

Part 1: Technical Indicators

1. SMA Simple Moving Average(SMA) is an average of prices over pas N days. It smooths out the volatility in a stock because of averaging and makes it easier to observe the trends in a stock. It can be calculated using the following formula

$$SMA(t) = \frac{1}{N} \sum_{i=0}^{i=N-1} price[t-i]$$

Since, SMA points up if the stock's price is increasing and points down if the stock's price is decreasing, we can use it as an indicator for trade signals. In order to get trade signals from SMA, we use the ratio:

$$SMA_Ratio(t) = \frac{Price[t]}{SMA(t)}$$

If SMA_ratio is greater than 1, it implies the stock is overbought and hence a sell signal. If the SMA_ratio is less than 1, it implies the stock is oversold and the the price is going to rise hence a buy signal. If SMA_ratio is equal to 1, it implied no change in the movement of the stock.



Figure 1: Simple Moving Average

We can observe from the plot that SMA captures the trend of the stock ignoring the volatility. However, the SMA_ratio has a high volatility.

2. Bollinger Bands Bollinger bands is a set of lines plotted two standard deviations above and below the simple moving average. Since standard deviation indicates volatility, widening of the gap between upper and lower bands marks periods of increased volatility and similarly when the bands contract it

indicates low volatility.

$$std(t) = \sqrt{\frac{1}{N} \sum_{i=0}^{N-1} (price[t-i] - SMA(t))^2}$$

$$BU(t) = SMA(t) + 2 * std(t)$$

$$BL(t) = SMA(t) - 2 * std(t)$$

$$BB_ratio = \frac{Price(t) - SMA(t)}{2 * std(t)}$$

BB_ratio can be used as an indicator. A value greater than 1 indicates the stock is overbought and hence a sell signal. A value less than -1 indicates the stock is oversold and hence a buy signal.

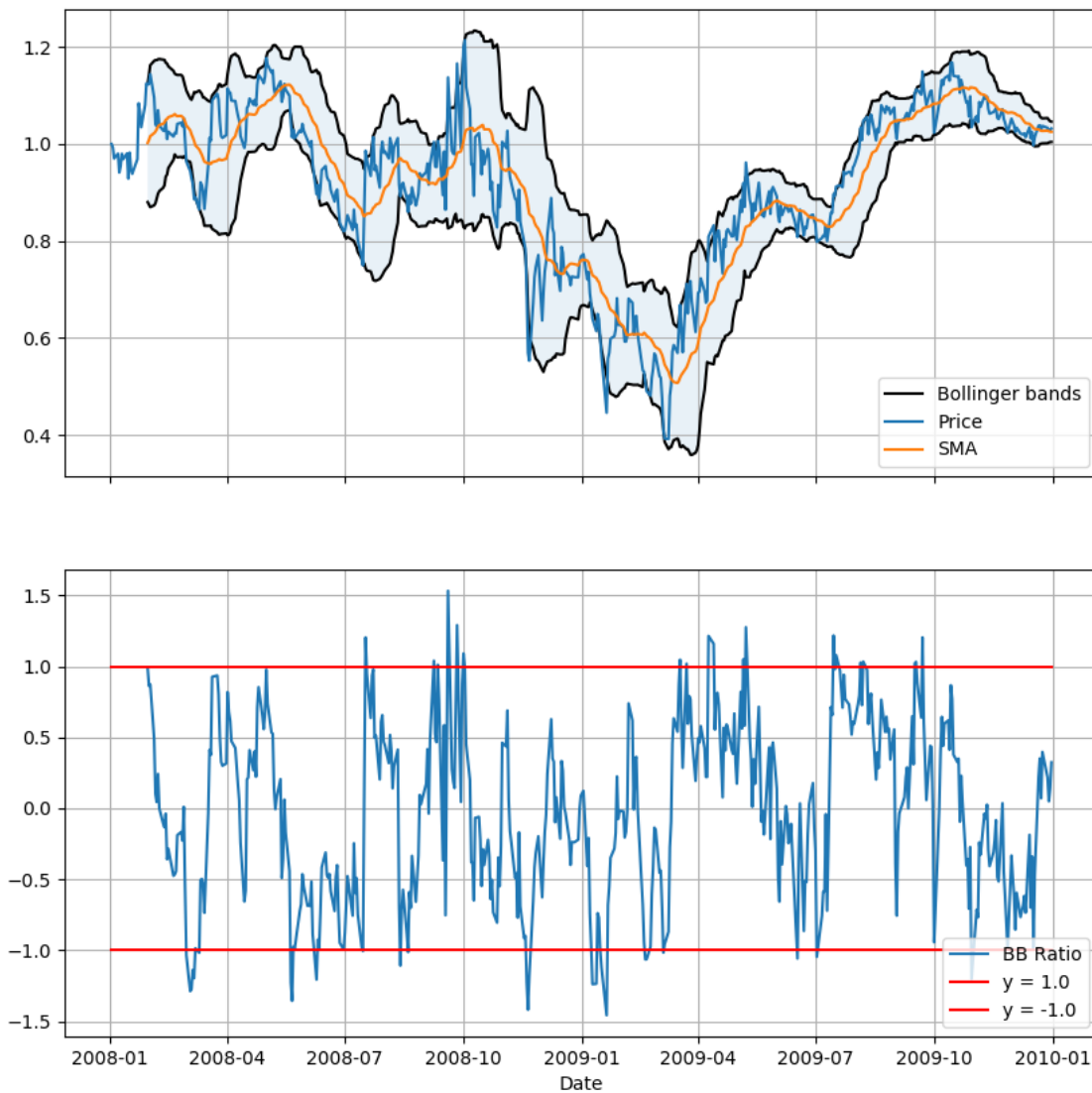


Figure 2: Bollinger bands

We can observe from the plot whenever, BB_ratio breaks out of the -1 and 1 bands, it indicates a strong signal of buy and sell respectively.

3. Momentum

Momentum is an indicator used to show the movement of a price over time and the strength of movement. The formula for momentum is as follows:

$$Mom(t) = \frac{Price(t) - Price(t - N)}{Price(t - N)}$$

Momentum indicates the rate of rise and fall of a stock price. As we can observe from the plots, higher positive values of momentum indicate steep rise in prices and vice versa. We can use the momentum crossings at 0 as potential indicator for buy and sell signals. If the momentum crosses zero from +ve to -ve value, it implies prices are going to fall, hence a sell signal. A crossover from -ve to +ve implies prices are going to rise, hence a buy signal.

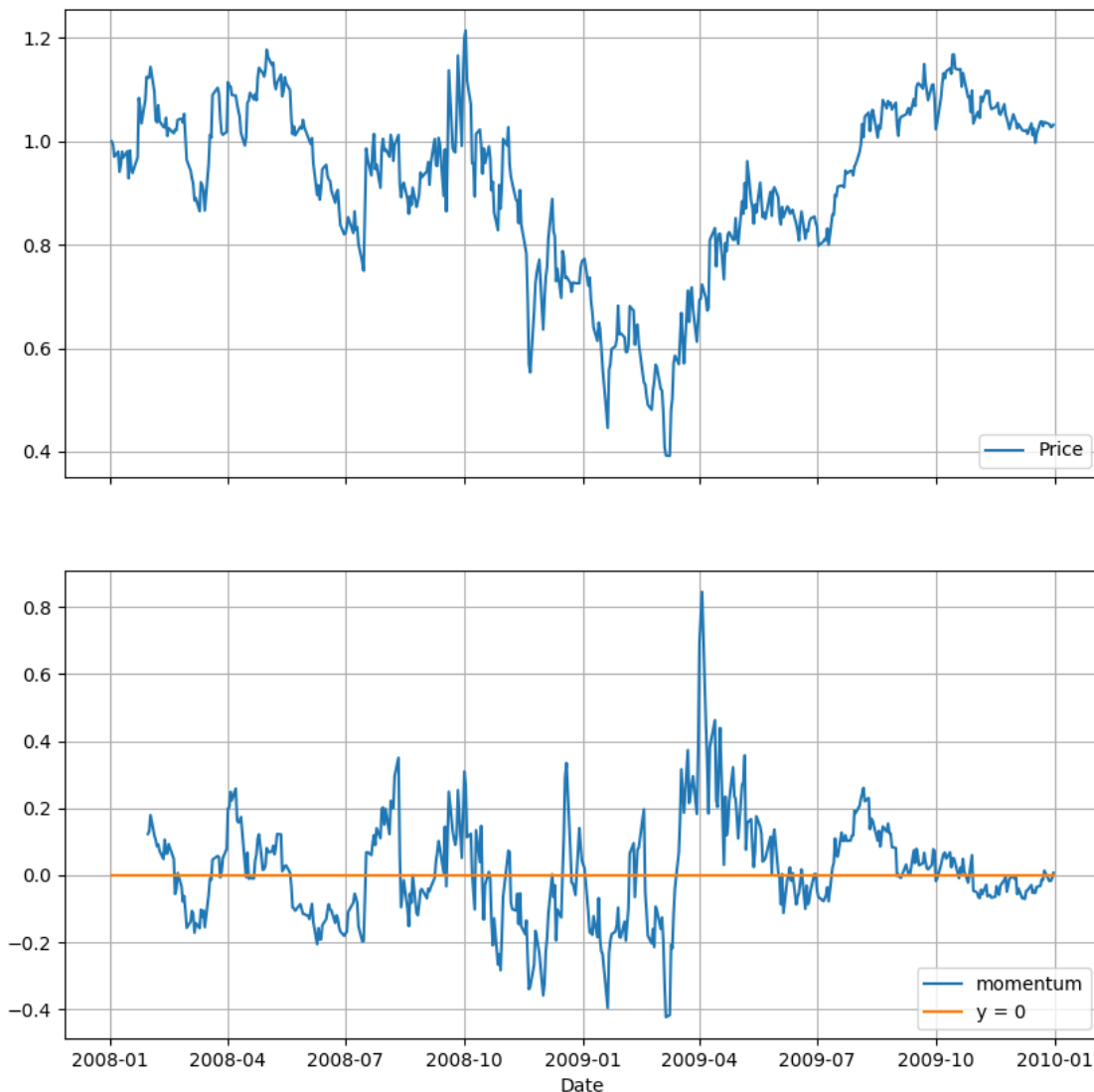


Figure 3: Momentum

We can observe from the chart, whenever the momentum crosses zero, it indicates a strong buy or a sell signal.

4. On Balance Volume (OBV) On Balance Volume is based on the volume of the stock traded. Since volume shows trends before price, we can use this indicator to predict future price trends. It is a leading indicator while others discussed above are lagging indicators. The OBV is calculated as follows:

- If $pricet > price(t - 1)$, $obv(t) = obv(t - 1) + vol(t)$
- If $pricet < price(t - 1)$, $obv(t) = obv(t - 1) - vol(t)$
- If $pricet = price(t - 1)$, $obv(t) = obv(t - 1)$

As the volume itself is not a very meaningful value, we used the slope of the obv as an indicator. A rising slope indicates the prices are going to increase as there is an increase in volume, hence a buy signal. A falling slope indicates the prices are going to decrease in as there is a drop in volume, hence a sell indicator.

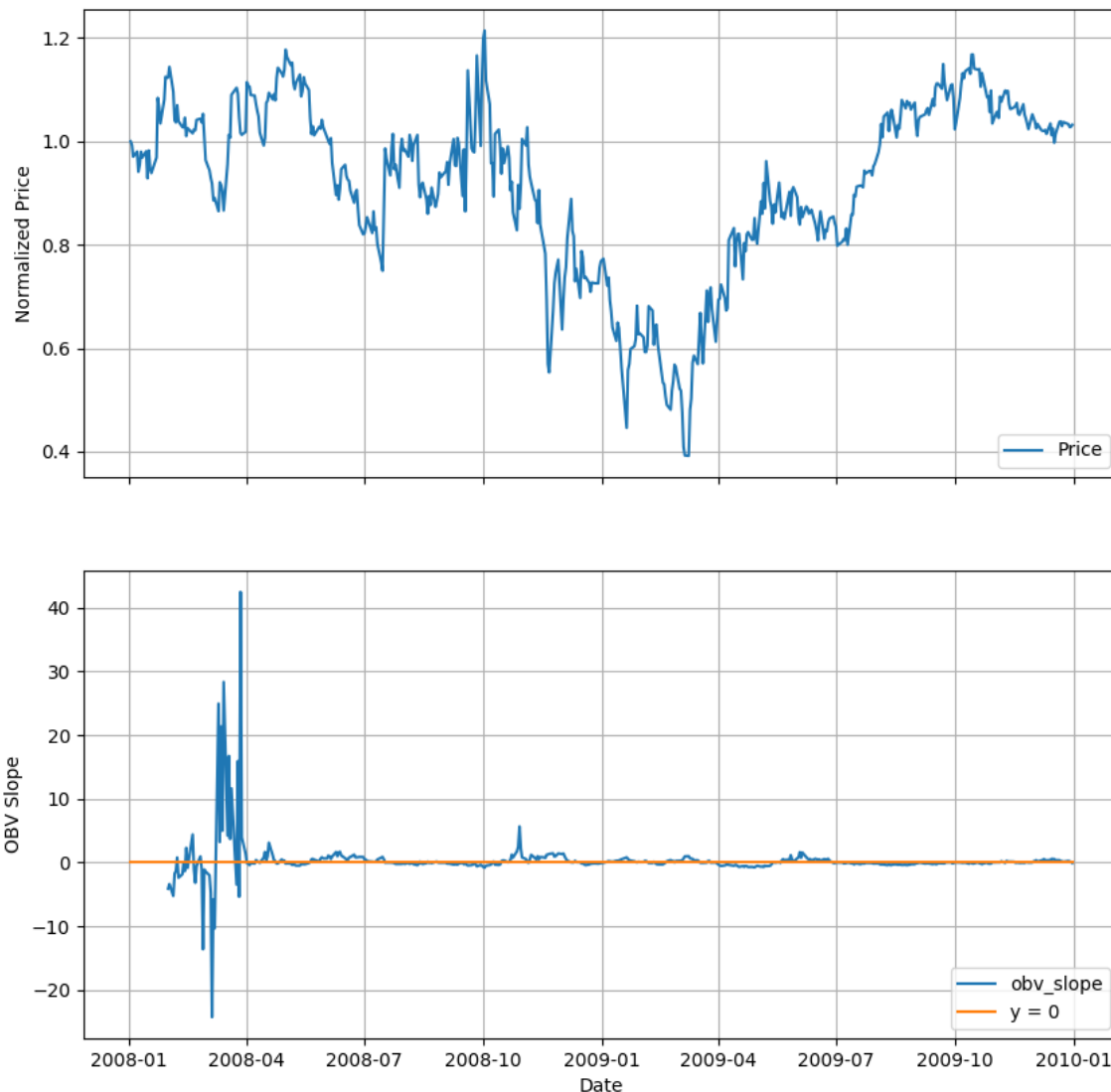


Figure 4: On Balance Volume Slope

We can observe from the chart that obv is not a very good indicator for JPM, as the cumulative volume apart from the initial start stays around the same value.

Part 2: Theoretically Optimal Strategy

The assumption of theoretically optimal strategy is that we can see the future. Since we can see the future, my possible strategy relies on the daily returns. On an overview level, based on tomorrow's daily returns I take a position long or short. Following rules are followed for making trades:

- If $\text{daily_returns}(t + 1) < 0$, short stock at time t if possible
- If $\text{daily_returns}(t + 1) > 0$, long stock at time t if possible
- if $\text{daily_returns}(t + 1) = 0$, do nothing

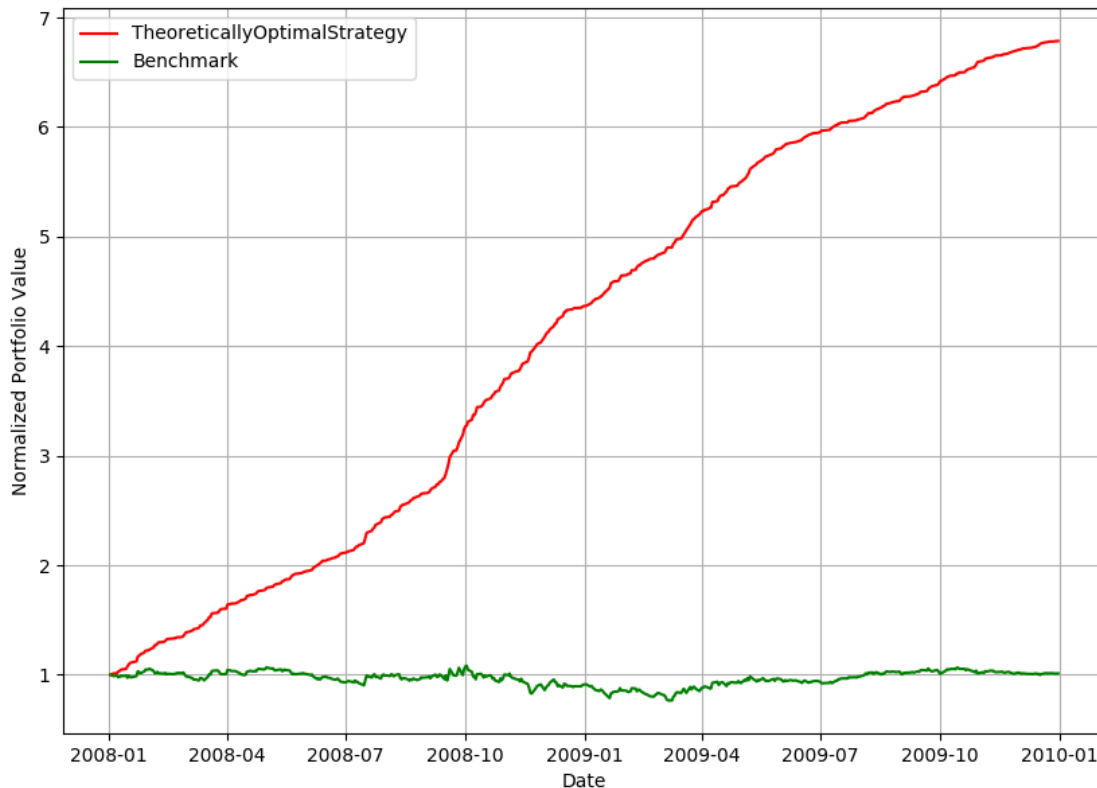


Figure 5: Theoretically Optimal vs Benchmark

Measure	Theoretically Optimal	Benchmark
cumulative return	5.786	0.012
average daily return	0.004	0.0
std of daily returns	0.005	0.017

We can observe from the chart and table, that theoretical strategy outperforms benchmark with relatively large cumulative returns and very low volatility as indicated by standard deviation. This was only possible because we could see the future prices.

Part 3: Manual Rule-Based Trader

In this strategy, we cannot see the future. To design my trading strategy I used `BB_ratio` and `SMA_ratio` as indicators. I used a logical AND combination of `SMA_ratio` and `BB_ratio` indicators as trend indicators. The trading strategy is as follows:

- If $SMA_ratio < 1$ AND $BB_ratio < -1$, long if possible
- If $SMA_ratio > 1$ AND $BB_ratio > 1$, short if possible
- If none of the above conditions satisfy, do nothing

As explained above, `SMA_ratio` greater than 1 indicates divergence and the price is going to drop, hence a sell signal. Similar `SMA_ratio` less than 1 indicates divergence in opposite direction, the price is went lower than it should, indicating a buy signal. `BB_ratio` works similarly to `SMA_ratio` but with thresholds 1 and -1.

Since `SMA_ratio` gave a good notion of trend but was very jittery, I combined it with `BB_ratio` using an AND operator to confirm that the trend. As we can see from the plots above, `BB_ratio` is a relatively stable indicator especially in breakout regions. A combination of these two gives a very stable notion of trend, since both need to predict the same trend in order to take a position.

Part 4: Comparative Analysis



Figure 6: Manual vs Benchmark (In Sample)

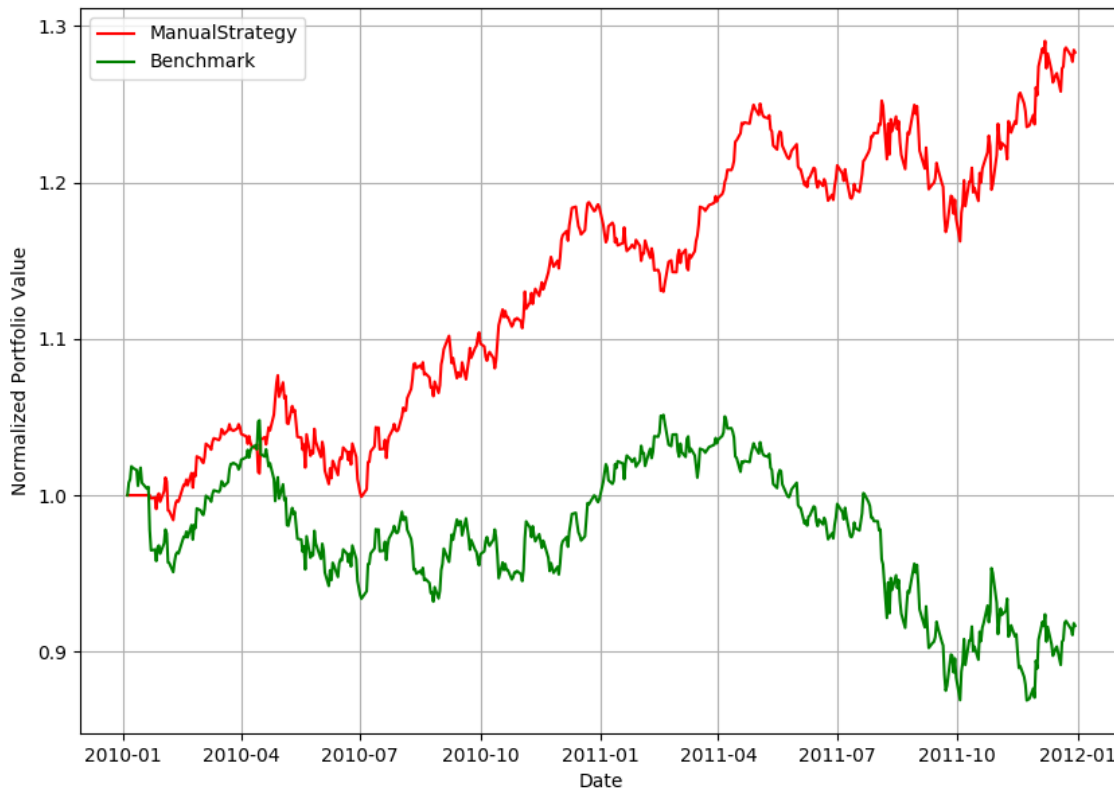


Figure 7: Manual vs Benchmark (Out Sample)

In Sample

Measure	Manual	Benchmark
cumulative return	0.316	0.012
average daily return	0.001	0.0
std of daily returns	0.013	0.017

Out Sample

Measure	Manual	Benchmark
cumulative return	0.283	-0.083
average daily return	0.001	0.0
std of daily returns	0.007	0.008

We can observe from the table, the out sample cumulative return is lower than in sample cumulative return. This is so because, we used our indicators in in-samples data and tuned their thresholds according to how they were performing on in sample data. The manual strategy overfits on in sample data. However, the overall performance of manual strategy on out sample data is better than benchmark strategy.