Chapter 5
Auctions

Alternative mechanisms

- The limit order book is the central starting point.
- The mechanisms discussed here either augment (assist) the book or (in some cases) serve as the sole mechanism.
  - Auctions (Ch. 5)
  - Dealers (Ch. 6)
  - Dark pools (Ch. 7)
Outline

- Why are auctions attractive?
- How to run a single-price double auction (SPDA)
- Problems and manipulations
- The NASDAQ opening auction.
- Buyers’ and sellers’ profits (surpluses)
- Auctions vs. floor markets
- Other uses of auctions.
- The Facebook IPO

Auctions in securities markets

- Generally concentrate all buying and selling interest at a single point in time.
  - Unlike (e.g.) a sequence of bilateral bargains
- By contrast, eBay auctions are generally
  - single-unit
  - seller’s auctions
  - open outcry (bidders see other bids and can make bids at any time)
Most securities auctions are
- Multiple unit
  - Many shares change hands
- Double-sided
  - Both buyers and sellers participate
  - Use modified open outcry formats
Most common use: opening and closing continuous trading sessions

Opening and closing a continuous market

- Most organized trading is not 24/7.
- Recall: liquidity is a network externality
  - Trading tends to cluster
- Many markets adopt implicit or explicit “regular trading hours”
  - Organized into one or more trading sessions
  - Example: the Tokyo Stock Exchange has a morning session (9:00am - 11:30am) and an afternoon session (12:30pm - 3:00pm)
Volume at the open and close

- At the open, volume driven by
  - Accumulated portfolio rebalancing needs.
  - Accumulated information.
- At the close, large volume pegged to closing prices.
  - Mutual funds: closing prices $\rightarrow$ net asset values $\rightarrow$ used to price customer purchases and redemptions.
  - On derivative final settlement days, closing prices used to compute settlement cash flows.

The typical opening is a single-price double auction (SPDA)

- Order accumulation
  - Buyers are ranked with high bids first.
  - Sellers are ranked with low offers first.
  - Buy orders $\rightarrow$ demand curve; sell orders $\rightarrow$ supply curve.
- The market clears where the supply and demand curves cross.
Buy orders and the demand function

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<th>Cumulative demand</th>
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Sell orders and the supply function

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<td>Jon</td>
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<td>4</td>
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</table>
The demand and supply curves are combined.

At any price, \( P \):
- The matched volume is the minimum of supply and demand at \( P \).
- If (at \( P \)) there is excess demand, there is a buy imbalance.
- If (at \( P \)) there is an excess supply, there is a sell imbalance.
- The net imbalance is the size of the excess.

- At $8, the matched volume is 10; there is sell imbalance of 2.
- At $6, the matched volume is 12; there is a buy imbalance of 2.
- At $5, the matched volume is \______; there is a _____ imbalance of ____.
At $8, the matched volume is 10; there is sell imbalance of 2.

At $6, the matched volume is 12; there is a buy imbalance of 2.

At $5, the matched volume is 8; there is a *buy* imbalance of 6.

The buyers are Alan+Beth+Cam (14 shares); the sellers are Gina+Hari (8 shares).

The clearing maximizes matched volume.

- At a price of $6, the supply, including Ilse, is 12 units.
- The demand, including Cam, is 14 units.
- The total traded quantity is the minimum (12).
- Cam only gets 2 of the 4 units he wanted.
How do we pick the clearing price?

- Economist: “Continuous, strictly monotonic supply and demand curves cross at one point.”

- In practice, discrete prices and units can lead to multiple possibilities.
- “Standard rules”
  - Pick the price that maximizes matched volume.
  - If multiple prices have the same matched volume, pick the price that minimizes the net imbalance.

- Complications and approximations
  - If there are multiple prices with the same matched volume and same net imbalance ...
    - Pick a price in the middle.
    - OR, pick a price that minimizes the change from a prior price.
    - OR, pick a price at random.

Examples ...

- At $14, the matched volume is 3, and there’s a sell imbalance of 2.
  - The buyers are Andy + Bev; the sellers are Aly + Ben + Cathy + Dave

- At $13, the matched volume is 3, and there is a sell imbalance of 1.
  - Buyers: Andy + Bev; sellers: Aly + Ben + Cathy

- At $12, the matched volume is 3, and the imbalance is zero.
  - Buyers: Andy + Bev; sellers: Aly + Ben
  - These buyers and sellers are also active at any price $P: 12 \leq P < 13$

- If we’re limited to whole-number prices, we’d pick $12$ as the clearing price.

- If we can pick any price in the range $12 \leq P < 13$, one option might be to pick the price that would have the smallest change from last trade price. If this were an opening auction ...
  - If the stock closed yesterday at $11, we’d pick “$12”
  - If the stock closed at $13, we’d pick $12.99
At $P = $11, the matched volume is 3; there is a buy imbalance of 1.
- Buyers: Andy+Bev+Chris
- Sellers: Aly+Ben

At $P = $14, the matched vol is 3; there is sell imbalance of 1
- Buyers: Andy+Bev
- Sellers: Aly+Ben+Dave

Between $11 and $14, that is for $11 < P < $14, the matched volume is 3 and the net imbalance is zero.
- For example, at $12, the buyers are Andy+Bev; the sellers are Aly+Ben.
- With these orders, based on matched volume and net imbalance, any price between $11 and $14 could be chosen as the clearing price.

Return to the original set of orders
Compute the profits (surplus)

![Diagram](image)

**Buyers' profits** = 16 + 12 = 28

**Sellers' profits** = 18 + 10 = 28

**Total profits** = 56

A single-price auction maximizes the total buyers and sellers profits.

- Economists call the “trading profits” the *surplus*.
  - It represents extra value gained from trade.
- It is generally true that a single-price double auction where everyone truthfully reveals their buying and selling limit prices achieves the largest total surplus.
- Most economists believe:
  - “If you replaced the inefficient continuous trading mechanism with a single-price auction, everyone would on average be better off.”
- In practice, auctions can be difficult to run.
What can go wrong? Manipulation

- Alan puts in two bids
  - His genuine market order for 4 shares
  - and an “artificial” bid for 10 shares, limit 9.
- The second bid discourages the other bidders (Beth, Cam, and Dana).
  - They don’t bid at all.
- At the last instant, Alan cancels his second bid.

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- The supply and demand curves cross at $4. At $4, the supply is 8 (Gina+Hari), and the demand is 4 (Alan). The matched volume is 4; the sell imbalance is 4.
- Matched vol of 4 and sell imbalance of 4 also holds for any price between $4 and $6.
- The clearing would have to be below $6: Alan would buy his shares below $6 (the price that would have cleared the market if Beth and Cam had joined the buyers.

After Alan pulls his second bid:
What can go wrong? Deadline effects

- When should we clear the market (that is, stop accepting orders and fix a price)?
- If we set a firm time, we often encounter *deadline effects*.
  - Everyone waits until the last moment.
  - These can lead to instabilities and manipulations.
- Should we extend the deadline until outcome looks stable?
  - In Facebook’s IPO, Nasdaq’s open was delayed by 30 minutes, required manual overrides of system safeguards, and left Nasdaq short three million shares.

Stabilization measures

- Randomization of clearing times
- Limited disclosure of demand and supply functions.
  - We don’t always show the full supply and demand curves in real time.
- Special order types
- Early submission and cancellation deadlines for certain orders ("freeze periods")
Randomization

- The auction deadline is a random time (within a narrow window)
  - The London Stock Exchange uses a 6-second window for FTSE-100 stocks
- You can’t submit/cancel “at the last moment”.
- Most US exchanges do not randomize.

The NASDAQ (normal) opening auction (“cross”)

- Illustrates the other stabilization tools (controlled display of supply/demand, special orders, freeze periods).
- Timing
  - NASDAQ systems operate 4am to 8pm.
  - Trading and order entry occurs 7am to 8pm.
  - Regular trading hours are 9:30am to 4pm
  - The opening cross occurs at 9:30am
    - The opening cross operates at the same time as continuous trading.
- Orders may be marked “on open” to indicate that they are only to be executed in the opening cross.
There are two limit order books: the opening book and the regular continuous book.
- They are combined in the open procedure.
- Opening orders must be received prior to 9:28am and cannot be canceled.
- Starting at 9:28am, the system transmits matched volume and imbalance information every five seconds.
- Between 9:28 and 9:30, the system accepts imbalance-only orders.
  - Imbalance only orders are only executed if they reduce the imbalance.
  - Example: if there is a buy imbalance (more buys than sells), a sell imbalance-only order would be executed.

The single-price double auction (SPDA): a second look

- Among all possible allocations, the SPDA maximizes the total buyers’ and sellers’ profits
  - Remember: our “profits” are what economists call “surplus”
- It is not the only procedure that maximizes profits.
- What’s so great about a single price?
What affects traders’ profits in auctions?

Start with the following set of limit orders, ranked from most to least aggressive.

Buyers

- Amy
- Bill
- Cat
- Dan
- Eve

Sellers

- Art
- Bev
- Cam
- Dora
- Ed

The single-price auction

- At $16, the matched volume is 3 and the net imbalance is zero.
- Amy, Bill, and Cat buy.
- Art, Bev, and Cam sell.
Profits at a $16 clearing.

- Amy: $20 - $16 = 4
- Bill: $19 - $16 = 3
- Cat: $16 - $16 = 0
  
  Total buyers' profits are $7

- Art: $16 - $14 = 2
- Bev: $16 - $15 = 1
- Cam: $16 - $16 = 0
  
  Total sellers' profits are $3

Total profits are $10

The single price auction achieves the highest total profits. The efficiency of alternative trading mechanisms is judged by how close they come to this maximum.

A variation: the matching market

- Pair off the most aggressive buyer (Amy) and the most aggressive seller (Art).
  - Cross them at the midpoint of their limit prices.
    
    Amy buys from Art at $17.

- Pair off Bill and Bev at their midpoints.
  Bill buys from Bev at $17.

- Cam and Cat are paired off at $16.
- Dan, Eve, Dora, and Ed don't trade.
**Profits in the matching market**

- Amy buys from Art at $17.
  - Amy’s profit = $3; Art’s profit = $3.
- Bill buys from Bev at $17.
  - Bill’s profit =$2; Bev’s profit = $2
- Cat buys from Cam at $16 (zero profits)
- Total buyer’s profits = $3 + $2 = $5
- Total seller’s profits = $3 + $2 = $5
- Total profits = $10
- *This is the same as the single price auction.*
- The ability of a double auction to maximize the total profits does not depend on there being a single price.

**An extreme alternative: the paired-off traders are always crossed at the buyer’s price.**

- Amy buys from Art at $20.
- Bill buys from Bev at $19.
- Cat buys from Cam at $16.
  - *The total profits are still $10.*
To achieve the maximum total profits, it isn’t necessary that the most aggressive buyers and sellers are paired off.

Suppose that we rearrange the buyers and sellers.
- Amy buys from Bev at any mutually-agreeable price (anything between $15 and $20)
- Bill buys from Cam (between $16 and $19)
- Cat buys from Art (between $14 and $16).

The total profits are still $10.

The maximum total profits are unchanged even if someone makes a mistake.

- In the last example, Amy and Bev have total profits (between them) of $5.
- Suppose that, in a floor market, due to confusion, Amy buys from Bev at $22, outside of her limit price.
- Bev's profit is $22 - 15 = 7
- Amy’s profit is $20 - 22 = -2
- Amy’s profit + Bev's profit is $7 - 2 = 5
What *can* go wrong? Suppose that the wrong people trade.

- In a floor market ...
  - Cat and Cam trade (zero profits)
  - Dan and Bev trade (zero profits)
  - Eve and Art trade (zero profits)

The total profits here are $4.

Art: “Why was Amy in such a hurry to buy? I would have given her a much better price?”

*Note that here, everyone trades.*

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**Allocational Efficiency**

- A SPDA achieves the maximum profits (surplus).
- Suppose that we have some other mechanism, like a floor market that makes other allocations.
- The (allocational) efficiency of the alternative is
  \[
  \text{Efficiency} = \frac{\text{Profits under the alternative allocations}}{\text{Profits in SPDA}} \leq 100\%
  \]
- In the last example (“what can go wrong”),
  \[
  \text{Efficiency} = \frac{\$4}{\$10} = 40\%
  \]
The single-price double auction procedures ...

- ... ensure that the “right people” trade (the most aggressive buyers and sellers)
- .... maximize total profits.
  - For this to occur, it is not necessary we don’t need a *single price*.
  - But widely varying prices over short time intervals leave customers with the impression that the market is volatile, and that other people are making better trades.

Problem

- The table on the next slide shows the actual orders and trades for one of our markets on September 10, 2015.
  - Note: The badge IDS have been anonymized!
- The table shows the direction (Buy or Sell) and the limit price.
- If there was a trade, the trade price is indicated, along with the contra and the contra’s limit.
<table>
<thead>
<tr>
<th>Badge</th>
<th>Dir</th>
<th>Limit</th>
<th>Trade Price</th>
<th>Profit</th>
<th>Profit in SPDA</th>
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Questions

- What were the total trading profits?
- If these orders had been handled in a single-price double auction,
  - What would the clearing price have been?
  - Who would have traded?
  - Are these the same people who actually traded?
  - What would the profits have been?
  - What was the efficiency of the floor trading?
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![Graph showing the price movements for different badges.](image)
Here are the trades that actually occurred. In the SPDA, AZU and BRI wouldn’t have traded.

<table>
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The efficiency of the floor-traded allocation is \( \frac{60}{62} = 97\% \)
Other financial auctions

- Periodic calls for low-activity securities.
- Initial public offerings (of debt and equity)
- Credit default swap settlements.
- High-frequency auctions

Auctions in low-activity securities

- Some stocks don’t trade frequently enough to sustain a continuous market.
- The Euronext markets (Paris, Amsterdam, Brussels, Lisbon) use twice-daily single-price call auctions to trade stocks that average fewer than 2,500 trades per year.
US Treasury Auctions

- US T-bills, notes and bonds are sold in auctions conducted at the Federal Reserve Bank of NY.
  - T-bills are auctioned most Mondays and Thursdays
  - T-notes and bonds on Wednesdays
- Two types of bids
  - Competitive bids specify a price and a quantity.
  - Non-competitive bids specify a quantity. The price is determined in the auction.
    - Like a market order.

IPO auctions

- Municipal bonds
  - Underwriting banks bid to purchase issue. They then resell to investors.
- Equity
  - Google IPO
  - WR Hambrecht’s OpenIPO (active, but lightly used)
High-frequency auctions

- Proposed as a replacement for continuous trading.
- Run a single-price call every minute.
- Proponents claim that trading once per minute would ...
  - satisfy most investors’ needs
  - remove the millisecond advantages reputedly used by high-frequency traders.

The Facebook initial public offering (IPO)

- On Friday, May 18, 2012, Facebook sold about 421 Million new shares at an offering price of $38/share.
  - In the primary market, an investment banking syndicate led by Morgan Stanley bought the shares from Facebook (at $38/share, less commission) and redistributed them to public buyers.
- Once the shares were in the hands of investors, they could be traded in the secondary market.
- Facebook chose NASDAQ as its primary listing exchange.
The NASDAQ opening cross for IPOs

- For the initial opening, orders are entered, canceled and revised during a *display-only period* (DOP).
- At the conclusion of the DOP, NASDAQ builds the supply and demand curves, and computes the price and quantity where supply ≈ demand.
- All eligible buyers and sellers are crossed at this price.
- Continuous trading commences.

What happened

- 7:56 NASDAQ announces that the DOP will run from 10:45 to 11:00.
- 10:58 Net Order Imbalance Indicator suggests an opening price of $43. Morgan requests an extension of the DOP to 11:05
- ~11:05 NASDAQ systems construct a cross. This takes about 20 ms.
- NASDAQ systems perform a validation check.
- During the 20 ms computation time, one order had been cancelled. The validation check fails.
- NASDAQ recomputes the cross, and performs a second validation check.
- During this computation, NASDAQ receives two more cancellations, so the second validation step fails.
- NASDAQ computes the cross (a third time), but fails to register one of cancellations, so the third validation fails.
- NASDAQ computes the cross (fourth time). One more cancellation. Validation fails.
- The procedure continues to loop.
- 11:05 NASDAQ management convenes a “code blue” conference call.

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The code blue call

- After a few minutes, the cross failure is attributed to the validation procedure.
- Is there a way to override the validation procedure?
- Yes. Move the cross to a duplicate system that has a few lines of code removed (the “failover” system).
- 11:25 Management approves this action.
- 11:30:09 The failover system computes the cross.
  75.7 million shares trade at $42.
- 13:50 NASDAQ learns that 38,000 orders entered between 11:11 and 11:30 weren’t included in the cross.
- NASDAQ determined that it had a 3 million share short position.
  - ... which it closed (by buying shares at a lower price) at a profit of $10.8 million.
The aftermath

- NASDAQ pays a US fine of $10 million.
  - ... and $62 million to brokers.
  - “NASDAQ will make technical changes to its ... Crosses ... NASDAQ will close its order ports to new orders and cancels after the calculation of a cross is triggered [started] ...”

- See: U.S. Securities and Exchange Commission, 2013. In the matter of the NASDAQ Stock Market LLC and NASDAQ Execution Services LLC ("Facebook").