CS7646

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***Abstract*—** The purpose of this paper is to introduce 5 technical indicators that can be used to come up with buy/sell strategies using the "JPM" ticker symbol. The paper will go over the five indicators, how to calculate them and demonstrate how they can be used with the aid of visuals. Finally, a demonstration of an optimal strategy using "JPM" will be showcased and compared to a basic strategy of simply holding 1000 shares long. The long basic strategy will be used as a benchmark and visually contrasted against the optimal strategy.

1 INTRODUCTION

Technical indicators are pattern based signals calculated using a stock or security's historical data, typically the high, low, or closing price and/or volume. These signals are used by some traders in an attempt to predict price changes and might be useful for coming up with positions in the present which might generate profit if the prediction comes true once a position is realized.

The five technical indicators this experiment will be analyzing are the SMA(simple moving average) price cross, the momentum, bollinger bands, the Commodity Channel index(cci) and the moving average convergence-divergence(MACD). A brief summary of each indicator will be provided as well as an explanation on how to derive it and how it can be used to determine whether it's indicative of a buying/selling opportunity.

2 INDICATORS

2.1 Simple Moving Average

The first technical indicator we will be discussing will be the simple moving average(sma) price cross. The formula for the simple moving average is the following:

$$SMA = \frac{P_1 + P_2 + ... + P_n}{n}$$

Where n is the number of days in a given window and P_n is the nth day in the window. Taking the sum of every day in the window up to P_n and dividing it by the number of days n

will give us the average for that window[1]. This procedure is then followed for all of the days in our "JPM" dataset and plotted in figure 1.

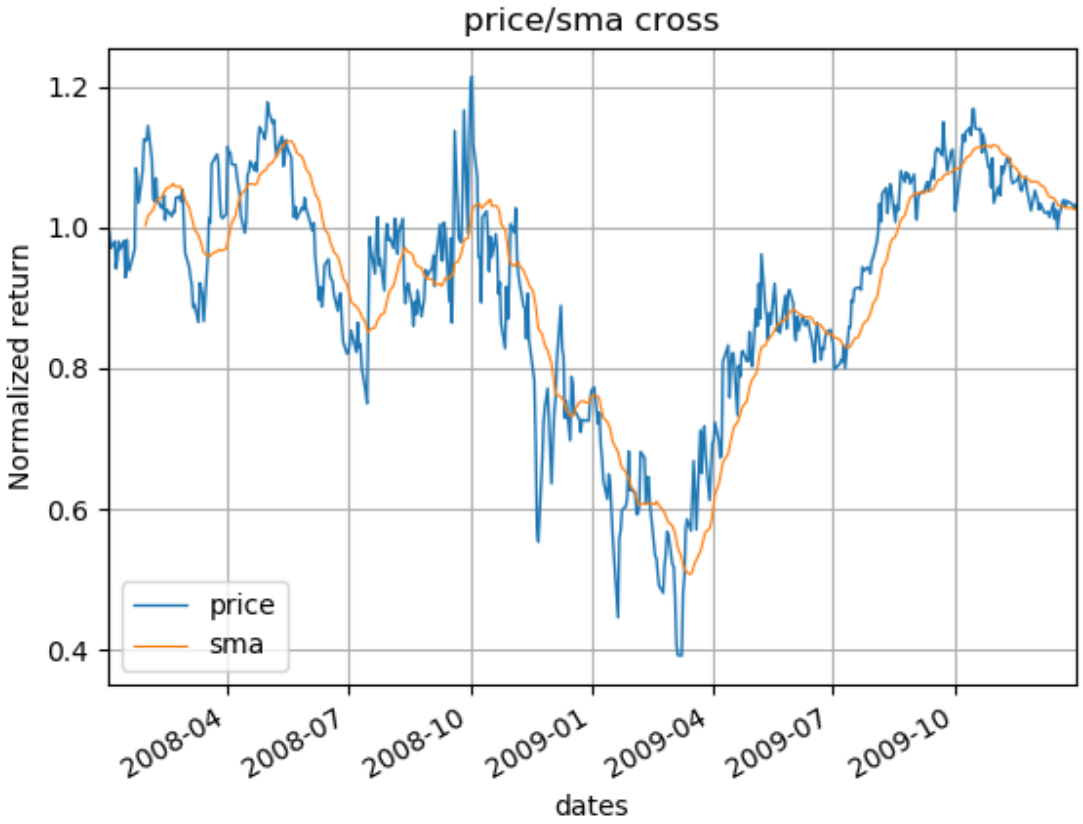

Figure 1— The figure shown displays the simple moving average line alongside the price(both are normalized). Several spots in the graph show times when the price crosses underneath the moving average. This can be interpreted as a bearish signal which might indicate a selling opportunity. In addition there are a few points where the sma crosses above the price which can be used to indicate a bullish signal.

The simple moving average is plotted alongside the price in figure 1 and showcases how the crossing of the sma and price can be used as potential buy/sell signals. When the price crosses underneath the 20 day moving average this can be interpreted as a sell signal. The opposite is true if the price crosses above the 20 day moving average(this would be a buy signal). This information seems to hold true at several points in the graph with some of them showing strong bear/bull signals. It's likely that a human or automated trading system following this strategy could generate large profits avoiding any loss in value holding onto shares during a downturn and optimized gains in the portfolio by holding during the upturn

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2.2 Momentum

The momentum is the rate of change between a stock at its current price and it's price and its price N days ago. A positive momentum can be indicative of future positive price movement and negative momentum can be a bearish signal that a stock's price will continue to trend downwards. Stocks whose price follows their momentum are known as momentum stocks. The formulas for a stocks momentum is the following:

$$M_i = \frac{P_i}{P_{i-N}} - 1$$

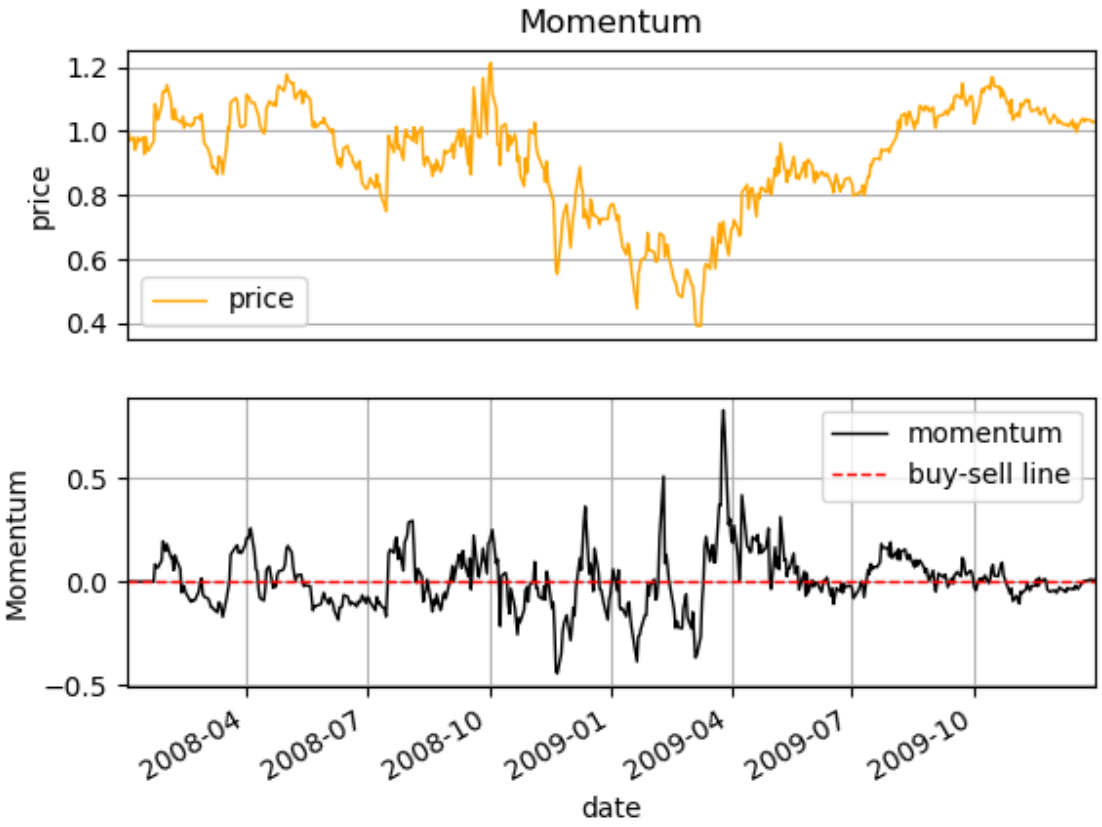

Figure 2— The figure shown displays the momentum of JPM. The buy-sell line is shown in red.

The momentum of JPM is shown in Figure 2. Here we see the price and its momentum juxtaposed side by side in two different plots. We can see that the increase in momentum seems to move in the same direction as the price. The second plot within Figure 2 also shows the buy-sell line in red. The buy-sell line is used to determine whether there is a buying or selling

opportunity. A buying opportunity is present whenever the momentum crosses above the buy-sell line, and a selling opportunity is present whenever it crosses underneath it and goes negative. Below the buy-sell line the value of the momentum is negative and above it the momentum is positive.

2.3 Bollinger Bands

The Bollinger Bands are a pair of lines which follow above and below the simple moving average of a security's price. Each of the lines follows two standard deviations above and below the simple moving average. These can be used to come up with buy or sell signals depending on where the price is at any given point in time relative to the upper and lower bands. The formula for upper and lower lines are the following where s is the standard deviation:

$$upperBand = SMA + 2 * s$$
$$lowerBand = SMA - 2 * s$$

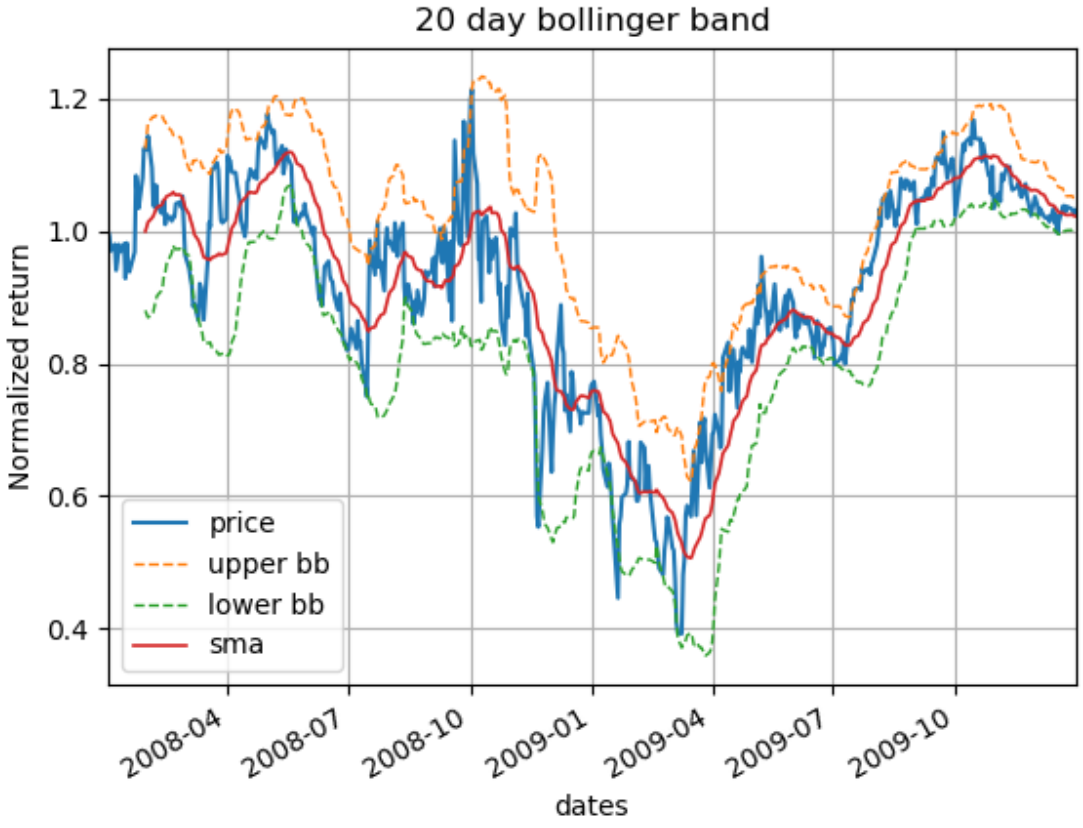

Figure 3— Figure 3 shows the normalized price plotted with the upper and lower bollinger bands. In addition the sma line is plotted as well.

Figure 3 shows the upper and lower bollinger bands plotted above and below the sma line. The price is also plotted to show how it can be used to devise a trading strategy using the upper and lower band. Ideally, someone using the bollinger bands could use it to detect when a stock has become overbought if it crosses above the upper band. The opposite is true and it's possible that a stock has become oversold if it crosses below the lower band. The idea also draws upon the concept of regression to the mean, which states that if a price ever deviates substantially from the mean it will come back towards the mean.

2.4 Commodity Channel Index

The commodity channel index is a kind of momentum indicator that can be used to determine if a security is overbought or oversold. It gauges the price trend and strength which can be useful when determining when to enter/exit a trade. The formula for the Commodity Channel index(cci) is the following where P is the price, TP is the typical price and MD is the mean deviation:

$$CCI = \frac{TP - MA}{0.015 * MD}$$

$$where : TP = \frac{1}{3}(P_{High} + P_{Low} + P_{Close})$$

$$And : MD = (TP - MA) \div P$$

Here the TP is the sum of the High, Low, and Closing price of a stock divided by 3. And the MD is the difference of the TP and the moving average divided by the price.MA is the moving average.

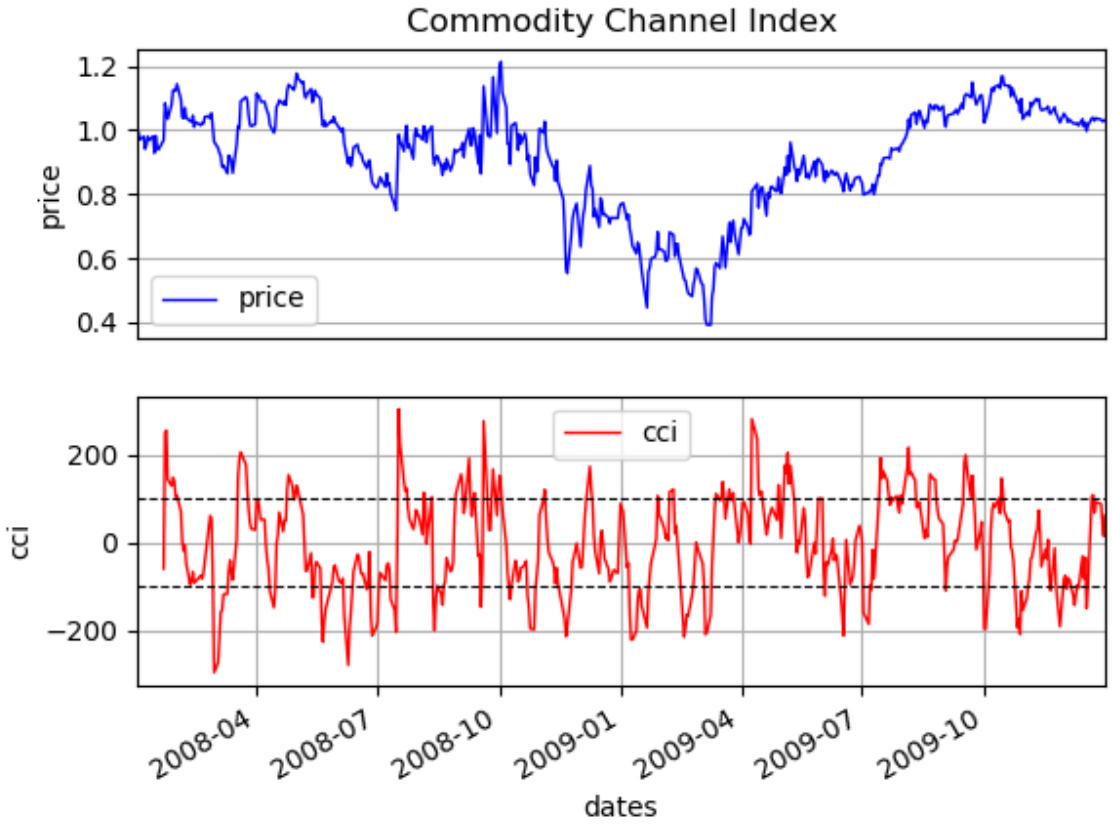

Figure 4— Figure 4 shows the commodity channel index alongside the normalized price of JPM. The buy and sell signals are denoted in the dashed black lines in the plot with the cci line.

Looking at Figure 4 we can see how the cci line can be used to spot buy/sell signals. Whenever the cci line crosses the +100 dashed line there are times where it successfully signals a buying opportunity. This is especially true in the month of April to July where the uptick in cci crossing the +100 line is a bullish signal seen clearly in the normalized price plot. The opposite is true when the cci line crosses the -100 line. From the period of October 2008 to January 2009 we see the cci line cross the -100 dashed line frequently which consequently follows large downturns in JPM price.

2.5 Moving average convergence divergence

Similarly to the bollinger bands the MACD is a trend following indicator which shows the relationship between two exponential curves. The two exponential curves used to determine signal information are calculated from taking the difference between the 26 day exponential moving average and the 26 day exponential moving average[2]. The resulting line is known as

the macd line. Once the macd line is calculated, a final "signal" line is calculated from the 9-day moving exponential moving average of the macd line. These calculations can be shown here:

$$macd = 12 - dayEMA - 26 - dayEma$$
$$macd_{signal} = P_i * k + EMA(y) * (1 - k)$$
$$where\, k = 2 \div (N + 1)$$

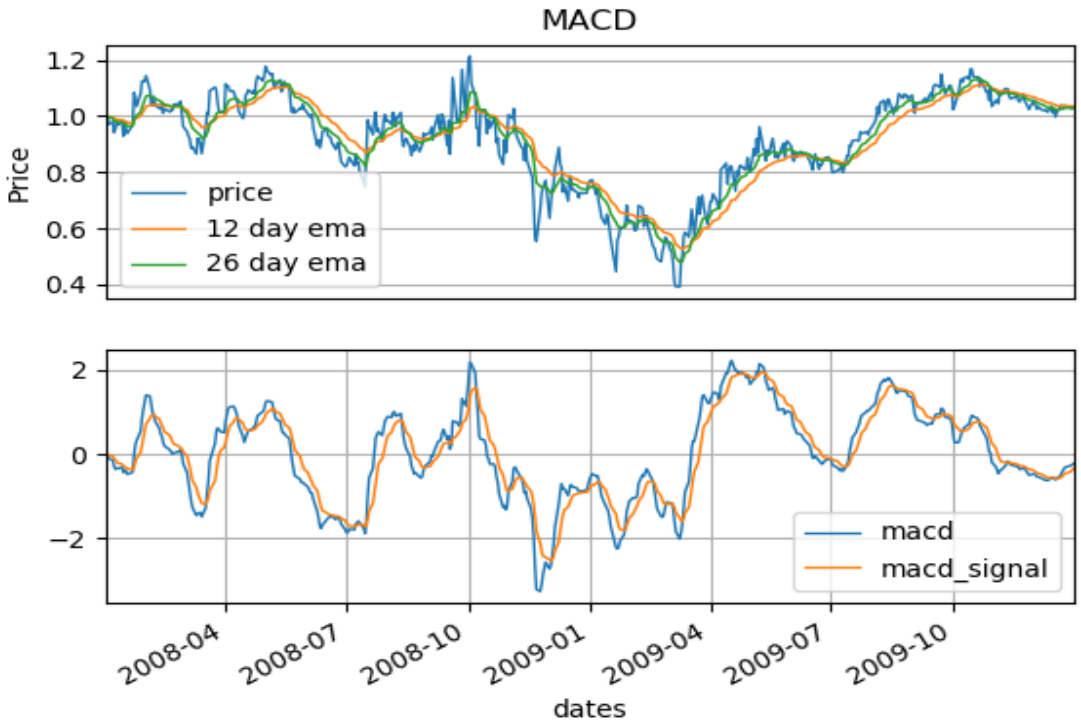

Figure 4— Figure 4 shows the macd and macd_signal lines plotted next to the price with the 12 and 26 day exponential moving average

In almost the same fashion to the bollinger bands when the macd line crosses above the signal line it can be interpreted as a buy signal. When the macd line crosses below the signal line we interpret this as a bearish signal. From figure 4 we can see several instances of this, with one of them being the time period of May 2009 where the macd line crosses above the signal line and we see the JPM price trend shift and move upwards.

3. **THEORETICALLY OPTIMAL STRATEGY**

The final part of the experiment consisted of coming up with an optimal strategy for JPM for the timeframe of January 1, 2009 to December 31 2009. The experiment also assumed that we could determine the optimal strategy by looking into the future from the current date. The reasoning behind this was to see how much profit trading in an optimal fashion can generate. Finally, we were only allowed to have positions consisting of +1000 shares, 0, or -1000 for the trading day.

In order to come up with the optimal strategy the python data was loaded for the JPM security for the dates of January 1, 2009 to December 31 2009. The adjusted closing price of the stock was then viewed using python and the retrieved dataframe. Depending on the shares currently held on the previous date, the value of the price on the future date we would determine what the optimal position for the current date would be. For instance, if we bought +1000 shares long yesterday, and we saw the price would go up tomorrow, we would keep our current position as 0 meaning we would hold on to the shares. On the other hand, if we purchased the +1000 shares yesterday and we saw tomorrow's value would trend downwards, then we would go short on 2000 shares.

Additionally, the optimal portfolio was to be compared with a benchmark portfolio using the same ticker. The benchmarked portfolio would start with $100,000.00 in cash and go long on 1000 shares of JPM. The optimal portfolio would start with the same amount of cash as the benchmarked portfolio but we would implement our optimal strategy determined by looking into the future. The cumulative return, standard deviation and mean of daily returns of the benchmarked portfolio is the following:

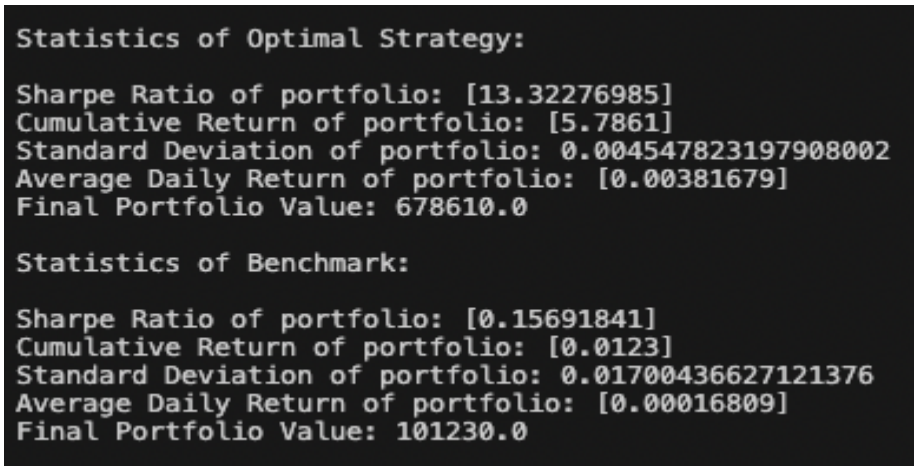

Figure 5— Figure 5 statistics collected from the optimal strategy and the benchmark portfolio

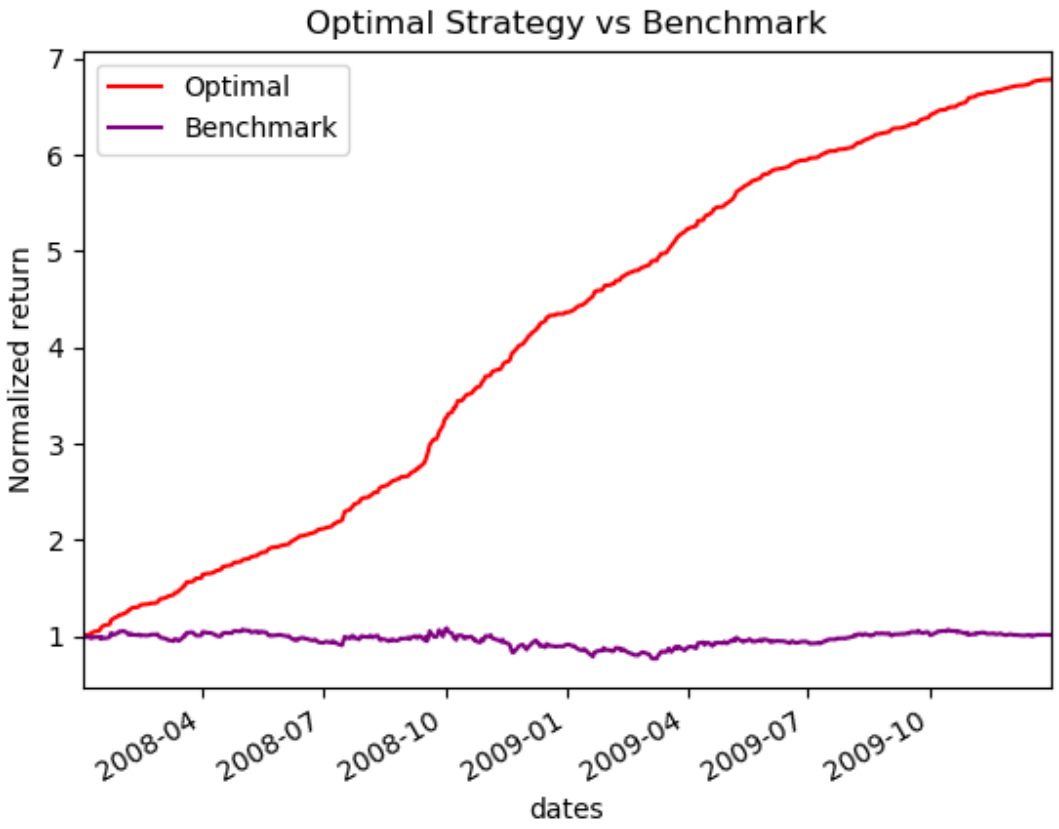

Figure 6— Figure 6. In red is the optimal portfolio showing significant gains and going to the moon, definitely past the stratosphere. In purple is the benchmark portfolio showing little to no gains at all.

Looking at figure 5 and 6 we see a starting difference in performance when comparing the optimal vs benchmark portfolio. The optimal portfolio had a cumulative return of 5.7861 while the optimal portfolio had a cumulative return of just over %1. What's more the optimal portfolio has an eye watering sharpe ratio of 13 and a much lower standard deviation than the benchmark portfolio. This essentially tells us how the optimal portfolio is not only better at generating profit, but it's also less volatile and risky in general than the benchmarked portfolio.

5 REFERENCES

1. "Moving average." *Wikipedia*, https://en.wikipedia.org/wiki/Moving_average. Accessed 22 October 2023.
2. "MACD." *Wikipedia*, https://en.wikipedia.org/wiki/MACD. Accessed 22 October 2023.