A CUSUM-Based Trading Strategy

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Introduction and Motivation

Problem Statement

Apply CUSUM method to detect an upward or downward daily stock return trend and develop a trading strategy based on it. When an upward (downward) trend of a security is observed, a long (short) position is taken. This active trading strategy will be evaluated against the buy-and-hold strategy over the same historical time period.

Motivation

Utilize CUSUM method to build an active trading strategy that can beat the market return.

Data Source

S&P 500 Adjusted Close from 1997-11-30 to 2022-11-30 as the proxy for the prices of a portfolio of stocks

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Mathematical Modeling

Methodology

– Assume stock price follows Geometric Brownian Motion

$$r_t = \ln \frac{S_t}{S_0}, \qquad r_t \sim \mathbb{N}(\mu - \frac{\sigma^2}{2}, \sigma^2)$$

where: S_t: stock price at time t, μ: expected return, σ: volatility

– Use window-limited MLE estimators to calibrate μ and σ

$$\max_{\mu,\sigma^2} l(\mu, \sigma^2; x_1, \dots, x_w) \Rightarrow \widehat{\mu_w} = \frac{1}{w}\sum_{i=1}^{w} x_i \quad \widehat{\sigma_w^2} = \frac{1}{w}\sum_{i=1}^{w} (x_i - \hat{\mu})^2$$

– CUSUM test: $Z_t^+ \geq h_1 \Rightarrow Long; Z_t^- \leq h_2 \Rightarrow Short$

$$Z_t^+ = \max(Z_{t-1}^+ + \log\frac{f_0(r_t)}{f_0(r_0)}, 0) \quad Z_t^- = \min(Z_{t-1}^- + \log\frac{f_0(r_t)}{f_0(r_0)}, 0)$$

where: $Z_0^+ = Z_0^- = 0$, $f_0(x) = \frac{1}{\sqrt{2\pi\widehat{\sigma_w^2}}} e^{-\frac{\left(x - \widehat{\mu_w} + \frac{\widehat{\sigma_w^2}}{2}\right)^2}{2\widehat{\sigma_w^2}}}$, $h_1 = \widehat{\mu_w} + a_1\widehat{\sigma_w}$, $h_2 = \widehat{\mu_w} - a_2\widehat{\sigma_w}$

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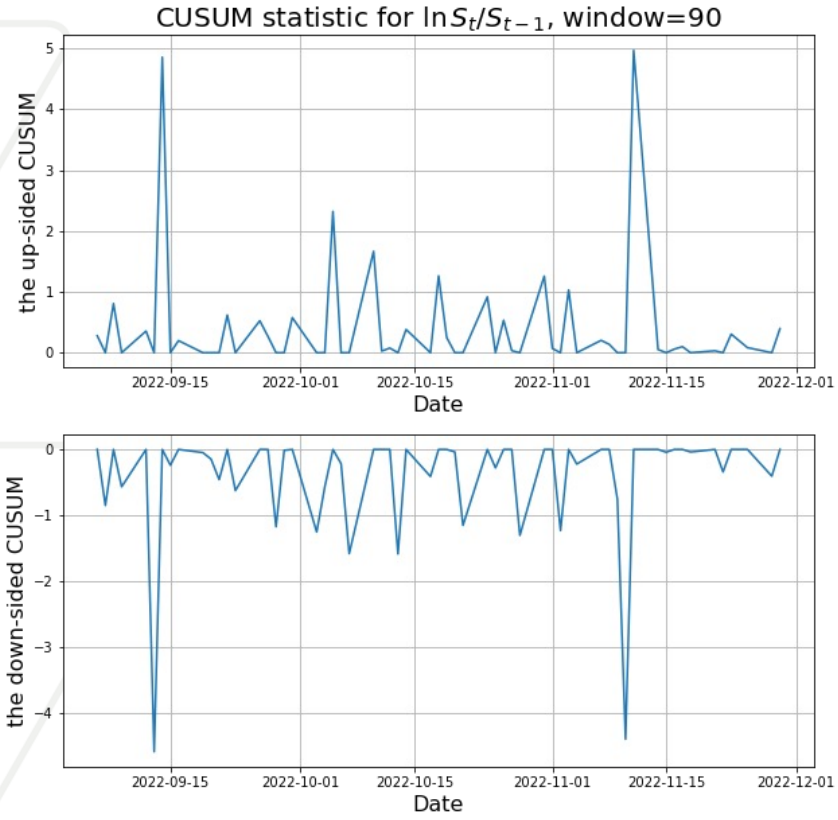
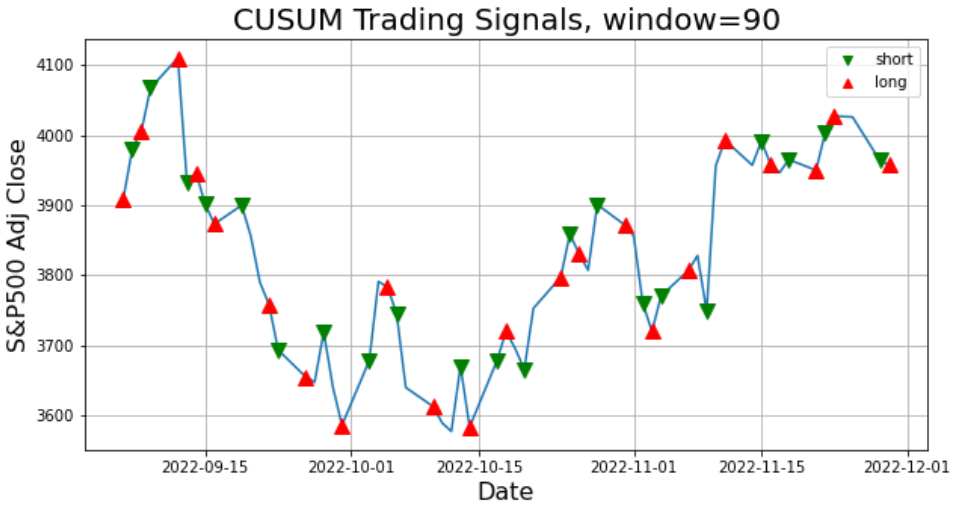
Main Results

CUSUM Statistics and Trading Signals

- Date: 2022/09/01 - 2022/11/30
- Rolling window: 90 days
- Threshold: $h_1 = \mu_w + \sigma_w, h_2 = \mu_w - \sigma_w$





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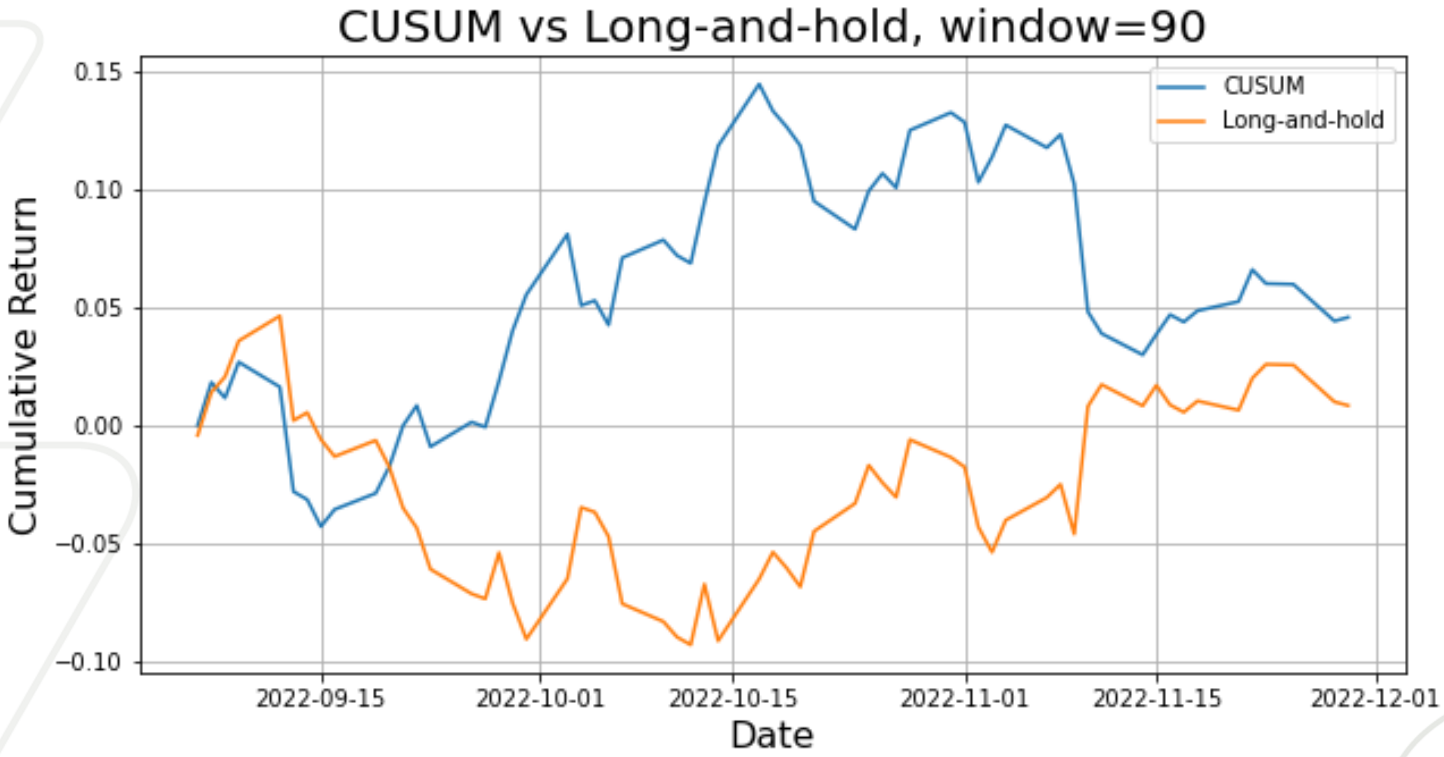
Main Results

Strategy Comparison

- Long-and-Hold : 0.85% Holding Period Return
- CUSUM : 4.58% Holding Period Return



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