Modeling High-Frequency Trading Activity
September 1 - 6, 2013

MEALS

*Breakfast (Buffet): 7:00–9:30 am, Sally Borden Building, Monday–Friday
*Lunch (Buffet): 11:30 am–1:30 pm, Sally Borden Building, Monday–Friday
*Dinner (Buffet): 5:30–7:30 pm, Sally Borden Building, Sunday–Thursday
Coffee Breaks: As per daily schedule, in the foyer of the TransCanada Pipeline Pavilion (TCPL)
*Please remember to scan your meal card at the host/hostess station in the dining room for each meal.

MEETING ROOMS

All lectures will be held in the new lecture theater in the TransCanada Pipelines Pavilion (TCPL). LCD projector and blackboards are available for presentations.

SCHEDULE

Sunday

16:00	Check-in begins (Front Desk - Professional Development Centre - open 24 hours)
17:30 - 19:30	Buffet Dinner, Sally Borden Building
20:00	Informal gathering in 2nd floor lounge, Corbett Hall
	Beverages and a small assortment of snacks are available on a cash honor system.

Monday

7:00 - 8:45	Breakfast
8:45 - 8:55	Introduction and Welcome by BIRS Station Manager, TCPL
8:55 - 9:00	Introduction, Organizers, Ramo Gençay and Richard Olsen
9:00 - 10:00	*High-frequency trading and public policy, Larry Harris, University of Southern California*
10:00 - 10:30	Coffee Break, TCPL
10:30 - 11:30	*Information cascades, critical liquidity and feedback loops: The complex ecology of financial markets, Jean-Philippe Bouchaud, Capital Fund Management*
11:30 - 11:45	Group Photo; meet in foyer of TCPL (photograph will be taken outdoors so a warm jacket may be of use).
11:45 - 14:00	Lunch
14:00 - 14:30	*High-frequency trading, Andrei Kirilenko, MIT*
14:30 - 15:00	*History of "Ideas", Christine Parlour, UC Berkeley*
15:00 - 15:30	Coffee Break, TCPL
15:30 - 16:00	*Economic Fluctuations & Statistical Physics: Quantifying Rare Events: "What Can We Do Before the Next Economic Crisis?", Eugene Stanley, Boston University*
16:00 - 17:30	*Day's Summary and Discussion Groups*
17:30 - 19:30	Dinner
19:30	Informal Discussions

Tuesday

7:00 - 9:00	Breakfast
9:00 - 9:30	*Flash crash, Albert Kyle, University of Maryland*
9:30 - 10:00	*Dealing with HFT in the foreign exchange market: The imposition of a minimum quote life and of other measures, Alain Chaboud, Federal Reserve Board*
10:00 - 10:30	*Building a market simulator for high frequency trading, Robert Almgren, New York University*
10:30 - 11:00	Coffee Break, TCPL
11:00 - 11:30	*High Frequency Trading and the 2008 Short Sale Ban, Terrence Hendershott, UC Berkeley*
11:30 - 12:00	*Assessing VPIN Measurement of Order Flow Toxicity Using Perfect Trade Classification, Torben Andersen, Northwestern University*
12:00 - 13:00	Lunch
13:00 - 13:55	Guided Tour of The Banff Centre; meet in the 2nd floor lounge, Corbett Hall
14:00 - 14:30	*High-frequency trading in institutional FX, Alec Schmidt, Kensho Finance*
14:30 - 15:00	*Cross-sectional universalities in financial time series, Gilles Zumbach, SwissQuant*
15:00 - 15:30	*Regulatory Issues, Paul Embrechts, ETH Zurich*
15:30 - 16:00	Coffee Break, TCPL
16:00 - 16:30	*Toxic arbitrage, Thierry Foucault, HEC, Paris*
16:30 - 18:00	*Day's Summary and Discussion Groups*
18:00 - 19:30	Dinner
19:30	Informal Discussions

Wednesday

7:00 - 9:00	Breakfast
9:00 - 9:30	*The latency advantage of high-frequency traders, Yacine Aït-Sahalia, Princeton University*
9:30 - 10:00	*High frequency trading and market shocks, Fabrizio Lillo, Scuola Normale Superiore di Pisa, Universita' di Palermo, and Santa Fe Institute*
10:00 - 10:30	*Hedging through a limit order book, Rossella Agliardi, University of Bologna*
10:30 - 11:00	Coffee Break, TCPL
11:00 - 11:30	*Trading Fast and Slow: Colocation and Market Quality, Jonathan Brogaard, University of Washington*
11:30 - 13:30	Lunch
13:30 - 17:30	Free afternoon – Alpine Hike
17:30 - 19:30	Dinner
19:30	Informal Discussions

Thursday

7:00 - 9:00	Breakfast
9:00 - 10:30	*Discussion of high-frequency trading. Led by Alain Chaboud, Richard Olsen and Alec Schmidt*
10:30 - 11:00	Coffee Break, TCPL
11:00 - 12:00	*Discussion on econometrics of high-frequency data. Led by Yacine Aït-Sahalia and Torben Andersen*
12:00 - 13:30	Lunch
13:30 - 15:00	*Discussion on quantitative risk management in a high-frequency environment. Led by Paul Embrechts and Larry Harris*
15:00 - 15:30	Coffee Break, TCPL
15:30 - 17:30	*Day's Summary and Discussion Groups*
17:30 - 19:30	Dinner
19:30	Informal Discussions

Friday

7:00 - 9:00	Breakfast
9:00 - 11:30	*Reflections. Led by Alain Chaboud, Thierry Foucault, Larry Harris, Albert Kyle and Fabrizio Lillo*
11:30 - 13:30	Lunch
12 noon	Checkout by 12 noon.

** 5-day workshop participants are welcome to use BIRS facilities (BIRS Coffee Lounge, TCPL and Reading Room) until 3 pm on Friday, although participants are still required to checkout of the guest rooms by 12 noon. **

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ABSTRACTS
(in the order of the workshop program)

Speaker: **Larry Harris** (University of Southern California)
Title: *High-frequency trading and public policy*
Abstract/Highlights:

- How does high frequency trading benefit other market participants?

- How does high frequency trading and algorithmic trading introduce systemic risks into the markets? How can they be controlled?

- How will the competition among high frequency traders unfold? Are high frequency traders engaged in a costly arms race, and, if so, should regulators intervene to reduce these costs, and if so, how should they intervene? What are the barriers to entry associated with various high frequency trading strategies?

- How should communications bandwidth be priced? Do regulators have to intervene to ensure that bandwidth is reasonably priced in fragmented markets in which competitive solutions may not be possible?

- What effect would a transactions tax on trading have on modern electronic markets and on the capital formation process?

- How do tick sizes and maker/taker pricing systems affect high frequency traders and the market in general? How do we know when the tick size is too small or too large? What costs, if any, are associated with competing to be first in the queue instead of competing to offer better prices?

- What is the role of machine learning as opposed to theory in the design of high frequency trading systems, both on the buy-side and on the sell-side?

- To what extent are high frequency traders engaged in trading strategies other than dealing and arbitrage? What can be done to protect slower traders from parasitic strategies that some high frequency traders implement?

- What innovations in exchange trading technologies will most benefit the markets in the future?

- What is the long-run demand for exchange and dealing services? How will trends in investment management and investor demography affect the trading industry?

Speaker: **Jean-Philippe Bouchaud** (Capital Fund Management)

Title: *Information cascades, critical liquidity and feedback loops: The complex ecology of financial markets*

Abstract: Markets are the loci of tensions between buyers and sellers, that must be resolved through ordered trading. This necessarily gives rise to a full ecology of market participants: low frequency "investors" vs. high frequency traders, liquidity consumers vs. liquidity takers, etc. This leads to a "hide and seek" game where nobody wants to show his hand, and where every trade maybe interpreted as information and therefore impact prices. This contributes to price volatility, and might even cause instabilities through feedback loops. Understanding price impact is, to our mind, crucial to understand the dynamics of prices and the stability of markets.

We will review recent empirical findings concerning the impact of trades on prices, which is related to bid-ask spreads at high frequencies, and to "latent liquidity" at lower frequencies, for so-called "metaorders". We discuss in particular a) the relation between spreads and volatility and the profitability of market making strategies and b) the rather surprising square root impact law of metaorders. We will argue that financial markets are (and have always been) on the verge of instability, with or without HFT.

Speaker: **Andrei Kirilenko** (MIT)

Title: *High frequency trading*

Abstract: High frequency trading is a recent innovation in financial intermediation that does not fit neatly into the standard liquidity-provision framework. While the net contribution of high frequency trading to market dynamics is still not fully understood, their mere presence has already shaken the confidence of traditional market participants in the stability and fairness of the financial market system as a whole.

Speaker: **Christine Parlour** (UC Berkeley)

Title: *History of "Ideas"*

Abstract: How has finance in high-frequency trading/market micro-structure evolved, different 'threads' of thinking, models and approaches.

Speaker: **Eugene Stanley** (Boston University)

Title: *Economic Fluctuations & Statistical Physics: Quantifying Rare Events: "What Can We Do Before the Next Economic Crisis?"*

Abstract: Recent analysis of truly huge quantities of empirical data suggests that classic economic theories not only fail for a few outliers, but that there occur similar outliers of every possible size. Specifically, if one analyzes only a small data set (say 10^4 data points), then outliers appear to occur as "rare events." However, when we analyze orders of magnitude more data (10^8 data points), we find orders of magnitude more outliers—so ignoring them is not a responsible option, and studying their properties becomes a realistic goal. We find that the statistical properties of these "outliers" are identical to the statistical properties of everyday fluctuations. For example, a histogram giving the number of fluctuations of a given magnitude x for fluctuations ranging in magnitude from everyday fluctuations to extremely rare fluctuations that occur with a probability of only 10^{-8} is a perfect straight line in a double-log plot, so one can quantify the probability of an event of any given size.

We demonstrate the principles of scaling and universality by describing very recent work [1-2]. Financial market fluctuations are characterized by many abrupt switchings on very short time scales from increasing "microtrends" to decreasing "microtrends"—and vice versa. We ask whether these ubiquitous switching processes have quantifiable features analogous to those present in phase transitions, and find striking scale-free behavior of the time intervals between transactions both before and after the switching occurs. We interpret our findings as being consistent with time-dependent collective behavior of financial market participants. Finally, we demonstrate that by analyzing changes in Google query volumes for search terms related to finance, we find patterns that may be early warning signs of stock market moves.

[1] T. Preis, J. Schneider, and H. E. Stanley, "Switching Processes in Financial Markets," Proc. Natl. Acad. Sci. USA **108**, 7674 (2011).

[2] T. Preis, H. S. Moat, and H. E. Stanley, "Quantifying Trading Behavior in Financial Markets Using Google Trends," Nature Scientific Reports 3, 1684 (2013).

Speaker: **Albert Kyle** (University of Maryland)
Title: *Flash Crash*
Abstract: The Flash Crash, a brief period of extreme market volatility on May 6, 2010, was a systemic event that raised questions about the integrity of U.S. financial markets. Using audit trail data, we argue that an automated execution program that rapidly sold 75,000 E-mini S&P 500 futures contracts (valued at approximately $4.1 billion) triggered the Flash Crash. Contrary to popular belief, high frequency traders (HFTs) did not cause the Flash Crash. However, by aggressively adjusting their inventories, HFTs exacerbated the downward movement in prices. We discuss lessons from the Flash Crash regarding market design and the evolution of trading.

Speaker: **Alain Chaboud** (Federal Reserve Board)
Title: *Dealing with HFT in the foreign exchange market: The imposition of a minimum quote life and of other measures*
Abstract: A number of the measures which have been proposed to deal with the impact of high-frequency trading in the equity market have been implemented or are being implemented in the institutional foreign exchange market. I present a brief overview of the measures implemented by EBS over the past few years, which include a minimum quote life of 250 milliseconds, a minimum trade to quote ratio, a reversal of a previous reduction in tick size, and, very recently, the announcement of a latency floor to be imposed by matching orders discretely every few milliseconds. I discuss how differences between the market structures of the FX and equity markets may have allowed for the introduction of these measures in the FX market.

Speaker: **Robert Almgren** (New York University)
Title: *Building a market simulator for high frequency trading*
Abstract: A market simulator is an essential tool for the development of high-frequency trading strategies. We will discuss the principles of constructing a simulator for interest rates futures products, taking account of the special features of these markets such as pro rata matching, implied liquidity, and pricing signals. Comparison with actual trade executions lets us do a quantitative assessment of the validity of the simulator.

Speaker: **Terrence Hendershott** (UC Berkeley)
Title: *High Frequency Trading and the 2008 Short Sale Ban*
Abstract: In September 2008, the U.S. Securities and Exchange Commission (SEC) temporarily banned most short sales in nearly 1,000 financial stocks. We examine the ban's effect on market quality, shorting activity, and the aggressiveness of short sellers. All but the smallest firms subject to the ban suffer a severe degradation in market quality. We decompose shorting activity into the component done by a sample of high frequency traders (HFTs) and other short sellers. We show the ban had a greater impact on HFTs' shorting than non-HFTs' shorting. We show that stocks where the decline in HFT activity is larger during the ban have greater degradation in market quality.

Speaker: **Torben Andersen** (Northwestern University)
Title: *Assessing VPIN Measurement of Order Flow Toxicity Using Perfect Trade Classification*
Abstract: The VPIN, or Volume-synchronized Probability of INformed trading, metric is introduced by Easley, Lopez de Prado and O'Hara (ELO) as a real-time indicator of order flow toxicity. They find the measure useful in predicting return volatility and conclude it may help signal impending market turmoil. The VPIN metric involves decomposing volume into active buys and sells. We use the best-bid-offer (BBO) files from the CME Group to construct (near) perfect trade classification measures for the E-mini S&P 500 futures contract. We investigate the accuracy of the ELO Bulk Volume Classification (BVC) scheme and find it inferior to a standard tick rule based on individual transactions. Moreover, when VPIN is constructed from accurate classification, it behaves in a diametrically opposite way to BVC-VPIN. We also find the latter to have forecast power for short-term volatility solely because it generates systematic classification errors that are correlated with trading volume and return volatility. When controlling for trading intensity and volatility, the BVC-VPIN measure has no incremental predictive power for future volatility. We conclude that VPIN is not suitable for measuring order flow imbalances.

Speaker: **Alec Schmidt** (Kensho Finance)
Title: *High-frequency trading in institutional FX*

Abstract: Three questions are addressed: What's HFT in institutional FX? How to measure volatility in high-frequency FX? Does HFT affect FX volatility? It is argued that HFT not just affects, it determines volatility of institutional FX market.

Speaker: **Gilles Zumbach** (SwissQuant)
Title: *Cross-sectional universalities in financial time series*

Abstract: When estimating process on financial time series, the usual method is to postulate the equations for the process and to estimate the parameter values for each time series. The implicit assumption is that the equations are universal (i.e. identical for all assets), while the parameters are specific (i.e. depending on the peculiarities of each asset). In this talk, we show that the parameter values can also be taken as universal. Two sets of time series are used for the study, one taken from the stock market and one generated by an ARCH process with fixed parameters. Both sets have the same number of time series and lengths. A broad panel of 40 statistical estimators is used to extract the properties of the data over 9 time horizons ranging from 1 day to 1 year, covering the known stylized facts. The total of 360 statistics constitutes a very stringent sieve for processes. The Kolmogorov-Smirnov test applied to the cross-sectional distribution for each of the statistics shows that the distributions are very similar, and only the mean volatility is found to have a component depending on the time series. This shows that the same data generating process can be used for all stocks.

Speaker: **Paul Embrechts** (ETH Zurich)
Title: *Regulatory issues*

Abstract: The recent financial crises have triggered a multitude of regulatory documents worldwide; some of these were more politically driven, others touched strongly on corporate governance within the banking world going forward, whereas a third category proposes specific guidelines for the calculation of risk capital. The latter, more methodologically oriented documents very much question some of the rules and practices in the calculation of Risk Weighted Assets. Based on the May 2012 Consultative Document "Fundamental Review of the Trading Book" by the Basel Committee on Banking Supervision, I will address in particular its Question 8: "What are the likely constraints with moving from Value-at-Risk to Expected Shortfall, including any challenges in delivering robust backtesting, and how may these be best overcome?" The relevance of this question for high frequency trading is clear! An important issue in my talk will concern Model Uncertainty, and this mainly through the calculation of best-worst bounds for risk measures under incomplete model assumptions. Part of the talk is based on the recent paper:

Embrechts, P., Puccetti, G., Rueschendorf, L. (2013): Model uncertainty and VaR aggregation. Journal of Banking and Finance 37(8), 2750-2764.

Speaker: **Thierry Foucault** (HEC Paris)
Title: *Toxic arbitrage*

Abstract: Arbitrage opportunities are either due to transient price pressures in one asset or asynchronous adjustment to information arrival for prices of related assets (stale quotes). The second type of arbitrage opportunities is toxic since it can result in a trading loss for liquidity suppliers with stale quotes. We develop a measure of dealers exposure to toxic arbitrage trades. Using this measure and data on high frequency triangular arbitrage opportunities in the FX market, we show that an increase in dealers exposure to toxic arbitrage trades has a significant positive effect on trading costs. The finding suggests a possible harmful effect of high frequency arbitrage activities.

Speaker: **Yacine Aït-Sahalia** (Princeton University)
Title: *The latency advantage of high frequency traders*
Abstract: We study the consequences for the price process of a market structure where a strategic trader enjoys a speed or latency advantage over other traders. The high frequency trader receives an imperfect signal regarding the future order flow and thanks to his latency advantage is able to revise his orders at a rate faster than that of other traders. We determine the optimal trading strategy of the high frequency trader and the price dynamics that result. We show in particular that the market will experience a high rate of order placement and a high rate of order cancellation, which conforms to what is observed in practice.

Speaker: **Fabrizio Lillo** (Scuola Normale Superiore di Pisa, Universita' di Palermo, and Santa Fe Institute)
Title: *High frequency trading and market shocks*
Abstract: Financial markets have always been characterized by instabilities at all time scales. In particular, price jumps are considered an important indicator of instabilities. This talk focuses on jumps and it is divided in two parts. In the first one, I will show that modern financial markets are characterized by a large probability of multiple cojumps, i.e. minutes in which a sizable number of stocks jump. I show that the dynamics of these cojumps is not described neither by a multivariate Poisson nor by a multivariate Hawkes model, which are unable to capture simultaneously the time clustering of jumps and the high synchronization of jumps across assets. I introduce a one factor model approach where both the factor and the idiosyncratic jump components are described by a Hawkes process and I show that the model reproduces very well the empirical data. By taking an historical perspective, I show that price jumps have always been present but the frequency of multiple cojumps has recently dramatically increased, signalling an increased synchronizaiton of assets or markets. In the second part of the talk I discuss the potential role of High Frequency Traders (HFTs) in destabilizing financial markets. Thanks to the availability of a database of Russian equity market, which allows to identify, in a coded way, the agent responsible of each order, we empirically investigate the behavior of HFTs around market shocks. After discussing the methods for identifying HFTs, we find that HFTs strongly modify their trading and order placement strategy during market shocks by increasing order placement and cancellations and creating a more sparse limit order book. However, at the investigated one minute time scale, no clear precursors of shocks due to HFTs trading is found.

Speaker: **Rossella Agliardi** (University of Bologna)
Title: *Hedging through a limit order book*
Abstract: We explicitly solve the portfolio problem of a large trader that needs to hedge its derivative position and incurs a price impact. Illiquidity is modeled both in terms of the depth and resilience of a limit order book. Some results hold for more general stochastic processes for the underlying, e.g. a generic Lévy process, thus extending previous literature. Furthermore, the trade-off between hedging and price manipulation is discussed. Finally, ongoing work is considering the hedging problem when limit orders are used instead of market orders.

Speaker: **Jonathan Brogaard** (University of Washington)
Title: *Trading Fast and Slow: Colocation and Market Quality*
Abstract: Using user-level data from NASDAQ OMX Stockholm, we investigate how different network connectivity speeds influences market participant dynamics. Participants utilizing colocated services adversely select non-colocated participants. We use an exchange system upgrade that allows colocated traders to upgrade to an even faster connection to identify a shock to the speed hierarchy. Participants that upgrade reduce their adverse selection costs and improve their inventory management ability, allowing them to increase their market share in liquidity provision. Non-colocated traders incur higher adverse selection costs after the event. Overall, however, the introduction of speed differentiation improves both bid-ask spreads and market depth. Our results suggest that the liquidity improvements are related to the fastest traders increased market share and enhanced inventory management.

Discussion topics offered by participants:

1. HFT and extreme volatility, how to study rare events? How responsible are current regulations for the rise of HFT? Is HFT becoming "perfectly" competitive?

2. Financial intermediation in automated markets; Financial Regulation 2.0; Application of machine-learning methods to financial data.

3. How to measure and model the implicit trading cost in high-frequency trading, such as price impact, opportunity cost, timing risk, especially in equity market as well as futures market.

4. What is the best way to minimize leakage for large block trades over a sequence of T periods with accelerating temporary and permanent impacts? What is the best way to measure the resiliency of the limit order book in a dynamic context? How to prevent a future Flash Crash or Splash Crash?

5. Optimal execution in FX: measures for evaluation; Optimal time frame for evaluation; Optimal execution strategies (order type, order venue, order size, order frequency, risk)

6. The segmented FX-market: Where does price discovery take place? How can data by synchronized across different venues?

7. Information theory in electronic markets: Has high frequency trading changed its validity? Can it be applied in a real time tick-by-tick environment?

8. Optimal portfolio execution using limit and market orders; The impact of the Tobin tax on HFT.

9. Tick size: Exchanges, at least in futures markets that are not subject to Reg NMS, are free to set the minimum price increment however they want. They adjust this value in order that the market activity have certain properties that they consider desirable. How should they set this tick size? What are the conflicting interests of various market participants?

10. Market design: To generalize the above, exchanges set the rules for trading. For example, short term interest rate products commonly use some version of pro rata matching rather than time priority (partially in response to the low volatility caused by the large tick size). And in equity markets, exchanges create more and more different types of orders beyond simple market and limit. How do these features of market design affect study of market microstructure and high-frequency trading? Can researchers make any recommendations on what kind of rules and orders should be allowed or encouraged?

11. Multiple markets: Many studies of high-frequency market behavior look only at a single market in isolation. For example, in the flash crash, researchers using only the CME data set for SP500 futures were not able to see trades and quotes in the underlying equities. Even in normal market situations, flows and activity in any particular instrument are likely part of a broad strategy. How should one study multi-asset market microstructure?

12. Information cascades, critical liquidity and feedback loops: the complex ecology of financial markets; HFT, FTT – how can one engineer the stability of financial markets?; What is the impact of large trades?

13. Model Uncertainty and Risk Aggregation (this is relevant for Quantitative Risk Management in a High Frequency Environment); Multivariate Hawkes Processes (they are especially useful for modeling HF returns); Quantitative Risk Management for High Frequency Trading: risk measures, regulation of markets; Theory and applications to HFT of Hawkes/Self-exciting Processes; The economics of HFT: influence on liquidity, volatility.

14. Is there a need for regulation/limitations/best practices in HFT? If so, why? If not, why not? Related to this, of course, is the question of what type of regulation/best practices could be useful, including minimum quote life, minimum fill ratios, random transmission delays.

15. Whether the brouhaha about HFT exists because HFT is affecting market quality (with the distinction here between "normal" conditions and rare events) or whether the brouhaha exists because the "old" players in the market are being replaced by new entrants, so the old players are just griping about losing their roles and their profits. The first possibility is something for regulators to worry about, the second option less so.

16. How does high frequency trading benefit other market participants?

17. How does high frequency trading and algorithmic trading introduce systemic risks into the markets? How can they be controlled?

18. How will the competition among high frequency traders unfold? Are high frequency traders engaged in a costly arms race, and, if so, should regulators intervene to reduce these costs, and if so, how should they intervene? What are the barriers to entry associated with various high frequency trading strategies?

19. How should communications bandwidth be priced? Do regulators have to intervene to ensure that bandwidth is reasonably priced in fragmented markets in which competitive solutions may not be possible?

20. What effect would a transactions tax on trading have on modern electronic markets and on the capital formation process?

21. How do tick sizes and maker/taker pricing systems affect high frequency traders and the market in general? How do we know when the tick size is too small or too large? What costs, if any, are associated with competing to be first in the queue instead of competing to offer better prices?

22. What is the role of machine learning as opposed to theory in the design of high frequency trading systems, both on the buy-side and on the sell-side?

23. To what extent are high frequency traders engaged in trading strategies other than dealing and arbitrage? What can be done to protect slower traders from parasitic strategies that some high frequency traders implement?

24. What innovations in exchange trading technologies will most benefit the markets in the future?

25. What is the long-run demand for exchange and dealing services? How will trends in investment management and investor demography affect the trading industry?

26. These topics primarily focus on the public policy issues that will ultimately determine what happens to the industry. To some extent, answers to these questions depend on knowing the electronic and financial engineering technologies that high frequency traders use so we should spend some time on discussing their methods.