CS7646 Spring 2022 Project 6 Indicator Evaluation

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1 Indicators

Indicators are trading signals generated from the calculation of historical stock price and trading volume to predict the future prices. In this project, 5 technical indicators were chosen to predict the stock price of JPM, they are

- Simple Moving Average (SMA)
- Bollinger Bands (BB)
- Momentum
- Moving Average Convergence Divergence (MACD)
- Percentage Price Oscillator

1.1 Simple Moving Average (SMA)

Simple moving average (SMA) is calculated by taking the average of the sum of a stock's prices over a fixed period. Here is the formula:

SMA = $\sum_{i=1}^{n} \frac{a_1 + a_2 + \ldots + a_n}{n}$ where a_i is the stock price at period n and n is the total periods

Plotting SMA helps to smooth volatility of stock's price so that an uptrend or downtrend can be easily seen. In this experiment, we use short term SMA (20-day) crosses long term SMA (50-day) to indicate buy/sell signal.

Long term SMA represents a more general trend of a stock's price while short term SMA represents a recent price movement. When the short term SMA breaks through long term SMA, it means a trend change occurs.

If the 20-day SMA crosses above the 50-day SMA and the 20-day SMA is in uptrend, it means the stock's price would probably go up. It is a buy signal.

If the 20-day SMA crosses below the 50-day SMA and the 20-day SMA is in downtrend, it means the stock's price would probably go down. It is a sell signal.

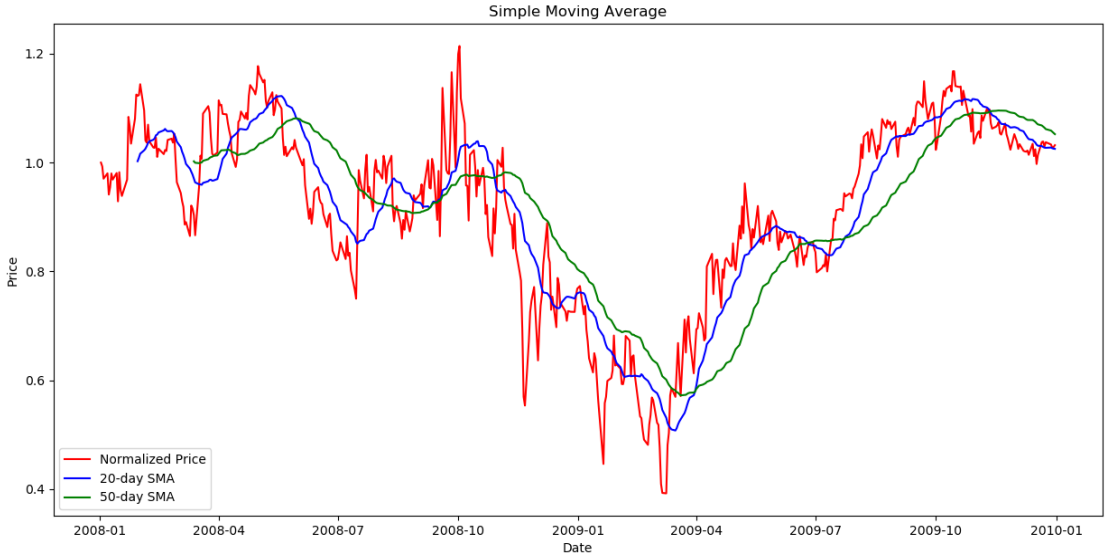

Figure 1—20-day SMA crosses 50-day SMA

To simplify this indicator, the short term SMA crosses long term SMA signals can be represented by a (20-day SMA / 50-day SMA) ratio.

If the (20-day SMA / 50-day SMA) ratio > 1, it is a buy signal.

If the (20-day SMA / 50-day SMA) ratio < 1, it is a sell signal.

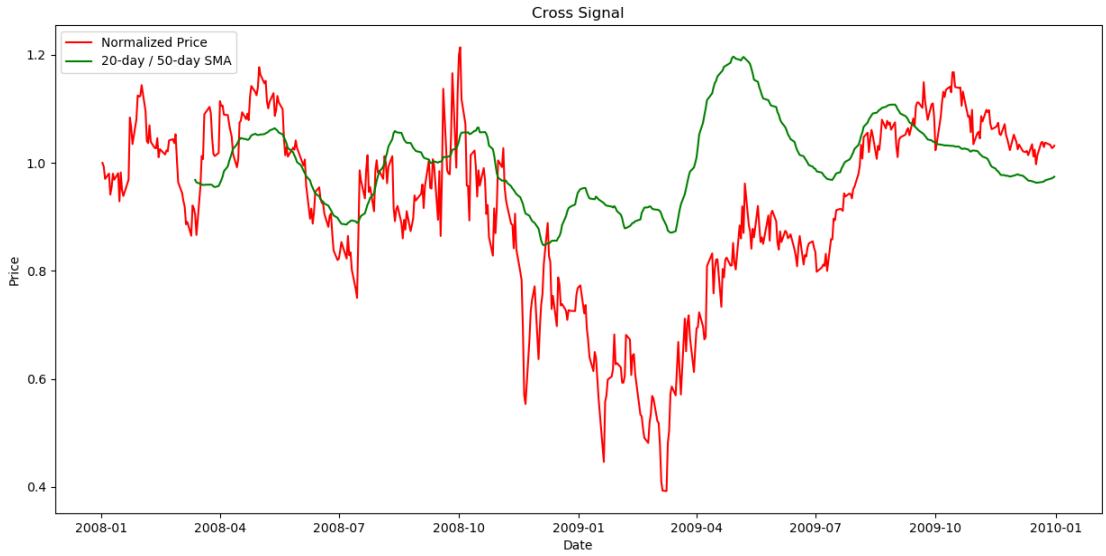

Figure 2—Cross signal derived from 20-day SMA / 50-day SMA

1.2 Bollinger Bands (BB)

Bollinger Bands uses simple moving average and then creates an upper band and lower band by adding and subtracting SMA by 2 standard deviations.

Upper band = SMA + 2 * rolling standard deviation

Lower band = SMA - 2 * rolling standard deviation

Traditionally, if the stock price is moving from the outside of the lower band into the band and towards SMA, it is a buy signal. If the stock price is moving out of the upper band and away from SMA, it is a sell signal.

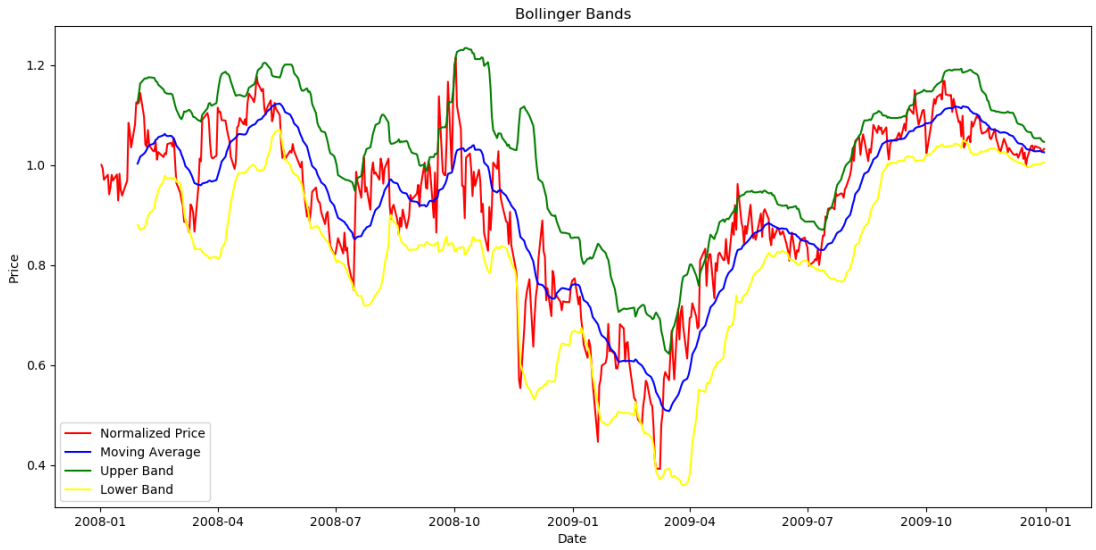

Figure 3—Bollinger Bands

To quantify this indicator's signal, BB percentage (BBP%) is used.

$$\text{BBP\%} = \frac{(price - lower\ band)}{(upper\ band - lower\ band)}$$

If BBP < 0, the price is below the lower band.

If BBP > 1, the price is above the upper band.

If BBP > 0.5, the price is above SMA.

If BBP < 0.5, the price is below SMA.

Therefore, when the price is above 0.8, it is near the upper band and can be interpreted as overbought. It is a sell signal.

When the price is moving below 0.2, it is near the lower band and can be interpreted as oversold. It is a buy signal.

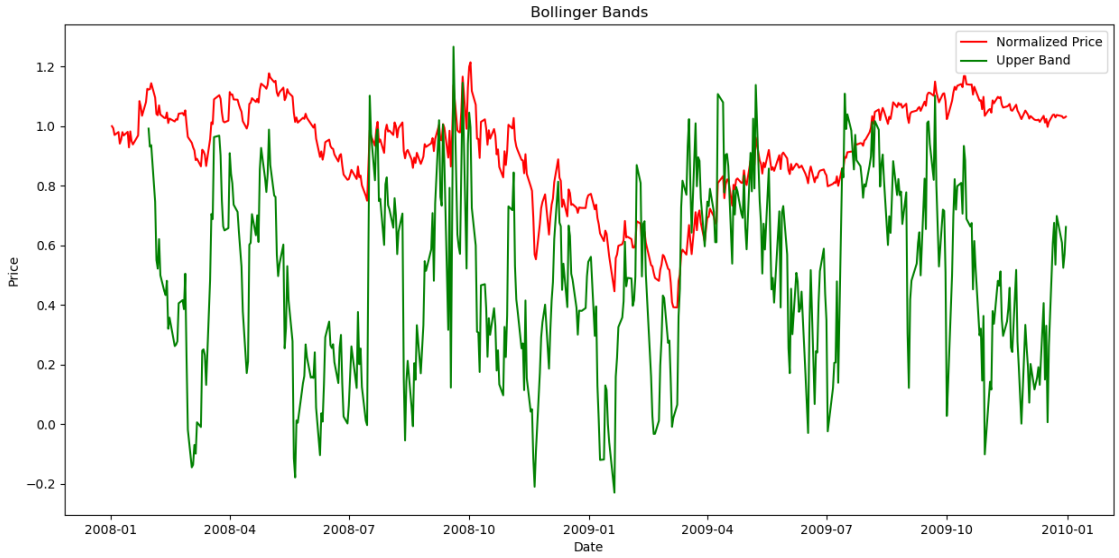

Figure 4—Bollinger Bands Percentage

1.3 Momentum

Momentum measures the rate of change of the stock's price over past certain days.

Momentum = $\frac{price\ of\ the\ day\ (t)}{price\ of\ the\ day\ (t-n)}$ - 1 , where **n** is the lookback period

If momentum > 0, it means the stock price has increased over the past n days. Increasing momentum means there is a buying pressure and indicates a buy signal.

If momentum < 0, it means the stock price has decreased over the past n days. Decreasing momentum means there is selling pressure and indicates a sell signal.

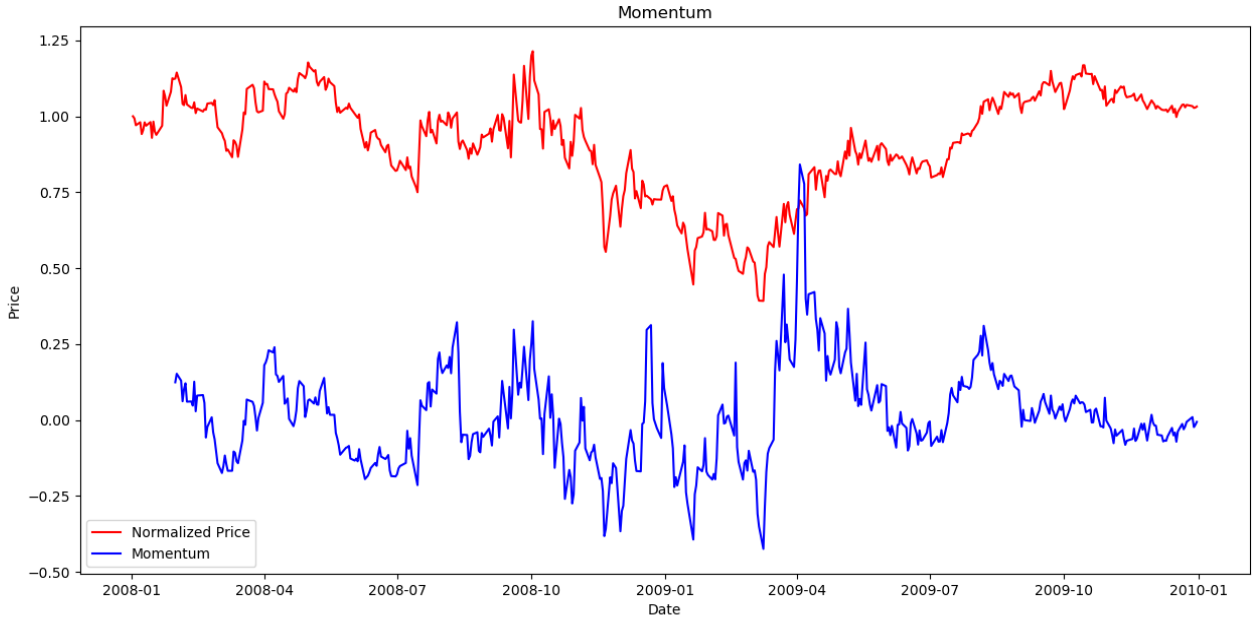

Figure 5—Momentum with lookback period of 20 days

1.4 Moving Average Convergence Divergence (MACD)

MACD measures the difference between 12 periods exponential moving average (EMA) and 26 periods EMA. EMA is an exponentially weighted moving average which weighs recent prices heavily rather than taking every price as the same weight as SMA. Thus, EMA reflects more on recent price movement.

In this experiment, **MACD = 12-day EMA - 26-day EMA**

A **9-day EMA** is used as a **signal line** to determine a buy/sell signal.

If the MACD line move crosses **above** the signal line, it is a buy signal.

If the MACD line move crosses **below** the signal line, it is a sell signal.

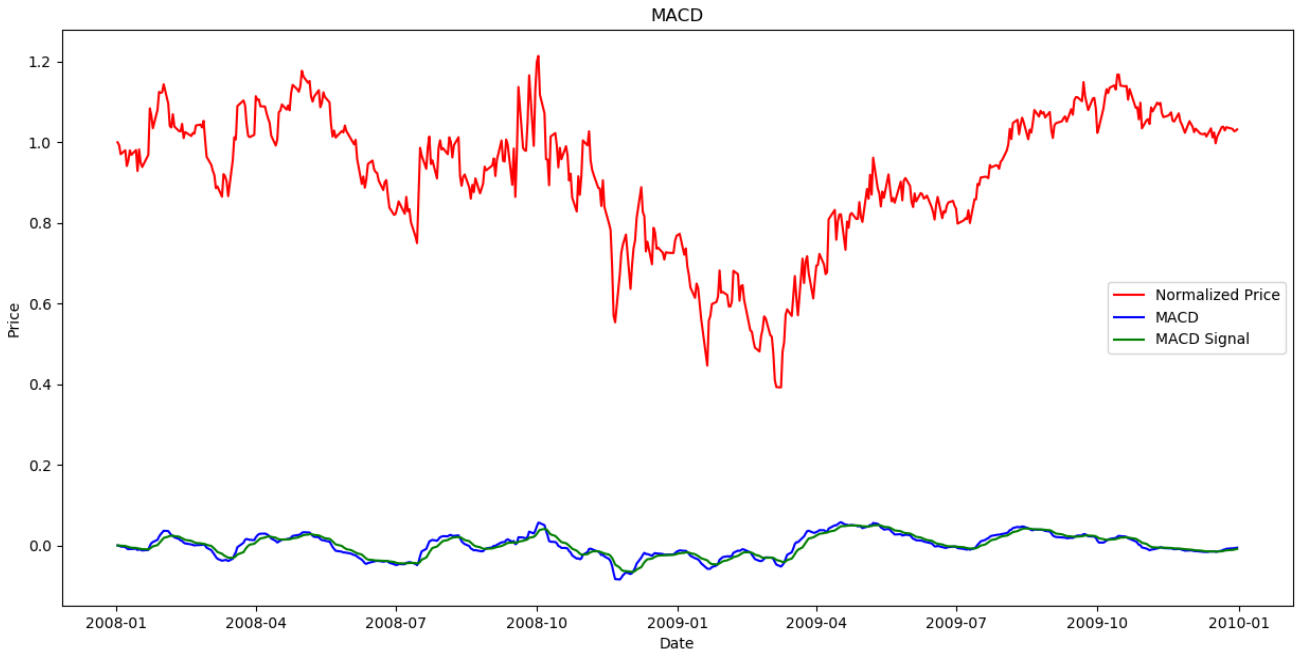

Figure 6—MACD & MACD signal

1.5 Percentage Price Oscillator (PPO)

Percentage Price Oscillator (PPO) is MACD divided by 26-day EMA.

$$\text{PPO} = \frac{12day\ EMA - 26day\ EMA}{26day\ EMA}$$

Signal line is 9-day EMA

When **PPO > 0**, it means the short term EMA (12-day) is larger than long term EMA (26-day). The stock price is in **uptrend**. If PPO > 0 and is **moving up and crosses** above the signal line, it is a buy signal.

When **PPO < 0**, it means the short term EMA is smaller than long term EMA. The stock price is in **downtrend**. If PPO < 0 and is **moving down and crosses** the signal line. It is a sell signal.

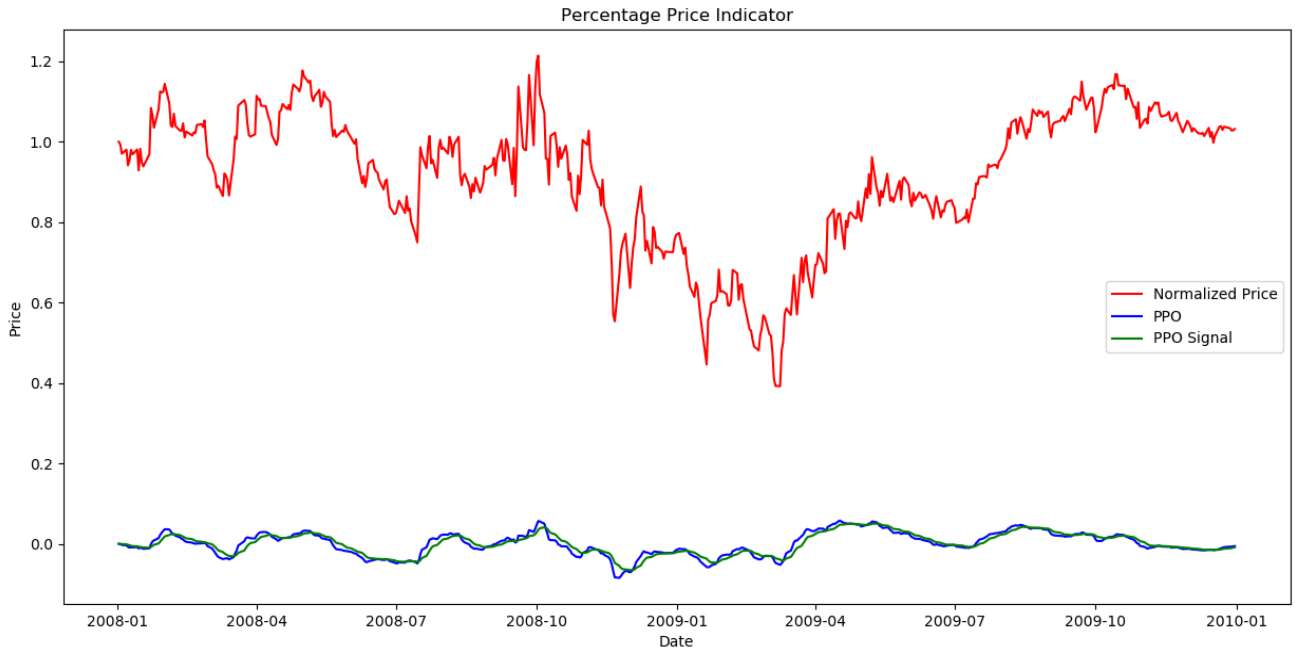

Figure 7—PPO & PPO signal

2 Theoretically Optimal Strategy (TOS)

2.1 How TOS is created

In this experiment, TOS is designed to earn a maximum amount on a stock within a given timeframe and trading conditions.

- Timeframe: Jan 1, 2008 - Dec 31, 2009
- Starting cash: $100,000
- Stock allowed to trade: JPM only
- Positions allowed: 1000 shares long / 1000 shares short / 0 shares

Assumptions:

- Commission $0
- Impact 0
- Future price of JPM is known
- Initial holding of JPM is zero

If price of JPM on the next day > today's price,

- Buy 1000 shares of JPM if current holding is zero

- Buy 2000 shares of JPM if current holding is -1000
- No action if current holding is 1000

If price of JPM on the next day < today's price,

- Sell 1000 shares of JPM if current holding is zero
- Sell 2000 shares of JPM if current holding is 1000
- No action if current holding is -1000

Basically the TOS is to maximize the return of each day under the ±1000 holding constraint when the future price of JPM is known.

A benchmark strategy is used as a comparison to the performance of TOS. The starting cash is also $100,000 (the same as TOS). But this strategy buys 1000 shares of JPM and holds until the end of the timeframe.

2.2 TOS performance vs the benchmark

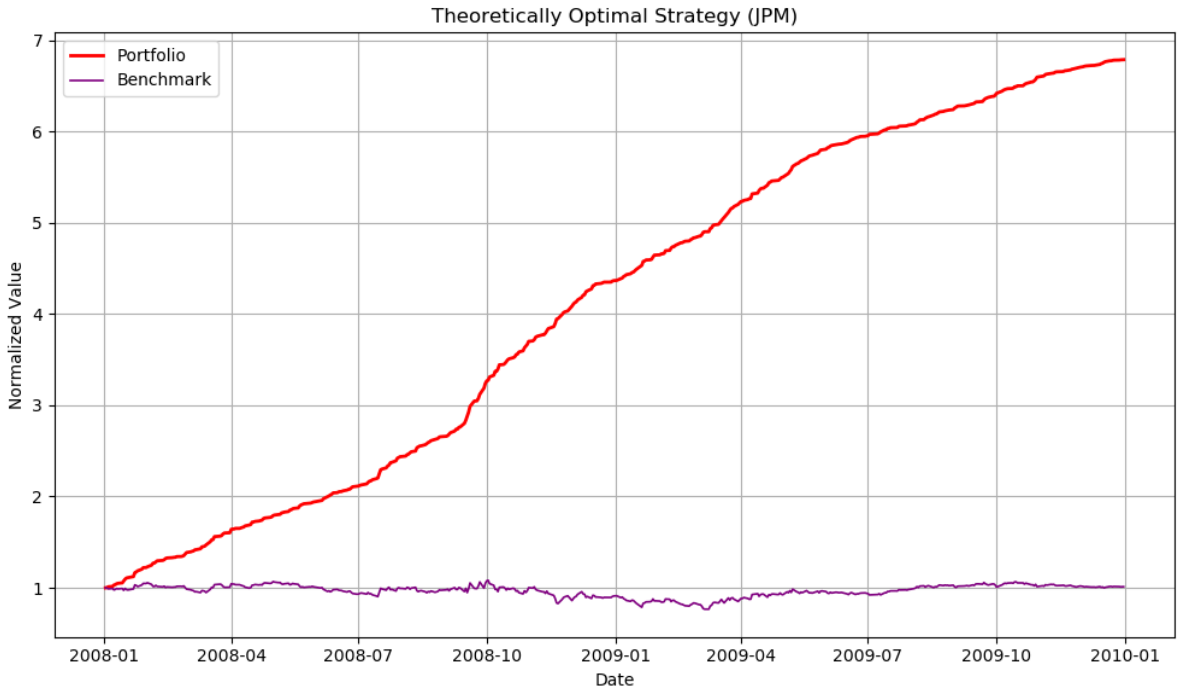

Figure 8—Theoretically Optimal Strategy performance versus the benchmark

2.3 Table - Benchmark and TOS performance

Table 1—Benchmark and TOS performance metrics

Strategy	**Benchmark**	**Theoretically Optimal Strategy**
Cumulative returns	0.012299	5.7861
Standard deviation of daily returns	0.017004	0.004547
Mean of daily returns	0.000168	0.003816