Exercise 6D: Ledoit-Wolf Shrinkage and Minimum-Variance Portfolios

BUSI 722: Data-Driven Finance II

The sample covariance matrix is noisy when the number of stocks is large relative to the number of time periods. Ledoit-Wolf shrinkage blends the sample covariance with a structured target to reduce estimation error. Load `merged.parquet` for this exercise.

Submission

Submit a **Jupyter notebook** (`.ipynb`) containing all code, output, and charts. Use markdown cells for any written discussion.

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1. From the merged dataset, select all **Technology sector** stocks that have complete monthly return data from January 2023 through January 2026. Use 2023–2024 as the **estimation window** and Jan 2025 on as the **evaluation window**. Report how many stocks are in this universe.

2. Using the estimation window, compute the **sample covariance matrix** and the **Ledoit-Wolf shrinkage covariance matrix** (use `sklearn.covariance.LedoitWolf`). Report the shrinkage intensity δ.

3. Using each covariance matrix, compute the **minimum-variance portfolio** (fully invested, long-only: $\mathbf{w}'\mathbf{1} = 1$, $w_i \geq 0$). Report the number of stocks with nonzero weight and the maximum weight for each.

4. Evaluate both minimum-variance portfolios **out of sample** (Jan 2025 on). Report the annualized realized volatility and Sharpe ratio for each. Also report results for an equal-weighted portfolio of the same stocks as a benchmark. Plot the cumulative returns of all three portfolios over the evaluation window.