CS 7646 ML4T
Project 6: Indicator Evaluation

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1 INDICATORS:

1.1 Simple moving average (SMA) and deviation rate (BIAS):

Simple moving average, SMA(N), is a simple and universal moving average in past N days. Deviation rate, BIAS(N), is the percentage of deviation between the price and SMA(N). The BIAS reflects the degree of deviation between the price and its SMA in a certain period. The possibility of price retreat or rebound due to deviation from the moving average trend when the price fluctuates sharply, and the credibility that the price moves within the normal fluctuation range to continue the original trend.

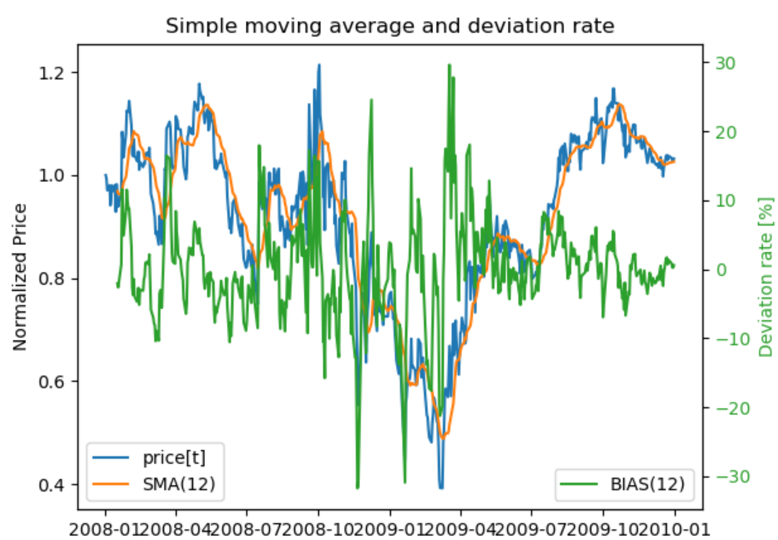

Figure 1—12-day simple moving average and deviation rate.

Here, the SMA(N) and BIAS(N) is defined as:

$$SMA(N) = \frac{1}{N}\sum_{i=0}^{N-1} price[t-i] \quad (1)$$

$$BIAS(N) = (price[t] - SMA(N)/SMA(N) \times 100\% \quad (2)$$

Figure 1 shows the price of JPM from 2008-01-01 to 2009-12-31, and the corresponding SMA(12) and BIAS(12)

In order to use the BIAS(N) to generate buy/sell signals, we can long the stock when BIAS(12) is less than -8% and short the stock when BIAS(12) is greater than 8%.

1.2 Bollinger Bands value (BOLL):

The Bollinger Bands (BOLL) was created by Mr. John Bollinger. It uses statistical principles to find the standard deviation of the stock price and using its confidence intervals to determine the fluctuation range and future trends of the stock prices. It uses two wave bands to show the safe high and low prices of stock.

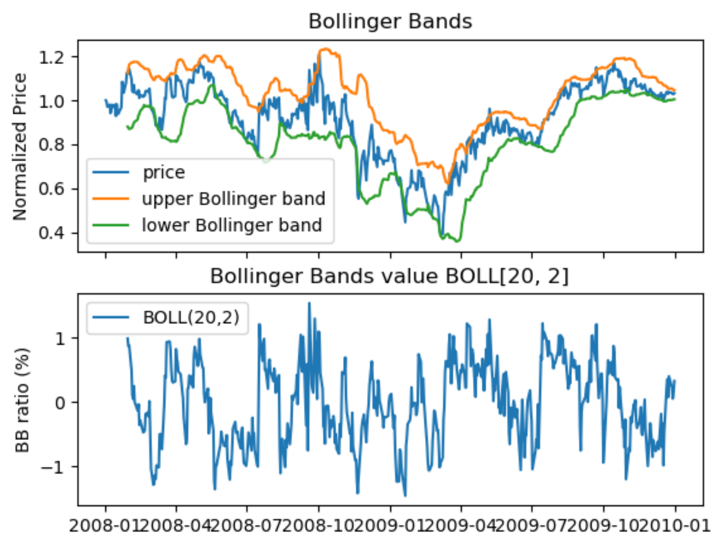

Figure 2—Bollinger Bands and the relative Bollinger Bands value BOLL(20, 2).

The upper and lower Bollinger bands are $SMA(N) \pm 2 \times \sigma$. Here, SMA(N) is N-day moving average, σ is the standard deviation of $SMA(N)$. As shown in Figure 2, we can use the indicator $BOLL(N, M)$ alone to generate buy/sell signals.

$$BOLL(N, M) = (price[t] - SMA(N))/(M \times \sigma[t]) \tag{3}$$

Here N is 20, and M is 2. When the price go into the lower band (BOLL(20, 2) change from less than -1 to more than -1), we long the stock. When the price go into the upper band (BOLL(20, 2) change from more than 1 to less than 1), we short the stock.

1.3 Momentum indicator (MTM):

The momentum indicator is a technical analysis tool to study the stock price volatility in the short-term. Momentum Index (MTM) is based on the assumption that stock price rise (down) trend continues in a short period, and the share price rise (fall) rate will remain roughly the same. Based on the changes in the rate of rise and fall of stock prices, the N-day momentum indicator, MTM(N) is defined as:

$$MTM(N) = price[t] - price[t-N] \tag{4}$$

In order to directly use the MTM(N) as a market signal, we define a momentum rate, MR(N):

$$MR(N) = MTM(N)/price[t-N] \tag{5}$$

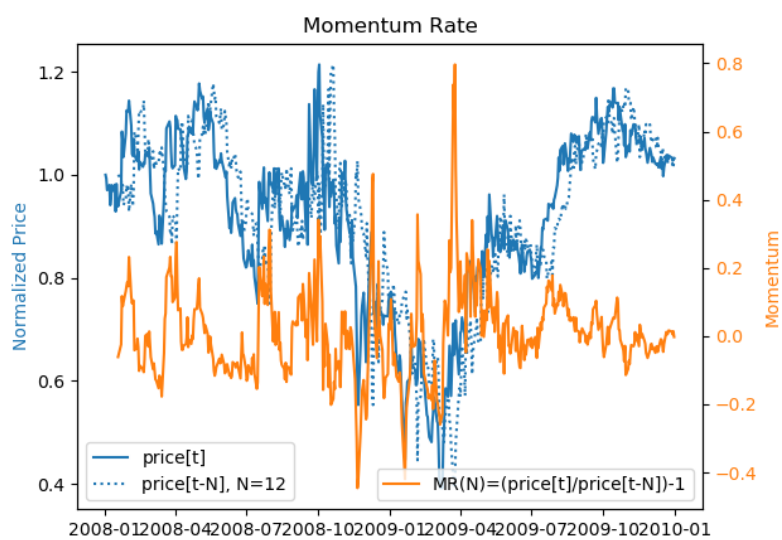

Figure 3—Momentum rate MR(12).

Here, we choose 12-day momentum rate, MR(12), as shown in Figure 3. When MR(12) changes from negative to positive, we long the stock. When MR(12) changes from positive to negative, we short the stock.

1.4 Volatility:

The volatility of stock prices is a measure of the uncertainty of stock returns and is used to reflect the risk level of stocks. High volatility of the stock prices represent the stronger the uncertainty of the return on stocks.

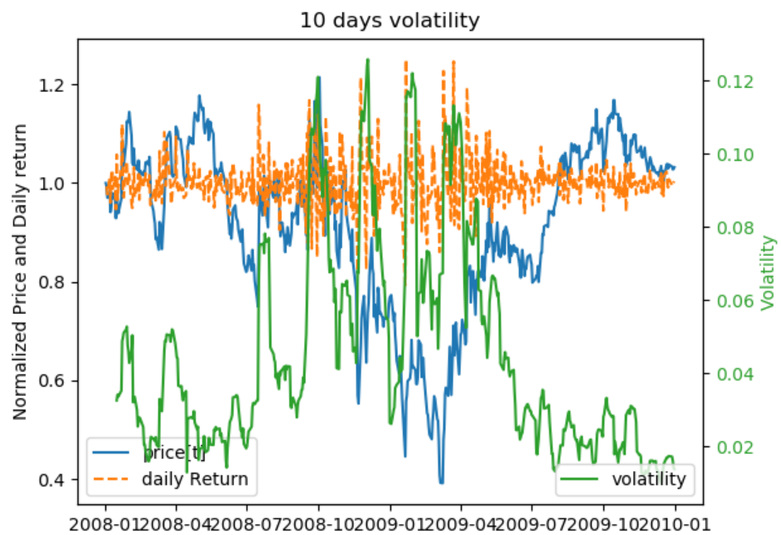

Figure 4—Volatility based on 10-day's daily return.

Here, we calculate the volatility based on the daily return rate, DRR[t]:

$$DRR[t] = price[t]/price[t-1] - 1 \tag{6}$$

Using the daily return rate DRR[t], we obtain the N-day volatility by calculation of the N-day standard deviation of the daily return rate:

$$volatility(N) = \sqrt{\frac{1}{N}\sum_{i=0}^{N-1}(DRR[t-i] - \widehat{DRR}[t-i])^2} \tag{7}$$

Figure 4 shows the 10-day volatility, volatility(10).

The volatility of the stock price is an important factor in the Black-Scholes option pricing formula. When calculating the theoretical price of an option, the historical volatility of the underlying asset is usually used. The greater the volatility, the higher the theoretical price of the option. If the strategy does not contain option trade, we can use the volatility as a risk index: when the volatility and price is high, we can close our positions to keep the profit.

1.5 Moving Average Convergence and Divergence (MACD):

Convergence and Divergence Moving Average, MACD, is developed from the double exponential moving average. The fast exponential moving average, EMA(12) is subtracted from the slow exponential moving average, EMA(26) to get the fast DIF, and then 2 (Express DIF-DIF's 9-day weighted moving average DEA) Get the MACD bar. The meaning of MACD is basically the same as the double moving average, that is, the dispersion and aggregation of the fast and slow moving averages characterize the current long-short status and the possible development trend of stock prices, but it is more convenient to read. The change of MACD represents the change of market trend, and the MACD of different K-line levels represents the buying and selling trend in the current level cycle.

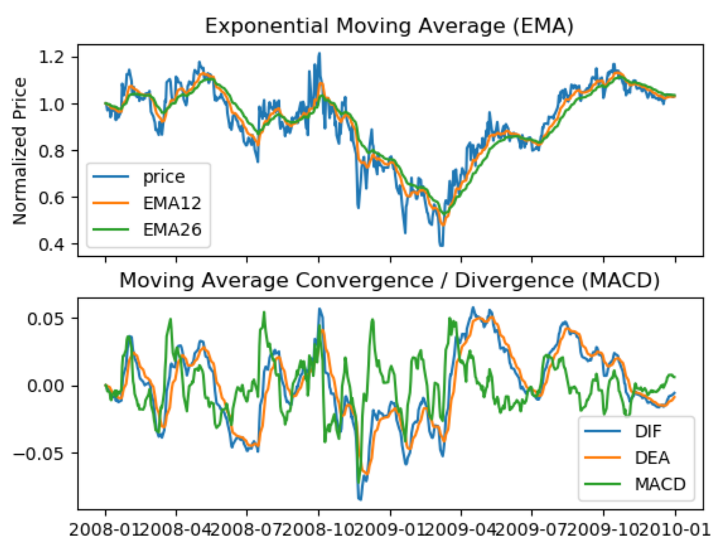

Figure 5—Exponential Moving Average, EMA(12) and EMA(26). Moving Average Convergence and Divergence, MACD.

In order to calculate the MACD, first we need to calculate the EMA. A N-day EMA, EMA(N) can calculate a recursive function:

$$EMA(N)[t] = \frac{2 \times price[t] + (N-1)EMA(N)[t-1]}{N+1}, \tag{8}$$

$$EMA(N)[0] = price[0] \tag{9}$$

Here price[0] is the earliest price we have in the record. Then we calculate the deviation value, DIF, of EMA(12) and EMA(26):

$$DIF[t] = EMA(12)[t] - EMA(26)[t] \tag{10}$$

Afterward, we calcualte the 9-day EMA of the DIF[t] value, and get the DEA[t]:

$$DEA[t] = \frac{2 \times DIF[t] + (N-1)DEA(N)[t-1]}{N+1} \tag{11}$$

Here, N=9, and $DEA[0] = DIF[0]$ is the first data point of DIF[t] Finally, we obtain the MACD[t] with:

$$MACD[t] = (DIF[t] - DEA[t]) \times 2 \tag{12}$$

Figure 5 shows the 12-day and 26-day exponential moving average of price on the top panel, and shows the calculation results of DIF[t], DEA[t], and MACD[t] on the bottom.

Using the MACD, we can make our trading strategy as this:

when DIF[t] and DEA[t] are both greater than 0, and moving upward, we can long the stock;

when DIF[t] and DEA[t] are both less than 0, and moving downward, we can short the stock;

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2 THEORETICALLY OPTIMAL STRATEGY:

In the theoretically optimal strategy, we can peek the future price. Thus, we can use the information of future price to maximize the profit. The basic idea is this: when we know the price will increase on the next trading day, we long the stock, the more shares we hold, the larger profit we can earn. In this situation, we keep our position on 1000 shares due to the position limit. We can make an order to buy 1000 shares if the current position is 0; we can buy 2000 if the current position is -1000; we do nothing if we already have 1000 shares in position. In contrast, if the stock price will decrease on the next day, we short the stock, and keep out position on -1000 shares as reaching the position limit. We can make an order to sell 1000 shares if the current position is 0; we can sell 2000 if the current position is 1000; we do nothing if we already have -1000 shares in position. The position on the last day of the trading period does not affect the final portfolio accumulated returns, so we can choose the close the position or do nothing.

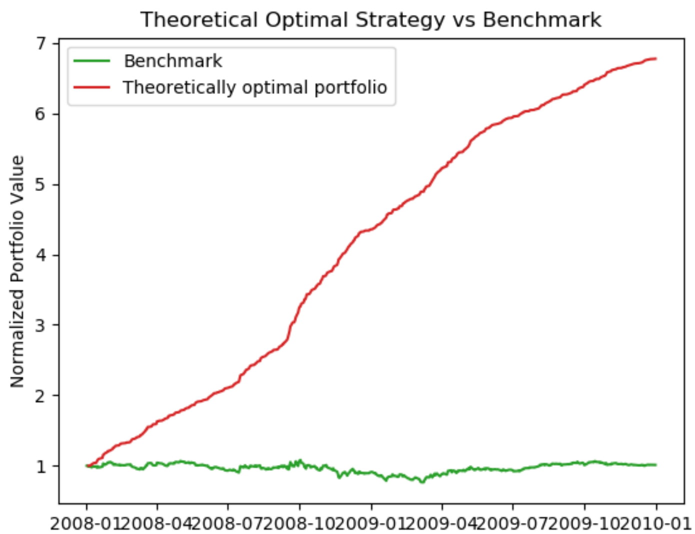

Figure 6—Comparison of theoretical optimal strategy and benchmark

Figure 6 shows the comparison of the normalized portfolio value of our theoretical optimal strategy versus the benchmark. The benchmark curve in green is based on the strategy that we buy 1000 shares of the stock at the first trading day and hold until the end of the trading period. The red curve is the normalized accumulated returns based on the theoretical optimal strategy.