

Project 6: Indicator Evaluation

CS 7646

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Abstract—This project implements five technical indicators - Exponential Moving Average(EMA), Momentum (MOM), Bollinger Bands Value (BBValue), Moving Average Convergence Divergence (MACD) and Relative Strength Index (RSI). Methods adopted are explained with the results obtained in this report. Later, it will present a comparison between a benchmark and theoretically optimal strategy to generate the trades by computing portfolio values.

1. INTRODUCTION

This report consists of two parts - defining five technical indicators and description of a strategy which generates trade in a theoretical optimum way assuming that we can foresee future. The indicator section will explain the method, pros and cons along with the charts obtained for given example. The second part of the project describes a theoretical strategy which is based on the fact that we have the knowledge of future prices. This strategy is supposed to maximise the cumulative return and is compared against the benchmark given.

2. METHOD

The project requires python installed with packages - numpy, matplotlib, scipy, time, math. The data used should be kept in Data folder only. JPM.csv data is used here from '2008-01-01' to '2009-31-12', window size = 20. To repeat the experiments run main function of testproject.py file from any IDE or run the command `PYTHONPATH=../:. python testproject.py`. To modify the stock, start date, end date, start value or window update the main function of this file.

3. TECHNICAL INDICATORS

These indicators are often used to provide signals for buy or sell. There are two kinds - overlays (EMA, BB, MOM), which are placed on top of the price chart; and oscillators (MACD, RSI) which are drawn below or above the price chart.

3.1. Exponential Moving Average (EMA)

Moving averages is used to smooth out the the price data to keep a constantly updated average. It is a lagging indicator because it is based on past data. Lagging increase if window size increase. Here we have used exponential moving average, an indicator purposed to put more weight on recent data while calculating average for a given period.

$$\text{EMA}[t] = V[t] * W + \text{EMA}[t-1] * (1 - W)$$

t = current day

V = adjusted close price today

W = multiplier = $2 / (P + 1)$

P = number of days

To calculate EMA we use previous period EMA and a weight multiplier. Firstly, to begin calculate the simple moving average for the period. Secondly, calculate the multiplier, for example, for a period (window or lookback) = 10 the multiplier is $2 / (10 + 1) = 0.1818$. Thus it will be a 10 period EMA or 18.18% EMA. Thirdly, calculate the current day EMA using previous day EMA = (current price - EMA(previous day)) * multiplier + EMA(previous day).

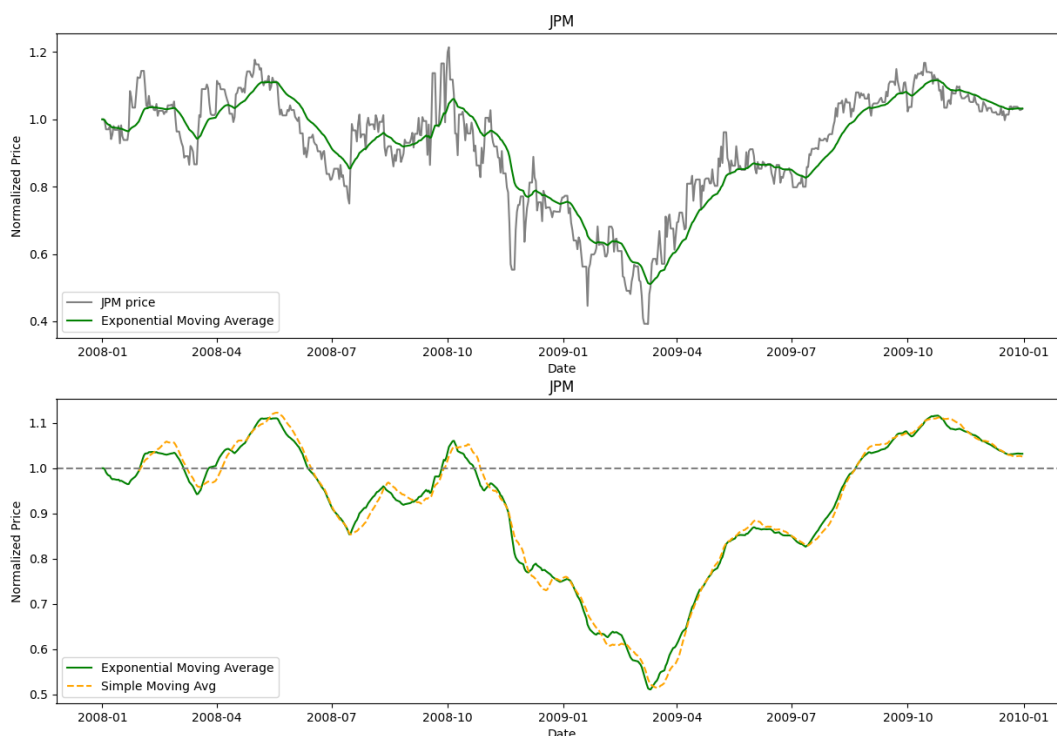


Figure 1—Exponential Moving Average along price and SMA.

EMA have less lag than SMA. It is used to generalise the trend of the stock prices. A long term rising average presents a strong upward trend in stocks and similarly for downward trend. Crossover signals of moving average with prices or different period moving average can be used as a signal. For instance, with simple moving average being stable if the price goes very high that can be a sell signal.

3.2. Moving Average Convergence/Divergence Oscillator (MACD)

This indicator turns two period moving average (12 day ema and 26 day ema) into a simple and most effective signal available. It represents the difference between the short and longer trend following indicators. This conjugates both trend following and momentum.

$$\text{MACD} = \text{EMA}[12 \text{ day period}] - \text{EMA}[26 \text{ day period}]$$

The MACD oscillates above and below zero line as the two moving averages converge(<0), cross (=0) and diverge(>0). The shorter trend is faster and longer trend is slower and less responsive to price changes. Positive EMA means that shorter EMA is higher than longer, therefore strong **upside momentum**. Negative value means shorter is lesser than longer, therefore strong **downside momentum**.

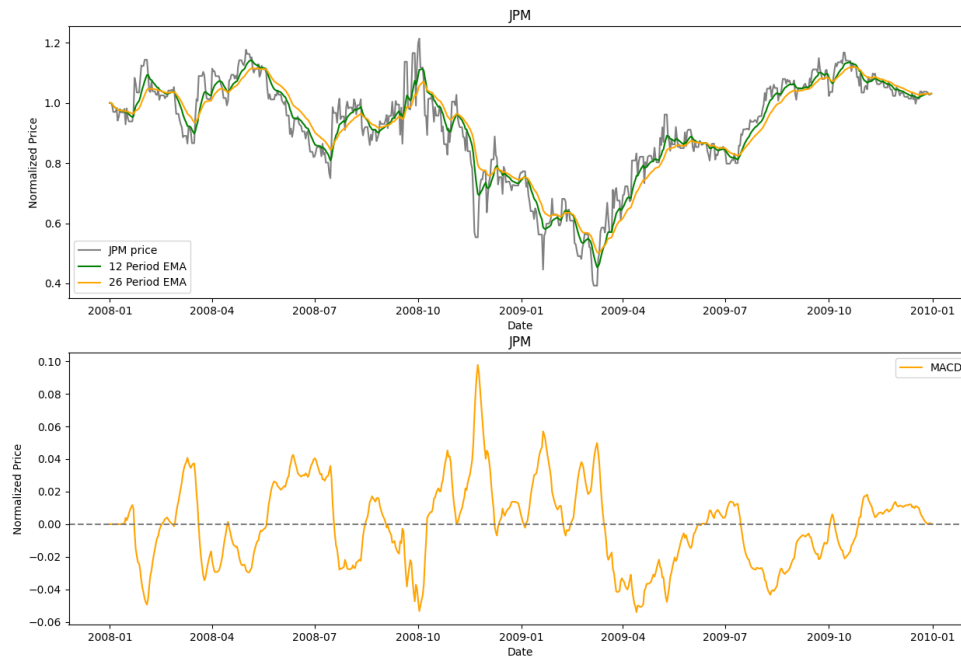


Figure 2—Moving Average Convergence/Divergence below price chart. Two 12 day EMA and 26 day EMA along price chart.

3.3.Momentum (MOM)

Momentum is price change over n day period given for analysis. This reflects the ratio by which price has change from n days back. It is calculated by dividing current day price and (n-1)th day price. It is similar to rate of change, and does not normalise the price.

$$\text{MOM}[t] = \text{Price}[t] - \text{Price}[t-n]$$

{ t: current day, n: period days ago}

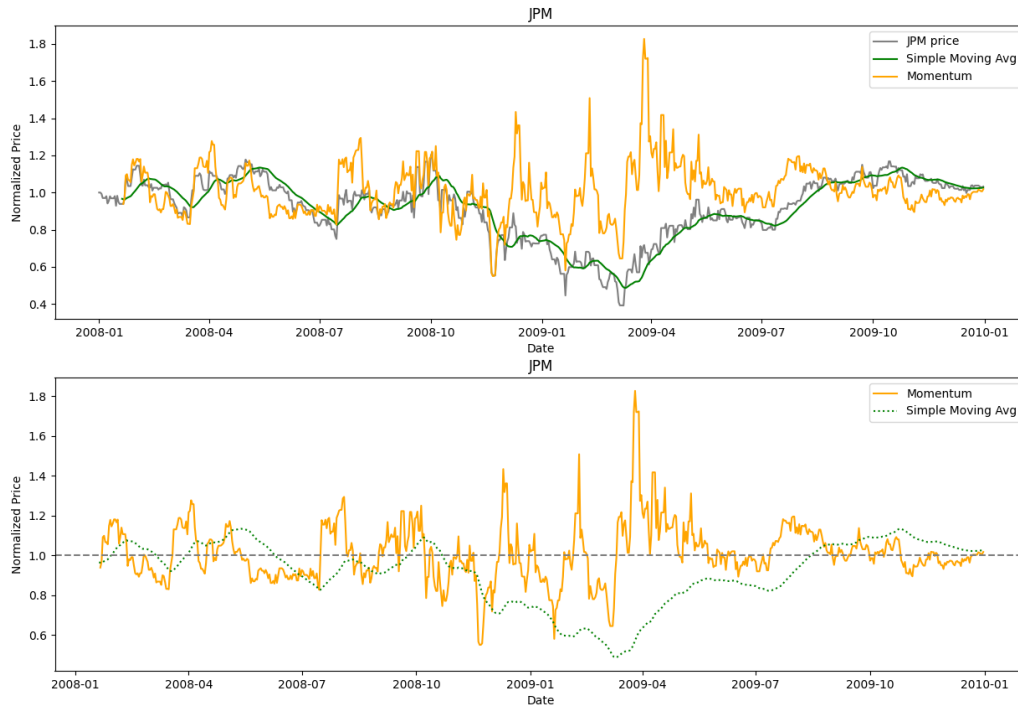


Figure 3- Momentum and Simple Moving Average combined to understand the strong price trends.

MOM is an oscillates above and below 1.0. Individually MOM and any Moving Average does not provide strong indications but as a popular example Momentum when combined with Simple moving average provides confidence in trends observed. MOM at extreme value shows a strong continuation in the trend observed by moving average, but if MOM moves along SMA, then this means that market is very much volatile. Whenever, prices make a new high or low which is not in sync with momentum then it means that the price reversal is guaranteed and hence a selling or buying signal.

3.4. Bollinger Bands Value (BB)

Bollinger Bands created by John Bollinger plots upper and lower enveloping bands around price indicators. It is at a distance of two times standard deviation from the moving average. It represents the volatility present in the stock price data. It is plotted with price and SMA. If the price moves out of the upper band that indicates to sell signal as it is said to be bound to resonate back to the moving average. Similarly, if the price goes below the lower band it is said to be underbought and hence a buy signal as it is expected to move back within the bands.

$$BB = [SMA + STD, SMA - STD]$$

$$BBValue = (Price[t] - SMA[t]) / 2 * STD[t]$$

t - Current Day

BB - Bollinger Bands

SMA - Moving Average

STD - Moving Standard Deviation

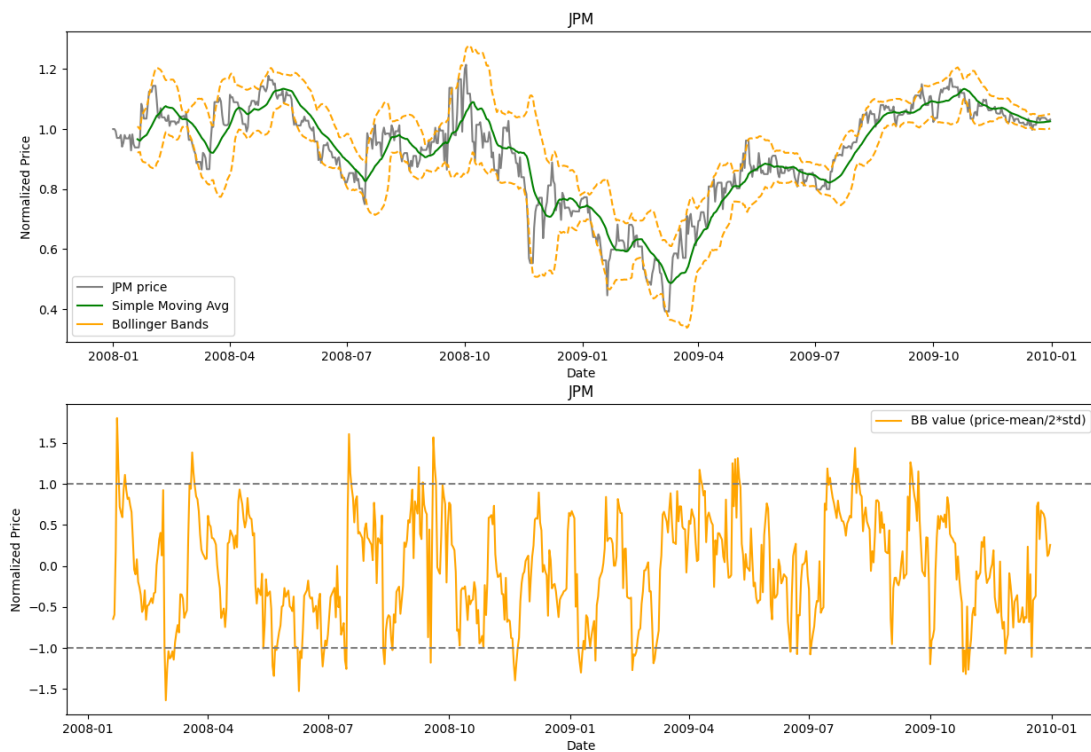


Figure 4- Above chart shows the Bollinger Bands enveloping prices. Below chart shows the oscillating value which sometimes crosses 1.0 and -1.0 to indicate moving out of the bands.

Bollinger bands can be represented by a value which is a ratio of difference between price and its moving mean to twice the moving standard deviation. This value moves above and below one (1.0). A value above 1.0 means that the stock price is above the upper band and below 1.0 means it is below the lower band.

BB can be combined with MACD to bring volatility along with trend-following and momentum. Breakout from the Bollinger bands present high volatility and high MACD represents an increasing divergence. This can indicate if we need to long the stock or short it.

3.5. Relative Strength Index (RSI)

RSI is an indicator which oscillate between 0 to 100 depicting the percentage to measure the recent price changes. It is similar to momentum indicator and signals an overbought or underbought situation. RSI is plotted beneath the price graph and signals overbought above 70% and underbought 30%.

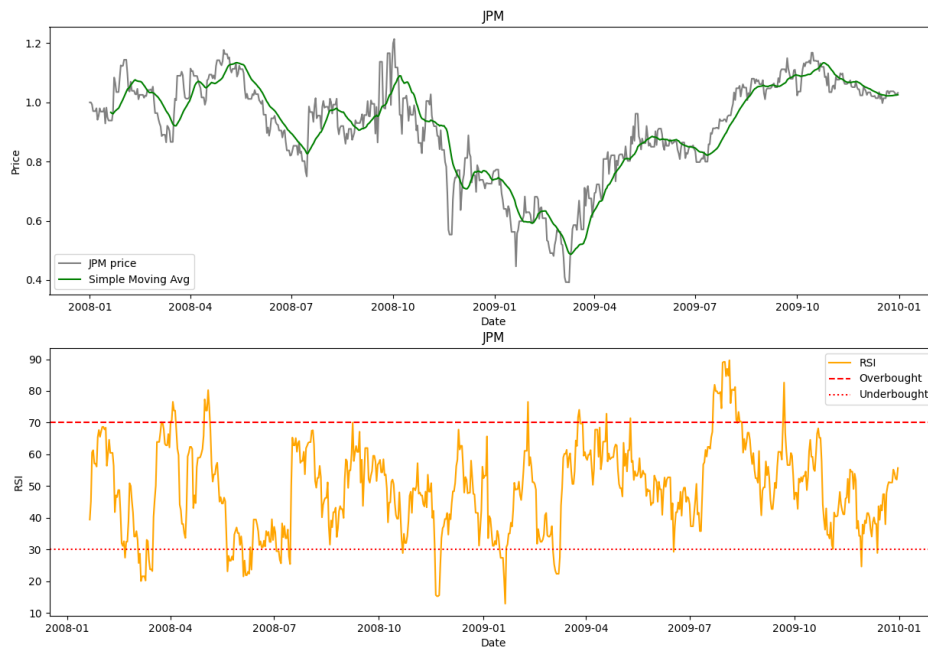


Figure 5- Graph showing the RSI value (momentum oscillator) with benchmark 70% and 30%. Beneath Price and SMA.

It is calculated for 14 day period on standard but here it is calculated for a window size of 20 days. Its calculation involves two parts - RS and RSI.

RS is the ratio of smoothed average of n-period gains divided by the absolute value of the smoothed average of n-period losses.

$$RSI = 100 - (100 / (1 + RS))$$

It represents the current price relative to the recent prices within the selected lookback window. RS is calculated based on the daily returns.

1. Find the daily returns for each day
2. Find the cumulative gains (where daily returns ≥ 0) and absolute (positive) cumulative losses (where daily returns < 0) for each day.
3. Subtract the cumulative gains[t] from cumulative gains[t-n]. Do the same for cumulative loss. Then divide the values by window size. This will create average gain and average loss vectors for each day.
4. Now for the first step $RS = \text{moving average gain} / \text{moving average loss}$ and for the second step find index RSI by using following formula given above.

The RSI will rise as the number and size of positive closes increase, and it will fall as the number and size of losses increase. A reading below 30 will be a buy signal and above 70 it will show a sell signal.

4. THEORETICALLY OPTIMAL STRATEGY

4.1. Development of strategy

It is clear that we have prior knowledge of price that it is going to be tomorrow. Therefore, to maximise the profits and keep it simple the everyday trade is decided on the basis of whether the price will move up or down tomorrow. Hence, there are three cases - $\text{price}[t+1] == \text{price}[t]$ (constant), $\text{price}[t+1] > \text{price}[t]$ (move upward), and $\text{price}[t+1] < \text{price}[t]$ (move downward).

Case 1 - Price constant : Nothing to be done, hold until market moves.

Case 2 - Price will go up : this provides an opportunity to maximise profit

BUY: If net holdings < 1000 . There are two ways if we are short of 1000 shares that is net holding is -1000, then we buy 2000. Or if we are at 0 net holdings then we are allowed to buy only max of 1000 units.

HOLD: If net holdings = 1000.

Case 3 - Price will go down : this provides an opportunity to either book profit or even short the stocks to maximise further. This again depends on net holdings -

SELL: If equal to 1000, then we can book profit and short by selling 2000, that is order will have -2000 value. If the net holdings = 0 then we can only short by creating an order for -1000.

HOLD: If net holdings = -1000.

For the last day it is programmed to have zero net holdings, thus, if we have net holdings = -1000 then we buy 1000, if it is equal to +1000 then we sell. And we have our cumulative return.

There were not any specific assumptions made apart from that the leverage will be unlimited with 0.0 commission and 0.0 impact. However, the trades were generated only for the eligible dates (when SPY traded too).

4.2. Results obtained

The results for this report were generated for 'JPM' stocks from '2008-01-01' to '2009-31-12' with a starting value of \$100,000. The trades generated using the strategy in section 4.1 was used. The portfolio values generated in last step were then compared and plotted against a given benchmark trade order where we buy the stock on first legal date and hold until the last eligible date.

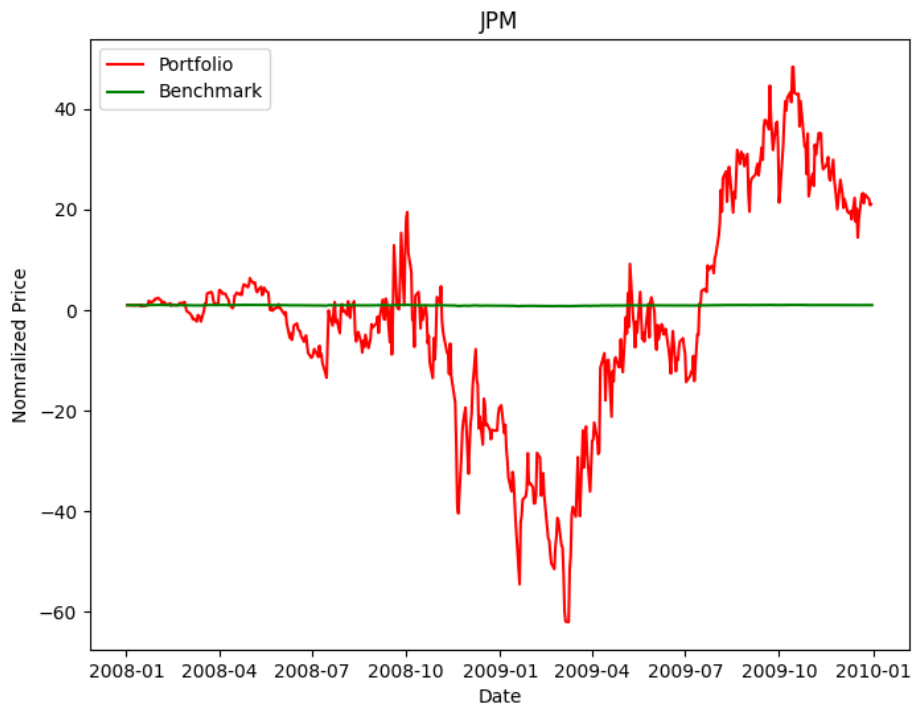


Figure 6- Portfolio values for trades generated against the benchmark order trade values.

4.3. Interpretation

From Table 1 we can safely say that theoretically optimum strategy has generated trades which has multiplied the starting balance by a factor of 21. This shows that the strategy worked. However, one thing notice is that the portfolio might have ended anywhere in the graph and there would have been a string downside trend if it ended in middle around 2009-04. But our strategy would have only benefitted as we must be shorting the stocks and making profits for small rises on daily basis. Therefore our strategy was never at risk. But only if knew the future price in real.

Trades	JPM (Benchmark)	JPM (theoretically optimum)
Sharpe ratio	20.0856	0.0123
Average Daily Returns	-0.222	0.157
Cumulative Returns	-0.134	0.000168
Standard Deviation	9.573	0.017
Final Portfolio Values (Normalised)	21.0856	1.0123
Final Cash Balance	21,08,560	1,01,230

Table 1- Comparison Summary

2. SUMMARY

The project helped in understanding several technical indicators and their pros and cons. In fact, developing a strategy in part two gives an idea how indicators will be helpful in day to day trading. The technical indicators are better when conjugated together, gives confidence in the trends observed. Trader should never trust just one indicator, more the merrier (only if they make sense together).

3. REFERENCES

1. <https://www.dailyfx.com/education/bollinger-bands/macd.html>
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3. http://lucylabs.gatech.edu/ml4t/wp-content/uploads/2020/05/CD-B_vectorize_me.pptx.zip
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