High Frequency Trading, Winner Takes All and Stochastic Latency

Andrei Kirilenko
MIT Sloan

From Human to Automated Markets

- It is not so long ago that exchange-traded securities and derivatives were traded by humans in face-to-face markets.

- An open outcry market was visible to the human eye: traders had names, served designated functions, and occupied specific locations on the trading floor.

- Within the last decade, trading floors have been replaced by server farms and the traders have been replaced by anonymous algorithms.

The Promise of Automated Markets

- Automated markets came with the promise of using faster and cheaper technology to drastically lower execution costs and improve price discovery for fundamental market participants.

- For investors who want to buy or sell one hundred shares or a couple of futures contracts, this promise seems to be realized:

- They can do it at narrower bid-ask spreads, greater market depth, and prices that can be discovered around the clock.

- Things are not the same if investors want to trade in size – they fall prey to high frequency traders (HFTs).

High Frequency Trading: An Asset Manager's Perspective

From an e-mal to me:

"I manage a '40 Act fund inside a major insurance company and see nothing but peril in HFT. The narrowing of spreads that the HFT apologists claim to provide for the rest of us redounds to their bank accounts, not ours. The other side—increased volatility, false signaling of volume and investor preference, market dislocations, exchanges' divided loyalties, and market stresses are not worth the risk. We are definitely paying for something we do not want."

High Frequency Trading: Good or Evil?

Good

Bryan Durkin, Chief Operating Officer, CME Group: "There is considerable evidence that high-frequency traders increase liquidity, narrow spreads and enhance the efficiency of markets."

Evil

Charlie Munger, Vice Chairman, Berkshire Hathaway: "It's legalized front-running. I think it is basically evil and I don't think it should have ever been allowed to reach the size that it did. Why should all of us pay a little group of people to engage in legalized front-running of our orders?"

HFTs and Market Dislocations: The Flash Crash

How did High Frequency Traders trade on May 6, 2010?

What may have triggered the Flash Crash?

What role did HFTs play in the Flash Crash?

"...increased volatility, false signaling of volume and investor preference, market dislocations,..."
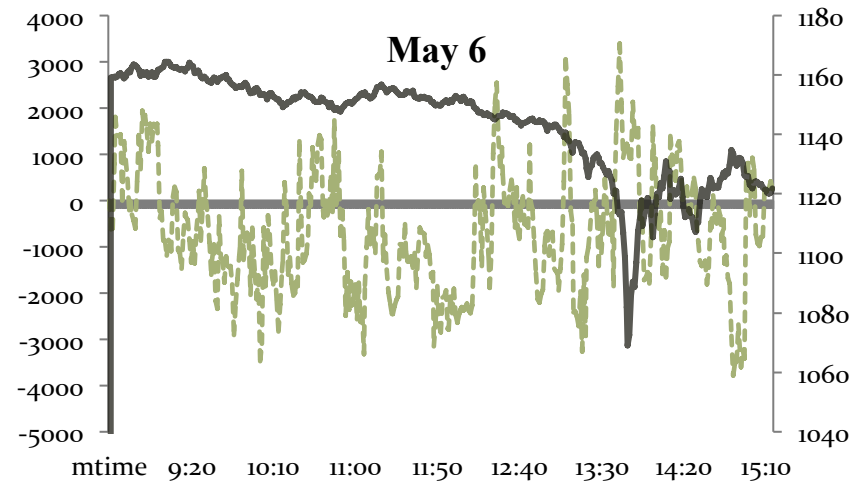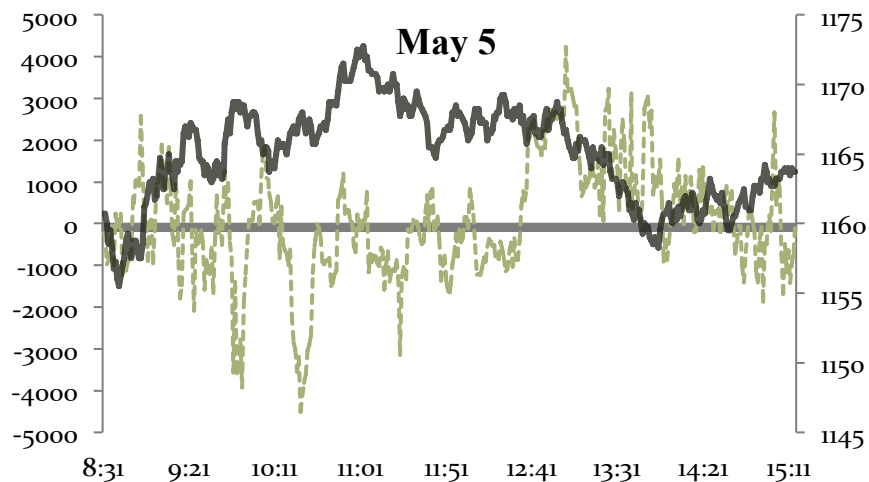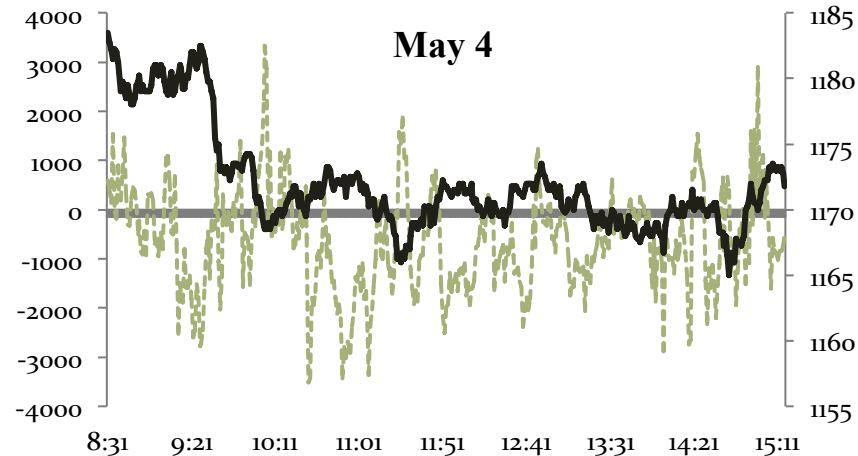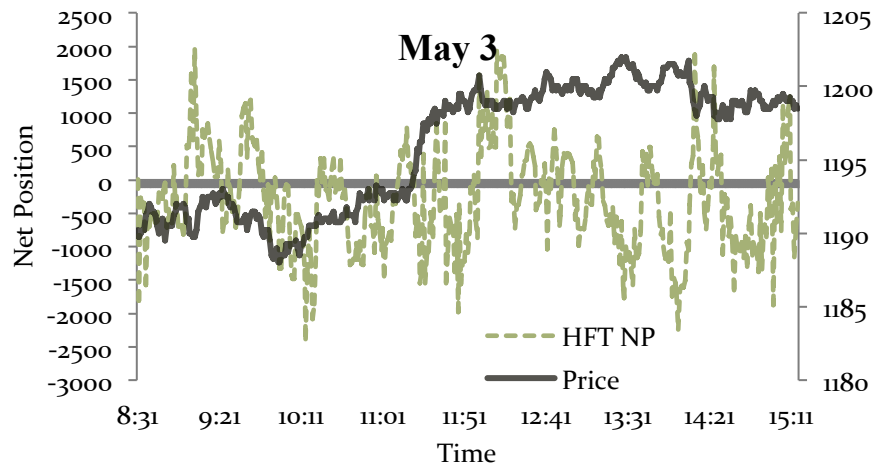
Classifying Traders

- HFTs:
  - High volume, low inventory, end the day flat

- Non-HFT Market Maker:
  - Provide liquidity

- Fundamental (Institutional):
  - Take directional positions

- Small (Retail):
  - Trade very few contracts

- Opportunistic:
  - Trade across multiple markets, against a model, during "events"

Trading Categories
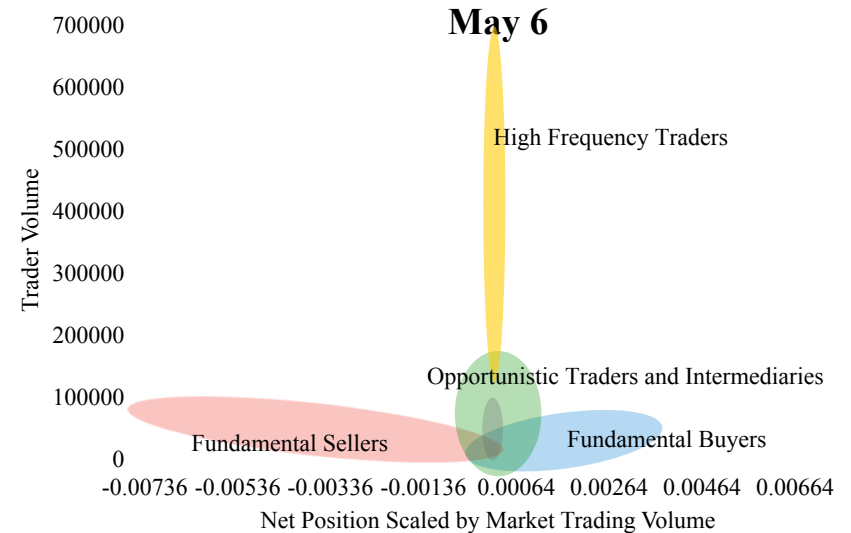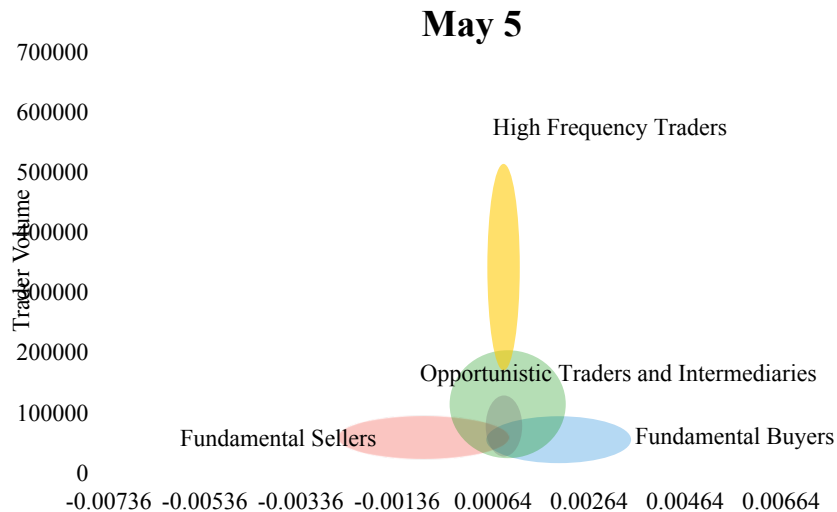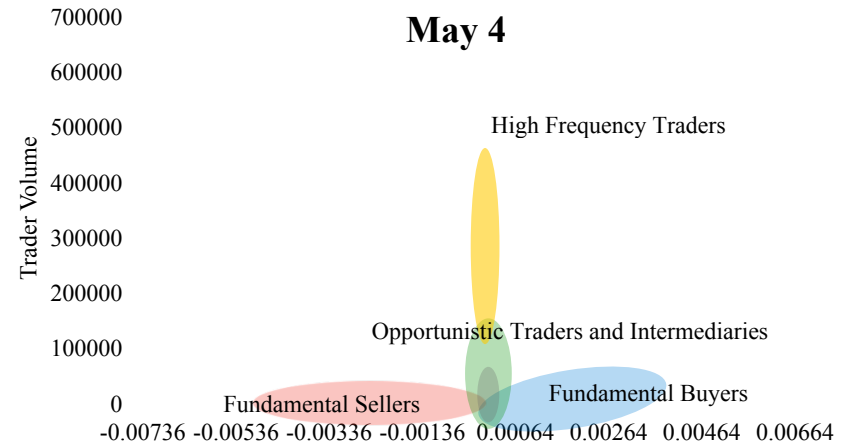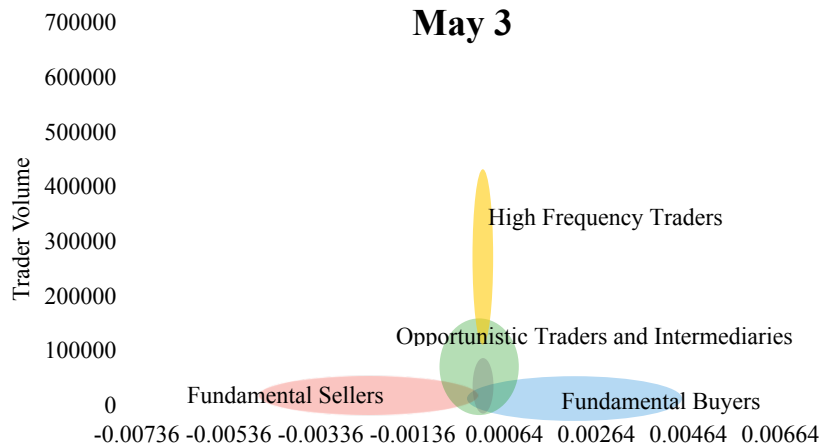
HFTs and Market Dislocations: Net Holdings

The Flash Crash

Large Fundamental Seller – hedges exposure in equities

Sell Algorithm – sell 75,000 E-mini's with 9% volume participation target

Size – Largest net position of the year executed in about 20 minutes

Price Decline – sells 35,000 ($1.9 billion) contracts in 13 minutes

Cross-Market Arbitrage – buy E-mini/sell SPY or basket of equities

Across the Board Price Declines – trigger automated pauses

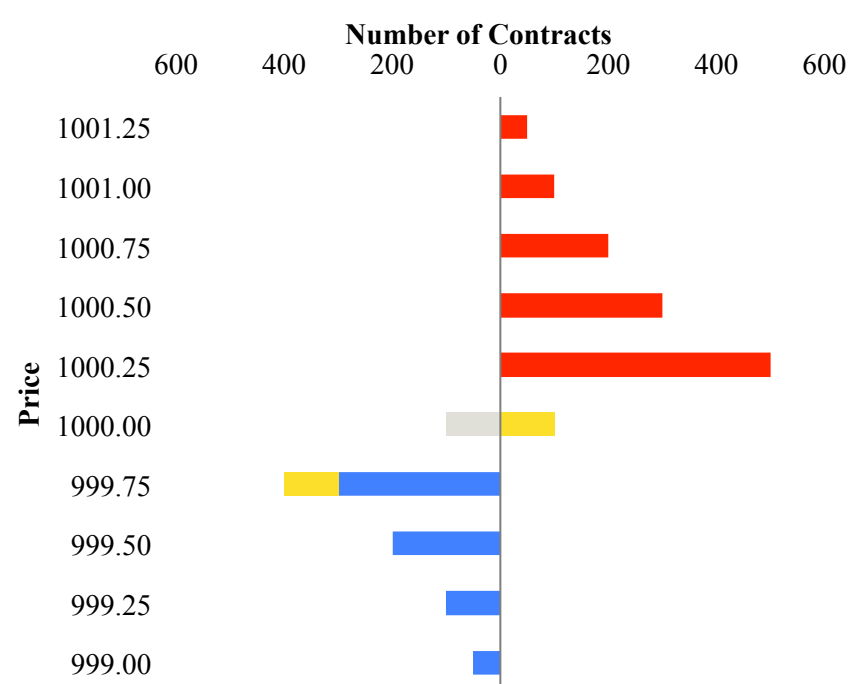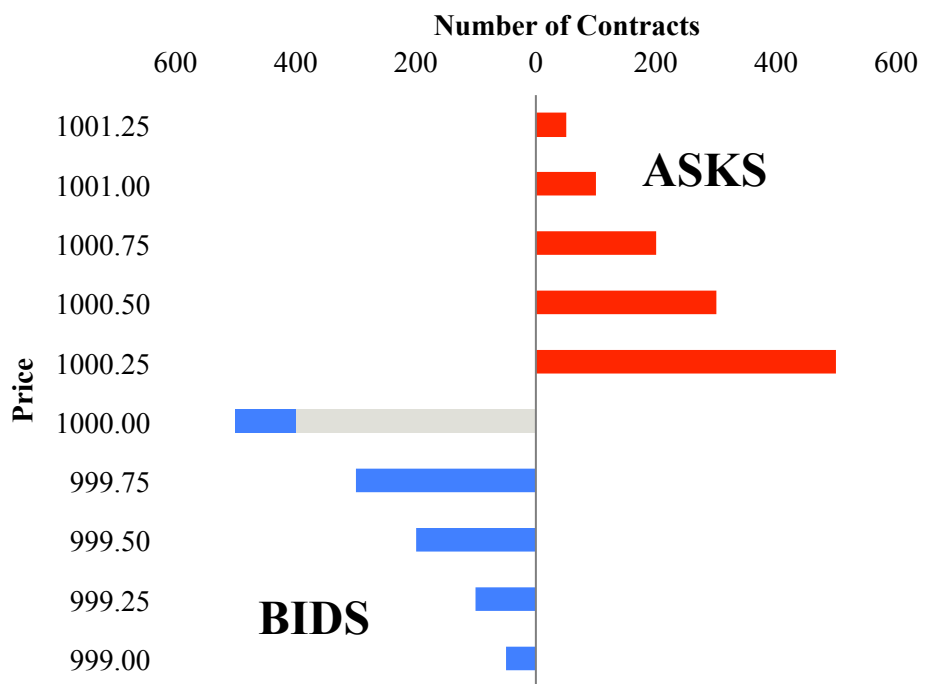Lack of Liquidity in Individual Equities – systems reset to reflect higher risk

Broken Trades in Equities – retail stop loss orders executed against stub quotes

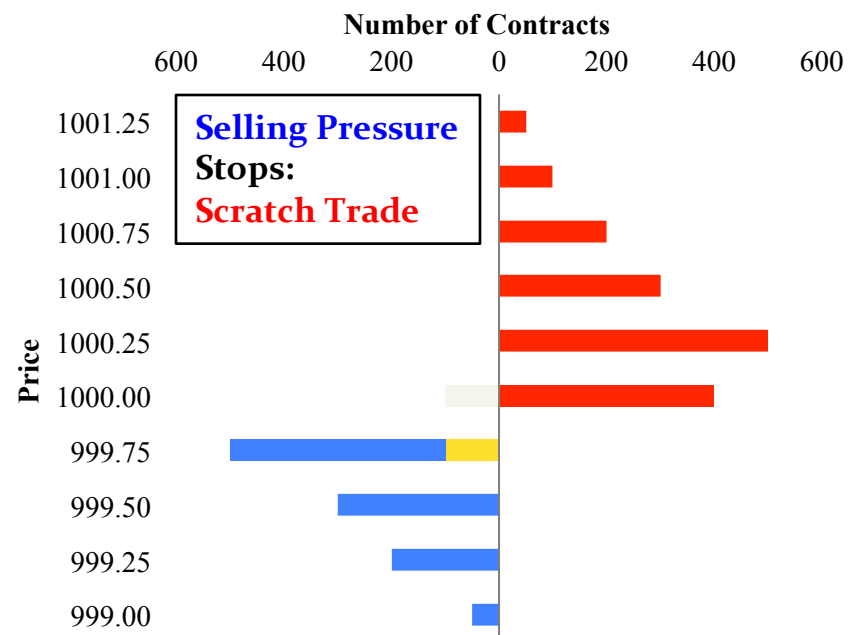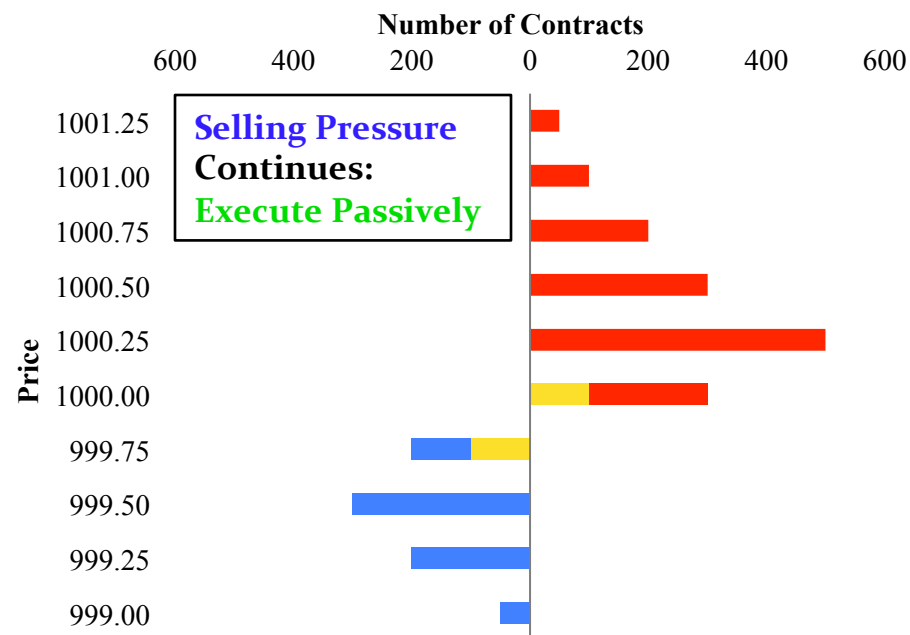Source: CFTC-SEC Report on the Events of May 6, 2010

HFTs and Market Dislocations: The Flash Crash

- On May 6, 2010, HFTs traded the same way as they did on May 3-5: Small inventory, high trading volume, take more liquidity than provide.

- High Frequency Traders did not cause the Flash Crash.

- A large, but short lived imbalance between Fundamental Sellers and Fundamental Buyers appeared.

- Opportunistic Traders held it, but for a massive price concession.

Source: CFTC-SEC Report on the Events of May 6, 2010

ASKS

BIDS

"...paying for something we do not want."

Selling Pressure Continues: Execute Passively

Selling Pressure Stops: Scratch Trade

HFTs under regular market conditions

(1) Are HFTs profitable?

(2) Do HFTs provide liquidity?

(3) Do HFTs bear commensurate risk?

"The narrowing of spreads that the HFT apologists claim to provide for the rest of us redounds to their bank accounts, not ours."
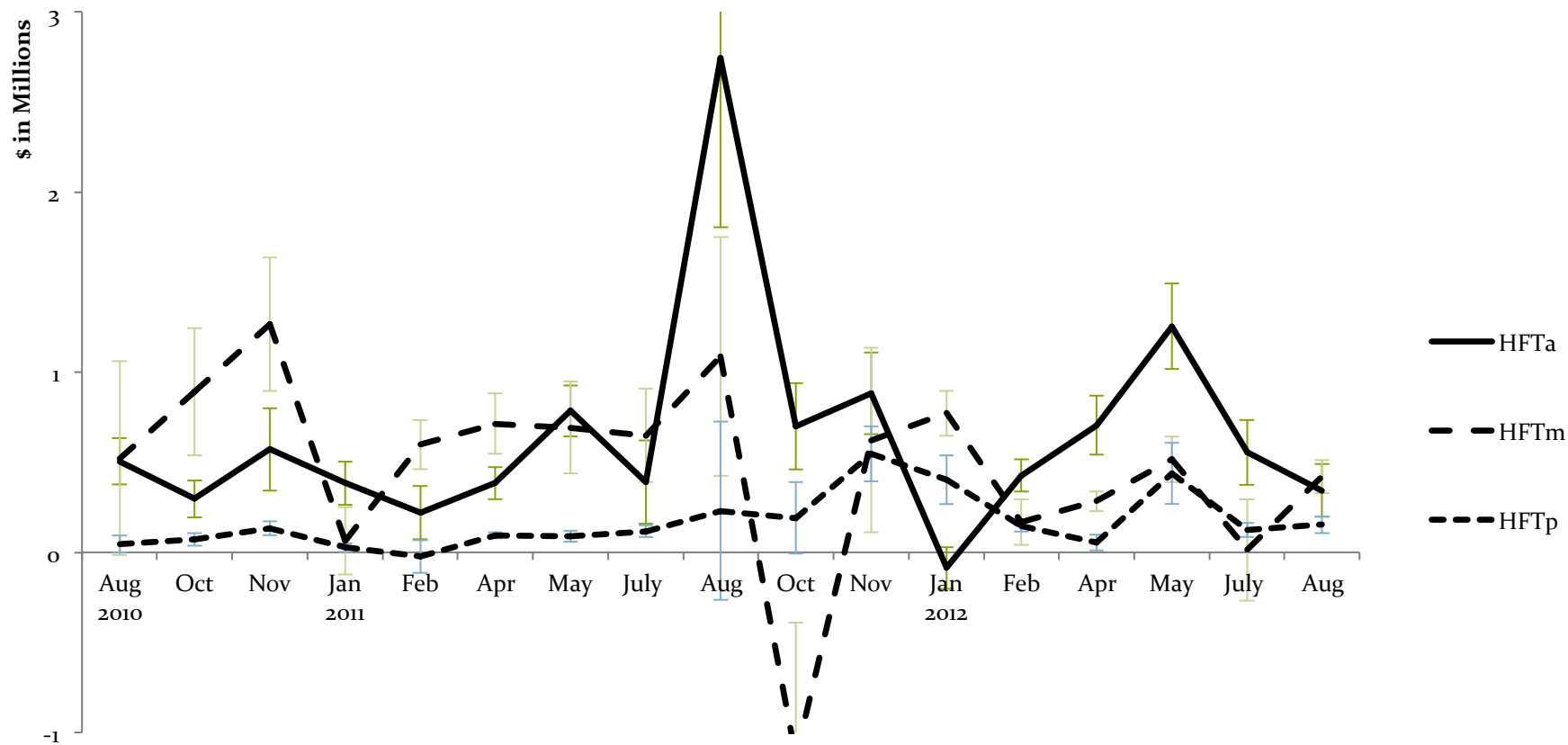
Classifying HFTs

HFTs:
a. high volume
b. low inventory
c. end the day with near zero positions

Not all HFTs are the same:
a. Aggressive – HFT + mostly take liquidity
b. Mixed – HFT + both take and provide liquidity
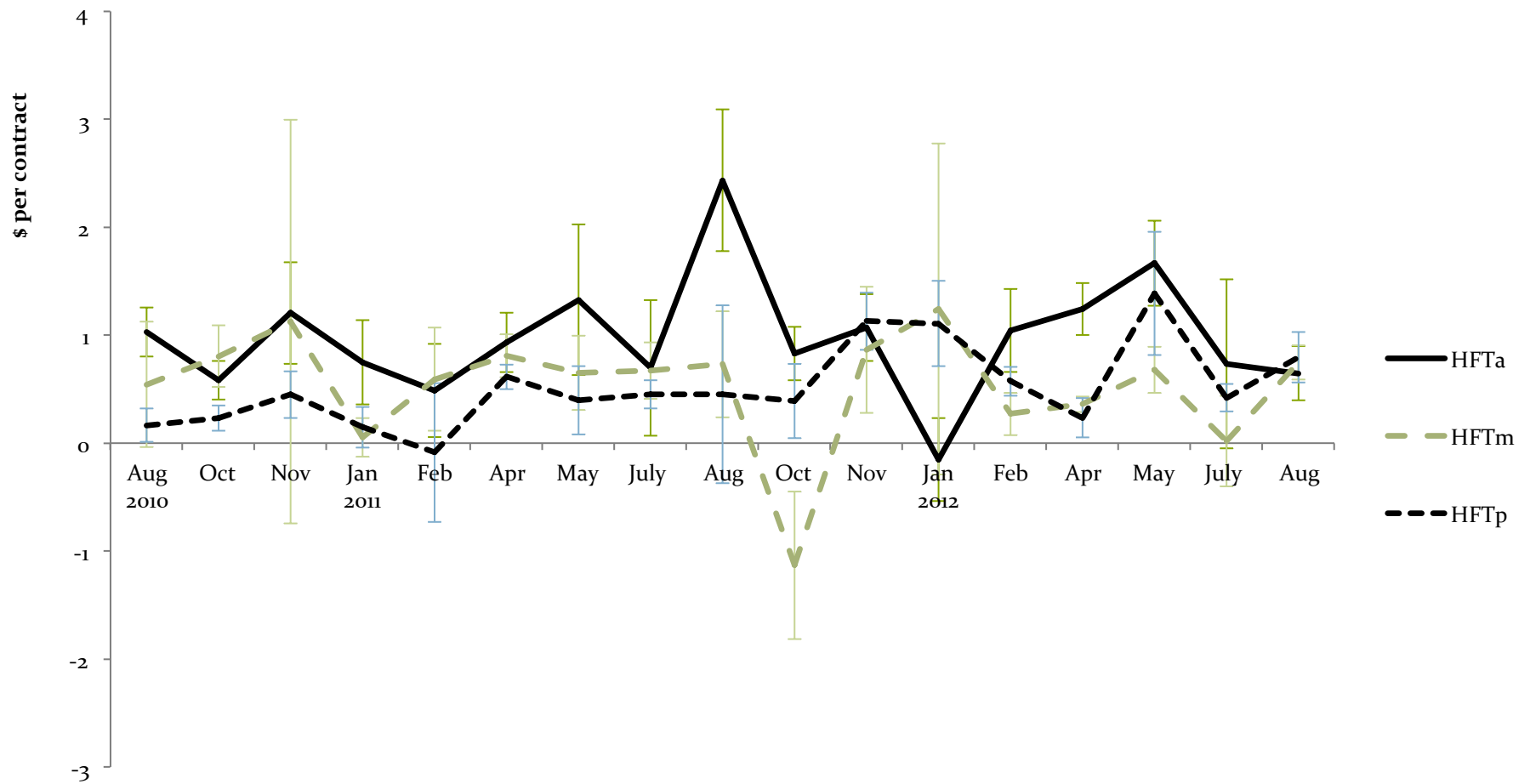c. Passive – HFT + provide liquidity

HFT Profitability
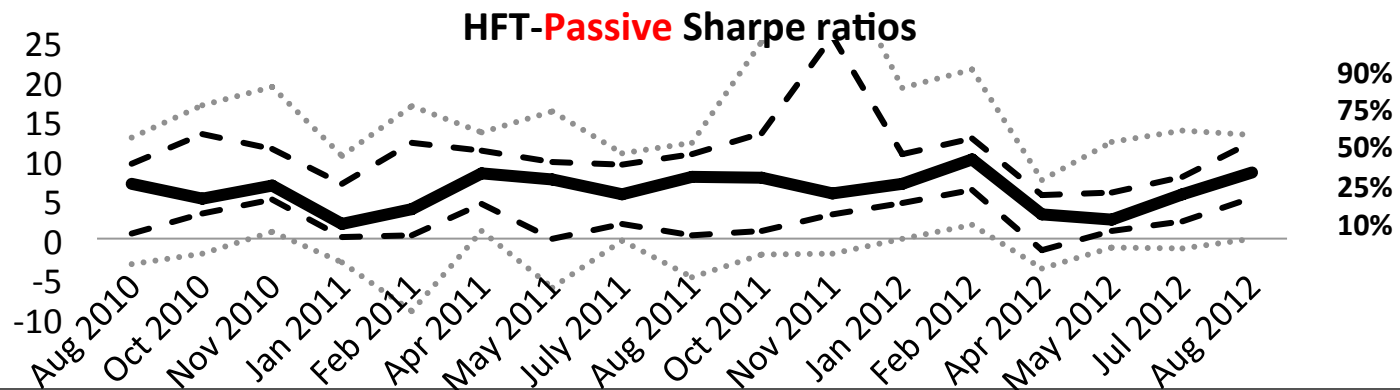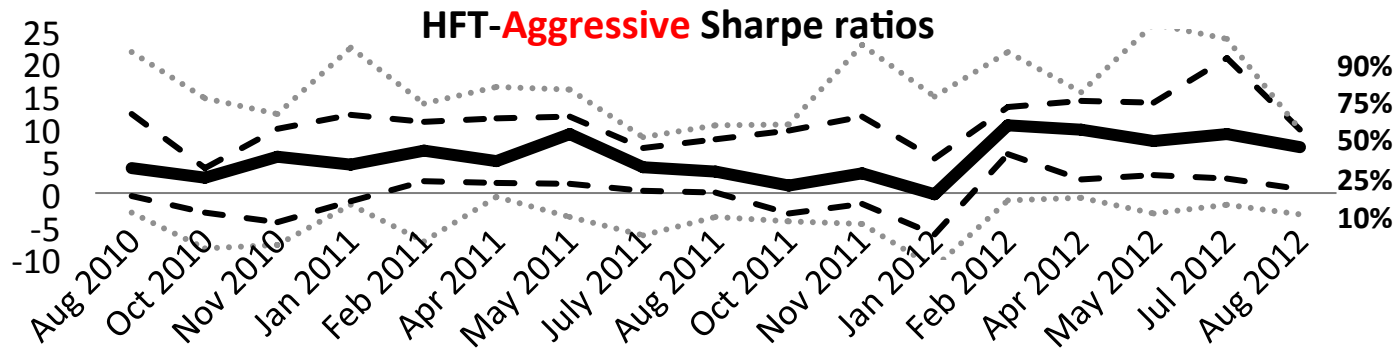

Average Daily HFT profits

HFT Profitability

Average daily HFT profits per contract

Sharpe ratios

$$\text{Sharpe Ratio} \quad = \quad \frac{E[r_i] - r_f}{SD[r_i]} * \sqrt{252} \quad \approx \quad \frac{E[\pi_i]}{SD[\pi_i]} * \sqrt{252}$$
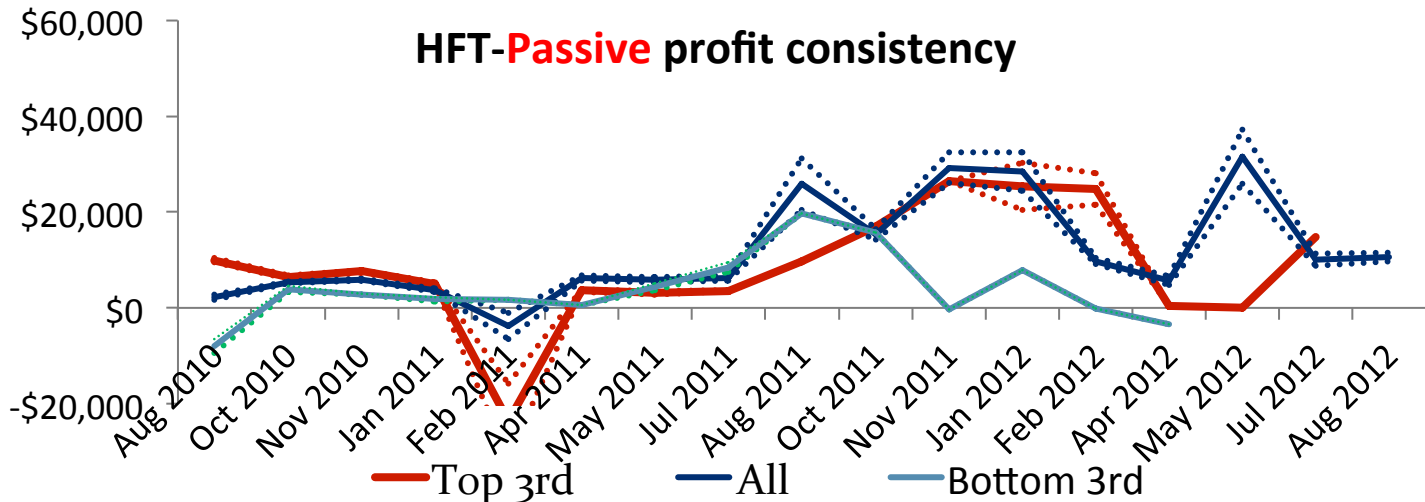
[Assuming constant capitalization over time and $r_f = 0$]

HFT-Aggressive Sharpe ratios

HFT-Passive Sharpe ratios

Profit consistency

Providing or Taking Liquidity?
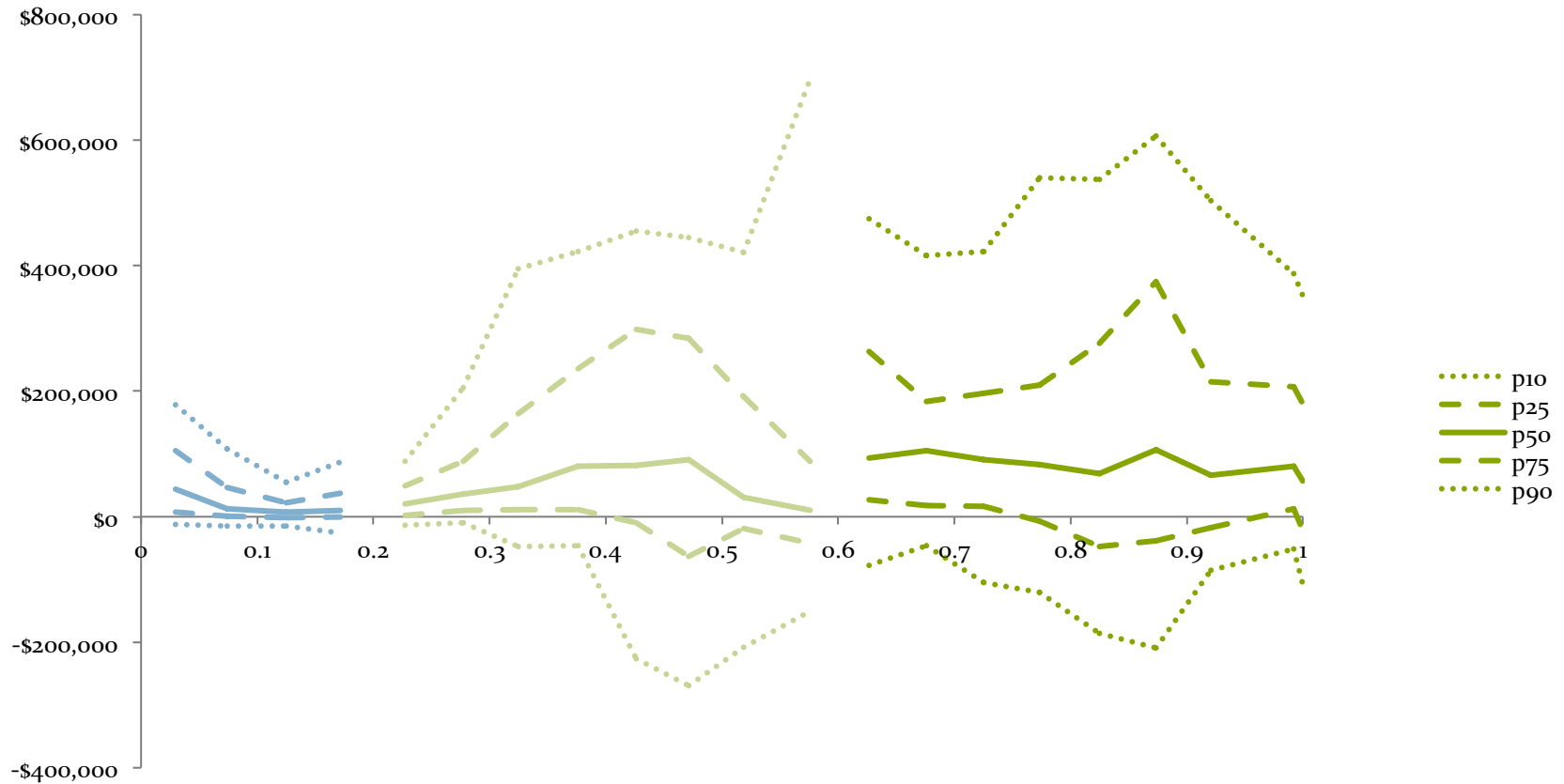
HFTs under regular market conditions

(1)   HFT Profitability:
- High profitability, very persistent.
- Very high Sharpe ratios and very low inventory.
- Large variations in profitability across firms.

(2)   Sources of HFT Profits:
- Over short time horizons.
- Aggressive HFTs make money on momentum.
- Mixed and Passive HFTs make money on the bid-ask spread.

(3)   HFT Liquidity Provision:
- Large heterogeneity in liquidity provision.
- Most profitable HFTs are liquidity takers.

Concentration of the HFT industry

Over a two-year period, the HFT industry remained dominated by a small number of fast and aggressive incumbents.

These incumbents earned high and persistent returns while taking little risk.

For some reason, competitive market forces did not seem to fully work and benefits of automated markets may not have been fully realized.

Instead of competing to provide best execution to customers, incumbent HFTs seemed to be engaged in a winner-takes-all arms race for small reductions in latency.

HFTs at times of market stress

1. HFTs trade the same as under regular market conditions.
2. HFTs "hot potato trading" leads to a spike in trading volume.
3. HFTs exacerbate volatility by aggressively unwinding inventory.

HFTs under regular market conditions

1. HFTs earn large, persistent profits, take little risk.
2. HFT profits increase in aggressiveness.
3. HFT industry is highly concentrated. Market forces not at work.

Charlie Munger: "I think the long term investor is not too much affected by things like the flash crash. That said, I think it is very stupid to allow a system to evolve where half of the trading is a bunch of short term people trying to get information one millionth of a nanosecond ahead of somebody else."

Latency

"...people trying to get information one millionth of a nanosecond ahead of somebody else."

Latency is the delay between the occurrence of an event and its manifestation or recording.

A standard way to measure latency is by determining the time it takes a given data packet to travel from source to destination and back, the so-called *round-trip time* or RTT.

The data packet we will use is the so-called message.

A message is a standardized packet of data that enables a trader and a trading venue to communicate with each other.

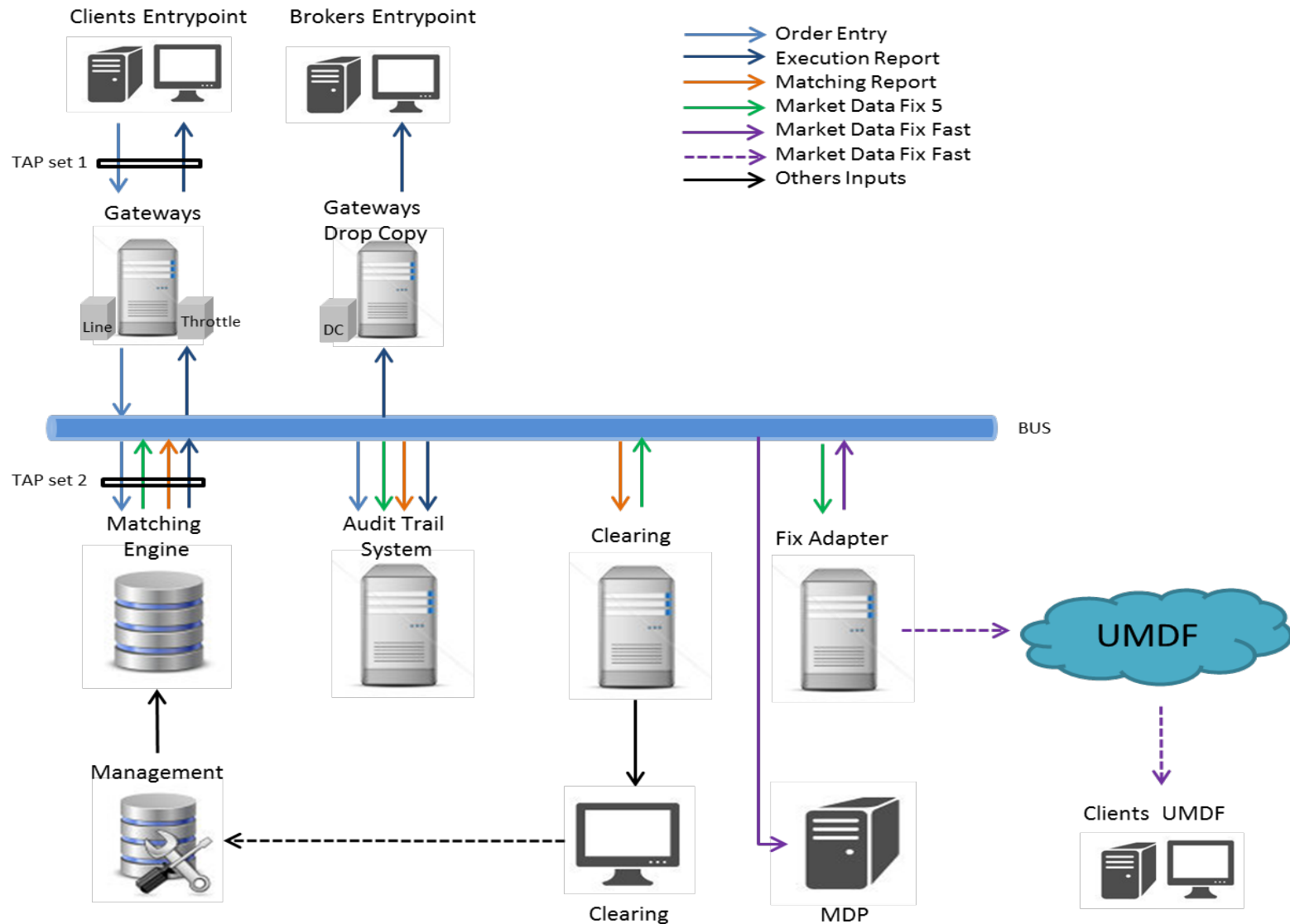# Latency of Automated Trading System

Three different types of latency.

Communication latency is the time it takes for a message to travel <u>between</u> an individual trader's computer and an automated trading venue.
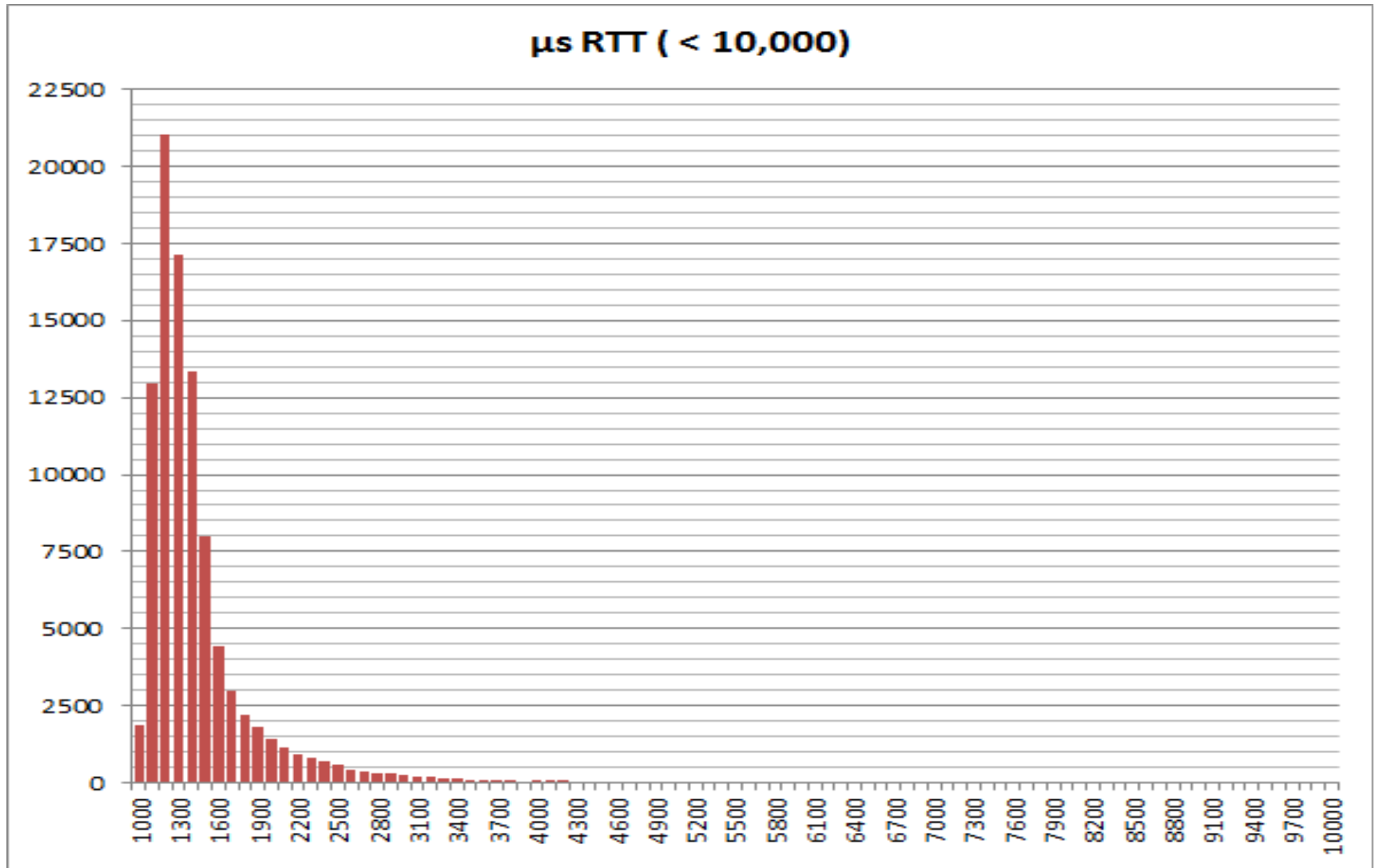
Market feed latency is the time it takes for an automated trading venue to disseminate market data <u>out</u> to all market participants.

Trading system latency is the time it takes for a message to travel <u>within</u> an automated trading venue from the initial entry to the eventual confirmation going back to the trader.
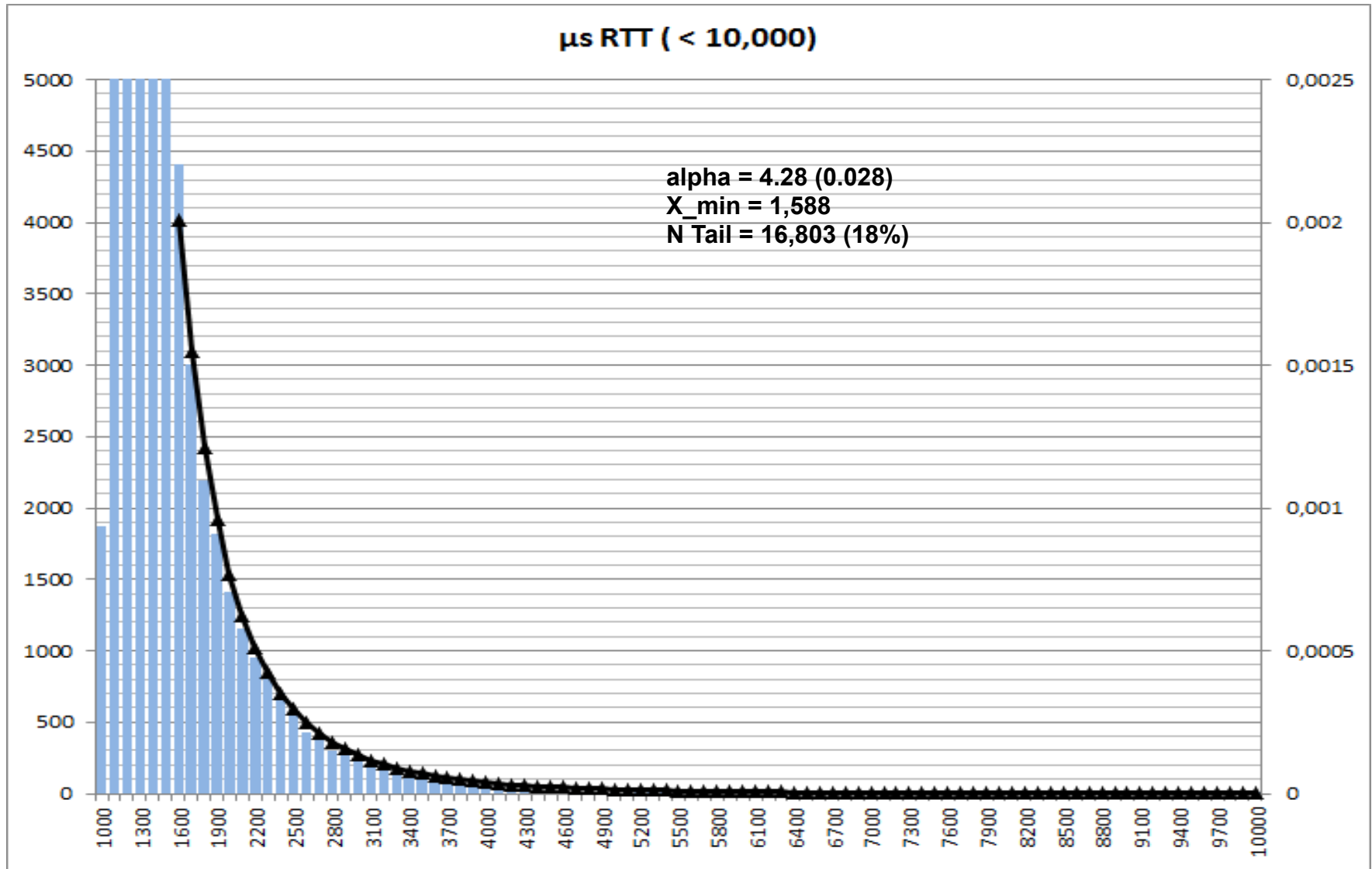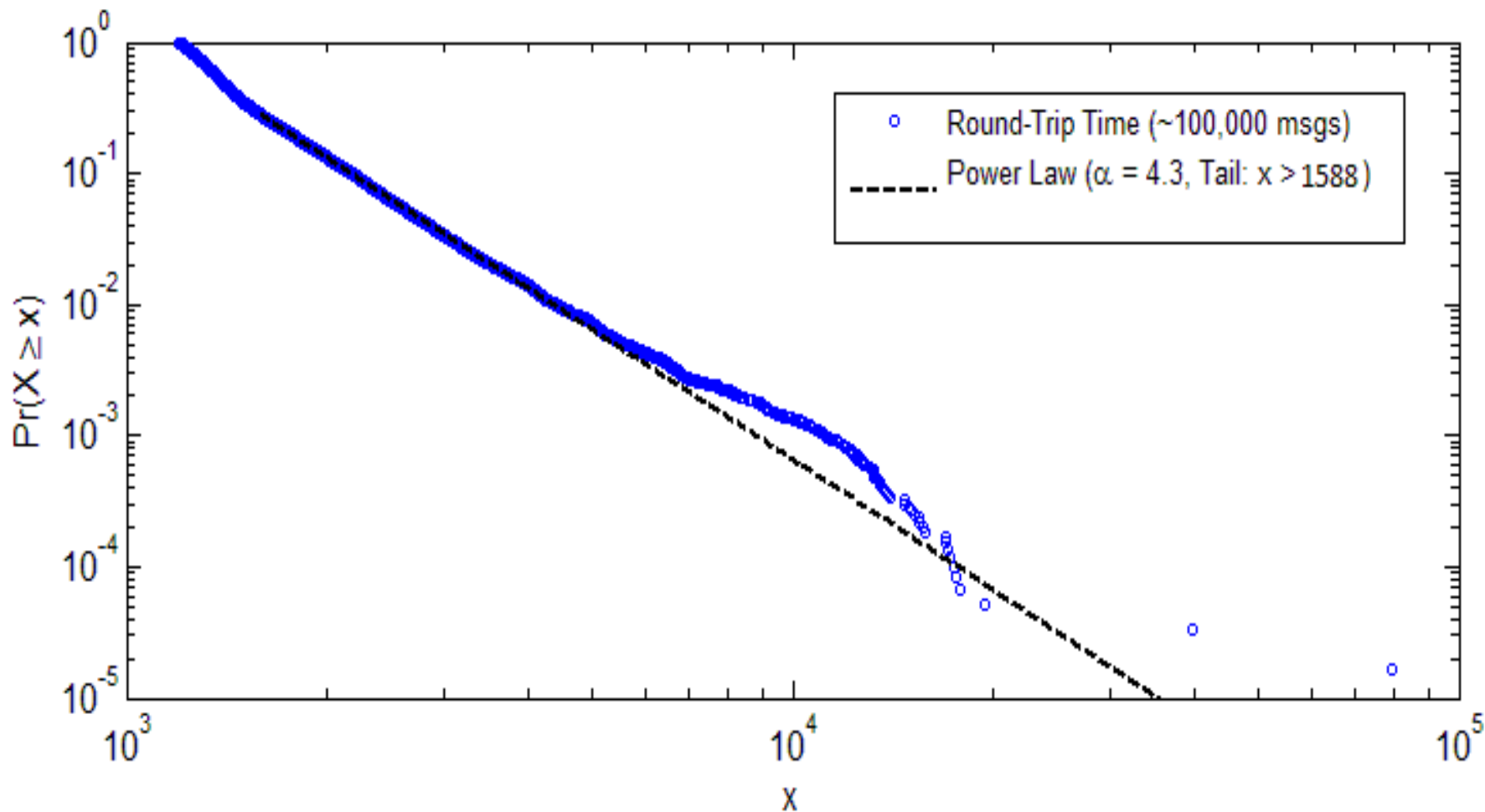
Measuring Trading System Latency

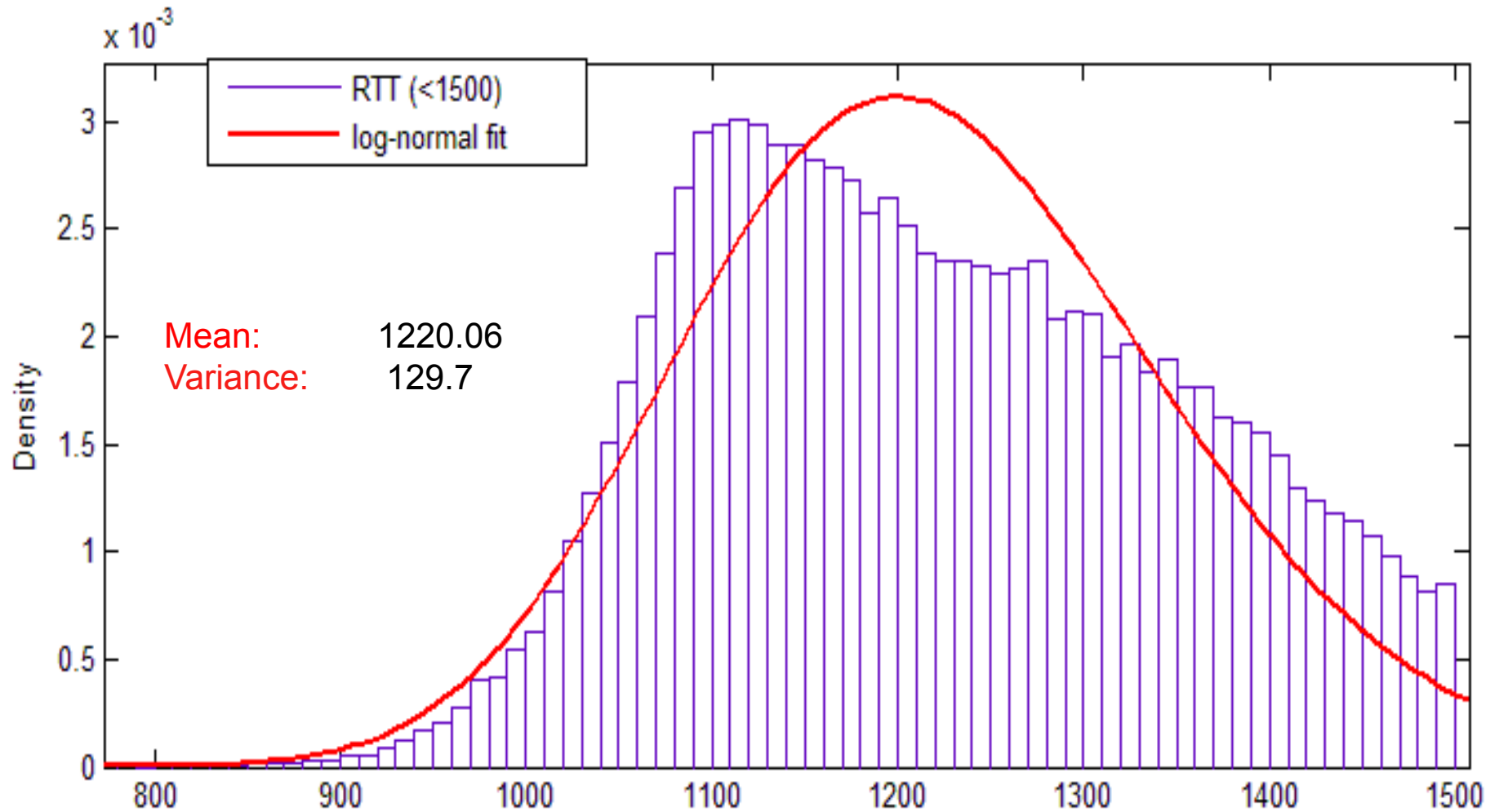# Trading System Latency: It's Random Variable!

Stochastic Latency: Power Law

μs RTT (< 10,000)

alpha = 4.28 (0.028)
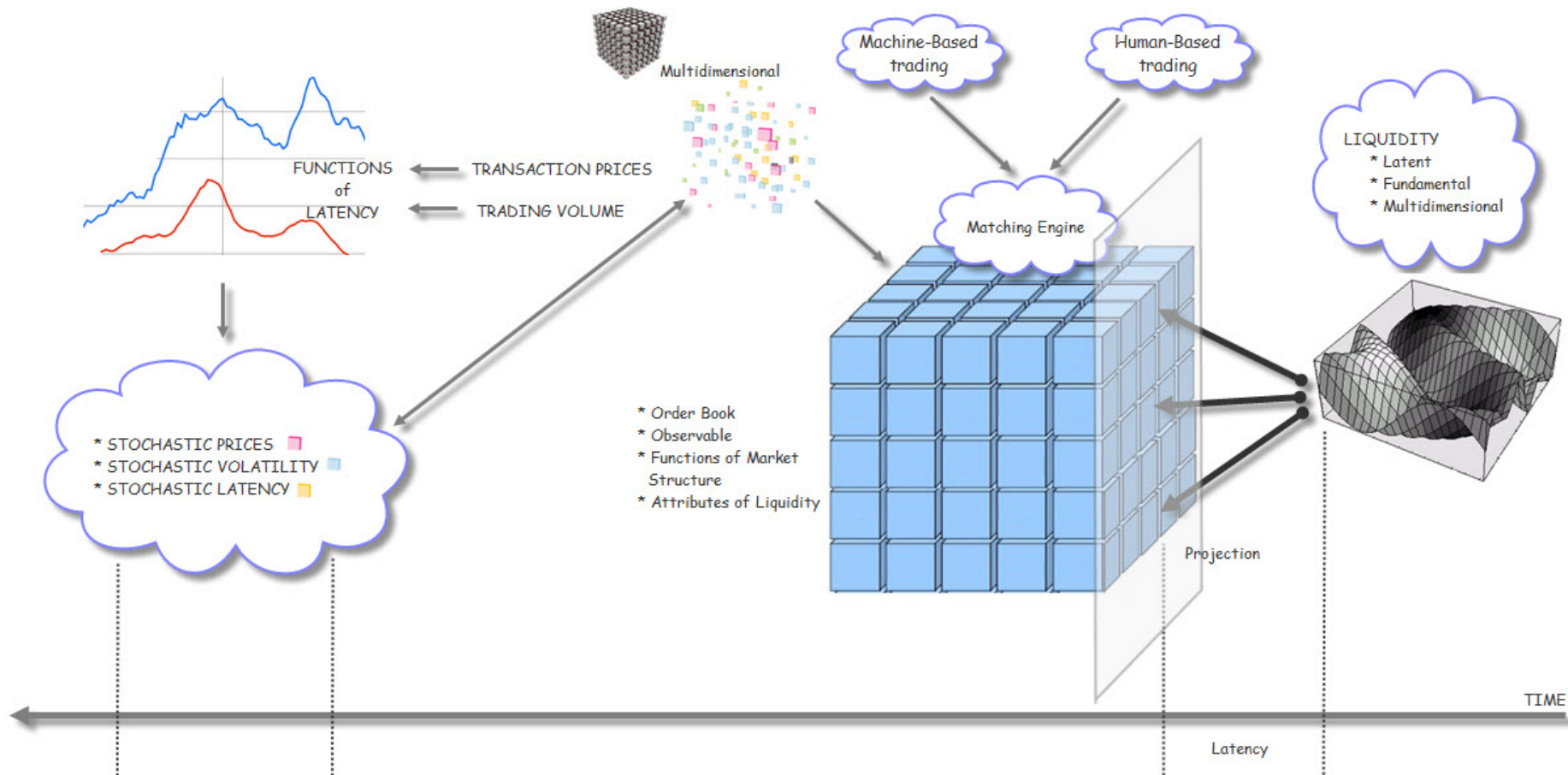X_min = 1,588
N Tail = 16,803 (18%)

Stochastic Latency: Power Law

Stochastic Latency: Lognormal

Stochastic Latency: A Risk Factor in Automated Markets

Suppose that there is a true price process with constant or stochastic volatility.

Suppose also that the true price process is observed with a stochastic delay (latency).

Stochastic latency (i.e., it's a random variable) increases the volatility of volatility.

Regulating latency?

Many regulators and policy makers decided to focus on latency measures:

to "slow things down", to put in "speed bumps", or to remove the "speed advantage" of HFTs.

It's not so simple though.

High frequency and automated trading lies in the intersection of four highly specialized fields:

- ✓ Regulation,
- ✓ Finance,
- ✓ Technology, and
- ✓ Data processing.

Or regulating markets?

While testifying to the U.S. Senate on June 13, 2014, I proposed:

On regulation: regulators need to create a broad definition of "automated brokers and traders" – similar to what used be called "floor brokers and traders" in human-based markets.

On finance: regulators need to closely examine whether competitive market forces are able to erode the high concentration of the HFT industry.

On technology: automated trading venues need to report latency measurements through the market feed.

On data: automated trading venues continue to broaden the use of short trading pauses and re-opening auctions.