Creating a Manual Trading Strategy

In this project 4 technical indicators (Price/SMA %, Bollinger Bands, MACD, and Volatility) were developed using historical price data of JPM stock from the period Jan-1-2008 to Dec 31-2009. These indicators were then combined using boolean logic into a basket-indicator that informed a manual trading strategy. The strategy's performance was then assessed by 1) measuring the cumulative returns of the strategy vs a benchmark over the training period 2) comparing the cumulative returns of the strategy over the training period with the cumulative returns generated in an unseen test period (Jan-1-2010 to Dec-31-2011).

Part 1: Creating Technical Indicators

1) Simple Moving Average (SMA)
The SMA is simply the average adjusted price of the stock over the last N days where N is a custom parameter. For this project, the last 20 Days was chosen as it performed better than other values like 7,14, 50. SMA's have the benefit of averaging price returns thereby reducing the impact of daily volatility and providing a smoother price trend. If the SMA is increasing then that could potentially imply the price will also continue to increase or vice versa.

For the trading strategy, the Price/SMA % itself was used over SMA. Price/SMA % is equal to the Price/SMA - 1 and provides a % of how much the Price is above or below its SMA. If the price is greatly above its SMA (Price/SMA % > 0), then that could mean the stock is overbought and prices may decline again to the mean. See Figure for illustration.

Figure 1 - Price, SMA and Price/SMA % Over Time

2) Bollinger Bands
Bollinger Bands show the simple moving average (SMA) of the stock bounded by an upper and lower Band that is 2 standard deviations away from its SMA. The Upper Bollinger Band is simply the 14 Day SMA + 2 * Standard Deviation of the Daily Price. The Lower Bollinger Band is the 14 Day SMA - 2*Standard Deviation of the Daily Price in the last 14 Days. The 14 Day parameter was chosen because it provided better cumulative returns in my trading strategy.

The intuition behind Bollinger Bands is that almost all short term price action occurs within 2 Standard Deviations of a stock's SMA. Thus, any breakouts above or below the bands are significant but albeit temporary events, and the price itself may eventually revert back to within 2 standard deviations of its SMA creating buy/sell opportunities.

For the trading strategy itself, Bollinger Bands can be used in the following ways:

1) Bollinger Bands %: Bollinger Bands % tell us where the Price is relative to the upper and lower bands and calculated as: BB % = (Price - Lower BB Band Price)/(Upper BB Band Price - BB Lower Band Price)
2) Bollinger Band Cross Overs: These occur when either the Price crosses down from above the Upper band back to within 2 standard deviations of the SMA or when the Price crosses up from below the lower band back to within 2 standard deviations of the SMA.

A BB% of 1 indicates that the price is at the upper band while a BB % of 0 indicates that the price is at the lower band. When the price crosses the upper band it can be considered overbought and an indicator that the price will fall in the future, while if they are below the lower band (BB% < 0) it can indicate the stock is oversold and the price may rise.

Bollinger Band Cross Overs can be useful because they might indicate the exact time a bearish or bullish price trend has begun and the price has started its reversion back towards its SMA. For example, when the Price crosses down from above the upper Bollinger Band to within 2 STDs of the SMA then that means prices might continue to fall. Figure 2 and 3 illustrate these indicators.

Figure 2 - Bollinger Bands

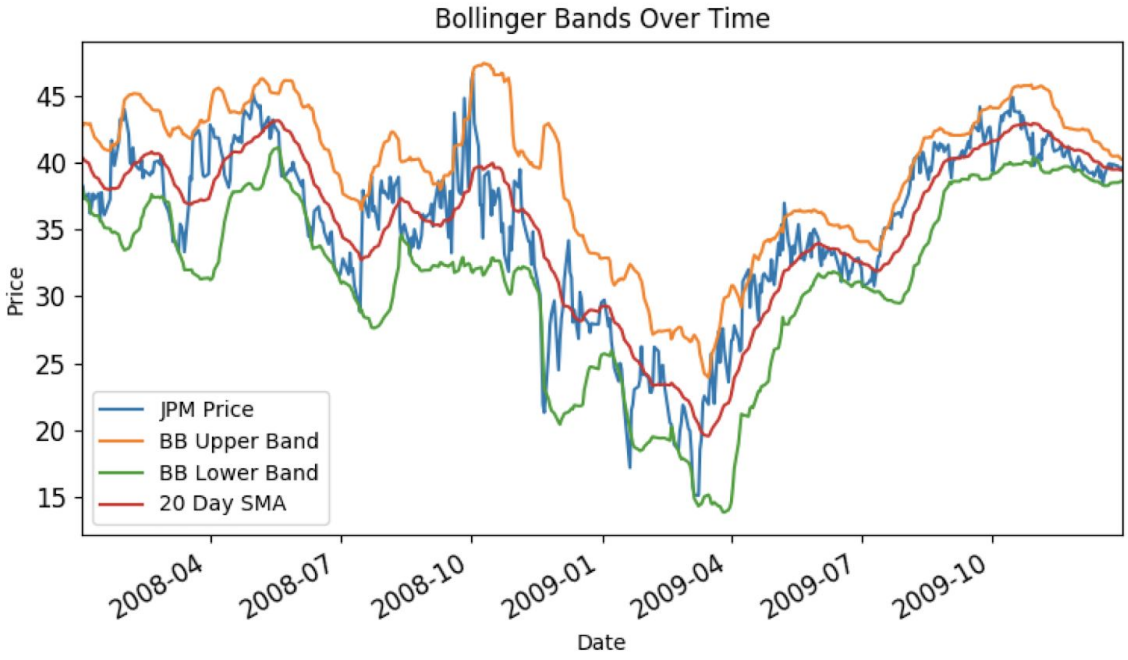
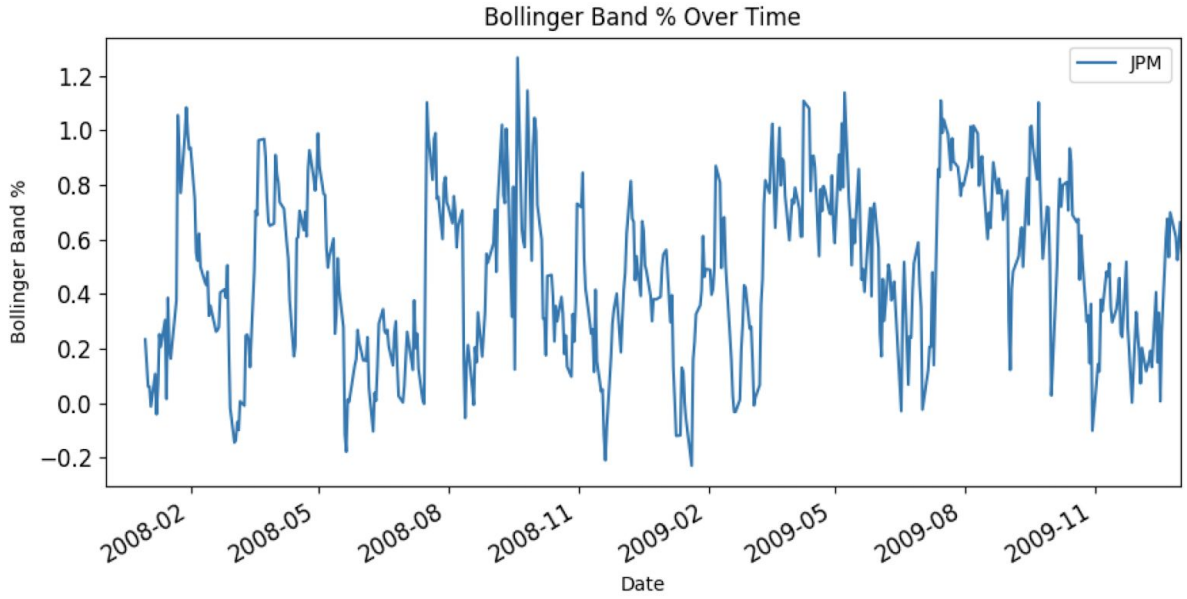


Figure 3 - Bollinger Band %



Notice in Figure 2 how the price crosses over the Upper Band in 10/2008 a few times and then immediately falls down again as we'd expect creating a selling opportunity. Similarly the Price crosses from the lower band back into the SMA in 02/2009 and immediately keeps rising creating a buying opportunity.

3) Moving Average Convergence Divergence (MACD)

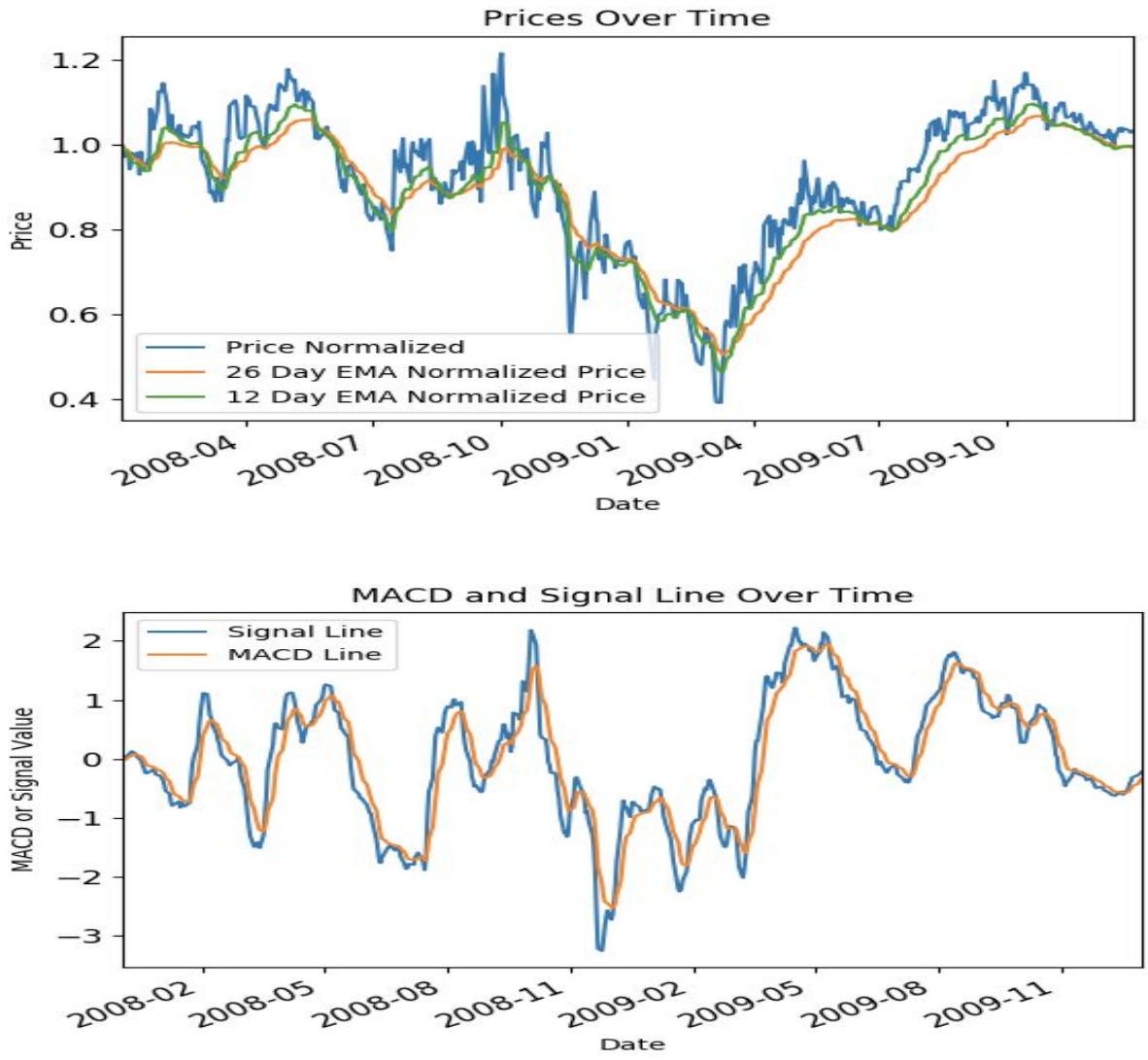
The Moving Average Convergence Divergence (MACD) is a momentum based indicator that follows the relationship between two exponential price moving averages (averages in which more recent price data is more heavily weighted vs prices from days that were long ago). The MACD Line is calculated by subtracting a Faster exponential moving average (12 days) from a Slower exponential moving average (26 days). In addition, a Signal Line is calculated which is simply the exponential moving average (9 days) of the MACD line itself.

MACD = 12 Day EMA of Price - 26 Day EMA of Price
Signal = 9 Day EMA of MACD

For trading strategies, MACD can be used when there are crossovers between the MACD and Signal Lines. When the MACD falls below the Signal line, it can mean that prices will continue to fall due and it is a sell signal. On the other hand when MACD rises above the Signal line, it can indicate that prices will rise and it is a time to buy.

Alternatively, When the MACD is rising quickly over a short period of time, this implies that the faster Price EMA is increasing more quickly than the slower Price EMA thereby suggesting that positive momentum is increasing and is a bullish signal and vice versa. Very large positive and very large negative MACD values can also indicate whether stock is overbought or oversold. When the MACD has a very positive value then this means that the shorter term price average is above the longer term average and that the stock may be overbought and a time to sell and vice versa.

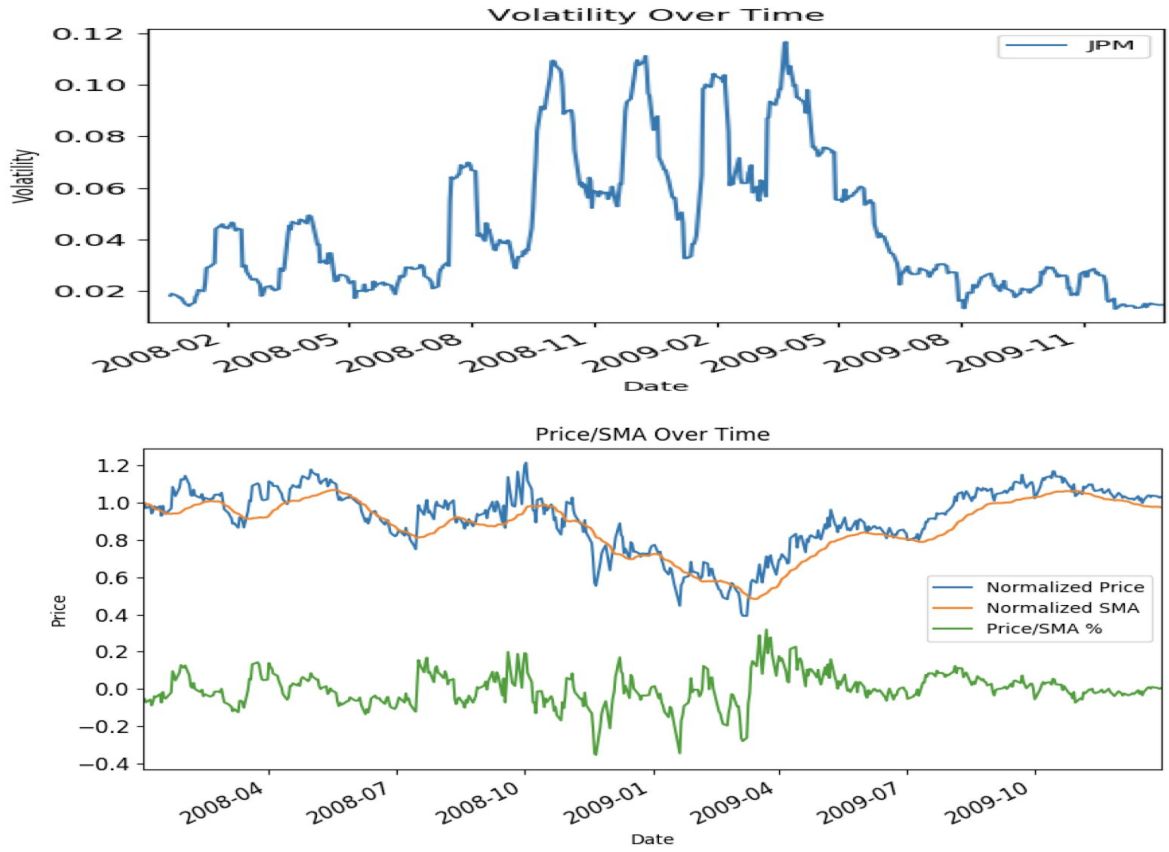
Figure 4 - EMA Prices and the corresponding MACD and Signal Lines over Time



4) Volatility

Volatility is measured as the standard deviation of the % changes in daily prices over over the last N days. Here, N was chosen as 14 days. Volatility can be used as an indicator because when volatility increases a lot it can suggest that the market isn't necessarily following a smooth trend and it can be hard to predict which direction the price of a stock is going to go. As such it can be used to deter long or short trades, or even taken as an exit market signal. The following chart illustrates volatility along with Price.

Figure 5 - Volatility and Prices over Time



Notice how in the period between 9/2008 and 4/2009 there are spikes in volatility. These then correspond to big spikes and troughs in the Price of the stock over the same period making the direction of the stock movement more difficult to predict. Increased volatility can be a time for investors to re-evaluate exposure to a stock.

Part 2: Best Possible Strategy

Before creating a trading strategy, I first created a 'best possible strategy' in which I could see into the future and know all the stock prices before hand. Doing so would help establish an upper limit to the amount I could gain in returns.

The best possible strategy was as follows:

1) If the price of the stock the next day was going to go down compared to the previous day then we would short shares up to our limiting constraint (If holdings = 0 =, then we would short sell 1000 shares, but if holdings = 1000 then we would short 2000 shares).
2) If the price of the stock the next day was going to go up then we would Buy shares up to our share limit constraint (If holdings = 0 then we would buy 1000 shares, but if holdings = -1000 then we would buy 2000 shares)

We repeat this for every day. For comparison I also established a benchmark which would simply be what our returns would be if we bought 1000 JPM shares at the start of the period and held it until the end. (Commission and Impact for both strategies = 0).

Figure 6 - Best Possible Strategy vs Benchmark Portfolio Value Over Time (Normalized)

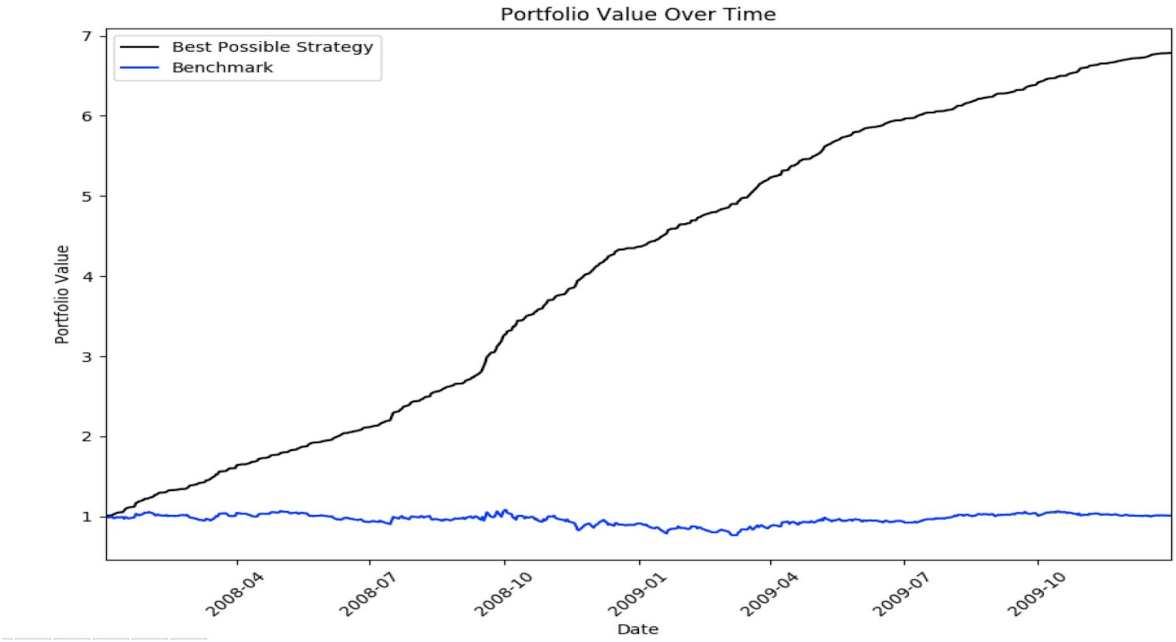


Table 1 - Benchmark vs Best Possible Strategy Performance Metrics

Metric	Benchmark	Best Possible Strategy
Cumulative Return %	0.012	5.78
Standard Deviation of Daily Return	0.017	0.0045
Average Daily Returns	0.0001	0.0038
Final Portfolio Value	101,230	678,610

From the charts, it can be seen that the 'Best Possible Strategy' keeps increasing as expected and never decreases in value vastly outperforming the benchmark. This is because we are exploiting all the price arbitrage between any two days by looking into the future. Or in other words we always know which direction the price will go the next day and either short or buy long based on that information making it impossible to make an error that would minimize gains.

Part 3: Manual Trading Strategy

With an upper limit on returns established through Best Possible Strategy, I now created a manual strategy using the technical indicators described in Part 1 on JPM stock over the training period.

In order to create a good manual strategy, I experimented with some different combinations of the 4 indicators described using boolean logic to create one single 'basket indicator' that would output one of 3 following actions. 1) Buy 2) Short 3) Exit (Sell) shares depending on the boolean value of the 3-4 indicators.

If the action were ‘Buy’ then I would buy up to 2000 shares of the stock. If the action were Sell then I would short up to 2000 shares of the stock and if the action was Exit, I would dispose whatever share (either long or short) I were holding making my holdings equal to 0. In addition, I could only act on the action if it never violated the holdings constraint. I.e: never violated the condition of accumulating more than 1000 total shares holdings.

Note on Data:
In order to create SMA, and other rolling indicators, data from prior to the start of the training period was used (December 2007). This would ensure that there would be values for the indicators starting from Day 1 of the training set. However December 2007 data was discarded after the indicators were created.

Deciding on the best combination of indicators

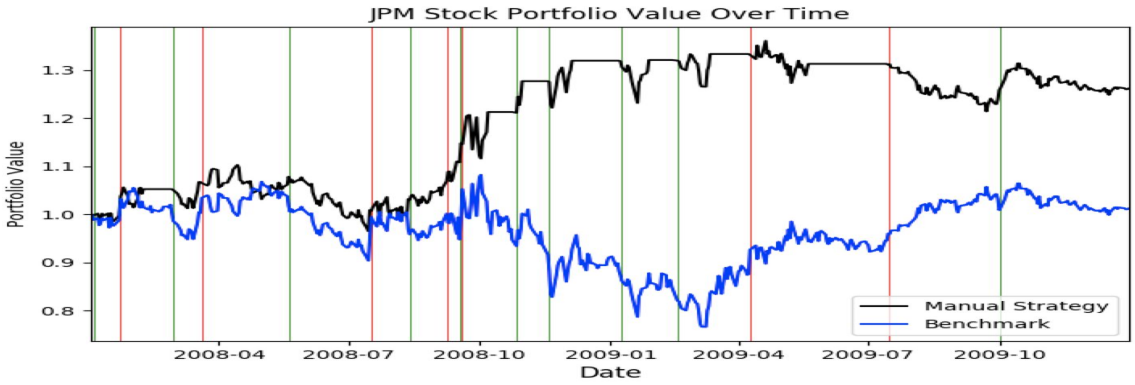
a) Using only Overbought/Oversold + Volatility Logic
To choose the best combination of indicators to combine into a basket indicator, I started with an assumption, that big short term price fluctuations were temporary noise and that prices tended to move back to their moving averages over the short terms. Hence, a huge spike in one day could eventually revert back to the SMA in the future.

Based on this assumption, I could infer that if the Price were significantly larger than the 20 Day SMA (Price/SMA % > 0.05) and if the Bollinger Band % was > 1 then this could mean that the price was likely to return back down to its SMA. The stock was overbought and this would trigger a trade to Short the stock (assuming the holding constraint wasn’t violated) as we would expect a decline in prices. On the other hand, I could infer that if the Price was significantly below the SMA (Price/SMA % < -0.05) and if the BB % was < 0 then this could mean that the price was likely to increase back towards its the SMA implying that the stock was oversold thereby triggering a trade to Buy the stock.

Finally, we would use a conservative approach to exit the market. if the Price just crossed its SMA and the Price Volatility was high (>0.04) over the last 14 days, then we would use that signal to exit the market as we might not be able to tell which direction the market would go anymore increasing the likelihood of us making a very damaging trade.

Using the criteria above, the cumulative gain came out to be around **26% after testing the strategy.** (Red lines = date when a Short Position entered. Green lines = date a Long position entered. Note: exit positions are not plotted,so possible to have 2 consecutive red/green lines).

Figure 7 - Using only (Price/SMA % + BB % + Volatility) in Manual Strategy (Overbought/Oversold)



b) Trying Bollinger and MACD Crossover Signals

However, relying on overbought/oversold logic alone can be risky and lead to false flags. For example a stock may be above its Price/SMA but this might be because it has very strong positive recent momentum which may be expected to carry it up even further. Also, exiting during increased volatility can mean we might miss out on huge gains from sudden price changes. For this reason I tried to see if relying on an entirely different approach of using crossover signals to buy long and sell short would yield better results.

The cross overs I used as buy or sell signal were either the MACD and Signal Line Crossover or the Price and Bollinger Band Upper/Lower Band Crossover (both described in Part-1). I then plotted my performance and cumulative returns of using 1 or both of these indicators combined.

Table 2 - Results of Different Crossover Strategies

Strategy for Long and Short	Final Portfolio Value	Cumulative Return %
Only if Price + Bollinger Band Cross Over occurred	$89,384	-10.6%
Only if MACD and Signal Line Cross Over occurred	$42,016	-57%
Only if either Bollinger crossover or MACD + Signal Line Crossover occured	$60,169	-39%
Both Bollinger Crossover and MACD + Signal Line Crossover occurred	$106,102	+6.1%

From above we see that using any combination of crossovers as signals to buy, exit, short led to poorer performance of the JPM stock compared to using just a strategy when the stock could be bought based on perceptions of overbought/oversold using Price/SMA and Bollinger Band %. Below are the charts from 2 of the underperforming crossover strategies showing losses/poor gains.

Figure 8 - Crossover Trade Strategy (Either a favorable Price over Bollinger Band Crossover occurred or a favorable MACD and Signal Line crossover occurred)

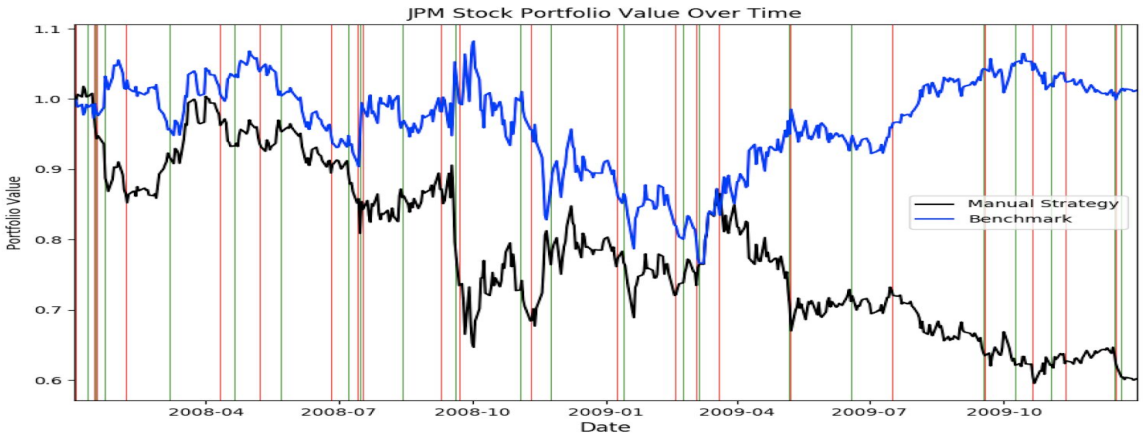
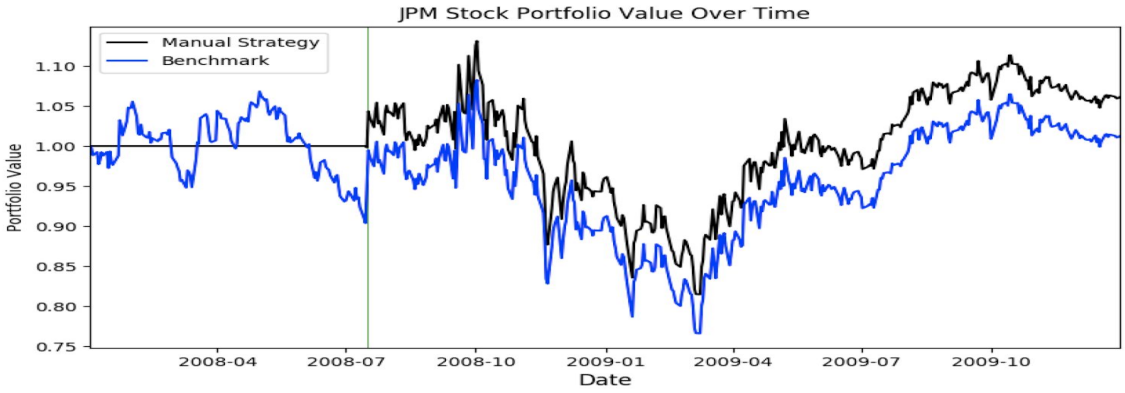


Figure 9 - Both Price Bollinger AND MACD Signal Line Crossovers Occurred at the same time



C) FINAL MANUAL STRATEGY - Using both Crossovers and Overbought/Oversold Indicators

Therefore, using Bollinger Band or MACD Line crossovers alone did not lead to improved performance. However, what if we diversified our strategy to account for both scenarios that is when MACD crossovers occurred but also when the stock could be overbought/oversold by looking at Price/SMA or BB %?

This would have the benefit of diversifying strategy so that it wasn't reliant on only one logical system and smooth the decision function to be less susceptible to noise from one signal. The intuition is similar to that of using a bagged learner where an ensemble of different models combined can lead to an aggregate improved performance by reducing overfitting and reducing false flags that one indicator might generate. Results for the combined strategy are below.

Figure 10 - FINAL STRATEGY = Combining MACD Crossover with (Price/SMA + BB %) and Volatility Exit Check

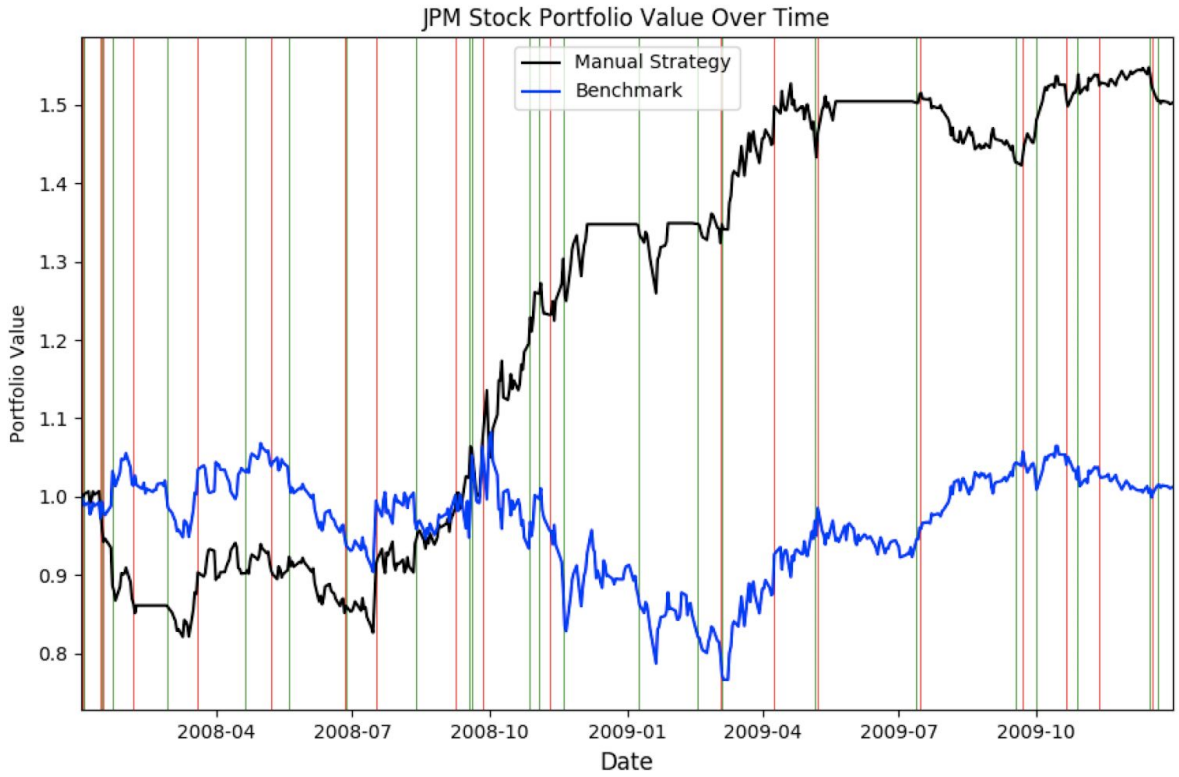


Table 3 - Benchmark vs Best Possible Strategy Performance Metrics

Metric	Benchmark	(Final) Manual Strategy
Cumulative Return %	1.2%	50.9%
Standard Deviation of Daily Return	0.017	0.013
Average Daily Returns	0.0001	0.0008
Final Portfolio Value	$101,230	$150,294

From the chart/table above, it can be seen that a diversified strategy that uses both crossover signals from the MACD crossing the Signal line as well as overbought/oversold logic using Price/SMA or Bollinger Band % combined with a Volatility Indicator yields the best return outperforming the individual components of its strategy. Adding MACD leads to improved performance by around 25%, even though using MACD by itself leads to horrible negative gains (see Figure 8). (Note: adding Bollinger cross over instead of MACD didn't improve performance so it was left out)

Final Manual Trading Strategy (based on above)

Therefore, based on the above findings, the final manual strategy used is as follows from part C:

a) If (price/sma % > 0.05 & bollinger band % > 1) or (MACD crosses below the Signal Line from above), then we Buy Long

b) Else if (price/sma % < -0.05 & Bollinger Band % < 0) or (MACD crosses above the signal line from below), Then we Short Stock

c) Else If Price crosses its SMA and Volatility > 0.04, then we Exit our position and sell whatever we hold

This strategy yields **50.8%** in returns.

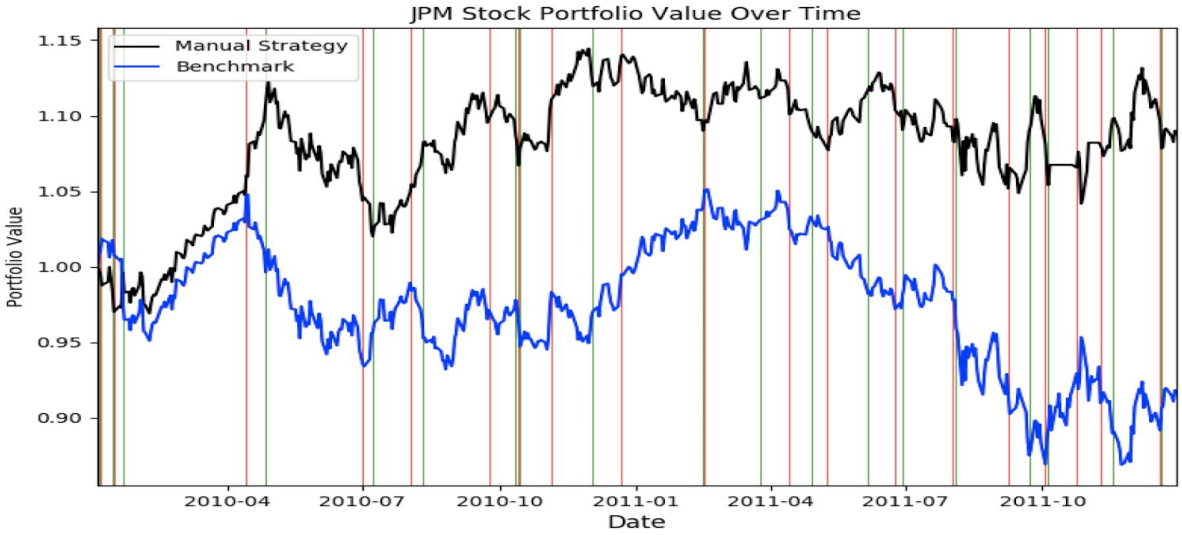
Part 4 - Comparative Analysis

Finally, we test the strategy on unseen out of sample test data from Jan 1, 2010 to Dec 31st 201. The results are summarized in Figure 11 below. From the chart/table we can see that the manual strategy performs worse on out of sample test data from 2010 to 2011 (drop in cumulative gains from 50% down to only 9% in out of sample). However, it still manages to beat the benchmark as the benchmark actually loses 8% in value over the test period.

Table 5 - Comparison of Manual and Benchmark Strategy Performance on In and Out Sample Data

	Manual Strategy Cumulative Return %	Benchmark Cumulative Return %	Difference in Returns
In Sample	50.8%	1.2%	49.6%
Out Sample	14.6%	-8.3%	22.9%

Figure 11 - Final Manual Strategy Performance on Out of Sample Data (Jan 2010 -Dec 2011)



The poorer performance of the manual strategy in out of sample data can be explained by the fact that training on the in sample period involved me to tweak parameters (choosing N for SMA, Bollinger Band etc) and run multiple simulations through numerous combinations of indicators, looking for the best performing combination of indicators for the strategy. However, this led to overfitting on the training data. Second, we only developed this strategy using 1 stock symbol. Focusing on a single stock increases the risk of overfitting as we can model noise. If we trained a strategy over a portfolio of many S&P 500 stocks we could create a more robust strategy.