INDICATOR EVALUATION

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PART 1. INDICATORS

The five indicators selected for this project are Simple Moving Average (SMA), Exponential Moving Average (EMA), Bollinger Bands (BB), Momentum, and Normalized Average True Range (NATR).

Simple Moving Average (SMA): calculates the average stock price for a rolling time window. In calculating *N*-periods' average, the SMA allocates equal weights $1/N$ to all prices within the time window. By its construction, the SMA typically lags actual price movements. The goal of the SMA is to identify general trends in price movements while ignoring the noise in high-frequency price movements. In one sense, the SMA may reflect the value of a stock price over time. Therefore, a more informative indicator would be the Price to SMA (Price/SMA) ratio. The formula used in the calculation of the Price/SMA is

$$(\boldsymbol{Price/SMA})_{\boldsymbol{t}} = \frac{\boldsymbol{price[t]}}{\boldsymbol{price[t - \ window: t].mean()}} - \mathbf{1}$$

The derived Price/SMA feature compares the price movement relative to its long- or short-term value. Figure 1 presents a relative plot of SMA, Price, and Price/SMA for JPM using a 14-day window.

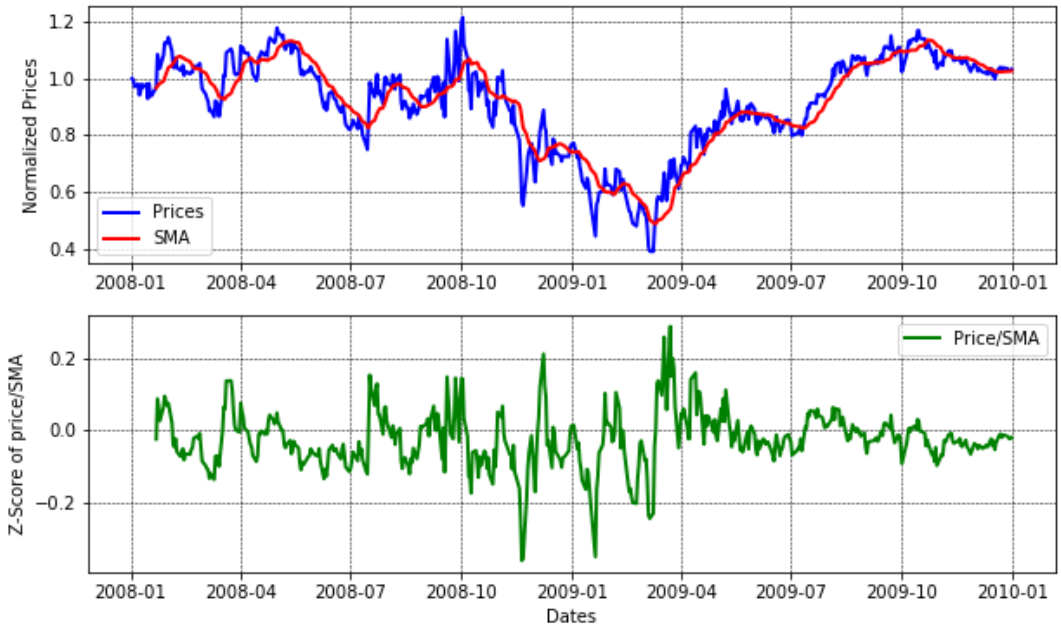

Figure 1: Simple Moving Average plot for JPM stock price

In technical analysis, a z-score of $\frac{Price}{SMA} > 2.0$ may signal that the stock is overbought. This means the stock prices are higher relative to the stock's real value (i.e., SMA) and prices may revert to the long run mean sometime in the future. Such as situation may signal a SELL opportunity. Conversely, a z-score $\frac{Price}{SMA} < -2.0$, may indicate the stock is oversold. This means selling pressures are causing the stock price to dip below its true value, which may signal a BUY opportunity.

Exponential Moving Average (EMA): also calculates the average stock price for a rolling time window. It is akin to the SMA in terms of averaging over a given period. The only difference stems from how these averages are calculated. The formula for calculating the EMA is

$$\boldsymbol{EMA_t = EMA_{t-1} + \alpha[price_t - EMA_{t-1}]}$$

where α is the speed of weight decrease, which is a constant factor bounded between 0 and 1. The EMA emphasizes (weights) on recent observations by using an exponential weighting instead of an equal weighting. The EMA is meant to smooth out the time series of prices to identify general trends in price movements. It lags less than the SMA. As such, it is quicker to react to prices movement. Due to this characteristic, the EMA is better suited for trading over short-term horizons. The ratio Price/EMA has the same implication for a trading decision as to the Price/SMA. Figure 2 below presents the relationship between Prices, 14-Day EMA, and Price/EMA for the JPM stock.

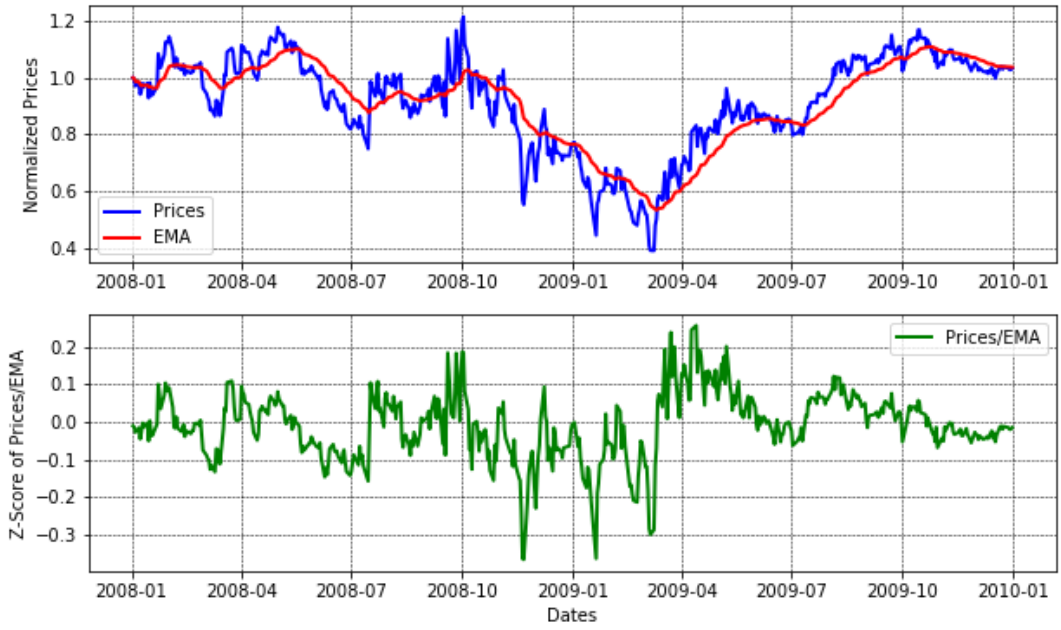

Figure 2: Exponential Moving Average plot for JPM stock price

Bollinger Bands (BB): The BB tracks the SMA and identifies where prices deviate significantly from the SMA for the same rolling window. The SMA plus 2 standard deviations constitute the upper Bollinger band, and SMA minus 2 standard deviations from the lower Bollinger band. The BB indicator is typically used as a trade signal when prices cross back into the band limits after being outside the bands (upper/lower). When one observes higher price excursions from the SMA beyond the upper band, it may signal a SELL opportunity. The intuition is that prices have overshot their long-run average and may be mean-revert.

Conversely, if there are large excursions below the lower band, this may signal a BUY opportunity. This may mean that prices have gone way below their long-run average and will be reverting to the mean. To derive a single quantitative indicator for BB, the formula below was used.

$$BB_t = \frac{price_t - SMA_t}{2 \times standard\ deviation_t}$$

Figure 3 reports the BB indicator relative to the SMA and prices for the JPM stock prices.

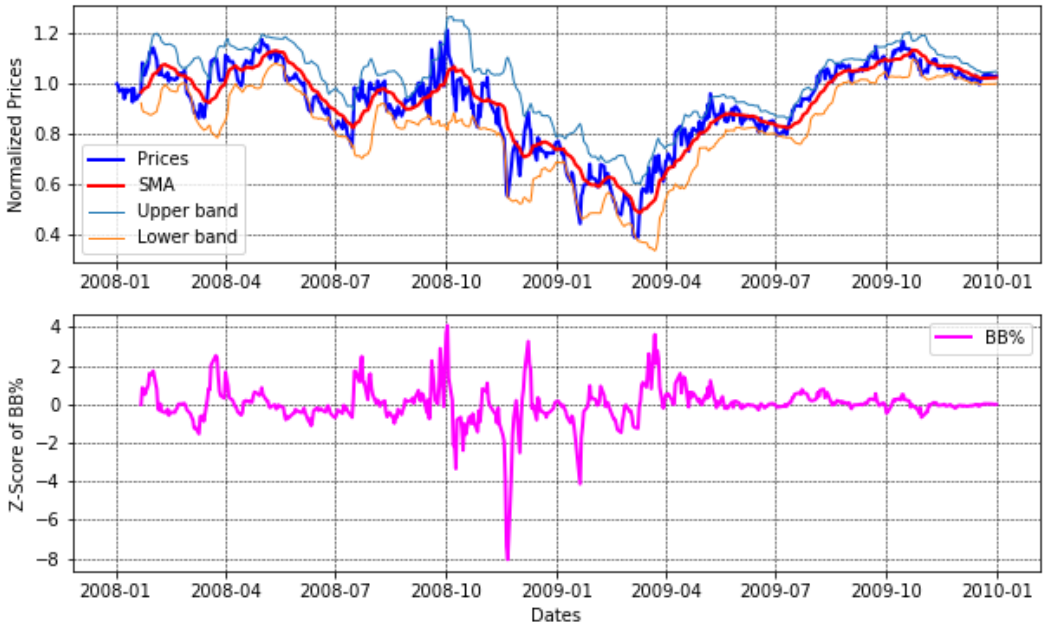

Figure 3: Bollinger Bands indicator plot for JPM stock price

Momentum: measures price changes over a specified number of days by the formula below:

$$\boldsymbol{Momentum_t = \frac{price_t}{price_{t-N}} - 1}$$

where N is the look back number of days. A high and positive momentum may signal a BUY opportunity in anticipation that the trend will continue in the future. Conversely, a negative momentum may signal a SELL opportunity. The momentum indicator can be combined with other indicators such as SMA to make a trading decision. For instance, when we observe a strong positive momentum at a point where prices cross SMA, it may indicate a BUY opportunity. Figure 4 below report the momentum indicator.

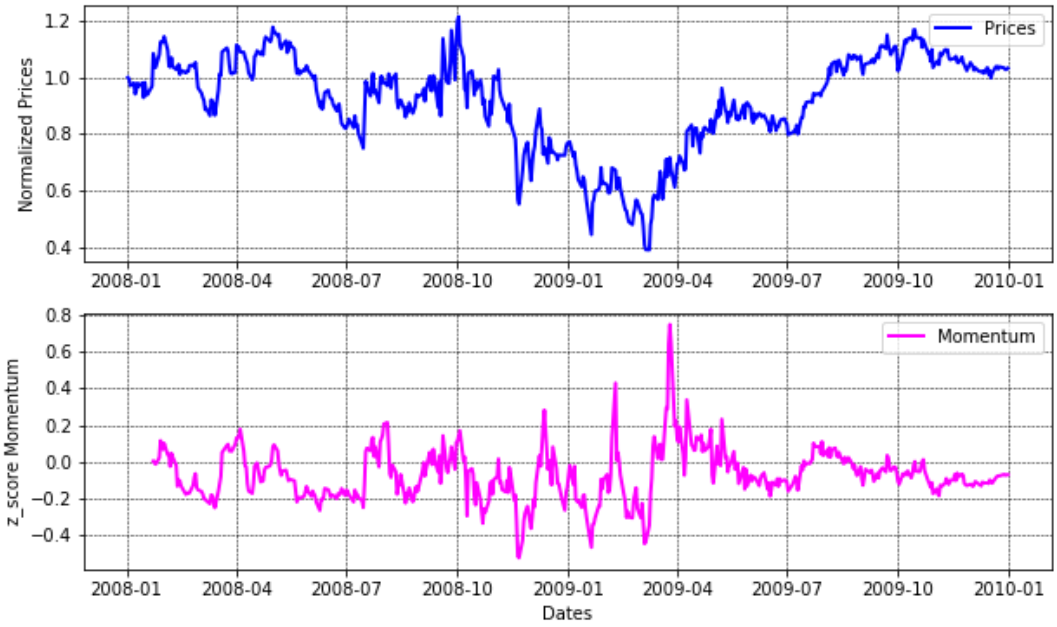

Figure 4: Momentum indicator plot for JPM stock price

Normalized Average True Range (NATR): is a measure for price volatility. This normalized version of the Average True Range (ATR) makes comparing volatility across different stocks easier. The NATR is calculated in the following steps:

- Calculate the True Range (TR) of stock prices as

$$\boldsymbol{TR = max[(High - Low), |High - Close_{previous}|, |Low - Close_{previous}|]}$$

- Calculate the Average True Range (ATR) as

$$\boldsymbol{ATR = \frac{1}{n}\sum_{i=1}^{n} TR_i}$$

- Calculate the NATR as

$$\boldsymbol{NATR_t = \frac{ATR_t}{Close_t} \times 100}$$

Stock price movements exhibit clustered periods of high volatility. The NATR indicator can be used to identify periods of extraordinary high frequencies of trades before they occur. When the NATR is moving upwards, the stock price is nearing its lower bound and will likely start to trend upwards. Conversely, when the NATR is moving slowly in a downward trend, it means that the stock price is nearing its upper bound and thus likely to move downward.
The scenario mentioned above can be traced out in Figure 5 below.

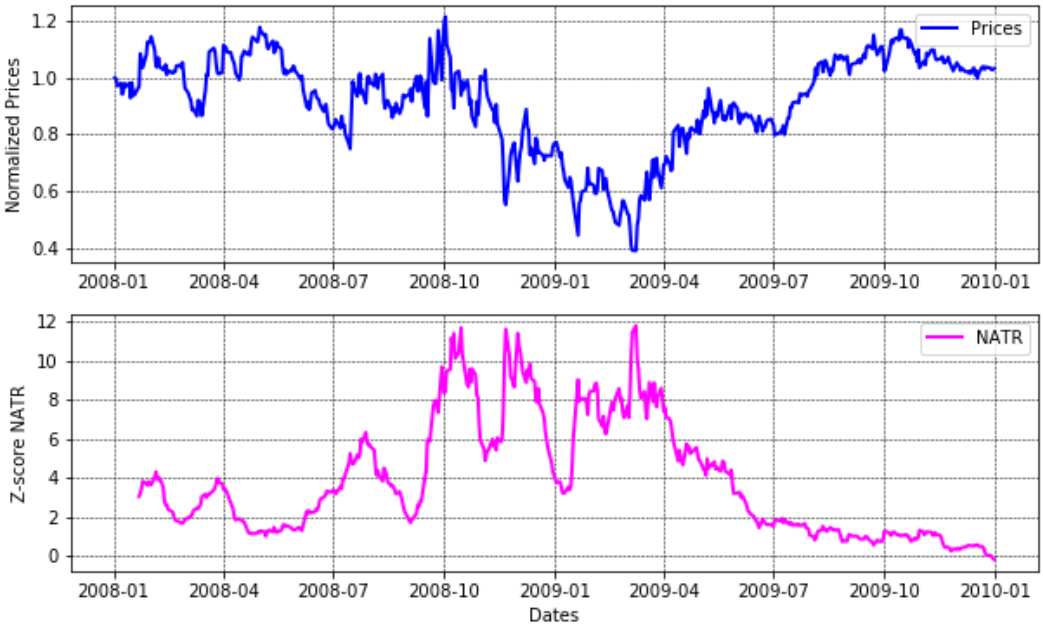

Figure 5: NATR indicator plot for JPM stock price

PART 2. THEORETICALLY OPTIMAL STRATEGY

When the future is known, then one can make the best trading decisions that can maximize profits. With this in mind, we develop the theoretically optimal strategy as follows:

holdings = 0
If the price[t+1] > price[t], then the price is going to rise, so we BUY 1000 shares.
new holdings = 1000
Else if the price[t+1] < price[t], then price is going down, so we SELL 100 shares.
new holdings = -1000
At any point in the trading period, our total number of shares is
shares = new holdings - holdings

The logic above was used to calculate the optimal portfolio and compared it with the benchmark portfolio, which invests 1000 shares in the stock and holds that position throughout the trading period. From Figure 6, observe that knowing the future allows us to make the maximum profits. The portfolio statistics are summarized in Table 1 for comparison.

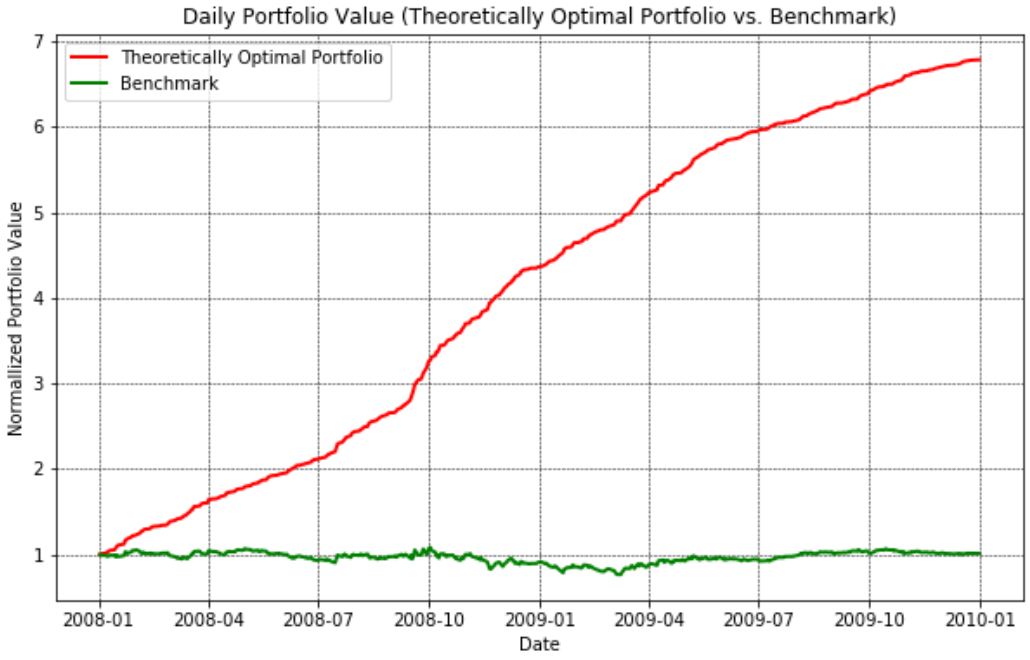

Figure 6: A comparison of portfolio value (Theoretically Optimal vs. Benchmark)

Table 1: Portfolio summary

Performance Metric	Theoretical Optimal Strategy	Benchmark
Sharpe Ratio	13.3227	0.1569
Cumulative Return	5.7861	0.0123
Standard Deviation	0.0046	0.0170
Average Daily Return	0.0038	0.0002
Final Value	678,610.0	101,230.0