

COMP226: Slides 06

Limit order books

Rahul Savani

rahul.savani@liverpool.ac.uk

Limit order book markets

- In academic work, often called **Continuous Double Auctions**
- Mechanism to **match buyers and sellers**
- Consists of two types of order
 - **Limit orders**
 - **Market orders**

Limit order book

- Limit orders are matched and/or stored
- Market orders are matched against limit orders if possible
- **Unmatched limit orders** are stored in the **order book**
- **Buy orders** or **bids** are stored in the **bid book**
- **Sell orders** or **asks/offers** are stored in the **ask book**

Example

Price	Vol.
104.5	45
103.0	2
102.0	12
101.5	10

100.5	4
99.0	32
92.0	22
91.5	1

- Bids appear below asks
- Price is ascending
- **Best bid** is 100.5
- **Best ask** is 101.5

- **Midprice**

$$\frac{100.5 + 101.5}{2} = 101$$

- **Bid-ask spread**

$$101.5 - 100.5 = 1$$

Limit order book with order IDs

Price	Vol.	ID
102.0	5	915
102.0	7	902
101.5	9	901
101.5	1	920

100.5	2	901
100.5	2	912
99.0	31	910
99.0	1	901

Market order: buy 14

Price	Vol.
103.0	2
102.0	12
101.5	10

100.5	4
99.0	32
92.0	22

- **Average price** paid

$$\frac{101.5 \times 10 + 102 \times 4}{10 + 4} = 101.6429$$

- Resulting limit order book:

Price	Vol.
103.0	2
102.0	8

100.5	4
99.0	32
92.0	22

- Midprice: 101 -> 101.25
- Spread: 1 -> 1.5

Tick sizes and bid-ask spreads

- **Tick size**: smallest increment in price that an equity, future, or other exchange-traded instrument can move by
- Tick sizes can be fixed (e.g. \$0.01, which is common for US equities, or a fixed number of points like 0.25 for an equities futures index), or may vary according to the current price
- For **heavily-traded** instruments **the bid-ask spread** will often be equal to the tick size ("the spread is one tick")
- Similarly, **it is often argued that smaller bid-ask spreads indicate more efficient markets** because a wide spread indicates uncertainty about the "real price"

Buying versus selling

- **Short selling** (also known as shorting or going short) is the practice of selling securities or other financial instruments that are not currently owned, and subsequently repurchasing them ("covering")
- In the event of an interim price decline, the short seller will profit, since the cost of (re)purchase will be less than the proceeds which were received upon the initial (short) sale
- **Shorting is a prevalent practice in equities markets**
- **Note:** in futures markets one is agreeing to delivery in the future and it is not necessary to borrow the underlying at the time the derivative contract is sold

Limit orders versus market orders

- **Limit orders** guarantee price but not execution
- **Market orders** guarantee execution (almost always) but not price
- For market orders, **slippage is an important consideration**

Slippage

Definition

The **slippage** of a trade is the **difference between** the **actual (average) execution price and expected execution price (also known as the "trigger" price)**

- With **market orders**, **slippage is a crucial consideration**, and could be arbitrarily bad
- With **limit orders** your worst-case price is guaranteed, **but you may not execute at all**

Expected execution price

- How accurately one can compute the expected execution price depends on what data is available
- For example, if one only has daily data and the open price is the trigger price that causes you to place a market order it will be very hard to have an accurate expectation of what price you will actually get executed at
- For a market order the **expected execution price can be calculated if one knows the current state of the order book** (e.g. see the earlier example of a buy market order)
- For example, **for a small enough buy order, it would be the best ask**; for a larger order it may be an average over multiple price levels

When does one incur slippage

One incurs slippage because:

- **the state of the order book changes** between when the order is placed and when it reaches the market; and/or
- **one didn't have accurate enough data** to compute an accurate execution price

Note

Slippage is an **extremely important consideration** when developing trading strategies:

- It's relatively easy to devise strategies that appear highly profitable on historic data without including slippage. They would typically have a small profit per round trip trade (completed buy and sell).
- However, these strategies will likely become unprofitable in real trading due to slippage: their expected profit per trade is too small.

Market data

Trading models are developed using historical market data. There are several granularities of market data:

- **Time-based Bars**, e.g., daily, 1-minute bars
- **Tick data** (tick stands for the change in prices due to a trade)
 - Just trades
 - **Level 1**: trades, best bid, best ask
 - **Level 2**: trades, multiple price levels (e.g. 5) in the book

Example of bid/ask data

NQ.csv:

```
"Index","Open","High","Low","Close","Volume","Bid","Offer","BidSize","OfferSize"  
2010-12-14 02:32:00,2209.5,2209.75,2209.25,2209.75,78,2209.5,2209.75,8,107  
2010-12-14 02:33:00,2209.5,2210,2209.5,2209.5,51,2209.25,2209.75,20,24  
2010-12-14 02:34:00,2209.5,2209.5,2209.5,2209.5,1,2209.25,2209.5,16,4  
2010-12-14 02:35:00,2209.25,2210.25,2209.25,2210.25,22,2210,2210.25,13,3  
2010-12-14 02:36:00,2209.75,2210,2209.75,2210,31,2209.75,2210.25,47,25  
2010-12-14 02:37:00,2210.25,2210.75,2210.25,2210.75,58,2210.5,2211,20,72  
2010-12-14 02:38:00,2210.75,2211,2210.5,2210.5,36,2210.5,2210.75,12,5
```

Example of bid/ask data

```
x <- read.csv(file="NQ.csv",  
              header=TRUE, # not needed  
              row.names=1,  
              sep=',', # not needed  
              stringsAsFactors=FALSE)  
  
library(xts)  
x <- as.xts(x)
```

Using `row.names=1` sets the date-times as the names of the rows

This is necessary to make `as.xts()` work

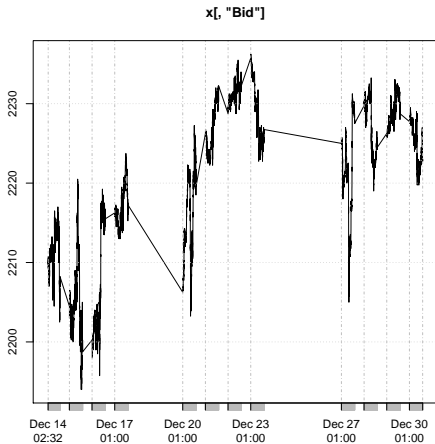
Example of bid-offer spread

```
> head(x)
```

	Open	High	Low	Close	Volume	Bid	Offer
2010-12-14 02:32:00	2209.50	2209.75	2209.25	2209.75	78	2209.50	2209.75
2010-12-14 02:33:00	2209.50	2210.00	2209.50	2209.50	51	2209.25	2209.75
2010-12-14 02:34:00	2209.50	2209.50	2209.50	2209.50	1	2209.25	2209.50
2010-12-14 02:35:00	2209.25	2210.25	2209.25	2210.25	22	2210.00	2210.25
2010-12-14 02:36:00	2209.75	2210.00	2209.75	2210.00	31	2209.75	2210.25
2010-12-14 02:37:00	2210.25	2210.75	2210.25	2210.75	58	2210.50	2211.00

	BidSize	OfferSize
2010-12-14 02:32:00	8	107
2010-12-14 02:33:00	20	24
2010-12-14 02:34:00	16	4
2010-12-14 02:35:00	13	3
2010-12-14 02:36:00	47	25
2010-12-14 02:37:00	20	72

```
plot(x[, "Bid"])
```



Example continued

Date/Time-based subsetting:

```
x <- x["2010-12-14",c("Bid","Offer","BidSize","OfferSize")]  
  
x <- x['T10:00:00/T12:00:00'] # use xts time-of-the-day subsetting  
  
plot.zoo(x, screens=c(1,1,2,2),  
          col=c("red","blue","red","blue"),  
          ylab=c("Bid/Offer","Bid/Offer size"))
```

nasdaqQuotes

