

Estimation Error in Portfolio Optimization

and how denoising can help to solve the problem

The Problem of Estimation Error

Definition

Refers to the inaccuracies in the parameters (mean returns, variances, and covariances) used for portfolio optimization, typically due to limited historical data or noisy market data.

Equation

$$\text{Error} = \theta^{\wedge} - \theta$$

Consider covariance matrix of asset returns. Errors in Σ lead to suboptimal portfolio weights.

Impact

- Highly sensitive weights in mean-variance optimization.
- Overfitting to noisy data results in poor out-of-sample performance.
- Increased risk and reduced diversification.

Challenge deep-dive

Data

Historical returns of the optimal portfolio using Markowitz Optimization weights for AMZN, NVDA, TSLA, KO, XOM.

Method

Denoising

Aims to reduce the noise caused by short-term price movements of assets, which in turn allows for the more accurate estimation of returns.

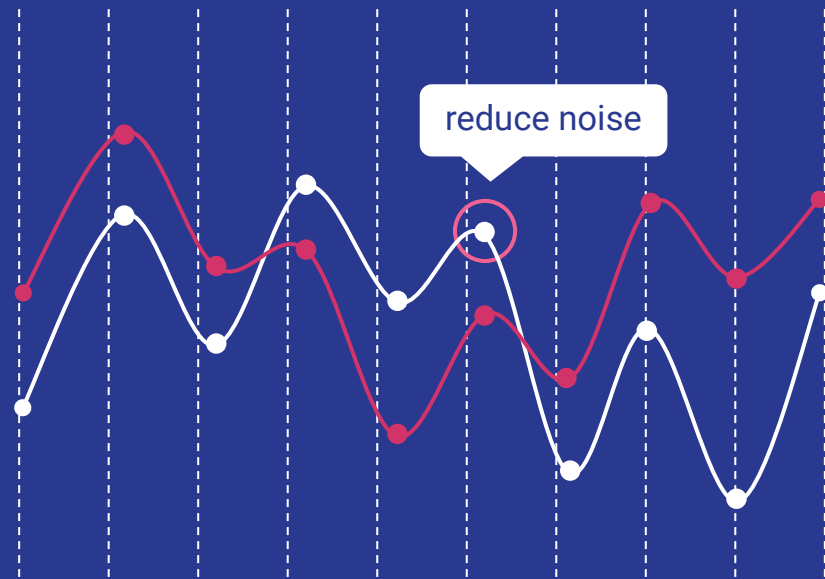
Benefits

- Noise reduction
- Improve risk-return profile
- Avoid overfitting
- Better out-of-sample performance

Impact

- Sharpe Ratio:
improved from 2.04 to 5.08.
- Sortino Ratio:
improved from 834 to 2386.
- Maximum Drawdown:
reduced from -3.58% to -0.35%.

→ The denoising method provided better risk-adjusted returns and robust portfolio weights, directly addressing estimation error.



Conclusion

→ Estimation error is a critical challenge in portfolio optimization, leading to unstable and suboptimal performance.

→ Denoising techniques can stabilize covariance estimates and improve portfolio metrics.

→ Demonstrated metrics show clear benefits of denoising, such as enhanced Sharpe and Sortino ratios and reduced drawdowns.
