Securities Trading: Principles and Protocols

Chapter 3
Limit order markets

Assignments

- STPP, Chapter 3.
  - Problems and exercises 1-16. In separate STTP Problems and Exercises notes (on line)
- STPP, Chapter 4. Skip section 4.5
  - Text problems 4.1
  - Embedded problem on NBBO calculation in these overheads.
The (electronic) limit order market

- The dominant trading mechanism for equities, exchange-traded futures contracts and options.
- In foreign exchange (FX), bonds, and swaps, dealer markets dominate.

The basics

- Orders specify direction (buy or sell), quantity and limit price.
  - “Buy 100 MSFT, limit 27”
    ⇔ “Buy 100 shares of Microsoft, up to $27 per share.”
- Orders that can’t be matched (executed) on arrival are added to the book.
  - The book is the collection of unexecuted (“resting”) orders.
- An arriving order is compared to the book.
- If there’s a compatible counterparty order, we have a match.
The terms of the match

- The quantity is the smaller of the quantities in the two orders.
- The match price is the limit price of the resting order.

What happens?

- Suppose that there is one bid in the book: “Buy 200 ABC, limit 20”
- What happens with an arriving order ...
  - Sell 200 ABC, limit 19?
  - Sell 50 ABC, limit 21?
  - Sell 50 ABC, limit 20?
  - Sell 500 ABC, limit 18?
Priority

- Suppose that the buy side of the book has ten bids for XYZ with limit prices at least $10.
- An order arrives: “Sell 39 XYZ, limit $10.” Who gets filled?
- In most markets, the priorities are:
  - Price
    - More aggressive prices (higher bids, lower asks) have priority.
  - Visibility
    - Displayed orders have priority over hidden orders.
  - Time
    - Orders entered earlier have priority.

Other interactions

<table>
<thead>
<tr>
<th>Price</th>
<th>Quantity</th>
<th>Submitted</th>
<th>Trader</th>
</tr>
</thead>
<tbody>
<tr>
<td>50.12</td>
<td>1,000</td>
<td>9:30</td>
<td>Cathy</td>
</tr>
<tr>
<td>50.11</td>
<td>500</td>
<td>9:32</td>
<td>Bill</td>
</tr>
<tr>
<td>$H$</td>
<td>200</td>
<td>9:30</td>
<td>Gina</td>
</tr>
<tr>
<td>SELL</td>
<td>50.10</td>
<td>9:31</td>
<td>Amy</td>
</tr>
<tr>
<td>50.05</td>
<td>1,000</td>
<td>9:30</td>
<td>David</td>
</tr>
<tr>
<td>50.04</td>
<td>500</td>
<td>9:32</td>
<td>Ellen</td>
</tr>
<tr>
<td>50.03</td>
<td>400</td>
<td>9:31</td>
<td>Fred</td>
</tr>
</tbody>
</table>

$H$: hidden
Hari sends in ...

- Buy 200, limit 50.10
- Sell 1,200, limit 50.04
- Sell 1,200, limit 50.05
- Buy 500, limit 50.11

Order modifiers and qualifications

- Immediate or Cancel (IOC)
  - Do it now or not at all.
  - Partial fill is okay, but cancel the remainder.
- All or None (AON)
  - Don’t give me a partial fill.
  - Order held unexecuted until it can be filled in its entirety
- Fill or Kill (FOK) = IOC + AON
  - Execute the entire order right now. Otherwise, cancel.
- Notes:
  - IOC is very common; AON less common.
  - In some markets AON defaults to FOK.
Suppose the book is ...

<table>
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</tr>
<tr>
<td>50.11</td>
<td>500</td>
<td>9:32</td>
<td>Bill</td>
</tr>
<tr>
<td><strong>H</strong> 50.10</td>
<td>200</td>
<td>9:30</td>
<td>Gina</td>
</tr>
<tr>
<td>50.10</td>
<td>400</td>
<td>9:31</td>
<td>Amy</td>
</tr>
<tr>
<td><strong>SELL H</strong> 50.09</td>
<td>100</td>
<td>9:29</td>
<td>Marte</td>
</tr>
<tr>
<td><strong>BUY 50.05</strong></td>
<td>1,000</td>
<td>9:30</td>
<td>David</td>
</tr>
</tbody>
</table>

*H*: hidden

How are the following orders handled?

- Buy 200, limit 50.09.
- Buy 200, limit 50.09, IOC
- Buy 200, limit 50.09, AON
- Buy 2,000 limit 50.10, IOC
- Buy 2,000 limit 50.10, FOK
Live limit order book

- Most exchanges make their books available in real time for a fee.
- BATS Global Markets provides real time books with no charge (batstrading.com)
  - In the Book Viewer panel (lower right), the book in SPY (the S&P 500 ETF) is continually updated.
  - SPY is an extremely active security. For contrast, try PRK.
Consolidated and fragmented markets

- In a **consolidated** market, all trading occurs in one place
  - (Formerly) one trading floor at one exchange.
  - (Currently) one computer system
  - Some US futures contracts trade only in the Globex limit order book.
- In a **fragmented** market, trading occurs in multiple places or systems.
  - US equity markets have multiple trading centers and multiple limit order books

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Trading and listing of US equities

- The “home” for trading a stock is the issue’s **primary listing exchange**.
  - The exchange provides trading facilities/procedures for the stock.
- The listing exchange does not have monopoly trading rights.
- Trading occurs in many venues, through many mechanisms.
Table 4-1. Trading volume (million shares) on Tuesday, January 17, 2012

<table>
<thead>
<tr>
<th>Listing venue</th>
<th>NYSE</th>
<th>NASDAQ</th>
<th>Amex</th>
<th>Arca</th>
</tr>
</thead>
<tbody>
<tr>
<td>New York (NYSE)</td>
<td>811</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chicago</td>
<td>10</td>
<td>4</td>
<td>0</td>
<td>11</td>
</tr>
<tr>
<td>CBOE</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>NYSE Arca</td>
<td>383</td>
<td>205</td>
<td>9</td>
<td>212</td>
</tr>
<tr>
<td>Nasdaq</td>
<td>530</td>
<td>466</td>
<td>11</td>
<td>166</td>
</tr>
<tr>
<td>NASD ADF</td>
<td>1,230</td>
<td>636</td>
<td>37</td>
<td>284</td>
</tr>
<tr>
<td>PSX</td>
<td>28</td>
<td>24</td>
<td>0</td>
<td>19</td>
</tr>
<tr>
<td>NYSE Amex</td>
<td>9</td>
<td>13</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Boston</td>
<td>94</td>
<td>47</td>
<td>1</td>
<td>21</td>
</tr>
<tr>
<td>National Exch</td>
<td>17</td>
<td>10</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>BATS (and BATS Y)</td>
<td>386</td>
<td>222</td>
<td>7</td>
<td>153</td>
</tr>
<tr>
<td>Edge (A and X)</td>
<td>374</td>
<td>187</td>
<td>8</td>
<td>75</td>
</tr>
<tr>
<td>Composite Total</td>
<td>3,865</td>
<td>1,810</td>
<td>88</td>
<td>945</td>
</tr>
</tbody>
</table>

A partial key

- CBOE: Chicago Board *Options* Exchange, which can also trade stocks
- NASD ADF Alternate Display Facility
  - Reporting channel for “dark” trades
- PSX (Nasdaq-owned former Philadephia Stock Exchange)
- BATS (“Best alternative trading system”)
Holding things together

- A fragmented market is difficult to use.
  - Buyers and sellers must search for the best terms of trade.
- To simplify the process, there are linking systems and procedures that aim to create ...
  - Virtual consolidation: the nodes in a fragmented market are linked to approximate the appearance of a consolidated market.
- Some systems are mandated by regulation
- Others have arisen in competitive response to perceived needs.

Market information systems

- Transmit trade reports, bid and ask quotes, etc. from the market centers to the users.
  - They are one-way: they don’t allow users to transmit orders to the market.
- The market information systems also consolidate information.
- The most important piece is the highest bid across all market centers and the lowest offer.
The National Best Bid and Offer (NBBO)

- All quoting market centers communicate their bids and offers to a consolidation system.
- The highest bid is the National Best Bid; the lowest offer is the National Best Offer.
- The NBBO are widely used as reference marks.
  - Later we’ll see that they are used to price retail orders and dark trades. Also used to assess trading costs.

Determination of the NBB

- Market centers generate quote updates through time.
- Maintain a list of what each center is bidding.
- The NBB is the max price in this list.
- Next: example
### Calculation of the NBO

- **Same process, only we use the min across exchanges.**

- **Next overhead: the NBBO spread.**
### NBBO notes

- The exchange(s) at the NBB may differ from those at the NBO.
- The NBBO spread is \( \text{spread} = \text{NBO} - \text{NBB} \).
- When \( \text{spread} = 0 \), the market is said to be **locked**.
  - In principle, a trade could occur.
- When \( \text{spread} < 0 \), the market is **crossed**.
  - In principle, there's an arbitrage.
- Locked and crossed markets only arise across different exchanges. Within any single exchange, locks and crosses don't occur.
- Next overhead: Embedded *practice* problem. Compute the NBBO and the spread. (Answers will be posted to web site.)
### Steps

- For the bid:
  1. Enter the bid for the exchange that just updated.
  2. Propagate the bids downwards for each exchange.
  3. Take the max to get the NBB
- Repeat for the NBO
- Compute the spread
<table>
<thead>
<tr>
<th>Time</th>
<th>Ex</th>
<th>Bid</th>
<th>Offer</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>NBB</th>
<th>AtBBid</th>
</tr>
</thead>
<tbody>
<tr>
<td>11:03</td>
<td>C</td>
<td>20.10</td>
<td>20.20</td>
<td></td>
<td></td>
<td></td>
<td>20.10</td>
<td></td>
</tr>
<tr>
<td>11:04</td>
<td>A</td>
<td>20.09</td>
<td>20.18</td>
<td></td>
<td></td>
<td></td>
<td>20.09</td>
<td></td>
</tr>
<tr>
<td>11:05</td>
<td>B</td>
<td>20.11</td>
<td>20.20</td>
<td></td>
<td></td>
<td></td>
<td>20.11</td>
<td></td>
</tr>
<tr>
<td>11:06</td>
<td>B</td>
<td>20.10</td>
<td>20.11</td>
<td></td>
<td></td>
<td></td>
<td>20.10</td>
<td></td>
</tr>
<tr>
<td>11:07</td>
<td>A</td>
<td>20.08</td>
<td>20.10</td>
<td></td>
<td></td>
<td></td>
<td>20.08</td>
<td></td>
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</tbody>
</table>

**Step 1.** Copy the bid for the updating exchange.

**Step 2.** Propagate the bids that haven’t changed.

**Step 3.** Take the max; see who matches the max.

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**Latency in market information systems**

- Most traders obtain data through consolidated feeds.
- Many market centers allow users ("subscribers") to obtain direct lines, which are faster.
- Next: two data paths
Access systems

- “Access” a quote: achieve an execution against the quote.
- Access systems transmit orders and other messages from users to the market centers.
- Must have verification and security to prevent unauthorized trading.
- Next: brokered vs. direct market access.
Routing systems

- The routing systems of a broker or market center decide where to send an order based on market conditions, relationships, legal obligations, and so on.

- Example: A customer order, “buy 100 MSFT at the market” is entered at E*TRADE (the broker).
  - E*TRADE might send it to Citigroup Capital Markets.
  - ... which might execute the order or send it to NASDAQ
  - ... which might execute the order or send it to ???
Priority in a fragmented market

- Within a single book, orders are usually prioritized by price, visibility, time.
- When there are two orders on different books, any and all of these priorities may be violated.

Trade-throughs

- A trade-through is a violation of price priority
- Example
  - Trader A bids 100,
  - Trader B bids 99
  - Trader C sells to B at 99
    ("C traded through A’s bid.")
  - The disadvantaged parties are A and C
    - or, if A and C are brokers, their customers
Why do trade-throughs occur?

- Ignorance (C may not be aware of A’s bid)
- C may desire a rapid execution.
- C may doubt the firmness of A’s bid.
- Violations of a broker’s agency responsibility to the client.

SEC Regulation NMS (“Reg NMS”)

- NMS: National Market System
- Adopted in 2005 after much debate.
- Established the ground rules for interaction of multiple US equity markets.
- Provisions
  - Order protection against trade-throughs
  - Access fees
  - Subpenny rule
  - Market data rules
Order protection and Reg NMS

- Before a market center executes an order, it must check to ensure that the execution would not cause a trade-through.
  - Check the bids and offers at the top of every other market’s books.
- If the execution would cause a trade-through, the market center must either
  - Return the order unexecuted.
  - Route the order to a market where it could be executed.
- Note: there is an alternative procedure, the intermarket sweep order (ISO), which will be discussed later.