

16:960:694 Foundations of Financial Statistics & Risk Management

Instructor: Dr. Neville O'Reilly

The emphasis of this course will be on the use of simple stochastic models and optimization for portfolio optimization, derivatives pricing and, most importantly, for risk management. Our examples will draw from many asset classes including equities, fixed income, foreign exchange, credit, mortgage-backed securities and structured products. We will also consider the role that some of these asset classes played during the financial crisis. If time permits, we will also discuss other applications including real options, energy and commodities modeling, and algorithmic trading among others.

Text: The course is intended to be **self-contained** but the following background readings provide more detailed coverage of some of the course material and will be used for to assign readings for fill-in coverage.

- 1) [Risk Mgmt & Financial Institutions: Hull, John](#) , 8<sup>th</sup> edition (this text will also be used in the Advanced Risk Mgmt Course)
- 2) FRM Exam Books, Part I
- 3) [Investment Science](#), by David G. Luenberger; Oxford University Press, 2013. A particularly good reference for the first five weeks of the course.
- 4) [Options, Futures, and Other Derivatives](#), by John C. Hull; Prentice Hall, 2012.

Selected Papers and Readings: Class specific papers and readings will be used for assignments and in class discussion. These will be posted on the course Sakai site

Homework: Homework assignments and due dates will be posted on Sakai each week. There are no extensions of time for submitting homework. Students may be called upon in class to review specific HW problem solutions. Solutions will be posted on the Sakai site after the due date.

Online Quizzes. Three online quizzes will be posted on Sakai covering weeks 3, weeks 4 thru 6, week 7 thru 9. These will have hard and soft deadlines and will allow multiple attempts up to the hard deadline

Final Exam: A final closed book exam will be given during the Fall semester final exam period.

The course outline follows

## Course Outline

WEEK	DESCRIPTION
1	<p><b>Financial Markets</b></p> <ul style="list-style-type: none"> <li>- Participants and Products</li> <li>- Modeling Financial Markets               <ul style="list-style-type: none"> <li>- Introduction to no-arbitrage argument</li> </ul> </li> <li>- Bloomberg Market Certificate (required)</li> </ul> <p><b>Types of Financial Institutions &amp; Risks Facing Them</b></p> <ul style="list-style-type: none"> <li>- Bank balance sheets and accounting metrics</li> <li>- Expected vs. Unexpected Losses</li> <li>- Financial Risk Events</li> <li>- Adding value with risk management</li> </ul>
2	<p><b>Option pricing and the binomial model</b></p> <ul style="list-style-type: none"> <li>- Replicating Strategies</li> <li>- Pricing Forwards &amp; Futures</li> <li>- the Black-Scholes model (convergence of binomial to BS)</li> </ul>
3	<p><b>Modern Portfolio Theory &amp; Mean Variance Optimization</b></p> <ul style="list-style-type: none"> <li>- Mean Variance with a risk free asset</li> <li>- Capital Asset Pricing Model</li> </ul>
4	<p><b>Interest Rate Risk</b></p> <ul style="list-style-type: none"> <li>- Short rate models               <ul style="list-style-type: none"> <li>- Parameterized short rate models</li> </ul> </li> <li>- Introduction to term structure lattice models</li> <li>- pricing bonds</li> <li>- interest rate sensitivity of bonds, duration, convexity</li> <li>- portfolio immunization, yield curve shifts, DV01</li> <li>- principal component analysis, gamma, vega</li> <li>- LIBOR, swap, treasury &amp; OIS rates</li> </ul>

WEEK	DESCRIPTION
5	<b>Fixed Income Derivatives</b> <ul style="list-style-type: none"> <li>- Options on bonds, bond forwards, bond futures</li> <li>- caplets, floorlets, swaps, swaptions</li> <li>- the forward equations</li> </ul>
6	<b>Defaultable Bonds</b> <ul style="list-style-type: none"> <li>- Pricing defaultable bonds (Default prob dists, loss distributions, credit ratings, risk neutral &amp; historical probabilities, hazard rates etc.)</li> <li>-- Model Calibration for interest rate derivativew</li> </ul>
7	<b>Hedging and Volatility</b> <ul style="list-style-type: none"> <li>- The Greeks Delta &amp; Gamma</li> <li>- The Greeks Vega &amp; Theta</li> <li>- Risk Management of Derivative Portfolios Using Hedging</li> <li>- Implied Volatility and the Volatility Surface</li> <li>- pricing derivatives using the volatility surface</li> </ul>
8	<b>VaR and Volatility</b> <ul style="list-style-type: none"> <li>- Definition of VaR, History of VaR, Calculation Examples</li> <li>- ES/cVaR</li> <li>- VaR and Capital, Coherent Risk Measures</li> <li>- Autocorrelations, marginal VaR, component VaR, incremental VaR</li> <li>- Euler's theorem &amp; aggregating VaRs</li> <li>- Backtesting</li> <li>- EWMA, ARCH, GARCH</li> <li>- Estimation &amp; Maximum Likelihood Estimates, Volatility Term Structures</li> </ul>
9	<b>Mortgage Backed Securities,</b> <ul style="list-style-type: none"> <li>- Mortgage Math and Mortgage Backed Securities</li> <li>- Prepayment risk and types of MBS with focus on pass-through</li> <li>- Principal only and interest only MBS and their associated risks</li> <li>- CMO's and pricing MBS</li> </ul> <b>Structured Credit, Correlations &amp; Copulas</b> <ul style="list-style-type: none"> <li>- CDOs and beyond</li> <li>- The Gaussian Copula Model</li> <li>- The mechanics of a synthetic CDO tranche</li> </ul>

WEEK	DESCRIPTION
	<ul style="list-style-type: none"> <li>- Computing the fair value of a CDO Tranche; cash vs. synthetic CDOs</li> <li>- Pricing and risk management of CDO portfolios (JP Morgan "belly of the whale" example)</li> <li>- CDO- Squareds and Beyond</li> </ul>
10	<p><b>The Financial Crisis of 2007-08</b></p> <ul style="list-style-type: none"> <li>- The role of structured credit &amp; sub-prime MBS</li> <li>- Contagion and Pro-cyclicality transmissions mechanisms &amp; examples</li> <li>- Role of incentives, importance of transparency</li> <li>- Lessons learned</li> </ul> <p><b>Some Other Financial Crises and Disasters</b></p>
11	<p><b>Regulation Before and After the Crisis</b></p> <ul style="list-style-type: none"> <li>- Overview of Basel Evolution</li> <li>- Basel II 2.5 outline</li> <li>- Since the crises: Basel III &amp; Dodd-Frank</li> <li>- Current Percolating Issues</li> </ul>
12	<b>Economic Capital, RAROC and Integrated Risk Management</b>
13	<b>Country and Sovereign Risk</b>