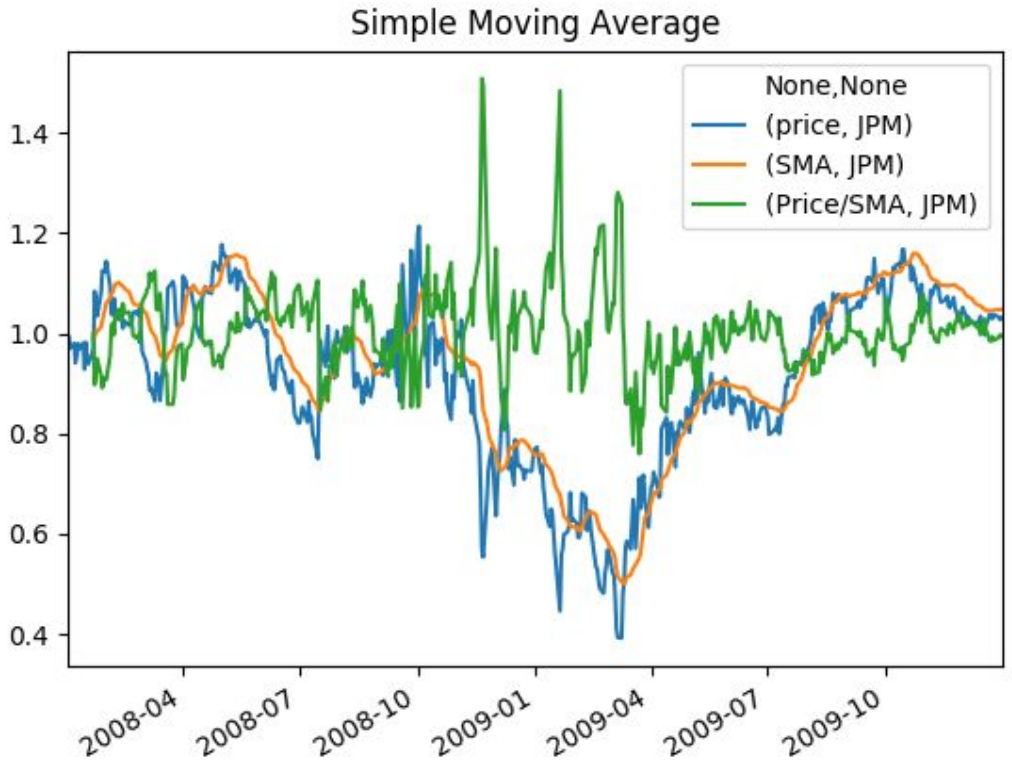
Part 1: Technical Indicators
1. Simple Moving Average

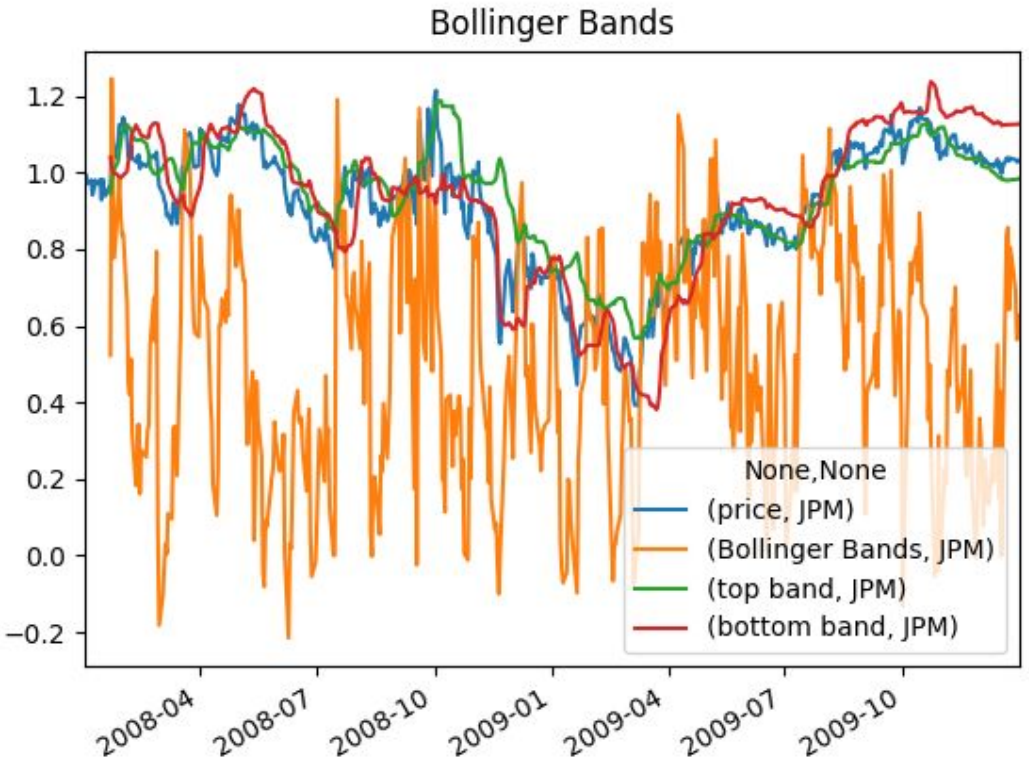


Description:
A simple moving average is an arithmetic moving average calculated by adding the closing price of the security for a number of time periods and then dividing this total by the number of time periods. SMA asks us to look back for n (we assume n = 14) days to calculate the mean of the price during that window period. As one of indicators, SMA can be compared with the price of the shares. If the current price belows to the SMA value, it means an arbitrage opportunity for LONG. If the current price aboves to the SMA value, it means an arbitrage opportunity for SHORT. In addtion, SMA can be used to show whether a stock is overvalued. To be more specific, we need to calculate the ratio of Price/SMA. If the ratio is greater than 1, then the stock is overvalued and if the ration is less than 1, then the stock is undervalued.

To implement of the SMA indicator, firstly we need to generate the mean of the price of the stock during the looking back period. Then to get the price/SMA ratio.
we can use the simple equation:

$$SMA_{ratio}[t] = \frac{price[t]}{price[t-n:t]}$$

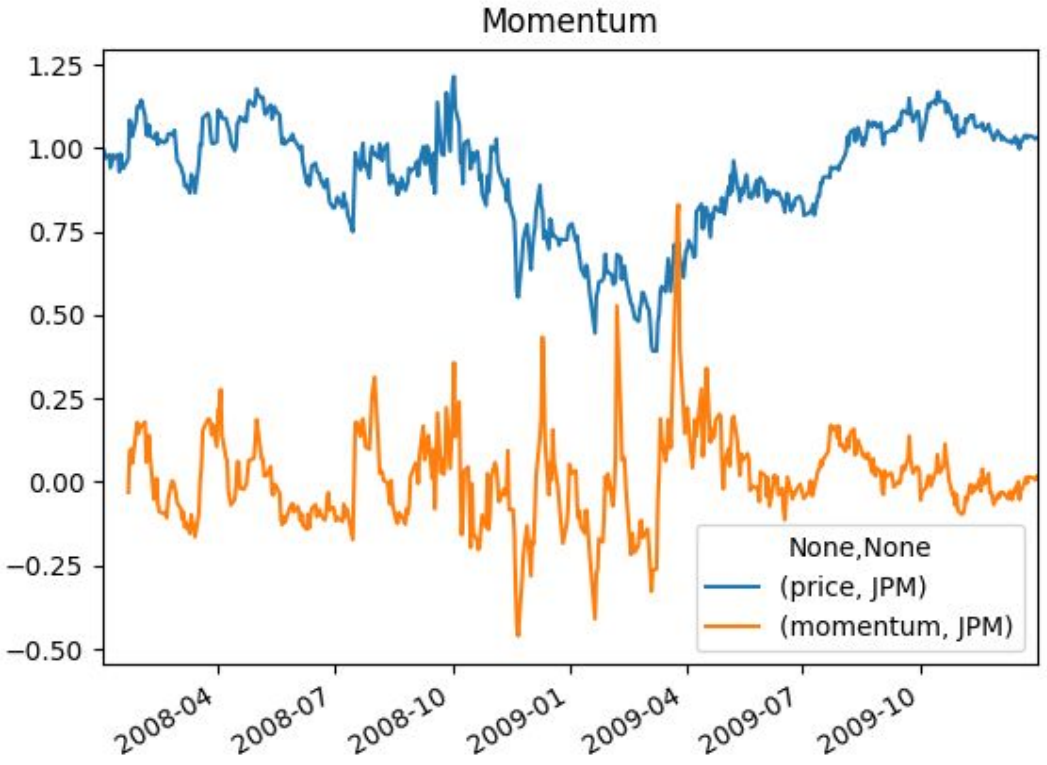
2. Bollinger Bands



Description:
Bollinger Bands are a volatility indicator, it considers simple moving average, an upper band during n period above the moving average, lower band and standard deviation of the price during n period below the moving average. n is the looking back window and we may assume the value is 14. Also, Both upper band and lower band is two standard deviation from the simple moving average. If the Bollinger Band value is greater than 1, it means the price of the stock is over the upper band and if the Bollinger Band is less than 0, then the price of the stock is below the lower band. Above upper band means overbought and below lower band means oversold.

To implement a Bollinger Band indicator, we need to first calculate the standard deviation of the price during the look back period. It is the volality of the price of the stock. Then we will implememt the upper and lower band, which is the 2*standard deviation of the price over look back window away from the simple moving average (SMA). After that the value of Bollinger Band equals to (price - lower_band) / (upper_band - lower_band).

3. Momentum

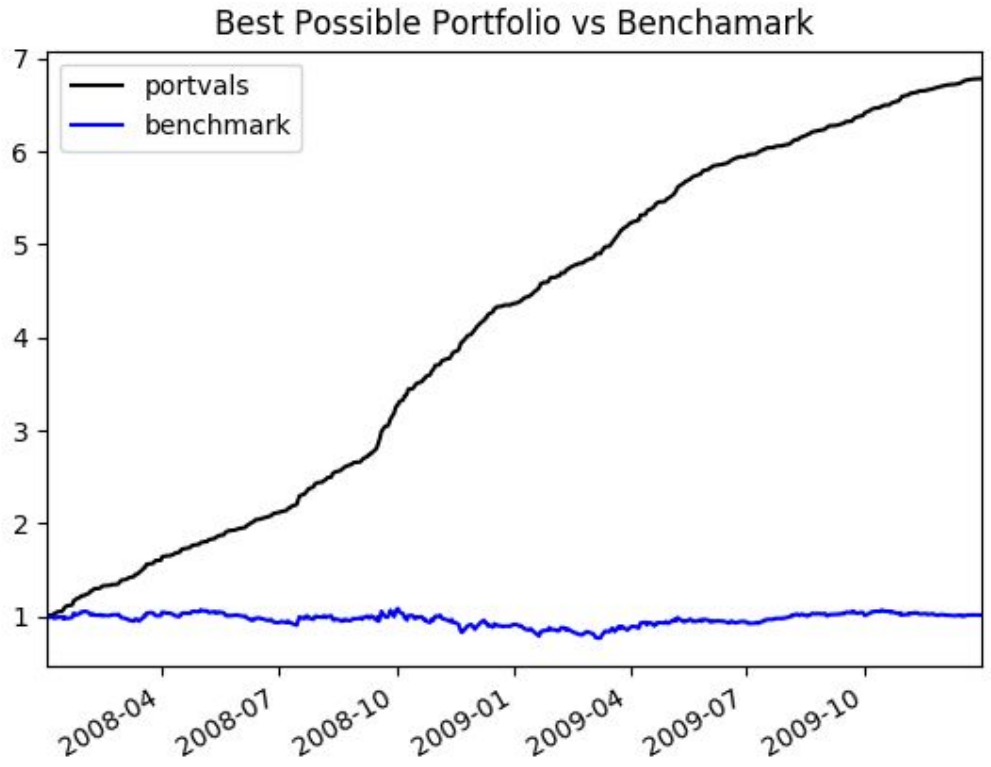


Description:
The momentum indicator compares the most recent closing price to a previous closing price during a look back period n, (n = 14). Momentum can be used as an indicator to indicate the uptrend and downtrend. If the value of momentum is greater than 0, then it is uptrend during the look back window. If the value of momentum is less than 0, then it is downtrend during the look back window.

To implement the momentum indicator, we need to look the history price over the look back window and use the equation:

$$Momentum = \frac{price[t]}{price[t-n]} - 1$$

Part 2: Best Possible Strategy



Portfolio:
Cumulative Return: 5.7861
Average Daily Return: 0.00381678615086
Standard Deviation Daily Return: 0.00454782319791

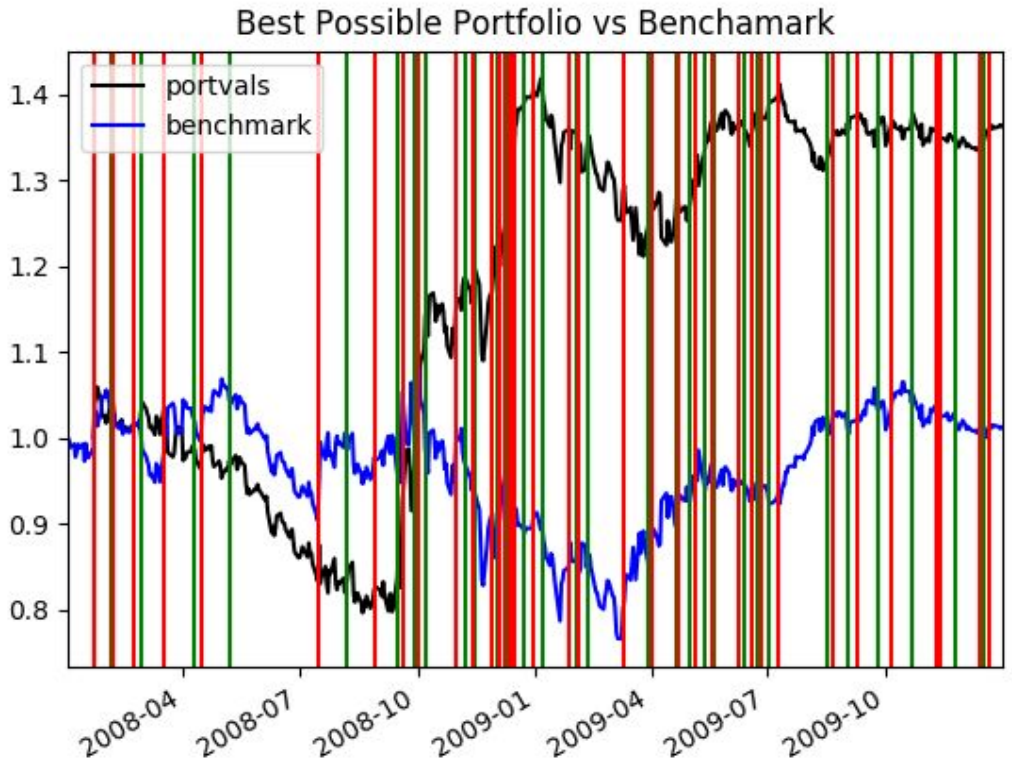
Benchmark:
Cumulative Return: 0.0123
Average Daily Return: 0.000168086978191
Standard Deviation Daily Return: 0.0170043662712

Description:
To implement the best possible strategy during the market, we need to look a price table for a stock during a time range. Assume that we know the future price in this part. To decide if the investor should buy or sell a price today, we actually need to compare today's price to tomorrow's price. If the today's price is greater than tomorrow, the investor should absolutely sell the share and if the today's price is less than tomorrow, the investor should absolutely buy the share. This is a pretty simple logic for the best possible strategy. Assume that we have a startcash at the beginning. Also, we may assume that the holdings for the inverstors are strcitly to 1000 shares. In order to max the profit, we absolutely want to buy or sell the maximum amount of shares in the range of 1000 holdings. The logic of the BUY or SELL action in the market to get the most profits will be shown below:

- Tomorrow's price > today's price (inicates BUY)
    - holds=0: BUY 1000 shares
    - holds=1000: BUY 0 shares
    - holds=-1000: BUY 2000 shares
- Tomorrow's price < today's price (indicates SELL)
    - holds=0: SELL 1000 shares
    - holds=1000: SELL 2000 shares
    - holds=-1000: SELL 0 shares

The holds is simultaneously updated in each step so that we can get the current holdings in each single day. Then we will get the best possible strategy for an action in the market during a trading. Compare the benchmark value to the portfolio value used by our action book, we may easily find that the best possible strategy works pretty well.

Part 3: Manual Rule-Based Trader
In sample:



Porfilio:
Cumulative Return: 0.362513113241
Average Daily Return: 0.000739696188111
Standard Deviation Daily Return: 0.0148560101526
Benchmark:
Cumulative Return: 0.0123249333401
Average Daily Return: 0.000168759162146
Standard Deviation Daily Return: 0.0170412470682

Description:
The Manual Rule-Based Trader depends on three indicators: Simple Moving Average, Bollinger Bands and Momentum that we calculated in the part1. The general idea of the Manual Rule-Based Trader is buy shares when the stock is oversold in the market and sell shares when the stock is overbought in the market, The usage of the indicators will help us to determine the status of the stock in the market. If a stock is oversold or undervalued, the investors should buy shares since the price will go up in the future. If a stock is overbought or overvalued, the investors should sell shares since the price will go down in the future. As part indicates:

1) If the value of momentum is greater than 0, then it is uptrend during the look back window. If the value of momentum is less than 0, then it is downtrend during the look back window.
2) If the Bollinger Band value is greater than 1, it means the price of the stock is over the upper band and if the Bollinger Band is less than 0, then the price of the stock is below the lower band. Above upper band means overbought and below lower band means oversold.
3) If the ratio of price/SMA is greater than 1, then the stock is overvalued and if the ration is less than 1, then the stock is undervalued.

We can define our strategy based on indicators for the action in a market for a trading:

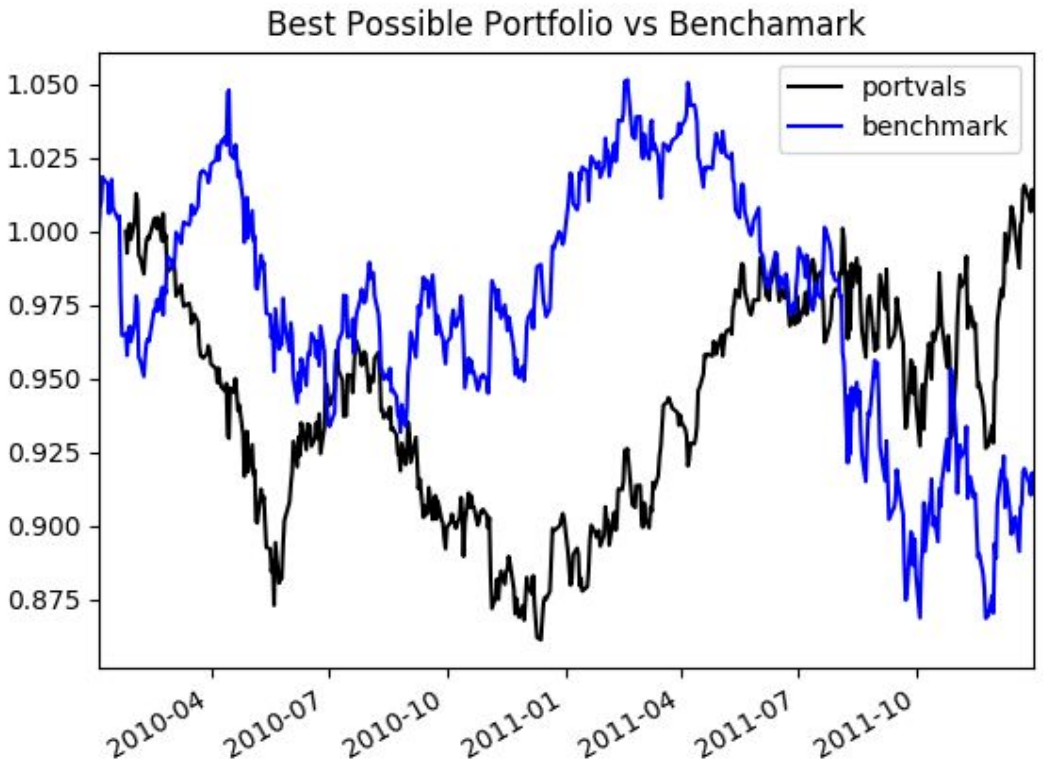
- LONG (oversold condition)
    - If price/SMA less than 0.85
    - If Bollinger Band less than -0.4
    - Momentum less than -0.03
- SHORT (overbought condition)
    - If price/SMA greater than 1.25
    - If Bollinger Band greater than 1.4
    - Momentum greater than 0.08
- EXIT when the price across the SMA

To create a fully BUY or SELL action table, considering the 1000 shares limited for holdings, we may also consider the status of current holds:

- LONG
    - holds=0: BUY 1000 shares
    - holds=1000: BUY 0 shares
    - holds=-1000: BUY 2000 shares
- SHORT
    - holds=0: SELL 1000 shares
    - holds=1000: SELL 2000 shares
    - holds=-1000: SELL 0 shares

That's the general overview for Manual Rule-Based Trader. Since different standard value for the indicators may change the different profits, we cannot guarantee the investor to get the maximum profits. However, this is a better performance for the investors because there is a divergence from the market.

Part 4: Comparative Analysis
out of sample:



Portfolio:
Cumulative Return: 0.0126078311234
Average Daily Return: 5.92821417814e-05
Standard Deviation Daily Return: 0.00820997045965
Benchmark:
Cumulative Return: -0.0835791100328
Average Daily Return: -0.000137429230389
Standard Deviation Daily Return: 0.00850015832233

	Cumulative Return	Average Daily Return	Standard Deviation Daily Return
In Sample	0.362513113241	0.00073969618811	0.0148560101526
Out of Sample	0.0126078311234	5.92821417814e-05	0.00820997045965

Explanation: The Manual Rule-Based Trader works best for the in sample data because we use the in sample data to train our models. It is just a prediction for testing the out of sample

data. The difference occurred because of the value we set for the indicators of when to SHORT or LONG the shares. So, it may lead that the performance of out of sample works not well as mush as the in sample data. However, from the graph, we may see that that the portfolio still works better than the benchmark. The strategy works for both in sample and out of sample data.