Overview of Electronic Market[1]

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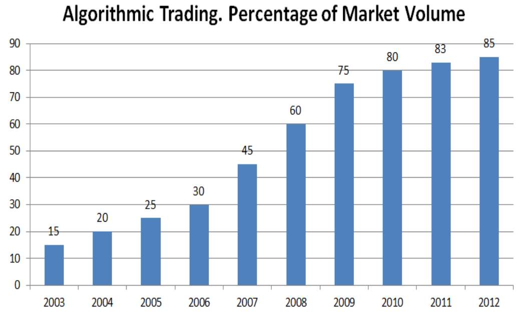
[1] Reference: Avellaneda (2011), Maglaras (2015)

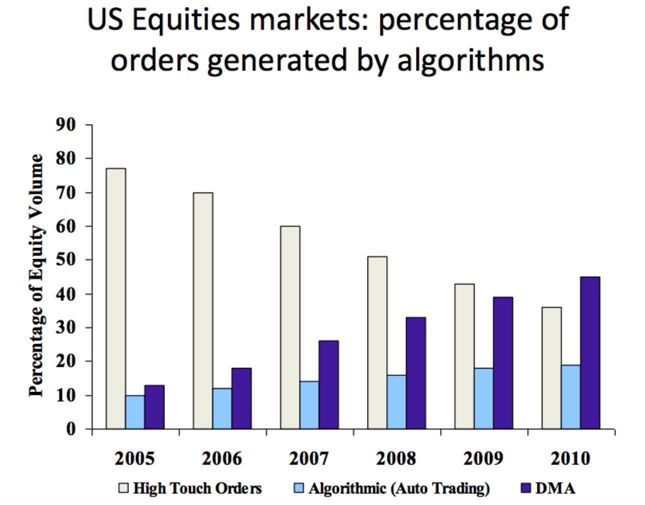
Increasing Percentage of Algo Trading



- A third of all European Union and United States stock trades in 2006 were driven by automatic programs, or algorithms.
- As of 2009, studies suggested HFT firms accounted for 60-73% of all US equity trading volume, with that number falling to $\sim 50\%$ in 2012.
- FX markets also have active algo trading ($\sim 25\%$ in 2006).
- Futures markets are considered fairly easy to integrate into algo trading, with $\sim 20\%$ of options volume by 2010.

Algo Trading in US Equity Market

- [2]

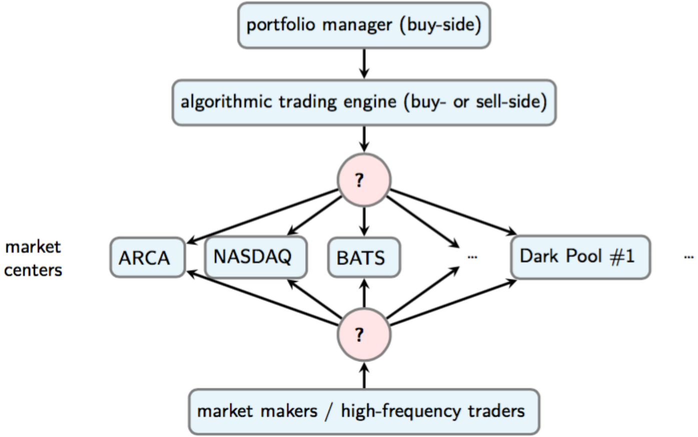


[2] Avellaneda (2011)

Increasing Percentage of Algo Trading (Cont)

- **Algorithmic Trading**
  - A method of executing a large order (too large to fill all at once).
  - Small slices of the order (child orders) are sent out to the market over time.
  - Orders are automatically designed by pre-programmed algorithms.
  - Variables accounted include time, price and volume.
  - Popular *algos* introduced in Lecture 2.
- **Direct Market Access (DMA)**
  - Normally, trading on the order book is restricted to broker-dealers and market making firms.
  - Using DMA, buy side firms use the information technology infrastructure of sell side firms, but control the way a trading transaction is managed themselves rather than passing the order over to the broker's own in-house traders for execution.
  - Today, DMA is often combined with algorithmic trading.

Simplified View of Trading



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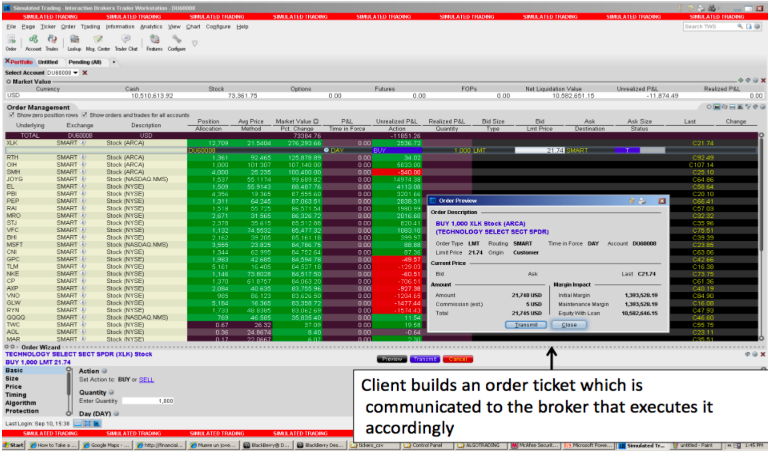
A few trading venues for US equity markets[3]

- ARCA-NYSE: electronic platform of NYSE (ex- Archipelago)
- BATS: (Kansas)
- BEX: Boston Equity Exchange
- CBSX: CBOE Stock Exchange
- CSXZ: Chicago Stock Exchange
- DRCTEDGE: Direct Edge (Jersey City, NJ)
- ISE: International Securities Exchange
- ISLAND: Acquired by Nasdaq in 2003
- LAVA: belongs to Citigroup
- NSX: National Stock Exchange (Chicago)
- NYSE: New York Stock Exchange
- TRACKECN: Track ECN

[3] Avellaneda (2011)

Electronic order-management and execution system (client-broker)

- [4]



Client builds an order ticket which is communicated to the broker that executes it accordingly

[4] Avellaneda (2011)

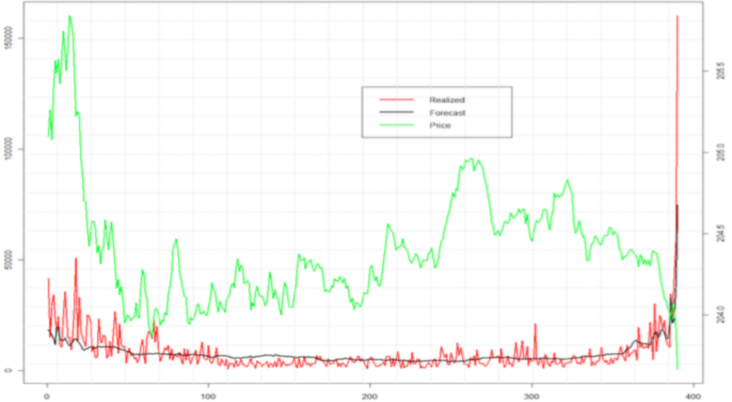
Modern US Equity Markets

- Electronic order-management and execution
- Decentralized/Fragmented
  - NYSE, NASDAQ, ARCA, BATS, Direct Edge, ...
- Exchanges ($\sim$70%)
  - electronic limit order books (LOBs)
- Alternative venues ($\sim$30%)
  - ECNs, dark pools, internalization, OTC market makers, etc.
- Participants increasingly automated
  - institutional investors: algorithmic trading
  - market makers: high-frequency trading ($\sim$60% average daily volume(ADV))
  - opportunistic/active (price sensitive) investors: aggressive/electronic
  - retail: manual ($\sim$5% ADV; small order sizes)

An Example

- How should you buy 250,000 shares of IBM stock between 12:30pm and 4:00pm?
  - Is this order "large"?
  - How fast should you trade? When to post orders?
  - How much will it cost you?
  - Who are you trading against?
- How is it done in practice?

Example Cont'd



- - Forecasted Volume 12:30-4pm = 1,525,000 shares
  - Average spread = \$.04 (1.95bps)
  - Expected Market Impact (12:30-4pm) ≈ 20bps ≈ 40 pennies/share
  - Expected Market Impact (12:30-1:30pm) ≈ 28bps ≈ 56 pennies/share

Institutional Traders (Informed Traders)

- Institutional traders are usually informed traders.
- *Investment decisions* and *trade execution* are often separate processes.
- Institutional order flow typically has "mandate" to execute.
- Traders select brokers, algorithms, block venue[5], ...
  - (algorithm $\approx$ cost optimization under trading constraints)
- Main considerations:
  - Best execution
  - Access to liquidity (larger orders)
  - Short-term alpha (discretionary investors)
  - Information leakage (large orders the spread over hours, days, weeks)
  - Commissions (soft dollar agreements)
  - Incentives (portfolio manager & trading desk; buy side & sell side)

[5] A block trade is a permissible, noncompetitive, privately negotiated transaction either at or exceeding an exchange determined minimum threshold quantity of shares, which is executed apart and away from the open outcry or electronic markets.

Institutional Traders (Cont'd)

- Execution costs feedback affects:
  - Portfolio selection decisions
  - Hedge fund performance
- S&P 500:
  - Average daily volume (ADV) $\approx< 1\%$
  - Market capital $\approx .1\% \sim 2\%$
  - **Depth** (displayed, top of book) $\approx$ .1% ADV
  - **Depth** (displayed, top of book) $\approx 10^{-6} \sim 10^{-5}$ of MktCap
- Orders need to be spread out over time.

Market Depth

CLIMBING THE MARKET

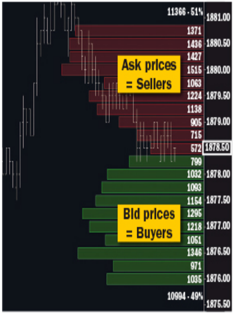
A price ladder or DOM displays market depth data.

Buy	Price	Sell
	1882.00	
	1881.75	
	1881.50	
	1881.25	
	1881.00	
	1880.75	
	1880.50	
	1880.25	1339
	1880.00	1643
	1879.75	1148
	1879.50	876
	1879.25	272
223	(1) 1879.00	
879	1878.75	
1010	1878.50	
1181	1878.25	
1028	1878.00	
	1877.75	
	1877.50	
	1877.25	
	1977.00	
	1876.75	
	1876.50	
Market	PnL	Market
Rev	Flat	Close

Source: NinjaTrader

CHARTING DEPTH

Market depth as an overlay on a price chart. The green bars represent interested buyers; the red bars show interested sellers.



Source: www.baranalyzer.com

Market Makers & HFT Participants

- Supply short-term liquidity and capture bid-ask spread
    - Mostly intraday flow
    - Limited overnight exposure
    - Small order sizes & depth
    - Short trade horizons/ holding periods
- Profit $\approx$ (Captured spread) - (Adverse selection) - (Trading cost)
- It is critical to model **adverse selection**.
    - Definition: Short-term price change conditional on a trade.
    - Essentially "uninformedness" price from information asymmetry.

Market Makers & HFT Participants (Cont'd)

- It is important to model short-term future prices ("alpha")
  - Microstructure signals (limit order book & instant price impact)
  - Time series modeling of prices (momentum Versus reversion)
  - Cross-asset signals (statistical arbitrage, ETF against underlying, ...)
  - News (NLP)
  - Detailed microstructure of market mechanism (human psycho reaction)
  - ...
- Position risks:
  - Adverse price movements
  - Flow toxicity
  - Accumulation of inventory & aggregate market exposure

Toxic Flows

- Types of Toxic Flows [6]
  - Latency arbitrage or "picking-off" the feed
    - Trading on pricing engines of MM's that are slow in updating prices.
    - Slow-price reaction from inefficient technology/ unsophisticated model
  - Market impact of multiple orders
    - Market maker may agree to provide liquidity of some amount at some price level to different platforms.
    - Buy side player may take advantage of this and fit all platforms at that price with larger amount.
  - News trading
    - Trade against market makers on a news release or unexpected event.
- VPIN[7]: Volume-Synchronized Probability of Informed Trading, a measure of order toxicity.
  - Higher VPIN indicates that it is more likely that short-term momentum is due to informed trading.

[6] Aratovskaya (2016)

[7] Easley et al. (2012)

Algo Trading Systems: Typically Decomposed into 3 Steps

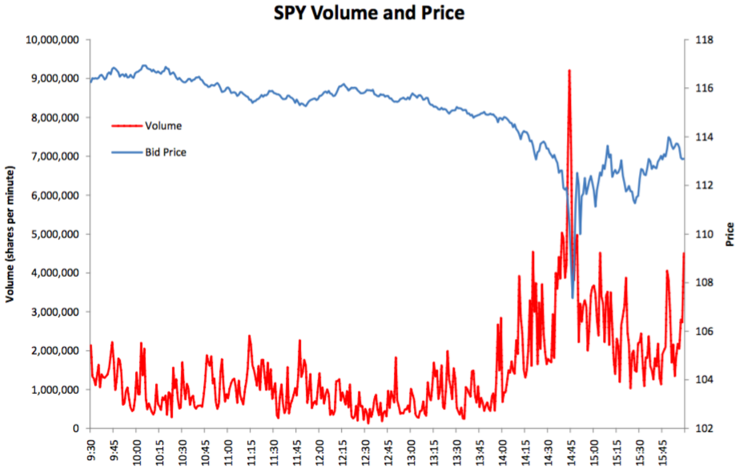
- **Trade scheduling (macro-trader):** splits parent order into $\sim$ 5 min slices (**Lecture 2**)
  - Relevant time-scale: minutes-hours
  - Schedule follows user selected strategy (VWAP, POV, IS, ...)
  - Reflects urgency, alpha, risk/return tradeoff
  - Schedule updated during execution to reflect price/liquidity/...
- **Optimal execution of a slice (micro-trader):** further divides slice into child orders (**Lecture 3**)
  - Relevant time-scale: secondsminutes
  - Strategy optimizes pricing and placing of orders in the LOB
  - Execution adjusts to speed of LOB dynamics, price momentum, ...
- **Order routing:** decides where to send each child order (**Lecture 4**)
  - Relevant time-scale: $\sim 1 - 50$ ms
  - Optimizes fee/rebate tradeoff, liquidity/price, latency, etc

Algorithmic Trading Systems: basic building blocks

- forecasts for intra-day trading patterns
  – volume
  – volatility
  – bid-ask spread
  – ...
- real-time market data analytics
- market impact model
- risk model
  – of the shelf risk models calibrated using EOD closing price data do not incorporate intra-day correlation structure
  – intra-day data? (tractable for liquid securities, e.g., S&P500 universe)
  – cross-asset liquidity model & market impact model

The May 6, 2010 Flash Crash

- [8]



[8] Source: Joint CTFC SEC Report, 9/30/2010

References I

Aratovskaya, A. (2016). What is toxic fx flow? https://www.financemagnates.com/forex/bloggers/what-is-toxic-fx-flow/.

Avellaneda, M. (2011). Algorithmic and high-frequency trading: an overview. https://www.math.nyu.edu/faculty/avellane/QuantCongressUSA2011AlgoTrading

Easley, D., de Prado, M. L. and O'Hara, M. (2012). Flow toxicity and liquidity in a high frequency world, *Rev. Finan. Stud.* **25**(5): 1457–1493.

Maglaras, C. (2015). Limit order book markets: a queueing systems perspective. https://www0.gsb.columbia.edu/faculty/cmaglaras/papers/IC-Lectures-2015.pdf.