CS 7646 Project 6: Indicator Evaluation

Nick DiNapoli
ndinapoli6@gatech.edu

***Abstract*—**In this work I create a theoretical optimal strategy (TOS) for trading a stock/equity by knowing/seeing the future (price over a period of time). I examine how well a portfolio could do for a particular stock given this strategy and its constraints and benchmark it against a passive holding strategy. Additionally, I use this data and evaluate 5 technical indicators of the stock over said time period. I analyze these indicators and discuss how they could be used to trade the equity. I use JPMorgan Chase & Co. (JPM) daily adjusted close data over the period January 1, 2008 to December 31, 2009.

1 THEORETICALLY OPTIMAL STRATEGY

I aimed to create a trading strategy that would yield optimal returns by examining the stock price of JPM over the two year period. In this way I was able to see into the future. I developed this strategy under the constraints that I could not have more than 1000 shares long or 1000 shares short but that I could trade 2000 shares at a time so long as these holding conditions are met. After developing this strategy, I compare the value of a portfolio based on my strategy and a benchmark strategy where I buy 1000 shares on day 1 and hold them for the entire time period. For this analysis and each strategy, I assume that I start with $100,000. I also assume that there is no commission or impact for each trade.

It is simple to develop a strategy that generate large returns when you know the future stock price but optimizing this strategy is a but nuanced. I first hypothesized a strategy that traded on each day because I know the value of the stock on the very next day. This makes sense and the real issue at hand here is how much to buy/sell each day. I soon found that this method just takes the weighted average of daily returns over a small window of time where the stock prices increases or decreases monotonically. It actually is more profitable to find the most profitable day in the near future and max out the long or short position (abiding by the constraints). I considered the fact that I could look into the future and choose the most profitable days to trade (by examining the daily returns of JPM), but the issue with this if those daily returns are all positive then I quickly run out of

shares to trade and again one ends up taking a weighted average of those returns.

The way that I see it, one could trade more efficiently but more sparse or nearly optimally efficiently but more frequent. Depending on the constraints and price data of the stock, one strategy may work better than the other. Instead of choosing a set day-window and looking at the largest future return in that period of time, the strategy that I developed used the change in sign of the daily returns as an indicator (i.e. a buy/sell is triggered the day before the stock goes from a negative return to a positive or a positive return to a negative). More elegantly, my trading strategy and pseudo code is as follows:

1. Calculate the daily returns of JPM over the time period
2. Initialized a data structure to store current holdings, trading dates and trading amounts
3. Iterate through the time series data
   (a) If the sign of the return on the next day is opposite of the current day (i.e. the price of JPM went down today but goes up tomorrow) trigger a buy/sell
   (b) If there isn't a sign change, don't trade any shares
   (c) Check sign change direction and current holdings
   (d) If the stock goes up tomorrow JPM_Price[t+1] buy the maximum number of shares allowed (1000 if holdings is 0 and 2000 if holdings is -1000) today JPM_Price[t+1]
   (e) If the stock goes down tomorrow JPM_Price[t+1] buy the maximum number of shares allowed (1000 if holdings is 0 and 2000 if holdings is -1000) today JPM_Price[t+1]
   (f) Add the trade date and the trade amount to the respective data structures
   (g) Update the current holdings
4. Return a dataframe of each day in the time period with the number of shares traded on that day (positive for buy, negative for sell)

Figure 1 shows the normalized daily portfolio value of two portfolios: one that uses my TOS and a benchmark that purchases 1000 shares of JPM on the first trading day of the time period and holds it through the end of the time period. Each portfolio starts with $100,000 but values here are normalized. Table 1 summarizes the comparison in a more quantitative manner.

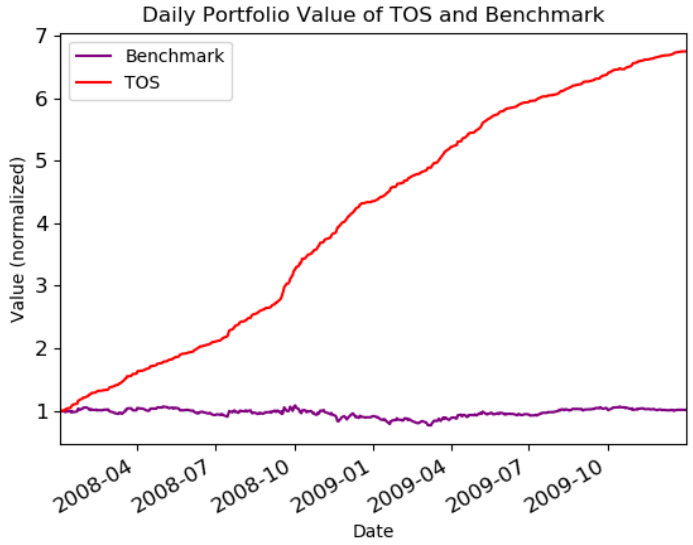

Figure 1—Portfolio value of my TOS versus the benchmark strategy. The TOS significantly outperforms the benchmark as expected.

Performance Metric	TOS	Benchmark
Cumulative return	5.752300	0.012300
Standard deviation of daily returns	0.004584	0.016987
Mean of daily returns	0.003799	0.000168

Table 1—Performance of TOS compared to the benchmark strategy.

It is clear from Figure 1 and Table 1 that the TOS significantly outperforms the benchmark strategy as expected. The TOS earned nearly 6X returns while the benchmark achieves about 12%. After all, I am looking into the future so I would expected it to outperform the benchmark by this amount. Also, the TOS earns much higher daily average returns as well as being much less risky with a smaller standard deviation of daily returns.

2 INDICATORS

I now turn to evaluating, implementing, and analyzing five technical indicators that can be used to assess a stock's price, and more importantly, be used to determine when someone should buy or sell the equity. As exemplar data, I use JPM again over the same time period.

2.1 Simple Moving Average (SMA)

The SMA calculates the average of a selected range of prices (1). In my implementation, the SMA calculates the average of the adjusted closing prices of the previous n days and this sliding window is applied to the entire time series such that it smooths over the noise and volatility of day-to-day price changes. Mathematically, the SMA is calculated as:

$$SMA = \frac{P_{t-n+1} + P_{t-n+2} + ... + P_t}{n} \tag{1}$$

where P is the adjusted closing price, t is index of the day (0 being today/the day one is calculating for) and n is the window size or number of days into the past one looks into. In my analysis I used the 50-day SMA (essentially a month of trading days). Figure 2 shows the price of JPM stock over the time period, the 50-day SMA, as well as the Price/SMA ratio.

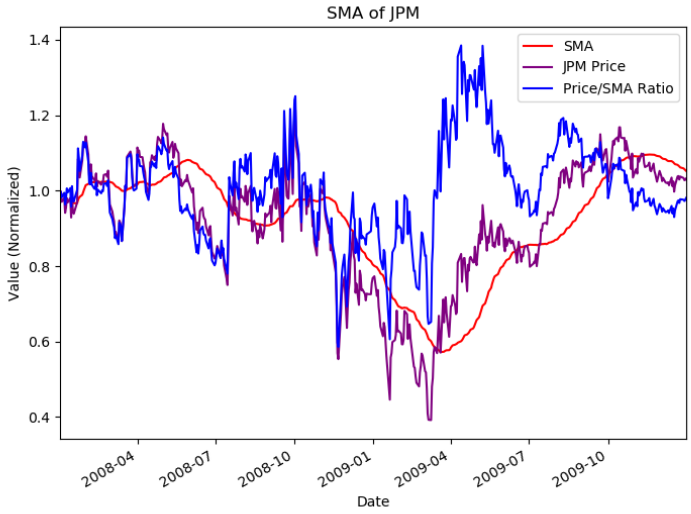

Figure 2—Price, 50-day SMA and Price/SMA ratio for JPM.

The SMA can be used in a host of ways. First, it can be used quickly to determine if an asset is trending upwards or downwards in the short/medium/long term (1). The short/medium/long term aspect is determined by the n days. Getting more specific, as an actual indicator many people compare the short and long term SMAs and analyze where they cross. For simplicity, here I include the Price/SMA ratio which can be used as an indication of when to buy/sell. For example, when the price is much higher than the 50-day SMA (look at April of 2009) the Price/SMA is much greater than 1 before the stock shoots up so this would be a buy signal. The same goes for the contrary. In this way, one might set upper and lower thresholds on the Price/SMA ratio and when the values exceed those thresholds, a buy/sell is triggered. An example for the data above might be thresholds of 0.9 and 1.1.

2.2 Momentum

The momentum of a stock measure the rate of rise or fall of stock prices in a given period of time (2). In a sense it is just the slope of the stock price over said time period. Once again the momentum can be short/long term depending on how far back one looks into the past. For my analysis I used a 20-day momentum of the adjusted closing price of JPM. Mathematically, the momentum is:

$$Momentum = \left(\frac{P_t}{P_{t-n}}\right) - 1 \tag{2}$$

where P is the adjusted closing price, t is the current time step and n is the number of days into the past one looks to calculate the rate of change.

Figure 3 shows the 20-day Momentum of JPM over the given time period. As it can be seen the 20-day momentum is a bit volatile because the JPM price does a fair bit of short-term rising and falling.

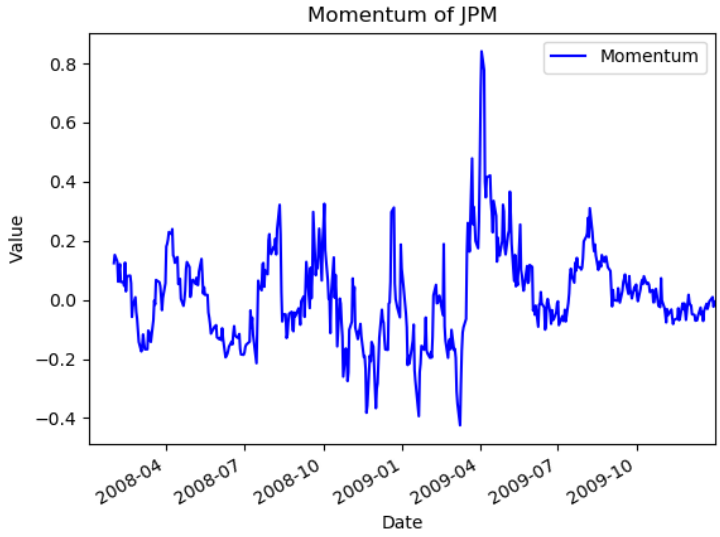

Figure 3—20-day Momentum of JPM.

Again, the ultimate goal is not just to view the momentum but use it as an indicator. Depending on the n used, Momentum could follow the Price/SMA quite closely but not exactly. To yield two indicators that could provide useful information on different time scales, I used a medium term SMA and a short-term Momentum. To indicate buy/sell signals, I could again set upper and lower thresholds (not necessarily centered however) and trade on days where they are exceeded. For this dataset I might consider setting a buy signal when Momentum exceeds 0.15 and a sell signal when Momentum drops below -0.15.

2.3 Stochastic Indicator

The Stochastic Oscillator/Indicator is another momentum indicator which compares the closing price of a stock to a range of its prices over a given period of time. It is used as a measure of overbought and oversold trading signals and is represented as a percentage (3). Mathematically, the Stochastic Oscillator is described as:

$$\mathrm{Stochastic\ Oscillator} = \left(\frac{C_t - L_{14}}{H_{14} - L_{14}}\right) \times 100 \tag{3}$$

where C_t is the current adjusted closing price, L_{14} is the lowest price traded in

the previous 14 day period, and H_{14} is the highest price traded in the previous 14 day period. Again, the sensitivity of the oscillator can be adjusted by changing the number of look back days but 14 days is the standard for the indicator and hence why it is used in my analysis. It is worth noting that Equation 3 is often referred to as the fast stochastic indicator and one could take the moving average of this to make it slow. Figure 4 shows the Stochastic Indicator for JPM over the time period.

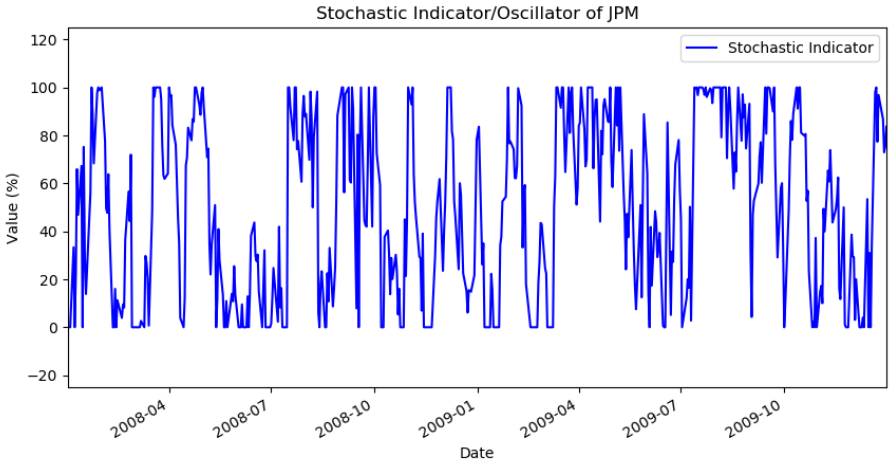

Figure 4—Stochastic Oscillator of JPM.

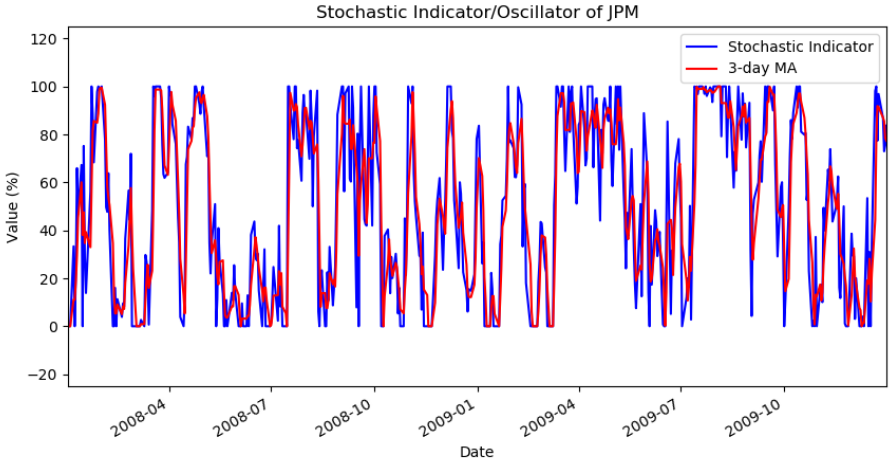

Figure 5—Stochastic Oscillator of JPM with its “slow" 3-day MA.

Typically, Stochastic Indicator values above 80% are considered the overbought range and likewise, under 20% the oversold range but these are not the tell all (3). Although these values are useful, it is the change in the Stochastic Indicator that is said to be a useful indication. It is common to look at where the fast stochastic oscillator crosses through the slow indicator because this could represent a reversal in the works (3). Figure 5 shows exactly this. In an upward trending market, prices will close near the high and the fast indicator will exceed the slow which can be used as a buy indicator. An example would be in April of 2009.

2.4 %B

The %B indicator quantifies a stock's price relative to the upper and lower Bollinger Bands and is often used to determine when a stock is overbought/oversold (4). Because it makes use of the Bollinger bands, it inherently uses the SMA which I employ using a 20-day SMA. The 20-day SMA is most common for the Bollinger Bands as well as %B Indicator. Mathematically, the %B Indicator is:

$$\%B = \left(\frac{P_t - Lower\ Band}{Upper\ Band - Lower\ Band} \right) \tag{4}$$

where P_t is the current adjusted closing price, Upper Band is the value of the upper Bollinger Band at period t, and Lower Band is the value of the lower Bollinger Band at period t. According to (4), there are six relationship levels:

- %B is below 0 when price is below the lower band
- %B equals 0 when price is at the lower band
- %B is between 0 and .50 when price is between the lower and middle band (20-day SMA)
- %B is between .50 and 1 when price is between the upper and middle band (20-day SMA)
- %B equals 1 when price is at the upper band
- %B is above 1 when price is above the upper band

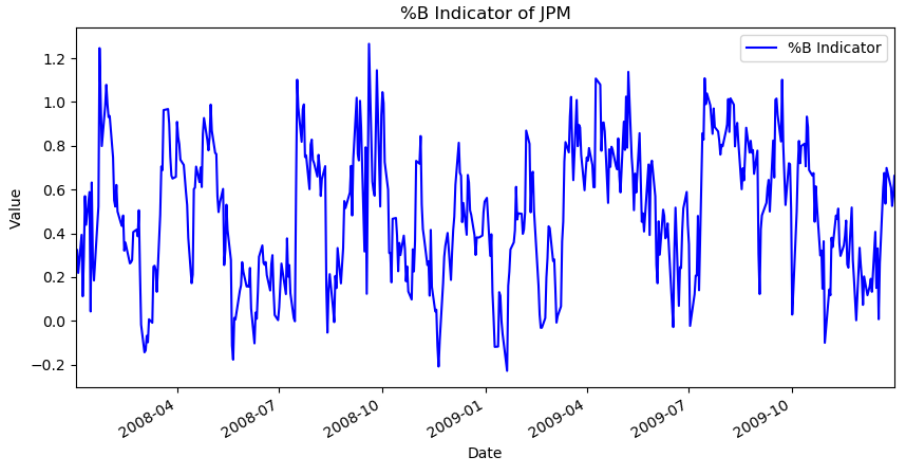

Figure 6—%B Indicator of JPM over the time period.

Figure 6 shows the %B Indicator for JPM during the same time period. John Bollinger claimed that an uptrend begins when the %B passes 0.8 (can be interpreted as overbought) and a downtrend is identified when %B falls below 0.2 (can be interpreted as oversold) (4). However to make better distinctions on trading signals it should be used with other indicators because it is best to hunt for short-term oversold periods with medium-term uptrends as well as the opposite with periods of overbuying and downtrends. In this way, one might combine this indicator with Momentum or the Stochastic Indicator for buying/selling.

2.5 True Strength Index (TSI)

The TSI is another momentum oscillator used to identify trends and reversals, and like other indicators of its kind, oversold and overbought conditions (5). Mathematically, its calculated as:

$$\mathrm{TSI} = \left(\frac{\mathrm{Double\,Smoothed\,PC}}{\mathrm{Double\,Smoothed\,Absolute\,PC}} \right) \times 100 \tag{5}$$

where PC is the price change of the current price minus the prior price and the double smoothing is the 13-day exponential moving average (EMA) of the 25-day EMA of the PC or absolute PC. Figure 7 shows the TSI for JPM over the given period.

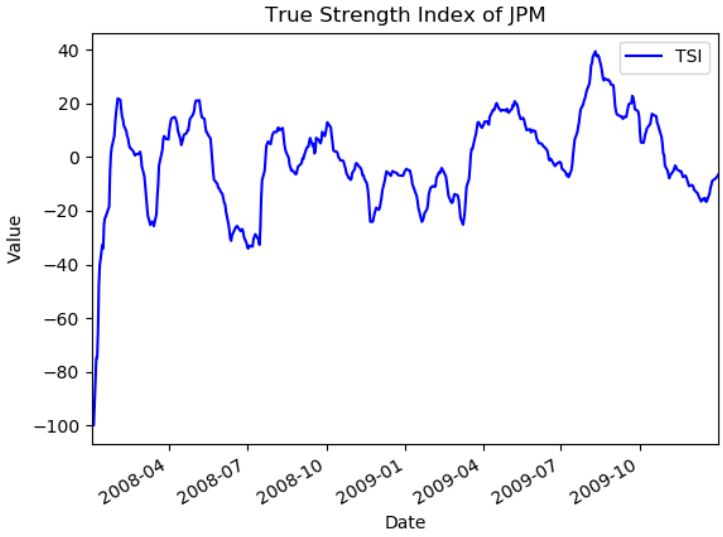

Figure 7—TSI of JPM over the time period.

According to (5), positive territory means the bulls are more in control of the asset and (6) claims that a string of positive price changes results in high positive readings and strong upwards momentum. Again, as an actual indicator, one could simply threshold values for buy/sell signal, look at the crossover line (when it passes up through 0, trigger a buy etc. or more comprehensively, combine it with another indicator. When the TSI passes through the zero-line to a positive index, this can mean a short-term upwards trend is coming. It is also common to note that trend/price reversals happen around values of +20 and -20 which may be used as well.

3 REFERENCES

1. https://www.investopedia.com/terms/s/sma.asp
2. https://www.investopedia.com/investing/momentum-and-relative-strength-index/
3. https://www.investopedia.com/terms/s/stochasticoscillator.asp
4. https://school.stockcharts.com/doku.php?id=technical_indicators:bollinger_band_perce
5. https://www.investopedia.com/terms/t/tsi.asp
6. https://school.stockcharts.com/doku.php?id=technical_indicators:true_strength_index