CFRM 551: TRADING SYSEMS
MARKET STRUCTURE

Slides to accompany High-Frequency Trading: A Practical Guide to Algorithmic Strategies and Trading Systems, 2nd edition, by Irene Aldridge

Theory vs. Reality of Trading

Theory	Reality
3.1 Markets are perfect!	3.1 Markets have "frictions"
3.2 Markets immediately reflect all fundamental information	3.2 Markets incorporate and leak information over time
3.3 Markets are uniform	3.3 Markets differ wildly
3.4 Markets are consolidated	3.4 Markets are highly fragmented

Market imperfections

Financial Theory	Trading Practice

• No "market frictions:"
  • No transaction costs
  • Can execute as big or as little position at the market price (unlimited depth)
  • Unlimited borrowing power at the risk free rate
  • No short-sale constraints
  • Market price is invariant to the order size
	3.1.1 Various transaction costs
	
	3.1.2 Finite market depth
	
	3.1.3 Market price subject to market impact

**Optimal algo execution helps navigate imperfections;
HFT exploits imperfections to deliver return = alpha**

Transaction costs

Transparent costs	Latent costs

- Broker commissions
  - Fixed (per order, per month)
  - Variable (per trade size)
  - Leverage costs
- Exchange fees
- Taxes

- Bid-ask spread
- Slippage
- Opportunity Cost

Broker commissions

Fixed Commissions

- Minimum per order
- Minimum per month

Leverage

- Financing charges

Variable Commissions

- Amount per trade size (contract or share)
- Amount per trade value
- Amount per monthly volume

Stocks, ETFs and Warrants	Options	Futures and FOPs	US SSFs	EFPs	Forex	Metals	Bonds	CFDs	Funds	Trade Desk	AQS

Metals (Gold USD/oz. (loco London), Silver USD/oz. (loco London))

IB Commissions

Monthly Trade Amount	Commissions	Minimum per Order
All	**0.15** basis point [1] *Trade Value	USD 2.00

Storage Cost Fees

All	Storage cost 0.10 % per annum.

Exchange fees

Exchange fees

- Can be positive and negative
- Positive fees:
  - Charged for removing liquidity = sending a market order
- Negative fees (rebates):
  - Provided for adding liquidity (posting limit orders)
- Additional fees charged for:
  - Special types of orders (e.g., MPL order on NYSE is a limit order that is not displayed)
  - Algo routing to a liquidity source

Example: NYSE Arca

NYSE Arca Rates Per 100 Shares

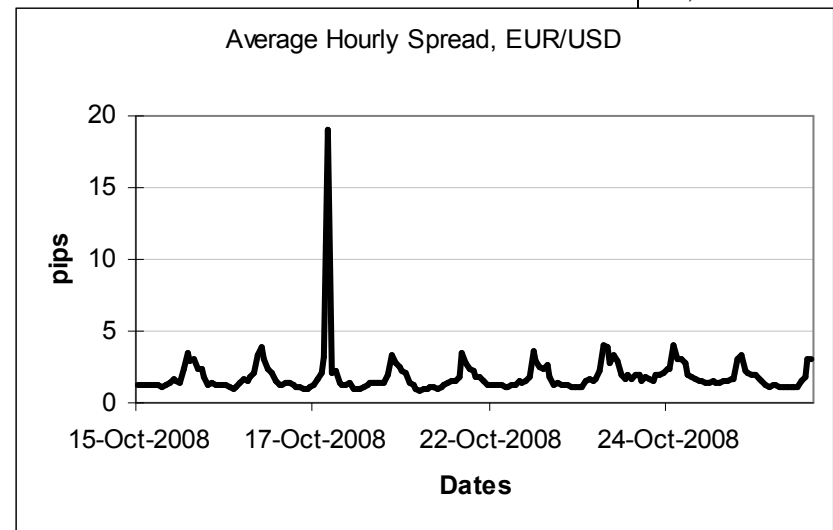| Tier	Tier Requirement(s)	Rebate for Adding[1]	Fee for Removing	Routing to NYSE[2]	Routing to Other Venues
			TAPE A (NYSE-LISTED)		
Tier 1	NYSE Arca Daily Adding as of % of US CADV in excess of 0.70%	$ (0.30)	$ 0.30	$0.21/$0.23	$ 0.30
Tier 2	NYSE Arca Daily Adding as of % of US CADV in excess of 0.30%	$ (0.29)	$ 0.30	$0.21/$0.23	$ 0.30
Tier 3	NYSE Arca Daily Adding as of % of US CADV in excess of 0.20%	$ (0.25)	$ 0.30	$0.21/$0.23	$ 0.30
Step-Up Tier 1	NYSE Arca Daily Adding as % of US CADV in excess of 0.15% over the	$ (0.295)	$ 0.30	$0.21/$0.23	$ 0.30

Bid-ask spread

Definitions

- = best ask price – best bid price
- The cost of instantaneous position reversal
- Premium on immediacy/market orders
  - Traders desiring to fill their orders ASAP pay the bid-ask spread
- Compensation for market-making/limit orders
  - Traders patiently willing to wait to execute charge the bid-ask spread
- Reflects uncertainty in the markets

Example, EUR/USD

- Average hourly bid-ask spread on EUR/USD spot for the last two weeks of October 2008 on a median transaction size of USD 5 mill

Spread on the weekend of Oct 18, 2008 – Oct

Average Hourly Spread, EUR/USD

pips

20

15

10

5

0

15-Oct-2008   17-Oct-2008   22-Oct-2008   24-Oct-2008

Dates

Slippage and Opportunity cost

Slippage

- The difference between the observed pre-order quote and the realized market price
- The price "slips" due to contemporaneous arrival of new orders
- Slippage is typically worst during periods of high trading activity
  - News announcements
  - Market open
  - Market close

Opportunity cost

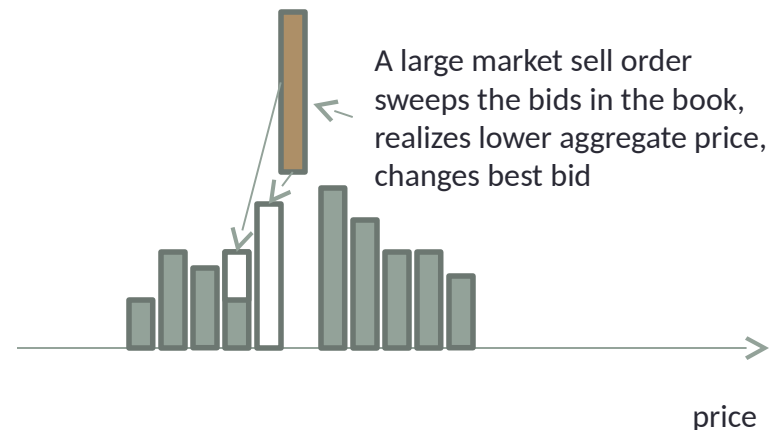- Return that could have been realized with the capital invested elsewhere

Finite market depth
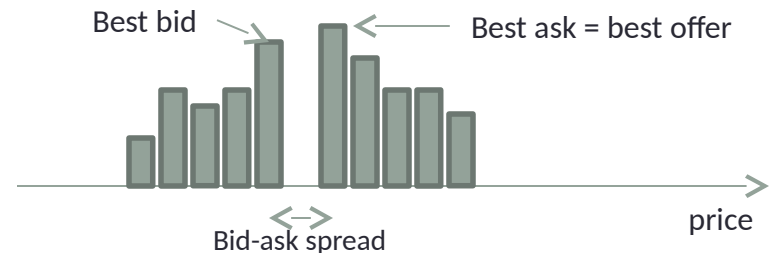
Definitions	Example

Definitions

- Most modern exchanges are organized as "limit order books"
- When a new limit order arrives, it is placed in a limit order bin corresponding to its price
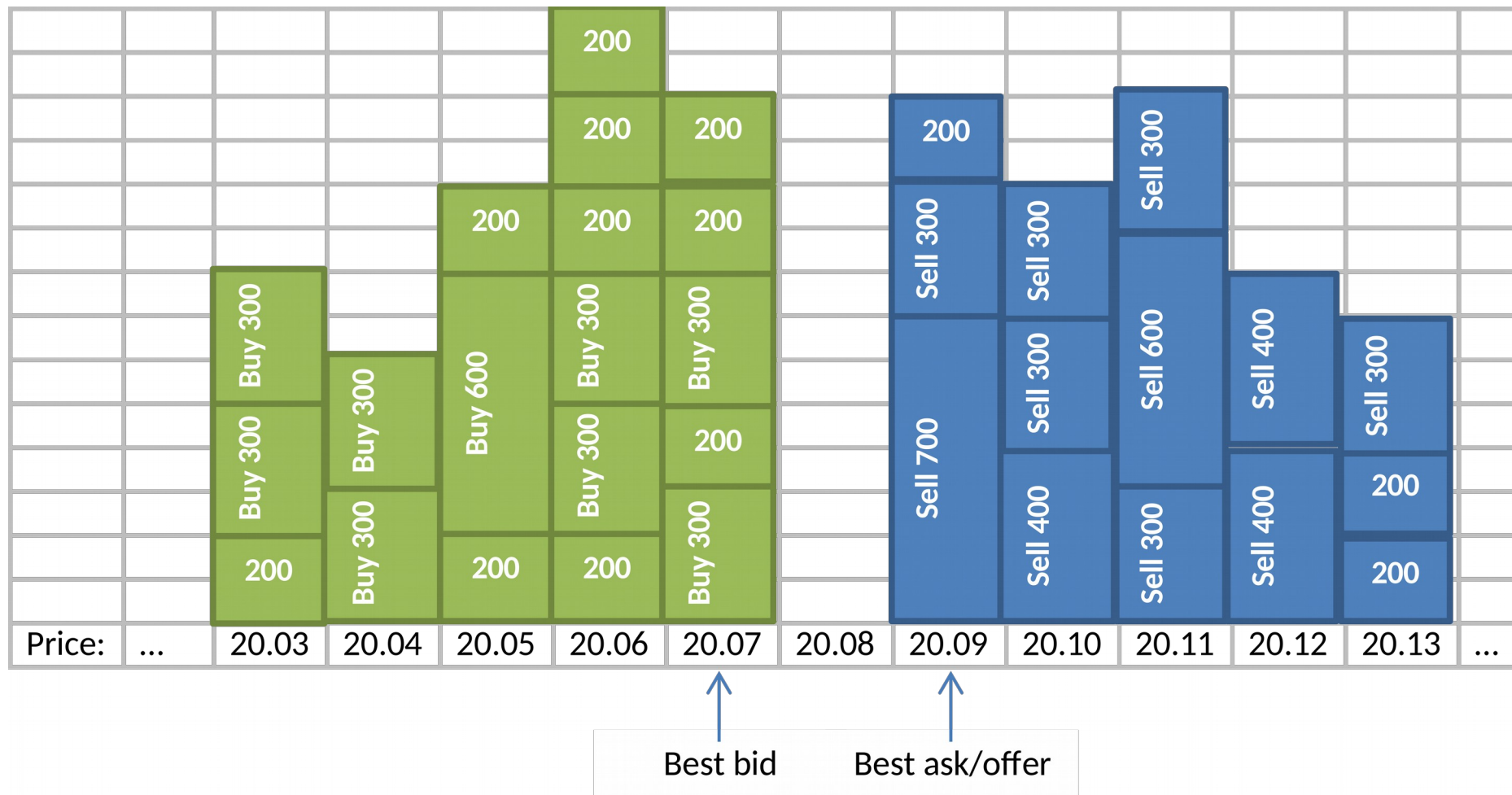- At each price, there is a finite aggregate liquidity = sum of limit order sizes

Example

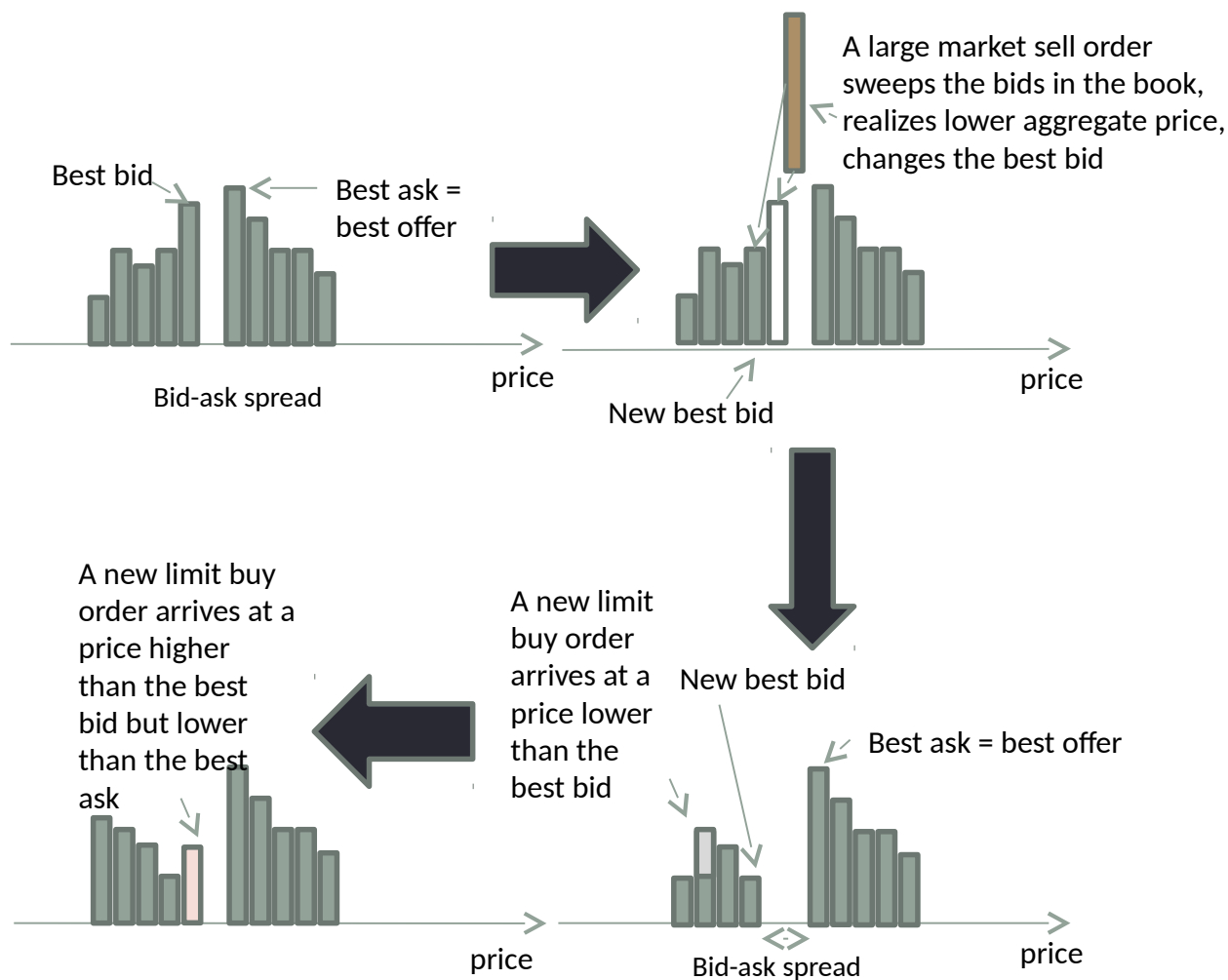- When a large market order arrives and "top of the book" liquidity is exhausted
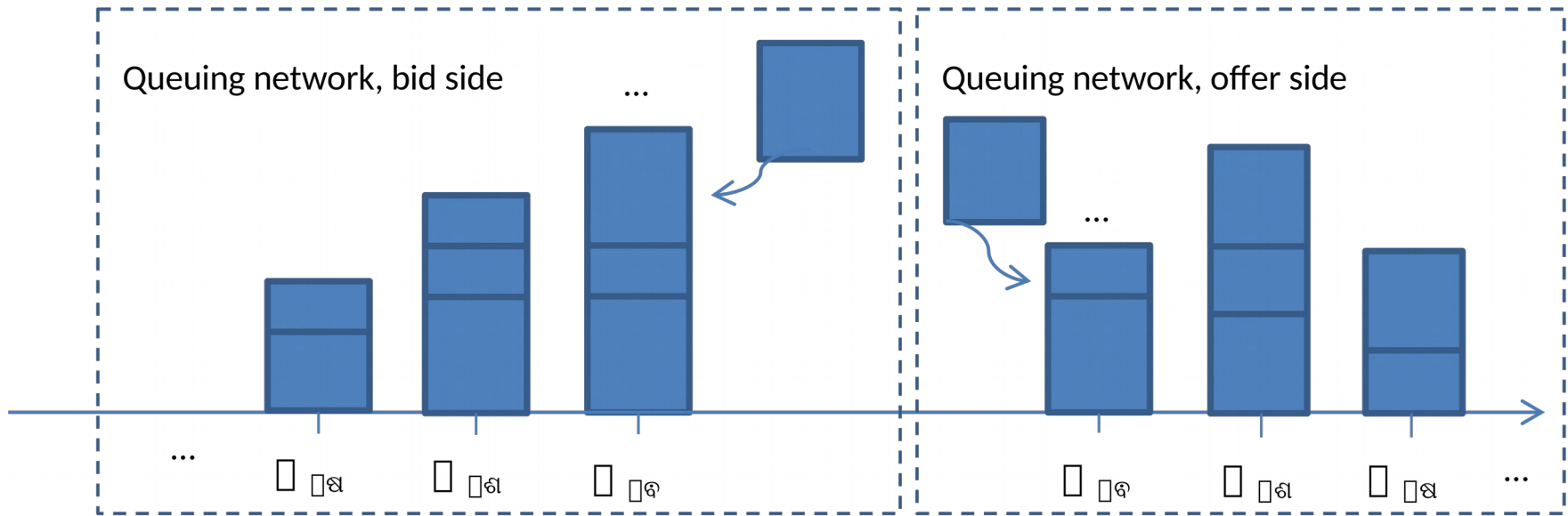 - The market order "sweeps" the book

Best bid   Best ask = best offer

<->
Bid-ask spread

price

A large market sell order sweeps the bids in the book, realizes lower aggregate price, changes best bid

price

Modeling Limit Order Books

| Price: | ... | 20.03 | 20.04 | 20.05 | 20.06 | 20.07 | 20.08 | 20.09 | 20.10 | 20.11 | 20.12 | 20.13 | ... |

Best bid — 20.07

Best ask/offer — 20.09

Sample dynamics

Best bid

Best ask = best offer

Bid-ask spread

price

A large market sell order sweeps the bids in the book, realizes lower aggregate price, changes the best bid

New best bid

price

A new limit buy order arrives at a price higher than the best bid but lower than the best ask

price

A new limit buy order arrives at a price lower than the best bid

New best bid

Best ask = best offer

Bid-ask spread

price

LOB = Queuing System!

LOB Queues

- Order cancellations are disallowed:

- Order cancellations are allowed (vanilla matching):
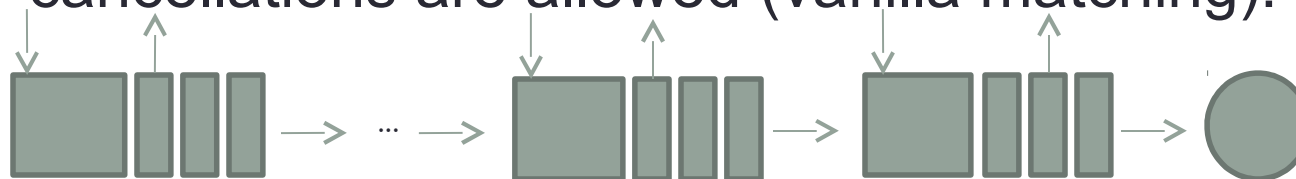
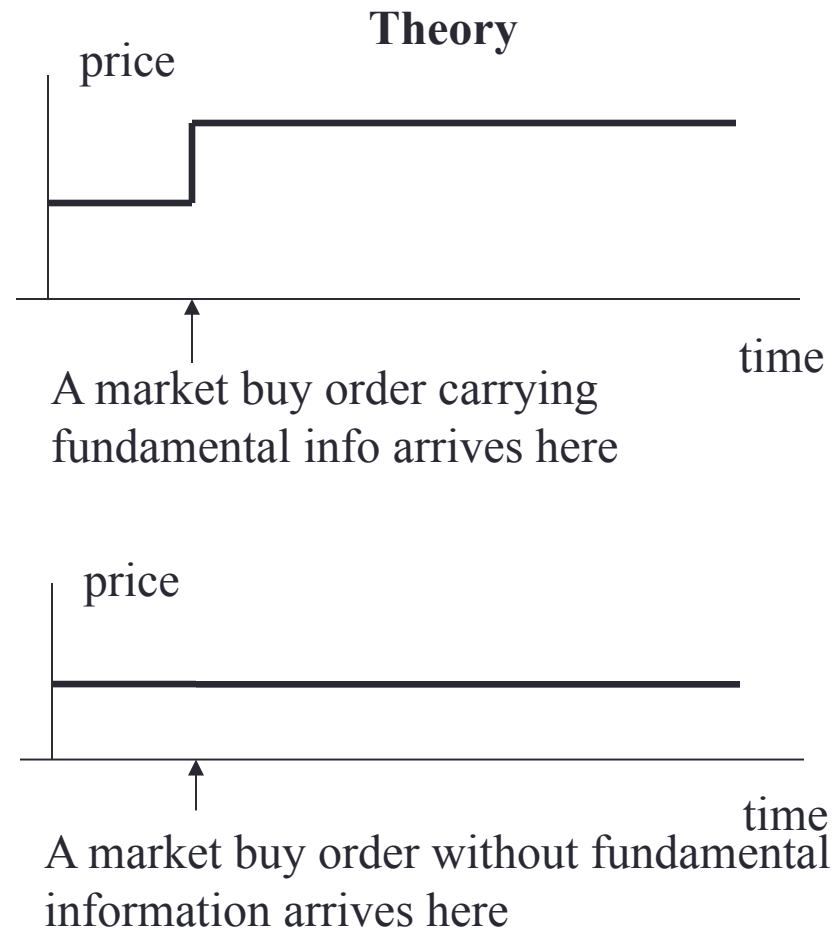- Top-of-the-book cancellations not allowed, but okay elsewhere
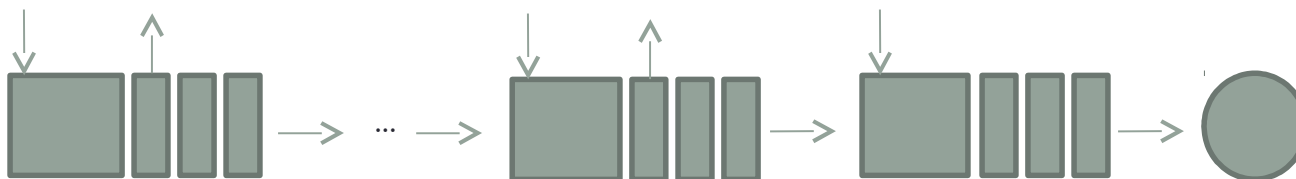
Related literature

- Cont, Stoikov and Talreja (OR, 2010)
- Cont and Kukanov (2012)
- Hasbrouck (2012, 2013)
- Easley, Lopez de Prado, and O'Hara (2011, 2012)
- Vanden Eijnden (2010, 2011, 2012)
- Many others

Market impact

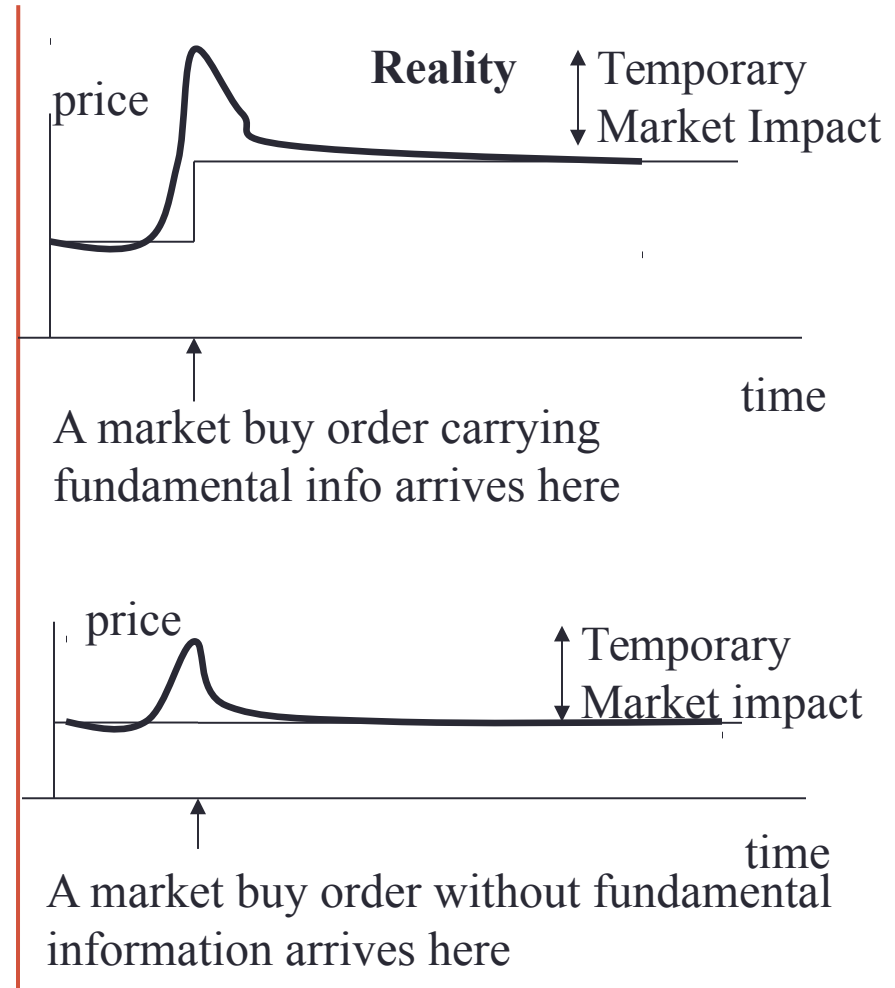| Theory |
| --- |

- In the idealized financial world:
  - Everyone interprets all information in the same way
  - Only fundamentals affect prices
  - As a result, a sharp step function in prices immediately following a fundamental news

Theory

price

time

A market buy order carrying fundamental info arrives here

price

time

A market buy order without fundamental information arrives here

Market impact

Reality

- Traders have different interpretation of news
- Long-term and short-term opinions often differ
  - Implication: short-term traders do not eat long-term traders' lunch;
  - Short-term traders reduce LT volatility instead
- Markets deviate from theory

price

Reality ↕ Temporary ↕ Market Impact

time

A market buy order carrying fundamental info arrives here

price

↕ Temporary ↕ Market impact

time

A market buy order without fundamental information arrives here
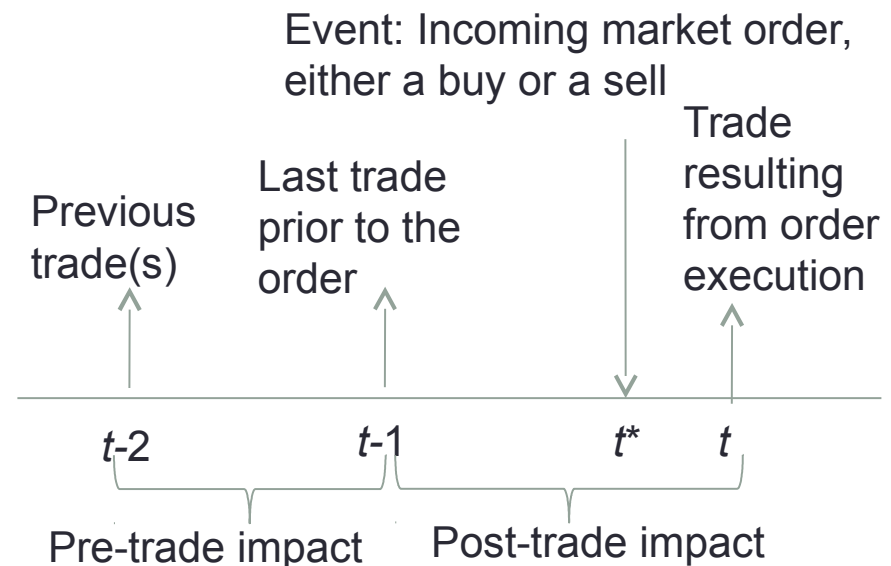
The cost of market impact

- In equities, the ITG's Global Trading Cost Review (2010) reported:
  - The average cost of an equities trade in the U.S. in the first quarter of 2010 was 0.476%,
  - 0.089% was spent on commissions
  - the remaining 0.387% were due to market impact (the numbers were comparable to those in the E.U., the U.K., and Japan; emerging markets posted higher costs).

Market impact

Measuring market impact

- Both pre-trade and post-trade market impact matter
- Pre-trade impact can be due to:
  - Anticipation of a market order
    - algos often "slice" a large order into a predictable sequence of small orders
  - limit orders of opposite direction
- Pre-trade impact ~ 25% of post-trade impact
  - NASDAQ: Hautsch and Huang (2011)
  - EUREX: Aldridge (2012)

Studies

Event: Incoming market order, either a buy or a sell

Previous trade(s)

Last trade prior to the order

Trade resulting from order execution

t-2 t-1 t^* t

Pre-trade impact   Post-trade impact

Information leakage

Trades "Leak" Information

- Market-makers ("specialists") observe market activity
  - Learn information content
  - Adjust quoted prices
- Prices reflect the expectation of security terminal value
  - Net Present Value (NPV) of future cash flows
  - Conditional on all public information, including prior trades
- Price adjustment is gradual
  - Short-run effect
  - Long-run effect
    - Hasbrouck (1991)

Information affecting prices

- News
  - Macroeconomic releases
  - Corporate earnings
  - Political news
  - …
- Trade prices
- Trade sizes
- Best bid/best offer quotes
- Best bid/best offer sizes
- Shape of the order book
- Duration between trades
- Duration between quote "arrival"

Endogenous dynamic between short-term price movements and other market microstructure variables.
Optimal execution algo navigates these issues.

Market con/divergence

Convergence	Divergence

Convergence

- Most markets can be accessed via FIX
- Most markets worldwide are based on limit order book model
- Many trading venues charge for market orders (taking away liquidity) and pay for limit orders (providing liquidity)

Divergence

- Equities are subject to Reg NMS rules
  - All market equity orders must be executed at the National Best Bid/Offer (NBBO)
  - Exchanges that cannot match NBBO must pass the orders on to other venues
- Futures have margining requirements
- Foreign exchange does not have centralized quotes or exchanges
- Options have so many products, that very few investors can keep track of them all
  - As a result, options markets are highly transparent

Market fragmentation

Exchange Competition

- Falling costs of technology allowed multiple start-ups in the exchange field
- Exchanges attempt to differentiate themselves with cost structures and other variables
- Normal exchanges
  - Charge for removing liquidity (MO)
  - Offer rebates for adding liquidity (LO)
- Inverted exchanges
  - Offer rebates to remove liquidity (MO)
  - Charge for adding liquidity (LO)
  - Boston (BX), BYX
  - Very Low Fees: EDGA

Example

- Source: Pragma Securities, "Inverted-Price Destinations and Smart Order Routing"

FIGURE 1

The X-axis indicates the percentage of the time that a venue has the NBB or NBO. The Y-axis indicates the percentage of trades that execute at this venue. The total share is 78%; the rest corresponds primarily to dark pools.

Market fragmentation

- Source: Pragma Securities, "Inverted-Price Destinations and Smart Order Routing"
- Inverted Fees: Boston (BX), BYX
- Low Fees: EDGA

Percentage of trades executed at each venue, given that a certain set of venues had the inside price.