Quantitative Investments

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Last lecture we discussed markets.

- Not all markets are the same — for good reasons;
- Markets handle differences in flexibility, trust, liquidity;
- For example: Moe and Joe...(!);
- Discussed types of markets, benefits, drawbacks;
- Introduced orders, quotes, and trades;
- Mentioned financial intermediation; and,
- Considered short selling and regulation.

Today we will talk about changes that led to modern markets.
Modern Markets

Chapter 4, *A Quantitative Primer on Investments with R*
This part discusses modern markets. Specifically:

- Electronic vs algorithmic vs high-frequency trading;
- Intermediation without specialists;
- Recent pro-competitive changes;
- Market structure effects;
- Problems and pseudo-problems; and,
- Recent regulation.
Almost all stock markets now allow electronic trading.

Pre-1971, stocks listed on NYSE or AMEX — or were unlisted.
  - Listing: requirements on reporting, size, etc.
  - Unlisted stocks traded OTC by broker-dealers.
  - Natl Assn of Securities Dealers (NASD) oversaw them.

1969: Instinet; 1971: NASD automated quotation = NASDAQ.


Mid-1980s: Electronic derivatives trading introduced.

Fully electronic stocks: Chile, 1989. (FI, SE, AU in 1990)
Jain (2005) compares electronic and floor-based markets:

<table>
<thead>
<tr>
<th>Feature</th>
<th>Floor</th>
<th>Electronic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Counterparty ID</td>
<td>Known pre-trade</td>
<td>Rarely known pre-trade; often known post-trade</td>
</tr>
<tr>
<td>Order Book</td>
<td>Often none/fleeting</td>
<td>Constantly exists</td>
</tr>
<tr>
<td>Liquidity Seen</td>
<td>Bid-Ask</td>
<td>N best bid-asks or entire order book</td>
</tr>
<tr>
<td>Matching Speed</td>
<td>10s–minutes</td>
<td>Sub-second</td>
</tr>
<tr>
<td>Order/Oper. Costs</td>
<td>Higher</td>
<td>Lower</td>
</tr>
<tr>
<td>Settlement Speed</td>
<td>Slower</td>
<td>Faster</td>
</tr>
<tr>
<td>Settlement Cost</td>
<td>Higher</td>
<td>Lower</td>
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Advantages of Electronic Trading

Electronic trading has many benefits:

- Easily record history of interactions (audit trail).
  - Lets us assess orders and trades: Did we get good execution?
- Allows machines (trading engines) to do the work of trading.
  - Automation $\implies$ economies of scale, reduces explicit costs.
  - Engines are unemotional; behavior does not change/get “spooked.”
- Audit trail and automation can reduce implicit order costs.
- Easy data collection lets us conduct experiments, tune behavior.
  - Tunable/adaptive machines are the core of algorithmic trading.
- Forces market (and agent) logic to be documented (in code).
  - Disincentive to encode manipulative/unfair behavior.
Electronic trading also has some drawbacks:

- Trading engines are only as good as we program them to be.
  - Recall: some concepts are not very well defined.
- Machines lack common sense; will do what you tell them.
- Startup (and incremental) infrastructure costs may be large.
  - This can be a barrier to entry for possible competitors.
  - May increase sophisticated–unsophisticated trader gap.
- Hard to gauge counterparty quality; important for some markets.

“Arms race” or constant evolution? (Sigh. Just... no.)
NASDAQ was run by competing broker-dealers; no specialists. These competing broker-dealers are called *market makers*. Market makers are different from specialists:
- Compete with each other; no monopolies on information or control.
- Competition should yield fair and orderly market.

Contrast the specialist with the market maker (MM):
- Specialist chooses when to step in, can stop market.
- MM has no advantage on discerning when to step in.

Thus MMs constantly face a tough optimization: profits vs risk.
- Instinet created by institutional traders.
- Way to trade large volume without MMs, paying full spread.

An ECN is a limit order book that:
- Displays orders; matches them in some priority; and,
- Informs involved traders, outside world of execution.
- Essentially, an ECN is an automated broker.

Can see price you will get (low uncertainty).

Superior software handles large volumes with low latency.
- 2000: NYSE fill \(\approx 3\)s; Island fill \(\approx 300\)ms round-trip.
- 2003: Island fill \(\approx 20–30\)ms round-trip.
- 2008: BATS match \(\approx 500\mu\text{s}\).\(^2\)
- Now: BATS match \(\approx 150\mu\text{s}\); most markets 2–20 ms round-trip.

\(^2\)Yes, measuring time through the matching engine is moving the goalposts.
Through mid-1990s, many investors insisted MMs overcharged.


- Fig. 3, p. 1823: Even eighths $\approx 20\%$ each.

- Is this pattern unusual? Yes, maybe 1-in-a-few-million.

Outcome: SEC charged $>40$ market makers with collusion.

- 1997: SEC changed rules to encourage hyper competition.
- 1998: settlements totalling more than $1\text{ bn.}$
To reduce collusion (and to punish), SEC adopted new rules:

- 1997: 11Ac1-1 changed, must quote if >1% of stock volume.
- 2000: 11Ac1-5, public+standard execution quality reports.
- 2000: 11Ac1-6, public+standard order routing reports.
- Minimum tick size reduced to 1/16-ths (1997), $0.01 (2001).

2005: Reg NMS repackaged these rules plus others.

- Access Rule: intermarket linkages to access quotes.
- Sub-penny Pricing Rule: No price increments <$0.01.
- Market Data Rules: fees re-allocated by execution quality.

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People discussing “Reg NMS” often mean these rule changes+Reg NMS.
Changes came at a propitious time: internet bubble burst.
  Good programming talent had just become very cheap.

Also was a sharp rise in two ways to promote new venues:
  Rebates+Access Fees: ECNs pay limit orders upon trading,
  and marketable order pays; aka “maker-taker fees”; and,
  Pay-for-flow: MMs pay broker for marketable orders.

These+execution quality reports= major shifts in market share.

Theory and evidence so far are clear, though:
  Maker-taker fees are OK, do not hurt investors; but,
  Pay-for-flow raises cost of trading, is a dominant strategy.
Differences in Intermediation?

- Glosten (1989, 1994) studied different forms of intermediation.
- MMs: Price increases linearly with order size.
  - However: market can fail if too many informed customers.
- ECN: Price slightly convex function of order size.
  - Huge orders get worse prices; even tiny orders pay fixed cost.
- Specialist: large orders get better price than small orders.
  (Loses on large orders to make money on small orders.)
- Are these necessarily good or bad? No.
- Rather, means we want a balance of all intermediary types.
Evidence of Success

  - Quoted spreads dropped; mean: $0.16 to $0.01.
  - Effective spreads\(^4\) dropped; mean: $0.12 to $0.02.
- These changes are largely why you can now buy stock for $10.
- Inspired EU Markets in Financial Instruments Directive (MiFID).
  - MiFID is like Reg NMS for EU markets; similarly successful.
- These changes have yielded decentralized “fragmented” markets.
  - But: huge cost savings; competition keeps markets together.

\(^4\) Effective spread: mean spread b/w buyer-, seller-initiated trades.
Decentralization Pros and Cons

- Main advantage, competition, brought many key changes:
  - Forced exchanges to execute orders faster and cheaper;
  - Popularized certain data (e.g. limit order book = LOB);
  - Punished cumbersome/anti-competitive market rules; and,
  - Made markets more robust to problems.\(^5\)

- However, decentralization fractures liquidity:
  - Liquidity tends to attract more liquidity;
  - Increases likelihood of being \textit{traded through};
  - Someone must connect to, monitor, route among \(N\) venues;
  - Unsophisticated customers likely ignorant of these issues.

\(^5\) Nasdaq crash on 2002 Russell rebalance.
Reg NMS stopped short of requiring a consolidated LOB.

Requirements to achieve synchrony would have been onerous.

For now, anti-competitive aspects of CLOB made clear.

But requirements to route away\(^6\) have a cost (esp. speed).

Some venues find this cost intolerable, anti-competitive.

One way out: go “dark.”

\(^6\)Send orders elsewhere for a better price.
Island Goes Dark (Hendershottt and Jones, 2005)

- Early 2000’s: Island took AMEX, NYSE market share by being fast.
- 2002: Island protested proposal to mandate intermarket linkage.\(^7\)
  - #1 venue for three most active ETFs; stopped publishing LOB.
- Effects were sudden and strong:
  - Market share: 58% ↓ 35%; price discovery moved to futures;
  - Trading costs increased overall; and,
  - Prices adjusted more slowly (quote changes became predictable).
- Island later re-illuminated; execution quality then increased.
- Government relented on proposal... but occasionally reconsidered.

\(^7\) Island said proposal would make all venues run at “slowest common denominator.”
Some investors use negotiated trades for large orders.
  - Negotiated due to liquidity, adverse selection risks.

Negotiated trades include:
  - block trades (10,000+ shares, direct search, declining);
  - arrival price (PRP) trades (priced wrt current bid/ask);
  - volume-weighted average price (VWAP) trades.

Most negotiated trades are programs=large portfolio trades.
Pre-1997, most trading automation was done for program trades:

- *Program trade*: 15 or more names totalling >$1 million.
- Initially done with runner+program (itinerary) of orders.
- Program trading *does not* mean trading by computers.
- However, program trading was an early adopter of computers.

As trading got cheaper, more flow routed through program trading.

True story bro: Systems trade cheaper, more reliably than humans.

- Block desk VWAP: charge 8cps, miss by 12, s.d. of 150.
- Algo VWAP: charge 2cps, miss by 1.5, s.d. of 0.5.
- Guess which desk was empty six months later....
Thus *algorithmic trading* is the automation of trading.

Uses execution, order management systems: OMS and EMS.\(^8\)

- OMS: orders planned across time to hit a benchmark/trajectory.
- EMS: order may be split across venues or updated strategically.

This requires theory, careful thinking about how best to trade.


- Idea: Split large (parent) order into smaller (child) orders.
- Time orders to optimize mean vs variance of trading cost.

EMS: key theory can be very complicated, may interact with OMS.

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\(^8\)You can think of OMS vs EMS like strategic vs tactical.
Index Arbitrage

- An early accomplishment of program trading: index arbitrage.
  - Trade index futures vs index stocks when implied prices differ.
  - Trader makes money at very low risk, low capital requirement.
  - Effect of trading: pushes prices closer together.

- Index arb is very beneficial to other investors:
  - Stocks, ETFs, index futures all kept at nearly same index level.
  - Thus I need not search for best deal to invest in index.
  - This also saves me money by reducing my IT spending.

- But... stocks traded in NYC; futures/options traded in Chicago.

- Hence high-speed (5ms vs 28ms) NY–Chicago microwave link.
  - Efficiency? Lower bid-ask spreads, quote changes less predictable.
  - If prices closer to true value, get better allocative efficiency.

One major laggard: short sales; still required price tests.
  - Could not short stock if it just fell or at price below bid.

2005: SEC tries an experiment; Reg SHO eliminates price tests.
  - Idea: Bring efficiency to pricing for overvalued stocks.
  - Result: Positive...w/tweaks (must have capital+locates).
At this time, simplest decisions became highly optimized. 
Made by true/false choices; even multiplying is too slow!

Idea: buy/sell instrument; exit position ASAP on another venue.
True/false choices implied venue most likely to earn slight profit.
Main speed advantage? From optimizing networks + connections.
This is what constitutes high frequency trading.

Make money on only 1 in 10000 (50000?) trades; else: break even.
But they trade a lot, so money adds up. (LLN at work)
How do HFTs add value? They keep prices the same across markets.
  Use their speed to spread information across all venues.
  Thus we need not fret so much about where we trade.
Glitches with any automation can get bad quickly.
  - Trading engines may mishandle orders or break rules/laws.
  - However, code documents logic, eases finding+fixing errors.
  - 1 Aug 2012: Knight Capital bug costs $440 MM in 45 minutes.

However, human breaches of common sense can also be nasty.

“Fat finger” errors are classic examples of this.
  - 9 Dec 2005 J-Com IPO; Mizuho employee fat fingers sell order.
  - Sells 610,000 at ¥1 (instead of 1 at ¥610,000).
  - TSE computers so busy, cancel takes 10 minutes. Cost: $330 MM.
The Flash Crash

- 6 May 2010: US markets open down (concern about Greece).
- 2:32 PM: Waddell & Reed sell, 75,000 ES\textsuperscript{9} via %-of-volume.
  - HFT firms provide liquidity, volume ↑ so W&R scale up too.
- 2:41–2:44 PM: S&P 500 futures (ES+SP), ETFs drop 3%.
  - Index arb engines trade heavily; effects bleed into equities.
  - Trading, MM engines exit as Δvolume triggers error flags.
- 2:45:13–2:45:27 PM: Half the day’s ES volume trades in 14s.
- 2:45:28 PM: CME pauses ES, SP for 5s; sends reset signal.
- 2:45:33 PM: Stocks and futures begin recovering.
- 3:00 PM: Most price changes from 2:32 on have reverted.
- Post-market-close: Some trades at price extremes canceled.

\textsuperscript{9}E-mini S&P 500 contracts; about $4 bn worth.
Flash Crash Questions

- Was it reckless to send a large %-of-volume order?
- Was it reckless to not supervise that order intensely?
- Should HFT firms have behaved differently? If so, how?
- How should trading engines handle unusual/erroneous data?
- Should trading+MM engines have stayed in the market?
- How did canceling trades affect traders the next day?
- Who was the main culprit? Who was hurt?
- Are there longer-term effects of canceling extreme trades?
- What are the longer term effects of such a crash?
We may worry about how modern markets hold up to stress. Gao and Mizrach (2016) study prevalence of flash crashes. Turns out they are not new nor exploding in frequency.
1999 **Gramm-Leach-Bliley Act**
- repealed parts of Glass-Steagall, Bank Holding Co. Acts;
- allowed mixing banking, inv. banking/brokerage, insurance.

2000 **Commodity Futures Modernization Act**
- repealed Shad-Johnson Accord;
- exempted off-exchange energy trading.\(^\text{10}\)

2002 **Sarbanes-Oxley Act**
- CEOs, CFOs must certify reports;
- severe penalties for fraud, malfeasance; created PCAOB.

2010 **Dodd-Frank Act**
- demands central clearing, execution facilities, public quote+trade data for most derivatives;
- creates Financial Stability Oversight Council, OFR;
- Volcker Rule: restricts proprietary trading.\(^\text{11}\)

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\(^{10}\) The “Enron Loophole” was repealed in 2008.

\(^{11}\) Not yet clear: value of CFPB, OLA, Fed as regulator.

\(^{12}\) B.T.
Some Thoughts on Regulation

- Often, talk of regulation is strongly polarized.
- Some insist gov’t is the problem; deregulation yields growth.
- Others insist regulation is needed to make capitalism work.
- However, note the theme of the best regulation we’ve covered:
  - Encourage move from opacity to open markets; and,
  - Create standards so competition can flourish + self-police.
- Also, think carefully about what such changes look like:
  - A group which resists competition will accrue lots of money.
  - Smart move: use that money to depict change as bad.
  - Always ask: who says it’s bad and how will this affect them?
- Theory and data — not claims — should guide policy.
We have covered modern markets; on to efficiency next time!

- Fundamentals: Efficiency;
- Measuring: Returns, Risk, and Diversification;
- Valuation: Fixed Income, Yield Curves, Equity Valuation;
- Valuation II: Factor Models, Microfoundations, Global Investing, FX;
- Risk Alleviation: Futures, Options, Credit, Structured Products; and,
- All Together Now: Active Portfolios, Investment Firms, Crises.