

Manual Strategy

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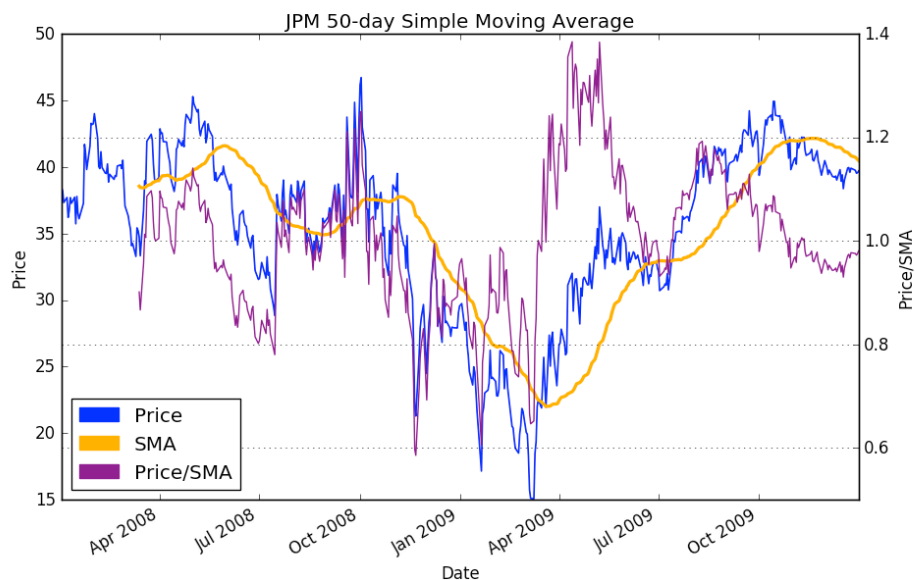
Technical Indicators

To create the trading strategy, three technical indicators are used to inform the decision making process. The indicators are charted using the in-sample data in order to assess the levels at which they serve as 'buy' or 'sell' signals. For this strategy, simple moving average, Bollinger Bands, and the SPY to JPM ratio are used.

Simple Moving Average

The simple moving average (SMA) indicator uses a lookback period to calculate the arithmetic mean price of a stock for the last n periods. For each new time step, SMA shifts its lookback period 1 time step forward to calculate the new value, effectively serving as a smoothing function over the price of the stock. While the price of the stock fluctuates stochastically, the SMA erodes noise and allows the overall trend to be visualized. Prices that deviate sufficiently from the SMA will tend to revert to the mean, allowing for it to be used as a signal to enter a profitable trade. To capture this deviation, we can use the ratio of price to SMA, where a ratio above one indicates an excursion of the price above the SMA, and below one indicates price level below the SMA. Thus, we would want to enter into a short position when the price/SMA ratio is above a threshold, and enter a long position when the ratio falls below a corresponding threshold.

We can now plot the SMA and Price/SMA indicators for two year in-sample data of JPM stock. A lookback period of 50 days is used in an effort to capture and evaluate long-term trends and appropriate thresholds.



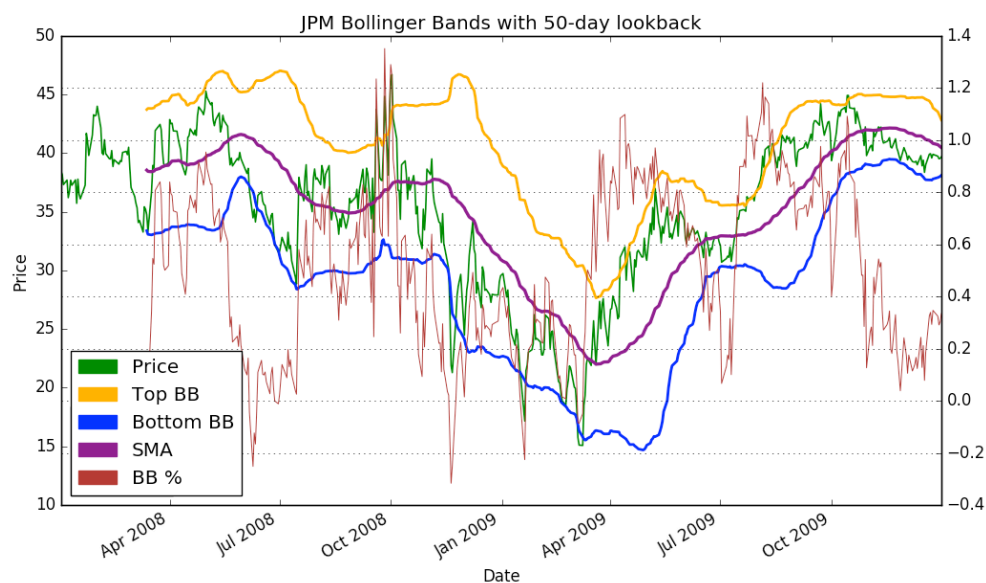
From the chart, we can see that prices deviating far above and below the 50-day SMA have a strong tendency to revert to the mean. This pattern is more prevalent when the Price/SMA ratio is above 1.05 and below 0.95. The former would thus serve as promising sign that the price will come down over the following weeks. Correspondingly, a ratio below 0.95 serves a signal that the price has deviated too far from the trend and is likely to rise towards the SMA. These threshold will be used to denote buy and sell signals for the manual strategy.

Bollinger Bands

Bollinger Bands (BB) take the concept of a simple moving average and extend it to include the standard deviation of a price from the SMA. To more definitively judge whether the price of a stock has over-drifted from the moving average, BB first calculates the price's moving standard deviation during the lookback period. It then adds and subtracts two standard deviations from the moving average to create the upper and lower Bollinger Bands.

The difference between the upper and lower bands will be largest when the volatility during the lookback period is high, and smallest when there has been little fluctuation in prices. The bands thus define a range of within we might expect price to fluctuate as a result of the lookback period's observed volatility. Prices reaching or exceeding these upper and lower bounds are therefore experiencing abnormally high levels of volatility, and likely foreshadow a reversion towards the trend represented by the SMA. We can make a formalized indicator by subtracting the lower band from the price, and dividing that quantity by the difference between the upper and lower bands. This BB% is thus less than zero when the price falls below the lower band and is greater than 1 when the price rises above the upper band.

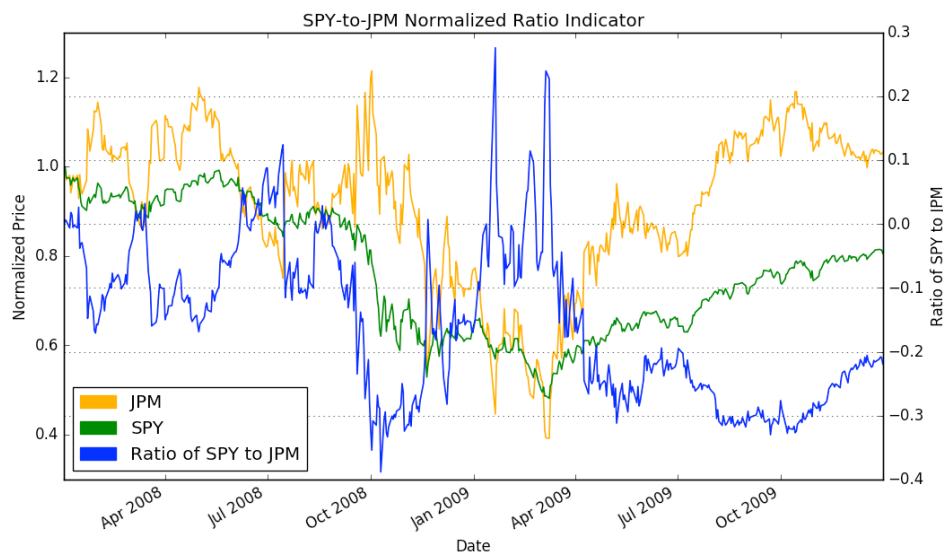
The Bollinger Band family is plotted on the same stock data.



This chart affirms the hypothesis behind the Bollinger Bands. In October 2008, the JPM spikes through the upper band (BB % of 1.0) and sharply reverts to the moving average. This is again seen in March 2008, with the price dropping beneath the lower band with corresponding BB% of 0, followed by a sharp mean reversion. These observations lead me to conclude that setting a BB % of 1.0 as a sell indicator threshold and BB % of 0 as a buy threshold could be a profitable levels to implement in the strategy.

SPY/JPM Normalized Price Ratio

The movement of large cap stocks is often highly correlated with market indices such as the S&P 500. When the market begins moving in one direction, its components tend to follow suit with some degree of variance. Since the market index represents 500 weighted stocks, we can expect the normalized price movement of SPY to experience less volatility than an individual stock like JPM. However, we still expect SPY and JPM to retain a high correlation. We can see that this phenomena holds true for the time period represented in the below chart.



To take advantage of this observation, we devise an indicator that represents the normalized price ratio between SPY and JPM. From the chart, we can see that SPY begins a steep descent in October 2008. This movement broadens the gap between its price and JPM's, and we see the ratio fall below -0.2, after which the two prices begin to converge. We can thus use this level as a sell threshold below which the investor is inclined to short JPM stock. Similarly, in February and March the same is noticed in the

reverse direction, where the ratio rises just above 0.1, and immediately after which JPM rises to meet SPY. We can use 0.1 as a threshold indicating to go long in JPM.

Best Possible Strategy

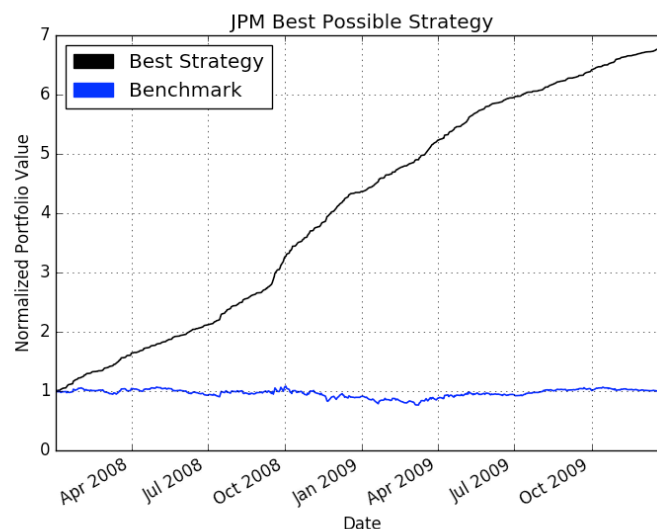
To set the upper and lower bounds of performance for our manual strategy, we conduct a simulation to deduce the best possible performance investing in JPM for the given in-sample date range of January 1, 2008 to December 31, 2009.

The key assumption made is that we have access to the entire period's price history at the beginning of the period, meaning that we can always make the best decision at any given point in time. This also implies that we will never have a flat position: since we know whether tomorrow's price will be higher or lower, we will take a position that makes the movement in price profitable.

We also limit holdings to ± 1000 shares, thereby limiting trading quantities to a maximum of 2000 shares. The resulting strategy can thus be described by a set of conditionals:

- if price tomorrow < price today:
 - if position = +1000: SELL 2000
 - if position = 0: SELL 1000
 - if position = -1000: HOLD
- if price tomorrow > price today:
 - if position = +1000: HOLD
 - if position = 0: BUY 1000
 - if position = -1000: BUY 2000
- if price tomorrow == price today:
 - HOLD

With perfect information, we always want to have the maximum allowable position on in order to maximize the profit from the change in price. This means reversing the position when we're long and tomorrow's price is lower, and vice-versa for when tomorrow's price is higher. The result of this perfect strategy is seen in the chart below.



Performance Statistics

	Perfect Portfolio	Benchmark
Cumulative Return	5.786100	0.012300
Stdev Daily Returns	0.004548	0.017004
Mean Daily Returns	0.003817	0.000168

As we expected, the perfect portfolio gains a massive cumulative return of 5.78, compared to the meager 0.012 accumulated by the benchmark. It also accomplishes this with about four times less volatility and a much higher mean return. We can expect the performance of the manual strategy to fall within the range of these two bounds.

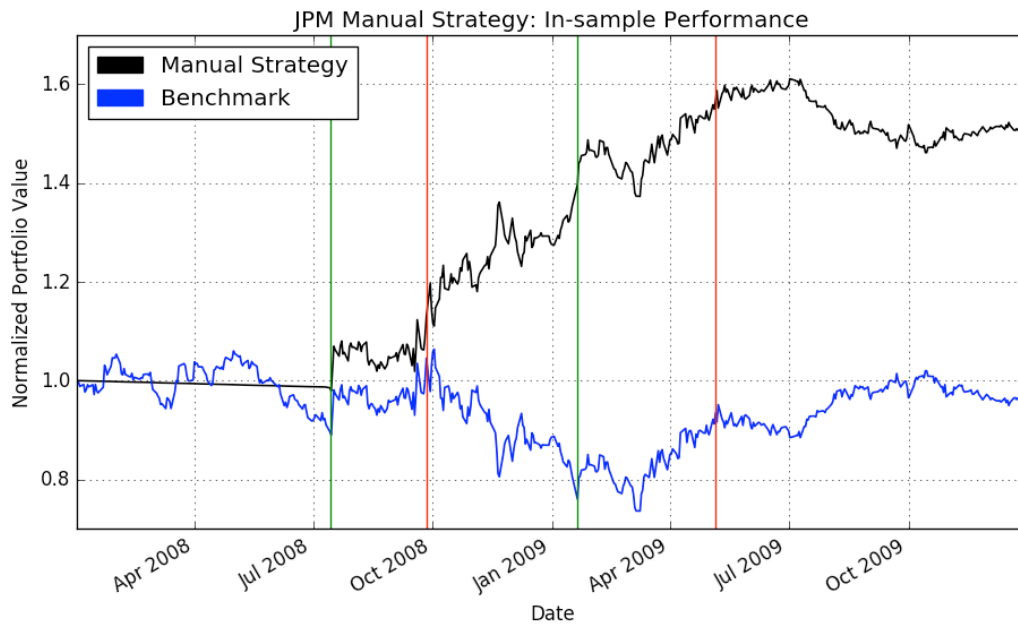
Manual Strategy

With the three technical indicators in place, the manual trading strategy can now be constructed. The three indicators each yield a signal to either buy, sell, or do nothing based on whether their respective thresholds have been exceeded. The three signals are then combined into a single buy or sell signal for the strategy to execute: if all indicators yield a buy signal, then buy. Similarly, if all three indicators yield a sell, signal, then sell. While each indicator individually signals an opportunity to make a trade, the three in tandem form a much stronger signal that we can have more confidence in. The entry strategy can be summarized by two conditionals:

- if (SMA < 0.95) and (BB% < 0) and (SPYratio > 0.1): BUY
- if (SMA > 1.05) and (BB% > 1) and (SPYratio < -0.2): SELL

The number of shares to trade is computed by first deciding the target holdings. If the strategy receives an indication to sell, then the target holdings will be -1000 shares (and similarly for a buy signal, +1000 shares). To exit the position, we wait until the price of the stock crosses the simple moving average. As we can see in the 50-day SMA chart, once the price reaches the SMA, the reversion is considered complete: there is little continuation in either direction to support holding to the position further. When this occurs, the profit or loss is realized and the desired holdings are therefore 0 shares, leaving a flat position. Once the target holdings are calculated for all trading days, then the orders dataframe is made by taking the difference in holdings between day t+1 and t. To illustrate, the result when holdings for day t+1 is 1000 shares and holdings for day t is 0, the difference of holdings[t+1] - holdings[t] will result in an order to buy 1000 shares on day t.

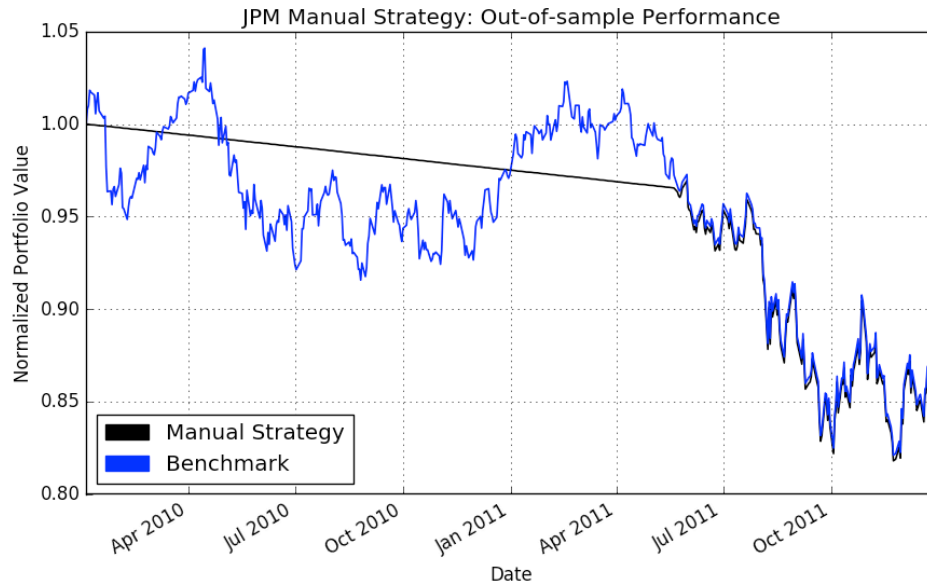
This strategy is applied to the in-sample period and charted for comparison with the benchmark.



As hoped, the manual strategy greatly outperforms the benchmark, earning a cumulative return of 0.54 more than the JPM baseline. The indicator thresholds were set fairly conservatively, resulting in few buy and sell signals realized by the strategy over the course of this two year period. This can be seen in the four total entry orders executed by the strategy (two buys and two sells). Although the breadth of this strategy is very small, it is also extremely effective: with a cumulative return of over 50%, this portfolio would be a top performer for any investor in the market. Of course, the strategy was crafted specifically to perform well on this in-sample training period, so it is unsurprising to see these extravagant results.

Comparative Analysis

To gauge the true value of the strategy, we apply it to an out-of-sample testing period and evaluate performance. The normalized portfolio and benchmark values are plotted and performance statistics gathered.



Performance Comparison

	In-Sample		Out-of-sample	
	Strategy	Benchmark	Strategy	Benchmark
Cumulative Return	0.508390	-0.037925	-0.136913	-0.133735
Stdev Daily Returns	0.011840	0.017468	0.006392	0.008781
Mean Daily Returns	0.000886	0.000075	-0.000272	-0.000247

Unfortunately, the out-of-sample performance is much worse than in-sample, and scarcely better than the benchmark itself. As can be seen from the chart, the strategy only calls for one entry trade (July 2011) and essentially follows the benchmark for the remainder of the period. The portfolio's cumulative return outperforms the benchmark by the meager margin of 0.0032, while the in-sample run saw the manual strategy gain 0.54 in cumulative return over the benchmark. Correspondingly, the mean of daily returns in the out-sample data mirrored the benchmark for the same period, and was 0.001 lower than the in-sample run.

The fact that only one entry trade was made in the out-sample period indicates that the indicator parameters were set too specifically for the in-sample data. While this resulted in a very good return for in-sample, it resulted in poor generalization for unseen data. This dramatic overfitting is not much of a surprise; the manual strategy was 'trained' by a mere mortal observing chart patterns and setting thresholds without much analytical rigor. To improve performance on the out-sample data, the strategy will have to be trained using machine learning methods.