CS7646 Project 6

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1 INDICATORS

In this project, we explore five key technical indicators commonly used in financial analysis to assess stock performance and make informed trading decisions. The indicators selected are Bollinger Bands, Simple Moving Average (SMA), Moving Average Convergence Divergence (MACD), Momentum, and the Stochastic Oscillator. Each indicator offers unique prospective into price trends, volatility, and market conditions, enabling traders to identify potential buy and sell signals. By implementing and visualizing these indicators, we aim to enhance our understanding of market behavior and improve decision-making strategies in trading. All of these strategies can be used stand alome or combine them to make a better more robust approach! I will generally start by describing my indicator , then showing the graphs and comment on why was it used and what it's purpose.

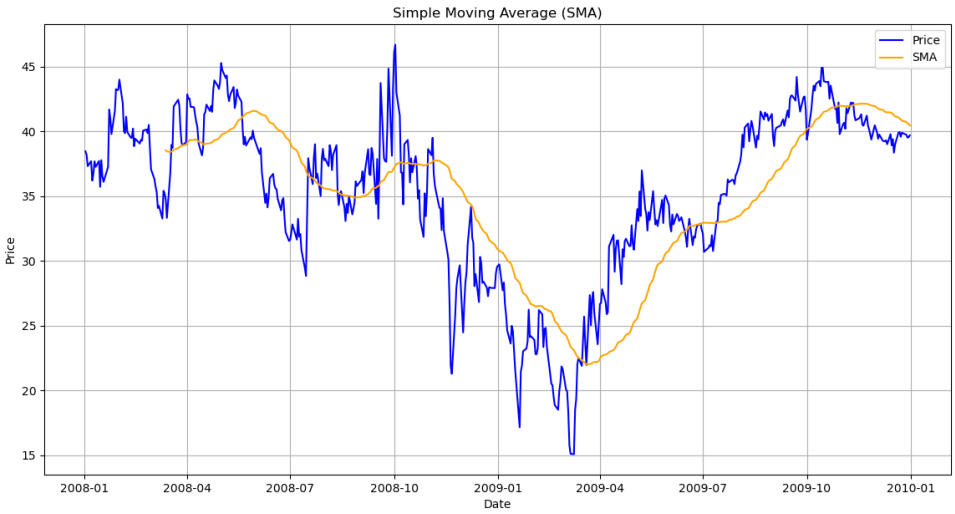
1.1 SIMPLE MOVING AVERAGE (SMA)

The Simple Moving Average is the average of a specified number of recent prices over a defined time period. It's purpose is to smooth the data and easily identify trends. One potential buy clause would be for the price to rise above the moving average , and a sell clause for the price to go down from the moving average, especially if we see a big trend on the line.

A pseudocode of how SMA could be calculated is this:

```
SMA(prices, window_size):
sma_values = []
  FOR i FROM window_size - 1 TO LENGTH(prices) - 1:
    window_sum = 0
    FOR j FROM i - window_size + 1 TO i:
      window_sum = window_sum + prices[j]
```

```
    sma = window_sum / window_size
    sma_values.APPEND(sma)
RETURN sma_values
```



I used a window size of 50 since we have a large number of data, with window size 50 we can easily balance long term and short term noise , and we can identify easily the trend . This graph provides us useful information about the direction of our stock , and many future work could be done by combine different windows and methods.

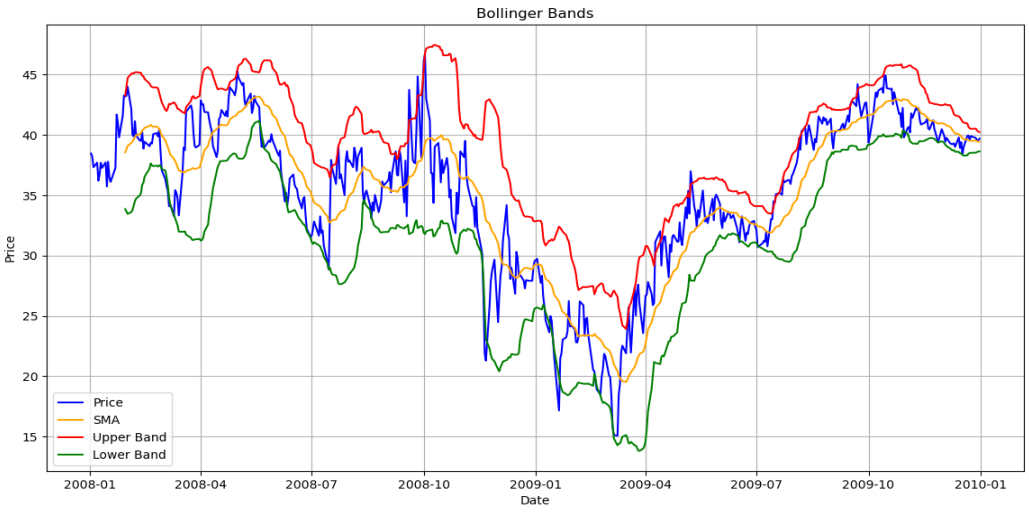
1.2 BOLLINGER BANDS

Bollinger Bands is a popular technical analysis tool developed by John Bollinger in the early 1980s. This volatility indicator consists of a middle band, which is a simple moving average, and two outer bands positioned a certain number of standard deviations away from the middle band, typically set to two. They are useful for assessing price volatility and identifying potential trading opportunities, as they dynamically adjust to market conditions—expanding during high volatility and contracting during low volatility. The outer bands can serve as potential support and resistance levels, indicating overbought or oversold conditions when the price touches or moves outside them. A good buy opportunity would be when the price cross down the down band and start to get high again , while on the opposite side a good sell oppor-

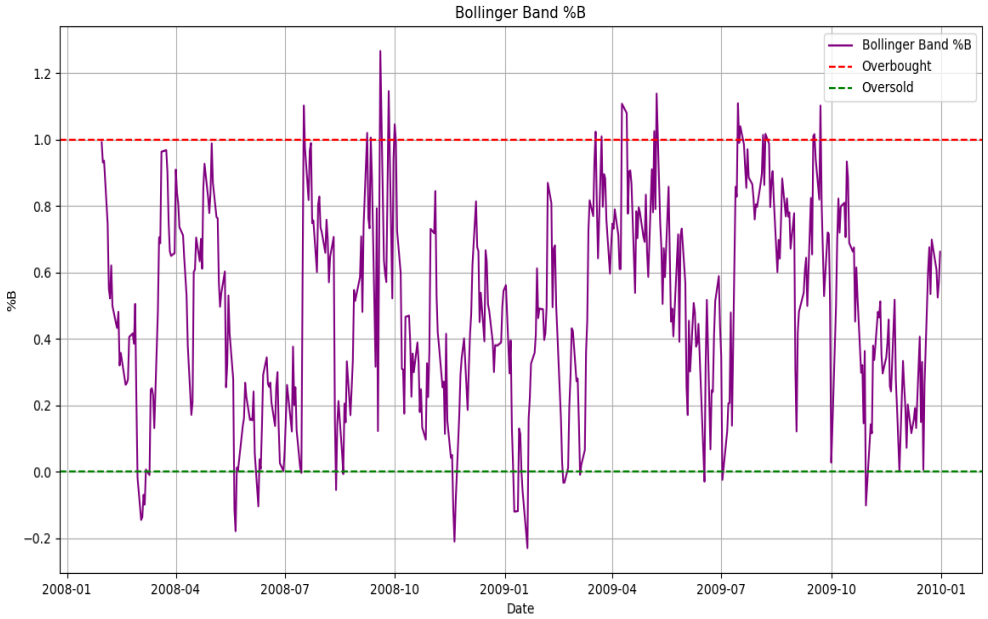
tunity would be when the upper band is crossed up and the price start to go down again and cross down the upper band.

```
CalculateBollingerBands(prices, window, num_std_dev):
    sma = ARRAY OF LENGTH EQUAL TO LENGTH OF prices
    FOR i FROM window-1 TO LENGTH OF prices - 1:
        sma[i] = AVERAGE(prices[i - window + 1 TO i])
    upper_band = ARRAY OF LENGTH EQUAL TO LENGTH OF prices
    lower_band = ARRAY OF LENGTH EQUAL TO LENGTH OF prices
    FOR i FROM window-1 TO LENGTH OF prices - 1:
        std_dev = STANDARD_DEVIATION(prices[i - window + 1 TO i]
        upper_band[i] = sma[i] + (num_std_dev * std_dev)
        lower_band[i] = sma[i] - (num_std_dev * std_dev)
    RETURN sma, upper_band, lower_band
```

As you can see bollinger band is easily calculated in some small steps .



The sma and the upper and lower bands are all that's needed.



I made 2 graphs , the first is the classical Bollinger bands. As we can see every time the buy and sell clause we described before is done(crossing the bands and recover) we would had made a profit following this strategy. The second graphs the bollinger bands percentage is just normalized bollinger band , that show us in a scale of 0 to 1 the bands so it's easier to identify the crosses and their relative strength .

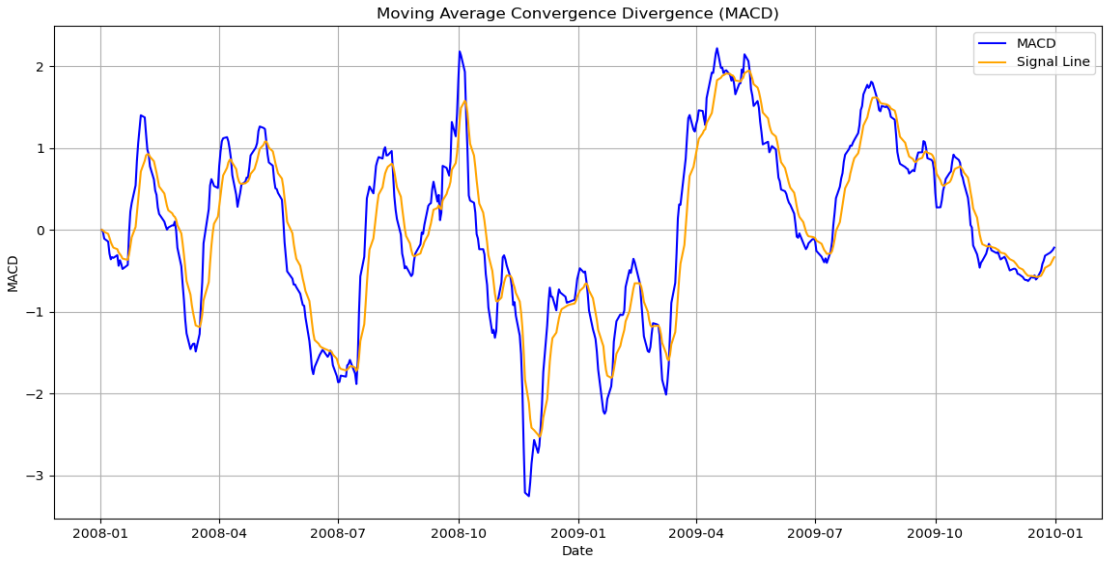
1.3 MOVING AVERAGE CONVERGENCE DIVERGENCE (MACD)

The Moving Average Convergence Divergence (MACD) is a popular momentum indicator used in technical analysis to identify potential buy and sell signals based on the relationship between two moving averages of a security's price. It consists of two lines: the MACD line, which is the difference between a 12-period and a 26-period exponential moving average (EMA), and the signal line, which is a 9-period EMA of the MACD line. The importance of MACD lies in its ability to capture changes in momentum and trend strength, making it a valuable tool for traders. A buy signal is typically generated when the MACD line crosses above the signal line, indicating potential upward

momentum, while a sell signal occurs when the MACD line crosses below the signal line, suggesting a possible downturn.

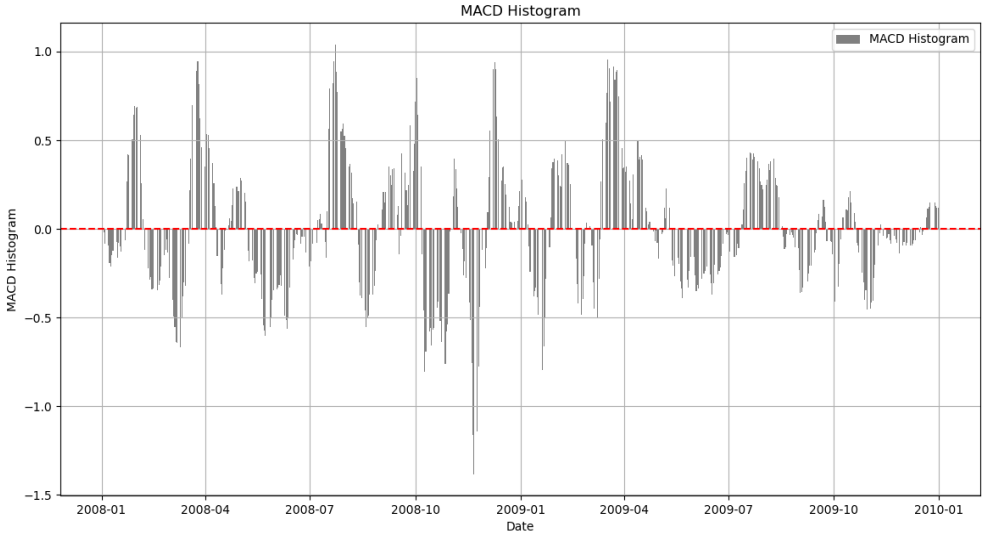
```
calculate_MACD(prices):
short_ema = EMA(prices, short_window=12)
long_ema = EMA(prices, long_window=26)
MACD_line = short_ema - long_ema
signal_line = EMA(MACD_line, signal_window=9)
return MACD_line, signal_line
```

That's how simple it is to calculate the MACD lines and the signal lines. Here we can see the described MACD lines and the signal lines. The crossover points are the points of interest where we might want to buy or sell based on the action happening.



Often included in MACD graphs, the histogram represents the difference between the MACD line and the signal line. The height of the histogram bars can indicate the strength of the momentum; larger bars

signify stronger momentum, while smaller bars indicate weaker momentum. Here is the histogram for our case.



1.4 SIMPLE MOMENTUM

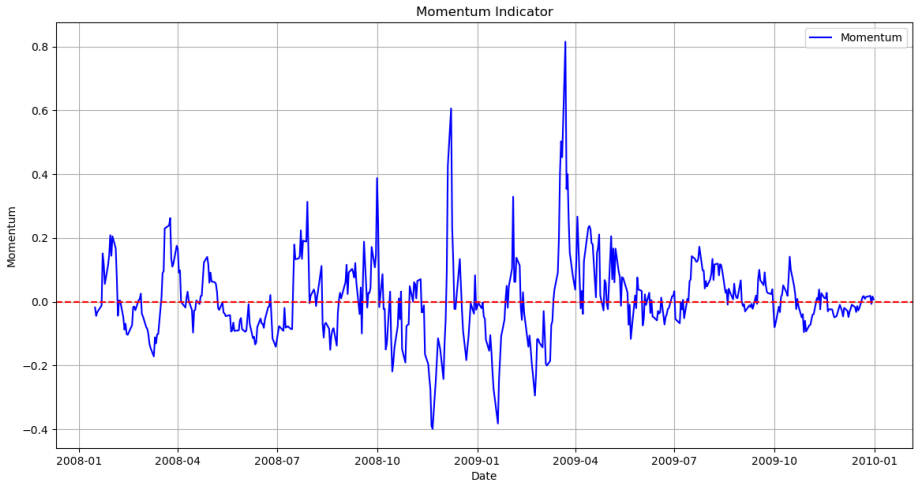
Momentum measures the rate of price change over a specific period, helping to identify the strength and direction of a stock's price movement. It is useful because it signals whether a stock is gaining or losing momentum, which can indicate potential trends or reversals. When momentum is positive, it shows that the stock price is increasing at an accelerating rate, which could be a good buying opportunity . Conversely, negative momentum suggests the stock price is declining, which could signal a potential sell. It is a useful information that can drive our overall process to the next level.

The calculation is extremely simple :

1. Get the current price and the price N days ago.

2. Calculate momentum: momentum = (current_price / price_N_days_ago) - 1.

3. Return the momentum value.



The momentum indicator is scaled around 0 and how far we are from the 0 shows us how strong the momentum is. We can see om 2009.04 for example the huge momentum the price had and how we could use this to make predictions about the stock.

1.5 STOCHASTIC OSCILLATOR

The Stochastic Oscillator is a momentum indicator that compares a stock's closing price to its price range over a specific period. It helps identify overbought and oversold conditions by showing where the current price is relative to the recent highs and lows. When the oscillator is above 80, it suggests the stock is overbought and may be due for a pullback, signaling a potential sell. When it's below 20, the stock is considered oversold, indicating a possible buying opportunity. The pseudocode is a little trickier but still easy to compute

1. Set the lookback period (N days).

2. For each day:

   a. Calculate the Lowest Low (min price over N days).

   b. Calculate the Highest High (max price over N days).

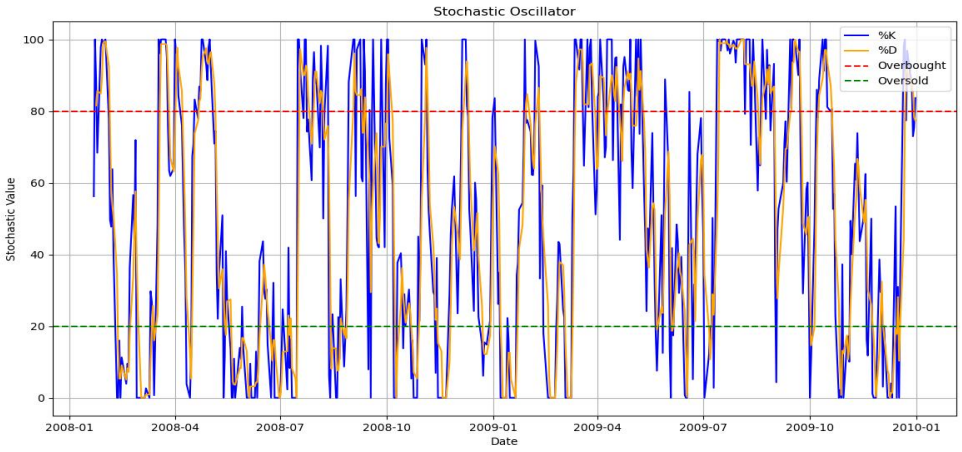
   c. Compute %K = (Current Close - Lowest Low) / (Highest High - Lowest Low) * 100.

3. Optionally, calculate %D as the moving average of %K over a smoothing period.

4. Use %K and %D to identify overbought and oversold conditions:

- If %K > 80: Overbought (potential sell).

- If %K < 20: Oversold (potential buy).



Here is our stohastic oscillator with k=14 and d=3 , as we can see the 80 and 20 marks are set and we can identify the opportunities based on the graph.

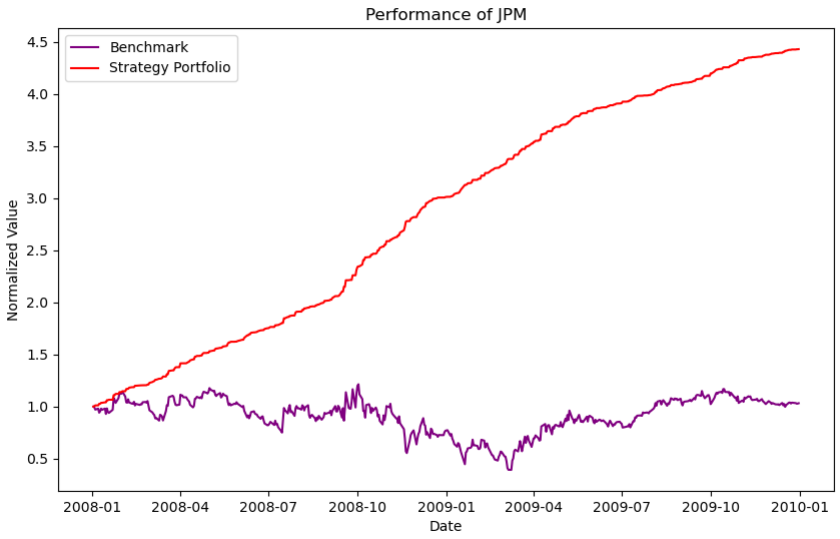
2 THEORETICALLY OPTIMAL STRATEGY (TOS)

The Theoretically Optimal Strategy (TOS) is designed to achieve the best possible trading performance by assuming access to future price movements. This approach involves creating trades that maximize returns based on projected price changes while adhering to constraints related to portfolio size and order limits. The strategy specifically focuses on the stock symbol "JPM" during the period, from January 1, 2008, to December 31, 2009.

To implement TOS, the algorithm iterates through historical price data and makes buy or sell decisions based on whether the price is expected to rise or fall

the following day. If the future price is anticipated to be higher, the strategy will buy shares; if it's expected to be lower, it will short the stock. Legal trade values are +1000 (buy), -1000 (sell), or 0 (no action), maintaining a net position within the limits of -1000, 0, or 1000 shares. The results from the trading strategy are then analyzed to generate key performance metrics, including cumulative returns, volatility, and mean daily returns, which provide insights into the strategy's effectiveness compared to a benchmark.

Here is our approach and results against a benchmark:



As we can see we constantly outperform market and we can see the power of a optimal strategy!

Here are some metrics to correctly evaluate the performance:

	Cum return	Standard Deviation	mean
Benchmark	3.197297%	0.827768	0.351708
Strategy	343.230000%	0.077490	0.748519

The performance metrics reveal a remarkable advantage of our theoretically optimal trading strategy over the benchmark during the period

from January 1, 2008, to December 31, 2009. The cumulative return of the strategy was an amazing 343.23%, compared to just 3.20%

for the benchmark, demonstrating a strong ability to capitalize on market movements. Moreover, while the benchmark exhibited an annualized standard deviation of 82.78%, indicating significant volatility, our strategy maintained a much lower standard deviation of 7.75%, highlighting its stability and lower risk profile. The mean annualized return for the strategy was 74.85%, substantially higher than the benchmark's 35.17%, showcasing consistent outperformance. In conclusion, our strategy not only achieved exceptionally high returns but did so with significantly reduced volatility, making it a compelling choice for investors seeking both profitability and stability in their portfolios. That shows the power of an optimal(but probably almost impossible strategy!)