E4708 Syllabus for 2007

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General Information
E4708 - Topics in Financial Engineering Spring 2007 will cover “Old and New Ideas in Quantitative Finance.”

The course is intended for students with enough experience to read an interesting paper on financial engineering or quantitative finance and present its contents to the class. You don't have to be an expert but you have to be willing to struggle a bit, and then contribute. Students will work alone or in small groups that will take responsibility for reading and reporting on a paper.

Students will gain experience in learning to make presentations that get across the point of the research and its results as well as the details of mathematics. This should be helpful for job interviews and general communication skills. We will critique each other’s presentations.

Some examples of topics and papers we will cover are (i) the classic Merton model for corporate structure (ii) recent papers by Xavier Gabaix, Eugene Stanley and their collaborators on the scaling behavior of stock return distributions, (iii) papers by David Heath et al incoherent measures of risk, (iv) the Black-Litterman asset allocation model, etc. Feel free to suggest a topic you think is interesting too.

Method of Instruction
We will select about 10 papers, some classic and some recent, all with interesting ideas in quantitative finance, and then study them together as a class. Each class two or three students in a group will be jointly responsible for reporting on one paper to the rest of the class, and then leading a class discussion. The students reporting on the paper may circulate questions for the class to think about a few days before the presentation. The rest of the class will have reheats paper too, and so be able to contribute to and participate in the discussion. Someone will volunteer to record and transcribe the class discussion, too.

At the first class I’ll distribute a list of the possible papers we might use for the class, and then we'll figure out the groups and the schedule.

Prerequisites
The class is open to about 30 students taking the Master's or Ph.D. program who should be capable of independent reading.

This is not a course for students with no previous background in quantitative finance. Students should have some familiarity with Black-Scholes theory and the general methods of quantitative
finance, either from self-study and work experience, or from the first semester or two of a financial mathematics, financial engineering or business program.

The accent in the course will be on the financial modeling ideas in some classic and some new papers, but most of these papers will involve some mathematics.

Students from diverse programs, whether in the Ph.D program or the masters's in financial engineering, in business or in math, are encouraged to participate in the course.

**Method of Evaluation**
The final grade will be based on the student's presentation to the class and/or a term paper related to the papers covered by the group. It will be the responsibility of the students, with advice from the instructor, to figure out a suitable topic. The idea will be to explain the topic in an intelligent and clear fashion, accentuating both the ideas, the theory and the mathematics.

**Syllabus**
In the syllabus section of this course I will distribute papers on about 18 different topics. During the first lecture we will briefly talk about these topics, perhaps think of some other ones that you suggest, which would be great, and then figure out how to assign one of these possible topics to each student group for their presentation.

In the first week each student group will choose one of these topics (or possibly a completely different one) for a presentation later in the semester.

Here are some examples of topics covered in previous years. I’ve marked with bullets the ones I think are especially interesting.

**Session 1: The Black-Derman-Toy Model**
- A One-Factor Model of Interest Rates and Its Application to Treasury Bond Options.
- Bond and Option Pricing when Short Rates are Lognormal (Black & Karasinski)

These are short-rate models of the yield curve. Black & Scholes showed how to value options by the principal of no riskless arbitrage or replication, where you can replicate an option out of stock and a riskless bond. Vasicek showed how to extend this principal to valuing bonds; in a one-factor model of interest rates you can replicate any one bond out of any other bond and a riskless investment. The Vasicek model, however, couldn’t match the current yield curve. In the late 1980s, as yields dropped, there was a burgeoning market in options on Treasury bonds, and to use a model to value an option on a Treasury bond, you first had to value all bonds correctly. The BDT model and the Black-Karasinski model, as well as the Ho-Lee model, were a response to this need. They are models with one underlying stochastic variable, the instantaneous short rate; all long-term interest rates are modeled through the future behavior of short-term rates, constrained to fit the current yield curve and its volatility.

**Session 2: Valuing Convertible Bonds as Derivatives**

Convertible bonds are one of the earliest structured products, a hybrid of equity and debt.
Until recently most investors used to buy convertible bonds for their coupon or stock appreciation; now, for the last 5 or 6 years, the buyers are predominantly hedge funds who often hedge out the stock or credit risk and buy them for their volatility or some other more subtle quality. As a result, models have become even more important. There has been a big shakeout in the convertible bond market recently.

There are many stochastic factors affecting convertible bond values, as well as supply and demand, and most models try to capture only one or two key elements. The paper here is an early model, vintage 1988 or so, originally developed by Fischer Black and then enhanced by the Goldman Sachs Quantitative Strategies group, and focuses on the equity risk in a convertible bond, and values it as a derivative in the spirit of Black-Scholes.

I can help you find other more modern papers on this topic too.

*** Session 3: Volatility and Variance Swaps


When you buy a corporate bond you get exposure to Treasury rates and credit spreads. Credit default swaps give you exposure to credit alone. Hence their popularity. It’s always easier to make a clean bet.

When you buy an option, you get exposure to stock price and volatility. Volatility and Variance Swaps are forward contracts on the realized volatility or variance of a stock or an index, and give you exposure to pure volatility. Hence their recent popularity. Nowadays the VIX, a volatility index, is computed using the theory of the papers above, and expressed in terms of traded options prices. Soon there will be futures and options on the VIX too, making volatility a traded asset.

*** Session 4: The Scaling Behavior of Stock Distributions

Recently some econophysicists have carried out statistical studies of stock price distributions, and have claimed to discover that there is a universal power law for stock return distributions satisfied for almost all stocks over all return time periods. They have found (i) a cubic law of returns: returns follow a power law distribution with exponent 3; (ii) a half cubic law of trading/volumes: volumes follow a power law distribution with exponent 3/2; (iii) an approximate cubic law of number of trades: the number of trades in a given time intervals follows a power law distribution with exponent around 3. These researchers also propose a new model to explain these fat tails of the distributions, a model in which the tails are created by large institutions that dominate the large trades, and in which you have to model the market’s price response to a trade. If these models are correct, they imply a very different world from that of the standard geometric Brownian motion view of stock price movement, accompanied by anomalous jumps.

- Scaling of the distribution of fluctuations of financial market indices
- Economic fluctuations and anomalous diffusion
- Price fluctuations and market activity
Session 5: Optimal Portfolio Execution
When you trade stocks, you drive the market down if you sell and drive the market up if you buy. And how much you move the market depends on how many shares you trade, and on how the market responds. Thus, there is an optimal way of executing a portfolio trade of many shares. This theory is important for both investment banks who do big block trades or do program trades to facilitate taking clients out of one portfolio and into another; it’s also increasingly important for statistical arbitrage traders, at investment banks or hedge funds, who try to take advantage of small mispricings in individual stocks, and whose profit could be wiped out by their market impact. There may be other papers on these topics too.

Session 6: Characteristics of Hedge Funds
Hedge funds have proliferated like crazy in the past five years to the point where there is more than a trillion dollars in hedge funds. They are also increasingly the employers of quants. Hedge funds, unlike mutual funds, can do anything, and it’s hard to understand whether they are an asset class or just a random set of traders. There are a variety of papers here that try to categorize hedge funds by a sort of style analysis in order to determine how to compare their risk and return and perhaps how to model them. Some of this work interestingly tries to look at the equivalent options position that mimics the dynamic trading strategy of a hedge fund.

Session 7: Credit Default Swaps
Credit default swaps have become immensely popular as a direct way of speculating on or hedging against credit. We will study some introductory papers on the valuation of credit default swaps. We may also take a look at the modeling of the correlation between defaults of individual bonds, which has become a very important variable for valuing defaults on baskets of bonds and CDOs, collateralized default obligations, another area in which hedge funds have had significant losses recently.

Session 8: A Survey of Behavioral Finance
Behavioral finance has become fashionable, a combination of finance and the study of human psychology, and the subject was recently the recipient of a Nobel prize in economics. We will try to overview the area. Is it just a bunch of anecdotes or a real theory, an alternative to neoclassical finance?
• Barberis and Thaler review: A Survey of Behavioral Finance

••• Session 9: Capital Structure and the Merton Model

The original paper is by Merton:

I don't have a PDF file but it also appears as a chapter in Merton's book on Continuous Time Finance. Other treatments to look at are Chapter 7 in Cox and Rubinstein's Options Markets book, and Chapter 19 in Ingersoll's book on Finance, which both cover capital structure applications of the Black-Scholes model. A recent interesting paper that links the price of credit default swaps to the implied volatility of out-of-the-money puts on stock via the Merton model is
• Merton's Model, Volatility Skews and Credit Risk, by Hull, Nelken and White, available on Courseworks.

This old model from the dawn of options theory has become the foundation for the valuation of all sorts of credit derivatives, as well as the underpinning of the KMV credit rating company.

••• Session 10: Coherent Measures of Risk

Since the market crashes of the Nineties, everyone talks about risk management, and mostly about VaR. How good is VaR? It has many conceptual flaws. Recently Arzner et al introduced the idea of better measures of risk, coherent measures of risk that satisfy certain logical axioms. Now some of these risk measures are starting to appear in risk management systems too. Here are a bunch of papers on this topic.

• Meyers: Coherent Measures of Risk for Actuaries
• Boyle: Risk and Probability Measures
• Heath et al: Thinking Coherently
• Arzner, Delbaen, Eber, Heath: Coherent Measures of Risk
• Acerbi and Tasche: Expected Shortfall:
• Longin: Beyond VaR

••• Session 11: Hedge Fund Risk Management

More on hedge funds and their properties, and what can happen when they try to value illiquid securities.
• Do Hedge Funds Hedge: Asness et al.
• Risk Management for Hedge Funds: Lo
• Statistics of Sharpe Ratios: Lo

••• Session 12: Introduction to Mortgages

An important segment of the market. A study of the models used, in particular the OAS model.
• Mortgage-backed Securities (A review by Lakhbir Hayre)
• Track down some other papers
Session 13: The Excess Return Expected from Illiquidity
Many hedge funds and trading desks make their profit from buying illiquid securities cheaply, because other people avoid them. What is the excess return to be expected from illiquidity? This is a hot and relevant topic. Some papers on this topic, by no means exhaustive, are

- Asset Pricing In Markets With Illiquid Assets: Francis Longstaff
- On the Excess Returns to Illiquidity: Robert Novy-Marx
- Liquidity Risk and Expected Stock Returns: Lubos Pastor & Robert F. Stambaugh
- Liquidity Risk and Arbitrage Pricing Theory: Umut Cetin, Robert A. Jarrow, Philip Protter
- Liquidation Risk: Darrell Duffie & Alexander Ziegler
- Asset Pricing with Liquidity Risk: Viral V. Acharya & Lasse Heje Pedersen
- Liquidity and Asset Prices: Yakov Amihud, Haim Mendelson, and Lasse Heje Pedersen

There may be more appropriate papers too, which we can search for.

Yakov Amihud will be giving one of the Financial Engineering Practitioners Seminars later in the semester; Lasse Pedersen will give another.

Session 12: The Delivery Option in Futures
Futures have various delivery options embedded in them and valuing them correctly used to be a source of great arbitrage profits for Salomon Bros. in the late 80’s and early 90’s. You need a yield curve model to value them properly. Here is one early paper -- we can look at more of them too.

- Salomon Bros. Delivery Option Model, Early 90's

Session 15: Mountain Range Options
Exotic options used to have complex payoff functions on simple underlyers. Lately they’ve turned to exotic underlyers, like baskets, where correlation is important.

- Mountain Options
- Himalayans

Session 16: Dividend Modeling
Stock dividends are often paid at discrete times in fixed amounts, not at all like the dividend yield assumed by simple Black-Scholes extensions. Here are several papers that attempt to model discretely paid fixed-dollar value dividends in options models. This is an important issue for European stocks, some of which pay a certain dollar value dividend on a certain date.

- A discrete question
- Dealing with discrete dividends
- Finessing fixed dividends
- Risk news article on the effects of dividend modeling
Session 17: Value at Risk and its Problems
What is Value at Risk and how good is it, really?
• Return to RiskMetrics: Esp. sections I, III
• The Emperor Has No Clothes

••• Session 18: Correlation Products/ Trading Correlation
Collateralized Default Obligations involve complex valuation issues and their valuation depends critically on correlation. Last May there was a sudden change in the correlation skew for tranched CDOs that caused many hedge funds to lose money and resulted in quite a panic. Here are some papers on the topic. It would also be interesting to have part of the presentation cover the market dislocation of last May.
• Duffie on CDOs
• Hull-White on CDOs

••• Session 19: New Facts in Finance
A discussion of some anomalies in financial theory.
• Cochrane 1
• Cochrane 2

••• Session 20: The Black-Litterman Asset Allocation Model
Papers to be provided. This is a widely used model in the asset management world.

••• Session 21: Fat Tails, Levy Process, Variance Gamma Models and their Use in Finance
Papers to be provided. Interesting topic: