Project 6:
Indicator Evaluation

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***Abstract*—**Technical indicators are commonly used to predict future price movement to inform trading decisions. This project researches and illustrates the application of 5 selected indicators in generating trading signals on a stock. To prepare for the evaluation of these indicators in a subsequent project, a Theoretically Optimal Strategy is developed to establish an upper bound performance reference.

1 METHODS

1.1 Technical Indicators

This section describes only the construction of the 5 technical indicators. The interpretation of the indicators and how they produce trading signals will be explained and illustrated via their application on a stock in the next section, Results.

1.1.1 *Percentage Price Oscillator (PPO)*

PPO is an oscillator that quantifies how far apart 2 exponential moving averages (EMA), one fast-moving and one slow-moving, are at any given time as a percentage of the slow-moving EMA. The 12-periods and 26-periods EMAs are used here. An additional signal line, 9-periods EMA, is often used together with PPO to generate signal. **However, in this project, this signal line will not be used**. The PPO at time t, is given by the following (ChartSchool, 2025a), where n is the number of time periods chosen for each of the EMAs and $n_{fast} < n_{slow}$:

$$PPO_t = \left(\frac{fast\ EMA_t - slow\ EMA_t}{slow\ EMA_t}\right) \times 100$$

$$EMA_t = (adj\ close_t - EMA_{t-1}) \times \left(\frac{smoothing}{1+n}\right) + EMA_{t-1}$$

Adjusted closing price is used as the price input for the EMA calculations. The choice of n depends on the trading time horizon and style. In general, smaller n for trading on shorter-term trend, and vice versa. The smoothing constant

controls the weight given to most recent data. Increasing it gives more weight to the recent data (ChartSchool, 2025b). Here, it is set to 2.

1.1.2 *Price-SMA ratio*

Price-SMA ratio measures how far the stock price at any given time deviates from the simple moving average (SMA) of a specified n periods. The Price-SMA at time t, is given by the following (Quant Investing, 2020), where n is the number of time periods chosen for the SMA:

$$price/sma_t = \frac{adj\ close_t}{SMA_t}$$

$$SMA_t = \frac{adj\ close_t}{\frac{\sum_{i=t-n+1}^{t} adj\ close_i}{n}}$$

Adjusted closing price is used as the price input for the above calculations. The choice of n depends on the trading time horizon and style. In general, smaller n for trading on shorter-term trend and vice versa.

1.1.3 *Momentum*

Momentum measures the rate at which price at any given time are changing in relation to the prices at n periods ago. Momentum at time t, can be calculated as follows (Fidelity.com, 2025a), where n is the number of periods prior to t:

$$momentum = \left(\frac{adj\ close_t}{adj\ close_{t-n}}\right) - 1$$

Adjusted closing price is used as the price input for the calculations. As with the above indicators, the choice of n is dictated by trading time horizon and style.

1.1.4 *Commodity Channel Index (CCI)*

CCI measures the deviation of stock price from its moving average of a specified n periods to identify cyclical turning points in price. Unlike the other indicators, the stock's typical price (as defined below), instead of the adjusted closing price, is used in computing CCI. The CCI at time t, is given by (ChartSchool, 2025c):

$$CCI_t = \frac{typical\ price_t - typical\ price\ SMA_t}{0.015 \times mean\ deviation}$$

The inputs to the CCI formula can be calculated as follows (ChartSchool, 2025c), where n is the number of periods:

$$typical\ price_t = \frac{adj\ high_t + adj\ low_t + adj\ close_t}{3}$$

$$typical\ price\ SMA_t = \frac{typical\ price_t}{\frac{\sum_{i=t-n+1}^{t} typical\ price_i}{n}}$$

$$mean\ deviation = \frac{\sum_{i=t-n+1}^{t} |typical\ price_i - typical\ price\ SMA_t|}{n}$$

The constant, 0.015, can be varied to control the number of CCI values that fall within -100 to +100 range. At 0.015, approximately 70-80% of the values fall within the range (ChartSchool, 2025c).

1.1.5 *Percent B (%B)*

%B is an indicator that measures the stock price's position relative to the Bollinger Bands. It encapsulates in a single number the information on stock price and Bollinger Bands to put the price action in the context of Bollinger Bands. Hence, before %B can be calculated, the Bollinger Bands need to be constructed first. The middle, upper and lower bands at time t of the Bollinger Bands can be computed as follows (ChartSchool, 2025d), where n is the number of time periods chosen:

$$Middle\ Band_t = SMA_t$$

$$Upper\ Band_t = SMA_t + 2 \times \sqrt{\frac{\sum_{i=t-n+1}^{t} (adj\ close_i - SMA_t)^2}{n}}$$

$$Lower\ Band_t = SMA_t - 2 \times \sqrt{\frac{\sum_{i=t-n+1}^{t} (adj\ close_i - SMA_t)^2}{n}}$$

%B can then be found by the following formula (Fidelity.com, 2025b):

$$\%B_t = \left(\frac{adj\ close_t - Lower\ band_t}{Upper\ band_t - Lower\ Band_t}\right) \times 100$$

Adjusted closing price is used as the price input for the calculations. The number of standard deviations, 2, is commonly used to capture 95% of the prices according to the normal distribution assumption (Thompson, 2024). However, it can be changed according to the trader's strategy or preference.

1.2 Theoretically Optimal Strategy (TOS)

Assuming that the future is known, a theoretically optimal strategy can be devised by making buy and sell decisions based on the daily returns of a stock. Buy

at time t, when the return of next day t+1, is positive, and sell at time t, when the return of next day t+1, is negative. No action is taken when next day's return is 0. In this project, leverage is unlimited and net position at any time is restricted to 0, 1000 (long) or -1000 (short) shares. Accordingly, when the net position is 1000, sell 2000 shares at time t, when the return at t+1 is negative. Take no action at time t, when the return at t+1 is positive. When the net position is -1000, buy 2000 shares at time t, when the return at t+1 is positive. Take no action at time t, when the return at t+1 is negative. When the net position is 0, buy or sell 1000 shares at time t, when the return at t+1 is positive or negative respectively. Daily portfolio values are calculated from holdings and daily price data. Performance metrics, such as cumulative return, mean and standard deviation of daily return, are derived from the portfolio values. Commission and slippage are omitted in the evaluation. A buy-and-hold strategy, whereby 1000 shares are bought at the beginning and held till the end, is used as a benchmark.

2 RESULTS

2.1 Technical Indicators

To illustrate how each of the 5 indicators generates signals to inform trading decisions, the indicators are applied to the price data of stock, JPM, from Jan 1, 2008 to Dec 31, 2009. Figure 1 shows how signals generated by PPO can be interpreted to inform trading decisions. When PPO > 0 (green), the fast-moving EMA is above the slow-moving one, indicating that price's uptrend remains intact. Price action on an uptrend displays upside bias. Conversely, when PPO < 0 (red), the fast-moving EMA is below the slow-moving one, indicating that price is trending downward. Price action on a downtrend displays downside bias. Traders should long the stock when PPO > 0, and short it when PPO < 0, to ride on the trends. Alternatively, traders could do the opposite by buying on weakness and selling into strength. The exact entry points can be fine-tuned with another indicators. PPO = 0, a key signal to watch, indicates a potential change of trend. As PPO is derived from moving averages which lag price movement, the turning points identified by the arrowheads (top) do not coincide with the peaks and troughs on the price chart. Such a lag could be advantageous to traders, as it serves as confirmation, reducing risk, before traders ride the trends.

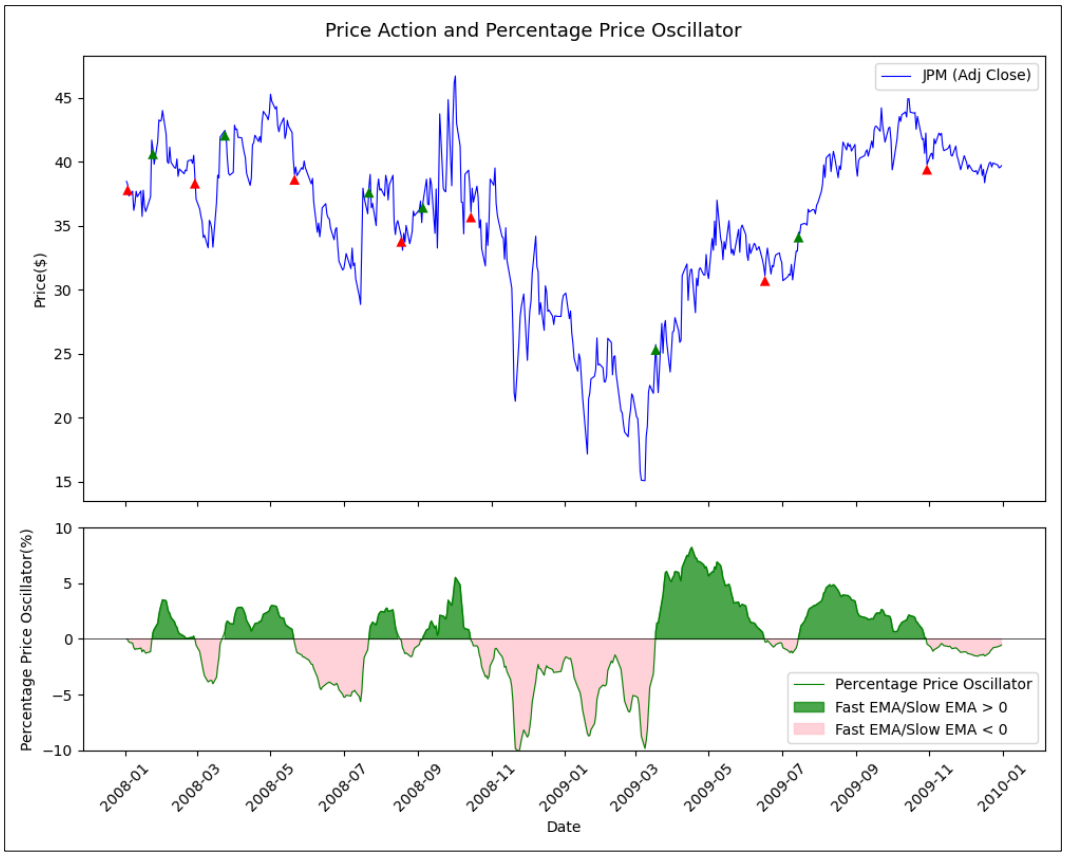

Figure 1 — Application of PPO on JPM stock price. [Top]: Adjusted closing price. Arrowheads correspond to where PPO changes from -ve to +ve (green) and +ve to -ve (red). [Bottom]: PPO derived from price action. Green and pink regions denote +ve and -ve PPO. 12-EMA and 26-EMA are used.

Similar to PPO, Price-SMA ratio identifies trends and their turning points but based on price and SMA, as shown in Figure 2. When Price-SMA > 1 (green), it means stock price is above its n-periods SMA, indicating that price is on the uptrend. When Price-SMA < 1 (pink), it means stock price is below its n-periods SMA, indicating that price is on the downtrend. Price-SMA = 1 indicates a potential turning point of trend. Since prices move faster than EMA, Price-SMA ratio can produce signals earlier than PPO, allowing better profit margin than could be achieved with PPO. Price-SMA identifies the turning point earlier (Figure 2, Top) than PPO (Figure 1, Top). However, this comes with the disadvantage of producing more turning point signals, some of which could be noises (Figure 2, Top). Both indicators can be used together to complement each other.

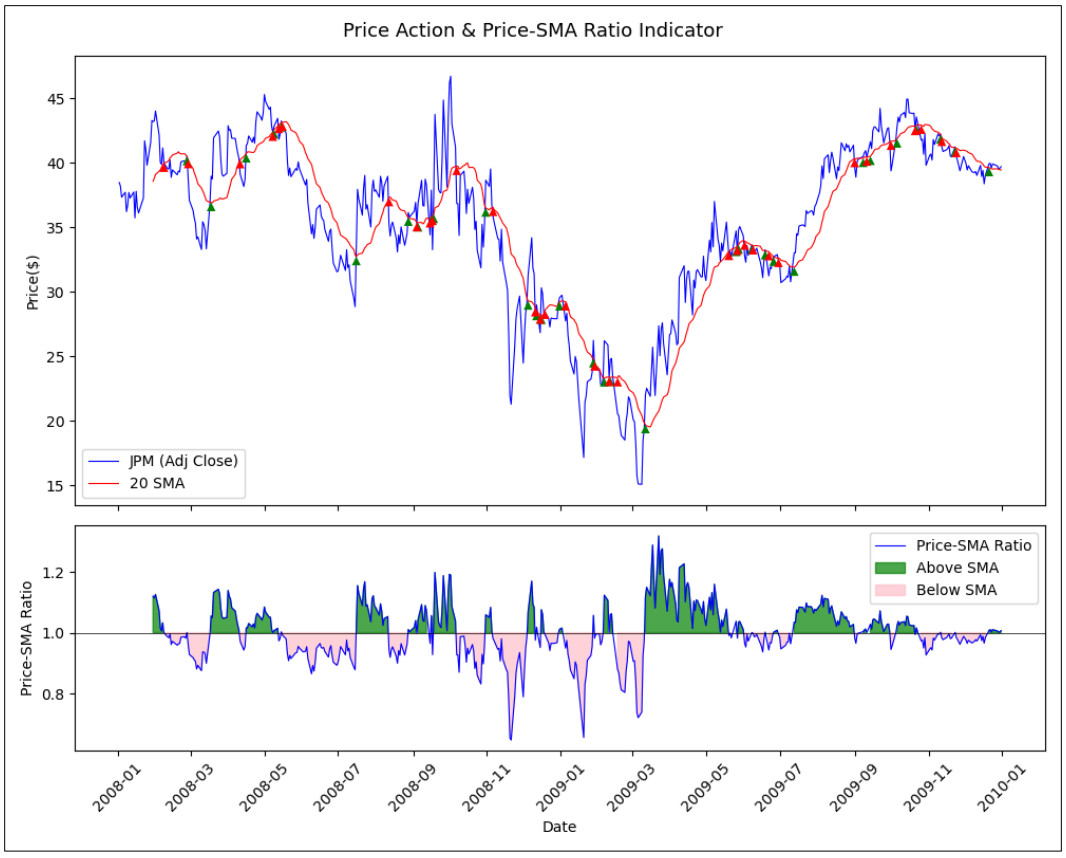

Figure 2 — Application of Price-SMA on JPM stock price. [Top]: Price action and 20-periods SMA. Green and red arrowheads identify where prices cross up and down the SMA. [Bottom]: Price-SMA ratio showing regions where price actions are above and below SMA. Points where Price-SMA = 1 correspond to the arrowheads on price chart

While PPO and Price-SMA ratio provide indication on the strength of trend, Momentum can be used with the 2 indicators to provide further confirmation. When Momentum > 0, it means price is higher than n periods ago. When Momentum < 0, it means price is lower than n periods ago. Accelerating Momentum in the positive or negative zone indicates strengthening trend in either direction, and vice versa. Figure 3 shows that accelerating and decelerating Momentum in the positive and negative zones (Bottom) correspond to strengthening and weakening of uptrend and downtrend in price action (Top). Such information can inform traders on whether to long, short or exit. Momentum = 0 indicates a potential

change in price direction. However, Momentum turning points are too many and noisy to be useful (Figure3, Top).

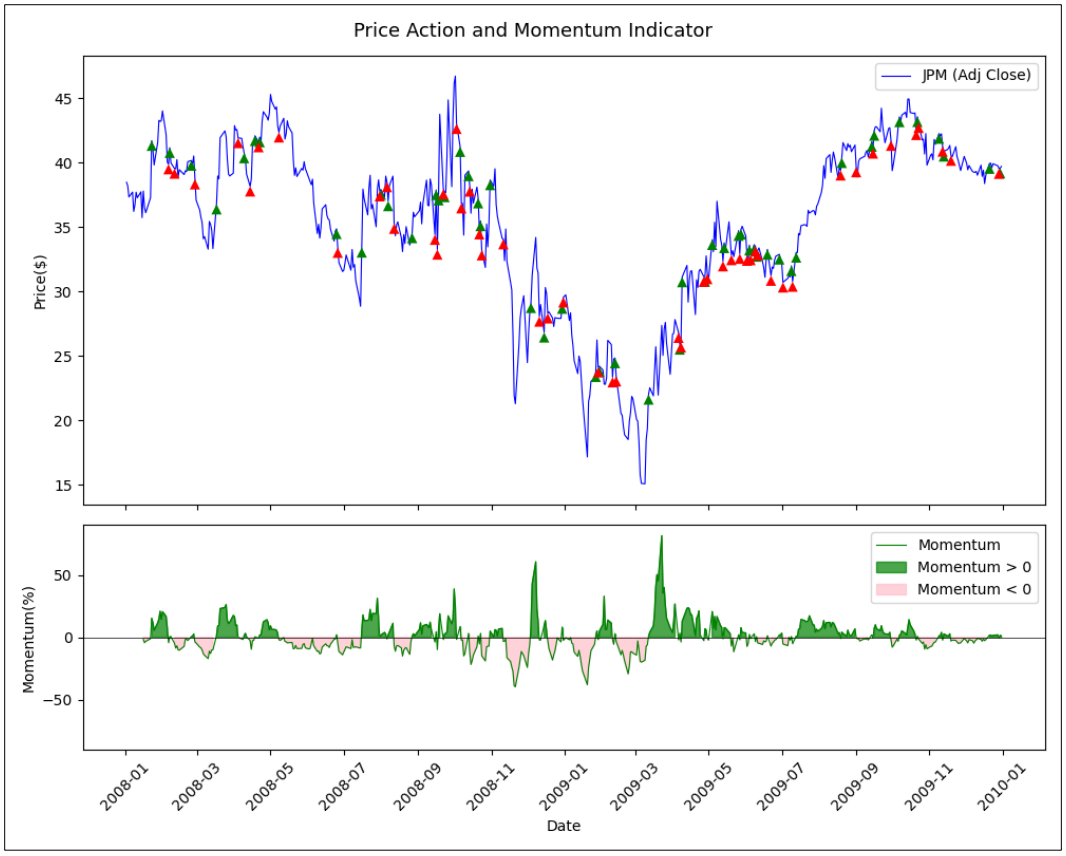

Figure 3 — Application of Momentum to JPM stock price. [Top]: Price action. Arrowheads point to prices where Momentum switches from -ve to +ve (green) or +ve to -ve (red). [Bottom]: Momentum derived from price actions. Green and pink denote +ve and -ve Momentum respectively. 10 periods is used here.

Instead of riding trends by holding onto a position, traders could make multiple entries and exits on pullbacks along the trends. Such trading style requires timing of pullbacks. CCI indicator can help to time such pullbacks by identifying overbought and oversold price action within a trend. When CCI > 100, price is rising too far from its n periods moving average, indicating that the stock is potentially overbought and due for a correction. When CCI < 100, price is dropping too far below its n periods moving average, indicating that the stock is potentially oversold and due for a reversion. CCI between -100 and 100 suggests the absence of abnormal price action. Figure 4 shows the application of CCI to identify potential overbought and oversold price actions. Several price points that

breach 100 or -100 (the colored regions) are identified (Bottom). These regions correspond to pullbacks in the price chart (Top). However, it must be noted that these regions may not always be followed by meaningful pullbacks or reversal. In a strong uptrend or downtrend, CCI can fluctuates in the overbought or oversold regions (e.g. 2009 – 7 to 2009 – 9).

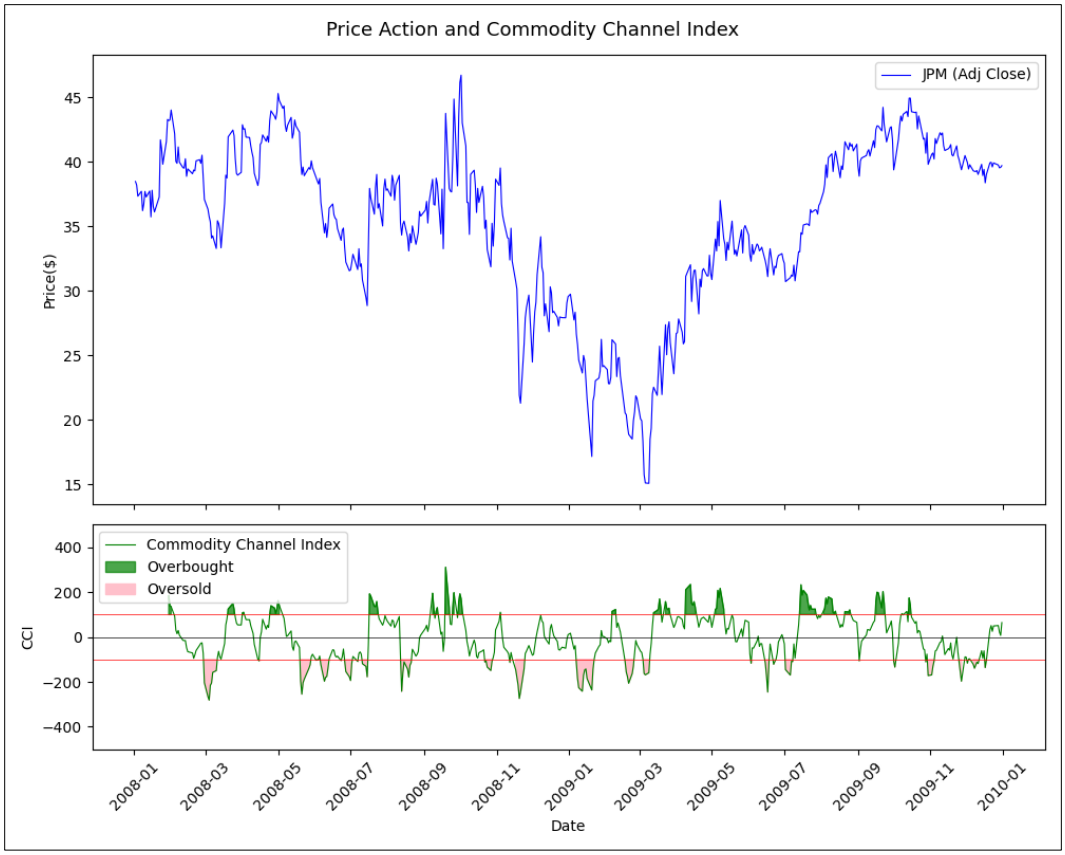

Figure 4 — Application of CCI on JPM stock price. [Top]: Price action. [Bottom]: CCI derived from price action. Green and pink regions identify the overbought and oversold price actions.

Similar to CCI, %B can also be used to identify pullbacks based on the principle of mean reversion. The larger %B is, the closer the price is to the Upper Band, and vice versa. When %B > 100 or %B < 0, price exceeds the Upper or Lower Band, indicating unusual price action in either direction. When %B = 50, price is at the SMA. Figure 5 illustrates the application of %B to predict potential reversion to the mean on JPM stock prices. The %B (Bottom) quantifies the price's position within the Bollinger Bands overlay on the price chart (Top). As can be seen, in most cases when %B touches or breaches 100 or 0, prices tend to revert

to 50. This correponds to prices reverting to the SMA line upon reaching the Upper and Lower Bands on the price chart (Top). Hence, %B can be used with CCI to identify entry and exit points in a trend.

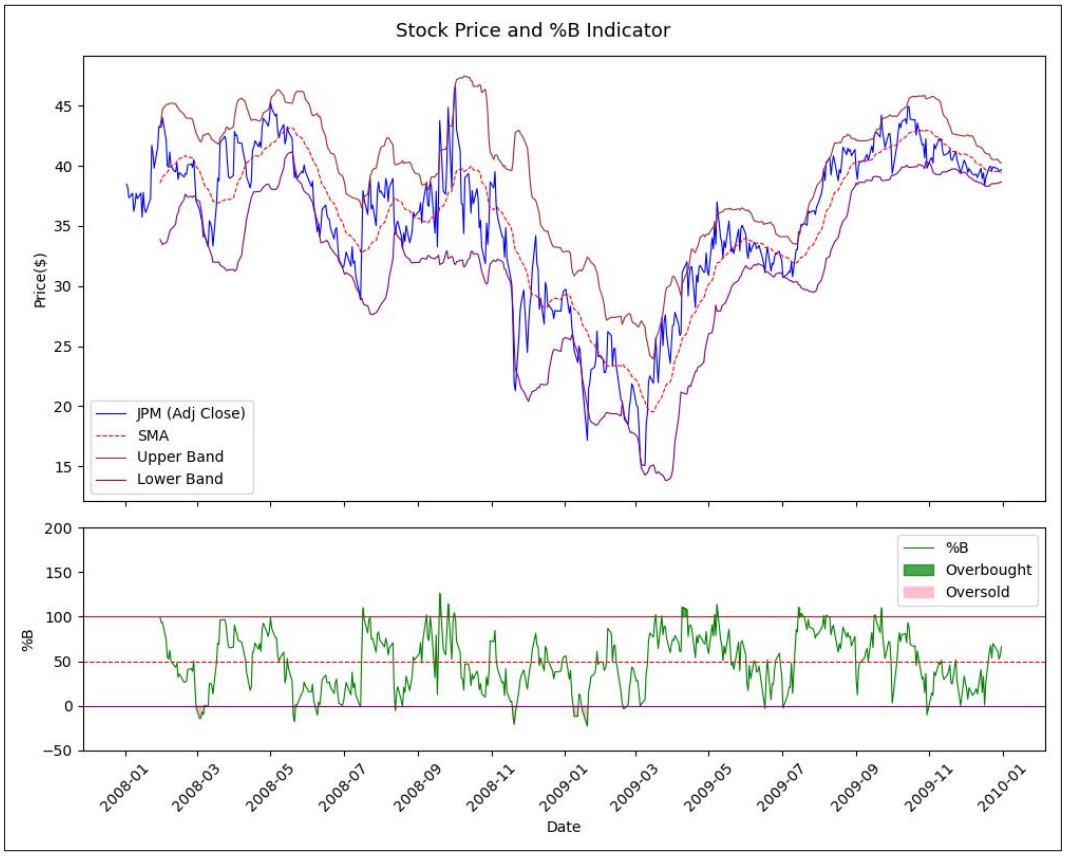

Figure 5 — Application of %B on JPM stock price. [Top]: Bollinger Bands overlay on adjusted closing price. [Bottom]: %B identifies overbought and oversold price actions.

Together, the 5 indicators can be used in complementary with one another to identify trends, entry and exit points within trends for informing trade decisions.

2.2 Theoretically Optimal Strategy (TOS)

Figure 6 compares the performance of TOS against the benchmark. It shows that TOS substantially outperforms the benchmark's buy-and-hold strategy. The cumulative returns of TOS and benchmark are 578% and 1.23% respectively (Table 1). This is expected as TOS actively captures the return of every up and down price movement by taking both long and short positions according to knowledge of the next day's price action. In contrast, the benchmark's passive strategy can

profit only from the stock's upside price action. The ability of TOS to profit from downside also means that TOS is less risky than the benchmark. TOS's daily return has a lower standard deviation than that of the benchmark (Table 1). TOS also has a substantially higher risk-adjusted return than the benchmark, as reflected in their Sharpe ratios (Table 1). However, such superb profitability will be unattainable in real-life, as it is impossible for traders to know the future.

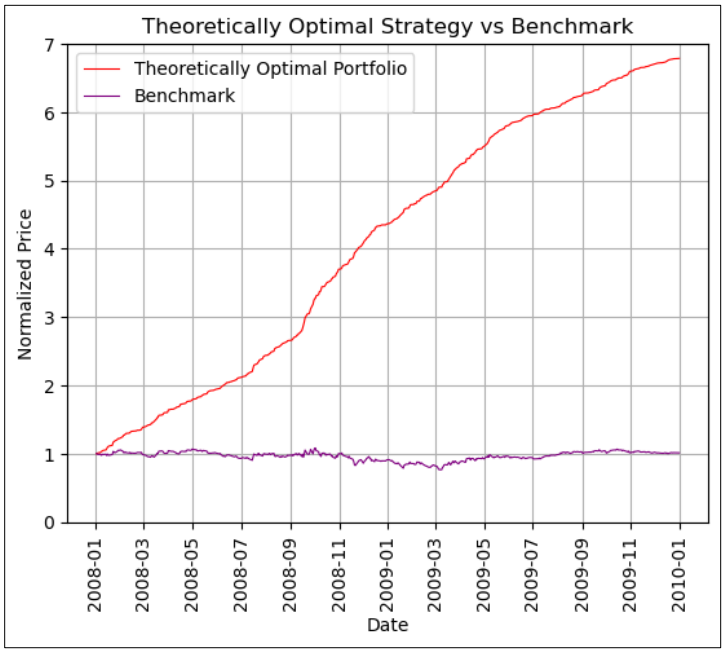

Figure 6 — Performance comparison of Theoretically Optimal Strategy (TOS) and Benchmark portfolios. Portfolio values are normalized to the values at the start of the study period.

Table 1 — Comparison of Theoretically Optimal Strategy (TOS) and Benchmark portfolios on several performance metrics. The values are calculated from their normalized portfolio values. Hence, they have no unit.

Metrics	**Theoretically Optimal Strategy**	**Benchmark (Buy-and-Hold)**
Cumulative Return	5.786100	0.012300
Mean Daily Return	0.003817	0.000168
Std Dev of Daily Return	0.004548	0.017004
Final Value	6.786100	1.012300
Sharpe Ratio	13.322998	0.156841

3 REFERENCES

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