SYLLABUS

IEOR E4733 – Algorithmic Trading

Term: Fall 2017
Department: Industrial Engineering and Operations Research (IEOR)

Instructors:
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TA: TBD

References:

Market Microstructure Theory, Maureen O’Hara, Blackwell Publishing 1995


Requirements: Basic understanding of financial markets and trading strategies, concepts and environment is recommended. Knowledge of stochastic processes, time series models and econometric analysis is also recommended. Knowledge of R, Matlab, S / S Plus or other statistical analysis software is also recommended.

Assignments and Grading: There will be 5-7 homework assignments and a group project that together determine the grade for this course. Homework assignments may involve implementation in R or other environments (e.g. Excel/VBA/Matlab). All assignments and the project will involve groups of 4-6 students based on the class size. Grades are individually assigned, based on performance on assignments (65%), the group project write-up and presentation (25%), and class participation (10%).

Office Hours: There will be weekly office hours by each TA, with location and other details to be announced during the first session of the course.
Course Website: Courseworks (E4733)
Course Description

During the past few decades financial markets have undergone a rapid expansion due to increases in computer power and proliferation of trading algorithms. At the same time there has been a significant increase in the number of trading venues, and alternative trading mechanisms and protocols. All this has led to the development of a number of new and novel quantitatively-driven investment styles, mostly based on automated computer-driven trading strategies executed on electronic platforms.

Microstructure is the study of trading mechanisms used for exchanging financial assets, and examination of processes and outcomes of such exchanges under specific trading rules. Microstructure studies examine the nature and consequences of different trading mechanisms, and explore how different trading protocols affect price formation, and why asset prices exhibit particular time series properties they do. In this course we will review the foundations of securities trading and market microstructure. We will review important models in the microstructure and present mathematical tools in their structural and statistical representations. We will discuss applications of univariate and multivariate autoregressive time series analysis to trades prices and order flows, and examine their economic underpinning arising from asymmetric information, inventory control and strategies of participants.

We will also discuss the costs associated with trading, how these costs are measured and strategies that minimize them, including the study of models for optimal splitting of the orders across time, to reduce transaction costs and control the temporary and permanent price adjustments that result from trades.

In addition, we will discuss the implementation and use of trading algorithms by buy and Sell-side firms. We will begin with an overview of common execution strategies and investigate certain strategies in some detail. Discussions of transaction cost measurement will be extended to include these execution strategies and we will review some of the implications of fragmented markets and market data on the selection and calculation of performance benchmarks. We will also consider some fundamentals of trading system design, as well as the operational risks associated with automated systems.
Course Outline

Foundations of Securities Trading and Market Microstructure

Nature of Markets and Prices

1. Sources for Value and Reasons for Trading
2. Mechanisms for trading
3. Liquidity and Transparency
4. Econometric Issues

Trading Mechanisms, Markets and Market Making

1. Limit Order Markets, Floor Markets, Dealer Markets
2. Auctions, Crossing Networks and Other Trading Mechanisms
3. Examples: NYSE and NASDAQ Markets

Univariate Time Series Analysis

1. Stationarity and Ergodicity
2. Moving Average Models
3. Autoregressive Models
4. Forecasting, Filtering, and Model Estimation
5. Wold Theorem

Information- and Inventory-Based Microstructure Models

Information-Based Model

1. Informed Traders and Uninformed Traders
2. Roll Model of Trade Prices
3. Random Walk Model of Security Price
4. Roll Model of Bid, Ask and Transaction Prices

Sequential Trade Model

1. Trade Quantities and Price Behavior
2. Simple Sequential Trade Model
3. Market Dynamics: Bid and Ask Quotes Over Time
4. Order Flow and Probability of Informed Trading
5. Distributions of Buys and Sells
6. Event Uncertainty and Poisson Arrivals
Strategic Trade Models

1. Strategic Behavior of Informed Traders
2. Strategic Behavior of Uninformed Traders
3. Link between Strategic and Sequential Trade Models

Generalized Roll Model

1. Structural Model and Its Statistical Representation
2. Forecasting and Filtering
3. General Univariate Random Walk Decompositions
4. Identification in Random Walk Decompositions

Applied Execution Strategies

Electronic Trading Algorithm

1. Trading Objectives
2. Applicable models
3. A Taxonomy of Implementation Strategies
4. Applicable models

Strategy Implementation

1. Arrival price
2. Participation
3. Hedging
4. Order routing

Time Series Analysis and Multivariate Models

Multivariate Linear Microstructure Models

1. Modeling Vector Time Series
2. Structural Model of Prices and Trades
3. Forecasts and Impulse Response Functions
4. Random Walk Decomposition in Multivariate Models
5. Other Structural Models

Multiple Securities and Multiple Prices

1. Stacked Model of Multiple Prices
2. The Structural Model
3. VMA Representation
4. VAR Representation
5. Cointegrated Prices and VECM Specification
Inventory Models

1. Order Arrival and Market Making
2. Market Maker’s Ruin Problem
3. Risk Aversion and Dealer’s Problem
4. Empirical Analysis of Dealer Inventories
5. Dynamics of Prices, Trades, and Inventories

Market Depth

1. Market Structures and Liquidity Providers
2. Limit Order Book Price Schedules
3. Competitive Dealer Market, Limit Order Market and Monopolistic Dealer

Trading Costs and Optimal Trading Strategies

Transaction Costs

1. Component Transaction Costs
2. Implementation Shortfall
4. Optimal Trading Strategies

Trading Benchmarks

1. Benchmark Prices, BAM and VWAP
2. VWAP Trading Strategies
3. Models of Order Slicing and Timing

High Frequency Trading Strategies

Evolution of High Frequency Trading

1. Comparison with Traditional Approaches to Trading
2. Evaluating Performance of High Frequency Strategies
3. Market Efficiency and Trading Opportunities at Different Frequencies

High Frequency Strategies

1. Trading on Microstructure: Inventory Based and Information Based
2. Event Arbitrage Strategies
3. Statistical Arbitrage Strategies
4. Managing Portfolios of High Frequency Strategies
Engineering and Operational Topics

Introduction to Trading Systems Design

1. System objectives
2. Market Structure Considerations
3. The Relevance of latency

Operational Risks in Algorithmic Trading

1. Operational Risk Defined
2. The Regulatory Landscape
3. Case Studies