

# Project 6: Indicators

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This project explores the development and evaluation of five technical indicators and the implementation of a Theoretically Optimal Strategy (TOS) to establish a performance baseline for future trading strategy design in later projects. The indicators I have selected are the Weighted Moving Average (WMA), Bollinger Bands (BB), Relative Strength Index (RSI), Momentum, and Moving Average Convergence Divergence (MACD) and were computed on JPMorgan Chase (JPM) stock data from January 1, 2008, to December 31, 2009. Each indicator was analyzed for its ability to identify overbought, oversold, or trend-confirmation signals, supported by visual plots that demonstrate their behavior relative to price movements.

The Theoretically Optimal Strategy simulates a perfect foresight trading system that achieves the best possible returns under the constraints of holding at most 1,000 shares long or short at any time. This strategy serves as an upper performance bound, independent of the indicators. A market simulator was used to compute portfolio values using zero transaction costs and market impact. The TOS significantly outperformed the buy-and-hold benchmark, achieving a cumulative return above 5.7 versus 0.01 for the benchmark and a Sharpe ratio exceeding 13, reflecting the idealized profit potential given perfect future knowledge.

### **WEIGHTED MOVING AVERAGE:**

The Weighted Moving Average is a variation of the simple moving average that assigns greater weight to more recent prices. This makes it more responsive to recent market behavior while still smoothing out short-term noise. The Weighted moving average for a given window (n) at time (t) is calculated by:

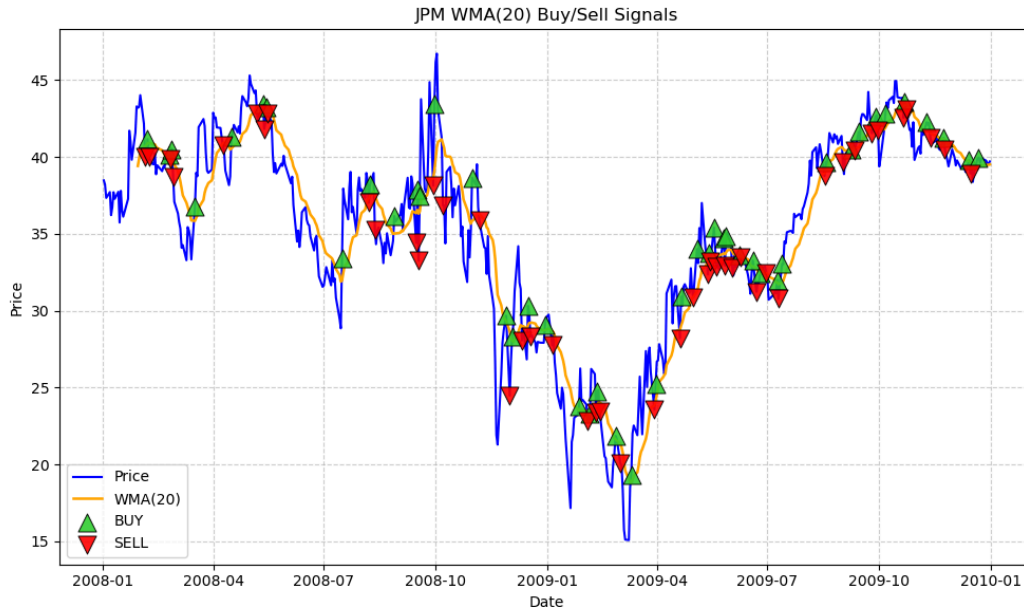
$$WMA = \frac{\sum_{i=1}^n (\text{Price}_i \times \text{Weight}_i)}{\sum_{i=1}^n \text{Weight}_i}$$

Where the numerator is calculated similarly to a regular moving average, but at every point a weight is multiplied. More recent prices receive a higher weight, while older prices receive a lower weight. This weighting makes the WMA more responsive to recent price movements than a simple moving average, where each observation contributes equally. This sum is then divided by the sum of all the weights. This method effectively allows the WMA to follow the price more closely, making it particularly good for detecting changes in momentum or trend direction. When plotted, it tends to hug the price curve more tightly than the SMA, which can lag behind during periods of sharp movement. I decided to choose this indicator to capture shorter-term price action with less lag than would be present in a simple moving average.

### **Buy/Sell Signal Strategy:**

The trading strategy I will implement with the weighted moving average is:

- **Buy (Go Long 1000 shares):**  
When the price crosses **above** the WMA
- **Sell Signal (Go Short -1000 shares):**  
When the price crosses **below** the WMA
- **Hold/Cash Position (0 shares):**  
When the price remains close to the WMA



This metric will need to be used in combination with other metrics as short term noise might influence this strategy too much and create false signals in the strategy. We can see this in the chart above as there are some rapid successions of buy and sells. There does seem to be some accurate signals as the indicator does seem to get some of the bottoms and tops correct.

#### **BOLLINGER BANDS %:**

Bollinger Bands help show when a stock's price might be too high or too low compared to its recent average. They create an upper and lower band around a moving average, where the distance of the bands is based on the standard deviation of prices.

$$\text{Upper Band} = \text{WMA} + 2 \times \text{Rolling Std}$$

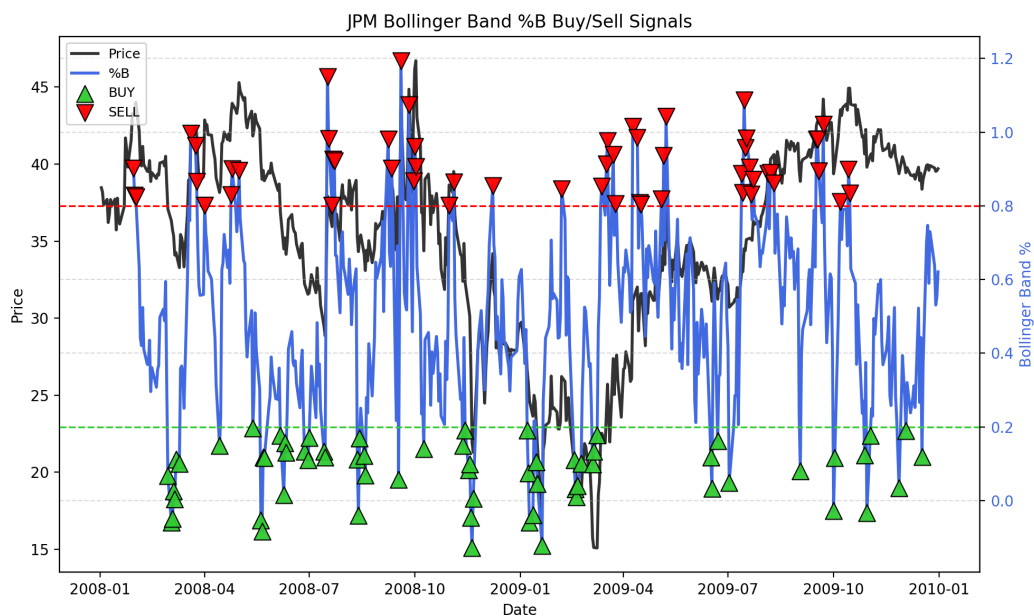
$$\text{Lower Band} = \text{WMA} - 2 \times \text{Rolling Std}$$

$$\%B = \frac{(\text{Current Price} - \text{Lower Band})}{(\text{Upper Band} - \text{Lower Band})}$$

## Buy/Sell Signal Strategy:

The trading strategy I will implement with the weighted moving average is:

- **Buy Signal (Go Long 1000 shares):**
  - When the %B value falls below 0.2
- **Sell Signal (Go Short -1000 shares):**
  - When the %B value rises above 0.8
- **Hold / Cash Position (0 shares):**
  - When the %B value stays between 0.2 and 0.8



Bollinger Bands provide valuable insight into when a stock may be overbought or oversold. Looking at the chart above, the indicator does a good job of capturing many of the tops and bottoms in price movement. However, during prolonged uptrends or downtrends, it can sometimes lag behind or generate signals that fail to capture the full benefit of the move. Because of this, Bollinger

Bands might be more useful in combination with other indicators. Ones that can capture potential longer term trends.

#### **MOVING AVERAGE CONVERGENCE DIVERGENCE (MACD):**

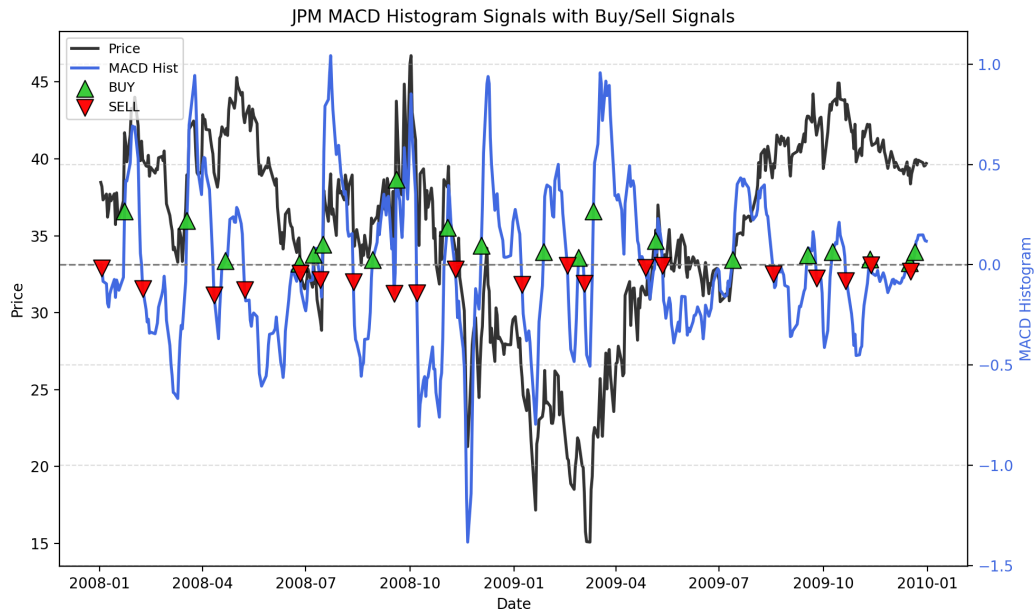
The MACD is a momentum based indicator that helps identify when a stock's price trend is strengthening, weakening, or reversing. The MACD indicator is calculated by taking a fast exponential moving average (less days) and a slow exponential moving average, then we take the difference of that value and the signal line another exponential moving average. The histogram is then made from those values.

$$\text{MACD Line} = EMA_{12} - EMA_{26}$$

$$\text{Signal Line} = EMA(\text{MACD Line}, 9)$$

$$\text{MACD Histogram} = \text{MACD Line} - \text{Signal Line}$$

- **Buy (Go Long 1000 shares):**
  - When the MACD histogram crosses above zero
- **Sell (Go Short -1000 shares):**
  - When the histogram crosses below zero
- **Hold (0 shares):**
  - When the histogram stays near zero



This graph seems to match the overall price trends more closely, with buy signals appearing near the start of upward moves and sell signals showing up as the trend begins to turn downward. This suggests that MACD does a good job of identifying changes in momentum before larger price shifts occur.

#### RELATIVE STRENGTH INDEX(RSI):

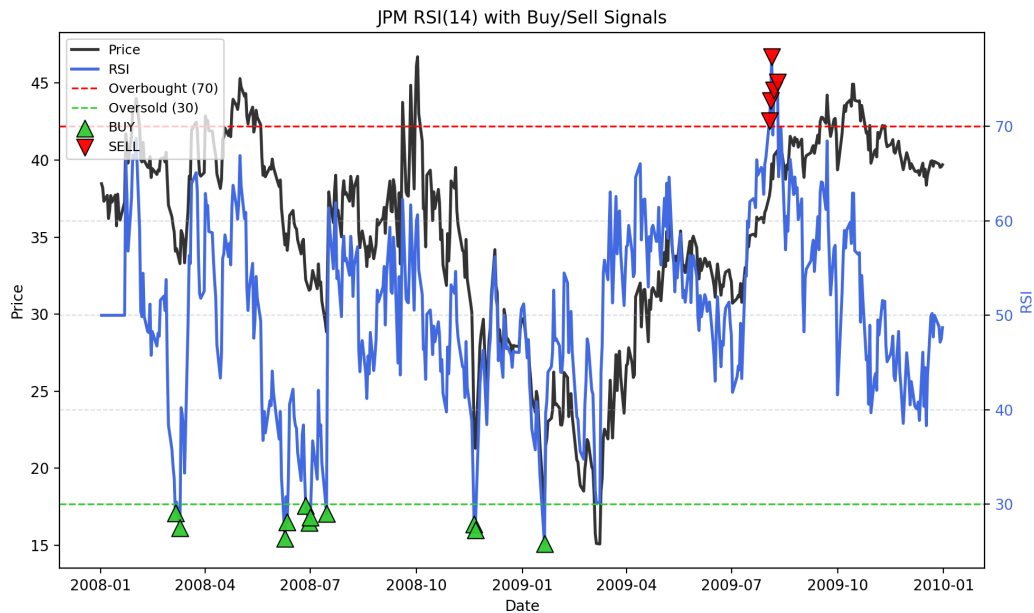
The RSI measures how quickly prices are rising or falling to identify when a stock may be overbought or oversold. It compares the size of recent gains to recent losses over a set period usually 14 days and converts that information into a number between 0 and 100.

$$RSI = 100 - \left( \frac{100}{1 + RS} \right)$$

- **Buy (Go Long 1000 shares):**

When the RSI drops below 30 (oversold) and begins to rise again

- **Sell (Go Short –1000 shares):**  
When the RSI rises above 70 (overbought) and begins to fall
- **Hold (0 shares):**  
When the RSI stays between 30 and 70



The RSI effectively identifies periods when momentum increases, signaling potential turning points in price. However, as seen in the chart, it can stay oversold or overbought for long stretches during strong trends meaning acting on RSI alone could lead to mistimed trades. This could be used in combination with other indicators as it can identify the strength of the change might signal a good opportunity to take a larger position.

### **MOMENTUM:**

The Momentum Indicator measures how quickly a stock's price is changing over time. It looks at the difference between the current price and the price from a certain number of days ago to see if the stock is gaining or losing speed. The formula shows the current price being divided by the price from N days ago minus 1. A positive momentum value means the stock's price is higher than it

was 10 days ago, showing upward strength, while a negative value means the price has fallen, showing downward pressure.

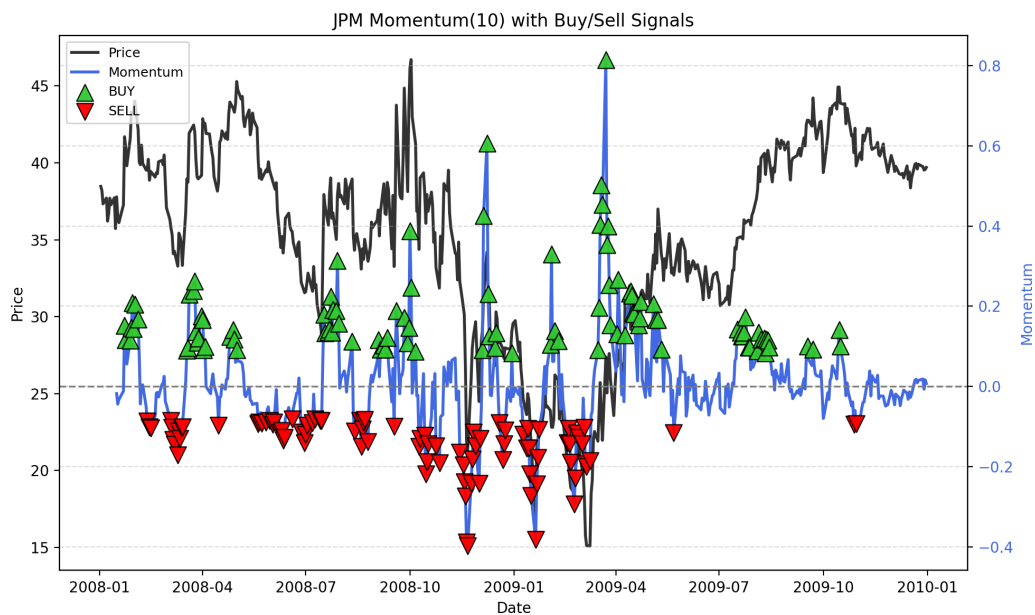
$$Momentum_t = \frac{Price_t}{Price_{t-N}} - 1$$

## Trading Signals

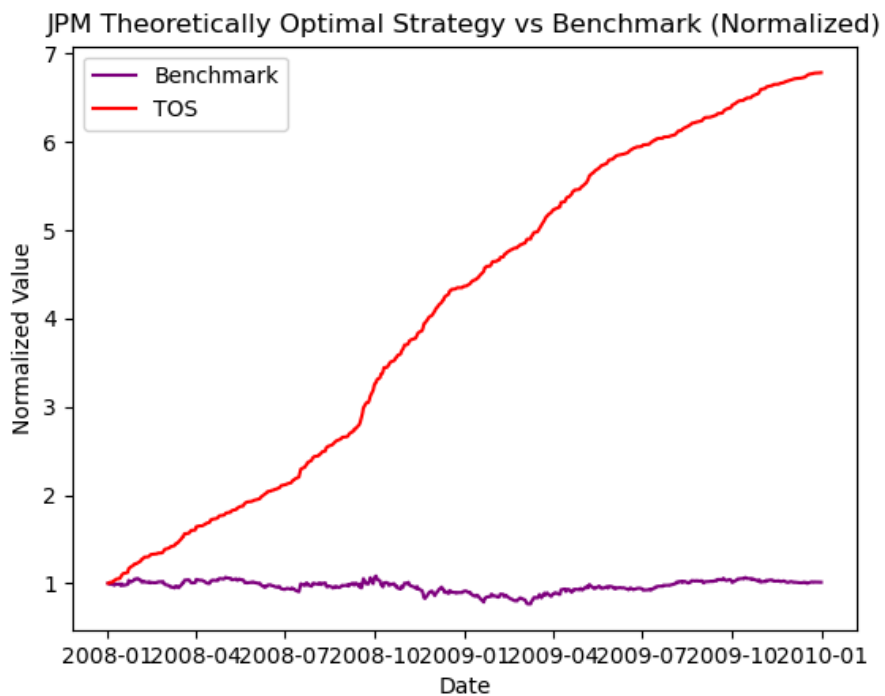
- **Buy (Go Long 1000 shares):**  
When the momentum value crosses above 0.08
- **Sell (Go Short -1000 shares):**  
When the momentum value crosses below -0.08
- **Hold (0 shares):**  
When the momentum value stays within the two values

Initially, the momentum indicator was too sensitive, triggering buy and sell signals almost constantly due to small price fluctuations. This made it difficult to distinguish between meaningful shifts and short-term noise. To fix this, the threshold for activation was increased to 0.08, ensuring that only stronger price movements generate signals. This could potentially be used to identify larger trends compared to the other indicators and may influence the strategy to keep the current position if the larger timeline trend is still the same. Ideally if the stock has been going down for 10 days but had a small uptick that would be caught by the indicators above it might be good to not change the position.





## Theoretically Optimal Strategy



The chart below compares the Theoretically Optimal Strategy (TOS) against a Benchmark strategy for JPM stock over the 2008-2009 period. Both portfolios start with a normalized value of 1.0 for easier visual comparison. The purple line represents the benchmark portfolio (buy 1000 shares and hold), while the red line shows the portfolio value of the theoretically optimal strategy.

The benchmark shown in purple in the picture stays relatively flat through the whole time showing that the buy and hold strategy does not produce meaningful returns as the stock does not appreciate that much. While the TOS strategy shows the returns if you made the correct trade every day. Buying if the stock will go up and selling if it will go down.

This strategy cannot be implemented by anyone as it would need the ability to look one day in the future. This strategy represents the optimal returns possible from solely buying and selling the stock.

Metric	Benchmark (Buy & Hold)	Theoretically Optimal Strategy (TOS)
Cumulative Return	0.012300	5.786100
Standard Deviation of Daily Returns	0.017004	0.004548
Mean of Daily Returns	0.000168	0.003817
Sharpe Ratio	0.156918	13.322770

Comparing the two strategies, the buy and hold (B & H) strategy returned 1.23% while the TOS returned 578.61%. The (B & H) had a std deviation of daily returns of 1.7% while the optimal strategy was a lot lower 0.045% and as we can see in the chart above was a lot steadier throughout the graph. The average daily returns were fairly low for the (B & H) as it did not increase much while the average daily returns for TOS were substantially higher at 0.58%. Lastly, taking a look at the sharp ratio, the (B & H) strategy sharpe ratio is 0.157 giving a very low risk adjusted performance while TOS at 13.32 is unrealistically good, but makes sense since it is the optimal strategy.