SFI Knowledge Catalyst
Connect with Finance Students

Master’s Theses: Financial Engineering for Portfolio Optimization

Are you looking for an industry partner for your industry-oriented Master’s thesis? The SFI Knowledge Catalyst provides you with the opportunity to write your Master’s thesis on portfolio optimization with OLZ & Partners Asset and Liability Management AG (Bern). Students interested in looking at real-world portfolio optimization problems are welcome to apply for these topics. OLZ can support you with datasets and R code and will mentor you during your thesis. However, no internship will be provided. OLZ is located in Berne.

Topics:

1. High Dimensional Covariance Estimation for Portfolio Optimization
2. Dynamic Portfolio Optimization with GARCH and Shrinkage
3. Market Impact Costs
4. Bayesian Portfolio Optimization
5. Critical Line Algorithm
6. Higher Order Moments for Portfolio Optimization

1. High Dimensional Covariance Estimation for Portfolio Optimization – Linear and Nonlinear Shrinkage

Classical mean-variance portfolio optimization requires an ex-ante estimate of the covariance matrix. For large scale optimization problems, where the number of assets (N) exceeds the number of available historical data points (T) the problem becomes particularly challenging. The rank of the sample covariance matrix is at most T, so it is not invertible. Even when T is comparable to or larger than N, the sample covariance has a significant amount of sampling error and its inverse is a highly biased estimator. Alternative methods based on (linear or nonlinear) shrinkage techniques may help to overcome those deficiencies.

1.1. Research Questions

- Assess the quality of linear and nonlinear shrinkage estimators in view of portfolio optimization purposes on financial data.
- Distinguish between an academic and a practitioner's point of view, where the latter has to deal with many constraints.

Readings:

Ledoit and Wolf (2003). *Improved Estimation of the Covariance Matrix of Stock Returns With an Application to Portfolio Selection.*

Ledoit and Wolf (2014). *Nonlinear Shrinkage of the Covariance Matrix for Portfolio Selection_Markowitz Meets Goldilocks.*

2. Dynamic Portfolio Optimization with GARCH and Shrinkage

Portfolio optimization stands or falls with the quality of the input parameter. In the case of minimum variance portfolio optimization the main input is the covariance matrix. If we chose a certain allocation today it is because we have a view on how assets will co-vary in the future. Hence, capturing the time-varying nature of asset volatilities and correlations is key. However, of-the-shelf econometric models like GARCH usually fail when the dimension becomes large (when we look at many assets). A recent advance in the literature marries time-series with cross-section methods in order to get the best out of both approaches.

2.1. Research Questions

- Implement the DCC GARCH with Shrinkage as in Engle, Ledoit and Wolf (2016).
- Backtest the model on large datasets (> 1000 stocks) and benchmark the results to simpler approaches.
- Extend the model to asymmetric GARCH or stochastic volatility processes.

Readings:

Engle, Ledoit and Wolf (2016). *Large Dynamic Covariance Matrices.*

3. Market Impact Costs

Market impact is the effect that a market participant has on the price of an asset when it buys or sells the asset. Especially for large investors, market impact is a key consideration that needs to be addressed as it may constitute the lion's share of overall transaction costs. The investor that is seeking to manage its market impact needs to limit the pace of its activity (e.g., keeping its activity below one-third of daily turnover) so as to avoid disrupting the price.

3.1. Research Questions

- What are good measures for market impact?
- How can the market impact be incorporated into the portfolio optimization process

- Find a “trade scheduling” that balances reducing market impact against opportunity costs and risk

Readings:
Almgren et al. (2005). *Direct Estimation of Equity Market Impact.*

Bertsimas and Lo (1998). *Optimal Control of Execution Costs.*

4. Portfolios from Sorts – Bayesian Methods for Portfolio Optimization

Modern Portfolio Theory suggests maximizing expected return for a given level of risk. This optimization procedure is highly sensitive to the accuracy of return estimates which are usually very noisy. This has led to the notion of “error maximization”. Instead of using point estimates of return forecasts some researchers have suggested to use ordering information (sorts) about the returns, i.e. only saying that asset A is better than asset B without giving exact values, thus potentially reducing estimation error.

4.1. Research Questions

- How can ordering information be incorporated into Markowitz optimization?
- Compare methods of Black and Litterman, Almgren, or Meucci (Entropy Pooling).
- Assess if there is a benefit of using ordering information over return estimates.

Readings:
Black and Litterman (1990). *Asset Allocation: Combining Investor Views with*

Market Equilibrium.

Almgren and Chriss (2005). *Portfolios from Sort.*

Meucci (2008). *Fully Flexible Views: Theory and Practice.*

5. Critical Line Algorithm

Harry Markowitz is well known to be the father of modern portfolio theory. What is less known is that he not only founded the theory for portfolio selection but also suggested a sophisticated quadratic programming algorithm to compute the efficient frontier under any linear constraints: the critical line algorithm.

Students interested in the topic are asked to implement the algorithm in the open source programming environment R, possibly referencing to lower level implementations in C and to test the application on high dimensional portfolio optimization problems (more than 1000 stocks).

Readings:
Lopez de Prado and Bailey (2013). *An Open-Source Implementation of the Critical Line Algorithm for Portfolio Optimization..*

Niedermayer and Niedermayer (2006). *Applying Markowitz's Critical Line Algorithm.*

Kwan (2007). *A Simple Spreadsheet Based Exposition of the Markowitz Critical Line Method for Portfolio Selection.*

6. Higher Order Moments

When asset returns deviate from normality, utility maximizing investors should account for higher order moments (skewness and kurtosis) in solving the portfolio selection problem. In a broader context, accounting for investor preferences on higher order moments may explain why the CAPM appears to fail empirically at explaining the return of the most risky stocks.

6.1. Research Questions

- Test if higher moments matter, either
  - within an equilibrium context (CAPM) or
  - for portfolio allocation.
- If the focus is on ii): test how higher moments affect portfolio allocation, implement an optimization algorithm and backtest it on a dataset of equity returns.

Readings:

Jondeau and Rockinger (2004).*Optimal Portfolio Allocation under Higher Moments.*

Schneider, Wagner and Zechner (2016). *Low Risk Anomalies?*

Interested?

Please send your motivation letter, CV, and university grades to Ms Désirée Spörndli at ds@sfi.ch and state for which topic you would like to apply.