Lecture 10

Market MicroStructure and Trading

Matthew Rothman

MIT Sloan School of Management

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Outline

- Overview of Market Microstructure: Why Should You Care?

- Spreads: What Are They And Why Do They Exist?

- What Do Markets Look Like Today

- How Did We Get Here? Scandals, Technology, Regulation & Their Interaction

- Low Latency: I Feel the Need for Speed

- Empirical Evidence of the Impact of High Frequency Trading

- Considerations If You Are An Asset Manager

- Summary

- Appendix: Types of Markets and Their Structures

- Appendix: Empirical Proxies for Bid-Ask Spread

Overview of Market Microstructure

Short Definition:

"The study of the process and outcomes of exchanging assets under explicit trading rules. While much of economics abstracts from the mechanics of trading, microstructure literature analyzes how specific trading mechanisms affect the price formation process."

-- Maureen O'Hara

Why Study Market Microstructure?

If you believe that prices might not always fully incorporate all available information – ***or that the actual nature of institutions, constraints and structure of those institutions, government regulations (or lack thereof), and the behavioral biases of individuals might keep prices from fully reflecting all available information*** – then you should also be concerned that the very specific set of rules for how securities are traded and how exchanges are structured might also keep prices from fully revealing all available information.

One buys at the ask price and sells at the bid. The difference between them is called: the spread.

Why do spreads exist?

1. Price you pay for immediacy (vs submitting limit order)

2. Dealer profitability: set to maximize their profitability (goldilocks)

But what determines the spread's size?

1. Temporary Component: Transaction Cost Component.

   • Cost of doing business. Transitory. Reverses.

2. Adverse Selection: Information Revelation or Permanent Spread

What Are "Spreads", Why Do They Exist & What Determines Their Size?

Adverse Selection:

- Dealers do not know if they are dealing with an informed traders or an uninformed trader (liquidity trader)

- If dealers set their prices to only reflect their normal costs of business, their loss to informed traders would eventually force them out of business

- Dealers must widen the spread to cover their losses to well-informed traders. They must recoup from uninformed traders what they lose to informed traders.

- Wider spreads also limits losses to informed traders by making some information not valuable

- Dealers must set prices such that they fully reflect all available information: the probability of whether she was trading against an informed trader, what they expect to lose to the informed trader (how much they must recover from the uninformed trader) and whether the next trader is a buyer or a seller.

- If they fully incorporate all information efficiently, the resulting sequence of estimates should be a random walk.

What Are "Spreads", Why Do They Exist & What Determines Their Size?

In practice what are some of the empirical determinants of spreads:

- Amount of asymmetric information/traders: if you think there are a lot of informed traders you are going to set spreads wide. These wide spreads will drive uninformed traders away. So only really informed traders trade. Vicious circle.

- Volatility: Volatility makes holding inventory unattractive. Volatile instruments are harder to value. Volatility is also a good proxy for asymmetric (or maybe just lots of new) information.

- Utilitarian Trading Interest: When there are lots of utilitarian (non-informed) traders – think gamblers ("noise traders"), hedgers, long-term investors, liquidity traders, indexers – then spreads should be smaller.

Good empirical proxies for each of these variables can be found in the Appendix at the end of the presentation.

Review them because there may be an example or two of how these types of informed vs. uninformed traders impact liquidity and market efficiency on the exam. There are sample questions on this in the back……
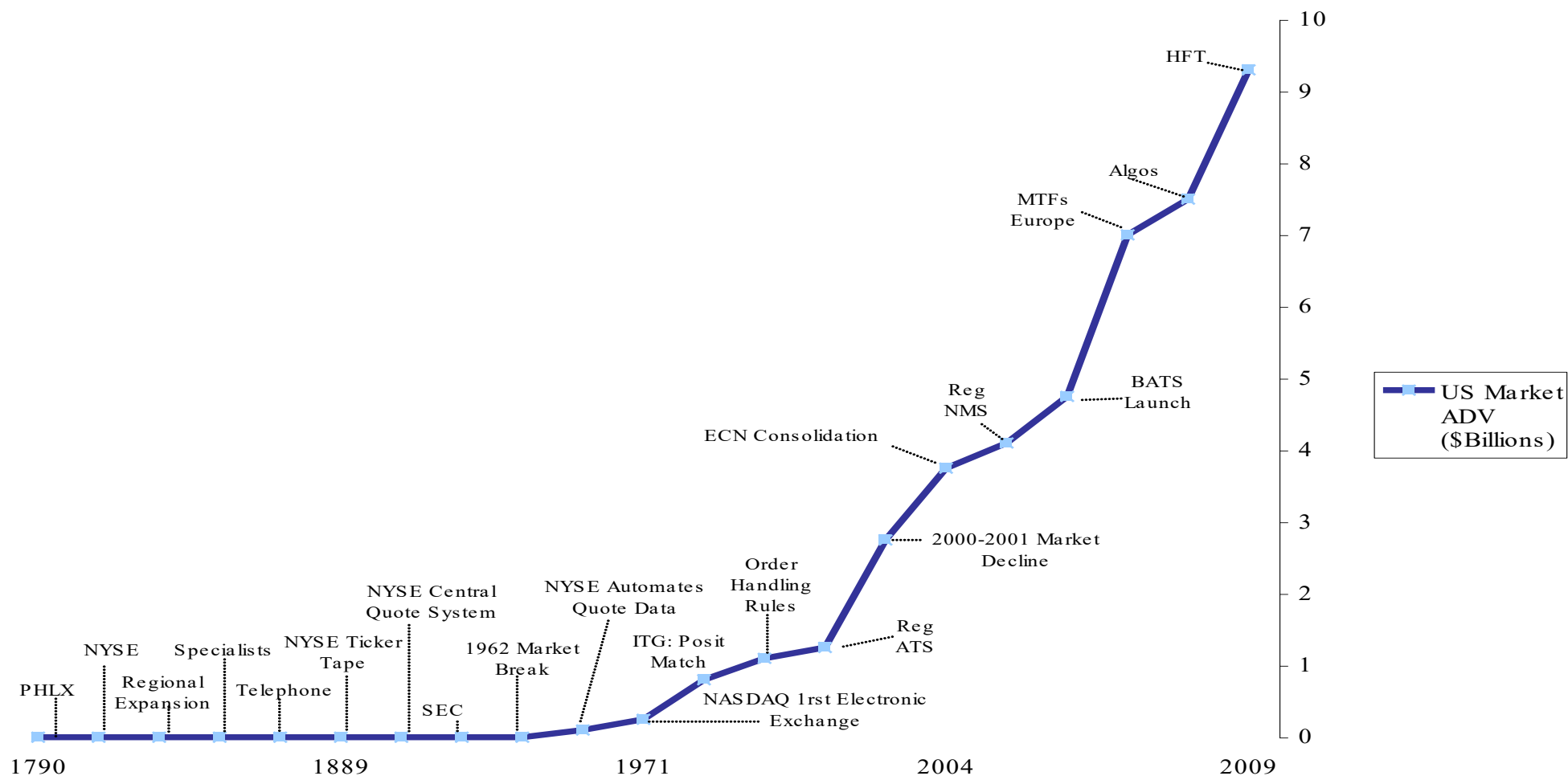
Question to ponder:

How much of the change in markets has been due to regulatory changes, technological changes, or some of interaction of both? What leads and what follows?
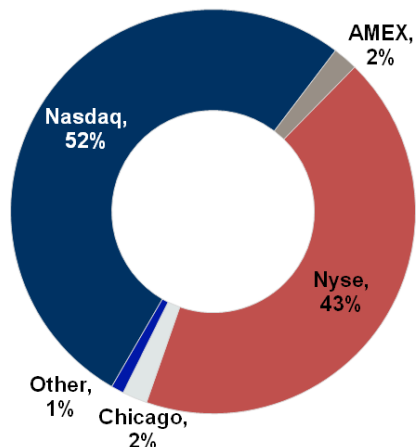
EVOLUTION OF US EQUITY TRADING:
Rate of Change

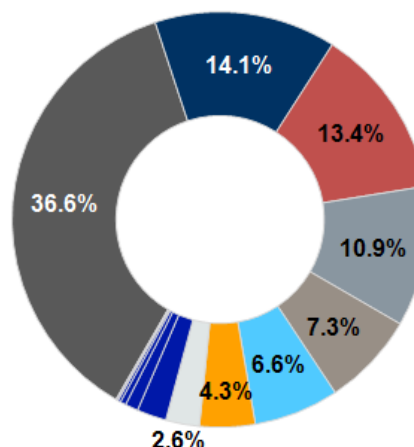Source: Deutsche Bank estimates and calculations

Markets Today: Highly Fragmented

1997 Market Share by Exchange

2016 YTD (through Q3) Market Share by Exchange

Exchange	Mkt Share	ADV (B Shrs)	Avg Trade Size
Off-Exchange	36.6%	2.73	342
Nasdaq	14.1%	1.05	146
NYSE	13.4%	1.00	306
NYSE Arca	10.9%	0.81	188
EDGX	7.3%	0.54	174
BATS-Z	6.6%	0.49	138
BATS-Y	4.3%	0.32	134
EDGA	2.6%	0.19	136
Nasdaq BX	2.3%	0.17	126
Nasdaq PSX	1.0%	0.08	164
CHX	0.4%	0.03	4,194
NYSE Mkt	0.2%	0.02	397
IEX	0.2%	0.01	181
NSX	0.01%	0.00	211
Total Market	100.0%	7.45	211

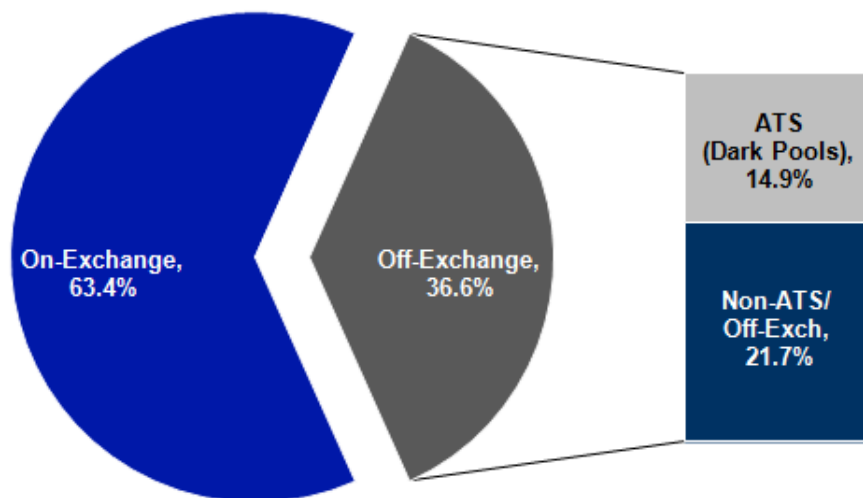Average Daily Share Volume & Average Daily Notional Volume: By Year

● Dark trading is even more fragmented than exchange trading

2016 YTD Market Share by Venue Type

On-Exchange, 63.4%
Off-Exchange, 36.6%
ATS (Dark Pools), 14.9%
Non-ATS/Off-Exch, 21.7%

What's included in "Non-ATS Off-Exchange" Volume?

• **Internalization:** Essentially "in house" liquidity pools at broker dealers.

• **Payment for order flow executions:** Dealers and market makers compete for retail trades through execution quality, and they may pay for the retail order flow as well. Many of these trades are executed internally at the brokers who purchase the orders – with only non-marketable or surplus orders being sent to external venues.

• **Single dealer platforms:** These systems allow clients to enter orders for execution against the bids and offers of a single dealer, and they are excluded from registering as an ATS with the SEC.

Some of this volume may not be "accessible liquidity" for institutional investors

Market Share & Average Trade Size by ATS 2016 Year-to-date (through 9/2/16) versus 2015 Full Year (market share as a % of total market volume)					
2016 Rank	ATS Name	2016 Volume (through 9/2)	2016 Market Share	2016 Avg Trade Size	Mkt Share +/- vs 2015
1	UBS ATS	28,574,062,475	2.25%	165	+
2	CS Crossfinder	20,789,957,366	1.64%	187	-
3	IEX	20,541,091,766	1.62%	214	+
4	DB SuperX	15,331,515,248	1.21%	201	-
5	MS Pool	13,292,335,105	1.05%	244	-
6	JPM-X	9,231,349,018	0.73%	232	+
7	BAML Instinct X	8,555,183,378	0.67%	215	-
8	Barc LX	8,500,367,666	0.67%	184	+
9	LeveL ATS	8,333,276,500	0.66%	176	+
10	GS SigmaX	7,512,307,666	0.59%	185	-
11	KCG Matchlt	6,436,141,287	0.51%	175	-
12	Instinet CBX	6,359,530,252	0.50%	226	+
13	BIDS	6,327,925,741	0.50%	677	-
14	ITG Posit	4,541,786,500	0.36%	289	-
15	Fidelity XStream	4,248,336,567	0.33%	455	+
16	MS Trajectory X	2,674,311,644	0.21%	178	+
17	ConvergEx Mill.	2,371,382,722	0.19%	324	+
18	Interactive Brks	2,276,292,901	0.18%	317	-
19	Liquidnet	2,011,510,370	0.16%	39,836	-
20	PDQ	1,939,080,693	0.15%	189	+
21	Citicross	1,714,134,282	0.13%	239	-
22	Dealerweb	1,616,300,030	0.13%	420,255	-
23	State St BlockX	1,403,255,803	0.11%	12,064	+
24	CS Lightpool	1,105,981,665	0.09%	177	-
25	Liquidnet H2O	900,392,000	0.07%	10,369	+
26	Instinet X'ing	660,473,499	0.05%	4,191	-
27	Bberg Tradebk	561,212,410	0.04%	266	-
28	US StockTrade	555,697,067	0.04%	777	+
29	Luminex	236,678,751	0.02%	29,959	+
30	MS Retail Pool	206,747,410	0.02%	236	+
31	Citi Liquifi	179,912,979	0.01%	17,611	-
32	Aqua	102,444,941	0.01%	10,972	-
33	RiverCross	36,543,750	0.00%	200	-
34	Weeden XE	26,586,778	0.00%	1,229	-
35	BAML ATS-1	26,479,300	0.00%	335	-
36	Barc DirectEx	1,583,910	0.00%	21,404	-
37	Pro Securities	102,200	0.00%	3,006	-
	Total ATSs	189,182,271,640	14.88%	215	-

2016 data represents ATS volumes through 9/2/2016, the most recent tier 1 & 2 FINRA ATS data currently available

Read Lindsey et al "The SEC's Order Handling Rules of 1997 and Beyond: *Perspective and Outcomes of the Landmark Regulation"*

Market intermediaries do not want to get out of the way. Exchanges, brokers, dealer, all intermediaries make their money by standing in between investors who are selling and those who are buying.

They provide value but is it worth its cost?

How Did We Get Here?

Markets have gone through periods of "fragmention" and "consolidation".

At the beginning of 19th century there were over 100 hundred stock markets in the U.S.! And then it consolidated. Why?

Technology allowed investors in far-flung cities to send almost instantaneously their orders that were hundreds or thousands of miles away. Technology allowed exchanges to compete in new ways and spurred consolidation.

But don't overlook regulatory impact:

- Manning Rule in 1994 (!) first time prevented market makers prohibited from executing ahead of customer limit orders.

- Christie and Schultz (1994) spurred mandated change with their seminal paper on market maker collusion and price fixing.

  - Led to the 1997 Order Handling Rules

Christie and Schultz, "Why do NASDAQ Market Makers Avoid Odd-Eighth Quotes", Journal of Finance, 1994

What did they find:?

"We examine the entire distribution of dollar spreads using an extensive sample of bid and ask quotes for the 100 most active NASDAQ Stocks in 1991.

We find that spreads of one-eighth are virtually non-existent for a majority of this sample. The lack of one-eighth spreads can be traced to an absence of either bid or ask quotes ending in odd-eighths (1/8, 3/8, 5/8, 7/8) for 70 of the 100 stocks.

In contrast, a sample of 100 NYSE and AMEX firms of similar price market value to our NASDAQ sample consistently use the full spectrum of eighths. This absence of odd-eighth quotes for the majority of NASDAQ sample implies a spread of at least $0.25.

We believe this surprising result reflects an implicit agreement of among market makers to avoid using odd-eighth quotes in quoting bid and ask prices and that a large number of market makers per stock is not necessarily synonymous with competition"
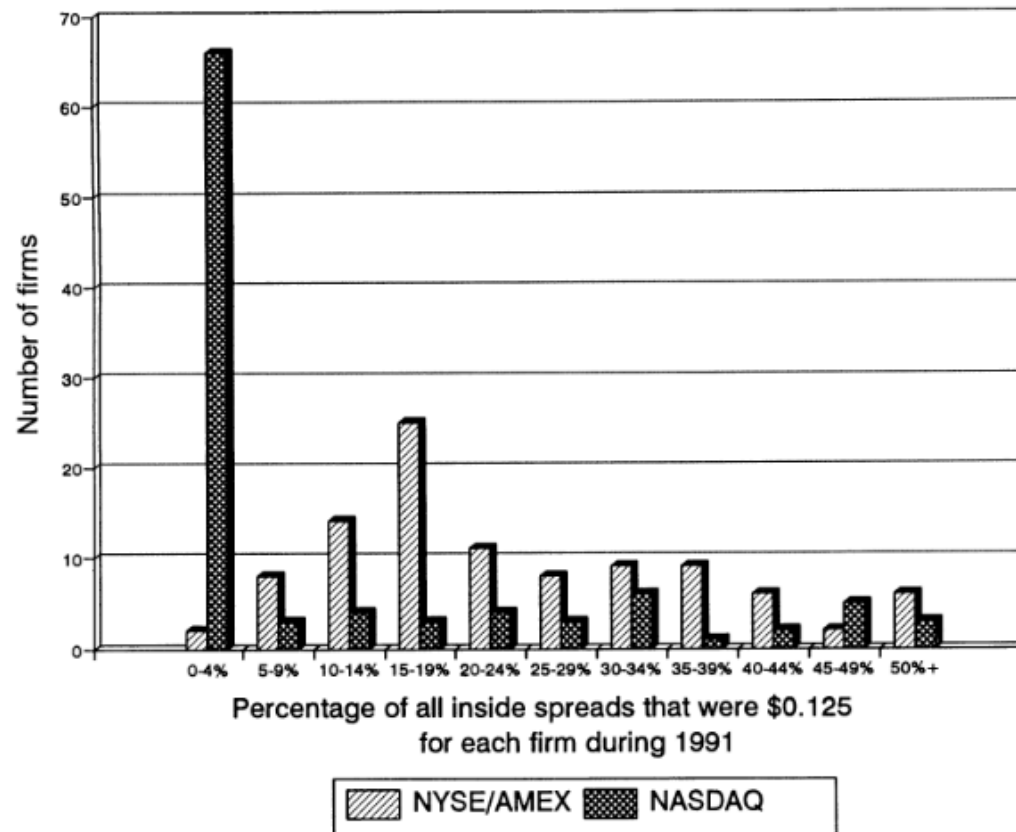
Scandal: Christie and Schultz 1994
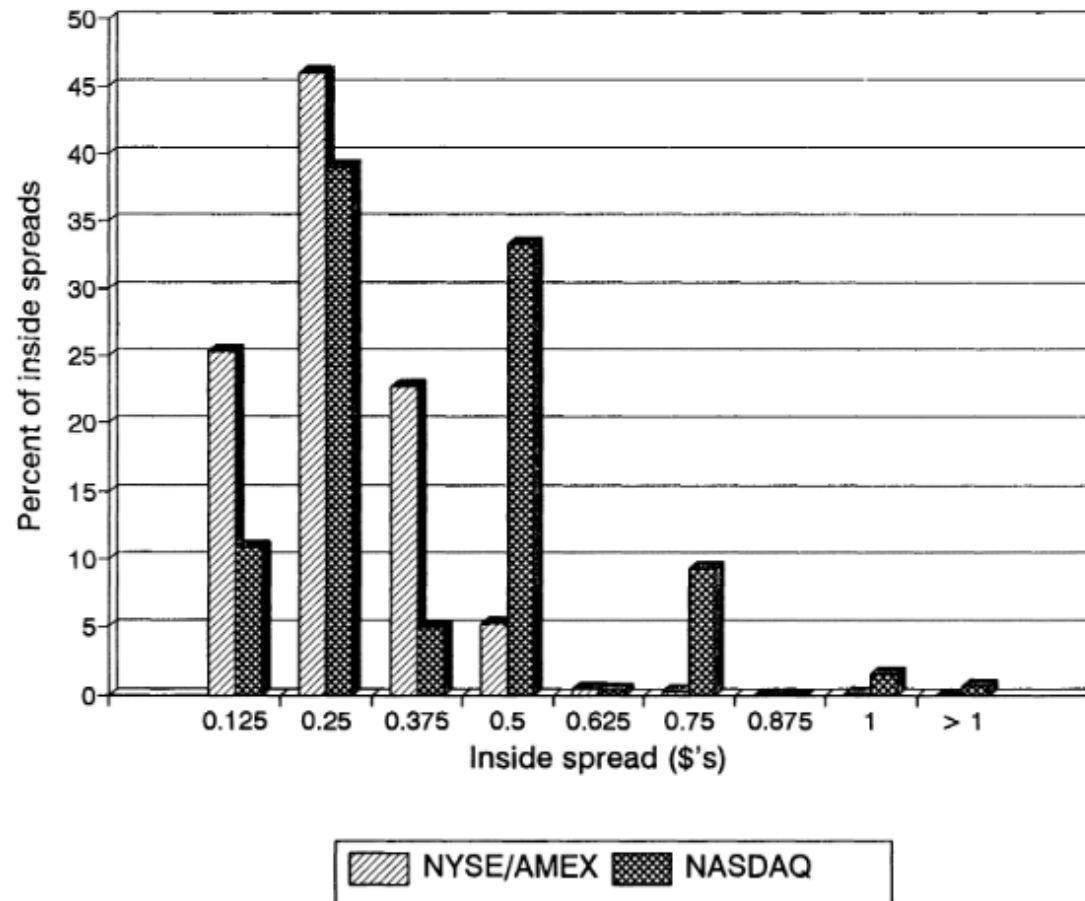
Figure 1. The distribution of inside spreads (in dollars) for 100 NASDAQ and 100 NYSE/AMEX securities of simialr price and end-of-year market capitalization. The distributions are computed using all inside quotes for all stocks in 1991. We exclude quotes where the inside bid and inside ask are unchanged from the previous inside quote within the same trading day. The horizontal axis shows the dollar inside spread. The vertical axis represents the percentage of all inside quote revisions that produce the specified spreads.

Figure 2. **The percentage of inside spreads that are $0.125 for 100 NASDAQ and 100 NYSE/AMEX securities of similar price and end-of-year market capitalization.** This figure contrasts the frequency of one-eighth spreads for stocks listed on the NYSE/AMEX versus stocks listed on NASDAQ in 1991. For each firm, we compute the percentage of quote revisions that produce a spread of $0.125 using all inside quotes. We exclude quotes where the inside bid and inside ask are unchanged from the previous inside quote within the same trading day. The height of the bar represents the number of firms whose frequency of one-eighth spreads corresponds to the percentages denoted on the horizontal axis. For example, for 66 of the 100 NASDAQ firms in our sample, fewer than 4 percent of all inside spreads are $0.125. In contrast, this small fraction of $0.125 spreads is shared by only 2 NYSE/AMEX stocks.

This led to a **real paradigm problem for many people** that they had a hard term grasping (and some people still do not do!).

- NYSE and AMEX specialists were awarded an exclusive franchise to act as dealer and auctioneer in each stock. In return, specialists are closely regulated and bound by an affirmative duty to maintain a "fair and orderly market."

  - They do face competition from order flow traders and from the limit order prices. Limit order prices are part of the spread displayed to the market and take precedence over specialist trades for their own account.

- NASDAQ traders do not have exclusive franchise and *not closely regulated*. Must only place firm quotes on both sides of the spread of at least 1000 shares.

- The fundamental premise of NASDAQ is that there will be *competition for order flow* among dealers and will lead to narrower spreads.

  - NASDAQ limit orders are not exposed to the public and executed if and only if the spread reaches the limit price. Thus public cannot use limit orders to compete with NASDAQ market makers and quotes don't reflect limit orders.

> *Dealers compete with each other, and have been reluctant to accept additional competition from the public order flow. The NASD depends on this interdealer competition to keep markets fair, orderly and liquid. ... Competing dealers face fewer regulatory restrictions than NYSE specialists because the NASD relies more on the constraints of a competitive environment to discipline dealer firms.*

Schwartz (1991)

> We are unable to envision any scenario in which 40 to 60 dealers who are competing for order flow would simultaneously and consistently avoid using odd-eighth quotes without an implicit agreement to post quotes only on the even price fractions. However, our data do not provide direct evidence of tacit collusion among NASDAQ market makers.

Schultz and Christie (1994)

What happened? After publication of the paper, literally almost overnight, prices started getting quoted in odd-eighths.

1997 Order Handling Rules:

Broke the convention of how NASDAQ (an OTC market) were handled. Spreads that were for years inexplicably larger than NYSE spreads, suddenly collapsed and became very close to the NYSE spreads. And NYSE spreads (and other obligated exchanges) also saw their spreads narrow too.

Also at this time this led to Reg ATS and the concepts of ECNs. Note these were regulatory driven changes that were designed to heighten competition among trading venues

Now at this time, NYSE and other markets started to move to decimalization. Note the U.S. was the only exchanges in the world where prices were not quoted in decimals.

Why? **Not** because of a regulatory change demanding. Yes, that is right.

What did happen?

How Did We Get Here?

In 1997, NYSE started to pressure member firms that were routing orders to OTC dealers for pricing that were making markets in NYSE securities. Why were members doing this? Because the OTC dealers were paying them for order flow! Legal but the NYSE didn't like this (and this should sound familiar).

NYSE (acting in guise of a regulator) said this can't be best execution!

A market market called the SEC and told them: Tell the NYSE to back off or I will go from quoting in eighths to sixteenths.

SEC said: Go tell NYSE yourself!

He did but the NYSE didn't back off.

Market maker called the SEC back and said: NYSE isn't backing off so I'm going to quote in sixteenths.

SEC: Go for it!

So convention of quoting in eighths that had held for over 200 years was broken and we had sixteenths.

Who was that market maker?

Bernie Madoff. Yes, that Bernie Madoff!

The Street went crazy! This is killing our spreads. But within weeks everyone was quoting in sixteenths.

And soon we went to decimals, which the SEC formally approved for implementation in 2001.

So how did we got there? How much of it was regulation, capitalism, technology and some cronyism?

The advent of ECNs and ATSs was due to:

1. A conscious choice by the SEC to allow and spur greater competition among exchanges into the market. It did not specify what that competition should exactly look like but wanted more competition.

2. The fact that traditional exchanges were not fulfilling investors needs with respect to the full range of order types available to investors, pricing, and methods (technology) to execute orders.

3. Technology evolving to the point to make these automated market possible.

This led to a massive fragmentation of order flow and the growth of multiple trading venues for investors.

This also led to the 2005 approval and 2007 implementation of Reg NMS.

What is Reg NMS?

The most significant part of Reg NMS passed by the SEC in 2005 is the Order Protection Rule (also known as the "Trade Through Rule"):

- Requires that each investor receive an execution price that is equivalent to what is being quoted on any other exchange where the security is being traded.

- Idea was to make financial markets more liquid and transparent.

- Previously, the rules did not protect investors across all exchanges at all times, especially on limit orders, so investors would get worse prices than those being quoted on another exchange.

- Rule aims to get all market participants the best possible execution price for orders that can be executed immediately.

Reg NMS was (is) highly controversial because it does not properly recognize the diversity and differential needs of traders:

1. Some traders may bypass better quotes on the NYSE for speedier trades on an automated system.

2. Trade-through-rule prohibits institutional investors from accessing large amounts of liquidity at prices slightly lower then the "inside" quote . It mandates price but completely ignores depth.

Some **claim** that it is Reg NMS that led to the advent of HFT along with a generally decreased market depth and increased market spreads.

They argue that as institutional investors were forced to break up their orders into smaller pieces (as they could no longer by-pass quotes with small depth but worse quotes but more depth), this allowed HFT firms to flourish:

– They used sophisticated programs to "sniff out" order flow of larger players and trade off of that order flow for lot of small gains, albeit pushing the prices up

The New York Times July 23, 2009

"Stock Traders Find Speed Pays, in Milliseconds"

Powerful computers, some housed right next to the machines that drive marketplaces like the New York Stock Exchange, enable high-frequency traders to transmit millions of orders at lightning speed.

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…

"It's become a technological arms race, and what separates winners and losers is how fast they can move," said Joseph M. Mecane of NYSE Euronext, which operates the New York Stock Exchange.

Definition of Latency:

Delay between a trading decision and its implementation

- Latency over time
  - 2 minutes (NYSE pre- 1980)
  - 20 second (NYSE 1980)
  - 100s of milliseconds (NYSE 2007)
  - 1 millisecond (NYSE Arca 2009) "low latency"
  - 10 – 100 microseconds (current state of the art) "ultra-low latency"
  - Nanoseconds are possible (co-located severs using naked DMA)

  Note: for perspective an actual physical blink of an eye is on average 250-400 millisecond

- **Driven by technological innovation and competition between exchanges**

- Why is low-latency trading important for market participants?
  - Contemporaneous decision making
  - Competitive advantage/disadvantage. Who?
  - Time priority rules in microstructure

Market Making / High Frequency Trading

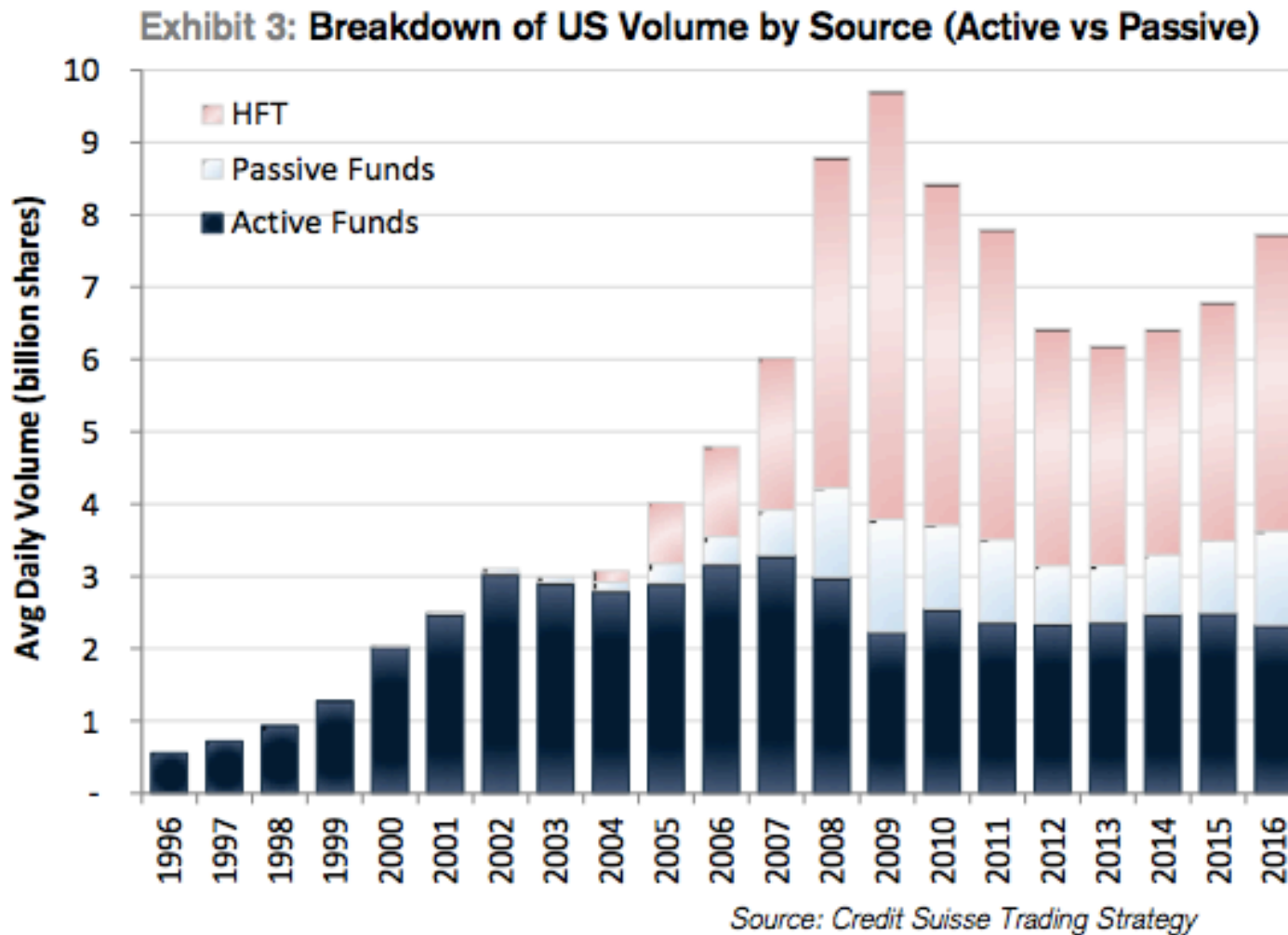| HFT Strategy	Description
Passive Market Making	Submit passive resting orders that provide liquidity at specified prices
Arbitrage	Capture pricing inefficiencies between related products or markets. E.g., Trading ETF and underlying basket of stocks
	Exploit structural vulnerabilities in the market or certain market participants
Directional	Short-term strategies that involve a proprietary firm taking a significant, unhedged position based on anticipation of intra-day price movement
Momentum Ignition	Initiate a series of orders and trades in an attempt to ignite a rapid price move either up or down
Order Anticipatory	Seek to ascertain the existence of a large order to trade ahead of and capture a price movement
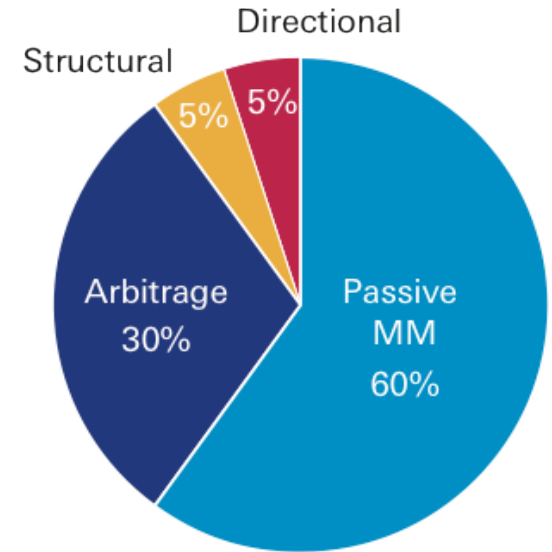
Note "Directional" strategies may be particularly challenging for the longer term investor and may border on market manipulation (see SEC Release: https://www.sec.gov/marketstructure/research/hft_lit_review_march_2014.pdf)

They have increased volumes in the market significantly (3 – 4 billion shares per day)

Exhibit 3: Breakdown of US Volume by Source (Active vs Passive)

Source: Credit Suisse Trading Strategy

Market Making / High Frequency Trading

US Share Volume by Market Participants

Overall HFT Volume ←

Largest decliner is Independent Prop HFT category

Largest increase was in Hedge Fund category

* TABB Group, Nov 2016

Legend: Retail · Long Only · Hedge Fund · HFT Hedge · Bank Flow/Specialists · Ind Prop · Market Makers · ● HFT

Year	Retail	Long Only	Hedge Fund	HFT Hedge	Bank Flow/Specialists	Ind Prop	Market Makers	HFT
2010	12.5%	11.5%	13.0%	7.0%	7.0%	17.7%	31.3%	56.0%
2011	13.5%	12.0%	14.0%	9.0%	5.5%	14.5%	31.5%	55.0%
2012	14.5%	12.5%	15.5%	7.5%	6.5%	12.5%	31.0%	51.0%
2013	14.0%	12.5%	17.0%	8.0%	7.5%	11.0%	30.0%	49.0%
2014	14.5%	12.5%	17.0%	7.0%	7.5%	10.5%	31.0%	48.5%
2015	14.5%	13.0%	16.0%	7.0%	7.5%	10.5%	31.5%	49.0%
2016e	14.0%	12.0%	15.0%	10.0%	7.0%	10.0%	32.0%	52.0%

— Largest increases in % of market volume were Hedge Fund and Retail categories

— HFT volumes have been declining with the largest decliner being the Independent Prop HFT Category
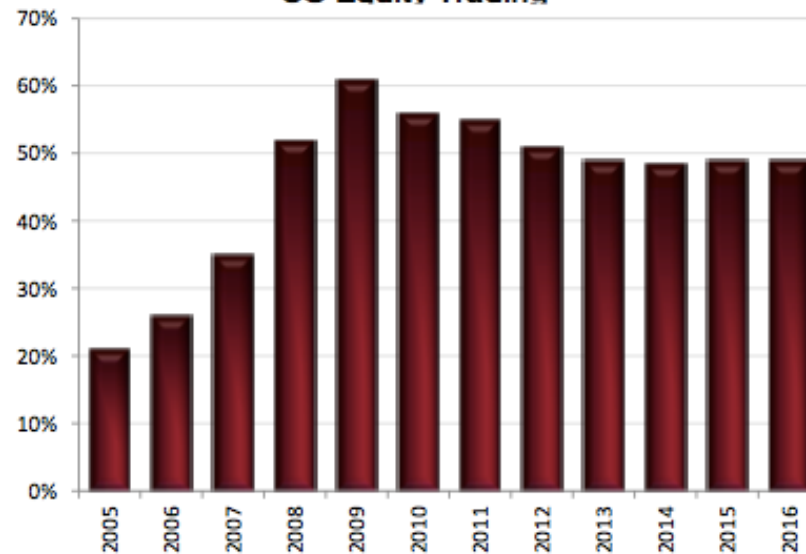
High Frequency Trading: Empirical Evidence

But overall volumes in HFT peaked in 2009 when S&P bottomed and VIX hit 80

At same time there was less demand for service, the field became more crowded. Thus, reduced profit opportunities.

Meanwhile, costs escalated: ever better technology needed for an edge. And data fees climbed at that time too.

Exhibit 1: High Frequency Trading as a % of all US Equity Trading

Source: TABB Group

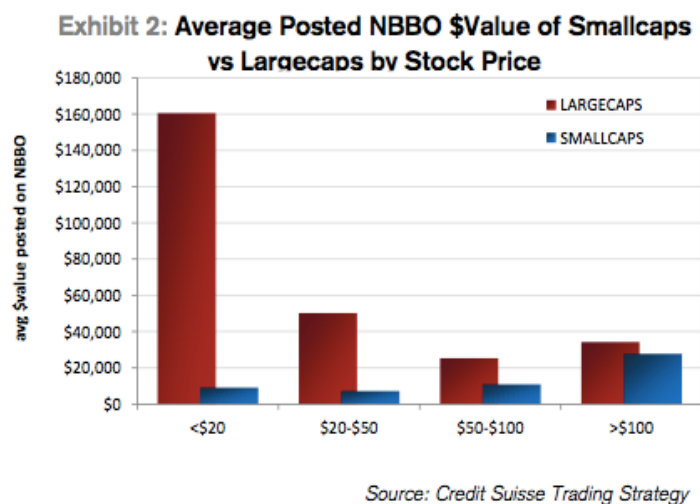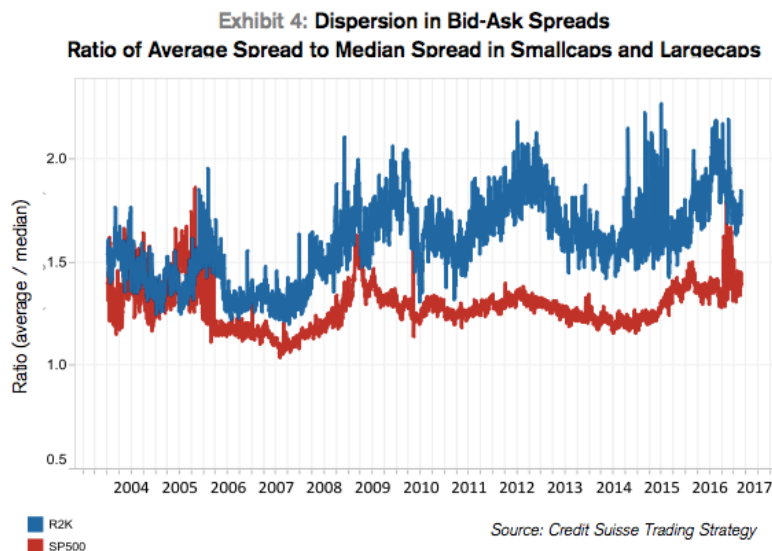Those HFT firms that remain, focused on the large cap liquid stocks and left the highly challenging small cap less liquid stocks alone.

Bid-asks spreads for large caps and small caps generally move in the same direction – they widen or narrow in accordance with volatility.

However since mid-2009 the dispersion in spreads between the two has grown.

At the same time, we can see the market spreads and liquidity has become highly skewed to the largest (most liquid stocks).
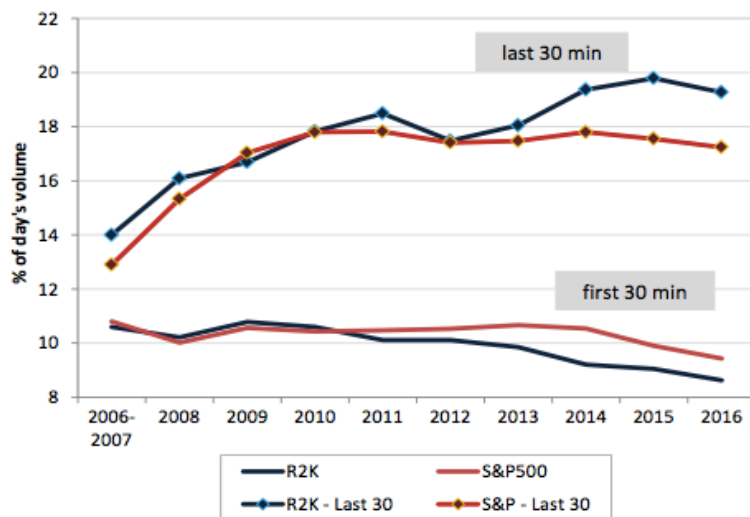

Exhibit 4: Dispersion in Bid-Ask Spreads
Ratio of Average Spread to Median Spread in Smallcaps and Largecaps

Source: Credit Suisse Trading Strategy

Exhibit 2: Average Posted NBBO $Value of Smallcaps vs Largecaps by Stock Price

Source: Credit Suisse Trading Strategy

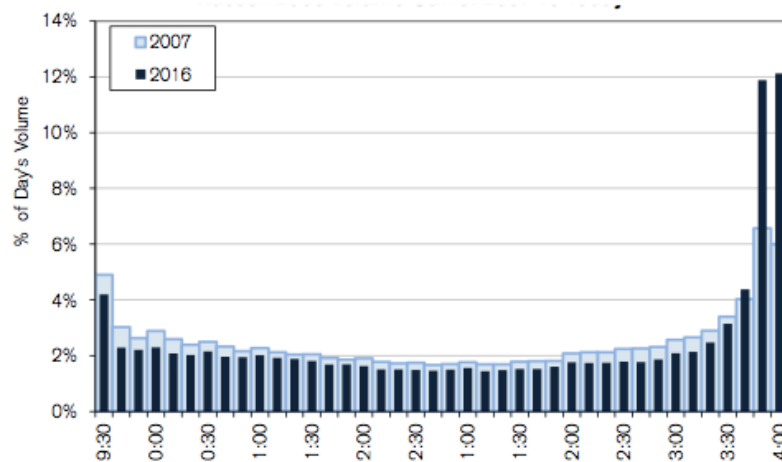Small caps stocks are also skewed as to when they trade during the day.

- Small cap stocks trade less at the open when the market is taking longer for price discovery.

- Also relative absence of "market makers" means that the "mostly natural" volume has shifted to the end of the day. As more and more "mostly natural" volume shifts there, this becomes a self-fulfilling prophecy

Exhibit 6: % of Day's Volume in First/Last 30 Minutes
Note: excludes the MOC auction
Source: Credit Suisse Trading Strategy

Exhibit 7: Russell 2000 Volume Curve: 2007 vs Today
Source: Credit Suisse Trading Strategy

At the same time the general efficiency of pricing for small cap stocks has declined.

It appears arbitrageurs are much less active in small stocks are price gaps are 40x more likely. What is most surprising is how this has changed over time and generally follows the pattern of HFT behavior we have seen elsewhere.

**Exhibit 8: Number of Price Gaps (at least 1%) in R2K Stocks vs S&P Stocks**
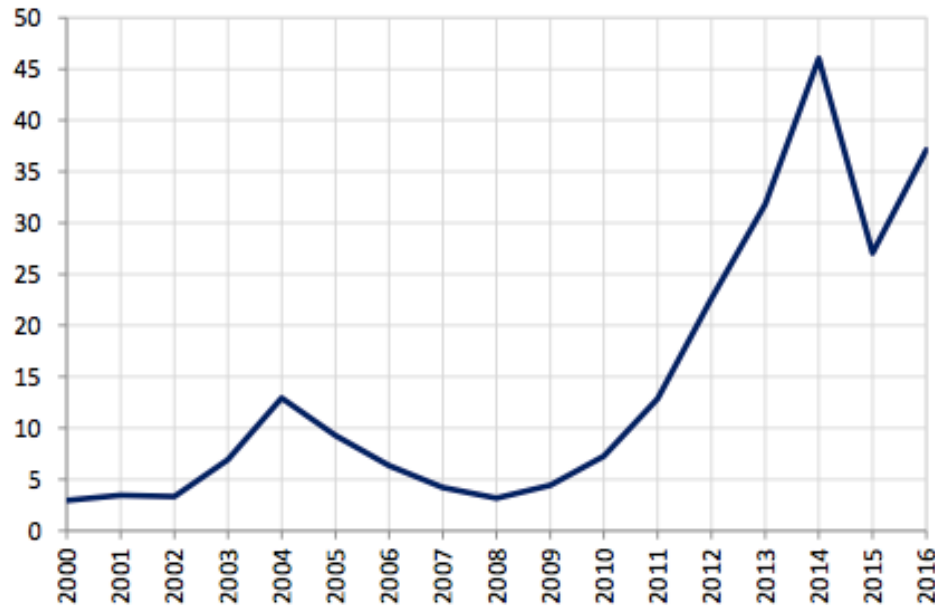
Source: Credit Suisse Trading Strategy

Everyone has become a HFT trader, though. People realized they needed to compete.

Updated their technology, routers, algos, and trading mechanisms. Brokers look like HFT shops! Similar logic and ultra-high speed infrastructure.

And even benefiting retail investors whereby discount brokers execute through retail wholesalers, who are often broker-dealers or HFT firms themselves!

Exhibit 9: **Number of NBBO Quote Changes Per Million Shares Traded**
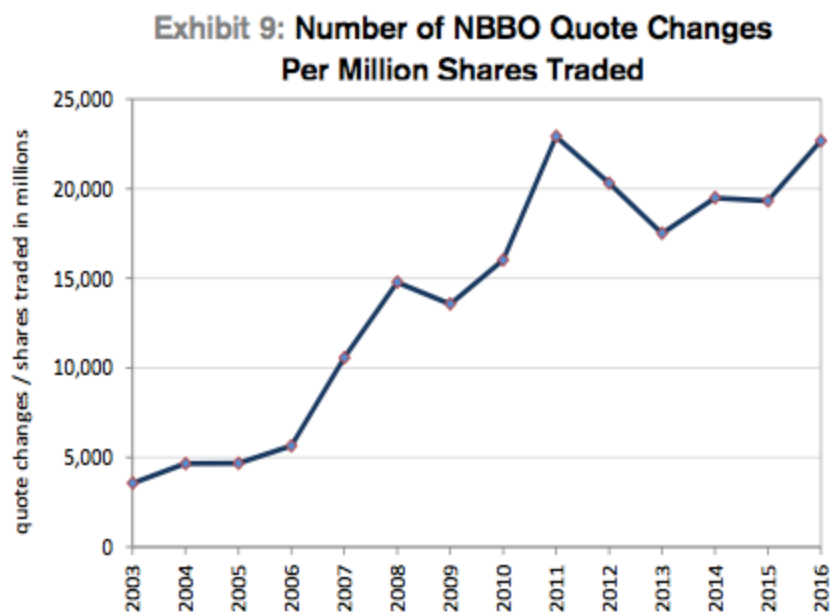
Source: Credit Suisse Trading Strategy

Sponsored Access (Direct Market Access)

Sponsored Access (or Direct Market Access) is the practice of a non-member firm using the broker-dealers "co-located" hardware and software ("pipes"), directly interacting with the exchanges, and by-passing the broker-dealers order management system.

Why would a firm want to do this? Don't want anyone seeing their trades!

Why wouldn't the Broker-Dealer want them to do this?

From a regulatory point of view there are big risks. Who is responsible if the non-member firm violates a regulatory check or applicable risk threshold? The member is!

Where are the pre/intra/post trade controls? Can one introduce a 3rd party system to monitor and not divulge information?

This is the issue of "naked" Sponsored Access.

What Exactly is Best Execution?

So how should we think of "Best Execution"?

- – Speed and price certainty

- – Opportunity for size and price improvement

- – Should depth be a part of best execution?

- Clients should decide which of these features is most important, what they are trying to accomplish, and should have the ability to opt-in and opt-out of various components that they feel do (or do not) meet their needs.

# Issues in Estimating Trading Costs and Market Making Strategies

1. **Decision Problems: Algorithmic Trading and Routing**

   – How to schedule trades over time?

   – Which market mechanisms to use? Limit orders, market orders, dark pools? At what price?

   – How to route trades across venues?

2. **Decision Problems: Market Making**

   – If and how much liquidity to supply?

   – At what price?

   – What market venues / mechanisms to use?

   – When to aggressively trade ahead of adverse price movements?
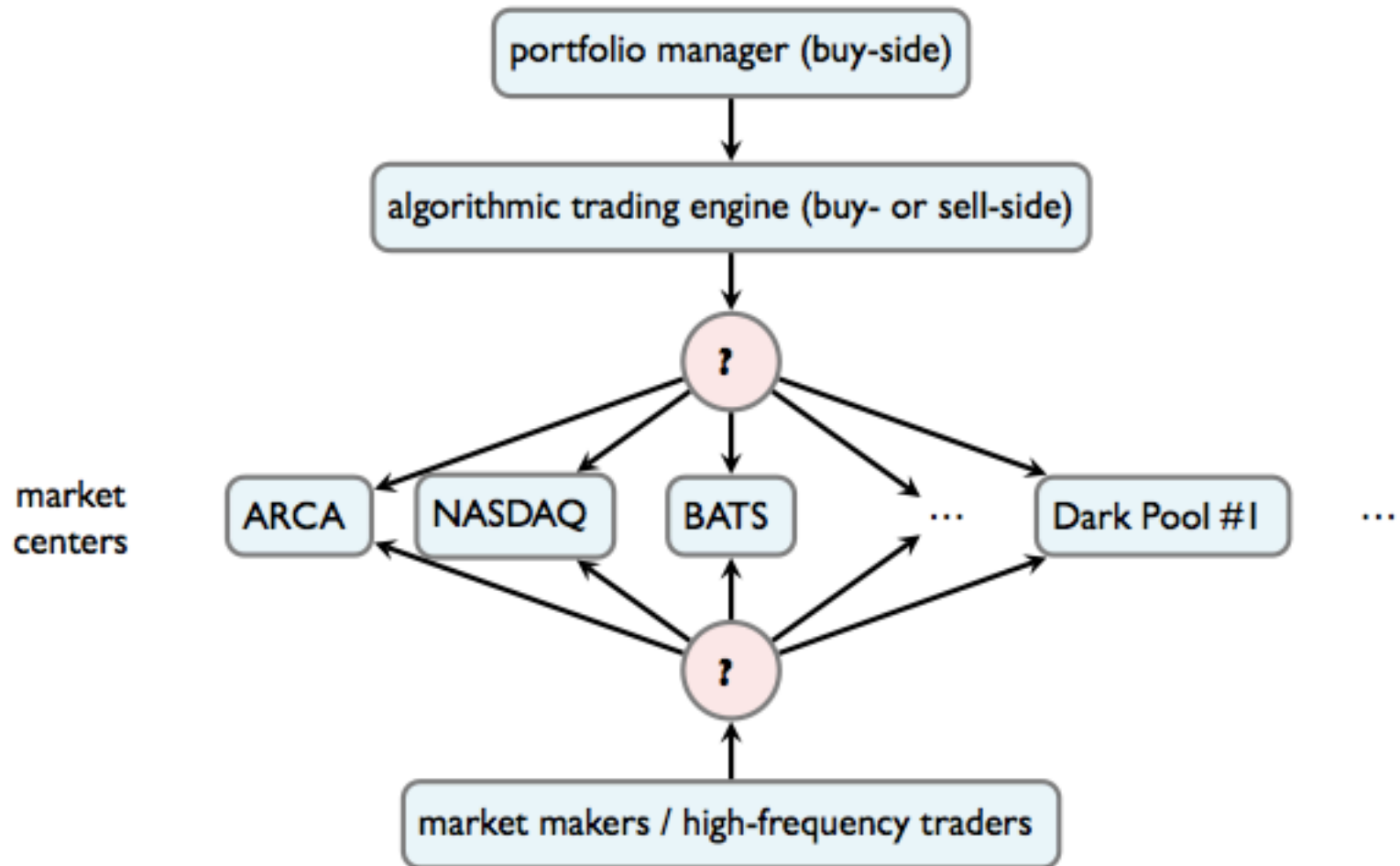
Algorithmic Trading of a large order is typically decomposed into three steps:

1. **Trade Scheduling:** splits parent order into "slices" (e.g. 5 min slices)
   – Relevant time scale: minutes – hours
   – Tradeoff time (decision price) with execution costs
   – Reflects price impact (temporary / permanent)
   – **Reflects urgency ("alpha" and "alpha decay" and "risk/return")**
   – Schedule is often updated (re-optimized) during execution to reflect price / liquidity

2. **Optimal Execution of a Slice**: divides "slice" further into child orders
   – Relevant time scale: seconds – minutes
   – Strategy optimizes pricing and placing of orders in the LOB, tradeoff price vs delay vs information revelation
   – Execution adjusts to speed of LOB dynamics, price dynamics, ….

3. **Order Routing**: decides where to send each child order
   – Relevant time scale ~ 1 – 50 microseconds
   – Optimizes fee/rebate tradeoff, liquidity/price, latency, information revelation, etc…

Market Making / High Frequency Trading

Supply short-term liquidity and capture the bid-ask spread

1. **Critical to Model Components of Bid-Ask Spread and Adverse Selection:**

   – Short-term price changes conditional on a trade, "order flow toxicity"

   – Profit of a single trade = (captured spread) – (adverse selection)

   – Depends upon news, volatility, market venue, counterparty, latency arbitrage, etc.

2. **Need to Control Inventory Risk / Adverse Price Movement Risk**

3. **Important to Model:**

   – Future Prices ("extremely short term alpha")

   – Microstructure Signals

   – News (Sentiment Analysis)

   – Price time-series modeling (momentum, mean reversion)

   – Cross-sectional signals (statistical arbitrage)

   – Cross Venue pricing (latency arbitrage)

4. **Strategies are VERY sensitive to microstructure details of market mechanisms**

Relevant Participant Questions

Estimation/prediction problems:

- Pre-trade analytics (e.g., execution costs)

- Short-term price changes are hard to model

    - Typically statistically weak (e.g., $R2 \ll 1\%$)

    - Highly non-stationary

- Interdependencies between prices and trades

    - Need to use your own data which means there is a significant endogeneity issue

    - Price impact and adverse selection are hard to estimate

- Other market primitives (e.g., volume, liquidity, volatility, ….) must be accounted for

- Other microstructure primitives (e.g., order fill probabilities, order completion times) need to be considered

- Post-trade analytics (measure / attribute performance)

Computational / Implementation Challenges:

- Big data:

  – 100+ GB per day (compressed!) for U.S. equities alone

  – Computational power can be a constraint: parallelism / memory efficient is important

- Real-time, low latency decision making is crucial

  – Down to microseconds time scale

  – Linear algebra is possible (e.g. Kalman filter updates)

  – Is optimization possible (e.g. mean-variance Quadratic Programming)?

  – How to implement a complex control program?

  – Decompose across CPUS, GPUS, across time scales?

  – Other exotic hardware?

Summary

Issue Facing A Money Management Firm

- How should you trade?

- How do you actually understand your "alpha" and its properties if you are not a quant manager?

- Should you invest in your own high frequency trading desk?

- How do you ensure that you are not being taken advantage of by others?

- Do you write your own algos?

- How do you determine the order type you need to use?

- How do you constantly keep with the changes in market microstructure and changing regulations?

- Do you use sponsored access, naked or otherwise?

- How should you rout your orders?

- Should you send to multiple desks and let them compete against themselves and chose the best one? Is their statistical power to actually distinguish between brokers? And are you simply picking the one that "rips you off" the least?

"I am younger than I once was / And older than I'll be / That's not mysterious / Nor is it strange / For after changes upon changes we are more or less the same."

-- Paul Simon

- Read "Reminiscences of a Stock Operator" by Edwin Leferve.

- The telephone and the telegraph essentially disrupted the way market operated by injecting massive new speed into markets that gave certain players an advantage.

- Co-location has been here forever. Football players literally dominated the pits. Floor trader and specialists at the NYSE were closer and hence faster. "Noise" / "Volume" on a broker-dealer's trading floor was shown to have information content.

- In 19th century, NYSE painted its windows black to prevent anyone from distributing prices off the floor of the NYSE. All prices controlled.

- Buttonwood Tree Agreement (May 17, 1792): Preference will be given to each other of the 24 members who make up the exchange in all negotiations for the sale and purchase of stocks (not duty to act in customers best interest).

- These are the same fights and will be the same fights as long as we have (financially motivated) intermediaries between buyers and sellers

- How has market structure evolved over the past twenty years? How much of the change was driven by regulatory changes or the advent of technology?

- What has lead to advent of high frequency trading? Do you think it was primarily technology or regulation? Could it have happened without the other?

- If you are an asset manager, how might you judge if your broker dealer is giving you best execution?

- You are the CEO of an asset manager and a client tells you that to get his large mandate to manage his money, you need to have your own internal trading desk with your own internal trading desk. What should you consider (aside from the money you will make from getting the mandate) in accepting those conditions?

- What are the benefits to having intermediaries (exchanges, broker-dealers) existing in the market? What are the cost to having these same intermediaries existing in the market?

- What has been the impact of HFT traders on the market? In what ways is the technology that led to HFTs existence the same and different from the invention of the telephone or telegraph?

- Do you like or dislike the advent of dark pools? If you were the regulator what rules might you want to impart upon them? Or are the functioning just fine as is?

- Has technology commoditized trading? Or made it more democratic? (Hint: please think about this question! And think about how this same issue of technological change might apply to other issues we've discussed through out the course! HINT)

- HFT has replaced the specialist and designated market maker. What are some of the pro's and con's of this?

- Lindsey states "I believe in free markets and competition. I did write rules and regulations but they were intended to spur competition. Because I believe that competition regulates markets better than regulation ever can." Comment. Please point to specific evidence where he might be right and might be wrong.

- How should own market data (prices, volumes, quotes)? What impact does it have on trading and market structure on who owns this?

- What trading hours should markets adopt? Should they be closed for lunch (as they are in Japan)? Should they be open on Saturdays (as they were on the NYSE from 1871 until 1952 when Saturday trading was abolished)? Should they be open 24 hours a day? What are the pro's and con's of these ideas?

- Is their a trade-off between informative prices and liquidity? If so, how should regulators balance these off? What are the normative considerations for both? What type of activities might a regulator allow and not allow? For example, should regulators actively encourage gambling/speculation in the market? What would be the pros and cons of such encouragement in the short-run and long-run for the market (prices, liquidity, volumes, information revelation, bubbles, etc)?

- In the same vein as above in August 2000 regulators adopted Reg FD which stated that issuers (management of stock) could not disclose material information to their favorite Wall Street analysts without disclose all information to everyone at the same time. Previously, the analysts (or their firms) or favorite clients would trade on this information first. What do you think of this rule? Who does it help and hurt? What happens to liquidity? Is price informativeness impacted?

Appendix:
Types of Markets and Structures
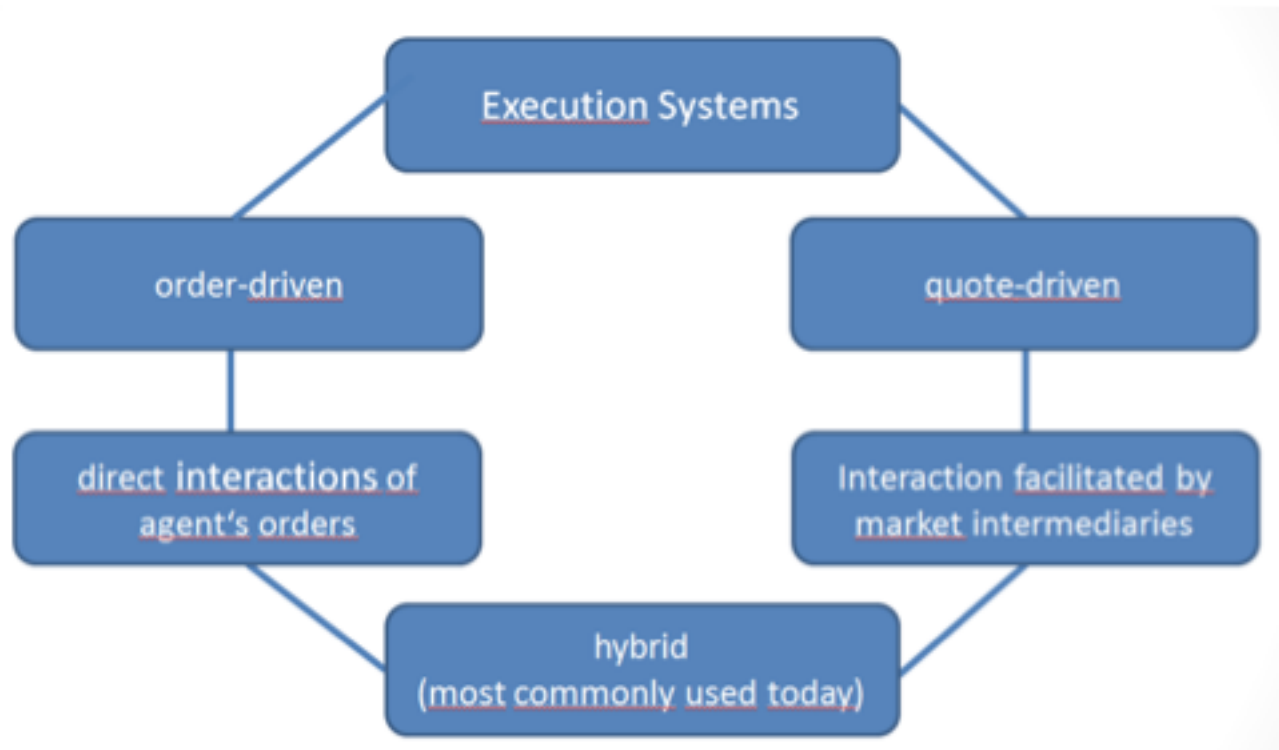
Market Structures

- Order Driven Markers:

  - Auction Markets: Order preference rules and trade pricing rules

    - Oral Auction Markets (open outcry in floors and pits)

    - Call (or Batch) Markets

    - Electronic Auction Markets

  - Crossing Networks: Order preference rules and derivative pricing rules

- Quote Driven Markets

  - Screen-based Markets: Dealer Markets

  - Continuous Auction Markets

  - Brokered Markets

- Hybrid Markets

Order Driven Markets

- Investors' buy and sell orders are matched directly, no intermediaries except brokers

- No market makers, liquidity resulting from steady and constant flow of orders from market participants

- Brokers transmit orders but do not maintain own positions

- Rules for order matching are imposed, can be auction or crossing network markets

Auction Driven Markets

- Dominant type in leading markets

- Call/batch auction characterized by simultaneous order submissions

- Call/batch auction can take place at opening, during trading day and at closing time

- Continuous auction characterized by possibility to submit at any time during trading phase

- Two types of orders in auction markets: market orders and limit orders

Market Orders vs. Limit Orders

- Market Orders:
  - Executed at market price, only buy/sell and quantity is specified
  - Executed with high probability, as long as demand and supply are present
  - Favorable for traders needing immediate transactions
  - Price at execution is not limited and therefore unknown

- Limit Orders:
  - Executed only when limit price is met or below for buy orders (met or above for sell orders)
  - Specification of security, buy/sell, quantity and limit price
  - Guaranteed price, but execution depends on availability of orders on other side (either limit order of opposite direction and limit price within, or market order in opposite direction)
  - Favorable for price-sensitive traders not in urgent need of execution
  - Not executed orders placed in limit order book (LOB) until execution or cancellation

- Oral Call Auctions

  - Market participants physically present at the floor, crying out buy and sell orders directly.

  - Prices and executions are open and public

  - Price priority: highest bid and lowest ask preferred

  - For given prices, time priority preferred; But price dominates time

- Electronic <u>Call</u> Auctions characterized by pre-determined time period,

  - All submitted orders are traded at the same time at the same equilibrium price given limit.

  - Uniform pricing rule

  - Most common is market on close on the NYSE

- Electronic <u>Continuous</u> auction characterized by trading sequentially over time, with market participants observing order flow, mainly automated trading

Market Rules: Order Driven Markets

- Electronic Continuous Auctions most frequent for stocks and derivatives and common form of order-driven markets, structured as open limit order book (OLOB)

  - Accumulation of limit orders and traded as described above

  - "At best" execution means that traded at best price in LOB for orders fulfilling limit

  - Precedence rules applied, price > time > others

Market Rules: Crossing Networks

- No price priority, only time priority

- Call system that crosses prices several times per day

- Primary stock markets are indicative for prices that are determined

- Finding of prices through derivative pricing rules

- No equilibrium price, prices found through rules

- Differing rules and differing assets traded lead to different actual crossing networks

Market Rules: Quote Driven Market

- Market-makers/dealers specify prices

- Monopoly of market-makers, they are liquidity providers

- Market-makers act on own account, but can act as brokers as well

- Trading done on prices and volumes as quoted by market-makers

- Low transparency, market-makers make price based on supply, demand and their risk of involuntarily having large inventory

- Negotiation possible

- Markets and types of trading lead to differing levels of transparency

- Differentiation between pre-trade and post-trade transparency

- Strategies affected by structure of transparency and information

GLOBAL MARKET STRUCTURE (2009)

Stock exchange	Structure	Call market, Market on close (MoC), Cross (Cr)			Pre-trade transparency				Hidden orders	Anonymity
		Mkt opening	Mkt closing	Intraday (trading halts)	Limit order book		Identities of liquidity providers			
					Members	Investors	Members	Investors		
Borsa Italiana (Bit)	AOD	yes	yes	yes	Full Book	5 Best B/A	no	no	yes	yes
Euro next	AOD	yes	yes	yes	Full Book	5 Best B/A	no	no	yes	yes
Frankfurt Stock Exchange (XETRA and Floor)	AOD/AQD	yes	yes	yes	Full Book	Best B/A	no	no	yes	yes
London Stock Exchange (SETs)	AOD	yes	yes	yes	Full Book	Full Book	no	no	yes	yes
London Stock Exchange (SEAQ-I)	SBQD	no	yes (Cr)	yes (2 Cr)	Best B/A	Best B/A	yes	no	no	no
NASDAQ (Integrated Single Book)	AOD	yes (Cr)	yes (Cr)	yes	Full Book	5 Best B/A	no	no	yes	yes
NYSE Hybrid Market (SuperDot)	AOD	yes	yes	yes	Full Book	Full Book	no	no	yes	yes
NYSE (Floor)	FBQD	yes (MoC)	yes (MoC)	yes	Full Book	Full Book	yes	no	yes	yes
Swiss Exchange (SWX)	AOD	yes	yes	yes	Full Book	Best B/A	no	no	yes	yes
Tokyo Stock Exchange (STP)	AOD	yes	yes	yes	5 Best B/A	5 Best B/A	no	no	no	yes
Toronto Stock Exchange (TOREX)	AOD/AQD	yes	no	yes	Full Book	Full Book	no	no	yes	yes

Note: AOD = Automated order-driven; AQD = Automated quote-driven; SBQD = Screen-based quote-driven; FBQD = Floor-based quote-driven; B/A = Bid/ask.

Appendix:
Proxies for Bid-Ask Spread Determinants

Empirical Proxies for the determinants of Bid-Ask Spreads

- Asymmetric Information Proxies

  - Information Disclosure Rules: Markets where there is more information disclosure required should have tighter spreads. These can be rules about firms financial conditions or about other information about firms holders and the like. For example, implementation of rules that require high audit, accounting and reporting standards should narrow spreads.

  - Market Condition Reports: Market conditions reports of supply and demand conditions will have a big impact on commodity prices. Markets where these reports are available or where governments have agencies that reliably report on these conditions will have smaller spreads.

  - Analyst Coverage: Securities that have many analysts following them have smaller spreads. Their reports generally serve to reduce information asymmetries.

  - Information Vendors: Companies that are covered by a wide variety of "information vendors" such as the press tend to have smaller spreads.

  - Diversified Companies: Conglomerates and large organizations generally have smaller spreads as it is harder for a trader to have material non-public information that is relevant to such a large well-diversified company.

- Asymmetric Information Proxies (continued):

  – Established vs. Emerging Industries: Firms in established industries are easier to value than those in emerging industries. These are typically value vs. growth stocks. Growth stocks have uncertain future growth prospects and often rely on the binary / success or failure of a product or idea (biomedical companies, new products, etc.). Established companies tend to rely more on cash flow analysis that is relatively easier to predict. Hence emerging industries (growth companies) tend to have more information asymmetry and larger spreads.

  – Age of the Firm: Young firms are often harder to value than older firms in the same industry. They may have newer uncertain technologies and/or younger less seasoned management. Hence, they have wider spreads, on average.

  – Markets with Rules Preventing Unequal Information Trading: Markets that seek to ensure that there is an even distribution of information among participants tend to have lower spreads. This is because it lowers the probability of trading against an informed trader.

  – When Material Information Is Expected: When material information is expected to be released, spreads to widen. Sometimes this is because there are concerns that the information has leaked. They also widen after the information has been publicly released because some traders are better able to process the information than others.

Empirical Proxies for the determinants of Bid-Ask Spreads

- Volatility Proxies

  – If you want to model future bid-ask spreads you need to predict future volatility. This is where volatility modeling comes in, as otherwise volatility is generally observable.

  – Future determinants of volatility where discussed in the risk-models section.

  – One might also think of numerous macroeconomic conditions for non-equity securities such as commodities (oil, wheat, orange juice futures), foreign exchange (political stability, inflation, etc) or fixed income securities (interest rates, credit shocks, inflation shocks)

- Utilitarian Trading Interest Proxies

  – <u>Trading Activity</u>: Active markets mean there is lower risk to holding inventory than for inactive markets. In active markets, dealers can quickly set-off inventory imbalances. Hence, they can quote lower spreads. Aside from obvious proxies such as trading volumes, active markets can be proxied for things such as major index inclusions (S&P 500 membership), large and disperse institutional ownership, and/or high share turnover.

  – <u>Firm Size</u>: This is related to many of the other proxies we discussed such as firm age, analyst coverage, mature industries, press coverage, established technologies, well-diversified company and index membership. In general, again, larger firms have smaller spreads than smaller firms.

  – <u>Volatility / Gambling Interest</u>: There is a secondary volatility effect in that high volatility stocks, or stocks that exhibit lottery like payoffs. These stocks tend to be much more actively traded than stocks not exhibiting these lottery / gambling characteristics. This high trading activity combined with the fact that these type of investors tend to be *uninformed* (and subject to the worst of behavioral biases) means these companies tend to have smaller spreads. Note this secondary volatility effect goes in the *opposite* direction of the primary volatility effect.