Why do we need alternatives to limit order markets?

- Markets are liquid for stocks of large companies ...
  - but books often empty for other stocks.
- Prices can change quickly in a limit order book ...
  - But this can generate pressure to trade quickly (not deliberately).
  - Quickly changing prices sometimes seem random and unfair.
The alternatives to a continuous electronic limit order book

- Auctions (Ch. 6)
  - Collect orders; match them all at once at a single price.
- Dealers (Ch. 7)
  - Use specialized traders who are tasked with “making a market”
- Dark pools (Ch. 8)
  - Accept *but don’t display* incoming orders.
  - When we have a matched buyer and seller, execute.

- These mechanisms work alongside the limit order book.
  - Or (sometimes) completely replace the limit order book.

The auction alternative

- Widely used for many things (aside from securities)
- Many auctions can be modeled mathematically.
  - Models → bidding strategies, and new ways to design auctions.
- Formats
  - Seller’s auction of one item
  - Seller’s auction of multiple items
  - Two-sided auctions (buyers and sellers)
The English Auction

- One item, one seller, many potential buyers
  - Art and collectibles
- Open outcry
  - Bidders can hear/see other bids
- Bids ascend until one bidder remains.
- Example: eBay auction.

Strategies and outcomes

- A buyer will bid up to her value ("limit price")
- The item will be sold to the buyer with the highest value
  - but the final price will be the second-highest value (+1 tick?)
- Example
  - Suppose the two highest values in the room are:
    - Alan's value=$2,000; Beth's value=$2,500.
    - If Beth bids $2,000 → Alan does not rebid.
      - Beth buys at $2,000
    - If Alan bids $2,000 → Beth bids $2,001.
      - Alan drops out. Beth buys at $2,001.
Optional features

- eBay auctions are *silent*
  - eBay records and displays the bids.
- A *reserve price* is the seller’s lowest acceptable.
- An *auctioneer* calls out bids (and suggest higher bids).
  - “I have $1,000. Do I have $1,200? ... $1,100?”
  - “$1,000 going once, ..., twice, ..., three times, ... SOLD!”
  - Auctioneers generate interest and excitement.
  - and higher sales prices for sellers.

Alternative auction formats

- *Sealed-bid*
  - Bidders don’t see other bids.
- *Descending price*
  - Start with a high price.
  - Reduce the price until one buyer claims the item (“Mine!”)
  - Also: clock auction.
- *Buyer’s auction*
  - One buyer, many potential sellers.
  - Example: a construction contract that goes to the lowest bid.
Multiple unit auctions

- Many units; bids specify price and quantity.
- US Treasury Securities.
  - Auctions regularly run by Federal Reserve Bank of New York.
  - System: TreasuryDirect
  - Format is sealed-bid

Example

- Treasury has 9 bonds to sell.
- The bids, arranged highest price to lowest, are:

<table>
<thead>
<tr>
<th>Trader</th>
<th>Quantity</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alan</td>
<td>2</td>
<td>$29</td>
</tr>
<tr>
<td>Beth</td>
<td>3</td>
<td>$28</td>
</tr>
<tr>
<td>Cam</td>
<td>1</td>
<td>$27</td>
</tr>
<tr>
<td>Dana</td>
<td>4</td>
<td>$26</td>
</tr>
<tr>
<td>Ed</td>
<td>2</td>
<td>$25</td>
</tr>
<tr>
<td>Fiona</td>
<td>3</td>
<td>$23</td>
</tr>
</tbody>
</table>
... then add the quantity to be sold

- The lowest accepted bid is $26 (Dana).
- In a single-price “Dutch” auction, all bidders pay this price.
- All bidders above $26 get their full quantities.
- Dana gets the three remaining units (one less than she wanted).

A variation: the discriminating “pay what you bid” auction

- Alan pays $29
- Beth pays $28
- Cam pays $27
- Dana pays $26
- Does this raise more money for the seller?
  - Bids will be lower.
  - Overbidding is expensive
    - Buyers might collude.
    - “So what were you thinking of bidding?”
The bidding protocol

- Competitive bids specify a quantity and a price.
- Noncompetitive bids just specify a quantity.
  - “I’ll pay the price that gets set in the auction.”
  - Limited to small ($5M) bids.

Same players, but CAM submits a noncompetitive bid.
The NY Fed posts auction results to Treasurydirect.gov

The NY Fed Treasury auction is a primary market.

- The initial sale or placement of a security.
- Trading after the initial issue of a security is called the secondary market.

Other primary market auctions

- Municipal bonds
- Equity IPOs.
  - See Hambrecht & Quist OpenIPO® at www wrhambrecht com /openipo/
What can go wrong? “Manipulations”

- Informally: any practice that is intended to deceive other auction participants and leads to an unfair, artificial, or distorted price.
- No precise legal or economic definitions.
  - Some practices are clearly illegal.
  - There are gray areas where we aren’t sure.

Seller’s manipulations

- Shilling
  - Seller’s friend places bids to drive the price up.
  - The friend does not want to really buy the item.
  - If the friend’s bid accidentally wins, the seller “buys back” the item at the sale price.
- Setting a high reserve price (gray area)
  - Seller sets a reserve price ten times the estimated value.
  - Seller has no intention of actually selling the item.
  - He really just wants to know how much other buyers would pay for it.
Buyers’ manipulations: Collusions

- Buyers coordinate their bids.
- “We all agree that we won’t bid more than $100. Whoever wins the auction agrees to resell it in a private auction (just us). The profits in this private auction will be shared among us.”
- If there are multiple auctions of different items:
  - “I won’t bid against you for \( x \) if you don’t bid against me for \( y \).”
  - Or, “We’ll take turns. I let you win the even-numbered auctions; you let me win the odd-numbers.”

Buyer Manipulations: Bid shielding

- Buyer places a high bid to discourage other bidders, then cancels it.
- Suppose that an antique desk has a value around $10,000.
- I bid $500. My partner bids $12,000.
  - The $12,000 bid discourages other bidders.
- Just before the auction ends, my partner cancels the $12,000 bid.
- My $500 bid wins.
- Note: eBay has a strict policy discouraging retractions.
The two-sided (double) auction

- Many buyers, many sellers, multiple quantities
- All trades occur at one price.
- Widely used to open and close 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”
  - Most US stock exchanges: 9:30am-16:00pm
  - The Tokyo Stock Exchange has a morning session (9:00am - 11:30am) and an afternoon session (12:30pm - 3:00pm)
- At the start and end of continuous trading ...
  - Trading volumes are high
  - Double auctions work well.
Opening and closing activity

- Based on overnight information, traders change their desired portfolio weights.
  - \(\rightarrow\) large trading needs when the market opens.
- At the close, many transactions use the “closing price” as a reference mark.
  - Futures and options are settled based on the closing price.
  - Mutual funds are valued at closing prices.

To open/close, most exchanges use single-price double-auction (SPDA)

- Double: there are many buyers and many sellers.
- 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 at supply and demand crossing.
At any price, $P$:

- The matched volume in 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 $9$, demand = 4, supply = 12, matched volume = 4, there's a sell imbalance = 8.
- At $6$, demand = 14, supply = 12, matched volume = 12, there's a buy imbalance = 2.
- At $4$, demand = __, supply = __, matched volume = __, there's a buy/sell imbalance = __.
Determining the clearing price

- Step 1. Find the price that maximizes the matched volume.
- Step 2. If >1 price from Step 1, find the smallest net imbalance.
- Step 3. If >1 price from Step 2, break the ties by:
  - Taking the average of the highest and lowest price, or
  - Taking the price that is nearest to the last closing.

Example

- At $6, the matched volume is maximized at 12. Ben gets a partial fill.
Example

At $6: \text{demand} = 14; \text{supply} = 8; \text{matched vol} = 8; \text{buy imbalance} = 6

At $7: \text{demand} = 10; \text{supply} = 12; \text{matched vol} = 10; \text{sell imbalance} = 2

At $8: \text{demand} = 10; \text{supply} = 16; \text{matched vol} = 10; \text{sell imbalance} = 6

At $3: \text{demand} = 16; \text{supply} = 8; \text{matched vol} = 8; \text{buy imbalance} = 8

At $4: \text{demand} = 12; \text{supply} = 8; \text{matched vol} = 8; \text{buy imbalance} = 4

At $5, $6, $7: \text{demand} = 8; \text{supply} = 8; \text{matched vol} = 8; \text{imbalance} = 0

At $8: \text{demand} = 8; \text{supply} = 12; \text{matched vol} = 8; \text{sell imbalance} = 4

$5, $6, and $7 are all candidates for the clearing price ...
$5, $6, and $7 are all candidates for the clearing price.

- If the stock last traded at $4, set clearing price to $5
- If the stock last traded at $10, set clearing price to $7

Computing trading profits

- At a single clearing price of $6 for all trades ...
- The buyers’ profits are $16 + $12 = $28
- The seller’s profits are $12 + $10 = $22
- The total profit is $50.
- These are the gains from trading.
Analysis of trading profits

- Trading profits also called the *surplus*, gains from trade.
- A single-price double auction gives the largest total surplus.
- BUT: the largest total surplus can also be reached by arrangements that don’t have a single price.
  - We can pair-off the buyers and sellers in different ways.

The profits in an alternative (floor market?) allocation

- Suppose we have a floor market and in floor trading ...
  - Seth sells 3 units to Brian @ $4.
  - Sara sells 1 unit to Brian @ $5
  - Sara sells 4 units to Beth @ $7
  - Sasha sells 2 units to Beth @ $8
- Buyers’, sellers’ and total profits?
An alternative to the SPDA: the matching market

- Pair off the buyer with the highest limit price and the seller with the lowest limit price*.
- They trade at the average of their limit prices.
- Pair off the buyer with the second highest limit price, and the seller with the second lowest limit price.
- ...
- Continue as long as trade is possible.
- *If there are multiple buyers or sellers at the same price, pick traders at random.

In a matching market, who trades? Profits?

- Brian and Seth trade 3 units at \((10 + 2)/2 = 6\)
- Brian and Sara: 3 units at \((10 + 4)/2 = 7\)
- Beth and Sara: 3 units at \(((8 + 4))/2 = 6\)
- Beth and Sasha: 2 units at \(((6 + 8))/2 = 7\)
Problems seem equal for SPDA, floor trading, matching market

- Does trading always give the same profits?
- We could always force people to trade at a loss.
- But if trading is voluntary (no force, no threats), do we always get the same profits?
- No: in a floor market, profits can be lower.

Suppose Bev buys three units from Seth @ $3. All other trades are the same as in the SPDA.
- Brian only gets to buy 1 unit (from Sara).
- Total profits?
If we don’t need a single price, do we need an auction?

- Most floor markets did not have an opening auction.
  - Futures pits, traders started bargaining (Citadex).
- “Turning on the switch” in a limit order market (RIT DA) works, but has high volatility.
  - Trades close in time can have very different prices.
  - Customer: “Why did I buy at $10?? In the same second there were trades at $9?”
  - Can a single-price auction give easy, reliable opening?

Deadline effects

- Competitors see our bids and offers: they can react to them.
- We should hold our best bids and offers until the final deadline.
  - Our competitors have less time to react.
eBay auction: 1940’s Oilzum thermometer sign (Feb, 2016)

- Metal, actual height around 15 inches.
- “Nice condition”
- Auction expires Monday, 15 Feb, 19:20:45 PST.
- Next: the bids through approx. 5am, 15 Feb.

Bidding history (as of approx. 5am, Monday, 15 Feb 2016)

<table>
<thead>
<tr>
<th>Bidder</th>
<th>Bid Amount</th>
<th>Bid Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>a**2 (1130 ★)</td>
<td>US $1,056.00</td>
<td>Feb-15-16 05:29:41 PST</td>
</tr>
<tr>
<td>_**n (private)</td>
<td>US $1,032.00</td>
<td>Feb-14-16 21:33:47 PST</td>
</tr>
<tr>
<td>_**m (378 ★)</td>
<td>US $1,000.00</td>
<td>Feb-10-16 07:58:07 PST</td>
</tr>
<tr>
<td>_**n (private)</td>
<td>US $967.00</td>
<td>Feb-14-16 21:33:45 PST</td>
</tr>
<tr>
<td>_**n (private)</td>
<td>US $957.00</td>
<td>Feb-14-16 21:33:43 PST</td>
</tr>
<tr>
<td>_**n (private)</td>
<td>US $897.00</td>
<td>Feb-14-16 21:33:41 PST</td>
</tr>
<tr>
<td>_**n (private)</td>
<td>US $837.00</td>
<td>Feb-14-16 21:33:38 PST</td>
</tr>
</tbody>
</table>

... 

| o**e (1107 ★) | US $19.99 | Feb-05-16 19:52:50 PST |
| m**z (2218 ★) | US $16.01 | Feb-05-16 20:25:57 PST |
| a**s (822 ★) | US $15.00 | Feb-05-16 19:40:54 PST |

Starting Price | US $9.95 | Feb-05-16 19:20:45 PST |

Note: eBay allows automatic bids (which rebid up to some pre-specified limit). The timestamp on an automatic bid refers to when it was originally entered.

Next: bidding near the deadline.
Notes

- eBay allows automatic bidding.
  - An automatic bid is programmed to rebid up to a pre-specified limit.
  - The time stamps on automatic bids are the original entry times, not the rebid times.
  - The price sequence is correct (even though the time stamps appear out of sequence)
- At 19:20:38 (with seven seconds left) bidder 938 makes a jump bid.
Some manipulations occur right before the deadline.

- Return to: Brian/Beth/Ben/Bev, Seth/Sarah/Sasha/Sam
- Brian puts in two bids
  - He wants to buy 4 units, limit $10.
  - He also enters a second, manipulative bid: “Buy 10 units, limit $11.”
- The second bid scares away other bidders.
  - Beth, Ben, and Bev don’t bid.
- At the last instant, Brian cancels his artificial bid.

- After Brian cancels his artificial bid, his original bid for 4 units is the only one left.
- The clearing price is $4. Brian pays $4 per unit (instead of $6).
In a securities auction, how should we set the deadline?

- When should we clear the market (that is, stop accepting orders and fix the price)?
- Because of deadline effects:
  - Everyone waits until the last moment.
  - These can lead to instabilities and manipulations.
- Should we extend the deadline until outcome looks stable?
  - The auction outcome might never stabilize.
  - 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.

One approach: 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.
  - The actual deadline is randomly chosen within this window.
- You can’t submit/cancel “at the last moment”.
Randomization vs. risk

- Randomization=uncertainty=risk?
- Doesn’t randomization increase risk?
- A random clearing time does not affect fundamental risk.
  - It does not make the dividends or earnings more random.
  - It changes the trading environment in a way that makes the market more fair.
- Randomization is not used in the US.

Alternative ways of stabilizing an auction

- Limited disclosure of demand and supply functions.
  - We don’t show the full supply and demand curves in real time.
  - We don’t see every bid or offer, so we can’t react to it.
- Special order types that work to offset imbalances.
- Early submission and cancellation deadlines.
The NASDAQ (normal) opening auction ("cross")

- **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": they will only 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.
  - Matched volume and imbalance are computed for a reference price.
  - "Please note that the Current Reference Price is determined by the price within the NASDAQ Inside [Best Bid and Offer] where the maximum number of shares are paired, the imbalance is minimized and the distance from the bid-ask midpoint is minimized, in that order."
- 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.
Closing auctions

- Many stock and futures exchanges use single-price auctions to close (as well as open) continuous trading.
- The auction procedures are similar to the opening auction except there is often high volume in the continuous market leading up to the auction.
- In the NASDAQ closing cross
  - Market on close (MOC) orders can be entered until 3:50 PM
  - Limit on close orders (LOC) are treated as imbalance orders, and can’t be cancelled after 3:50 PM
  - Imbalance display starts at 3:50 PM

Manipulation: “Marking/banging the close”

- In the closing auction, a trader enters
  - A large buy order, to drive the price up, or
- The trader knows that the price will fall at the next open.
  - Buy high, sell low → the trader is losing money.
- Why?
Traders trying to move prices for VIX futures and options could achieve this by betting on the options at a special auction that takes place each month to calculate settlement values.

ACQ is taking over TGT

- ACQ agrees to buy TGT stock at 10% over tomorrow’s closing price.
- Mark owns 500,000 shares of TGT.
  - If TGT closes $1 higher than today’s close, then Mark makes an extra $1.10 × 500,000 = $550,000.
- Can Mark try to bid up the price of TGT?
- Can someone who holds ACQ try to force the closing price of TGT down (by selling)?
- Both of these actions are illegal.
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.

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.