Exercises

Portfolio Optimization: Theory and Application
Chapter 6 – Portfolio Basics

Daniel P. Palomar (2025). *Portfolio Optimization: Theory and Application.*
Cambridge University Press.

portfoliooptimizationbook.com

Exercise 6.1: Effect of rebalancing

a. Download market data corresponding to N assets (e.g., stocks or cryptocurrencies) during a period with T observations, $\boldsymbol{r}_1, \ldots, \boldsymbol{r}_T \in \mathbb{R}^N$.
b. Start with the $1/N$ portfolio at time $t = 1$ and let the portfolio weights naturally evolve as the assets' prices change over time. Plot the portfolio weights and the NAV over time (assuming transaction costs of 90 bps).
c. Repeat using a regular calendar-based rebalancing scheme.
d. Repeat using an adaptive rebalancing scheme when the difference exceeds a threshold.

Exercise 6.2: Portfolio constraints

Consider a universe of $N = 2$ assets and draw the set of feasible portfolios under the following constraints:

a. Budget and no-shorting constraints:

$$\mathbf{1}^\mathsf{T}\boldsymbol{w} \leq 1, \quad \boldsymbol{w} \geq \mathbf{0}.$$

b. Budget fully invested and no-shorting constraints:

$$\mathbf{1}^\mathsf{T}\boldsymbol{w} = 1, \quad \boldsymbol{w} \geq \mathbf{0}.$$

c. Budget, no-shorting, and holding constraints:

$$\mathbf{1}^\mathsf{T}\boldsymbol{w} \leq 1, \quad \boldsymbol{w} \geq \mathbf{0}, \quad \boldsymbol{w} \leq 0.6 \times \mathbf{1}.$$

d. Budget and turnover constraints:

$$\mathbf{1}^\mathsf{T}\boldsymbol{w} \leq 1, \quad \|\boldsymbol{w} - \boldsymbol{w}_0\|_1 \leq 0.5,$$

with $\boldsymbol{w}_0$ denoting the $1/N$ portfolio.

e. Leverage constraint:

$$\|\boldsymbol{w}\|_1 \leq 1.$$

Exercise 6.3: Performance measures

a. Download market data corresponding to the S&P 500 index.
b. Plot the returns and cumulative returns over time.
c. Calculate the annualized expected return with arithmetic and geometric compounding.
d. Calculate the annualized volatility.
e. Plot the volatility-adjusted returns and cumulative returns over time.
f. Calculate the annualized Sharpe ratio with arithmetic and geometric compounding.
g. Calculate the annualized semi-deviation and Sortino ratio.
h. Calculate the VaR and CVaR.
i. Plot the drawdown over time.

Exercise 6.4: Heuristic portfolios

a. Download market data corresponding to N assets during a period with T observations.
b. Using 70% of the data, compute the $1/N$ portfolio and quintile portfolios using different ranking mechanisms.
c. Plot and compare the different portfolio allocations over time.
d. Using the remaining 30% of the data, assess the portfolios in terms of cumulative returns, volatility-adjusted cumulative returns, Sharpe ratio, and drawdown.

Exercise 6.5: Risk-based portfolios

Repeat Exercise 6.4 with the following risk-based portfolios:

a. GMVP
b. IVolP
c. MDivP
d. MDecP