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Enhanced Portfolio Optimization in a Multi-Asset Portfolio

(Topic Presentation)

Arttu Malmlund

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Objectives

- **Evaluate the Simple Enhanced Portfolio Optimization** (EPO^s) (Pedersen et al. 2021)
- **Compare** the performance of EPO^s **with standard mean-variance optimization** and **naïve non-optimized** (1/N, 1/σ) portfolio models
- **Carry out comparison based on the Sharpe ratio** (Sharpe 1966),

$$\frac{R_p - R_f}{\sigma_p},$$

where $\boldsymbol{R_p}$ is the portfolio return, $\boldsymbol{R_f}$ is the risk-free rate, $\boldsymbol{\sigma_p}$ is the standard deviation of portfolio excess returns

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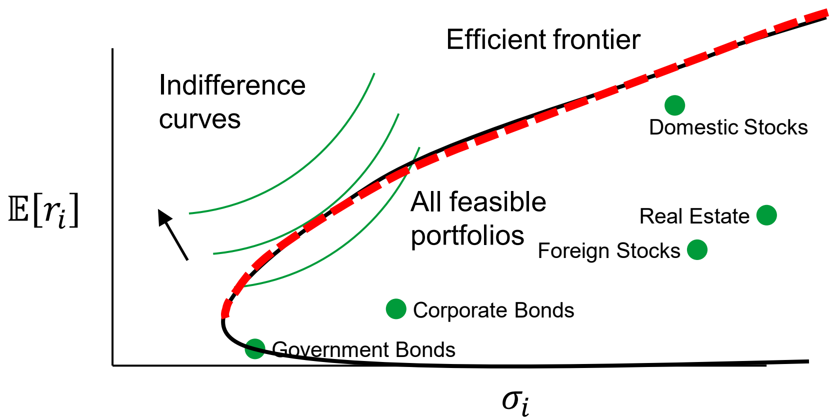
Mean-variance optimization model (Markowitz 1952)

- Markowitz (1952) developed the mean-variance (MV) framework for optimized diversification
- MV optimization minimizes risk for different expected returns
  → Efficient frontier
- Risk preferences determine the desired level of risk and return

MV optimization

$$\begin{cases} \min_{W} \frac{1}{2}\sum_{i=1}^{n}\sum_{j=1}^{n} w_i w_j \sigma_{ij} \\ s.t. \sum_{i=1}^{n} w_i \overline{r_i} = \bar{r}, \sum_{i=1}^{n} w_1 = 1 \end{cases}$$

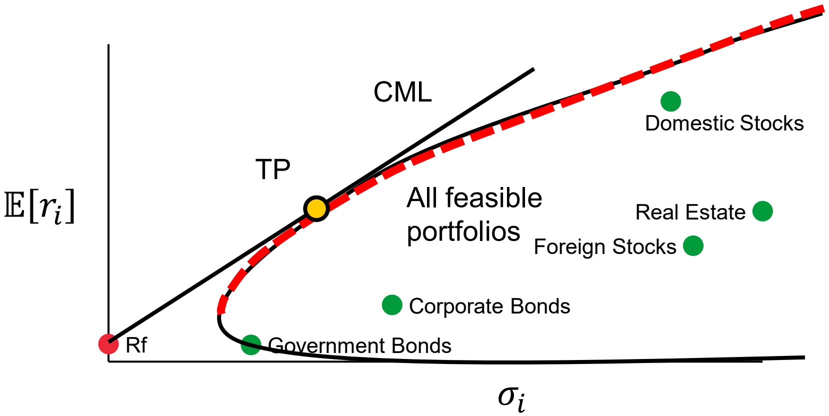


Markowitz, H. (1952). Portfolio Selection. The Journal of Finance, 7(1), 77–91. https://doi.org/10.2307/2975974

Mean-variance optimization and Sharpe ratio

- When it is possible to invest at the risk-free rate, the asset allocation decision can be split into two parts (Tobin 1958):
  1) Finding tangency portfolio, TP
  2) Allocating between TP and the risk-free rate
- Efficient allocations form Capital Market Line (CML)
- Sharpe Ratio $(\mathbb{E}[r_i] - r_f)/\sigma_i$ is the slope of CML

- The portfolio that is optimal for one period may not be optimal for another



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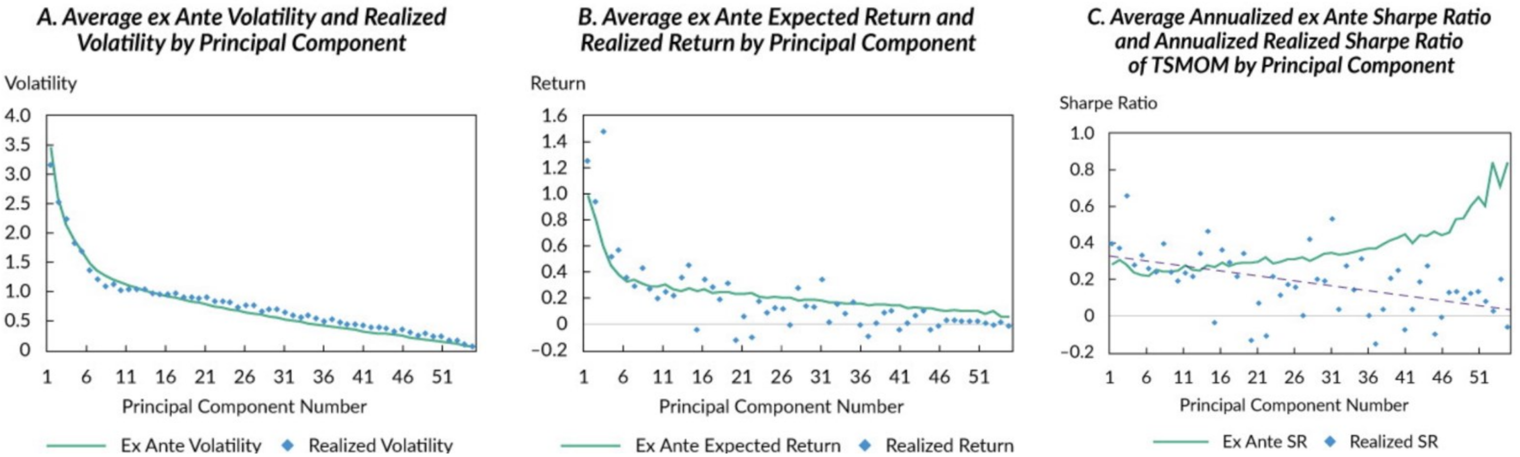
Enhanced Portfolio Optimization Pedersen et al. (2021)

- Pedersen et al. (2021) present the Enhanced Portfolio Optimization (EPO) method to improve MVO
- Using principal components, they identified portfolios in MVO that are most sensitive to errors in return estimates
- EPO downweigh these portfolios by shrinking asset correlations



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Enhanced Portfolio Optimization Pedersen et al. (2021)

- Let $\boldsymbol{n}$ represent the number of assets, $\boldsymbol{x} = (\boldsymbol{x_1}, \ldots, \boldsymbol{x_n})'$ be the portfolio weights, $\boldsymbol{\Sigma}$ be $n \times n$ variance-covariance matrix, $\boldsymbol{s} = (\boldsymbol{s_1}, \ldots, \boldsymbol{s_n})'$ be each assets' signal of expected return, and $\boldsymbol{\gamma}$ represent risk aversion
- **The solution of the EPO^s resembles that of MVO**

MVO optimal	→	EPO^s optimal
$\boldsymbol{x^{MVO}} = \frac{1}{\gamma}\Sigma^{-1}s$		$\boldsymbol{EPO^s}(\boldsymbol{w}) = \frac{1}{\gamma}\Sigma_w^{-1}s$

- The shrunk variance-covariance matrix Σ_w depends on the shrinkage parameter $\boldsymbol{w}$

$$\boldsymbol{\Sigma_w} = (1 - w)\Sigma + \mathrm{w}\,\sigma^2$$

where $\boldsymbol{\sigma^2} = \mathbf{diag}(\boldsymbol{\Sigma_{11}}, \ldots, \boldsymbol{\Sigma_{nn}})$ is the diagonal matrix of asset variances

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Data

- **Daily close price of selected total return indices**[1] from Bloomberg and FRED[2] – Total of 24 indices:
  - **U.S. Equity**: Total Market, Large-Cap, Small-Cap, Growth, Value, Momentum
  - **Developed Markets ex U.S. Equity**: Total Market
  - **Emerging Markets ex U.S. Equity**: Total Market
  - **Government Bonds**: U.S. Treasuries, Euro Government Bonds
  - **Corporate Bonds**: Investment Grade Bonds, High Yield Bonds
  - **Commodities**: Diversified, Industrial Metals, Precious Metals, Oil…
- These are typically used as benchmarks in ETF products

- **Long-term risk premiums** are estimated based on Dimson et al. (2023)
- **Risk-free rate** (1-month U.S. Treasury bill rate) from Kenneth R. French Data Library

Note: 1) Total return index adjust dividends and other corporate actions. 2) FRED = Federal Reserve Bank of St. Louis

Dimson, E., March, P, & Staunton D. (2023) Credit Suisse Global Investment Returns Yearbook 2023 Summary Edition

Methodology – Samples

- **Construct optimized portfolios for two samples** that differ in used risk model, return signal and rebalancing period
- **Short-term portfolio** reflect the Global 1 -portfolio in Pedersen et al. (2021)
- **Long-term portfolio** is based on conservative assumptions proven to be effective in financial literature (Kritzman et al. 2010)

Portfolio	Dataset	Risk Model, Σ	Return Signal, s	Rebalancing period	Start of Data	Start of Backtest
Short-Term Portfolio	Equities, bonds, and commodities	Exponentially weighted daily volatilities and 3-day overlapping correlations[1]	TSMOM[2]	1 Month	1994	2004
Long-Term Portfolio	Equities, bonds, and commodities	60 months equal weighted	Long-Term Risk Premiums	1 Year	1994	2004

1) Risk model in Short-Term Portfolio reflect the model used in Pedersen et al. (2021) in their Global 1 portfolio.
2) TSMOM is time-series momentum signal as in Pedersen et al. (2021).

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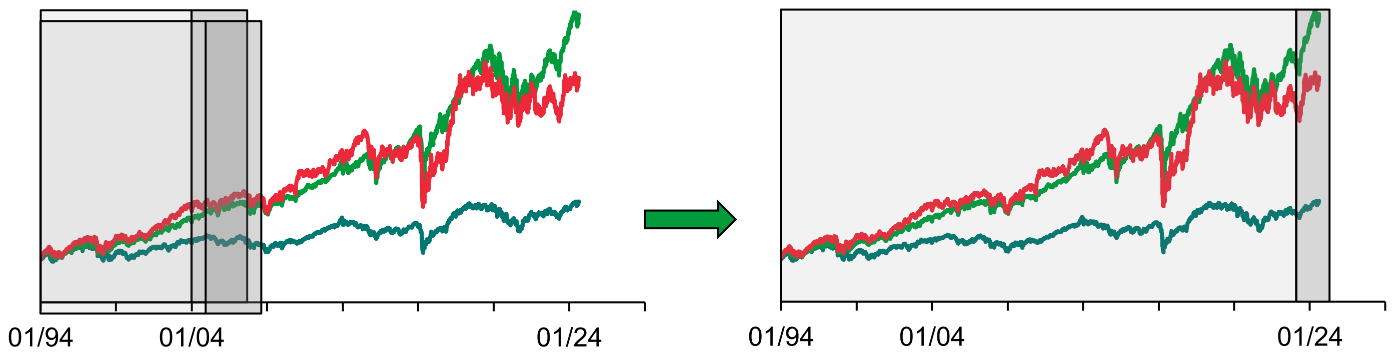
Methodology



- At the beginning of each month, the portfolio will be revised for the next period (1 month or 1 year)
- Methods will be evaluated based on their Sharpe ratio during the out-of-sample period
- The parameter w is estimated using only data available before each month
- Backtest start 2004, so there is always at least 10 years of data to select the out-of-sample EPO parameter w

Key dates

- Presentation of the topic – 17.6.2024
- Data collection and analysis – by 5.7.2024
- 1st version (literature review and results) – by 19.7.2024
- Final version – by 4.8.2024
- Final presentation – in August 2024

References

Markowitz, H. (1952). Portfolio Selection. The Journal of Finance, 7(1), 77–91. https://doi.org/10.2307/2975974

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