

Backtesting Crypto Trading Strategies

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Learning objectives/motivation

- How to evaluate the performance of trading strategies?
- Simple Moving Average strategy for cryptos as an example to show how multiple testing issues arise through data mining.
- Adjust performance measures for multiple testing, for example, by calculating a “haircut Sharpe ratio”.

Related literature

- Harvey, C. R., & Liu, Y. (2015). Backtesting. *The Journal of Portfolio Management*, 42(1), 13-28.

Simple moving average trading strategy

- Use past prices to predict future prices of underlying.

If {short-term moving average > long-term moving average}:

Long underlying # Upward-trend

else:

Short underlying # Downward-trend

Test if strategy is profitable

- Given a sample of historical returns (r_1, r_2, \dots, r_T) with mean $\hat{\mu}$ and standard deviation $\hat{\sigma}$.
- Null hypothesis that strategy is not profitable ($\hat{\mu} = 0$, two-sided test):

$$t\text{-ratio} = \frac{\hat{\mu}}{\hat{\sigma}/\sqrt{T}}.$$

$$\widehat{SR} = \frac{\hat{\mu}}{\hat{\sigma}},$$

$$\begin{aligned} p^S &= Pr(|r| > t\text{-ratio}) \\ &= Pr(|r| > \widehat{SR} \cdot \sqrt{T}) \end{aligned}$$

- Assumption returns are i.i.d. normal, t-statistic follows a t-distribution with $T - 1$ degrees of freedom under the null hypothesis.

Let's test the strategy...

Multiple Testing

- If you test $N = 1$ strategy, what is the probability to find a profitable trading strategy at significance level $\alpha = 0.05$?
- If you test $N = 10$ strategies, what is the probability to find a profitable trading strategy at significance level $\alpha = 0.05$?

$$\begin{aligned} p^S &= \Pr(|r| > t\text{-ratio}) \\ &= \Pr(|r| > \widehat{SR} \cdot \sqrt{T}) \end{aligned}$$

$$\begin{aligned} p^M &= \Pr(\max\{|r_i|, i = 1, \dots, N\} > t\text{-ratio}) \\ &= 1 - \prod_{i=1}^N \Pr(|r_i| \leq t\text{-ratio}) \\ &= 1 - (1 - p^S)^N. \end{aligned}$$

- $N = 1$: 0.05; $N = 10$: 0.4013

“Haircut”/Adjusted Sharpe Ratio

$$p^M = \Pr(|r| > \widehat{HSR} \cdot \sqrt{T})$$

Conclusion

- Evaluating the profitability of trading strategies needs to account for multiple testing.
- Potential solutions are a haircut Sharpe ratio or other multiple testing frameworks (e.g. family-wise error rate and false-discovery rate corrections): Bonferroni; Holm; Benjamini, Hochberg and Yekutieli (BHY); etc.
- Multiple testing methods are designed to limit incorrectly “discovering” a profitable trading strategy.