: 214.06% (CAGR: 7.50%)

The results show a high profit factor, which is because of the elimination of possible losses from shorting. The Sharpe ratio and CAGR are also comparatively higher than other strategies. The MDD is lower than other strategies from the previous parts. The -0.786 level outperforms the 89HMA Long Only Strategy in terms of profit factor, net profit, MDD, and CAGR. Besides, the number of closed trades is significantly reduced. This means that in reality, when the commission is not 0, there will be less trading costs.

6.2. ATR Stop-Loss Strategy

Considering the good results from the ATR Stop-Loss Strategy in Part 2, this strategy aims to further reduce the volatility in this part of the study. Like the 89HMA Benchmark strategy, a long trade is placed when the 89HMA is positive for 2 consecutive candlesticks, and when the setup conditions are fulfilled. The strategy exits the trades when the Fibonacci projection level is crossed. An ATR stop-loss is placed.

6.2.1. Results: ATR Stop-Loss Strategy

Table 15
ATR Stop-Loss Strategy Results

Profit Targets	Profit Factor	Net Profit	Sharpe Ratio	Max Drawdown	CAGR	Closed Trades
-0.236	2.16	41.95%	0.03	11.36%	2.21%	33
-0.382	2.50	57.80%	0.05	10.65%	2.88%	32
-0.618	2.79	75.85%	0.06	11.78%	3.59%	31
-0.786	3.26	100.28%	0.08	11.32%	4.44%	30
Average	2.68	68.97%	0.05	11.28%	3.28%	32

Start Year – End Year: 2004 – 2020
Buy and hold return: 219.26% (CAGR: 7.50%)

The results show a higher profit factor and a lower MDD compared to the 89HMA Benchmark. However, the net profit, Sharpe ratio, and CAGR are lower. This is expected, as the ATR aims to reduce the volatility of the trades, but at the expense of lower profitability. Again, the -0.786-projection level outperforms other projection levels in terms of profitability and volatility.

6.3. Results: Average – Strategy Testing (Part 3)

Table 16

Average Results from Strategy Testing (Part 3)

Profit Targets	Profit Factor	Net Profit	Sharpe Ratio	Max Drawdown	CAGR	Closed Trades
-0.236	2.05	50.50%	0.03	14.55%	2.53%	28
-0.382	2.23	67.23%	0.05	14.05%	3.14%	27
-0.618	2.45	89.58%	0.06	14.47%	4.00%	26
-0.786	2.82	117.20%	0.08	13.56%	4.93%	25
Average	2.39	81.13%	0.06	14.16%	3.65%	27

Start Year – End Year: 2004 – 2020
Buy and hold return: 216.66% (CAGR: 7.50%)

Based on the results, it can be seen that changing the time period to 89 instead of 100 and restricting the trades to only long entries has significantly improved the results in terms of profitability and volatility. The 89HMA Benchmark Strategy can be used for risk-loving investors, while the ATR Stop-Loss Strategy from Part 3 of the study can be used for risk-averse investors.

7. Conclusion

The passive trading strategy outperforms the active trading strategy using Fibonacci retracements, as evidenced by the higher buy and hold return and CAGR compared to the active trading strategy's net profit and CAGR. This might signal that Fibonacci retracements might not be a very good technical analysis tool. After all, there is no scientific evidence as to why prices tend to follow the Fibonacci numbers[13]. However, the Fibonacci retracement is still very useful in determining the levels of support and resistance, and also a good way for traders to mark their target profit. Thus, traders should use the Fibonacci retracement tools with caution and should use it in combination with other indicators to verify the trades.

Furthermore, contrary to popular belief that the -0.618-projection level is considered to be the "best" take profit level, Part 3 of the study concludes that the -0.786-projection level provides the best return to risk ratio, as shown by the relatively high Sharpe ratio. Thus, technical traders who wish to use Fibonacci retracements should use this level as a take profit level instead of the -0.618 level.

[13] Bhattacharya, Sukanto & Kumar, Kuldeep. (2006). A computational exploration of the efficacy of Fibonacci Sequences in Technical analysis and trading.

Appendix A
Strategy Testing (Part 1)

Table A - 1

VV – EMA Benchmark Strategy

Start Date	End Date	Profit Targets	Net Profit	Profit Factor	Sharpe Ratio	Total Closed Trades	Percent Profitable	Max Drawdown	Buy & Hold Return	CAGR
07/26/2004	05/18/2020	-0.236	23.64%	1.223	-0.01	54	46.30%	36.18%	215.67%	1.34%
07/26/2004	05/18/2020	-0.382	18.22%	1.174	-0.01	49	42.86%	35.17%	215.67%	1.05%
07/26/2004	05/18/2020	-0.618	37.00%	1.325	0.02	45	40.00%	38.48%	215.67%	1.99%
07/26/2004	05/18/2020	-0.786	54.10%	1.476	0.03	37	43.24%	33.80%	215.67%	2.74%
	Average		33.24%	1.300	0.01	46	43.10%	35.91%	215.67%	1.78%

Table A - 2

VO – EMA Benchmark Strategy

Start Date	End Date	Profit Targets	Net Profit	Profit Factor	Sharpe Ratio	Total Closed Trades	Percent Profitable	Max Drawdown	Buy & Hold Return	CAGR
07/26/2004	02/25/2020	-0.236	99.06%	1.823	0.07	40	57.50%	31.85%	255.35%	4.40%
07/26/2004	02/25/2020	-0.382	144.21%	2.110	0.08	33	51.52%	33.40%	255.35%	5.74%
07/26/2004	02/25/2020	-0.618	37.00%	1.325	0.02	45	40.00%	79.39%	255.35%	-4.51%
07/26/2004	02/25/2020	-0.786	-57.14%	0.620	-0.04	29	41.38%	77.85%	255.35%	-5.16%
	Average		55.78%	1.470	0.03	1.470	47.60%	55.62%	255.35%	0.12%

Table A - 3

VB – EMA Benchmark Strategy

Start Date	End Date	Profit Targets	Net Profit	Profit Factor	Sharpe Ratio	Total Closed Trades	Percent Profitable	Max Drawdown	Buy & Hold Return	CAGR
07/07/2004	06/05/2020	-0.236	0.37%	1.002	-0.01	54	50.00%	35.81%	201.87%	0.02%
07/07/2004	06/05/2020	-0.382	71.74%	1.283	0.05	34	55.88%	42.99%	201.87%	3.44%
07/07/2004	06/05/2020	-0.618	115.70%	1.387	0.07	30	53.33%	44.60%	201.87%	4.92%
07/07/2004	06/06/2020	-0.786	137.62%	1.427	0.07	27	51.85%	44.57%	201.87%	5.56%
	Average		81.36%	1.275	0.04	36	52.77%	41.99%	201.87%	3.49%

Table A - 4

VV – Trend Reversal Indicator

Start Date	End Date	Profit Targets	Net Profit	Profit Factor	Sharpe Ratio	Total Closed Trades	Percent Profitable	Max Drawdown	Buy & Hold Return	CAGR
07/26/2004	05/18/2020	-0.236	11.88%	1.150	-0.04	86	24.42%	14.47%	220.68%	0.70%
07/26/2004	05/18/2020	-0.382	13.09%	1.175	-0.04	75	22.67%	15.52%	220.68%	0.77%
07/26/2004	05/18/2020	-0.618	9.24%	1.118	-0.03	73	20.55%	21.21%	220.68%	0.55%
07/26/2004	05/18/2020	-0.786	56.54%	1.769	0.04	66	22.73%	15.08%	220.68%	2.84%
	Average		22.69%	1.303	-0.02	75	22.59%	16.57%	220.68%	1.22%

Table A - 5

VO – Trend Reversal Indicator

Start Date	End Date	Profit Targets	Net Profit	Profit Factor	Sharpe Ratio	Total Closed Trades	Percent Profitable	Max Drawdown	Buy & Hold Return	CAGR
07/26/2004	02/24/2020	-0.236	13.33%	1.177	-0.04	80	23.75%	15.12%	260.52%	0.79%
07/26/2004	02/24/2020	-0.382	37.59%	1.452	0.01	76	22.37%	15.11%	260.52%	2.01%
07/26/2004	02/24/2020	-0.618	89.91%	1.913	0.07	74	21.62%	15.11%	260.52%	4.09%
07/26/2004	02/24/2020	-0.786	122.73%	2.220	0.08	68	22.06%	17.62%	260.52%	5.13%
	Average		65.89%	1.691	0.03	75	22.45%	15.74%	260.52%	3.01%

Table A - 6

VB – Trend Reversal Indicator

Start Date	End Date	Profit Targets	Net Profit	Profit Factor	Sharpe Ratio	Total Closed Trades	Percent Profitable	Max Drawdown	Buy & Hold Return	CAGR
07/26/2004	05/05/2020	-0.236	11.88%	1.150	-0.04	86	24.42%	36.92%	206.63%	0.70%
07/07/2004	04/27/2020	-0.382	-4.71%	0.953	-0.06	83	19.28%	37.65%	206.63%	-0.30%
07/07/2004	04/27/2020	-0.618	-22.68%	0.773	-0.09	77	11.69%	34.49%	206.63%	0.55%
07/07/2004	04/27/2020	-0.786	56.54%	1.064	-0.03	60	15.00%	29.23%	206.63%	2.84%
	Average		10.26%	0.985	-0.06	77	17.60%	34.57%	206.63%	0.95%

Table A - 7

VV – EMA Crossover Strategy

Start Date	End Date	Profit Targets	Net Profit	Profit Factor	Sharpe Ratio	Total Closed Trades	Percent Profitable	Max Drawdown	Buy & Hold Return	CAGR
02/14/2005	05/18/2020	-0.236	12.43%	1.125	-0.02	46	50.00%	36.16%	185.86%	0.78%
02/14/2005	05/18/2020	-0.382	14.18%	1.144	-0.02	42	45.24%	35.19%	185.86%	0.77%
02/14/2005	05/18/2020	-0.618	30.13%	1.286	0.01	38	42.11%	38.47%	185.86%	1.77%
02/14/2005	05/18/2020	-0.786	42.80%	1.411	0.03	34	44.12%	33.78%	185.86%	2.40%
	Average		24.88%	1.242	0.00	40	45.37%	35.90%	185.86%	1.43%

Table A - 8

VO – EMA Crossover Strategy

Start Date	End Date	Profit Targets	Net Profit	Profit Factor	Sharpe Ratio	Total Closed Trades	Percent Profitable	Max Drawdown	Buy & Hold Return	CAGR
04/07/2005	02/25/2020	-0.236	146.26%	2.170	0.10	35	62.86%	18.26%	199.08%	6.19%
04/07/2005	02/25/2020	-0.382	212.36%	2.526	0.11	29	58.62%	18.27%	199.08%	7.89%
04/07/2005	02/25/2020	-0.618	-40.11%	0.732	-0.01	26	50.00%	76.21%	199.08%	-3.36%
04/07/2005	02/25/2020	-0.786	-50.85%	0.668	-0.03	24	41.67%	76.21%	199.08%	-4.62%
	Average		66.92%	1.524	0.04	29	53.29%	47.24%	199.08%	1.52%

Table A - 9

VB – EMA Crossover Strategy

Start Date	End Date	Profit Targets	Net Profit	Profit Factor	Sharpe Ratio	Total Closed Trades	Percent Profitable	Max Drawdown	Buy & Hold Return	CAGR
01/18/2005	06/05/2020	-0.236	-1.46%	0.992	-0.01	46	52.17%	29.27%	180.67%	-0.10%
01/18/2005	06/05/2020	-0.382	48.37%	1.226	0.03	28	57.14%	42.98%	180.67%	2.67%
01/18/2005	06/05/2020	-0.618	69.57%	1.294	0.05	25	52.00%	44.57%	180.67%	3.58%
01/18/2005	06/05/2020	-0.786	108.85%	1.386	0.06	23	52.17%	44.60%	180.67%	5.03%
	Average		56.33%	1.225	0.03	31	53.37%	40.36%	180.67%	2.80%

Table A - 10

VV – Trend Reversal Indicator + EMA Crossover Strategy

Start Date	End Date	Profit Targets	Net Profit	Profit Factor	Sharpe Ratio	Total Closed Trades	Percent Profitable	Max Drawdown	Buy & Hold Return	CAGR
02/14/2005	05/18/2020	-0.236	16.48%	1.240	-0.04	72	25.00%	13.81%	185.86%	0.96%
02/14/2005	05/18/2020	-0.382	13.96%	1.216	-0.04	63	22.22%	14.50%	185.86%	0.82%
02/14/2005	05/18/2020	-0.618	36.01%	1.517	0.01	59	22.03%	20.61%	185.86%	1.94%
02/14/2005	05/18/2020	-0.786	45.54%	1.735	0.03	57	21.05%	14.42%	185.86%	2.37%
	Average		28.00%	1.427	-0.01	63	22.58%	15.84%	185.86%	1.52%

Table A - 11

VO – Trend Reversal Indicator + EMA Crossover Strategy

Start Date	End Date	Profit Targets	Net Profit	Profit Factor	Sharpe Ratio	Total Closed Trades	Percent Profitable	Max Drawdown	Buy & Hold Return	CAGR
04/07/2005	02/24/2020	-0.236	14.37%	1.228	-0.05	70	25.71%	14.31%	199.08%	0.84%
04/07/2005	02/24/2020	-0.382	32.83%	1.483	0.01	66	24.24%	12.21%	199.08%	1.79%
04/07/2005	02/24/2020	-0.618	70.83%	1.917	0.06	64	23.44%	11.78%	199.08%	3.40%
04/07/2005	02/24/2020	-0.786	91.42%	2.199	0.07	58	24.14%	13.53%	199.08%	4.14%
	Average		52.36%	1.707	0.02	65	24.38%	12.96%	199.08%	2.54%

Table A - 12

VB – Trend Reversal Indicator + EMA Crossover Strategy

Start Date	End Date	Profit Targets	Net Profit	Profit Factor	Sharpe Ratio	Total Closed Trades	Percent Profitable	Max Drawdown	Buy & Hold Return	CAGR
01/18/2005	04/27/2020	-0.236	6.34%	1.076	-0.05	69	24.64%	21.90%	180.67%	0.38%
01/18/2005	06/05/2020	-0.382	19.16%	1.216	-0.02	67	22.39%	24.88%	180.67%	1.10%
01/18/2005	06/05/2020	-0.618	1.35%	1.015	-0.05	62	14.52%	21.01%	180.67%	0.08%
01/18/2005	06/05/2020	-0.786	8.92%	1.103	-0.02	59	15.25%	19.44%	180.67%	0.54%
	Average		8.94%	1.103	-0.03	64	19.20%	21.81%	180.67%	0.53%

Table A - 13

VV – RSI Strategy

Start Date	End Date	Profit Targets	Net Profit	Profit Factor	Sharpe Ratio	Total Closed Trades	Percent Profitable	Max Drawdown	Buy & Hold Return	CAGR
07/26/2004	05/18/2020	-0.236	-31.99%	0.641	-0.12	67	22.39%	43.48%	220.06%	1.21%
07/26/2004	05/18/2020	-0.382	-8.35%	0.912	-0.05	58	22.41%	38.26%	220.06%	-0.54%
07/26/2004	05/18/2020	-0.618	-3.96%	0.959	-0.03	58	22.41%	38.23%	220.06%	1.80%
07/26/2004	05/18/2020	-0.786	-2.12%	0.978	-0.03	58	22.41%	38.23%	220.06%	1.79%
	Average		-11.60%	0.873	-0.06	60	22.41%	39.55%	220.06%	1.06%

Table A - 14

VO – RSI Strategy

Start Date	End Date	Profit Targets	Net Profit	Profit Factor	Sharpe Ratio	Total Closed Trades	Percent Profitable	Max Drawdown	Buy & Hold Return	CAGR
09/20/2004	03/23/2020	-0.236	21.20%	1.200	0.05	61	36.07%	35.20%	262.12%	1.18%
09/20/2004	03/23/2020	-0.382	27.56%	1.288	0.06	54	29.63%	35.83%	262.12%	0.82%
09/20/2004	03/23/2020	-0.618	33.01%	1.358	0.06	53	28.30%	35.50%	262.12%	2.45%
09/20/2004	03/23/2020	-0.786	32.88%	1.403	0.06	51	27.45%	29.18%	262.12%	1.79%
	Average		29.55%	1.264	0.06	56	30.91%	33.93%	262.12%	1.90%

Table A - 15

VB – RSI Strategy

Start Date	End Date	Profit Targets	Net Profit	Profit Factor	Sharpe Ratio	Total Closed Trades	Percent Profitable	Max Drawdown	Buy & Hold Return	CAGR
07/07/2004	03/23/2020	-0.236	-4.95%	0.965	0.03	62	32.26%	38.63%	212.69%	-0.32%
07/07/2004	03/23/2020	-0.382	50.15%	1.322	0.07	59	33.90%	38.63%	212.69%	2.57%
07/07/2004	03/23/2020	-0.618	40.67%	1.242	0.06	53	30.19%	38.63%	212.69%	2.16%
07/07/2004	03/23/2020	-0.786	36.43%	1.211	0.06	54	29.63%	38.63%	212.69%	1.96%
	Average		29.55%	1.264	0.06	56	30.91%	38.63%	212.69%	1.90%

Table A - 16

VV – HMA Strategy

Start Date	End Date	Profit Targets	Net Profit	Profit Factor	Sharpe Ratio	Total Closed Trades	Percent Profitable	Max Drawdown	Buy & Hold Return	CAGR
07/26/2004	01/16/2019	-0.236	39.12%	1.623	0.02	35	60.00%	22.60%	218.52%	2.08%
07/26/2004	01/16/2019	-0.382	24.41%	1.346	0.00	31	54.84%	22.63%	218.52%	1.37%
07/26/2004	01/16/2019	-0.618	44.56%	1.559	0.03	29	51.72%	22.59%	218.52%	2.33%
07/26/2004	01/16/2019	-0.786	43.42%	1.540	0.03	27	51.85%	18.50%	218.52%	2.28%
	Average		37.88%	1.517	0.02	31	54.60%	21.58%	218.52%	2.02%

Table A - 17

VO – HMA Strategy

Start Date	End Date	Profit Targets	Net Profit	Profit Factor	Sharpe Ratio	Total Closed Trades	Percent Profitable	Max Drawdown	Buy & Hold Return	CAGR
07/26/2004	02/25/2020	-0.236	30.85%	1.351	0.00	47	53.19%	27.34%	256.31%	1.69%
07/26/2004	02/25/2020	-0.382	43.75%	1.413	0.03	31	48.39%	28.97%	256.31%	2.29%
07/26/2004	02/25/2020	-0.618	-64.26%	0.506	-0.06	28	42.86%	74.74%	256.31%	-4.51%
07/26/2004	02/25/2020	-0.786	-64.52%	0.544	-0.06	27	40.74%	72.76%	256.31%	-6.27%
	Average		-13.55%	0.954	-0.02	33	46.30%	50.95%	256.31%	-1.70%

Table A - 18

VB – HMA Strategy

Start Date	End Date	Profit Targets	Net Profit	Profit Factor	Sharpe Ratio	Total Closed Trades	Percent Profitable	Max Drawdown	Buy & Hold Return	CAGR
07/26/2004	06/05/2020	-0.236	66.40%	1.054	-0.03	48	56.25%	61.77%	218.62%	-4.87%
07/26/2004	06/05/2020	-0.382	-39.78%	0.668	-0.11	31	38.71%	53.52%	218.62%	-3.12%
07/26/2004	06/05/2020	-0.618	-37.55%	0.748	-0.09	30	33.33%	59.40%	218.62%	-2.90%
07/26/2004	06/05/2020	-0.786	-26.44%	0.846	-0.06	30	33.33%	57.77%	218.62%	-1.90%
	Average		-9.34%	0.829	-0.07	35	40.41%	58.12%	218.62%	-3.20%

Appendix B
Strategy Testing (Part 2)

Table B - 1

VV - HMA Benchmark Strategy

Start Date	End Date	Profit Targets	Net Profit	Profit Factor	Sharpe Ratio	Total Closed Trades	Percent Profitable	Max Drawdown	Buy & Hold Return	CAGR
07/26/2004	03/11/2020	-0.236	70.27%	1.848	0.05	51	54.90%	21.26%	218.52%	3.38%
07/26/2004	03/12/2020	-0.382	16.84%	1.186	-0.01	44	47.73%	33.01%	218.52%	0.98%
07/26/2004	03/12/2020	-0.618	50.99%	1.506	0.03	42	45.24%	31.09%	218.52%	2.61%
07/26/2004	03/16/2020	-0.786	107.04%	1.993	0.07	41	46.34%	31.94%	218.52%	4.65%
	Average		61.28%	1.633	0.04	45	48.55%	29.33%	218.52%	2.91%

Table B - 2

VO - HMA Benchmark Strategy

Start Date	End Date	Profit Targets	Net Profit	Profit Factor	Sharpe Ratio	Total Closed Trades	Percent Profitable	Max Drawdown	Buy & Hold Return	CAGR
07/26/2004	06/18/2020	-0.236	48.80%	1.427	0.03	47	53.19%	28.11%	256.31%	2.68%
07/26/2004	06/18/2020	-0.382	69.95%	1.510	0.04	44	47.73%	32.01%	256.31%	3.37%
07/26/2004	06/18/2020	-0.618	-64.99%	0.558	-0.06	39	43.59%	74.33%	256.31%	-6.35%
07/26/2004	06/18/2020	-0.786	-57.33%	0.648	-0.04	40	45.00%	72.92%	256.31%	-5.18%
	Average		-0.89%	1.036	-0.01	43	47.38%	51.84%	256.31%	-1.37%

Table B - 3

VB - HMA Benchmark Strategy

Start Date	End Date	Profit Targets	Net Profit	Profit Factor	Sharpe Ratio	Total Closed Trades	Percent Profitable	Max Drawdown	Buy & Hold Return	CAGR
07/15/2004	06/18/2020	-0.236	15.76%	1.096	0.01	48	56.25%	33.61%	207.32%	0.92%
07/15/2004	06/18/2020	-0.382	101.18%	1.486	0.06	43	55.81%	30.93%	207.32%	4.47%
07/15/2004	06/18/2020	-0.618	137.17%	1.512	0.07	35	54.29%	26.75%	207.32%	5.55%
07/15/2004	06/18/2020	-0.786	163.97%	1.485	0.08	32	53.13%	35.27%	207.32%	6.25%
	Average		104.52%	1.395	0.06	40	54.87%	31.64%	207.32%	4.30%

Table B - 4

VV – EMA Crossover Strategy

Start Date	End Date	Profit Targets	Net Profit	Profit Factor	Sharpe Ratio	Total Closed Trades	Percent Profitable	Max Drawdown	Buy & Hold Return	CAGR
06/14/2005	01/16/2019	-0.236	55.28%	2.047	0.06	29	68.97%	12.44%	183.82%	2.79%
06/14/2005	01/16/2019	-0.382	41.48%	1.639	0.03	26	61.54%	12.45%	183.82%	2.19%
06/14/2005	01/16/2019	-0.618	72.53%	1.974	0.07	25	60.00%	12.40%	183.82%	3.47%
06/14/2005	01/16/2019	-0.786	77.16%	2.176	0.07	22	63.64%	18.50%	183.82%	3.64%
	Average		61.61%	1.959	0.05	26	63.54%	13.95%	183.82%	3.02%

Table B - 5

VO – EMA Crossover Strategy

Start Date	End Date	Profit Targets	Net Profit	Profit Factor	Sharpe Ratio	Total Closed Trades	Percent Profitable	Max Drawdown	Buy & Hold Return	CAGR
05/31/2005	02/25/2020	-0.236	74.65%	1.830	0.06	27	62.96%	19.68%	195.67%	3.55%
05/31/2005	02/25/2020	-0.382	92.18%	1.813	0.07	25	56.00%	22.21%	195.67%	4.17%
05/31/2005	02/25/2020	-0.618	-51.31%	0.640	-0.03	22	50.00%	72.93%	195.67%	-4.40%
05/31/2005	02/25/2020	-0.786	-56.03%	0.616	-0.04	21	42.86%	72.95%	195.67%	-5.01%
	Average		14.87%	1.225	0.01	24	52.96%	46.94%	195.67%	-0.42%

Table B - 6

VB – EMA Crossover Strategy

Start Date	End Date	Profit Targets	Net Profit	Profit Factor	Sharpe Ratio	Total Closed Trades	Percent Profitable	Max Drawdown	Buy & Hold Return	CAGR
06/09/2005	06/05/2020	-0.236	-42.77%	0.656	-0.10	31	51.61%	53.26%	172.36%	-3.43%
06/09/2005	06/05/2020	-0.382	-22.88%	0.798	-0.08	23	47.83%	44.47%	172.36%	-1.61%
06/09/2005	06/05/2020	-0.618	-21.96%	0.840	-0.06	22	40.91%	54.13%	172.36%	-1.54%
06/09/2005	06/05/2020	-0.786	-22.01%	0.864	-0.05	22	36.36%	60.33%	172.36%	-1.54%
	Average		-27.40%	0.790	-0.07	25	44.18%	53.05%	172.36%	-2.03%

Table B - 7

VV – ATR Stop-Loss Strategy

Start Date	End Date	Profit Targets	Net Profit	Profit Factor	Sharpe Ratio	Total Closed Trades	Percent Profitable	Max Drawdown	Buy & Hold Return	CAGR
12/02/2004	05/19/2020	-0.236	6.49%	1.064	-0.02	94	23.40%	28.76%	187.68%	0.39%
12/03/2004	05/19/2020	-0.382	34.97%	1.319	0.03	84	22.62%	26.29%	187.68%	1.89%
12/04/2004	05/19/2020	-0.618	67.57%	1.601	0.06	74	20.27%	27.64%	187.68%	3.28%
12/05/2004	05/19/2020	-0.786	124.07%	2.283	0.10	60	20.00%	15.24%	187.68%	5.17%
	Average		58.27%	1.567	0.04	78	21.57%	24.48%	187.68%	2.68%

Table B - 8

VV – ATR Stop-Loss Strategy

Start Date	End Date	Profit Targets	Net Profit	Profit Factor	Sharpe Ratio	Total Closed Trades	Percent Profitable	Max Drawdown	Buy & Hold Return	CAGR
12/02/2004	06/24/2020	-0.236	-29.72%	0.720	-0.13	101	21.78%	52.68%	207.27%	-2.18%
12/02/2004	06/24/2020	-0.382	-10.32%	0.913	-0.06	96	19.79%	45.68%	207.27%	-0.68%
12/02/2004	06/24/2020	-0.618	3.26%	1.026	-0.03	89	16.85%	40.04%	207.27%	0.20%
12/02/2004	06/24/2020	-0.786	-12.13%	0.903	-0.05	85	12.94%	41.21%	207.27%	-0.80%
	Average		-12.23%	0.891	-0.07	93	17.84%	42.31%	207.27%	-0.87%

Table B - 9

VB – ATR Stop-Loss Strategy

Start Date	End Date	Profit Targets	Net Profit	Profit Factor	Sharpe Ratio	Total Closed Trades	Percent Profitable	Max Drawdown	Buy & Hold Return	CAGR
03/15/2005	06/24/2020	-0.236	-7.95%	0.951	-0.04	88	15.91%	32.17%	174.05%	-0.52%
03/15/2005	06/24/2020	-0.382	-13.88%	0.907	-0.06	92	19.57%	32.57%	174.05%	-0.93%
03/15/2005	06/24/2020	-0.618	-7.95%	0.951	-0.04	88	15.91%	33.23%	174.05%	-0.52%
03/15/2005	06/24/2020	-0.786	-3.92%	0.978	-0.03	85	14.12%	39.19%	174.05%	-0.25%
	Average		-8.43%	0.947	-0.04	88	16.38%	34.29%	174.05%	-0.55%

Table B - 10

VV – RSI Strategy

Start Date	End Date	Profit Targets	Net Profit	Profit Factor	Sharpe Ratio	Total Closed Trades	Percent Profitable	Max Drawdown	Buy & Hold Return	CAGR
07/26/2004	03/10/2020	-0.236	42.39%	1.510	0.02	61	34.43%	31.49%	218.52%	2.23%
07/26/2004	03/10/2020	-0.382	83.84%	1.894	0.06	53	33.96%	25.45%	218.52%	3.88%
07/26/2004	03/10/2020	-0.618	90.39%	1.941	0.06	53	33.96%	25.45%	218.52%	4.11%
07/26/2004	03/10/2020	-0.786	93.57%	1.965	0.06	53	33.96%	25.45%	218.52%	4.21%
	Average		77.55%	1.828	0.05	55	34.08%	26.96%	218.52%	3.61%

Table B - 11

VO – RSI Strategy

Start Date	End Date	Profit Targets	Net Profit	Profit Factor	Sharpe Ratio	Total Closed Trades	Percent Profitable	Max Drawdown	Buy & Hold Return	CAGR
07/26/2004	03/23/2020	-0.236	14.62%	1.162	0.04	56	37.50%	36.65%	256.31%	0.86%
07/26/2004	03/23/2020	-0.382	-33.65%	0.694	-0.01	45	28.89%	42.45%	256.31%	-2.53%
07/26/2004	03/23/2020	-0.618	-31.44%	0.721	-0.01	45	28.89%	41.87%	256.31%	-2.33%
07/26/2004	03/23/2020	-0.786	-31.86%	0.690	-0.01	44	29.55%	41.31%	256.31%	-2.37%
	Average		-20.58%	0.817	0.00	48	31.21%	40.57%	256.31%	-1.59%

Table B - 12

VB – RSI Strategy

Start Date	End Date	Profit Targets	Net Profit	Profit Factor	Sharpe Ratio	Total Closed Trades	Percent Profitable	Max Drawdown	Buy & Hold Return	CAGR
07/15/2004	03/23/2020	-0.236	54.43%	1.442	0.07	60	41.67%	19.15%	207.32%	2.75%
07/15/2004	03/23/2020	-0.382	150.77%	1.903	0.11	56	41.07%	19.16%	207.32%	5.91%
07/15/2004	03/23/2020	-0.618	132.43%	1.673	0.10	52	36.54%	21.45%	207.32%	5.41%
07/15/2004	03/23/2020	-0.786	142.91%	1.702	0.10	52	36.54%	21.48%	207.32%	5.70%
	Average		120.13%	1.680	0.09	55	38.96%	20.31%	207.32%	4.95%

Appendix C
Strategy Testing (Part 3)

Table C - 1

VV – HMA Long Only Strategy

Start Date	End Date	Time Period	Net Profit	Profit Factor	Sharpe Ratio	Total Closed Trades	Percent Profitable	Max Drawdown	Buy & Hold Return	CAGR
04/30/2004	07/09/2020	55	101.97%	1.680	0.08	92	47.83%	15.62%	207.07%	4.49%
06/01/2004	06/26/2020	89	111.86%	1.527	0.08	98	46.94%	14.87%	201.69%	4.80%

Table C - 2

VO – HMA Long Only Strategy

Start Date	End Date	Profit Targets	Net Profit	Profit Factor	Sharpe Ratio	Total Closed Trades	Percent Profitable	Max Drawdown	Buy & Hold Return	CAGR
06/01/2004	06/26/2020	55	74.51%	1.368	0.05	98	40.82%	41.21%	208.48%	3.54%
06/24/2004	04/23/2020	89	99.32%	1.720	0.09	61	47.54%	17.96%	241.45%	4.41%

Table C - 3

VB – HMA Long Only Strategy

Start Date	End Date	Profit Targets	Net Profit	Profit Factor	Sharpe Ratio	Total Closed Trades	Percent Profitable	Max Drawdown	Buy & Hold Return	CAGR
06/01/2004	06/26/2020	55	111.86%	1.527	0.08	98	46.94%	39.19%	174.05%	4.80%
06/23/2004	04/28/2020	89	132.24%	1.795	0.11	65	49.23%	16.84%	207.21%	5.41%

Table C - 4

VV – 89HMA Benchmark

Start Date	End Date	Profit Targets	Net Profit	Profit Factor	Sharpe Ratio	Total Closed Trades	Percent Profitable	Max Drawdown	Buy & Hold Return	CAGR
07/01/2004	10/28/2019	-0.236	44.91%	1.984	0.03	22	54.55%	18.14%	201.84%	2.35%
07/01/2004	11/15/2019	-0.382	44.35%	1.765	0.03	21	47.62%	17.28%	201.84%	2.32%
07/01/2004	01/08/2020	-0.618	79.76%	2.220	0.06	20	45.00%	15.93%	201.84%	3.73%
07/01/2004	02/06/2020	-0.786	127.23%	2.954	0.08	18	50.00%	15.60%	201.84%	5.26%
	Average		74.06%	2.231	0.05	20	49.29%	16.74%	201.84%	3.42%

Table C - 5

VO – 89HMA Benchmark

Start Date	End Date	Profit Targets	Net Profit	Profit Factor	Sharpe Ratio	Total Closed Trades	Percent Profitable	Max Drawdown	Buy & Hold Return	CAGR
09/20/2004	06/18/2020	-0.236	32.35%	1.461	0.01	23	65.22%	20.56%	241.50%	1.77%
09/20/2004	06/18/2020	-0.382	38.94%	1.451	0.02	21	57.14%	20.60%	241.50%	2.08%
09/20/2004	06/18/2020	-0.618	69.67%	1.764	0.05	19	57.89%	15.07%	241.50%	3.36%
09/20/2004	06/18/2020	-0.786	108.72%	2.046	0.08	19	57.89%	14.27%	241.50%	4.71%
	Average		62.42%	1.681	0.04	21	59.54%	16.65%	241.50%	2.98%

Table C - 6

VB – 89HMA Benchmark

Start Date	End Date	Profit Targets	Net Profit	Profit Factor	Sharpe Ratio	Total Closed Trades	Percent Profitable	Max Drawdown	Buy & Hold Return	CAGR
06/25/2004	05/19/2020	-0.236	99.87%	2.388	0.09	25	68.00%	14.51%	198.85%	4.42%
06/25/2004	05/19/2020	-0.382	146.69%	2.678	0.10	24	62.50%	14.47%	198.85%	5.81%
06/25/2004	05/19/2020	-0.618	160.54%	2.347	0.10	22	54.55%	20.46%	198.85%	6.17%
06/25/2004	05/19/2020	-0.786	166.43%	2.126	0.09	20	50.00%	17.51%	198.85%	6.32%
	Average		143.38%	2.385	0.09	23	58.76%	16.74%	198.85%	5.68%

Table C - 7

VV – ATR Stop-Loss Strategy

Start Date	End Date	Profit Targets	Net Profit	Profit Factor	Sharpe Ratio	Total Closed Trades	Percent Profitable	Max Drawdown	Buy & Hold Return	CAGR
07/01/2004	10/28/2019	-0.236	33.90%	2.330	0.00	30	26.67%	6.99%	207.03%	1.84%
07/01/2004	11/15/2019	-0.382	48.03%	2.819	0.03	29	24.14%	6.49%	207.03%	2.48%
07/01/2004	01/08/2020	-0.618	71.78%	3.541	0.05	28	21.43%	6.49%	207.03%	3.44%
07/01/2004	02/06/2020	-0.786	97.45%	4.377	0.07	27	22.22%	6.49%	207.03%	4.34%
	Average		62.79%	3.267	0.04	29	23.62%	6.62%	207.03%	3.03%

Table C - 8

VO – ATR Stop-Loss Strategy

Start Date	End Date	Profit Targets	Net Profit	Profit Factor	Sharpe Ratio	Total Closed Trades	Percent Profitable	Max Drawdown	Buy & Hold Return	CAGR
09/20/2004	06/24/2020	-0.236	48.98%	2.370	0.03	31	29.03%	9.02%	247.54%	2.52%
09/20/2004	06/24/2020	-0.382	72.26%	2.843	0.06	30	26.67%	9.03%	247.54%	3.46%
09/20/2004	06/24/2020	-0.618	76.64%	2.786	0.06	29	24.14%	9.03%	247.54%	3.62%
09/20/2004	06/24/2020	-0.786	104.94%	3.209	0.08	29	24.14%	9.03%	247.54%	4.59%
	Average		75.70%	2.802	0.06	30	26.00%	9.03%	247.54%	3.55%

Table C - 9

VB – ATR Stop-Loss Strategy

Start Date	End Date	Profit Targets	Net Profit	Profit Factor	Sharpe Ratio	Total Closed Trades	Percent Profitable	Max Drawdown	Buy & Hold Return	CAGR
06/25/2004	05/19/2020	-0.236	42.96%	1.767	0.04	39	33.33%	18.08%	203.20%	2.26%
06/25/2004	05/19/2020	-0.382	53.11%	1.843	0.05	38	28.95%	16.44%	203.20%	2.70%
06/25/2004	05/19/2020	-0.618	79.13%	2.029	0.07	37	24.32%	19.82%	203.20%	3.71%
06/25/2004	05/19/2020	-0.786	98.44%	2.208	0.08	35	22.86%	18.45%	203.20%	4.38%
	Average		68.41%	1.962	0.06	37	27.37%	18.24%	203.20%	3.26%