Minimum Variance Portfolio Optimization

Humphrey Hui, Peyton Gibbs, Jack Feen

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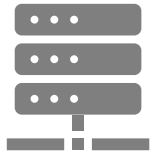
Methodology



Collecting Data

- Query user for tickers before contacting WRDS CRSP.MSF for monthly returns
- Check for 3 consecutive months missing / 10% missing
- Ask user for weight constraints on each stock
- Return a dataframe of returns and dictionary of constraints

MVO

- Once we get parameters and stocks of choice, we create covariance matrix to compute GMV
- Use Ledoit-Wolf shrinkage method to adjust for noise, implement on new GMV portfolio
- Force matrix symmetry

Rolling Window

- Query user to enter a list of lookback periods to compare
- Align performance results using length of shortest returns list

Performance

- Test performance differences on Ledoit-Wolf / Sample Covariance on different lookbacks
- Compute plots & summary statistics for returns, variance, weight turnover, weight deviation, etc.

Key Implementation Choices

Collecting Data

- **Permitted Stocks:** Only US common stock in major exchanges
- **Time Period:** 15 years (2010-2024) for more rolling window periods
- **Consecutive Months:** No more than 3 consecutive months of return information missing
- **Missing Data:** Fill any missing months with 0

MVO

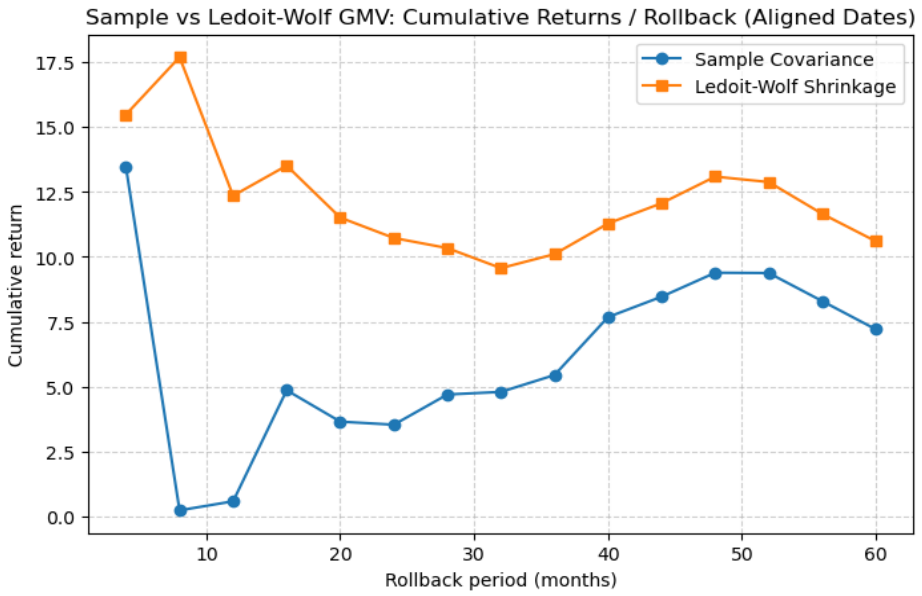
- **Optimization:** Using CVXPY to optimize our portfolio with GMV formula
- **Shrinkage:** Using Ledoit-Wolf Shrinkage method to reduce noise and improve out of sample performance

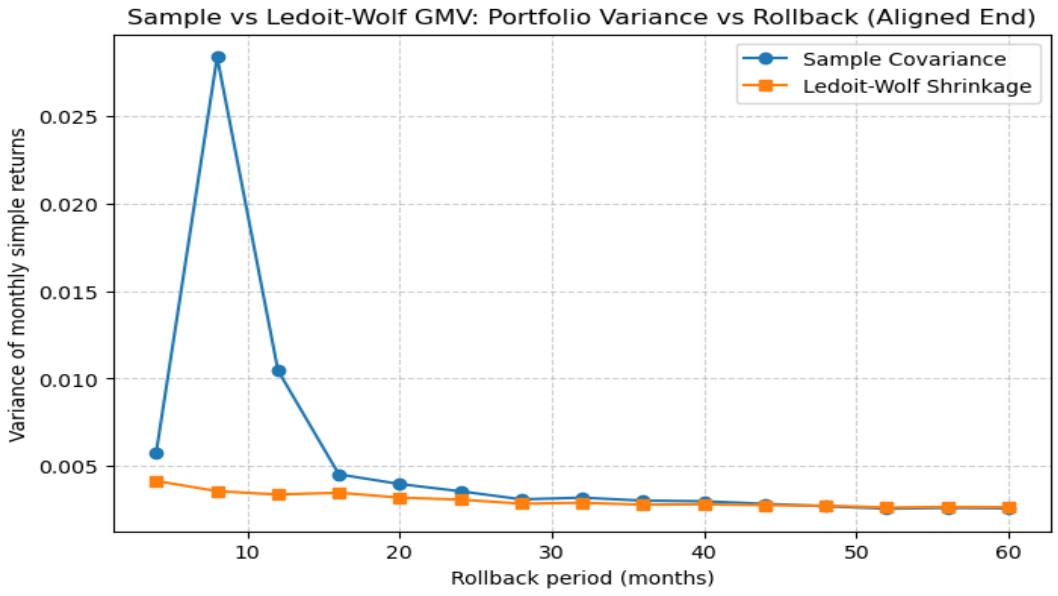
Rolling Window

- **Lookback Comparisons:** Showcase shrinkage effectiveness at different lookback periods
- **Consistent Lookback:** Ensure returns, turnover, and variability tests are run on the same forward-looking period while comparing results of different lookback periods

Results – Returns

Out Of Sample Testing for Returns





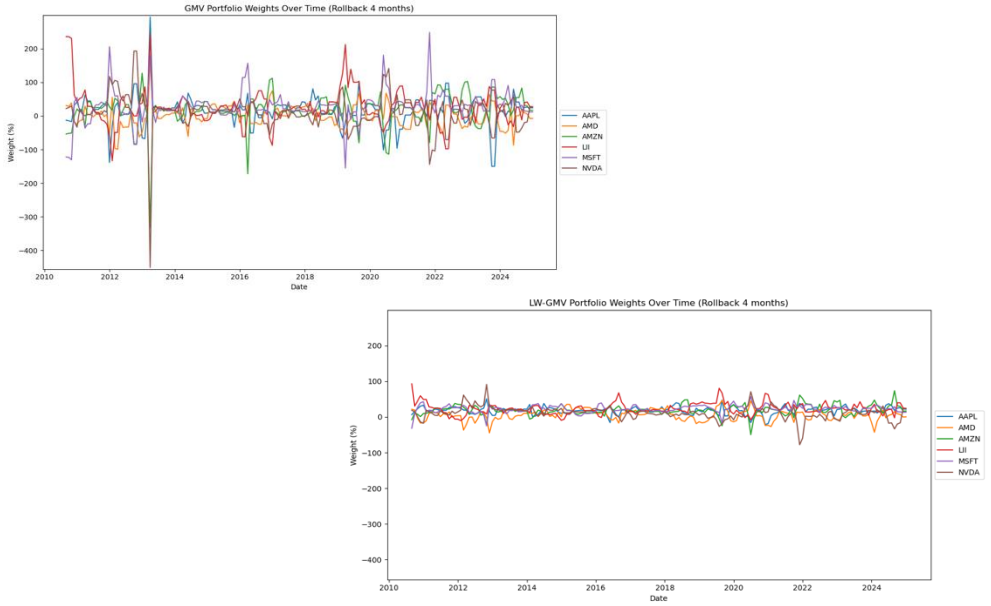
Key Takeaways

- Ledoit-Wolf has better performance on out-of-sample data across all rollback periods
- Sample covariance method starts with extreme variance of returns that converges to the Ledoit-Wolf variance as rollback periods increase

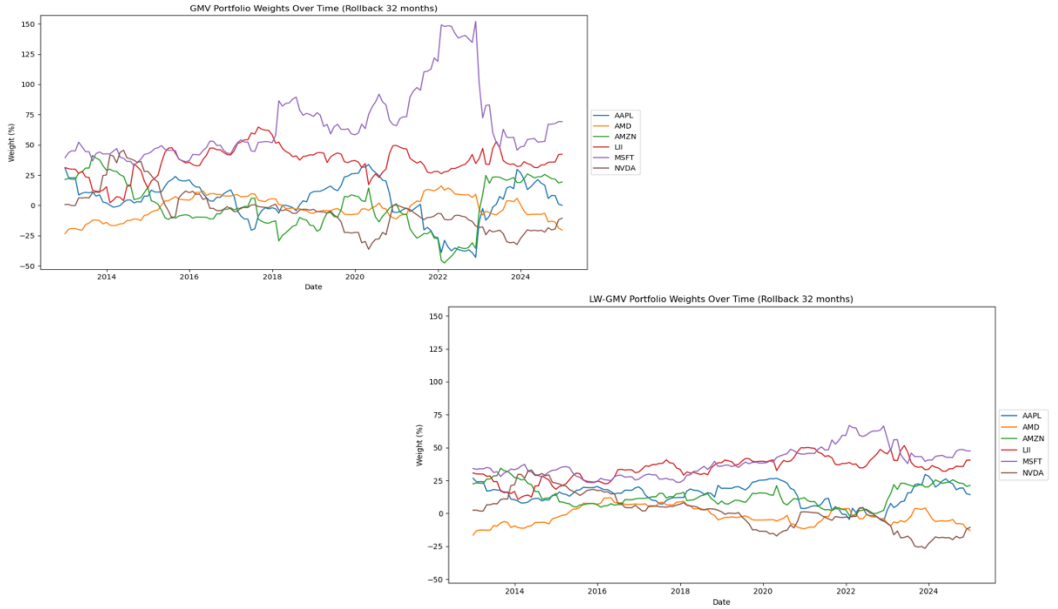
Results – Variance

Portfolio Weights for Sample Covariance and LW-Shrinkage

4 months lookback



32 months lookback

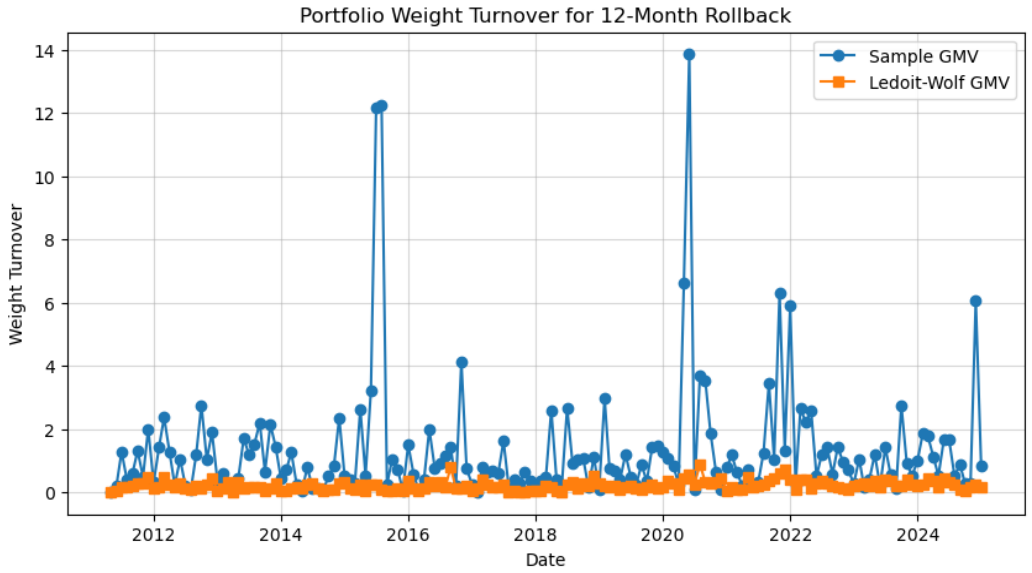


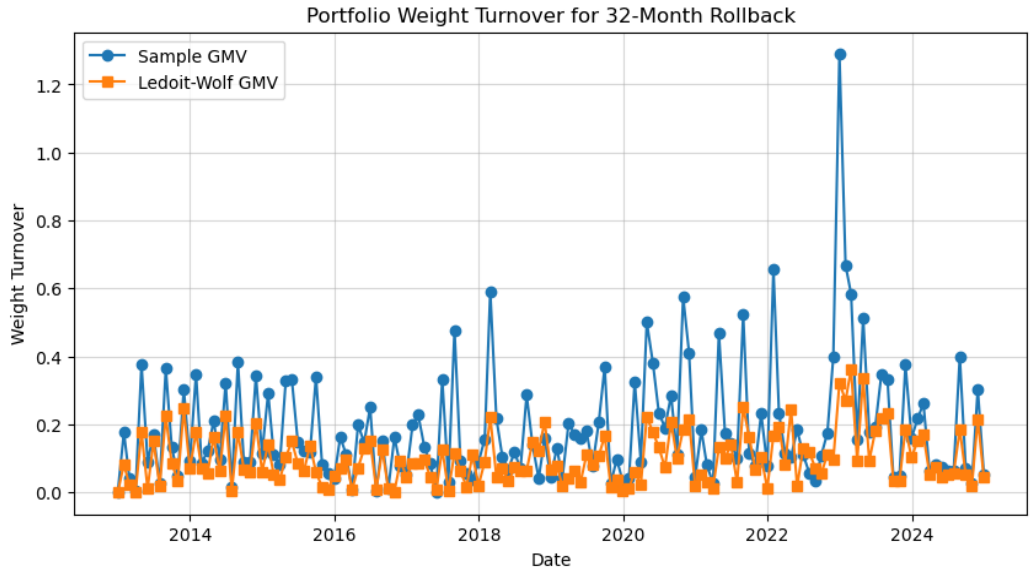
Key Takeaways

- At the end of 2024, the 4-month lookback had a portfolio weight standard deviation of 0.13 for sample covariance and 0.08 for Ledoit-Wolf, representing a 38% decrease
- The 32-month rollback had a standard deviation of 0.34 and 0.25 for sample covariance and Ledoit-Wolf respectively, representing a 26% decrease

Results – Portfolio Weight Turnover

Sum of Absolute Differences in Portfolio Weights





Key Takeaways

- For the 32-month lookback period, the average monthly turnover in the Ledoit-Wolf portfolio was half of the sample covariance
- For smaller lookback periods, the results are drastically magnified