

Lecture 9

Equity Market Structure

US capital markets

- We have discussed US equity markets extensively. Why?
 - Large and important for capital formation
 - Have the longest data for testing investment strategies and developing new investment methodologies
 - Have the best liquidity and technology
- In many ways, US equity markets set an example for markets for bonds, derivatives, etc.



Key Market Characteristics

	Market Size (Amount Outstanding)	2016 Issuance	Average Daily Volume	Representative Issuers	Representative Investors	Representative Intermediaries
Equities^{2,3}	\$29 trillion	\$200 billion	\$270 billion	Corporations	Individuals, asset managers, institutions such as pensions	Exchanges, broker-dealers
U.S. Treasuries^{4,5}	\$14 trillion (marketable securities)	Bills: \$6.1 trillion Notes: \$2.0 trillion Bonds: \$190 billion	\$510 billion	U.S. government	Individuals, banks, pensions, insurers, foreign governments	Broker-dealers, trading platforms
Corporate Bonds⁶	\$8.5 trillion	\$1.5 trillion	\$31 billion	Corporations	Insurers, pensions, asset managers	Broker-dealers
Foreign Currencies⁷	N/A	N/A	\$5.1 trillion	Central banks	Central banks, asset managers, corporations	Trading platforms, broker-dealers
Derivatives⁸	Interest rate: \$200 trillion (notional) Credit: \$3.6 trillion (notional)	N/A	Interest rate: \$900 billion (notional) Credit: \$110 billion (notional)	N/A	Corporations, hedge funds, individuals	Central Counterparties, exchanges, broker-dealers, trading platforms
Securitized Products⁹	Mortgage related: \$8.9 trillion Other ABS: \$1.3 trillion	\$2.1 trillion	Mortgage related: \$210 billion Other ABS: \$1.3 billion	Banks, nonbank financial companies, government-sponsored enterprises	Banks, insurers, pensions, hedge funds, asset managers	Broker-dealers

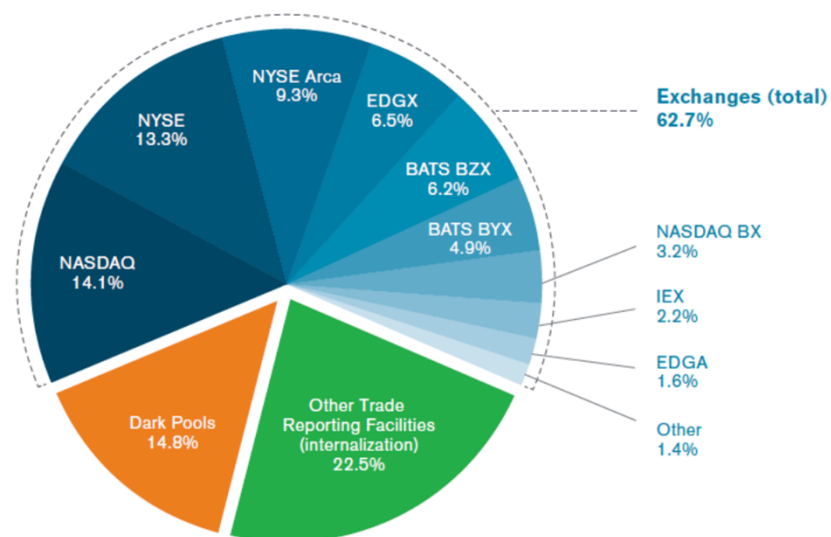
Source: Treasury report

US equity market structure

- But how do US equity markets work?
- A well-functioning market facilitates capital formation and reduces transaction costs.
- Three exchange groups (NYSE, NASDAQ, CBOE) operates ~13 exchange markets.
 - NYSE used to be the only one
 - NASDAQ used to be a dealers' market
 - CBOE bought BATS in 2017, and BATS became an exchange in 2008.
- Dozens of “dark pools” ~ 15% volume
- Hundreds of broker-dealers ~25% volume



Figure 5: Equities Market Share by Venue



Source: Rosenblatt Securities, July 2017

Source: Treasury report

Exchange mechanism

- Exchanges are transparent, or “displayed” venues.
- They are the primary source of price discovery.
- When exchanges report the trades, the trade report shows the identity of the exchange. (In the US, trade reports from non-exchange venues are lumped together in “trade reporting facilities”; see later.)
- An exchange uses two mechanisms:
 - Open/close auctions at market open and close;
 - Continuous limit order books between open and close.



Exchange mechanisms: open/close auctions

- Open auctions on NYSE and NASDAQ (close auctions are similar)
 - Before 9:30am, investors submit orders to buy or sell.
 - The orders could be market orders: buy/sell X shares at the market-clearing price
 - Or, they could be limit orders: buy X shares at price no higher than p , or sell X shares at prices no lower than p
 - All these orders are summed up to form a demand curve and a supply curve. Limited information is disclosed to participants as orders enter.
 - The opening price is where the demand curve crosses the supply curve.



Exchange mechanism: continuous limit order books

- Outside the 9:30am and 4pm auctions, US exchanges operate continuous limit order books (CLOBs).
- The order books are central marketplaces where buyers and sellers meet.
- Quote/price/liquidity “makers” put in limit buy and limit sell orders on the book.
- Quote/price/liquidity “takers” trade at the displayed prices.
- The same investor (trading account) can be makers sometimes and takers other times. “Market makers” refer to institutions that consistently provide quotes.
- At any moment in time, the snapshot of the CLOB gives a good view of the supply of liquidity on both sides.

Top of the limit order book		
	Shares	Price
Asks ----->	1900	34.56
	1700	34.54
	1200	34.53
	400	34.52
	300	34.51
<----- Bids	1000	34.49
	1100	34.48
	1400	34.47
	1500	34.46
	2200	34.45



Order book mechanism

- Best bid, best ask/offer, the “mid”
- Bid-ask spread = best ask/offer – best bid
 - What’s the transaction cost of buying or sell 100 shares?
- Walk the book, price impact
 - A market buy order for 2000 shares at \$34.53 arrives.
 - What are the transactions?
 - After the transaction, how does the order book look like, assuming no other change on the order book?
 - What if a market order for 4000 shares arrives instead?

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Determinants of bid-ask spread and liquidity

- Fixed costs—computers and traders, etc.
- Inventory costs—holding inventory ties up capital and incurs the cost of capital
- Market power—degree of competition
- Adverse selection—some investors may know better about the asset value than the market makers do



Multiple exchanges

- National best bid and offer, NBBO, are the best bid and best offer across exchanges.
- Under the order protection rule of Reg NMS, exchanges are not supposed to fill orders at prices worse than NBBO.
- An exchange that is not quoting the NBBO must route an incoming order to an exchange that makes the best quotes, or reject that order.
- If a new exchange improves the price quoted by others, it gets orders.

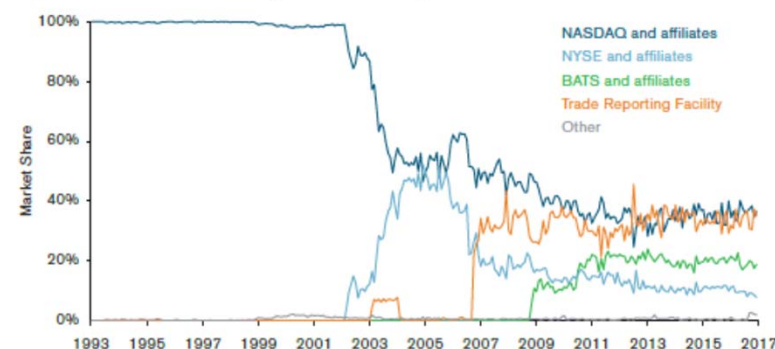


Figure 3: NYSE-Listed Equities by Exchange



Sources: Office of Financial Research analysis, U.S. Equities Trade and Quote (TAQ), calculated (or derived) based on data from Daily Stock File ©2017 Center for Research in Security Prices (CRSP), the University of Chicago Booth School of Business.

Figure 4: NASDAQ-Listed Equities by Exchange



Sources: Office of Financial Research analysis, U.S. Equities Trade and Quote (TAQ), calculated (or derived) based on data from Daily Stock File ©2017 Center for Research in Security Prices (CRSP), the University of Chicago Booth School of Business.

Source: Treasury report

Measuring transaction costs

- There are several measures of transaction costs, and all use market prices.
- The effective cost/spread is the difference between the execution price and the price before execution starts. $p^{execution} - p^{before}$ for buy and $-(p^{execution} - p^{before})$ for sell.
 - p^{before} is typically the mid price right before the execution.
 - It's common to convert the dollar costs into a percentage of value, by dividing by p^{before} .
 $(p^{execution} - p^{before})/p^{before}$
- The realized cost is the difference between the execution price and the price after the execution. $p^{execution} - p^{after}$ for buy and $-(p^{execution} - p^{after})$ for sell.
 - It's common to use mid quote a few (e.g. 5) minutes after execution for p^{after} .
 - Measure takes into market impact of trade



Measuring transaction costs

- The quality of execution can also be evaluated by comparing your own transaction prices to the market-wide volume-weighted average price, VWAP of transactions on same day.
- Example: you bought 100,000 shares at \$10 and 200,000 shares at \$11. What's the VWAP of your transactions? Then do the same calculation for all the transactions in the market (publicly reported).
- Cost to VWAP can be misleading because it's not an absolute measure but rather a relative measure.



Measuring transaction costs

- Implementation shortfall is defined as

$$IS = \text{Performance of paper portfolio} - \text{performance of real portfolio}$$

- The paper portfolio doesn't incur transaction costs and assumes that you can trade immediately. But the real portfolio incurs transaction cost and the price may drift away from you as you execute the trades.
- IS also is often measured as the difference between the price when portfolio manager submitted the order and the weighted average price at which the orders were filled, converted into a fraction of the value of paper portfolio. "IS is 10 bps."



Implications for investors

- Since transaction costs (eventually) increase with size, most trading strategies have a limited capacity.
- Before trading you must estimate expected trading costs from the strategy.
- Often it is optimal to split large trade into many small trades and execute patiently over time

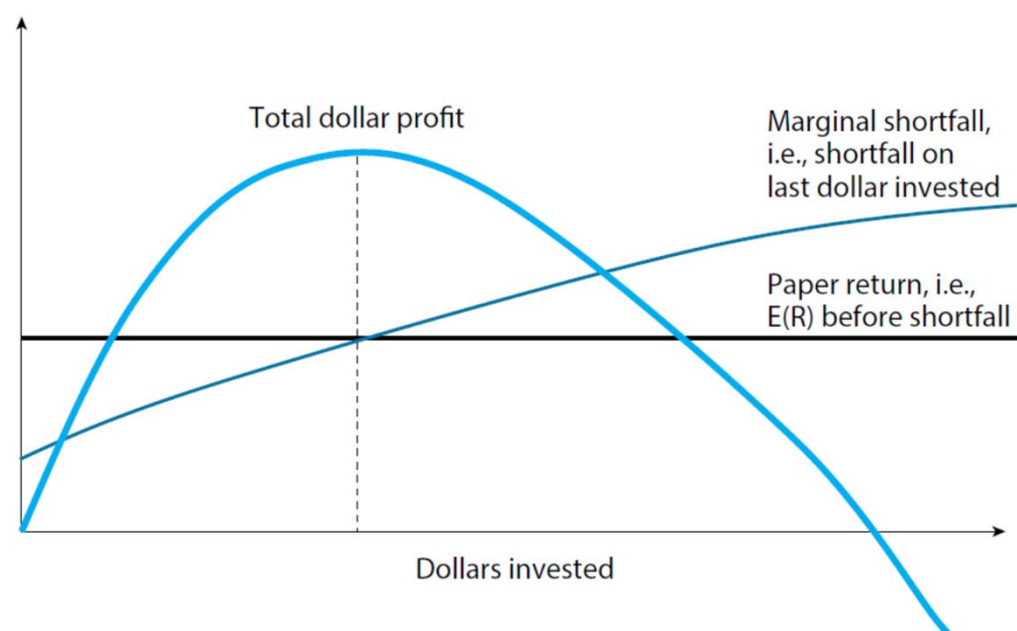


Figure 5.2. The capacity of a trading strategy.

Source: Pedersen book



Implications for investors

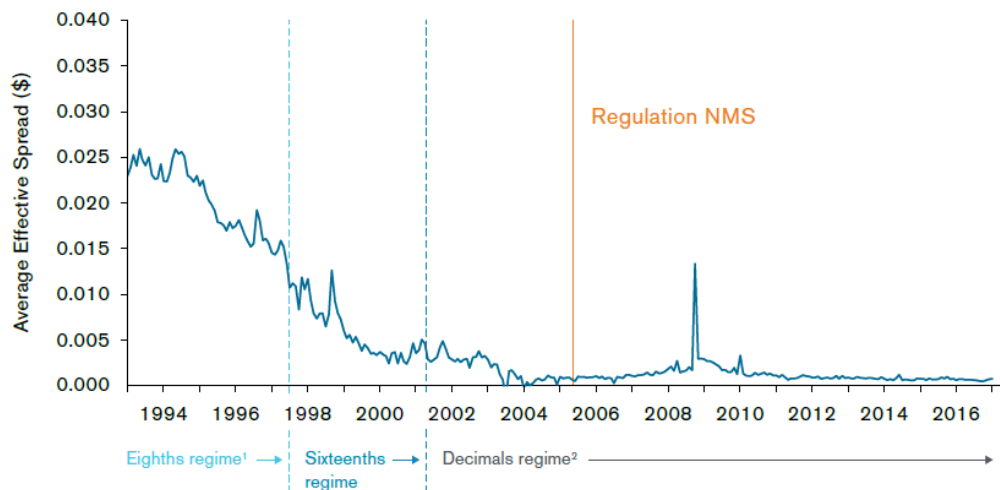
- For small orders transactions costs average 4 bps.
- For larger orders (above 1% daily volume) transactions costs average 27 bps.
- For even larger orders (above 10% daily volume) average is 40 bps.
- Orders larger than 10% are almost always split over multiple days



Transaction costs have declined over the past 20 years

Figure 6: Value-Weighted Effective Spreads on NASDAQ

Trading costs have fallen



Source: Treasury report

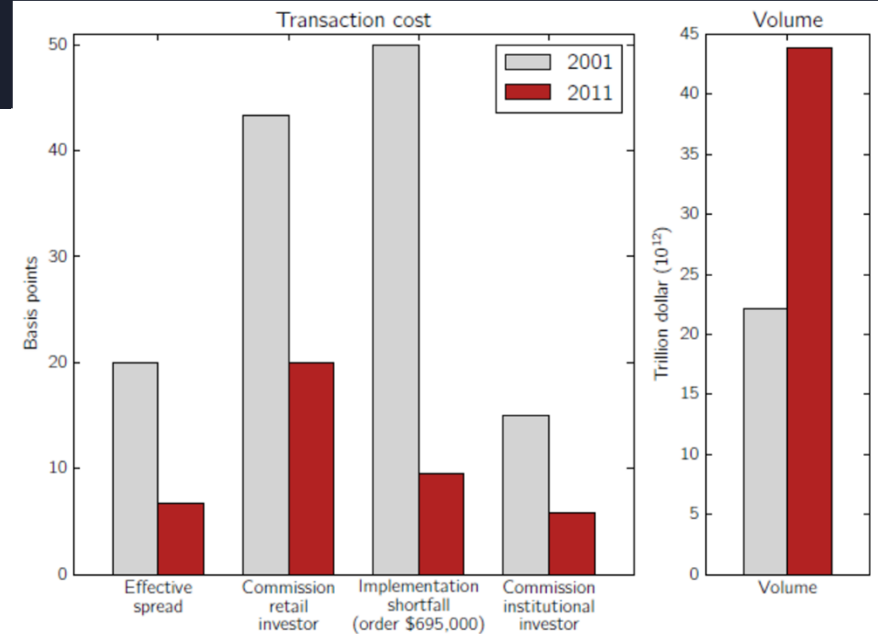


Figure 2

This figure plots estimates of implicit and explicit transaction cost for US equity in 2001 and 2011, arguably pre- and post-HFT-entry. The NYSE/NASDAQ effective spread and retail commission were taken from Angel, Harris & Spatt (2015), implementation shortfall from Frazzini (2012), and institutional investor commission from Cappon (2014). Average stock price was assumed to be \$30 (Angel, Harris & Spatt 2015, p. 23) and the average retail order size was assumed to be \$6000 (Lee & Radhakrishna 2000, p. 102). Volume is expressed in Feb 2016 dollars and was taken from data.worldbank.org.

Source: Menkveld (2016)

The role of high frequency trading

- High-frequency traders use advanced technology to submit, modify, and cancel quotes at high speed.
- They “collocate” their servers next to the exchange servers to minimize latency.
- Machines replaced human traders.
- Virtu Financial, Citadel Securities, Two Sigma Securities, Tower Research Capital, Jump Trading, DRW, etc.
- Substantial debate on whether they enhance market efficiency – they bring both benefits and costs to markets

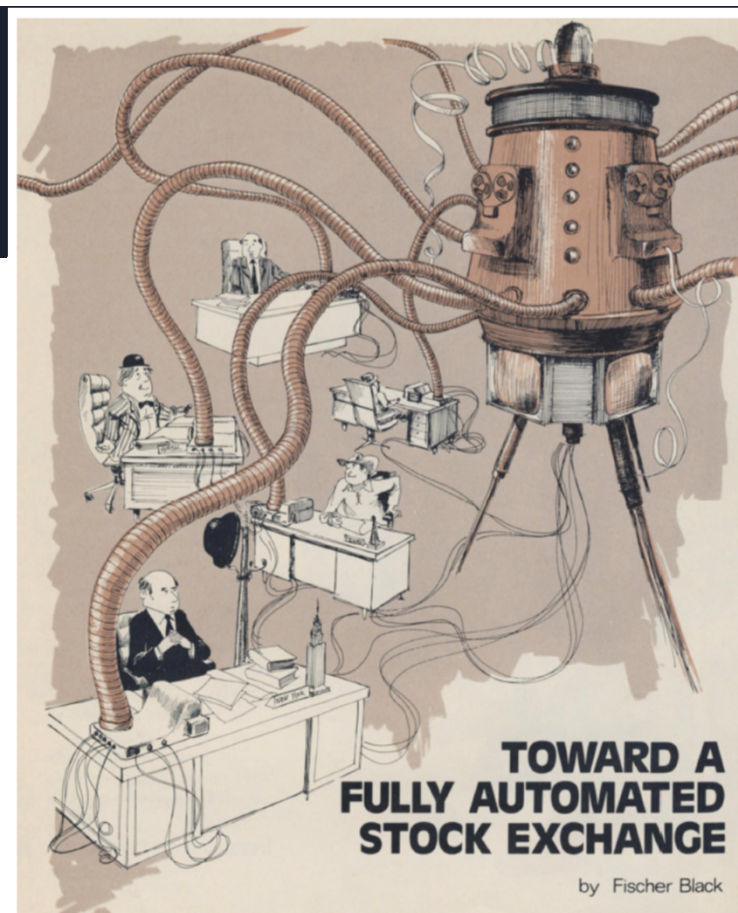


Figure 1

Fisher Black's vision of a fully automated exchange appeared in the Financial Analyst Journal in 1971 (Black 1971a, 1971b).

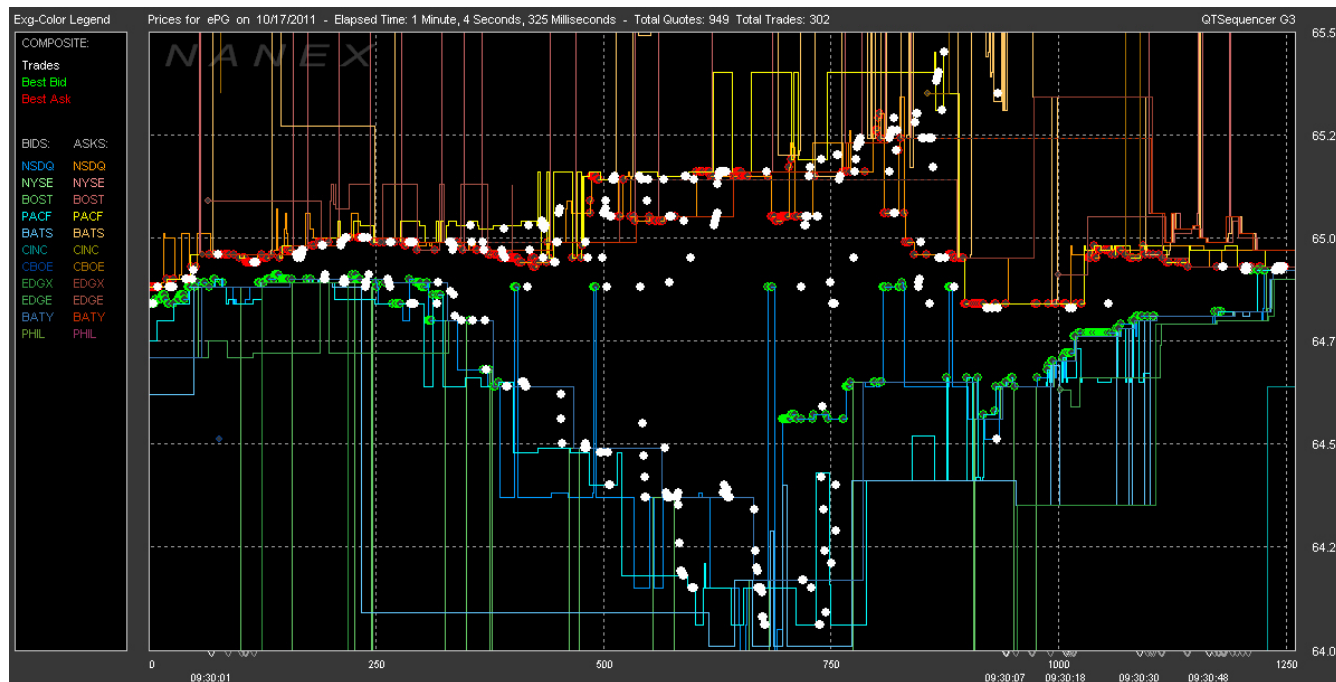
Source: Menkveld (2016)

The true markets are the data centers



Activity at high frequency

Proctor & Gamble, 10/17/2011. 1 min, 4 sec, 325 ms. 949 quotes, 302 trades.



What's the impact of high-frequency trading on market quality?

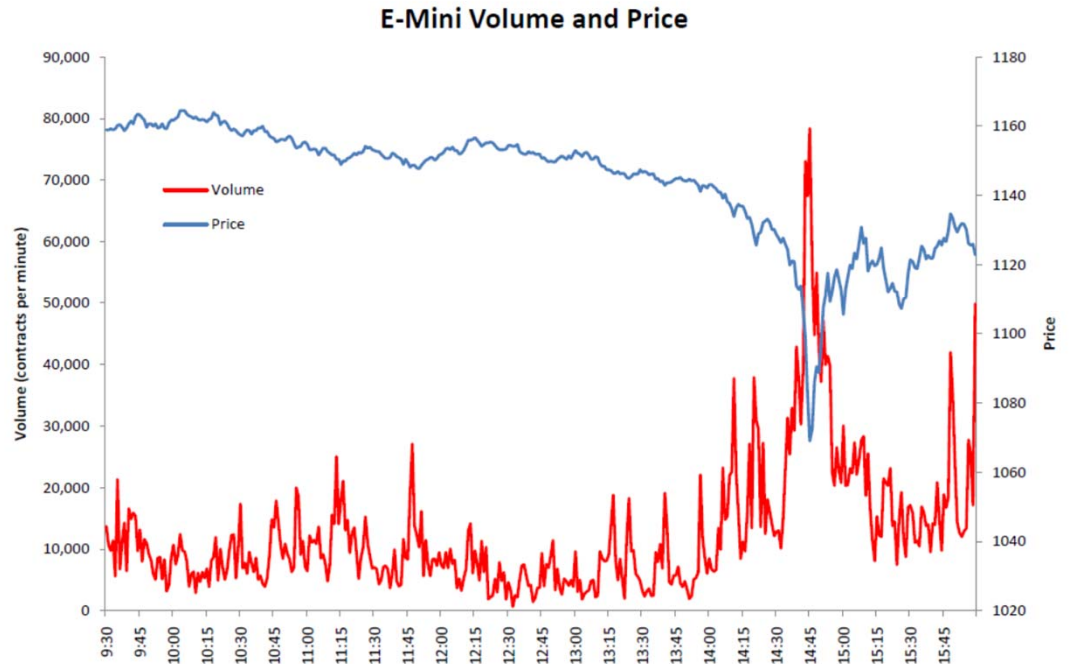
- First view: high-frequency traders are liquidity providers. Their speed enables them to quote competitive prices (since they can also cancel fast). They try to make money from the spread (and exchange rebate), while avoiding being “picked off”. Under this view, they are beneficial to market quality. There is evidence supporting this view.
- Second view: high-frequency traders are predators. Institutional investors are too big to hide their tracks. HFTs figure out their trading direction and “front-run” them. Under this view, HFTs harm institutional investors. Michael Lewis’ best seller *Flash Boys* has a colorful presentation of this view. There is also evidence supporting this view.
- Menkveld (2016) reviewed the academic evidence and theories, and concluded that on balance, HFTs are beneficial to market quality.



Flash crashes

FIGURE 1.1: E-Mini Volume and Price

- On May 6, 2010, the E-mini S&P 500 futures price dropped by more than 5% within 5 minutes, before recovery.
- There was no significant “fundamental” information in that period.
- Wake-up call about the vulnerability of high-frequency markets.
- Since then, major flash crashes happened in US Treasuries and foreign exchange markets.



Source: CFTC-SEC Flash Crash report



When algos go wrong

New York Times, "Knight Capital Says Trading Glitch Cost It \$440 Million", Aug 2, 2012:

"\$10 million a minute.

That's about how much the trading problem that set off turmoil on the stock market on Wednesday morning is already costing the trading firm.

The Knight Capital Group announced on Thursday that it lost \$440 million when it sold all the stocks it accidentally bought Wednesday morning because a computer glitch."



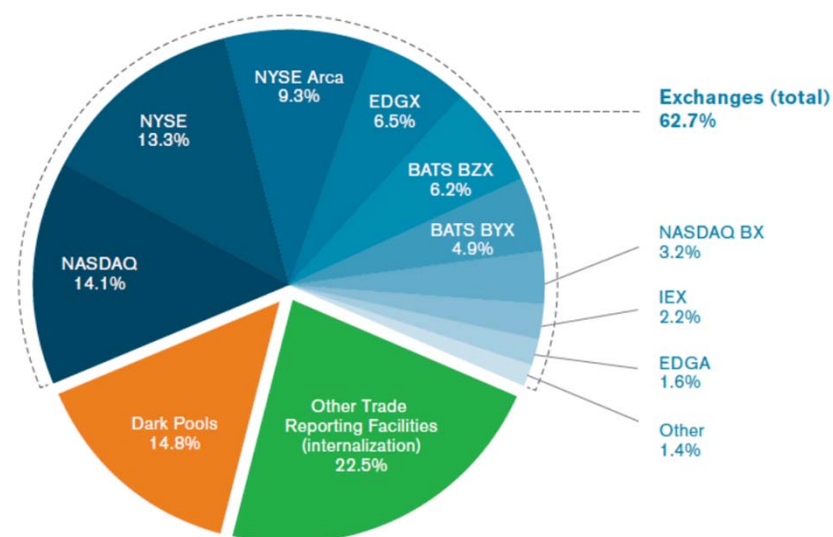
" Sir, while we were installing the new auto-trading software one of the techs sneezed and, long story short, our portfolio just lost a third of its value. "



The role of off-exchange trading

- In the US, about 15% of equity volume is executed in “dark pool” and about 25% by “internalization”.
- When these trades are publicly reported, they show as “trade reporting facility” (TRF). We observe the price and the quantity of a “dark” trade, but not where it happened. It could be one of the dozens of dark pools or hundreds of broker-dealers.

Figure 5: Equities Market Share by Venue



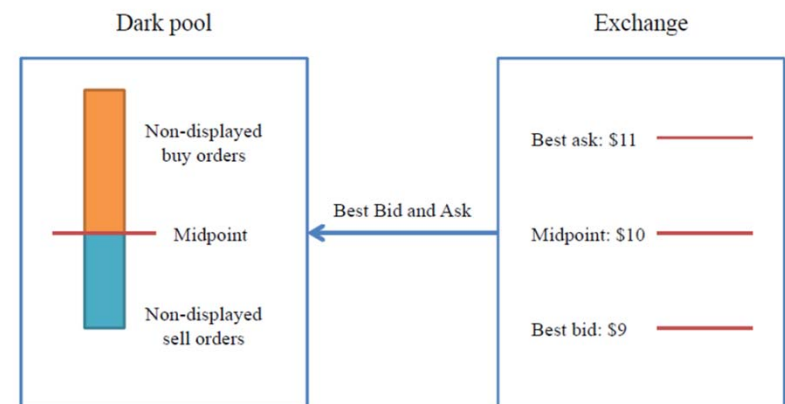
Source: Rosenblatt Securities, July 2017

Source: Treasury report



Dark pools

- Trading within the NBBO looks attractive.
- Hence the birth of “dark pools”—marketplaces that do not display prices and match buyers and sellers within the exchange bid-ask spread.
 - Benefit: saving the spread
 - Cost: your order may or may not be filled entirely, depending on the imbalance
 - Examples include ITG POSIT and Liquidnet.
- Today, most dark pools are operated by broker-dealers (e.g. UBS, Credit Suisse), and they are essentially “dark” limit order books. They see what’s on the exchange, but not vice versa.
- Active debate as to how “dark pools” contribute to market performance



Source: Zhu (2014)



Internalization

- Internalization means customer orders are executed out of a broker-dealer's own inventory, rather than sent to the broader market.
- By Reg NMS, internalized trades should happen within or at NBBO.
- A particularly important category of internalization is the handling of retail orders, and the practice of “payment for order flow.”



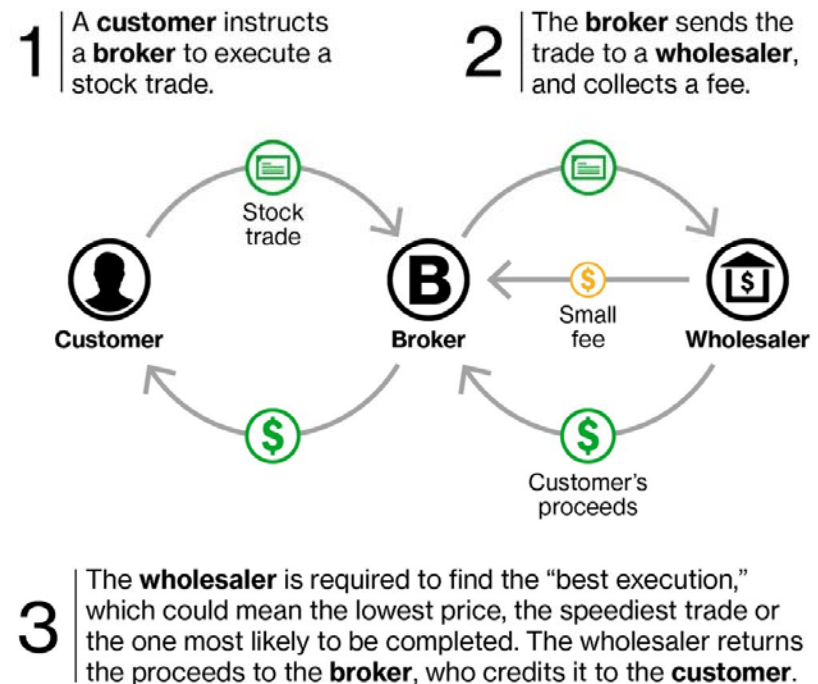
Payment for order flow

- In today's US equity markets, marketable retail orders (i.e., they can be executed immediately at current market prices) are almost always internalized.
- The broker (e.g. TD Ameritrade) sends retail orders to a wholesaler (e.g. Citadel) and gets a small fee for it.
- Hence, "Payment for order flow".
- The retail order is filled by the wholesaler, with tiny price improvement over NBBO.
- The broker must file regulatory reports to disclose how much was paid, etc.
- Why are retail orders valuable?



How Payment for Order Flow Works

Retail brokers typically don't execute their customers' orders. Instead they pass the trades to wholesalers like Citadel Securities or KCG that pay them a fee.



Source: Bloomberg

Summary

- How does the market work?
- Market mechanisms: auctions, continuous limit order books, dark pools, internalization, payment for order flow
- Players: institutional investors, retail investors, high-frequency traders, exchanges, dark pool operators, broker-dealers, regulators
- Ultimately, investors and issuers care about how the market works for them—low cost, efficient, transparent, fair, and stable.

