New York University Tandon School of Engineering

Financial Risk Engineering

FRE-GY6921: Selected Topics in Financial Engineering

Factor Approach to Optimal Strategic Asset Allocation

Fall 2024

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Course Prerequisites

- Matriculation into the MFE program or permission from the instructor
- FRE-GY 6083 (Quantitative Methods in Finance)
- One of the following: FRE-GY 6331(Financial Risk Management and optimization), FRE-GY 6351 (Econometrics and Time Series Analysis), FRE-GY 6571 (Asset-backed Securities and Securitization), or FRE-GY 6711 (Quantitative Portfolio Management)
- Beyond standard engineering math, proficiency in Excel, Python/Matlab/R etc. and data handling ability (sql or even orderly *.csv files) is expected. It's not a programming course, but we'll be working with data and students' projects will require computation.

Course Description

Endowments, Insurance Companies, Pension Funds and Sovereign Wealth Funds are end-investors with some of the largest balance sheets in the world. Over the past 20 years all of these types of end-investors have embraced assets of increasing complexity alongside traditional asset classes, including private alternatives (Private Equity, Venture Capital, Private Real Estate, Leveraged Loans), Hedge Funds, and structured products (ABS, CDOs, CLOs, CMOs, CMBS, RMBS, etc.). The core mission of all these asset managers is to create and execute the best possible Strategic Asset Allocation (SAA), given their institutional restrictions and objectives. Given the seeming exploding complexity of different asset classes, how is a CIO (Chief Investment Officer) to cope? The answer is using factor-based optimization, to cut through the complexity and identify the true return and diversification characteristics of these complex assets. Accordingly, this course develops a factor-based portfolio construction framework extended from Modern Portfolio Theory to explore solutions to the SAA challenges faced by the largest asset managers in the world.

The course covers:

- Key financial concepts and methods required to understand the risk and return characteristics of major asset classes, liquid and alternative
- Background and analysis of major global asset classes that large end-investors invest in
- Institutional background of the world's large end investors: who they are, where their funds come from, who their beneficiaries are
- Quantitative methods required to analyze and solve the challenge of strategic asset allocation, including portfolio optimization, factor analysis, arbitrage pricing theory and linear regression
- A quantitative framework for estimating asset class expected returns at the strategic (10+ years) horizon

- An operational factor-based, optimal SAA framework that solves for the asset allocations

Who should take the course? Students with an interest in how financial markets work and in the broad context of the institutions that make up the financial system today. The course will require a strong finance background already, meaning participants should have completed the MFE program Core Courses. There will be plenty of classroom discussion and students will be expected to read the financial press in the course of the term since discussion will draw on current market events and news stories for illustrations and context.

What should you expect from the course? A broad and operational understanding of what drives ultimate demand for assets in global financial markets. The course will give students a comprehensive roadmap of major asset classes and which institutions invest in them that most finance professionals only encounter years into their careers.

Course Objectives

- Familiarize students with leading global end-investment institutions and quantitatively characterize the asset allocation problems they face
- Explore the characteristics of major asset classes large end-investors manage in their portfolios, both liquid and alternative
- Derive a factor-based optimal allocation framework general enough to accommodate differing institutional requirements of large end-investors and use it to explore leading issues in asset allocation today
- Develop students' abilities to apply and combine a broad range financial principles and models spanning linear algebra, econometrics, optimization, portfolio theory, security valuation, etc., into unified commercial investment processes
- Build allocation intuition through familiarity with long-term historical asset class returns, their cross-distributional characteristics, data sources, data biases and errors in data
- Practice the art of applied portfolio optimization through an exploration of robust optimization, inverse optimization, input bias correction, and use of risk party and equal risk contribution as regularizations, etc.

Course Structure and Requirements

Classes are in-person and will meet from 6p – 8:41p on Tuesdays for 7 weeks. There will be 2 homework assignments, 2 quizzes and a final project. Class participation will also contribute to grades. Questions by students for clarification, additional information or especially if you are a bit confused are highly valued – if you have a question your fellow classmates are likely to have it too. Questions in class especially count toward the participation grade.

Assignment	% of Final Grade
Homework	25%
Class Participation	10%
Quizzes	25%
Final Project	40%

Grading range:

Letter Grade	Percent of Available Points
A	94% - 100%
A-	90% - 93.9%
B+	85% - 89.9%
B	80% - 84.9%
B-	75% - 79.9%
C+	70% - 74.9%
C	60% - 69.9%
F	<60%

Readings

Required:

There will be three course texts:

- Ang, Andrew, 2014. Asset Management, Oxford, Financial Management Association Series.
- Zvi Bodie, Alex Kane and Alan J. Marcus, 2014. Investments, 10th Edition, New York, NY: McGraw-Hill/Irwin.
- Anti Illmanen, 2015. Expected Returns on Major Asset Classes, CFA Institute and Wiley.

There will be topic-specific assigned readings, available on-line or in PDF, that appear in the Course Schedule, below.

Tentative Course Schedule

The course topics are probably more suitable for a full semester. To cover the material in 7 weeks we will focus selectively "deep" on certain topics. Remaining topics will not be omitted entirely, but will be given "survey" treatment: the course will introduce important issues and concepts in the area, and review sources/materials for deeper study.

Lecture slides will be distributed within a few days after each lecture. There will be some guest lectures, taking a fraction of a given weeks' class time. Speakers will be announced a week or two prior.

Subject matter for projects will be drawn from the "survey" topics that we cannot cover in depth. Students' Final Project materials will be distributed to the class as a whole as supplemental materials to the lectures.

Week 1. Introduction and adapting portfolio optimization to the problem of Strategic Asset Allocation

Topics:

1. Course overview
2. Large end-investors: their structure, objectives, and general operations; typical holdings/allocations; "implied liabilities" of each; characterization of objectives, important institutions, evolution of their holdings over the past 20 years
    a. Endowments
    b. Insurance Companies
    c. Pensions
    d. Sovereign Wealth Funds
3. The strategic investment time frame
4. Assets classes held by large end-investors
5. Course themes
6. Review of analytical tools:
    a. The Sharpe ratio, portfolio risk, and the mechanics of diversification
    b. Heuristics: Risk Parity, Equal Risk Contribution, inverse optimization
7. Portfolio optimization review

Readings:

1. Ang, Chapters 1, 2, 3 and 4.1
2. Ma Et. Al. (2024). Estimating Long-Term Expected Returns, *Financial Analysts Journal* 80(4): 134-154.

Week 2. Expected Returns: Risk Premia, Stocks and Bonds

1. OLS regression review
2. CAPM Review
3. Ross APT Review
4. Relationship between MVO, CAPM and APT
5. Modelling single securities versus modelling entire asset classes
6. Bond term premium

7. Equity risk premium to bonds

Readings:

1. Bodie EtAl, Chapters 9, 10
2. Ang, Chapter 6
3. Illmanen, Chapters 2 and 3 OR Ang Chapters 8 and 9
4. Gordon, M.J and Eli Shapiro (1956) "Capital Equipment Analysis: The Required Rate of Profit," Management Science, 3(1) (October 1956) 102-110. Reprinted in Management of Corporate Capital, Glencoe, Ill.: Free Press of, 1959.
5. Gordon, Myron J. (1959). "Dividends, Earnings and Stock Prices". Review of Economics and Statistics. The MIT Press. 41(2): 99–105.

Supplementary Readings:

6. Cochrane and Piazzesi (2005). "Bond Risk Premia," American Economic Review 95: 138-160.
7. Fama and French, 2004. "The Capital Asset Pricing Model: Theory and Evidence," Journal of Economic Perpsectives
8. Mehra and Prescott, 1985. "The Equity Premium: a Puzzle," Journal of Monetary Economics
9. Ross (1976). "The Arbitrage Theory of Capital Asset Pricing," Journal of Economic Theory

Week 3. Expected Returns: Credit and Private Equity

Problem Set 1 Due
Guest Speaker: Amit Sinha, Ares Management Corporation, Factor and Return Attribution of Private Equity Portfolios

1. Projects: outline of requirements, suggested topics
2. Credit risk premium
    a. Estimation of default risk
    b. Merton model of corporate bonds and capital structure
    c. Expected default and recovery rates for corporate credit
3. Private Equity – asset class characteristics
4. Private Equity – accounting for smoother returns than public equities

Readings:

1. Illmanen chapters 4 and 5
2. Merton (1974). "On the Pricing of Corporate Debt: The Risk Structure of Interest Rates," Journal of Finance 29(2): 449-470.
3. "Credit Loss Rates on Similarly Rated Loans and Bonds", Moodys Manuscript, 2004
4. "An Introduction to Leveraged Buyouts," Cambridge Associates Manuscript, 2014
5. Illmanen, et al (2019). "Demystifying Illiquid Assets: Expected Returns for Private Equity," manuscript, AQR & CFA
6. Chen and Greenberg (2017), "Consistent Risk Modeling of Liquid and Illiquid Asset Returns", Journal of Portfolio Management, 73:89.

Week 4. Expected Returns: Private Real Estate, Private Credit, Structured Credit and Hedge Funds

Quiz 1

1. Private Real Estate
2. Structured Credit
3. Private Credit
4. Hedge Funds
5. Factors: Applying APT to our 8 asset classes

6. Estimating E[rtns]

Readings

1. Ang, Chapters 7 and 11
2. Illmanen, et al (2019). "Demystifying Illiquid Assets: Expected Returns for Private Real Estate," manuscript, AQR & CFA
3. Jobst, Andreas (2006). "A Primer On Structured Finance," IMF.
4. Anson Et Al. (2012), Chapters 11 and 12: "Introduction to Hedge Funds" and "Hedge Fund Returns and Asset Allocation"

Supplementary Readings:

1. Bollinger Et Al. (2019). "Another Look at Private Real Estate Returns by Strategy," Journal of Portfolio Management
2. Coval, Et Al. (2009). "The Economics of Structured Finance," Journal of Economic Perspectives 23(1): 3-25
3. Private Credit reading TBD

Week 5. Computing Expected Risk and Optimization for Strategic Asset Allocation

Problem Set 2 Due
Guest Speaker: Valentine de Weck, JP Morgan: Specific Considerations for Optimal SAA for Life Insurers

1. Deriving the covariance matrix from expected returns factors
2. Estimating E[risk]
3. LTCMAs (Long Term Capital Market Assumptions): JP Morgan, Black Rock
4. Embedding input assumptions into an optimization framework
5. Problems with optimizers – error maximizers
6. Robust optimization

Readings: TBA

1. JP Morgan. 2023 Long Term Capital Market Assumptions
2. Cheng Et Al (2019). "Optimal Portfolio Construction Beyond Risk Parity," JP Morgan Manuscript.
3. Garlappi Et Al. 2007. "Portfolio Selection With Parameter and Model Uncertainty," Review of Financial Studies

Week 6. Applications of Optimization Framework to Specific Investor Types

Quiz 2

1. Deploying the framework: Optimal SAA for Endowments and SWFs
2. Deploying the framework: Optimal SAA for Pension Funds
3. Deploying the framework: Optimal SAA for L&R Insurers
4. Macro scenario-conditioned forecasts

Readings:

1. Jacobs Et Al (2021). "Strategic Asset Allocation for Endowment Funds," Journal of Portfolio Management.
2. Jiang Et Al (2020). "The Solvency Sharpe Ratio: Strategic Asset Allocation for Insurers," Neuberger Berman White Paper
3. Ambachtsheer (2021). "Canadian Pensions: Past, Present and Future," Journal of Portfolio Management

Week 7. Project Presentations & Course Summary

1. Presentations
2. Course conclusion

Readings: None

Inclusion Statement

The NYU Tandon School values an inclusive and equitable environment for all our students. I hope to foster a sense of community in this class and consider it a place where individuals of all backgrounds, beliefs, ethnicities, national origins, gender identities, sexual orientations, religious and political affiliations, and abilities will be treated with respect. It is my intent that all students' learning needs be addressed both in and out of class, and that the diversity that students bring to this class be viewed as a resource, strength and benefit. If this standard is not being upheld, please feel free to speak with met.

Moses Center Statement of Disability

If you are student with a disability who is requesting accommodations, please contact New York University's Moses Center for Students with Disabilities (CSD) at 212-998-4980 or mosescsd@nyu.edu. You must be registered with CSD to receive accommodations. Information about the Moses Center can be found at www.nyu.edu/csd. The Moses Center is located at 726 Broadway on the 3rd floor.

NYU School of Engineering Policies and Procedures on Academic Misconduct

A. Introduction: The School of Engineering encourages academic excellence in an environment that promotes honesty, integrity, and fairness, and students at the School of Engineering are expected to exhibit those qualities in their academic work. It is through the process of submitting their own work and receiving honest feedback on that work that students may progress academically. Any act of academic dishonesty is seen as an attack upon the School and will not be tolerated. Furthermore, those who breach the School's rules on academic integrity will be sanctioned under this Policy. Students are responsible for familiarizing themselves with the School's Policy on Academic Misconduct.

B. Definition: Academic dishonesty may include misrepresentation, deception, dishonesty, or any act of falsification committed by a student to influence a grade or other academic evaluation. Academic dishonesty also includes intentionally damaging the academic work of others or assisting other students in acts of dishonesty. Common examples of academically dishonest behavior include, but are not limited to, the following:

    1. Cheating: intentionally using or attempting to use unauthorized notes, books, electronic media, or electronic communications in an exam; talking with fellow students or looking at another person's work during an exam; submitting work prepared in advance for an in-class examination; having someone take an exam for you or taking an exam for someone else; violating other rules governing the administration of examinations.
    2. Fabrication: including but not limited to, falsifying experimental data and/or citations.
    3. Plagiarism: intentionally or knowingly representing the words or ideas of another as one's own in any academic exercise; failure to attribute direct quotations, paraphrases, or borrowed facts or information.
    4. Unauthorized collaboration: working together on work that was meant to be done individually.
    5. Duplicating work: presenting for grading the same work for more than one project or in more than one class, unless express and prior permission has been received from the course instructor(s) or research adviser involved.
    6. Forgery: altering any academic document, including, but not limited to, academic records, admissions materials, or medical excuses.

If you are experiencing an illness or any other situation that might affect your academic performance in a class, please email Deanna Rayment, Coordinator of Student Advocacy, Compliance and Student Affairs: deanna.rayment@nyu.edu. Deanna can reach out to your instructors on your behalf when warranted.