

## B8835 Quantitative Finance: Models and Computation, Spring 2012

### Course Description

Modern financial markets are marked by the widespread prevalence of new financial products, the importance of risk management, and the availability of powerful computational technology. In this class, we develop financial models and computational methods to solve pricing, hedging, and portfolio optimization problems that appear everyday in financial markets. The emphasis is on a practical approach: we apply models and methods in a hands-on fashion to real problems, and simultaneously highlight their limitations in real situations. We develop techniques to price a wide array of equity derivatives, including path-dependent options and multi-asset options. We explore the related problems of hedging and risk management, and we address issues that arise in short and long term portfolio optimization. We construct models for the evolution of interest rates, to allow for the pricing and hedging of interest rate derivatives. Finally, we discuss models for credit sensitive securities.

B8835-002 is the ‘technical’ section of this course, and the lectures will cover some additional, advanced mathematical and computational topics. The homework and grading is identical across the two sections. Non-MBA students in either section will be required to program in Visual Basic in order to complete the homework assignments and the final exam. Students should feel free to register for either section and can also separately choose which section to attend.

### Course Outline

- **Hedging.** (1 lecture) Statistical models for risk management and hedging.
- **Numerical Option Pricing.** (6 lectures) Modeling and computational underpinnings for pricing equity options in the Black-Scholes framework, including analytic methods, lattice methods, and simulation methods. Pricing and hedging of exotic derivatives including path-dependent options (e.g., barriers, look-backs, Asian options) and multi-asset options (e.g., spread, out-performance, and basket options).
- **Beyond Black-Scholes.** (3 lectures) Discussion of the deviations of real markets from the assumptions of the Black-Scholes model. Extensions of the Black-Scholes model, including jump-diffusion models and stochastic volatility models.
- **Structured Option Portfolios.** (1 lecture) Investing in and hedging options portfolios in practice.
- **Single & Multi-Period Portfolio Optimization.** (3 lectures) Asset allocation and portfolio optimization over short and long term investment horizons.

- **Treasury Yield Curve.** (1 lecture) Statistical analysis and modeling of the evolution of interest rates.
- **Interest-Rate Models.** (6 lectures) 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.** (1 lecture) Introduction to the pricing and hedging of credit sensitive securities (e.g., credit default swaps).

### Recommended Background

This course assumes a working knowledge of statistics (at the level of the B6014 Statistics course) and optimization and simulation (at the level of the B6015 Decision Models course). Students must also be familiar with basic options concepts (at the level of the B8311 Options Markets course) and fixed income concepts (at the level of the B8308 Debt Markets course). Students must also be proficient in Excel, the use of the Solver (Excel's built-in optimizer), and Crystal Ball for spreadsheet simulation. This course is intended to be complementary to the B8312 Advanced Derivatives course.

A good review for the course would be to read or reread chapters 1–14 of Hull's textbook:

- J. C. Hull, *Options, Futures, and Other Derivatives*, 8th Edition. Prentice Hall, 2012.

Non-MBA students must be able to program in Visual Basic in order to complete the homework assignments and final exam. For links to free VBA books, use the Columbia Library Books 24x7:

- <http://www.columbia.edu/cu/lweb/eresources/databases/3262539.html>

Follow this link, click "Connect" and login with your UNI. Then, select "View by: IT and Technical Topics", then "Programming Languages", and then "Visual Basic".

Alternatively, a very good book on VBA is:

- S. C. Albright, *VBA for Modelers: Developing Decision Support Systems Using Microsoft Excel*, 2nd Edition. South-Western College Publishers, 2006.

### Methods of Evaluation

The grade for the course will be based on homework assignments and a final exam. The homework will count for 60% of the final grade. The final exam will count for 40% of the final grade. There will be approximately five homework assignments throughout the term. Students may work on the homework in groups of three or less. Homework assignments

done in groups of four or more people will receive only 50% credit for the assignment. The recommended way to work in a group is to do all of the assigned problems individually. Only after that should the group get together to meet to check the results for consistency and resolve any discrepancies.

Students taking this course in the past have described the workload as heavy. If you decide to take this course, you should be prepared to spend a significant amount of time outside of the lectures to learn the material, solve the homework assignments, and prepare for the final exam. The homework and final exam questions will be designed to be as relevant, applicable and instructive as possible. They are not 'make-work'. But as a consequence, the time requirement will be substantial. If you are not prepared to make this commitment, do not take this course.

MBA students from sections B8835-001 and B8835-002 will be graded together as a group, with the Visual Basic programming questions being graded as extra credit.