The Hong Kong University of Science and Technology

UG Course Syllabus

Title: Data-Driven Portfolio Optimization

Course code: ELEC/IEDA3180

Credits: 3

Pre-requisites: Good knowledge of linear algebra (MATH2111 or MATH2121 or MATH2131 or MATH2350), probability (IEDA2510 or IEDA2520 or IEDA2540 or ELEC2600), and programming in Python or R.

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Course 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 alternatives such as robust optimization methods, alternative measures of risk, regularization via sparsity, improved estimators of the covariance matrix, robust estimators for heavy tails, factor models, volatility clustering models, risk-parity formulations, index tracking, etc.

This course will explore the Markowitz portfolio optimization in its many variations and extensions, with special emphasis on Python programming. All the course material will be complemented with Python code that will be studied in class. The homework and project will be in Python.

Intended Learning Outcomes (ILOs)

By the end of this course, students should be able to:

1. Acquire basic knowledge on optimization problems
2. Be able to solve optimization problems in practice with Python
3. Learn about financial data and modeling techniques
4. Learn about portfolio design in financial systems
5. Be able to employ the theoretical and practical knowledge on optimization for portfolio design
6. Learn more sophisticated portfolio optimization formulations and solve them

Assessment and Grading

This course will be assessed using criterion-referencing and grades will not be assigned using a curve. Detailed rubrics for each assignment are provided below, outlining the criteria used for evaluation.

Assessments:

[List specific assessed tasks, exams, quizzes, their weightage, and due dates; perhaps, add a summary table as below, to precede the details for each assessment.]

Assessment Task	Contribution to Overall Course grade (%)	Due date
Homeworks	25%	During first half of the course
Mid-Term	25%	Mid of the course
Final project	35%	Day before last class
Lightening presentation	15%	Last class

* Assessment marks for individual assessed tasks will be released within two weeks of the due date.

Mapping of Course ILOs to Assessment Tasks

[add to/delete table as appropriate]

Assessed Task	Mapped ILOs	Explanation
Homework #1	ILO1, ILO2, ILO4, ILO5	This task assesses students' ability to solve a mean-variance portfolio optimization in Python.
Homework #2	ILO1, ILO2, ILO3	This task assesses students' ability to model data and solve it in Python.
Homework #3	ILO1, ILO2, ILO3, ILO4, ILO5, ILO6	This task assesses students' ability to model financial data and design a variety of portfolios in Python.
Mid-Term	ILO1, ILO2, ILO3, ILO4, ILO5, ILO6	This task assesses students' ability to model financial data and design a variety of portfolios in Python.
Final project	ILO1, ILO2, ILO3, ILO4, ILO5, ILO6	This task assesses students' ability to perform an in-depth study on either data modeling or portfolio optimization.

Grading Rubrics

[Detailed rubrics for each assignment will be provided. These rubrics clearly outline the criteria used for evaluation. Students can refer to these rubrics to understand how their work will be assessed.]

Final Grade Descriptors:

[As appropriate to the course and aligned with university standards]

Grades	Short Description	Elaboration on subject grading description
A	Excellent Performance	[Example: Demonstrates a comprehensive grasp of subject matter, expertise in problem-solving, and significant creativity in thinking. Exhibits a high capacity for scholarship and collaboration, going beyond core requirements to achieve learning goals.]
B	Good Performance	[Example: Shows good knowledge and understanding of the main subject matter, competence in problem-solving, and the ability to analyze and evaluate issues. Displays high motivation to learn and the ability to work effectively with others.]
C	Satisfactory Performance	[Example: Possesses adequate knowledge of core subject matter, competence in dealing with familiar problems, and some capacity for analysis and critical thinking. Shows persistence and effort to achieve broadly defined learning goals.]
D	Marginal Pass	[Example: Has threshold knowledge of core subject matter, potential to achieve key professional skills, and the ability to make basic judgments. Benefits from the course and has the potential to develop in the discipline.]
F	Fail	[Example: Demonstrates insufficient understanding of the subject matter and lacks the necessary problem-solving skills. Shows limited ability to think critically or analytically and exhibits minimal effort towards achieving learning goals. Does not meet the threshold requirements for professional practice or development in the discipline.]

Course AI Policy

Students are free to use AI as they wish but should mention how they used it.

Communication and Feedback

Announcements before each lecture will be sent via Canvas. Assessment marks for individual assessed tasks will be communicated via Canvas within two weeks of submission. Feedback on assignments will include strengths and areas for improvement. Students who have further questions about the feedback including marks should consult the instructor within five working days after the feedback is received.

Resubmission Policy

NA

Required Texts and Materials

Daniel P. Palomar (2025). *Portfolio Optimization: Theory and Application*. Cambridge University Press. [portfoliooptimizationbook.com]

Academic Integrity

Students are expected to adhere to the university's academic integrity policy. Students are expected to uphold HKUST's Academic Honor Code and to maintain the highest standards of academic integrity. The University has zero tolerance of academic misconduct. Please refer to Academic Integrity | HKUST – Academic Registry for the University's definition of plagiarism and ways to avoid cheating and plagiarism.

[Optional] Additional Resources

- Yiyong Feng and Daniel P. Palomar. *A Signal Processing Perspective on Financial Engineering*. Foundations and Trends® in Signal Processing, Now Publishers, 2016. [https://palomar.home.ece.ust.hk/papers/2016/Feng&Palomar-FnT2016.pdf]
- Konstantinos Benidis, Yiyong Feng, and Daniel P. Palomar, *Optimization Methods for Financial Index Tracking: From Theory to Practice*. Foundations and Trends® in Optimization, Now Publishers, 2018. [https://palomar.home.ece.ust.hk/papers/2018/BenidisFengPalomar-FnT2018.pdf]
- S. Boyd and L. Vandenberghe. *Convex Optimization*. Cambridge University Press, 2004. [https://web.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.