Experimental Finance

Course Outline

Contents

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Course Introduction

This is a proposal for a new course in experimental finance using the IVY® database. It is intended as an intimately hands-on course with time split almost evenly between classroom and computer lab.

The aims of the course are two-fold: to expose students to the striking differences between static, thermodynamic/SDE model solutions and real (time-of-flight) pricing, with the further goal of seeing where actual money-making opportunities may exist; and of familiarizing students with computational avenues and techniques for modeling and testing proposals for trading strategies.

It should be pointed out strongly that this is a radically new and needed course. Columbia graduates with this course on their résumés will be able to advertise a proven ability to thoroughly test any models via numerical experiments, as well as propose their own dynamical checks. It is in dynamics that current theory is noticeably silent.

The lectures will alternate between theory and the design of numerical experiments, and performing the actual numerical, experimental techniques.

Why is this Course Valuable?

The ability of future financial engineers to propose trading schema, to organize tests via options or stock databases, and then to carry out those tests efficiently and accurately would be an enormous asset. Currently there is no comparable course anywhere in the New York area. A Columbia graduate in financial engineering should have this ability, and will have a great advantage applying for a job with this skill. Additionally, it should be a strong selling point for recruiting students.

The development of options pricing models and their application in finance is relatively recent. The benchmark and workhorse has been the Black-Scholes-Merton models (BS) and their related cousins, all of which are *equilibrium* or *thermodynamic* models (Examples: stochastic vol, CEV, SABR). Leaving aside the natural objections that studies of returns argue for including *jumps* in the models of stock processes, the nature of thermodynamic models is that they cannot account for repricings which are continuously happening, and which reflect a change in market sentiment as a function of changing supply-and-demand, perceived upcoming events such as earnings or drug announcements, and world or national news.

The explicit consequence of these observations is that the value of an option, whether it is too high or too low, cannot be determined by direct comparison with equilibrium theory. Options values are dynamically changing and **there is no non-equilibrium theory** of options (currently) which is general enough to handle what happens in the market day in and day out.

However, very recently, large, inclusive financial databases have become available which allow for the performance of *dynamical experiments*. These are back-tested investigations of predictions based on observation and intuition. Already, using IVY®, Poteshman, et al., were able to validate intuitions regarding stock pinning which were in direct conflict with the underlying hypotheses of the BS models. A great number of dynamical properties which are presently completely unknown can be tested. For example, when volatility expands (or contracts) quickly over a short time frame, does it persist indefinitely (until the options expire) or decay back to a baseline as some function of time?

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Note

The course is designed to alternate lectures on the theory and structure of options in the actual marketplace and their real, evidenced, characteristics with laboratory lectures devoted to working with the IVY® database and extracting efficiently and cleanly the relevant numerical material.

The IVY® Database

The IVY® DB is the first widely available, comprehensive source of high-quality historical price and implied volatility data for the US equity and index options markets. Encompassing more than eight years of data, IVY® DB contains accurate historical prices of options and their associated underlying instruments, correctly calculated implied volatilities, and option sensitivities. IVY® DB. Gives the ability to back-test trading strategies, evaluate risk models, and perform sophisticated research on all aspects of options investment.

Comprehensive coverage
IVY® DB contains data on all US exchange- listed and NASDAQ equities and market indices, as well as all US listed index and equity options, starting from January, 1996.

Prices, Adjusted Returns, Dividends, and Corporate Actions
IVY® DB contains high, low, and close prices for all securities; calculated daily cum- and ex-dividend total returns; and best bid, best offer, last trade price, volume, and open interest for options. A complete history of dividend, split, and special payment information, including announcement date, ex-date, payment date, and type of payment, is available for each security.

Implied Volatility and Sensitivities
With each option price quote is stored the option's implied volatility, calculated using American or European models where appropriate. All option calculations use historical LIBOR/Eurodollar rates for interest rate inputs, and correctly incorporate discrete dividend payments. Standard option sensitivities (delta, gamma, vega/kappa, and theta) are calculated as well.

Option Price Continuity
Option data is directly linked with the underlying issue data to ensure consistency of the historical series even when option symbols or strike prices change. Options on a particular underlying can be tracked over the entire range of historical dates regardless of changes to the underlying ticker symbol or CUSIP.

Volatility Surface
An additional set of standardized options is constructed via interpolation for each underlying series every day, and implied volatilities are computed at standardized deltas between 0.20 and 0.80, with 30, 60, 91, 152, 182, and 365 day expirations (longer expirations are available for some series) giving the ability to directly observe the dynamics of the entire implied volatility surface. *

[* extract from IVY® materials]

Course Prerequisites

Student Prerequisites

Students should have had a course on derivative securities which thoroughly covered the Greeks, American exercise, put-call parity, etc. They should have a degree of facility with numerical computing and MS Excel.

Grading

Students will be graded on their lab course assignments, as well as their research project and final presentation. The research project will entail a proposal for a testable, dynamical property, and its subsequent measurement.

Equipment Requirements

Lab
- One computer with overhead projection for teacher.
- Sufficient Lab computers for two students/computer
- Networked with Database Server
- Campus access for laptops / home computers

Database
- IVY® Database (Oracle or SQL)
- Access to WRDS

Server Hardware
- Pentium IV 2.4 GHz +
- 1GB RAM +
- 200GB hard disk

Lecture 1 – Introduction and Course Details

Summary:

An introduction to the students of the practical problems faced by real traders and of the impossibility of unthinkingly applying BS theories. An exploration of where work needs to be done.

Lecture:

- Introduction
- Trading to make money
- Thermodynamic pricing vs. the dynamical game of real trading
- What might a trading strategy be?

Lecture 2 (Lab) – Practice, not Theory

Summary:

Introduction to the lab component of the course. Overview of historical databases, database systems and data mining tools. Overview of IVY® and the systems used throughout the course and a several examples to get students working on the computers.

Introduction to data-mining. Overview of the standard Query Language (SQL) and Microsoft Excel, used to extract and analyze IVY® data.

Lecture:

- Historical Databases
- IVY®
- WRDS (Wharton)

- Database Server
- Microsoft SQL
- Oracle

- Client Interfaces
- Excel
- Microsoft Query Analyzer
- Other 3rd party tools

- SQL Statements
- JOINS
- Filters (e.g. date ranges, specific stocks, option chains)
- Stored procedures and calculations
- Views
- Data transformations

Assignments

Students will perform various exercises such as extracting groups of stocks by:

- option series
- sector
- date ranges, expiration timelines
- numeric ranges (price, volatility)

Lecture 3 – Stock Pinning (a non-classical, static property)

Summary

BS type models assume a *stock process* independent of supply and demand. Removing that assumption naturally led to a prediction of stock pinning: a non-classical property which was confirmed independently via IVY®. This is a very strong example of the constructive uses to which database mining can be employed in exploration of a static property.

Lecture

- Static Properties vs. Dynamical Properties

- Example of a static, non-classical property:
  - The Avellaneda-Lipkin model of stock pinning
  - Poteshman-Pearson-Ni's test of the theory on IVY®

- Can the data be reproduced?

Lecture 4 (Lab) – Data Cleaning

Summary

Students will learn the practical necessity to extract and analyze data for validity before conducting the Pinning Model tests. Unavailable data, erratic market close pricing and spurious errors will be examined and data sets cleaned before tests are performed.

Lecture

- Data Cleaning
- Missing Data
- Do we care?
- Extrapolation

- Bad Data
- Limits and out of bounds data
- Data errors (find using e.g. fitting curves)

- Examples:
    - Negative Prices
    - Market Close Bid/Ask Spreads

Assignment

Generate several datasets and examine their validity for testing purposes. Examine what kind of analysis the data sets could or could not be used for.

Lecture 5 – Introduction to Dynamical Properties

Summary

Dynamical properties are the next frontier of finance. We know very little about the way that price fluctuations should evolve in time. But traders and other practitioners have strong intuitions about the persistence of volatility spikes, especially near earnings dates. Here we introduce the students to what actually happens near earnings and explore what might be found in the database.

Lecture

- Dynamics vs. Statics
- Volatilities at earnings and drug announcements.
- Time scales - when does this happen?
- Exponential vs. power-law decay of fluctuations.

Lecture 6 (Lab) – Static Tests: The Pinning Model – True or False

Summary

During the lab session, students will apply experience gained during the past lecture to conduct a test of the Avellaneda-Lipkin pinning theory using past data series.

Lecture

- Datasets for the pinning model
- Pinning equations

Lecture 7 – Dynamical Properties, continued

Summary

Here we take an excursion into dynamical systems, in general, and some of the broad properties that are often discovered. In natural systems there is usually a return to equilibrium in the absence of a continued driving force, but in finance it is not clear what the driving force is and when it ceases. (A good bet is $$ flowing into the stock, but there is no clear way of measuring this.) On the other hand, we can measure the consequences of fluctuations directly via IVY®, even without a predictive theory. This is extremely important for the success of trading schema.

Lecture

- Dynamics continued
- Approach to equilibrium in dynamic systems
- Correlation functions
- Does price in finance behave like temperature in natural systems?

Lecture 8 (Lab) – Dynamic Tests

Summary

Students will be introduced to extracting and manipulating time-series data using IVY®. Analyze volatility profiles near earnings dates and determine decay properties.

Lecture

- How to manipulate time-series data
- Averaging
- Curve fitting
- Decay Characteristics

Assignment

Find earnings dates from an external source and correlate them with options data from the IVY® database for a particular market sector.

Lecture 9 – Index Options (and more)

<u>Summary</u>

The current equity option landscape is richer than it was only a few years ago because there are ETFs and index options which permit correlative (or dispersion) trading. But there are additional questions which are dynamical and await inquiry. For example: how long does it take for a volatility spike in a component to spread out across all the components of an index, or does it stay confined to the single component? Also we introduce the students to hard-to-borrow securities and their unusual properties.

<u>Lecture</u>

- Experimental Modeling
- Time-scale separation
- Hard-to-borrow stocks
- Dispersion trading
- Index options

Lecture 10 (Lab) – Hard-to-Borrow Stocks

<u>Summary</u>

Determining the characteristic failures of put-call parity in hard-to-borrows. Can effective negative interest rates or fictitious dividends properly reproduce the data?

<u>Lecture</u>

- Data extraction on hard-to-borrows
- Locating hard-to-borrows using IVY®

Lectures 11 and 12 – Student Presentations

Summary

Student projects (done in groups of three) will be presented. The class will discuss the consequences of the tests. Can profitable trading come from this or do the markets already remove arbitrage?

Lecture

- Student presentations

- Money-making opportunities or normative behavior?