Introductory Backtesting Notes for Quantitative Trading Strategies

Maybe Some Eye-catching Subtitle

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Abstract

"All models are wrong, but some are useful", Box 1976. This note is compiled for COMP4971C in Fall 2019 to assist the research of quantitative trading strategies.

Contents

1 Introduction

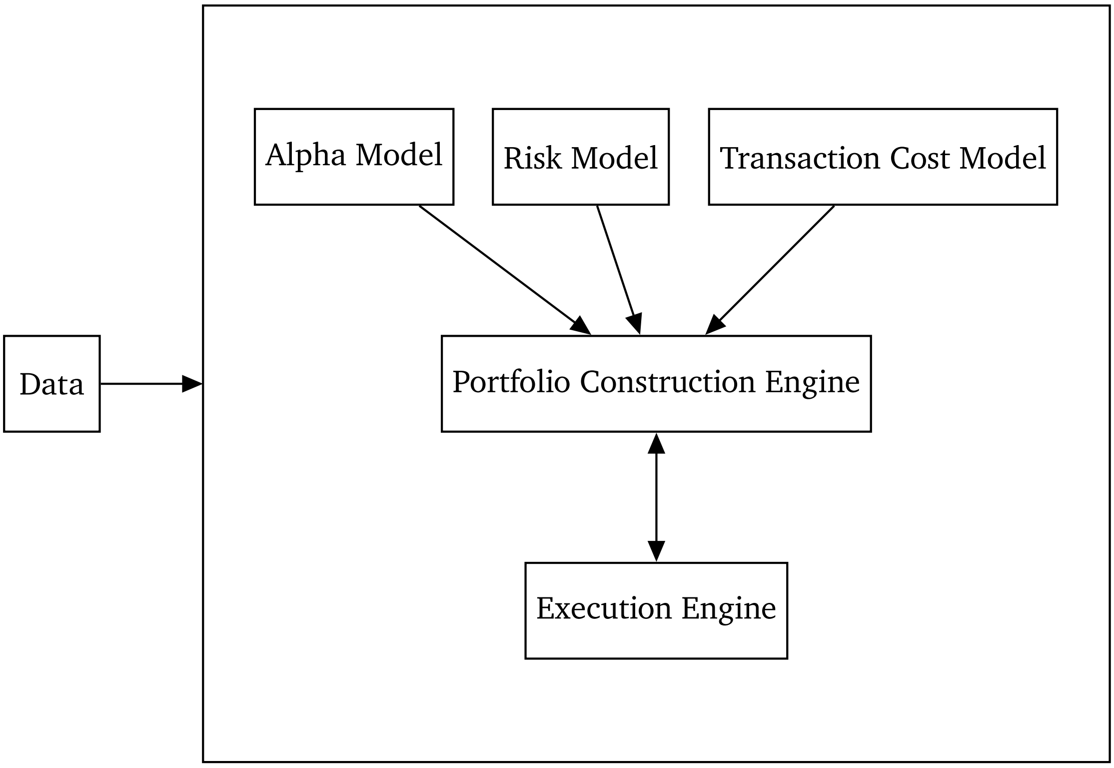
Backtesting is a compulsory stage in the development of any quantitative trading strategies. It evaluates the performance of a strategy with historical data and provides the following usages:

1. validate the effectiveness of the trading idea
2. tune the parameters of the strategy
3. predict the future performance (assuming repeating market patterns)

This note briefly introduces some industrial practices in backtesting a quantitative trading strategy for general first order securities (e.g. equity share, commodity future, etc.) along with some common mistakes. The majority of the content comes from several books and articles including but not limited to Narang 2013, QuantStart 2014, Chan 2008. All references are listed at the end of the note.

The structure diagram of a suggested backtest system is included below.

Structure of Backtest System



2 Note and Assumption

1. All “suggested” values are annualized, calculations are stated below
2. All “suggested” values are calculated after deducting transaction cost
3. Returns at different time t are assumed to be IID, otherwise the estimation of Sharpe ratio from sample needs to be adjusted accordingly

3 Primary Metrics

Primary metrics should be used for all types of trading strategies.

3.1 Sharpe Ratio

Metric Introduction

Sharpe ratio is first introduced by Sharpe 1966. Its original name “Reward-to-Variability Ratio” reflects its nature of balancing return and risk of a strategy. According to the definition in Sharpe 1994, assume R_{Pt} as a t-period return series, R_{ft} as the risk-free rate series over the same period. Then the Sharpe ratio S_h from $t = 1$ to $t = T$:

$$
\begin{aligned}
S_h &\equiv \frac{\overline{D}}{\sigma_D} \\
\text{where } D &\equiv R_{Pt} - R_{ft} \\
\overline{D} &\equiv \frac{1}{T}\sum_{t=1}^{T} D_t \\
\sigma_D &\equiv \sqrt{\frac{\sum_{t=1}^{T}(D_t - \overline{D})^2}{T-1}}
\end{aligned}
$$

This Sharpe ratio indicates the historical average differential return per unit pf historical variability of the differential return (Sharpe 1966). In simpler terms, Sharpe ratio measures the expected return gained per unit of risk taken for a zero investment strategy. The Sharpe ratio does not cover cases in which only one investment return is involved (Sharpe 1994).

Suggested Level

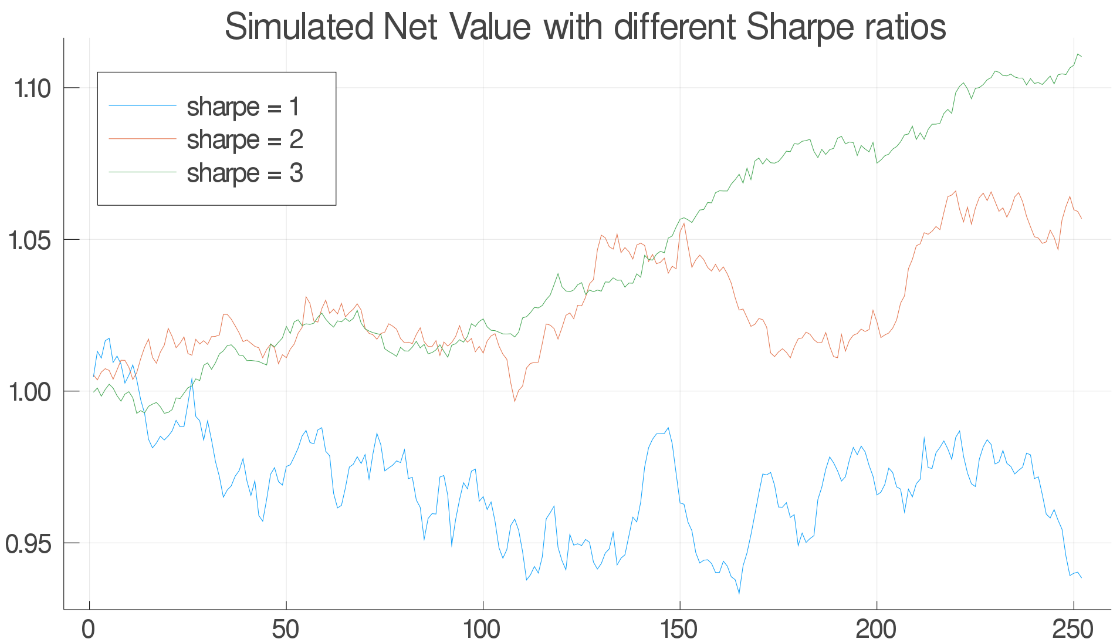


Figure 1: Net value graph of multiple sharpe ratios

The above diagram shows 3 different return series of Sharpe ratios ranging from 1 to 3, with 252 steps (simulating year-long daily returns). For a day-frequency strategy, $S_h > 1$ usually is not enough to generate consistent profits. A Sharpe value greater than 1.5 or even 2 is recommended. For longer-frequency strategies (i.e. weekly, monthly), $S_h > 0.7$ can be acceptable, $S_h > 1.2$ can be regarded as very good.

All values in the above section should be treated as reference instead of absolute limit/standard to judge a strategy.

3.2 Maximum Drawdown

Metric Introduction

Maximum drawdown is a specific measure of drawdown (the peak-to-trough decline during a specified timespan) that measures the greatest decline from a peak, before a new peak is reached.

$$MDD = \min DD_i \qquad \text{where } i \in \{0, ..., T\}$$
$$DD_t = \frac{V_t}{\max\{V_0, V_1, ..., V_t\}} - 1 \qquad \text{for } t \in \{0, ..., T\}$$

Note that it only measures the size of the largest loss, not the frequency of large losses. MDD does not indicate how long it took an investor to recover from the loss, or if the investment even recovered at all.

Suggested Level

insert (maximum) drawdown figure

3.3 Win Rate, Profit-Loss Factor and Payoff Ratio

Metric Introduction

Let π be the profit/loss of each trade, N be the total number of trades. Assume every trade results in non-zero profit or loss, i.e. $n_{\pi=0} = 0$, then $n = n_{\pi<0} + n_{\pi>0}$.

$$w = \frac{n_{\pi>0}}{N}$$
$$PnL = \frac{\sum_{i=1}^{N} \pi_{\pi>0}}{\sum_{i=1}^{N} \pi_{\pi<0}}$$
$$r = \frac{\sum_{i=1}^{N} \pi_{\pi>0}}{\sum_{i=1}^{N} \pi_{\pi<0}} \cdot \frac{n_{\pi<0}}{n_{\pi>0}}$$
$$w = \frac{PL}{PL + r}$$
$$RoR = (1 - w)^R$$

lorem

Suggested Level

lorem

4 Secondary Metrics

Secondary metrics provide easy explanation for non-finance-heavy personnel.

4.1 Compound Annual Growth Rate (CAGR)

Metric Introduction

Compound annual growth rate (CAGR) is the annualized, required rate of return for an investment to grow in timespan T (in years), assuming the intermediate profits are reinvested.

$$CAGR = \left(\frac{V_T}{V_0}\right)^{\frac{1}{T}} - 1$$

CAGR is not the true rate of return, but rather a smoothed, representational figure, usually used for easier explanation and comparison.

Suggested Level

The desired CAGR depends on the nature of the security and even its sector. Different types of securities (e.g. equity, fixed income, index, derivative) have different return characteristics.

4.2 Volatility of Return

Metric Introduction

lorem

$$y = f(x)$$

lorem

Suggested Level

lorem

4.3 Maximum Drawdown Duration

Metric Introduction

lorem

$$y = f(x)$$

lorem

Suggested Level

lorem

5 Common Pitfall

This section introduces multiple common mistakes made by quants in backtest.

5.1 Survivorship Bias

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5.2 Transaction Costs

lorem

5.3 Market Nature/Pattern

lorem

5.4 Look Ahead Bias

lorem

5.5 Overfitting

lorem

Conclusion

lorem

Reference

[1] George E. P. Box. "Science and Statistics". In: *Journal of the American Statistical Association* 71.356 (1976), pp. 791–799.

[2] Rishi K. Narang. *Inside the Black Box. A Simple Guide to Quantitative and High Frequency Trading*. 2nd ed. Wiley, Mar. 20, 2013.

[3] QuantStart. *Successful Algorithmic Trading. A Step-by-step Guide to Quantitative Strategies*. 2014.

[4] Ernest Chan. *Quantitative Trading. How to Build Your Own Algorithmic Trading Business*. Wiley, Nov. 17, 2008.

[5] William F. Sharpe. “Mutual Fund Performance”. In: *The Journal of Business* 39.1 (1966), pp. 119–138.

[6] William F. Sharpe. “The Sharpe Ratio”. In: *The Journal of Portfolio Management* 21.1 (1994), pp. 49–58.