# MAFS6010R – Portfolio Optimization with R
# MSc in Financial Mathematics
# Fall 2018-19, HKUST

## Basic Information

Instructor: Prof. Daniel P. Palomar (http://www.danielppalomar.com)
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MAFS6010R – Portfolio Optimization with R [3-0-0:3]
Website: https://www.danielppalomar.com/mafs6010r---portfolio-optimization-with-r
Lecture Time: Tue 19:30 – 22:20
Lecture Venue: LTE

## Description

Modern portfolio theory started with Harry Markowitz's 1952 seminal paper "Portfolio Selection," for which he would later receive the Nobel prize in 1990. He put forth the idea that risk-adverse investors should optimize their portfolio based on a combination of two objectives: expected return and risk. Until today, that idea has remained central in portfolio optimization. However, the vanilla Markowitz portfolio formulation does not seem to behave as expected in practice and most practitioners tend to avoid it.

During the past half century, researchers and practitioners have reconsidered the Markowitz portfolio formulation and have proposed countless of improvements and variations, namely, robust optimization methods, alternative measures of risk (e.g., CVaR or ES), regularization via sparsity, improved estimators of the covariance matrix via random matrix theory, robust estimators for heavy tails, factor models, mean models, volatility clustering models, risk-parity formulations, etc.

This course will explore the Markowitz portfolio optimization in its many variations and extensions, with special emphasis on R programming. Each week will be devoted to a specific topic, during which the theory will be first presented, followed by an exposition of a practical implementation based on R programing.

## Textbooks

- Yiyong Feng and Daniel P. Palomar, *A Signal Processing Perspective on Financial Engineering*. Foundations and Trends® in Signal Processing, Now Publishers, 2016. [http://www.ece.ust.hk/~palomar/Publications_files/2016/Feng&Palomar-FnT2016.pdf]
- S. Boyd and L. Vandenberghe, *Convex Optimization*. Cambridge University Press, 2004. [http://www.stanford.edu/~boyd/cvxbook/]
- G. Cornuejols and R. Tutuncu, *Optimization Methods in Finance*. Cambridge Univ. Press, 2007.
- F. J. Fabozzi, P. N. Kolm, D. A. Pachamanova, and S. M. Focardi, *Robust Portfolio Optimization and Management*. Wiley, 2007.

## Prerequisite:

Good knowledge of linear algebra and some programming knowledge in R (or similar). Willingness to spend countless of hours programming in R.

## Grading:

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| Homework (based on R): | 30% |
| Weekly portfolio game (based on R): | 40% |
| Final 1-min presentation with 3 slides: | 30% |

## Course Schedule

| Date | Week | Topic |
|---|---|---|
| 4-Sep | 1 | Theory: Introduction to convex optimization |
| | | Practice: R for finance primer |
| 11-Sep | 2 | Theory: Convex optimization problems |
| | | Practice: Solvers in R |
| 18-Sep | 3 | Theory: Portfolio optimization |
| | | Practice: Portfolio optimization with R |
| 2-Oct | 4 | Theory: Factor models for asset returns |
| | | Practice: Factor models with R |
| 9-Oct | 5 | Theory: Prior information: Shrinkage and Black-Litterman |
| | | Practice: Prior information: Shrinkage and Black-Litterman with R |
| 16-Oct | 6 | Theory: Regularized robust estimators under heavy tails and outliers |
| | | Practice: Heavy-tailed estimators with R |
| 23-Oct | 7 | Theory: Time series modeling of financial data |
| | | Practice: Time series modeling of financial data with R |
| 6-Nov | 8 | Theory: Robust portfolio optimization |
| | | Practice: Robust portfolio optimization with R |
| 13-Nov | 9 | Theory: Portfolio optimization with alternative risk measures |
| | | Practice: Portfolio optimization with alternative risk measures with R |
| 20-Nov | 10 | Theory: Risk-parity portfolio |
| | | Practice: Risk-parity portfolio with R |
| 27-Nov | 11 | Theory: Sparse index tracking via majorization-minimization (MM) |
| | | Practice: Sparse index tracking with R |
| 28/29/30-Nov | 12 | Theory: Pairs trading |
| | | Practice: Pairs trading with R |
| 4-Dec | 13 | Project presentations by students |