Project 6 Report:
Indicator Evaluation

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Abstract—In this report, financial technical indicators are analyzed, assessed, and developed from scratch using Python and data from 2008-2009 of the JPM stock. This initiative is to understand their discrepancies and use cases in order to produce an efficient trading strategy. Furthermore, a theoretically optimal strategy is implemented to get a better understanding of the maximum return a portfolio could achieve within a given time.

Introduction

Technical analysis is a fundamental method used to predict price movement by leveraging historical data, specifically price and volume in a given time period. With enough information about a stock's price movement, technical indicators can simplify a subset of historical data to produce insight into trading decisions to hopefully gain a profit. Additionally, understanding the basis of the maximum potential a portfolio could have allows for a great vantage point when constructing an optimal strategy within a market.

Indicators

Bollinger Bands are based on the simple moving average of the price of a security. They include an upper and lower band which help categorize the price volatility. The average of the price is calculated based on a specific time window, in this case, a window of 20-days is used. This acts as our starting point, we then calculate the standard deviation of the price within this same window throughout the time period to acquire the rolling standard deviation. On the graph, assuming data is normalized the final plot would contain the price or moving average, upper bound, and lower bound across a given period.

The upper and lower bands can be calculated as follows:

Simple Moving Average + Rolling Standard Deviation * 2 → Upper Band

Simple Moving Average - Rolling Standard deviation * 2 → Lower Band

Assuming the stock's price moment accounts for all factors when the price breaks below the lower band this can be seen as a sell signal as it indicates the price change with respect to the moving average minus two standard deviations. When the price breaks above the upper band this can be seen as a buy signal as it indicates the same principle, but with the moving average plus two standard deviations.

Moving average convergence divergence (MACD) is based on the exponential moving average (EMA) of the price of a security. It includes two lines that swing back and forth without boundaries, the crossover of these lines indicates a trading signal. The exponential moving average is calculated by including a weighted multiplier which incorporates a specified window of time placing greater weight on the most recent data points.

The multiplier can be calculated as follows:

$$\textbf{multiplier} = 2 \div (\textbf{time period} + 1)$$

The final calculation is calculated by subtracting the long-term EMA with 26 periods from the short-term EMA of 12 periods. On the graph, assuming data is normalized the final plot would contain the MACD which is the subtraction of

the 26-period EMA from the 12-period EMA and the signal which is the 9-day EMA of the MACD line.

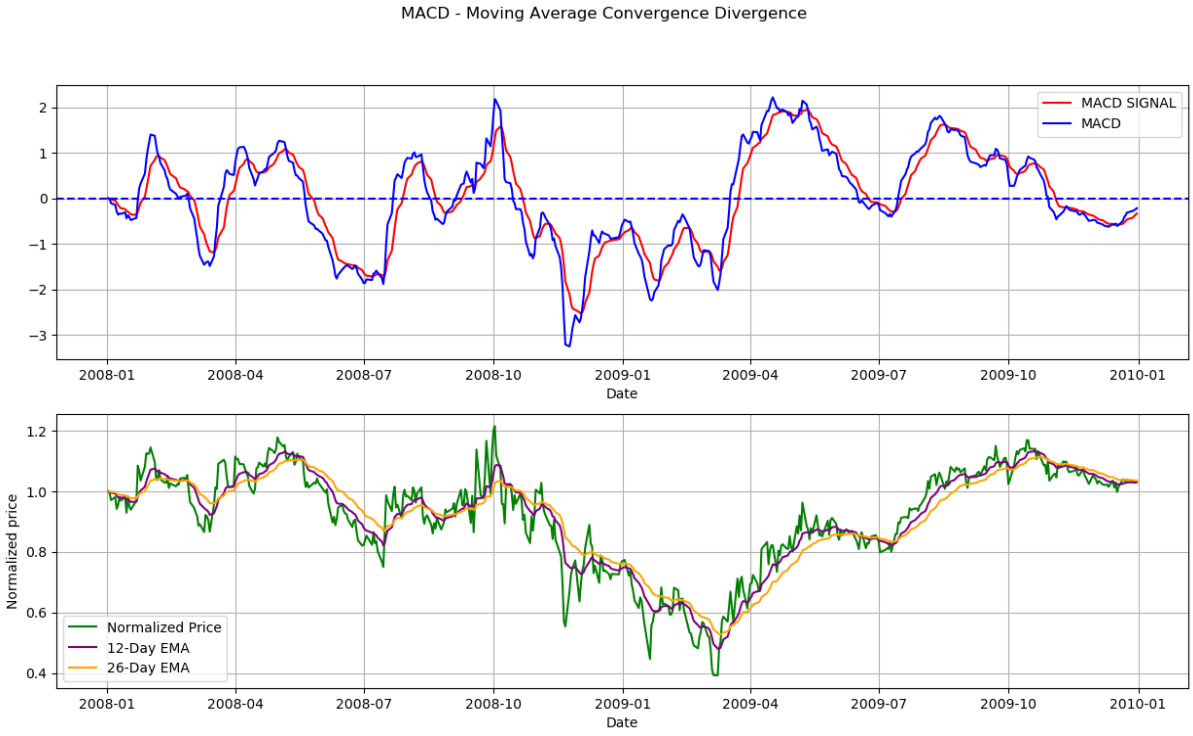
The EMA, MACD and MACD Signal can be calculated as follows:

EMA = Closing Price - (EMA of previous day) x (multiplier) + (EMA of previous day)

MACD = 12-Period EMA - 26-Period EMA

MACD Signal = 9-day EMA of MACD

Assuming the stock's price moment accounts for all factors when the signal line or the MACD line breaks below the zero line this can be seen as a sell signal. A buy signal can be seen if either cross above the zero line as a threshold. Furthermore, when the MACD line crosses above the MACD signal line this can be seen as a buy signal, and when the MACD line crosses below the MACD signal line this can be seen as a sell signal.



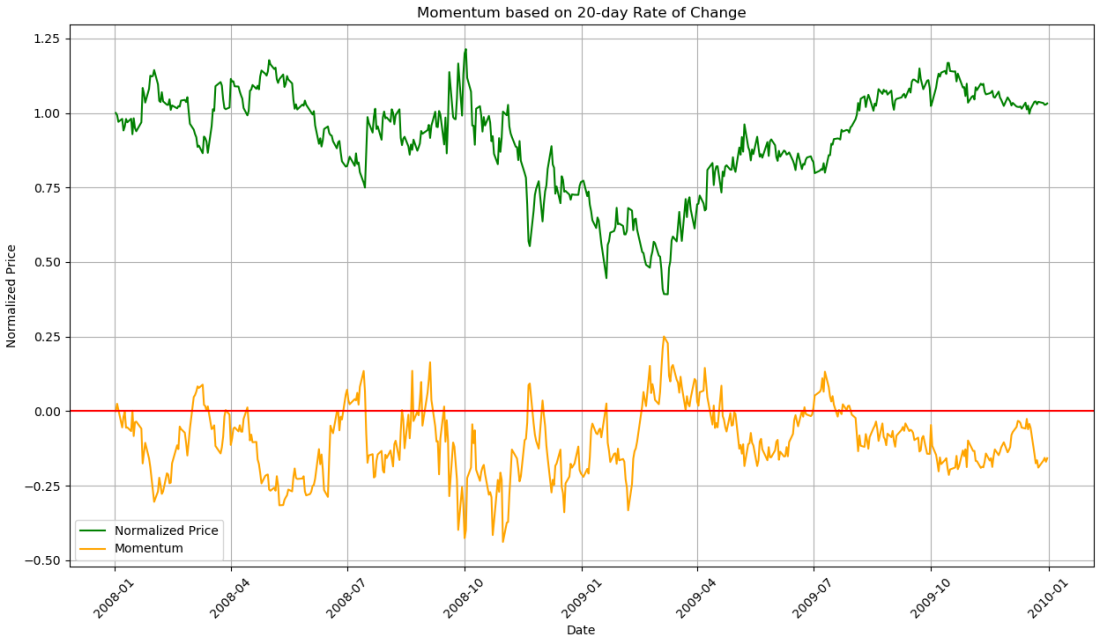
Momentum is based on price differences within a fixed time interval, it measures the volatility of stock prices in trend analysis and shows the strengths and weaknesses. It includes one line that may cross above or below zero. The zero line shows the trend of where the security is trading, the more momentum the farther away the line will be from zero. The relationship between the closing

price of the time specified and the latest price is seen through the momentum line.

The momentum can be calculated as follows:

Momentum = Latest Price - Closing Price at the time specified

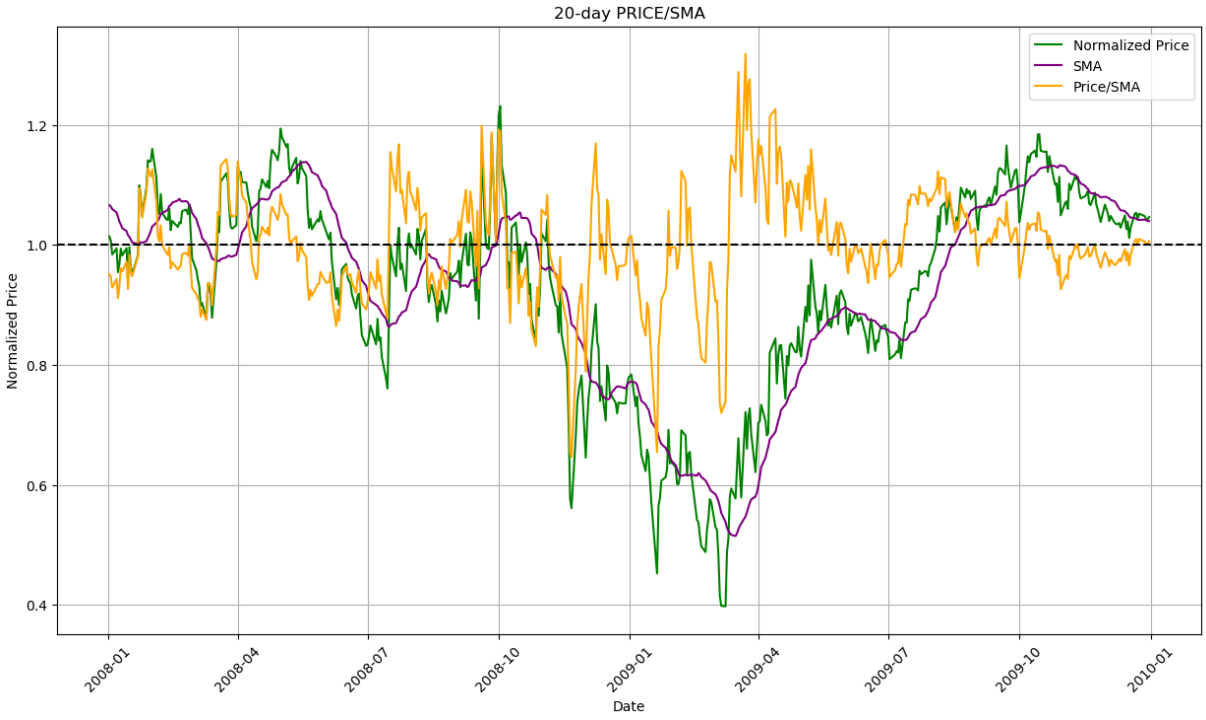
When the momentum line crosses above zero this may be indicated as a signal to buy, and when the line crosses below zero this may be an indication to sell. This can be seen by the normalized price of the security between 2009-01 and 2009-04, if one were to have purchased shares the moment the indicator went above zero they would see returns given the increase in stock price at that time period.



Simple Moving Average (SMA) is based on the average of prices of a stock within a fixed time window, it can be aggregated as the rolling simple moving average which shows a smoothed line with respect to the stock price. In this use case, the indicator presented is the price divided by the SMA which gives a ratio that can indicate when to buy or sell based on the zero line. The zero line shows the trend of the divisor relationship between the normalized price and SMA. The SMA is simply calculated by aggregating the average price for the window of days

selected for each consecutive day of the stock. This will induce a lag in the spectrum of data, for this use case we have fed data before 2008-01 to prevent this lag from being seen.

In order to make use of this indicator, a buy signal can be seen with the line above 0, and when the line is below 0 a sell signal can be seen. This has a directly correlative relationship with the price and SMA lines as when they converge this indicates a buy signal, however when they diverge this indicates a sell signal.



Stochastic Oscillator is momentum driven and shows insight into whether the state of the security is in an overbought or oversold position. The values of the stochastic oscillator are from 0 to 100 and a focus on y-axis lines 20 and 80 is imperative in order to see the levels of the overbought or oversold positions. There are two lines involved, one which expresses the current state of that security in terms of price known as %K, and the other which is a moving average of the previous line described to integrate insight on signals without the 80 and 20 bands spoken about earlier known as %D. Direct relationships between %K

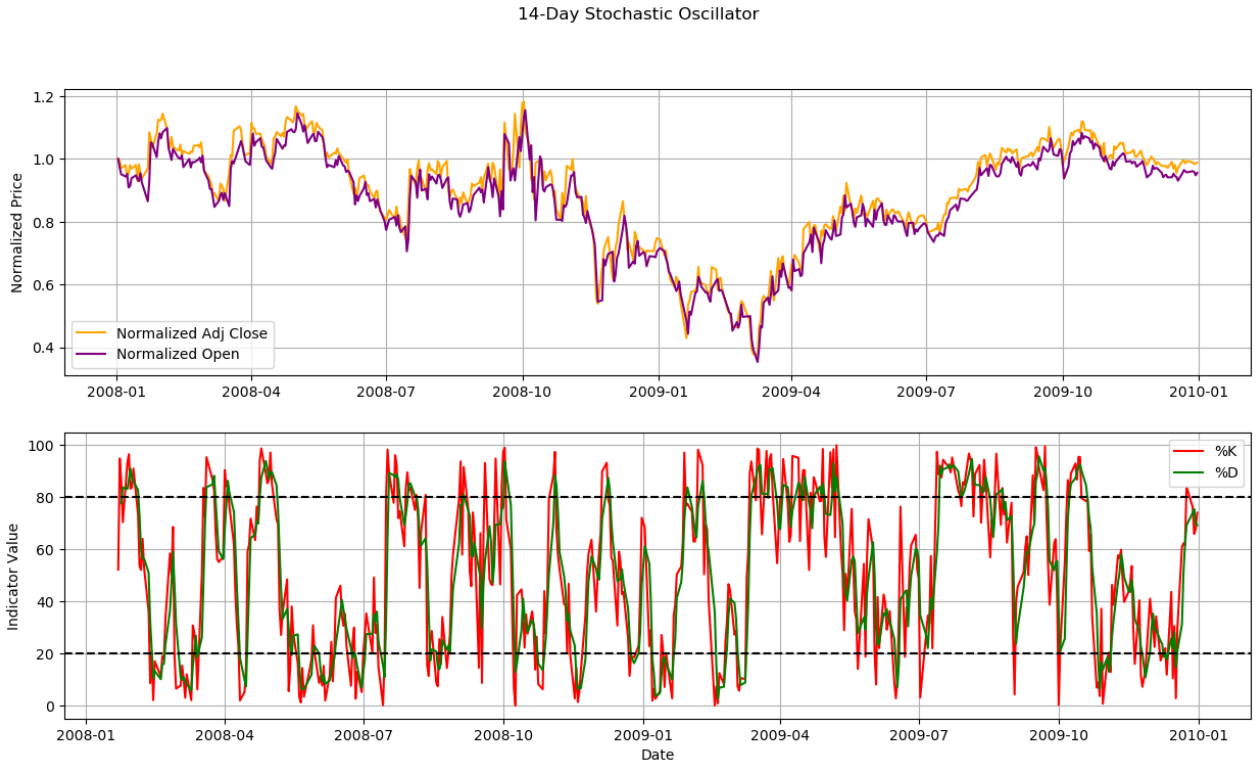
and %D show trend reversals in the security and have a positive correlation with the high and low prices of the normalized price within the trading period.

The following can be calculated as follows:

$$\%K = \frac{100 * (Recent\ Close - Lowest\ Price\ of\ 14\text{–}Day\ Period)}{(Highest\ Price\ of\ 14\ Day\ Period - Lowest\ Price\ of\ 14\text{–}Day\ Period)}$$

$$\%D = 3 - Day\ Rolling\ Average\ of\ \%K$$

If the %K line is below 20 and the %D line is below 20 this would indicate a buy signal, while if the %K line is above the %D line and all lines are above 80 this would indicate a sell signal. This strategy can be applied with the focus on the default value of the rolling average of %K for %D being 3 days, in which different market or security conditions can alleviate a different window being selected.

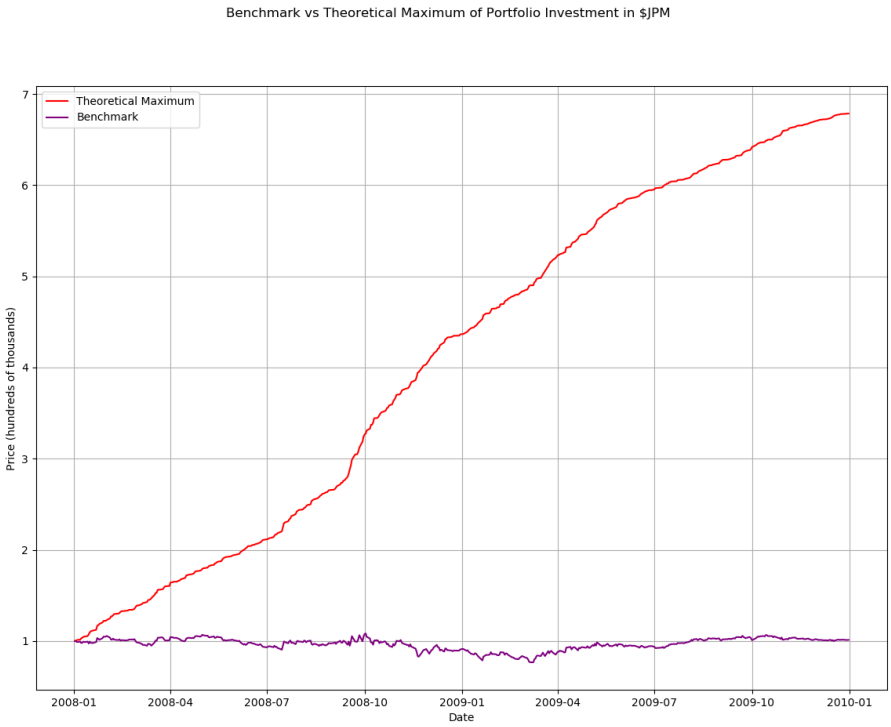


Theoretically Optimal Strategy

The theoretically optimal strategy was constructed under the paradigm that the future prices of the security would be known. Since information on the stock used $JPM available, an algorithm was specified to make trades that would give the highest potential portfolio value. The main interest to make this algorithm work was the price valuation for each given date and the importance of making comparative reviews of the previous date and the current date with respect to the decision to buy or sell shares of the security. This algorithm would not be possible to be applied in the real world given that we do not know the future prices of securities, but could be applied if we put in predicted values by a machine learning algorithm as the placeholder of what is "known".

Assuming that the input data is forward and backward-filled to ensure there are no gaps in the data that is used as a reference, the first step is to iterate through every single date within the given date period we are trying to construct the strategy to achieve the maximum portfolio value. Then, if the price of the security at the date ahead of the current date by 1 is greater than the price of the security at the current date this would be a signal to purchase 1000 shares. On the contrary, when the price of the date ahead of the current date by 1 is less than or equal to the price of the security then this would be a signal to sell 1000 shares or form a short position if there are no shares to be sold.

A plot of the benchmark and the optimal strategy can be seen below as well as its summary statistics:



In this plot, the benchmark is the portfolio value of purchasing 1000 shares of JPM and holding that position, while the theoretical maximum is the portfolio value of our trading strategy throughout the time period.

Summary Statistics of the theoretical maximum strategy (p6_results.txt):

Type	Cumulative Returns	STD of Daily Returns	MEAN of Daily Returns
Benchmark	0.012300	0.017004	0.000168
Theoretical	5.786100	0.004548	0.003817