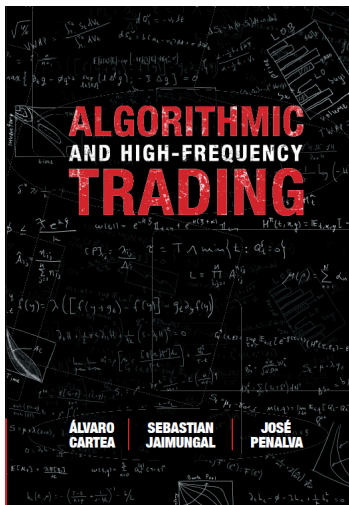


Algorithmic Trading : Introduction

Sebastian Jaimungal

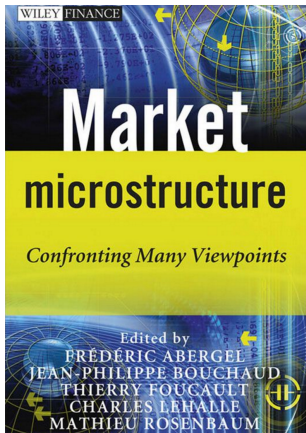
University of Toronto

Jan, 2018



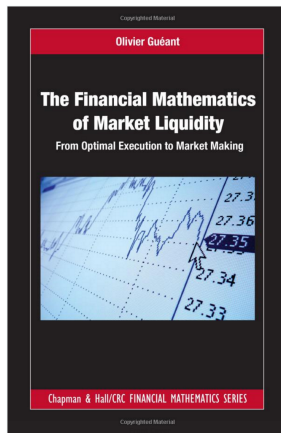
Álvaro Cartea,
Sebastian Jaimungal,
and
José Penalva

Cambridge University Press
(Aug, 2015)



Fréd'eric Abergel, Jean-Philippe
Bouchaud, Thierry Foucault,
Charles-Albert Lehalle, and
Mathieu Rosenbaum

Wiley (2012)



Olivier Guéant,
Chapman and Hall/CRC (2016)

Introduction

Introduction

- ▶ **Algorithmic Trading (AT)**: The use of computer algorithms that make trading decisions, submit orders, and manage those orders after submission.
- ▶ **High-Frequency (HF) Trading**: refers to the subset of AT trading strategies that are characterised by their reliance on speed differences relative to other traders to make profits based on short-term predictions and also by the objective to hold essentially no inventories for more than a very short period of time.

Introduction

- ▶ Why AT? One example
 - ▶ **Institutional investors** need to **trade large volume** of securities. These quantities are too large for the market to process without prices moving in the 'wrong direction' (slippage).
 - ▶ Thus, large orders are broken up in small ones and these are traded over time (minutes, hours, days, weeks, or even months) and across different venues.
 - ▶ Deciding how to break up and execute a large order can mean saving millions of dollars for large players

Introduction

- ▶ Why AT? Another example
- ▶ **Proprietary traders** devise strategies to maximise profits.
 - ▶ Speed based: short-lived signals, news, arbitrage across exchanges
 - ▶ Exploit predictable patterns: pairs trading, co-integrated prices

Exchanges

Exchanges

An exchange is a 'place' where 'people' meet to buy/sell securities: shares, commodities, derivatives, etc

- ▶ **Order Driven Market:**

- ▶ All buyers and sellers display the prices and quantities at which they wish to buy or sell a particular security.

- ▶ **Quote Driven Market:**

- ▶ Designated market makers and specialists display bids and asks for a specific security – e.g., even now **FX markets** are like this.

Order Driven Market

- ▶ All participants can post **limit buy or sell orders** – **provide liquidity**
- ▶ **limit orders** show an intention to buy or sell and must indicate the **amount of shares** and **price** at which the agent is willing to trade
 - ▶ limit buy order with the highest price is known as the **best bid**
 - ▶ limit sell order with the lowest price is known as the **best offer/ask**
 - ▶ The best bid/ask is also called the **touch**
- ▶ The difference between the best bid & offer is called the **spread**
- ▶ All participants can execute **market orders** for buy/selling at the best available prices – **take liquidity**

Evolution of markets

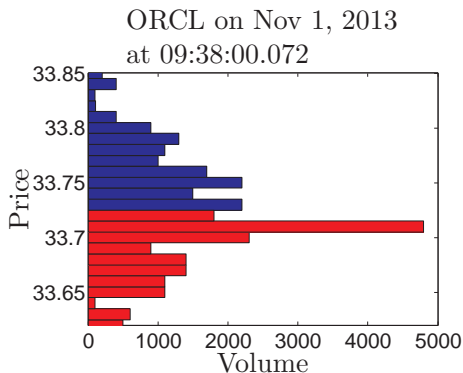
- ▶ Old days brokerage model: Ring a broker, broker sends order to the pit and after screaming and hand signalling the order is executed.
- ▶ Electronic market: Ring or use internet to contact broker who sends the order to the electronic exchange (no screaming)
- ▶ Direct Access Market: clients send orders directly to market

There are a multitude of exchanges... IEX (approved June 2016), ARCA-NYSE: electronic platform of NYSE, BATS (Kansas), BEX: Boston Equity Exchange, CBSX (CBOE Stock Exchange), CSXZ (Chicago Stock Exchange), DRCTEDGE (Direct Edge, Jersey City, NJ), ISE (International Securities Exchange), ISLAND (Acquired by Nasdaq in 2003), LAVA (Citigroup), NSX (National Stock Exchange, Chicago) TRACKECN (Track ECN), ChiX, LSE (London Stock Exchange), BM&F BOVESPA (Brazill) etc, etc

Limit Order Books

Limit Order Book

- ▶ **Limit orders** are accumulated in the limit order book (**LOB**) until they find a counterparty for execution or are cancelled
- ▶ The counterparty is a **market order** which is an order to buy or sell an amount of shares, regardless of the price, and is **immediately executed** against the **best prices**



Limit Order Book

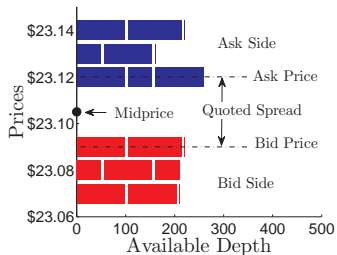
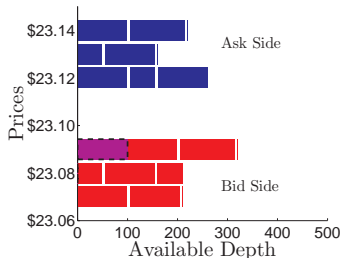
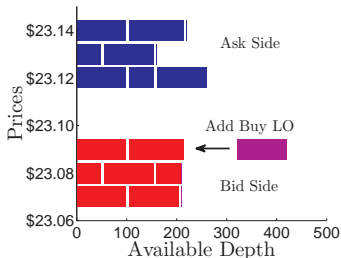


Figure: LOB illustration of a buy LO added to the queue at the best bid.



Limit Order Book

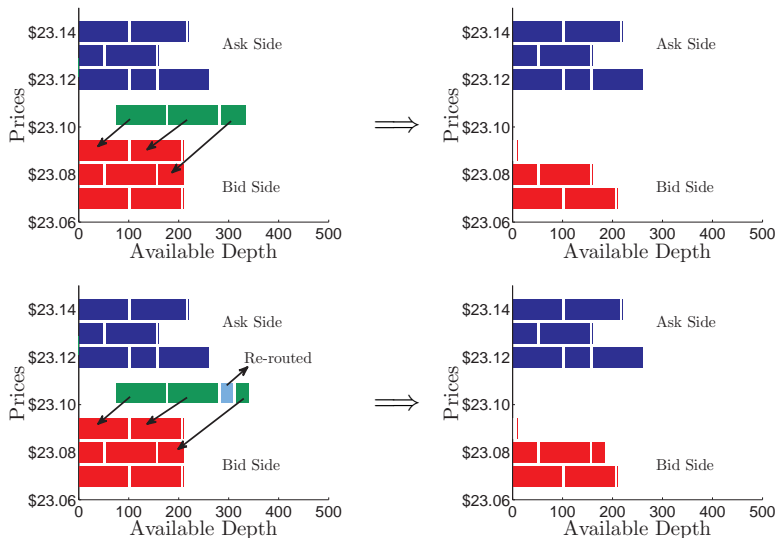
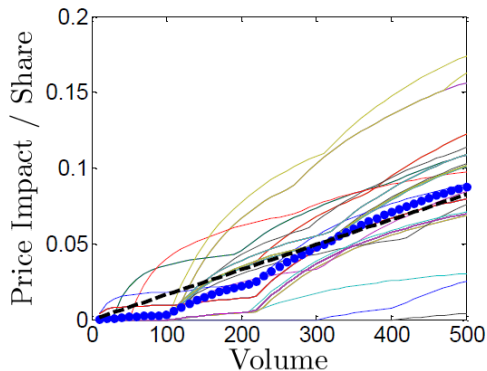


Figure: LOB: a sell MO walking the LOB with and without re-routing.

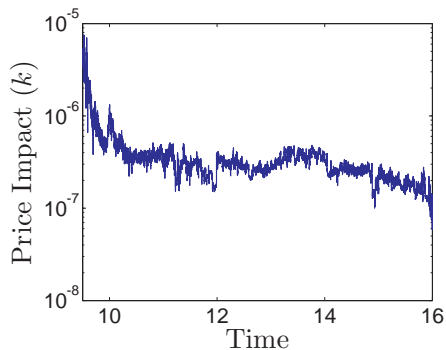
Limit Order Book

Market orders can **walk the LOB** and incur **immediate execution costs**



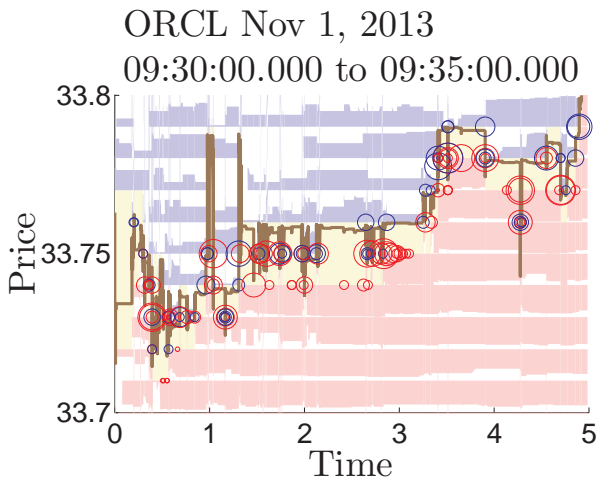
Limit Order Book

Impact dynamics throughout the day



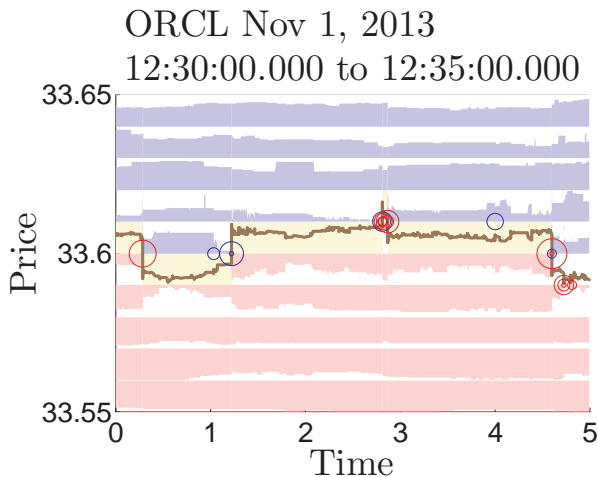
Limit Order Book

Trade Activity



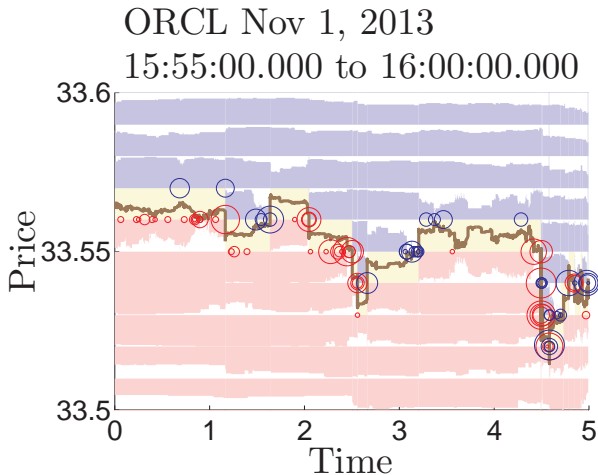
Limit Order Book

Trade Activity



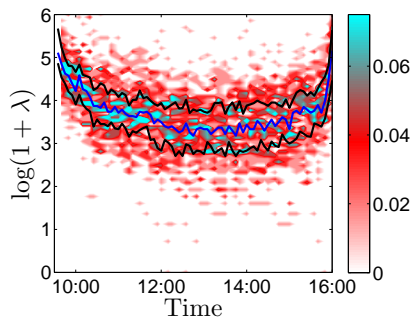
Limit Order Book

Trade Activity



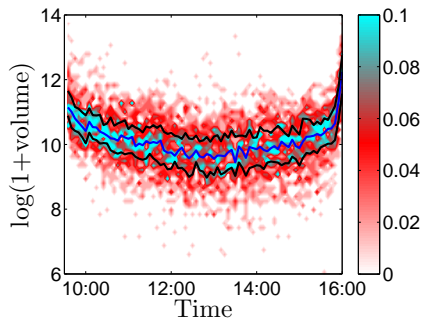
Limit Order Book

Trade Activity: INTC for Oct-Dec, 2014 (5min)



Limit Order Book

Trade Volume: INTC for Oct-Dec, 2014 (5min)



Order Imbalance

Order Imbalance

- **Order Imbalance** measures whether the LOB is buy or sell heavy

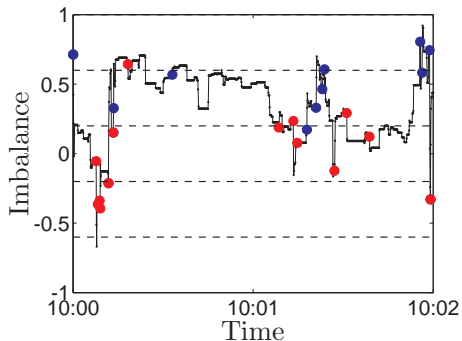
$$\rho_t = \frac{V_t^b - V_t^a}{V_t^a + V_t^b} \in [-1, +1]$$

- Order imbalance is a good **predictor of trade direction**

ORCL Nov 1, 2013						
ρ	direction	buys		sells		Total
		num	perc.	num	perc.	
all		1699	53%	1526	47%	3225
< -0.5	sell heavy	67	12%	506	88%	573
< 0	sell	313	23%	1059	77%	1372
> 0	buy	1385	75%	462	25%	1847
> +0.5	buy heavy	745	89%	91	11%	836

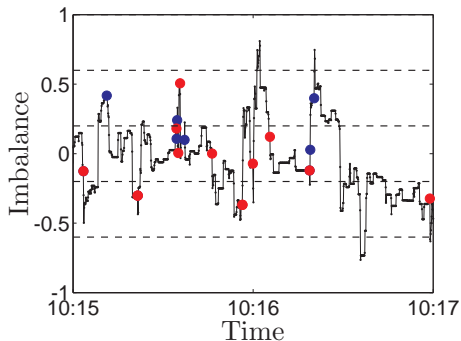
Order Imbalance

A slice of OI for ORCL 10:00am to 10:02am on Nov 1, 2013



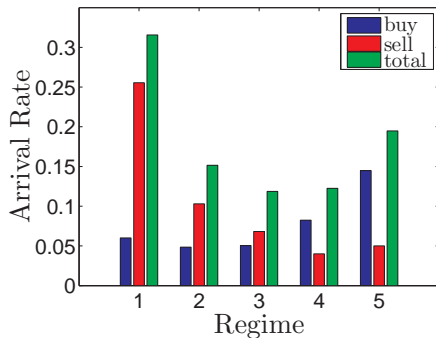
Order Imbalance

A slice of OI for ORCL 10:15am to 10:17am on Nov 1, 2013



Order Imbalance

MO arrival rates conditional on OI: ORCL on Nov 1, 2013



Order Imbalance

- Distribution of midprice change 10ms after a market order.

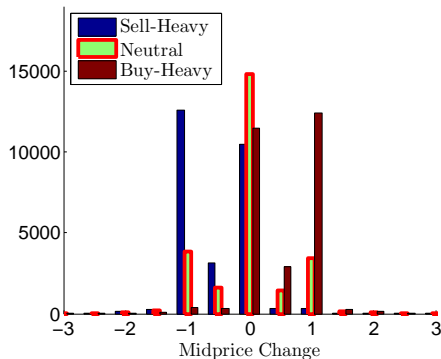


Figure: ORCL: one month of NASDAQ trades. Imbalance ranges are $[-1, -0.33)$, $[-0.33, 0.33]$, and $(0.33, 1]$.

Order Imbalance

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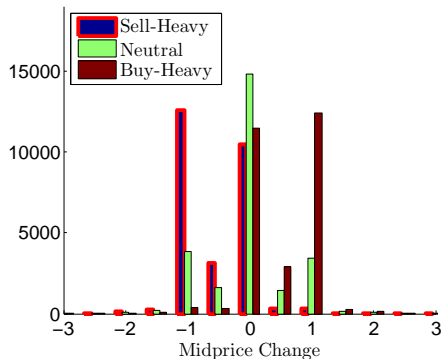


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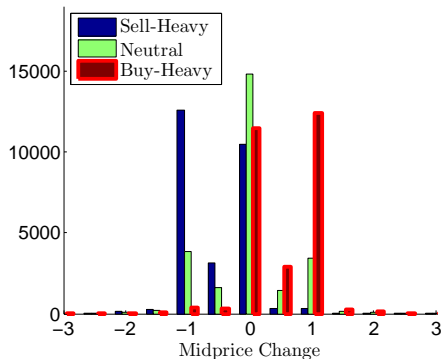


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