

Eigenvalue Dynamics and Minimum Variance Portfolios

February 10, 2026

Data

- Dataset: Fama–French 49 US Industry Portfolios
- Frequencies: Daily and Monthly returns
- Source: https://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html

Tasks

A. Covariance Matrix Analysis

- On 2022–12–31, estimate sample covariance matrices using daily returns with window sizes $N = 55, 60, 65, \dots, 500$
- Plot minimum eigenvalue of the covariance matrix versus N
- Plot condition number of the covariance matrix versus N
- For 2005–03–31 to 2025–07–31, using a rolling daily window of $N = 1000$:
 - Estimate the sample covariance matrix
 - Plot the maximum eigenvalue through time

B. Portfolio Backtesting

- Period: 2005–03–31 to 2025–07–31
- Monthly rebalancing using a rolling daily window of $N = 500$
- Construct long-only minimum variance portfolios using:
 - Sample covariance matrix (Sample.Port)
 - Double-decay EWMA covariance matrix with:
 - * Correlation half-life: 252
 - * Volatility half-life: 126
 - Equally weighted portfolio (EQW.Port)
- Apply estimated weights to monthly industry returns
- Plot cumulative returns for all portfolios
- Report for each portfolio:
 - Annualized return
 - Annualized volatility
 - Sharpe ratio (risk-free rate = 0)
- Plot average industry weights through time for Sample.Port
- Repeat the backtest with a maximum weight constraint of 5%