NYU Tandon School of Engineering – Financial Engineering

Course title: Risk Preference and Portfolio Selection, FRE-GY 7841 - I2 (21574)

Meets: Thursdays September 2, 9, 16, 23, 30; October 7, 14, 2021. 6PM-8:41PM

Instructor: Ken Winston, kjw241@nyu.edu

Prerequisites: Multivariate calculus, linear algebra, probability, and Python.

Course motivation and aim: Prices of financial assets combine (a) estimates of success or failure; and (b) compensation for risk taking. Disentangling the two effects is difficult. This short course explores portfolio management techniques that attempt to take advantage of the interplay between these two effects.

Learning outcome: At the end of this course, students will have been introduced to the nature of risk in financial markets; risk metrics; and how risk affects prices. We will explore stochastic discount factors (SDFs, or pricing kernels) in theory and in practice as they affect portfolio construction techniques.

Format and evaluation: The lectures of this half-semester class will be based on assigned readings in the online Jupyter Notebook text *Quantitative Risk and Portfolio Management*, and class notes. Students will be given homework to solidify and deepen their understanding as well as to get exposed to the practical aspects of the materials taught.

Each student will be graded based on their performance in (1) Class participation (18%); (2) individual homework assignments (32%), and (3) a final exam (50%).

Course description: This course starts with an introduction to risk and to stochastic discount factor (SDF) theory, which has for a long time (a) dominated academic pricing theory; and (b) been thought utterly useless by practitioners. Recent developments have begun to move the theory into useable practice, and new investing techniques based on SDF theory have begun to emerge. However, there are practical problems with implementation that we will discuss.

We will also discuss classical portfolio management techniques in light of risk preference, and show how the most reliable techniques are due to the ability to be compensate for risk-taking and not the ability to predict success or failure.

It is important that students taking this course have good working knowledge of multivariate calculus, linear algebra and calculus-based probability. Students will be required to have (or to quickly acquire) facility with Python.

Readings

Quantitative Risk and Portfolio Management, by Ken Winston (“QRPM”)

Software

- Jupyter / iPython notebook
    - Book is hosted on mybinder but your own instance is recommended, preferably Anaconda
    - Python Libraries: Pyplot, Scipy, Pandas, Numpy

Inclusion Statement

The NYU Tandon School values an inclusive and equitable environment for all our students. I hope to make this class a place where each and every student is recognized on the basis of individual qualifications without regard to background, beliefs, ethnicity, race, color, religion, sex (including pregnancy), national origin, age, disability, veteran status, genetic information, sexual orientation, and gender identity.

Schedule (subject to change)

Week 1 (September 2, 2021):

What is risk? Venture vs. Peril. Frank Knight's framework
Class polls – what would you do in risky situations?
Economic terminology
Capital markets terminology
Probability terminology
Utility Theory
St. Petersburg paradox, early forms of utility functions
von-Neumann Morgenstern axioms – lotteries and prizes, big-U and small-u utility equivalence
Risk tolerance: Aversion; Neutrality; Seeking. Coefficients of risk aversion. Characterizations of utility functions with respect to risk tolerance.
Problems with utility theory: behavioral, Rabin's Paradox, background noise

QRPM Chapter 1

Week 2 (September 9, 2021):

"*Caveat Laws" – Rules about lack of rules*
Risk metrics:
  Standard Deviation, MAD, Semi-Standard Deviation, Inter-p-tile range
  VaR, ES, cVaR
  Coherent Risk
Risk-adjusted reward metrics
Risk-averse prices
No-arbitrage
State Prices and Risk-Neutral Probabilities
Stochastic Discount Factors (SDF's)
The Hansen-Jagananthan bound

QRPM Chapter 2

Week 3 (September 16, 2021):

The time-varying nature of volatility
- *Historical volatility*
- *Volatility as a tradable asset*
- *Implied volatility*
- *Skews and smiles*

Stochastic and Local Volatility Models; SABR
Review of time series
- *ARCH – AutoRegressive Conditional Heteroskedasticity volatility modeling*
- *GARCH – Generalized ARCH*
- *The Merton model (en passant)*
- *Variants of ARCH – EGARCH, TARCH*

QRPM Chapter 8

Week 4 (September 23, 2021):

Breeden-Litzenberger
Computing VIX®
Pukthuanthong-Ross SDF estimation
The Ross Recovery Theorem
Jackwerth's Critique

QRPM Chapters 2, 8

Week 5 (September 30, 2021):

Equity modeling
Markowitz efficient frontier
- *Equality-constrained frontier*
- *Equality-constrained frontier: example*
- *Inequality constraints*
- *Efficient frontier and utility functions*
- *The capital market line*
- *Benchmark-relative*
- *Efficient frontiers: theory and practice*

Bayes' Rule
- *Shrinkage estimators*
- *Statistical tests*
- *Resampled efficient frontier*

Black-Litterman
- *Market equilibrium*
- *Investor views*

QRPM Chapter 4

Week 6 (October 7, 2021):

Factor Models
- *Capital Asset Pricing Model (CAPM)*
- *Four-Factor Model (Fama-French-Carhart)*
- *Arbitrage Pricing Theory (APT)*
  - *Exact*
  - *Specific*
- *Factor models in practice*

Principal Components Analysis

QRPM Chapter 5

Week 7 (October 14, 2021):

Betting Against Beta
Long/Short Portfolio Management
Problems with lognormal distributions
The Kirk Approximation
Constant Leverage

QRPM Chapter 12