Course Description

Financial markets are characterized by continuous innovation in the creation of financial products, evolving risk management techniques, and increasingly powerful computational capabilities. In this course, we will discuss financial models and computational methods that help solve problems which appear every day in the financial markets. Examples of problems we will discuss are pricing and hedging techniques for equity derivatives, hedging and risk management, short and long term portfolio optimization, interest rate models and interest rate derivatives, credit sensitive securities, volatility estimation, etc. We will use a hands-on approach and apply the financial models and the computational methods to real-world problems. We will focus on the context in which the financial models and the computational methods are applicable, and highlight their limitations.

Course Outline (Tentative)

- **Hedging.** Statistical models for risk management and hedging.
- **Numerical Option Pricing.** Models and computational techniques for pricing and hedging of equity options in the Black-Scholes framework, including exotic derivatives (e.g. including path-dependent options) and, possibly, multi-asset options (e.g. spread, out-performance, and basket options).
- **Beyond Black-Scholes.** Deviations of real markets from the assumptions of the Black-Scholes framework. Extensions of the Black-Scholes framework.
- **Structured Option Portfolios.** Investing in and hedging options portfolios in practice.
- **Single & Multi-Period Portfolio Optimization.** Asset allocation and portfolio optimization over short and long term investment horizons.
- **Treasury Yield Curve.** Statistical analysis and modeling of the evolution of interest rates.
- **Interest-Rate Models.** Models for the pricing of interest-rate sensitive securities, including single factor models (e.g. Ho-Lee, Black-Derman-Toy) and multi-factor models (e.g. Heath-Jarrow-Morton). Model calibration to market data, and applications including the pricing of caps, floors, swaptions, callable bonds, mortgage-backed securities, and other interest-rate sensitive securities.
• Pricing Credit-Sensitive Securities. Introduction to the pricing and hedging of credit sensitive securities (e.g. credit default swaps).

Recommended Background

For the discussion of the topics in the course, we will assume:

(a) working knowledge of probability and statistics (at the level of B6100 Statistics);

(b) working knowledge of elementary optimization and simulation (at the level of B6101 Business Analytics);

(c) familiarity with basic concepts in fixed income (at the level of B8308 Debt Markets);

(d) familiarity with basic concepts in options.

Good review reading material for the course may be found in the textbooks:

• J. C. Hull, *Options, Futures, and Other Derivatives*, Prentice Hall;


For the homework assignments (see below), we will assume:

(e) proficiency with Excel, including its Solver (the built-in optimizer);

(f) working knowledge of Crystal Ball (for spreadsheet simulation);

(g) sufficient knowledge, or willingness to acquire sufficient knowledge, of Visual Basic (VBA).

Links to free VBA books can be found in the Columbia Library Books 24x7. Alternatively, a useful book on VBA is:


Grading

The grade for the course will be based on homework assignments, a final exam, and in-class participation; there will not be a mid-term exam. Homework assignments will count for 50% of the final grade. The final exam will count for 40% of the final grade. In-class participation will count for 10% of the final grade. There will be approximately four homework assignments throughout the semester. Students may work on the homework assignments in groups of up to three students per group. It is highly recommended that students first work on their own on all the problems in the homework assignments, and then confer with the other members of the group to check results, discuss difficulties, and/or resolve discrepancies. The homework assignments and the final exam will be designed to be as relevant, applicable and instructive as possible. Students taking this course are expected to spend a significant amount of time outside of the lectures to digest the material, complete the homework assignments, and prepare for the final exam.