Quantitative Portfolio Management: Theory and Practice

Syllabus and How Course is Organized

Raman Uppal
EDHEC Business School

2025-2026

Table of contents

Road map

Instructor for the course

Instructor	Raman UPPAL, Professor of Finance, EDHEC
Office hours	By appointment and by email
Email	Raman.Uppal@edhec.edu
Homepage	https://www.ramanuppal.com

Name cards

- Please bring a name card to each class.
- This will help make the class a more personal experience.
- I will ask questions in each class and will always start by first asking those students who do not have a name card.

Road map

Course objectives

- The objective of this course is to study cutting-edge methods to construct optimal equity portfolios that perform well out of sample.
- The course provides a solid foundation of the theory of portfolio choice and the knowledge required to implement this theory.
- A key part of the course is learning how to use Python to work with data to implement state-of-the-art portfolio-choice models.

Learning outcomes

After having taken this course, you will be able to understand:

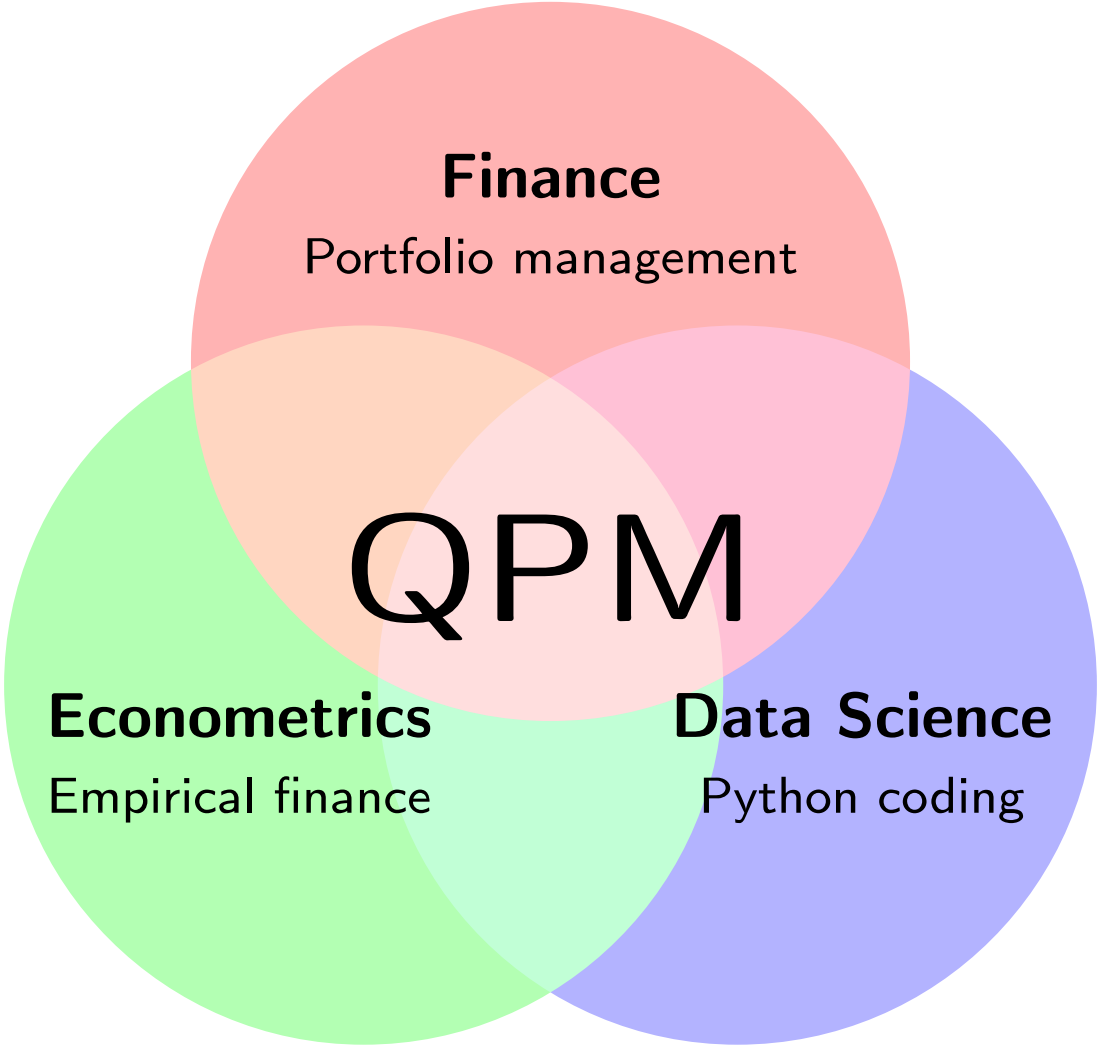
LO1 How to use Python to obtain data from various sources, including Yahoo!Finance, Qandl, Ken French Data Library, and Open Source Asset Pricing.

LO2 How to use Python to evaluate the performance of portfolios.

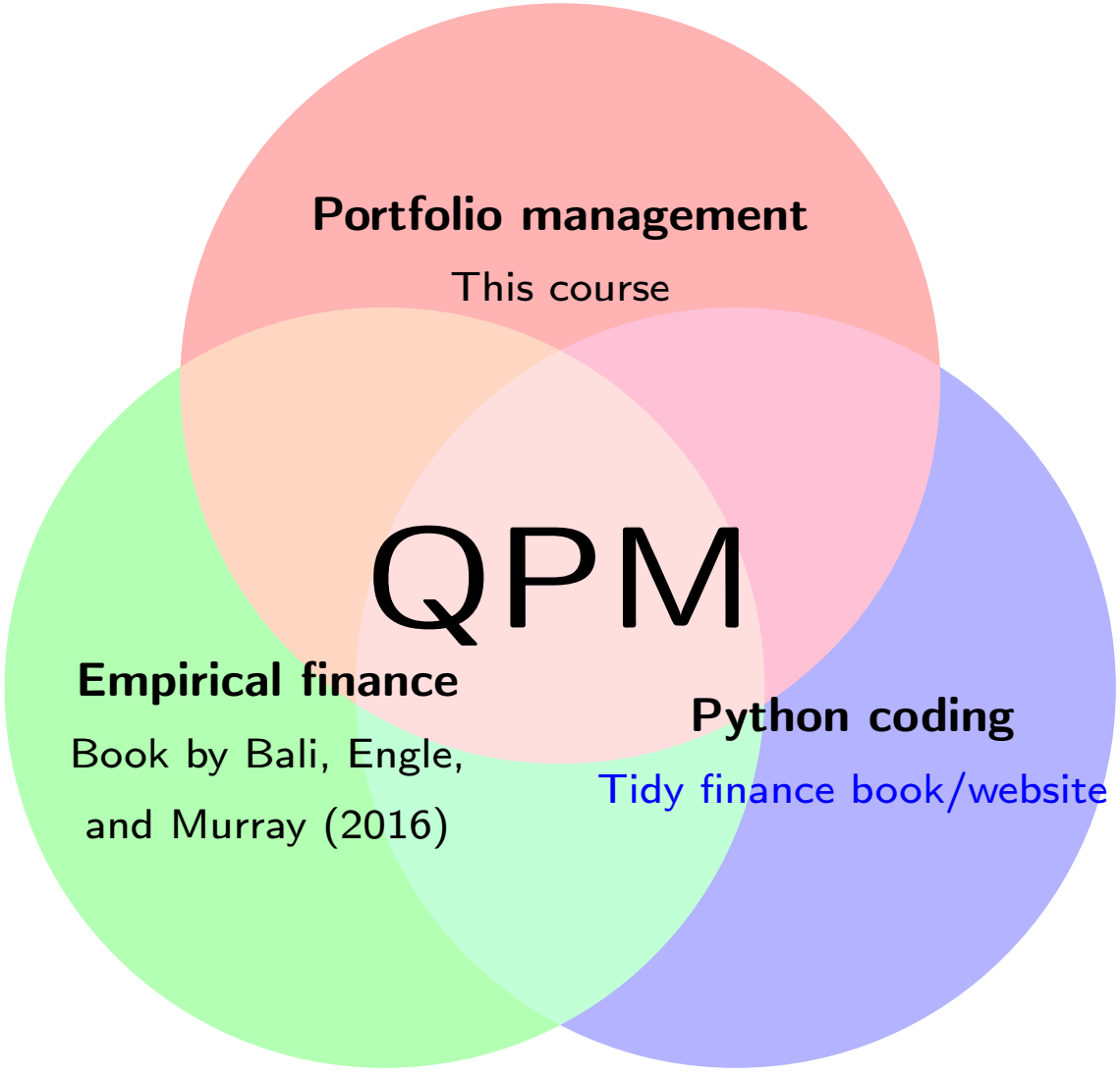
LO3 How to use Python to construct mean-variance efficient portfolios in the presence of short-sale constraints, position limits, LASSO and elastic-net constraints, and transaction costs.

LO4 How to use Python to improve portfolio performance by adjusting for errors in estimating means, variances, and covariances of asset returns and by using conditioning information.

Key ideas in the course combine insights from: Finance, Econometrics, and Data Science.



Resources: Where to find the answers



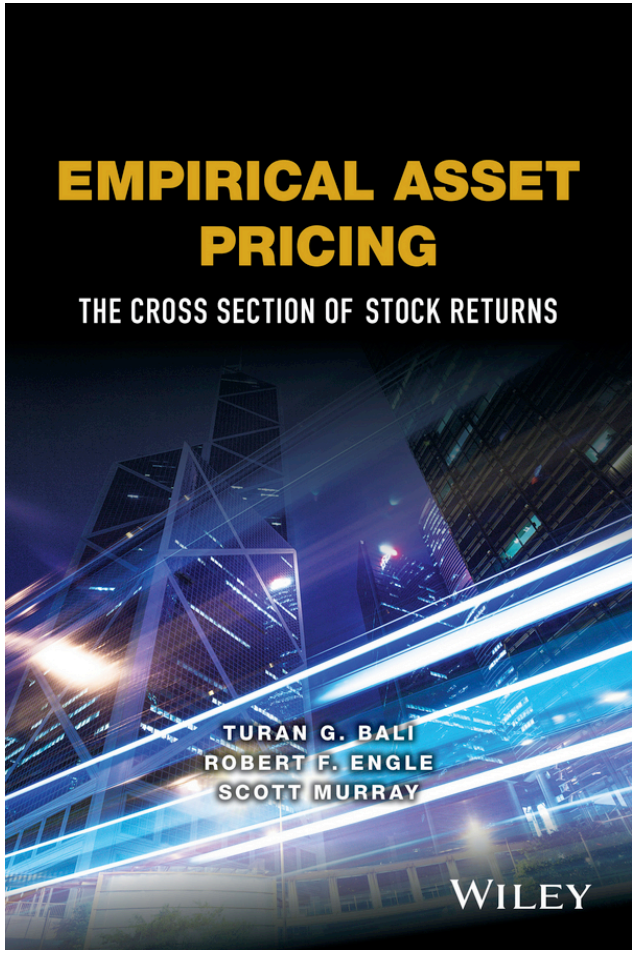
Resources: Where to find the answers

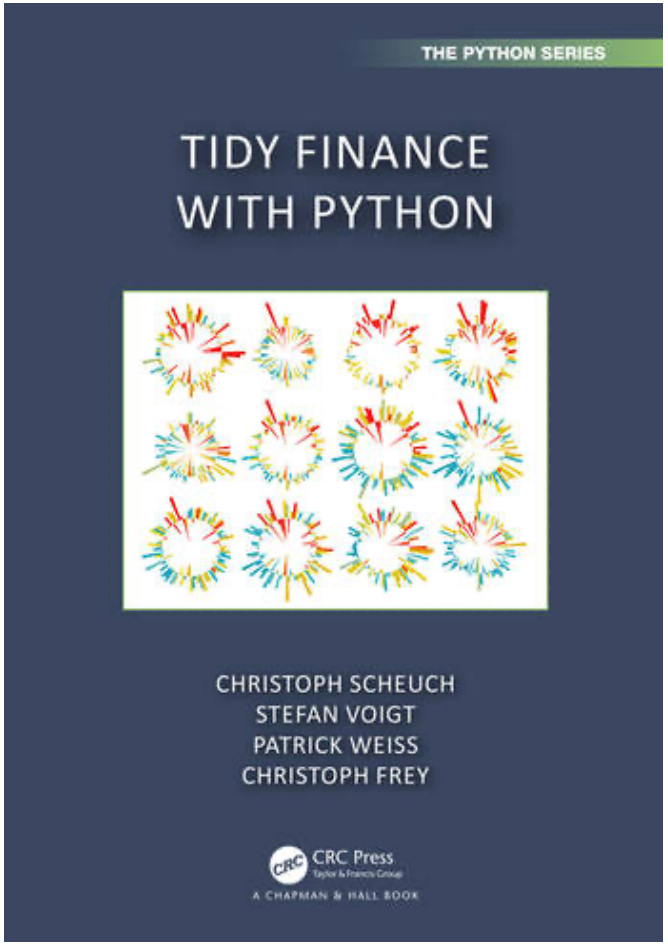
- As the picture on the previous page illustrates, the course combines
  - ideas from empirical finance and
  - skill in coding in Python to
  - solve problems of portfolio management.
- All the material that you need is collected in a textbook that I have written just for this course: **Quantitative Portfolio Management**.
- You can download this textbook using the link provided in the first email I sent to you.
- Please do not distribute this book—it is only for people enrolled in this course.

Other resources available to you

- There are many other excellent resources available to help you:
  - See the online book titled "Quantitative Investing" by Alan Moreira, which includes Python code.
  - For coding in Python: see website Tidy finance with Python or, the same material in a book by Scheuch, Voigt, Weiss, and Frey (2024);
  - For empirical finance: see book by Bali, Engle, and Murray (2016);
  - Other resources are listed at the end of these slides.

Main reference books

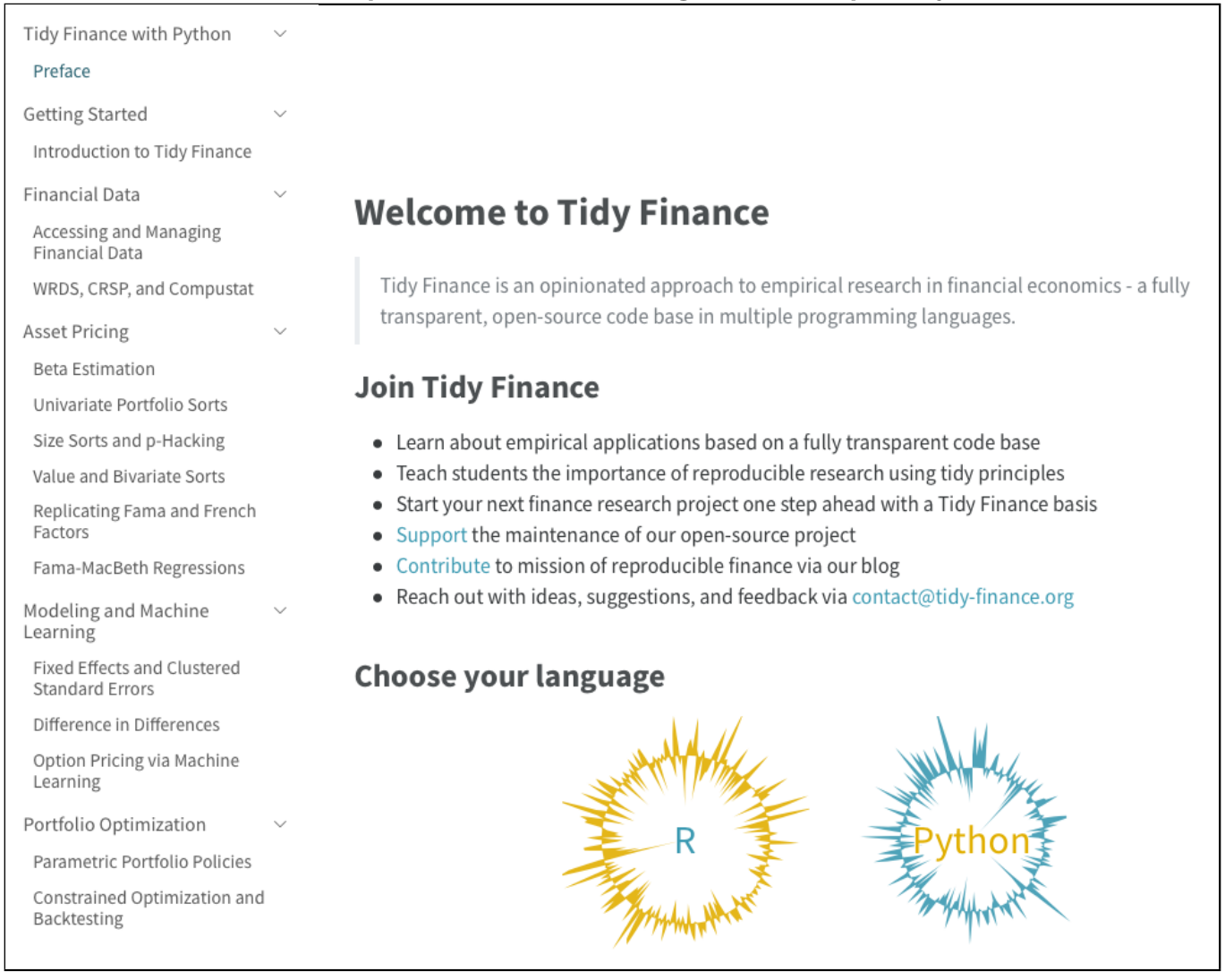




Main resource for Python: Tidy Finance

Link to Tidy Finance website

Christoph Scheuch, Stefan Voigt, & Christoph Frey

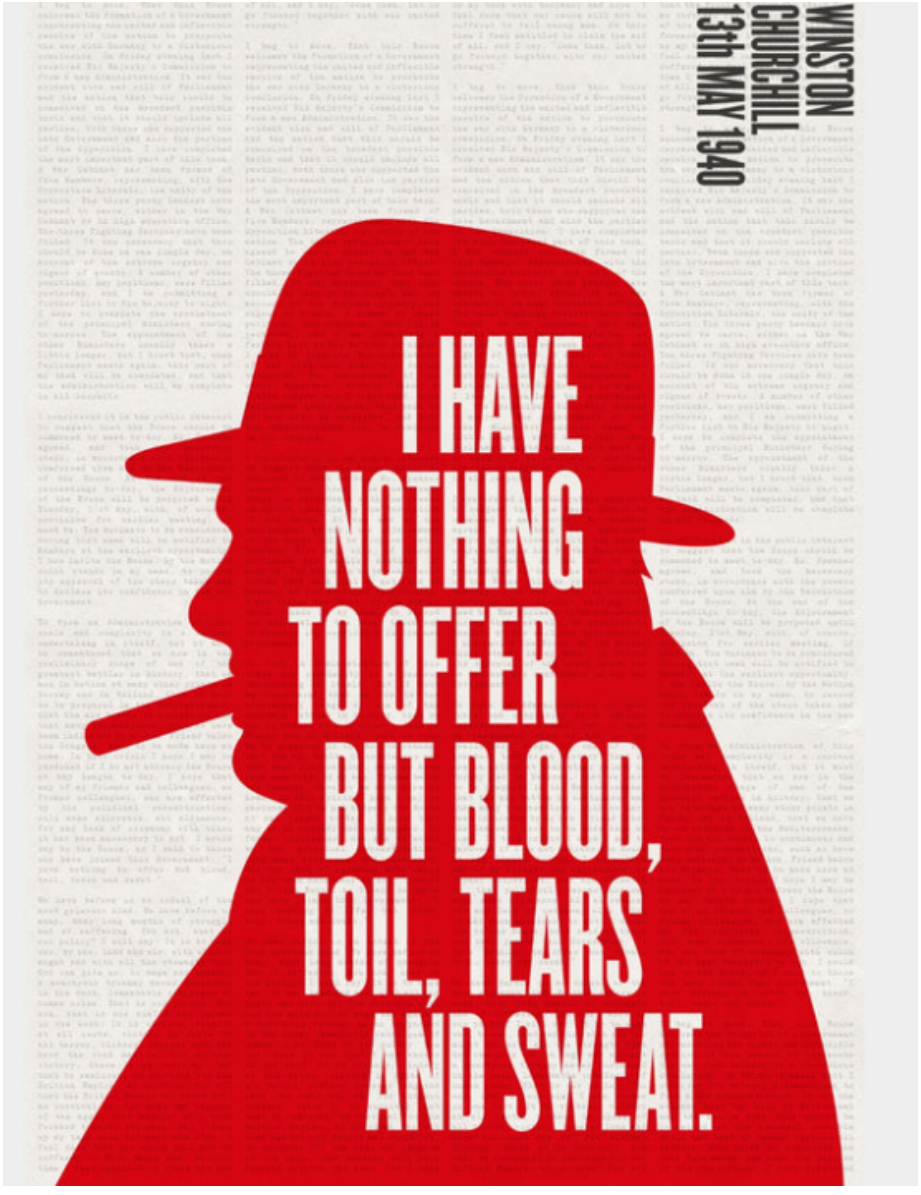


Other Python resources

- Installing Python and code editors
- Style guide for writing Python code.
- Link to PDF for book by Yves Hilpisch on Python For Finance.
- Other Python books.
- A simple guide to using WRDS with Python.
- Managing financial databases, including CRSP, Compustat North America, IBES, Thomson Reuters 13F, Compustat Global, Datastream, and Execucomp.

Course prerequisites

- You should have a basic knowledge of:
  1. Calculus and linear algebra;
  2. Finance and, in particular, Markowitz portfolio optimization;
  3. Empirical finance and basic econometrics; and
  4. Coding in Python.
- Most importantly, you should be willing to work extremely hard: understanding the theory and putting it into practice will stretch you.
- In particular, each class will require you to work on an assignment, which will entail coding in Python.


WINSTON
CHURCHILL
13th MAY 1940
I HAVE
NOTHING
TO OFFER
BUT BLOOD,
TOIL, TEARS
AND SWEAT.

Road map

Assessment method

30% **Four assignments**

- Each assignment is worth 7.5 points
- Each assignment is based on material covered in the classes that week.
- Each assignment should be done in groups of 4 or 5 students. Groups of 1, 2, 3, 6, etc., are not allowed and will get a grade of 0.

70% **Final exam**

- The final exam will be in-class and closed-book.
- The final exam will test your understanding of
  1. Portfolio theory and
  2. Python code to implement this theory.

Due dates for assignments

- Due dates for assignments are as follows:
  - Assignment #1 due before 10 pm on 11 November
  - Assignment #2 due before 10 pm on 16 November
  - Assignment #3 due before 10 pm on 25 November
  - Assignment #4 due before 10 pm on 30 November
- Assignments submitted late will not be accepted (grade = 0), so please do not email me assignments after the deadline.

Detailed instructions for all the assignments . . . I

- Assignments are to be done in groups of 4 or 5 students.
  - This means that groups of 1, 2, 3, 6, etc. are not allowed.
  - Diversity in groups is strongly encouraged
    (people from different countries, different genders, different financial knowledge, and different coding abilities, etc.)
- Each assignment should be emailed to:
  - Raman.Uppal@edhec.edu
  - The subject line of the email should be:
    "QPM 2025-2026: Assignment n," where $n = \{1, 2, 3, 4\}$.

Detailed instructions for all the assignments . . . II

- Each assignment should be emailed as an executable Jupyter file.
- The Jupyter file should include the following (use Markdown):
  - Section "0" with information about your submission:
    - Line 1: Submission date
    - Line 2: QPM 2025-2026: Assignment n
    - Line 3: Group members: listed alphabetically by last name, where the last name is written in CAPITAL letters
    - Line 4: Any comments/challenges about the assignment
  - Section "k" where $k = \{1, 2, \ldots\}$.
    - First type Question k of Assignment n.
    - Then, below the question, provide your answer.
    - Your code should include any packages that need to be imported.

Philosophy of the course . . . I

- The main philosophy of the course is

"getting it done"

- It does not matter how you learn the material to do the assignments.
- So you are allowed to consult
  - Other students in the class
  - Other people on this planet (in school and outside of school)
  - Code available on Tidy finance website.
  - Resources on the internet, including Chat GPT and GitHub Copilot.
- If you use "outside help or resources," please mention this in your assignment (there is no penalty for using outside resources).

Philosophy of the course . . . II

- Thus, the only important thing is that you learn the material in class and, in particular, you learn how to do the assignments.
- But, ultimately,

YOU must learn the material

Philosophy of the final exam

- The final exam will test what you have learned.
  - During the final exam, YOU will not be allowed to consult anyone.
  - So, your performance will depend only on what you have learned.

My commitment

- During the time this course is running (i.e., in October-November), I will work closely with you to help you learn this material.
- I will be available to you almost all of the time (except when I am sleeping).
- You can send me an email with any questions you have about the course material, and I will get back to you within 24 hours.
  - Please start the subject line of your email with "QPM-2025-2026"

I will be available to help you scale great heights

Your commitment

- If you commit to working hard, I promise you can learn the material.
- The usual expectation for 1 hour of lecture time is for you to spend three hours doing independent study to learn the material taught.
- I would like you to spend at most two hours per hour of lecture time
  - to review the lecture material and
  - to do the assignment.
- I will try my best to make it easy for you to master this material.
- If you master the material in this course, you have a good chance of landing a well-paying job.

Two simple rules for the course

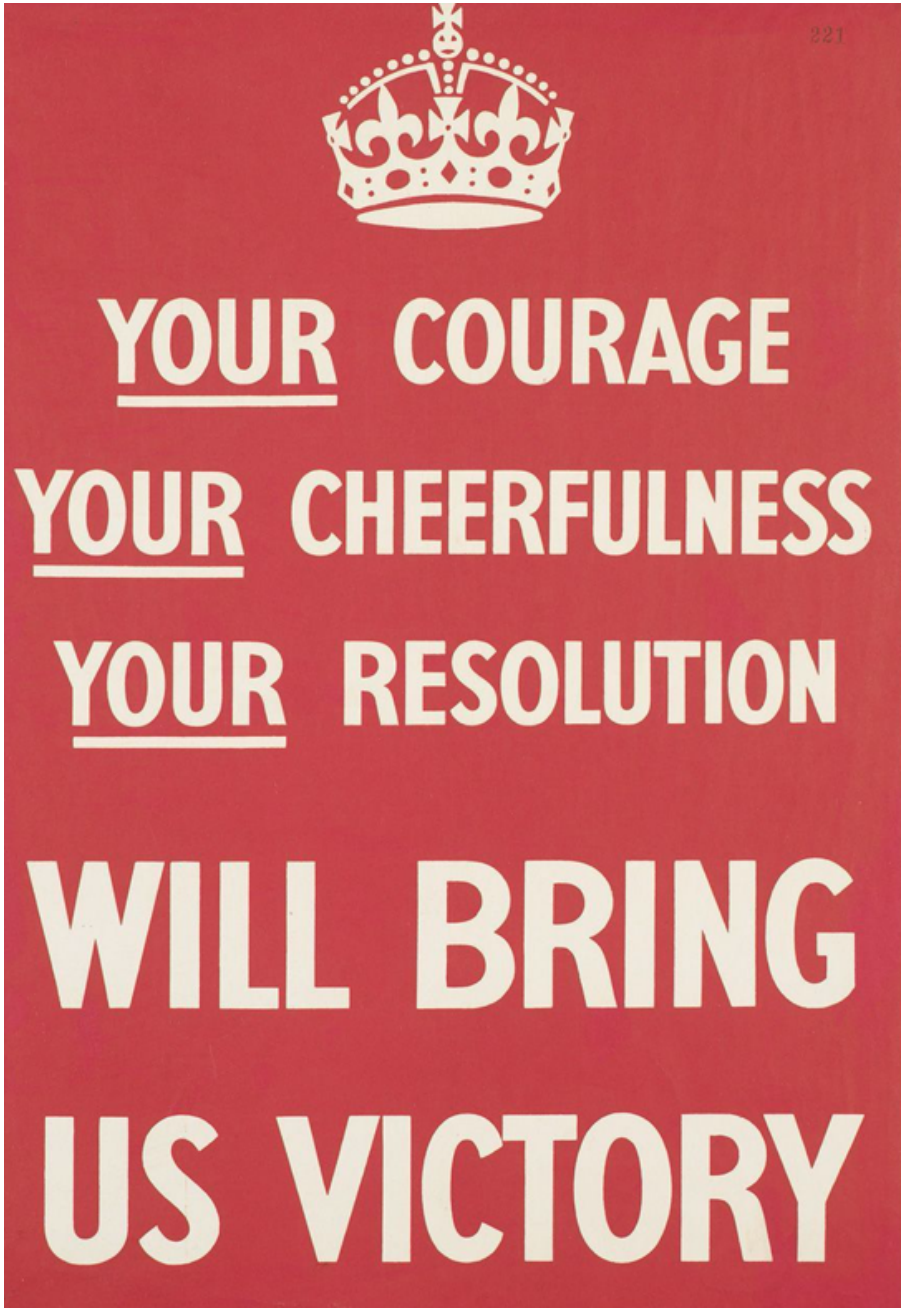
1. Integrity in our own behavior, and
2. Respect for the other people in the course.

Integrity

- **Work ethic**
  - Please come prepared for each class and complete the assigned work.
  - Assignments submitted late will not be accepted (grade = 0).
- **Attendance**
  - Attendance is mandatory.
- **"Double-badging"**
  - Both the person double-badging and the person on whose behalf you are double-badging will be assigned a grade of 0 for the entire course.
- **A more honest alternative to double-badging**
  - Email the HUB (and copy me) to explain why you wish to miss class.
  - Ask HUB to excuse your absence (if it is within the rules).

Respect for other people in the course

- **Help other students to learn**
  - If anyone in the class needs any kind of help, please do your best to provide assistance.
  - If you are good at Finance, please share your expertise.
  - If you are good at Python, please share your expertise.
- **Do not do anything that disturbs other students**
  - Please do not use your phone in class.
  - Please use your computer only for course-related activities.
  - Students having private conversations in class will be asked to leave.


221
YOUR COURAGE
YOUR CHEERFULNESS
YOUR RESOLUTION
WILL BRING
US VICTORY

Output = f (input)

What you get out of the course will depend on what you put into it.

Your choice what to get out of the course:

Beauty, fragrance, or nectar?

Road map

Overview

Road map

List of classes and outline of topics covered REVISIT

Chapter 0: Python, financial econometrics, and investment management

Part A: Preliminaries

Chapter 1: Managing financial data

Chapter 2: Performance measurement (especially out of sample)

Part B: Modern portfolio management

Chapter 3: Mean-variance portfolios that *ignore* estimation error

Chapter 4: Mean-variance portfolios that *adjust for* estimation error

Part C: Post-Modern Portfolio Management

Chapter 5: CAPM-based portfolios: Black-Litterman model

Chapter 6: Factor-based portfolios: Parametric portfolio policies

Chapter 7: Volatility-timed factor portfolios

Chapter 8: Portfolios exploiting systematic risk factors *and* unsystematic risk

Road map

Details of topics covered . . . pre-course

Ch. 0: **Python basics** (to be done before coming to first class)

0.1 How to use Python on your computer

- Make sure that Python is installed on your computer
- Make sure you know how to install packages

0.2 How to use Python for empirical finance

- Familiarize yourself with the material on Tidy finance, which we will be using throughout the course.

0.3 How to use Python for investment management

- MOOC on "Investment Management with Python" offered by EDHEC via Coursera. Link to all the required files on GitHub.

Details of topics covered . . . I

Ch. 1: **Understanding financial and macroeconomic data**

1.1 Understand different kinds of data on stock prices, firm characteristics, and macroeconomic quantities.

- Using Python APIs to obtain publicly available price data from: Yahoo!Finance;
- Obtaining non-price publicly available data from sources, such as Ken French's data library and Open Source Asset Pricing (Chen and Zimmermann 2022).

1.2 Manipulating data

- Computing stock returns from stock prices.
- Computing time-series & cross-sectional factor-mimicking portfolios.
- Computing doubles-sorted portfolios of firm characteristics.
- Visualizing data.

Details of topics covered . . . II

Ch. 2: **Performance measurement**

- 2.1 Different metrics for measuring performance out of sample
- 2.2 Risk management: Value at Risk, Expected Shortfall, Maximum Drawdown,
- 2.3 Backtesting and manipulation-proof measures of performance.
- 2.4 Accounting for transaction costs and price-impact costs
- 2.5 Bootstrapping p-values (Ledoit and Wolf 2008)
- 2.6 p-Hacking and multiple testing biases

Details of topics covered . . . III

Ch. 3: **Mean-variance portfolios that ignore estimation error**

- 3.1 Theory of Markowitz mean-variance portfolios (Merton 1972; Roll 1980; Huang and Litzenberger 1988).
- 3.2 Performance of mean-variance portfolios in sample
- 3.3 Constraints on short sales
- 3.4 Constraints on position sizes, including LASSO and elastic-net
- 3.5 Constraints on leverage
- 3.6 Transaction costs and market-impact costs
- 3.7 Higher moments
- 3.8 Performance out of sample

Details of topics covered . . . IV

Ch. 4: **Mean-variance portfolios that adjust for estimation error**

4.1 Adjusting for estimation error in return means

- Bayesian approaches to dealing with estimation error (Jorion 1985, 1986; Jorion 1988; Jorion 1991, 1992).
- Three-fund portfolio (Kan and Zhou 2007).
- Global minimum-variance portfolio.

4.2 Adjusting for estimation error in return covariances

- Shortsale-constrained portfolios (Jagannathan and Ma 2003).
- Shrinking the covariance matrix. (Ledoit and Wolf 2003, 2004a, 2004b, 2017).
- Norm-constrained portfolios (DeMiguel, Garlappi, Nogales, and Uppal 2009).

4.3 Evaluating performance out of sample.

Details of topics covered . . . V

Ch. 5: **CAPM-based portfolios: Black-Litterman model**

5.1 The Black-Litterman model developed at Goldman Sachs, described in Black and Litterman (1990, 1991a, 1991b, 1992).

5.2 Motivation for the Black-Litterman model.

5.3 The intuition underlying the Black-Litterman model; see He and Litterman (1999), which is available from this link;

5.4 Detailed derivation of the Black-Litterman model.

5.5 Numerical example of the Black-Litterman model.

Details of topics covered . . . VI

Ch. 6: **Factor-based portfolios: Parametric portfolio policies**

- 6.1 Single-factor and multifactor models
- 6.2 Portfolio construction using a factor model
- 6.3 Fundamental-weighted portfolios (Arnott, Hsu, and Moore 2005)
- 6.4 Risk-parity portfolios (Roncalli 2013).
- 6.5 Parametric portfolio policies (Brandt, Santa-Clara, and Valkanov 2009)
- 6.6 Performance out of sample

Details of topics covered . . . VII

Ch. 7: **Volatility-timed factor portfolios**

7.1 Conditioning portfolio weights on volatility
(Kirby and Ostdiek 2012; Moreira and Muir 2017, 2019)

7.2 Performance of volatility timed factors net of transaction costs
(Barroso and Detzel 2021)

7.3 Performance of volatility timed factors out-of-sample
(Cederburg, O'Doherty, Wang, and Yan 2020)

7.4 Performance of volatility timed factors out of sample and net of transaction costs
(DeMiguel, Martín-Utrera, and Uppal 2024)

Details of topics covered . . . VIII

Ch. 8: **Beyond factor-based portfolios**

8.1 What is missing in asset-pricing factor models? Asset pricing with unsystematic risk, (Dello-Preite, Uppal, Zaffaroni, and Zviadadze 2025).

8.2 Portfolio choice with unsystematic risk, (Raponi, Uppal, and Zaffaroni 2023)

8.3 Performance out of sample.

Level of difficulty of each part of the course

Class	Level of difficulty of	
	Finance theory	Python coding
Part A: Preliminaries		
Class 1: Managing financial data	Low	Low
Class 2: Performance measurement	Low	Low
Part B: Modern portfolio management		
Class 3: Mean-variance portfolios that *ignore* estimation error	Low	Medium
Class 4: Mean-variance portfolios that *adjust for* estimation error	Medium	Medium
Part C: Post-Modern Portfolio Management		
Class 5: CAPM-based portfolios: Black-Litterman model	High	Medium
Class 6: Factor-based portfolios: Parametric portfolio policies	Medium	Medium
Class 7: Volatility-timed factor portfolios	Medium	Medium
Class 8: Portfolios exploiting systematic *and* unsystematic risk	Medium	Medium

- My advice to you:
  1. Come to each class – it is the easiest way to learn this material
  2. Review regularly the material covered in class (do not fall behind)

Road map

1. Introduction to the course: How the course is organized
2. Topics covered in the course
3. Why take this course? Why learn this material?
4. How the course slides are designed
5. Course resources
6. Bibliography

Why take this course? . . . I

- This course addresses the most fundamental question in finance: How should you invest your money?
- This course covers over 70 years of research (from 1952 to 2024).

Why take this course? . . . II

- The course covers the research of several Nobel-prize winners:

Awarded in	To
1970	Paul Samuelson
1972	Kenneth Arrow
1981	James Tobin
1983	Gérard Debreu
1990	Harry Markowitz
1990	William Sharpe
1997	Robert Merton
2011	Thomas Sargent
2013	Eugene Fama
2013	Lars Hansen
2017	Richard Thaler
2022	Phil Dybvig

Why take this course? . . . III

- In contrast to learning just the *theory* of finance, this course shows you how to implement state-of-the-art asset-management theory.
- This course teaches you how to use financial datasets, an important skill given the large amounts of data available now.
- This course allows you to develop hands-on skills in using Python, one of the most-used coding languages in the finance industry.

What this course does not cover

- This is not a course about an introduction to Python.
  - Classes will be focused on finance, not programming.
  - If you do not know Python, you will have difficulty doing this course.
- This is not a course on machine learning.
  - There is another course focused entirely on machine learning.
- This is not a course on pure data science and AI.
  - The course will not discuss AI or large language models.

Road map

1. Introduction to the course: How the course is organized
2. Topics covered in the course
3. Why take this course? Why learn this material?
4. How the course slides are designed
5. Course resources
6. Bibliography

A note about the design of each chapter . . . I

- There are a large number of slides because
  - I wanted to collect all the information you need in one place;
  - Each slide expresses a single idea
    (so lots of white space, just like this slide).
  - When one idea is explained over many slides, then the slide-header is numbered (just like this one . . . see the number I)

A note about the design of each chapter . . . II

- We will not discuss every slide in class.
- That is, some slides have information that you can read by yourself and do not need my help to understand.
- So, when I skip slides in class, keep calm and carry on.

A note about the design of each chapter . . . III

- The material for every chapter has the same structure:
  - What we want to do in this chapter . . . main objective for today
  - Slides for the topic of this chapter . . . core slides for today
  - Takeaways . . . closing slide
  - Work due for the next chapter . . . what you need to do
- Colors
  - Important content is highlighted in red.
  - Links (to other slides, readings, and web pages) are in blue.
  - You can use these links to navigate through the slides quickly.

Road map

Road map

Course material: Required

- The only two things that are required for the course are:
  1. A solid understanding of the theory in each chapter;
  2. The ability to implement the theory on financial data using Python.
- After each class, you will be required to do an assignment to test your understanding of the theory and coding.
- The required reading for each class will consist of one or two academic or practitioner papers related to the assignment.
- The course has only a single required textbook, titled "QPM."
- The next few slides list optional course resources – websites and books – that you can consult if you wish.

Road map

Websites related to the course material . . . I

- Material closely related to our course
  - An online book/course on quantitative investing that includes Python code: Moreira, A. 2021. *Quantitative investing.* Available online from this link.
  - Tidy Finance is an excellent website that contains high-quality code in Python (and R) along with very clear explanations of how to undertake empirical research in Financial Economics.
- Background material: Python and investment management
  - MOOC on "Investment Management with Python" offered by EDHEC via Coursera. Link to all the required files on GitHub.

Websites related to the course material . . . II

- Data sources
  - Python APIs to obtain data from Yahoo!Finance;
  - Obtaining data from Ken French's data library.
  - Python APIs to obtain data from Qandl.
  - Obtaining data from Open Source Asset Pricing; the data is described in the paper by Chen and Zimmermann (2022).
  - Python APIs to obtain data from WRDS (CRSP & Compustat);

Books on **theory** of portfolio management . . . I

1. Back, K. 2010. *Asset pricing and portfolio choice theory.* Oxford University Press.
2. Bodie, Z., A. Kane, and A. J. Marcus. 2005. *Investments.* 6th ed. McGraw Hill.
3. Campbell, J. Y. 2017. *Financial decisions and markets: A course in asset pricing.* Princeton University Press.
4. Cochrane, J. 2009. *Asset pricing: Revised edition.* Princeton university press.
5. Connor, G., L. Goldberg, and R. A. Korajczyk. 2010. *Portfolio risk analysis.* Princeton, New Jersey: Princeton University Press.
6. Ferson, W. 2019. *Empirical asset pricing: Models and methods.* MIT Press.
7. Fischer, B. R., and R. Wermers. 2012. *Performance evaluation and attribution of security portfolios.* Academic Press.
8. Huang, C.-F., and R. Litzenberger. 1988. *Foundations for financial economics.* New Jersey: Prentice Hall.
9. Jorion, P. 2001. *Value at risk.* Second. McGraw Hill.
10. Markowitz, H. M. 1959. *Portfolio selection: Efficient diversification of investments.* New York: Wiley.
11. Markowitz, H. M. 1987. *Mean-variance analysis in portfolio choice and capital markets.* Basil Blackwell.

Books on **theory** of portfolio management . . . II

12. Markowitz, H. M. 2009. *Harry Markowitz: Selected works.* Vol. 1. World Scientific.
13. Meucci, A. 2005. *Risk and asset allocation.* Springer.
14. Merton, R. C. 1990. *Continuous time finance.* Cambridge MA: Basil Blackwell.

Books on **practice** of portfolio management . . . I

1. Ang, A. 2014. *Asset management: A systematic approach to factor investing.* Oxford University Press.
2. Arnott, R., G. Sauter, and J. Siegel. 2007. *Fundamental indexing smackdown.* Sept./Oct: Journal of Indexes.
3. Bali, T. G., R. F. Engle, and S. Murray. 2016. *Empirical asset pricing: the cross section of stock returns.* John Wiley & Sons.
4. Chincarini, L. B., and D. Kim. 2006. *Quantitative equity portfolio management: An active approach to portfolio construction and management.* McGraw-Hill.
5. Grinold, R. C., and R. N. Kahn. 2000. *Active portfolio management: A quantitative approach for providing superior returns and controlling risk.* Second. McGraw-Hill.
6. Ilmanen, A. 2011. *Expected returns: An investor's guide to harvesting market rewards.* West Sussex, UK: Wiley Finance.
7. Isichenko, M. 2021. *Quantitative portfolio management: The art and science of statistical arbitrage.* John Wiley & Sons.
8. Jurczenko, E. 2017. *Factor investing: From traditional to alternative risk premia.* Elsevier.

Books on **practice** of portfolio management . . . II

9. Jurczenko, E., and B. Maillet. 2006. *Multi-moment asset allocation and pricing models.* John Wiley & Sons Hoboken, NJ.
10. Kaplan, P. D. 2012. *Frontiers of modern asset allocation.* John Wiley & Sons.
11. Kinlaw, W., M. P. Kritzman, and D. Turkington. 2017. *A practitioner's guide to asset allocation.* John Wiley & Sons.
12. Lee, W. 2000. *Theory and methodology of tactical asset allocation.* Vol. 65. John Wiley & Sons.
13. Litterman, R. 2003. *Modern investment management: An equilibrium approach.* New York: Wiley.
14. Lumholdt, H. 2018. *Strategic and tactical asset allocation.* Palgrave Macmillan.
15. Naik, V., M. Devarajan, A. Nowobilski, S. Page, and N. Pedersen. 2016. *Factor investing and asset allocation: A business cycle perspective.* CFA Institute Research Foundation.
16. Pedersen, L. H. 2019. *Efficiently inefficient: How smart money invests and market prices are determined.* Princeton University Press.
17. Prigent, J.-L. 2007. *Portfolio optimization and performance analysis.* Chapman / Hall.

Books on **practice** of portfolio management . . . III

18. Qian, E. E., R. H. Hua, and E. H. Sorensen. 2007. *Quantitative equity portfolio management.* Boca Raton, FL: Chapman / Hall.
19. Roncalli, T. 2013. *Introduction to risk parity and budgeting.* Boca Raton, FL: Chapman / Hall/CRC Financial Mathematics Series.
20. Satchell, S., and A. Grant. 2020. *Market momentum: Theory and practice.* John Wiley & Sons.
21. Scherer, B. 2010. *Portfolio construction and risk budgeting.* 4th. London: Risk Books.
22. Swensen, D. F. 2009. *Pioneering portfolio management.* 2nd. The Free Press.

Books on Finance with Python

1. Brugière, P. 2020. Quantitative portfolio management. *Springer Texts in Business and Economics.*
2. Coqueret, G., and T. Guida. 2023. *Machine learning for factor investing: Python version.* CRC Press.
3. Garita, M. 2021. *Applied quantitative finance: Using Python for financial analysis.* Palgrave Macmillan.
4. Hilpisch, Y. 2020b. *Python for finance: Analyze big financial data.* O'Reilly Media, Inc.
5. Kelliher, C. 2022a. *Quantitative finance with Python: A practical guide to investment management, trading, and financial engineering.* CRC Press.
6. Kelliher, C. 2022b. *Supplement to quantitative finance with Python: A practical guide to investment management, trading, and financial engineering.* CRC Press.
7. Matthes, E. 2023. *Python crash course.* no starch press.
8. Moreira, A. 2021. *Quantitative investing.* Available online from this link.
9. Scheuch, C., S. Voigt, P. Weiss, and C. Frey. 2024. *Tidy finance with Python.* Chapman-Hall/CRC. Available online from this link
10. Weiming, J. M. 2015. *Mastering Python for finance.* Packt Publishing Ltd.

Books on Finance with R

1. Coqueret, G., and T. Guida. 2020. *Machine learning for factor investing: R version.* CRC Press.
2. Regenstein Jr, J. K. 2018. *Reproducible finance with R: Code flows and shiny apps for portfolio analysis.* CRC Press.
3. Scheuch, C., S. Voigt, and P. Weiss. 2023. *Tidy finance with R.* 1st. Chapman / Hall/CRC.
4. Würtz, D., H. Bailer, Y. Chalabi, F. Grimson, and T. Setz. 2011. *Long term statistical analysis of US asset classes.* Rmetrics.
5. Würtz, D., Y. Chalabi, W. Chen, and A. Ellis. 2009. *Portfolio optimization with R/Rmetrics.* Rmetrics.
6. Würtz, D., A. Ellis, and Y. Chalabi. 2010. *Financial market data for R/Rmetrics.* Rmetrics.
7. Würtz, D., L. Lam, A. Ellis, and Y. Chalabi. 2010. *Basic R for Finance.* Finance Online Publishing.
8. Würtz, D., T. Setz, Y. Chalabi, and A. Ellis. 2014. *Chronological objects with Rmetrics.* Rmetrics.

Books on machine learning

1. Efron, B., and T. Hastie. 2021. *Computer age statistical inference, student edition: algorithms, evidence, and data science.* Vol. 6. Cambridge University Press.
2. Coqueret, G., and T. Guida. 2020. *Machine learning for factor investing: R version.* CRC Press.
3. Coqueret, G., and T. Guida. 2023. *Machine learning for factor investing: Python version.* CRC Press.
4. Hansen, B. 2022. *Econometrics.* Princeton University Press.
5. Hastie, T., R. Tibshirani, and M. Wainwright. 2015. *Statistical learning with sparsity: The lasso and generalizations.* CRC press.
6. Hilpisch, Y. 2020a. *Artificial intelligence in finance: a Python-based guide.* O'Reilly Media.
7. James, G., D. Witten, T. Hastie, and R. Tibshirani. 2013. *An introduction to statistical learning.* Vol. 112. Springer.
8. Kuhn, M., K. Johnson, et al. 2013. *Applied predictive modeling.* Vol. 26. Springer.
9. Nagel, S. 2021. *Machine learning in asset pricing.* Vol. 1. Princeton University Press.

Road map

1. Introduction to the course: How the course is organized
2. Topics covered in the course
3. Why take this course? Why learn this material?
4. How the course slides are designed
5. Course resources
6. Bibliography

Bibliography . . . I

Ang, A. 2014. *Asset management: A systematic approach to factor investing.* Oxford University Press. (Cited on page 67).

Arnott, R., J. Hsu, and J. Moore. 2005. Fundamental indexation. *Financial Analysts Journal* 60 (2): 83–99. (Cited on page 46).

Arnott, R., G. Sauter, and J. Siegel. 2007. *Fundamental indexing smackdown.* Sept./Oct: Journal of Indexes. (Cited on page 67).

Back, K. 2010. *Asset pricing and portfolio choice theory.* Oxford University Press. (Cited on page 65).

Bali, T. G., R. F. Engle, and S. Murray. 2016. *Empirical asset pricing: the cross section of stock returns.* John Wiley & Sons. (Cited on pages 12, 67).

Barroso, P., and A. L. Detzel. 2021. Do limits to arbitrage explain the benefits of volatility-managed portfolios? *Journal of Financial Economics* 140 (3): 744–767. (Cited on page 47).

Black, F., and R. Litterman. 1990. Asset allocation: Combining investor views with market equilibrium. Goldman, Sachs & Co. (Cited on page 45).

Black, F., and R. Litterman. 1991a. Combining investor views with market equilibrium. *Journal of Fixed Income* 1 (2): 7–18. (Cited on page 45).

Bibliography . . . II

———. 1991b. Global asset allocation with equities, bonds, and currencies. *Fixed Income Research* 2 (15-28): 1–44. (Cited on page 45).

———. 1992. Global portfolio optimization. *Financial Analysts Journal* 48:28–43. (Cited on page 45).

Bodie, Z., A. Kane, and A. J. Marcus. 2005. *Investments.* 6th ed. McGraw Hill. (Cited on page 65).

Brandt, M. W., P. Santa-Clara, and R. Valkanov. 2009. Parametric portfolio policies: Exploiting characteristics in the cross-section of equity returns. *Review of Financial Studies* 22 (9): 3411–3447. (Cited on page 46).

Brugière, P. 2020. Quantitative portfolio management. *Springer Texts in Business and Economics.* (Cited on page 70).

Campbell, J. Y. 2017. *Financial decisions and markets: A course in asset pricing.* Princeton University Press. (Cited on page 65).

Cederburg, S., M. S. O'Doherty, F. Wang, and X. Yan. 2020. On the performance of volatility-managed portfolios. *Journal of Financial Economics* 138 (1): 95–117. (Cited on page 47).

Bibliography . . . III

Chen, A. Y., and T. Zimmermann. 2022. Open source cross-sectional asset pricing. *Critical Finance Review* 11 (2): 207–264. (Cited on pages 41, 64).

Chincarini, L. B., and D. Kim. 2006. *Quantitative equity portfolio management: An active approach to portfolio construction and management.* McGraw-Hill. (Cited on page 67).

Cochrane, J. 2009. *Asset pricing: Revised edition.* Princeton university press. (Cited on page 65).

Connor, G., L. Goldberg, and R. A. Korajczyk. 2010. *Portfolio risk analysis.* Princeton, New Jersey: Princeton University Press. (Cited on page 65).

Coqueret, G., and T. Guida. 2020. *Machine learning for factor investing: R version.* CRC Press. (Cited on pages 71, 72).

———. 2023. *Machine learning for factor investing: Python version.* CRC Press. (Cited on pages 70, 72).

Dello-Preite, M., R. Uppal, P. Zaffaroni, and I. Zviadadze. 2025. Cross-sectional asset pricing with unsystematic risk. Available at SSRN 4135146.

Bibliography . . . IV

DeMiguel, V., L. Garlappi, F. J. Nogales, and R. Uppal. 2009. A generalized approach to portfolio optimization: Improving performance by constraining portfolio norms. *Management Science* 55 (5): 798–812. (Cited on page 44).

DeMiguel, V., A. Martín-Utrera, and R. Uppal. 2024. A multifactor perspective on volatility-managed portfolios. *Journal of Finance* 79 (6): 3859–3891. (Cited on page 47).

Efron, B., and T. Hastie. 2021. *Computer age statistical inference, student edition: algorithms, evidence, and data science.* Vol. 6. Cambridge University Press. (Cited on page 72).

Ferson, W. 2019. *Empirical asset pricing: Models and methods.* MIT Press. (Cited on page 65).

Fischer, B. R., and R. Wermers. 2012. *Performance evaluation and attribution of security portfolios.* Academic Press. (Cited on page 65).

Garita, M. 2021. *Applied quantitative finance: Using Python for financial analysis.* Palgrave Macmillan. (Cited on page 70).

Grinold, R. C., and R. N. Kahn. 2000. *Active portfolio management: A quantitative approach for providing superior returns and controlling risk.* Second. McGraw-Hill. (Cited on page 67).

Bibliography . . . V

Hansen, B. 2022. *Econometrics.* Princeton University Press. (Cited on page 72).

Hastie, T., R. Tibshirani, and M. Wainwright. 2015. *Statistical learning with sparsity: The lasso and generalizations.* CRC press. (Cited on page 72).

He, G., and R. Litterman. 1999. The intuition behind Black-Litterman model portfolios. *Investment Management Research (Goldman, Sachs & Company).* (Cited on page 45).

Hilpisch, Y. 2020a. *Artificial intelligence in finance: a Python-based guide.* O'Reilly Media. (Cited on page 72).

———. 2020b. *Python for finance: Analyze big financial data.* O'Reilly Media, Inc. (Cited on page 70).

Huang, C.-F., and R. Litzenberger. 1988. *Foundations for financial economics.* New Jersey: Prentice Hall. (Cited on pages 43, 65).

Ilmanen, A. 2011. *Expected returns: An investor's guide to harvesting market rewards.* West Sussex, UK: Wiley Finance. (Cited on page 67).

Isichenko, M. 2021. *Quantitative portfolio management: The art and science of statistical arbitrage.* John Wiley & Sons. (Cited on page 67).

Bibliography . . . VI

Jagannathan, R., and T. Ma. 2003. Risk reduction in large portfolios: Why imposing the wrong constraints helps. *Journal of Finance* 58 (4): 1651–1684. (Cited on page 44).

James, G., D. Witten, T. Hastie, and R. Tibshirani. 2013. *An introduction to statistical learning.* Vol. 112. Springer. (Cited on page 72).

Jorion, P. 1988. Bayes-stein estimation for portfolio analysis. *Journal of Financial and Quantitative Analysis* 21 (3): 279–292. (Cited on page 44).

Jorion, P. 1985. International portfolio diversification with estimation risk [in English]. *Journal of Business* 58 (3): pp. 259–278. (Cited on page 44).

———. 1986. Bayes-stein estimation for portfolio analysis. *Journal of Financial and Quantitative Analysis* 21 (3): 279–292. (Cited on page 44).

———. 1991. Bayesian and capm estimators of the means: Implications for portfolio selection. *Journal of Banking and Finance* 15 (3): 717–27. (Cited on page 44).

———. 1992. Portfolio optimization in practice. *Financial Analysts Journal* 48 (1): 68–74. (Cited on page 44).

Jorion, P. 2001. *Value at risk.* Second. McGraw Hill. (Cited on page 65).

Bibliography . . . VII

Jurczenko, E. 2017. *Factor investing: From traditional to alternative risk premia.* Elsevier. (Cited on page 67).

Jurczenko, E., and B. Maillet. 2006. *Multi-moment asset allocation and pricing models.* John Wiley & Sons Hoboken, NJ. (Cited on page 68).

Kan, R., and G. Zhou. 2007. Optimal portfolio choice with parameter uncertainty. *Journal of Financial and Quantitative Analysis* 42 (3): 621–656. (Cited on page 44).

Kaplan, P. D. 2012. *Frontiers of modern asset allocation.* John Wiley & Sons. (Cited on page 68).

Kelliher, C. 2022a. *Quantitative finance with Python: A practical guide to investment management, trading, and financial engineering.* CRC Press. (Cited on page 70).

———. 2022b. *Supplement to quantitative finance with Python: A practical guide to investment management, trading, and financial engineering.* CRC Press. (Cited on page 70).

Kinlaw, W., M. P. Kritzman, and D. Turkington. 2017. *A practitioner's guide to asset allocation.* John Wiley & Sons. (Cited on page 68).

Bibliography . . . VIII

Kirby, C., and B. Ostdiek. 2012. It's all in the timing: Simple active portfolio strategies that outperform naive diversification. *Journal of Financial and Quantitative Analysis* 47 (2): 437–467. (Cited on page 47).

Kuhn, M., K. Johnson, et al. 2013. *Applied predictive modeling.* Vol. 26. Springer. (Cited on page 72).

Ledoit, O., and M. Wolf. 2003. Improved estimation of the covariance matrix of stock returns with an application to portfolio selection. *Journal of Empirical Finance* 10 (5): 603–621. (Cited on page 44).

———. 2004a. A well-conditioned estimator for large-dimensional covariance matrices. *Journal of Multivariate Analysis* 88 (January): 365–411. (Cited on page 44).

———. 2004b. Honey, I shrunk the sample covariance matrix. *Journal of Portfolio Management* 30, no. 4 (December): 110–119. (Cited on page 44).

———. 2008. Robust performance hypothesis resting with the Sharpe ratio. *Journal of Empirical Finance* 15:850–859. (Cited on page 42).

Ledoit, O., and M. Wolf. 2017. Nonlinear shrinkage of the covariance matrix for portfolio selection: Markowitz meets goldilocks. *Review of Financial Studies* 30 (12): 4349–4388. (Cited on page 44).

Bibliography . . . IX

Lee, W. 2000. *Theory and methodology of tactical asset allocation.* Vol. 65. John Wiley & Sons. (Cited on page 68).

Litterman, R. 2003. *Modern investment management: An equilibrium approach.* New York: Wiley. (Cited on page 68).

Lumholdt, H. 2018. *Strategic and tactical asset allocation.* Palgrave Macmillan. (Cited on page 68).

Markowitz, H. M. 1959. *Portfolio selection: Efficient diversification of investments.* New York: Wiley. (Cited on page 65).

———. 1987. *Mean-variance analysis in portfolio choice and capital markets.* Basil Blackwell. (Cited on page 65).

———. 2009. *Harry Markowitz: Selected works.* Vol. 1. World Scientific. (Cited on page 66).

Matthes, E. 2023. *Python crash course.* no starch press. (Cited on page 70).

Merton, R. C. 1972. An analytic derivation of the efficient portfolio frontier. *Journal of Financial and Quantitative Analysis* 7 (4): 1851–72. (Cited on page 43).

Merton, R. C. 1990. *Continuous time finance.* Cambridge MA: Basil Blackwell. (Cited on page 66).

Bibliography . . . X

Meucci, A. 2005. *Risk and asset allocation.* Springer. (Cited on page 66).

Moreira, A. 2021. *Quantitative investing.* Available online from this link. (Cited on pages 63, 70).

Moreira, A., and T. Muir. 2017. Volatility-managed portfolios. *Journal of Finance* 72 (4): 1611–1644. (Cited on page 47).

———. 2019. Should long-term investors time volatility? *Journal of Financial Economics* 131 (3): 507–527. (Cited on page 47).

Nagel, S. 2021. *Machine learning in asset pricing.* Vol. 1. Princeton University Press. (Cited on page 72).

Naik, V., M. Devarajan, A. Nowobilski, S. Page, and N. Pedersen. 2016. *Factor investing and asset allocation: A business cycle perspective.* CFA Institute Research Foundation. (Cited on page 68).

Pedersen, L. H. 2019. *Efficiently inefficient: How smart money invests and market prices are determined.* Princeton University Press. (Cited on page 68).

Prigent, J.-L. 2007. *Portfolio optimization and performance analysis.* Chapman / Hall. (Cited on page 68).

Bibliography . . . XI

Qian, E. E., R. H. Hua, and E. H. Sorensen. 2007. *Quantitative equity portfolio management.* Boca Raton, FL: Chapman / Hall. (Cited on page 69).

Raponi, V., R. Uppal, and P. Zaffaroni. 2023. Robust portfolio choice. Working Paper, SSRN eLibrary. (Cited on page 48).

Regenstein Jr, J. K. 2018. *Reproducible finance with R: Code flows and shiny apps for portfolio analysis.* CRC Press. (Cited on page 71).

Roll, R. 1980. Orthogonal portfolios. *Journal of Financial and Quantitative Analysis* 15 (5): 1005–1023. (Cited on page 43).

Roncalli, T. 2013. *Introduction to risk parity and budgeting.* Boca Raton, FL: Chapman / Hall/CRC Financial Mathematics Series. (Cited on pages 46, 69).

Satchell, S., and A. Grant. 2020. *Market momentum: Theory and practice.* John Wiley & Sons. (Cited on page 69).

Scherer, B. 2010. *Portfolio construction and risk budgeting.* 4th. London: Risk Books. (Cited on page 69).

Scheuch, C., S. Voigt, and P. Weiss. 2023. *Tidy finance with R.* 1st. Chapman / Hall/CRC. (Cited on page 71).

Bibliography . . . XII

Scheuch, C., S. Voigt, P. Weiss, and C. Frey. 2024. *Tidy finance with Python.* Chapman-Hall/CRC. Available online from this link. (Cited on pages 12, 70).

Swensen, D. F. 2009. *Pioneering portfolio management.* 2nd. The Free Press. (Cited on page 69).

Weiming, J. M. 2015. *Mastering Python for finance.* Packt Publishing Ltd. (Cited on page 70).

Würtz, D., H. Bailer, Y. Chalabi, F. Grimson, and T. Setz. 2011. *Long term statistical analysis of US asset classes.* Rmetrics. (Cited on page 71).

Würtz, D., Y. Chalabi, W. Chen, and A. Ellis. 2009. *Portfolio optimization with R/Rmetrics.* Rmetrics. (Cited on page 71).

Würtz, D., A. Ellis, and Y. Chalabi. 2010. *Financial market data for R/Rmetrics.* Rmetrics. (Cited on page 71).

Würtz, D., L. Lam, A. Ellis, and Y. Chalabi. 2010. *Basic R for Finance.* Finance Online Publishing. (Cited on page 71).

Würtz, D., T. Setz, Y. Chalabi, and A. Ellis. 2014. *Chronological objects with Rmetrics.* Rmetrics. (Cited on page 71).