Stylized Facts on Market Microstructure I

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LAMA-UPEC

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Outline

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A transaction in an OTC market:

- Is done with **any imaginable instrument** e.g. forwards or exotic options.
- But has **no guarantee** that the trading parts will honor the agreement $\Longrightarrow$ Counterparty or credit risk.

La Criée - from 1774 to 1987

Ticker Tape

SF.I.I.PR.....SF.....RT.IN....ST.....USSPR.....
.....200.76....64¼.....7¾....16⅝.....200.94¼.⅜

RG.I.PR.....A.AJ.....SS.I.....ST.....SF.I.I..PR....
..... 200.8[½.....66.92¾.....20.99....16⅝.....76

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RG. I. PR. . . . . A. AJ. . . . . SS. I. . . . . ST. . . . . SF. I.I.. PR. . . .
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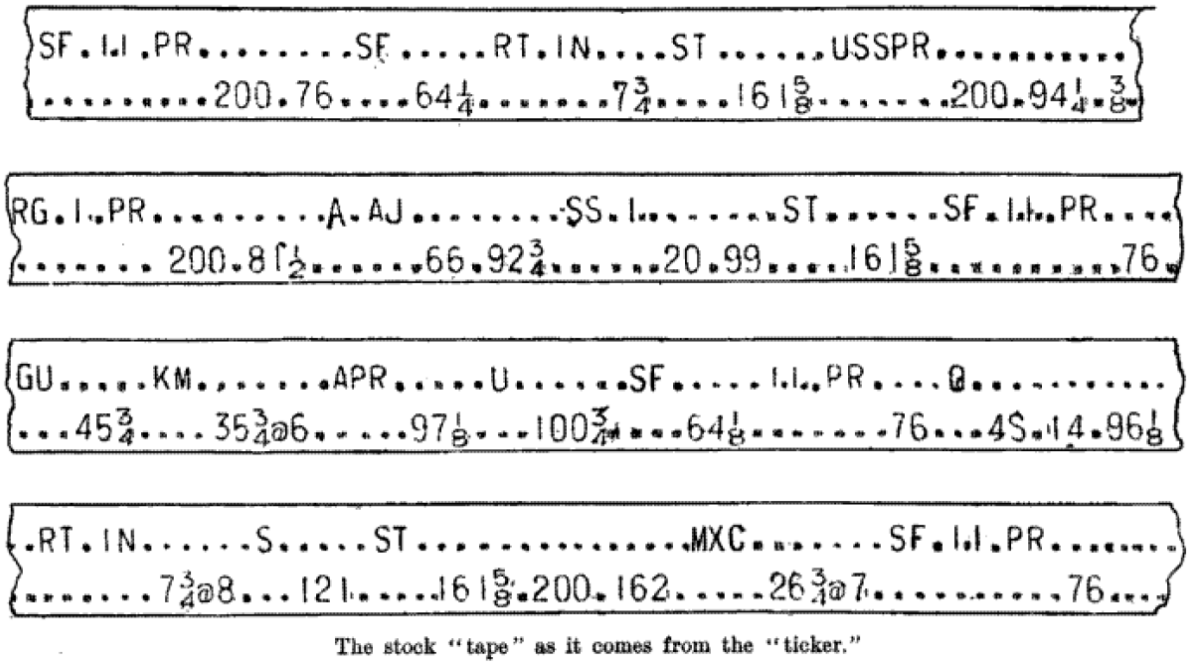
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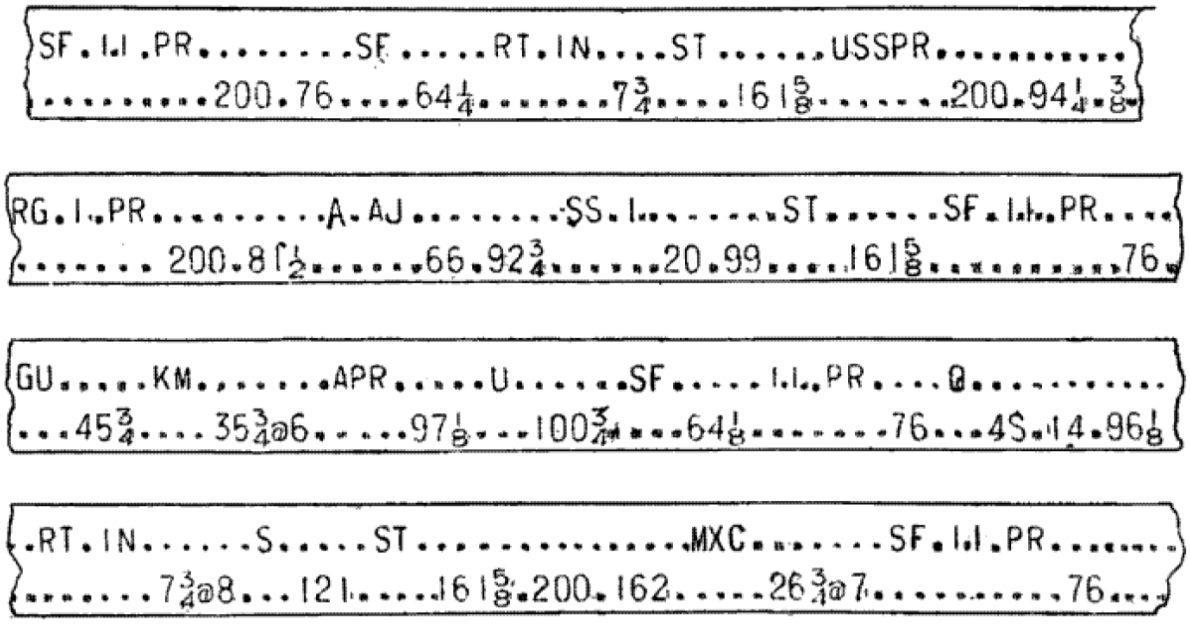
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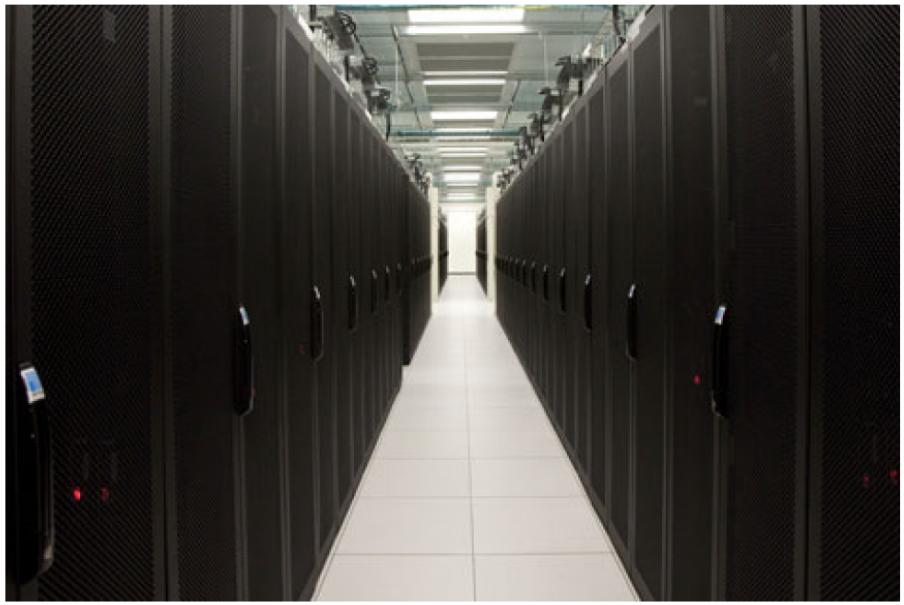
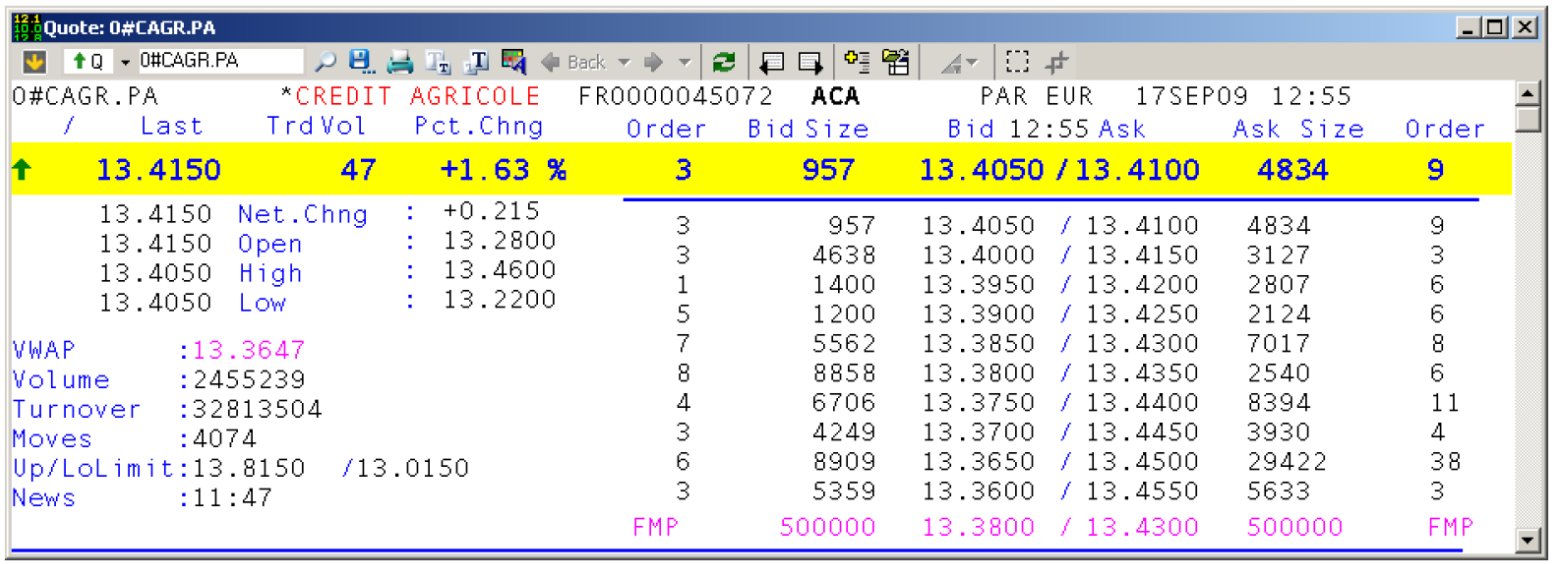
- It consisted of a paper strip that ran through a machine called a stock ticker, which printed abbreviated company names as alphabetic symbols followed by numeric stock transaction price and volume information.
- The term "ticker" came from the sound made by the machine as it printed.

Two possible versions of an exchange



Electronic trading



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- In Europe, the **MPDS** (Market Price Display Service, in London in 1970) has been the **first standardized computer-based price dissemination system** available to the securities industry, but the UK had no success with his IDN (Integrated Data Network) program (1981-1984) that never gave birth to a trading system.

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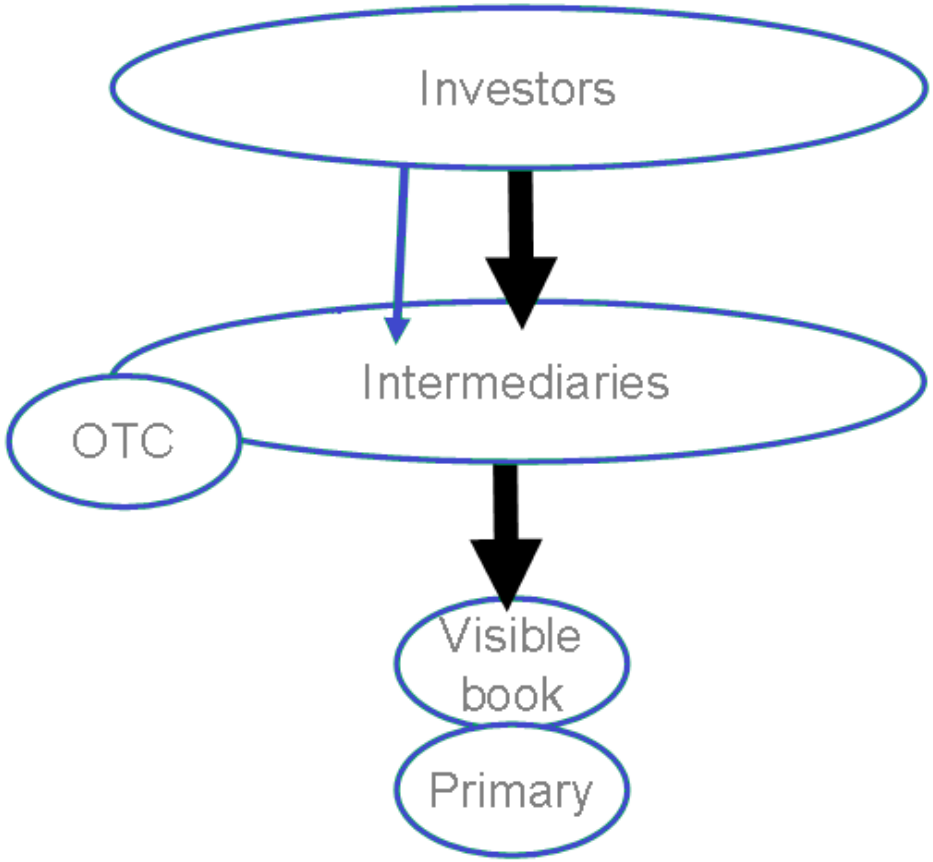
- France introduced automated trading via the **CATS system** (renamed **CAC**, Cotation Assistée en Continu) in 1989.
- followed by Germany in 1991 with **IBIS** (Inter Banken Informationen System).

Old Organization



OTC: Over the Counter.

Reg NMS (2005)

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This regulatory ruling is comprised of four main components:

- The **Order Protection (or Trade Through) Rule** aims to ensure that investors receive the best price when their order is executed by removing the ability to have orders traded through (executed at a worse price). This rule requires trading centers to establish, maintain, and enforce written policies and procedures that are reasonably designed to prevent the execution of trades at prices that are inferior to protected quotations displayed by other trading centers. This rule also created the National Best Bid and Offer (NBBO) requirement that requires brokers to route their orders to the venues offering the best-displayed price.

- The **Access Rule** aims to improve access to quotations from trading centers in the National Market System by requiring greater linking and lower access fees. This rule includes a mandate that each national securities exchange and national securities association adopts, maintains, and enforces written rules prohibiting their members from displaying cross automated quotations or quotations that lock.

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- **Market Data Rules** allocate revenue to self-regulatory organizations that promote and improve market data access (allocation amendment, governance amendment, Distribution and Display Rules).

How Reg NMS Influences Market Efficiency

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There have been critiques of Reg NMS, in particular, the Order Protection Rule that mandates stocks must be traded on exchanges that show the best-quoted prices. One of the criticisms is that the rule gives an advantage to high-speed traders. There is also a perception that the rule makes the market more expensive. Pension funds and other institutions can also find it more difficult to execute trades. Further updates to Reg NMS have been recommended by its critics. Some have gone as far as suggesting the policies be replaced entirely in favor of new rules more in line with current trading practices.

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- MiFID covers almost all tradable financial products with the exception of certain foreign exchange trades. This includes commodity and other derivatives such as freight, climate and carbon derivatives.

Substance of MiFID

- **Authorization, regulation and passporting**: Firms covered by MiFID will be authorized and regulated in their "home state" (broadly, the country in which they have their registered office). Once a firm has been authorized, it will be able to use the MiFID passport to provide services to customers in other EU member states. These services will be regulated by the member state in their "home state" .

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- **Client order handling**: MiFID has requirements relating to the information that needs to be captured when accepting client orders, ensuring that a firm is acting in a client's best interests and as to how orders from different clients may be aggregated.

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- **Systematic Internaliser**: A Systematic Internaliser (SI) is a firm that executes orders from its clients against its own book or against orders from other clients. MiFID treats SI as mini-exchanges, hence, for example, they will be subject to pre-trade and post-trade transparency requirements.

MiFID II

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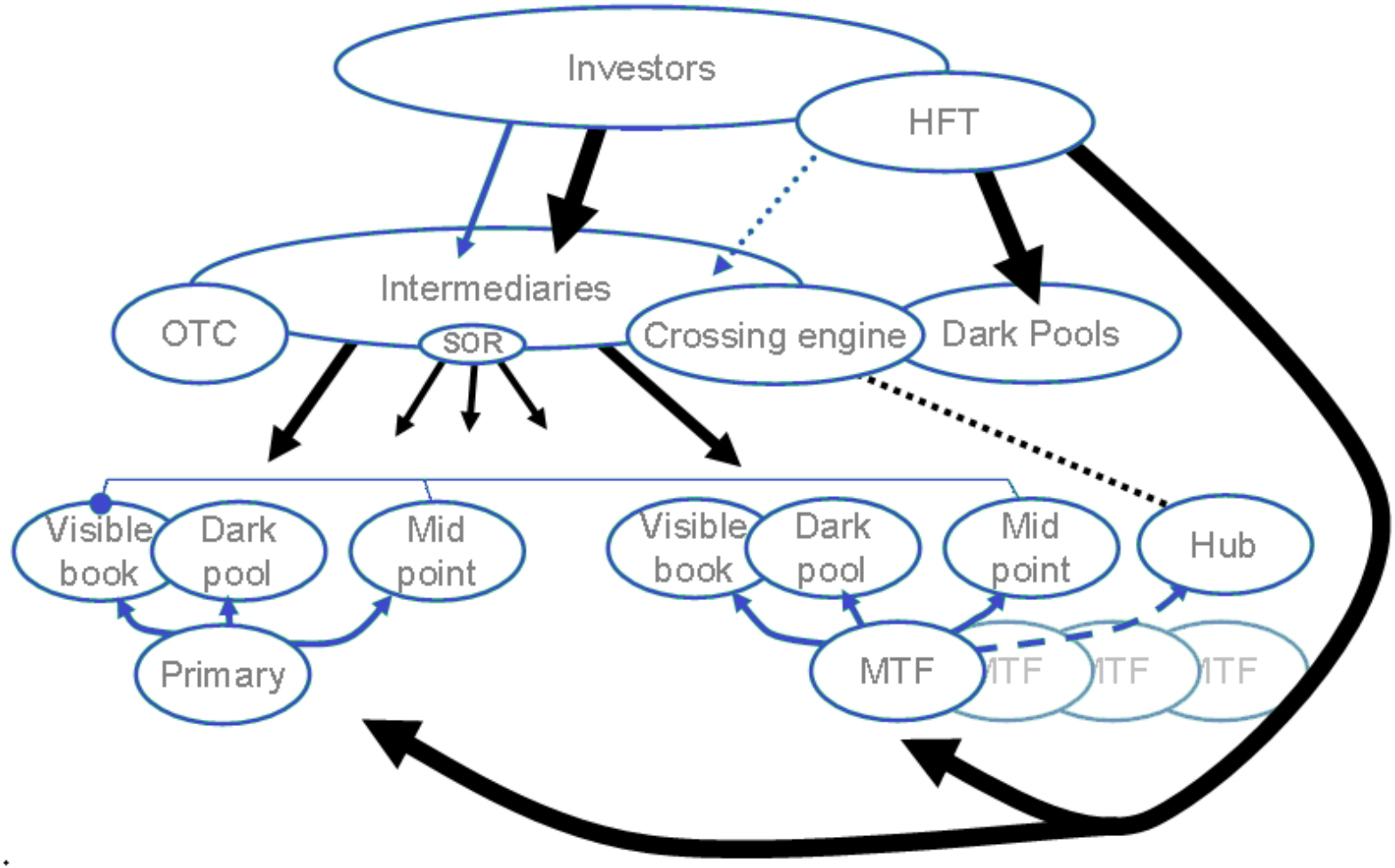
- The new regulations also target high-frequency trading. Algorithms used for automated trading have to be registered, tested and have circuit breakers included.
- MiFID II also places restrictions on inducements paid to investment firms or financial advisors by any third party in relation to services provided to clients. Banks will no longer be able to charge for research and transactions in a single bundle, forcing fragmentation and possibly improving the quality of research available to investors. Brokers will have to provide more detailed reporting on their trades, including price and volume information, and store all communications, including phone conversations.

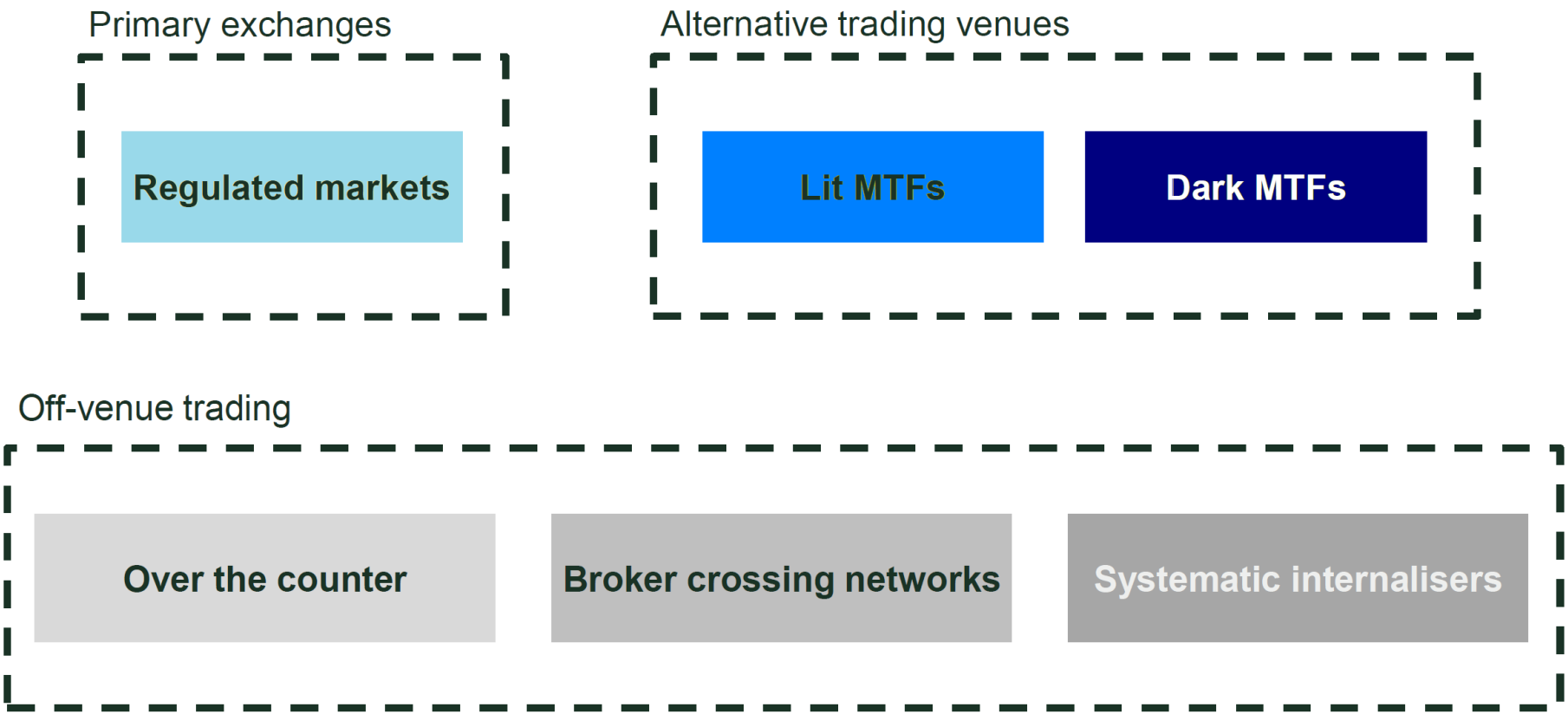
Present Organisation : Fragmentation

US: Reg NMS / EU: MiFID



OTC: Over the Counter; MTF: Multilateral Trading Facilities; HFT: High Frequency Trader; SOR: Smart Order Routing.

Types of Trading Venues



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- **Lit pool.** A trading destination with a visible order book.
- **Dark pool (mid-points).** A trading destination that does not disclose its order book. Trades are often reported with a delay. Dark or mid-point book accepts hidden orders smaller than the Large in Scale (LIS), and matches only at the mid-point of the Primary Best Bid and Offer. Dark integrated books accept all visible orders and hidden orders larger than the Large In Scale (LIS). These venues are said to be adapted to trade large quantities without leaving a footprint in the market.

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- **Electronic communication network (ECN).** This is a type of computer system that facilitates trading of financial products outside of stock exchanges. For example, Instinet (acquired by NASDAQ) or Archipelago (acquired by the NYSE).

Fragmentation : Glossary II

- **Alternative trading system (ATS).** It is a US regulatory term for a non-exchange trading venue that matches buyers and sellers to find counterparties for transactions. Alternative trading systems are typically regulated as broker-dealers rather than as exchanges (although an alternative trading system can apply to be regulated as a securities exchange).

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- **Systematic internalizer (SI).** Traditionally called market maker, it is an investment firm who could match buy and sell orders from clients in-house, provided that they conform to certain criteria. Instead of sending orders to a central exchange such as the London Stock Exchange, banks can match them with other orders on its own book. Examples of such firms are Credit Suisse and UBS.

Fragmentation : Glossary III

- **Broker crossing network (BCN).** It is an alternative trading system that matches buy and sell orders electronically for execution without first routing the order to an exchange or other displayed market. The order is either anonymously placed in a black box or flagged to other participants of the crossing network. Its advantage is to enable large block order execution without impacting the public quote.

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- **Proprietary Trading System (PTS).** It refers to an original trading market system created by a securities firm. PTS allows investors to trade stocks and bonds through electronic trading systems without stock exchanges. The Financial System Reformation Law made it possible for securities firms to start PTS in Japan. The first nighttime PTS was Monex Nighter launched by Monex Securities, and the second was kabu.com PTS launched by kabu.com Securities. PTSs are the equivalent of ECNs in the US or MTFs in Europe.

Geographic Concentration as a Tool for Competition

With Reg NMS (US, 2006) and MiFID (EU, 2007), electronic trading widely opened for competition. In the US, a trading facility can be an Exchange, an ATS (Alternative Trading System) or an ECN (Electronic Communication Network). In Europe, it can be a Regulated Market, a Multilateral Trading Facility, or (within MiFID II) an Organized Trading Facility.

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Competition Among Exchanges: Trading facilities compete on

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With Reg NMS (US, 2006) and MiFID (EU, 2007), electronic trading widely opened for competition. In the US, a trading facility can be an Exchange, an ATS (Alternative Trading System) or an ECN (Electronic Communication Network). In Europe, it can be a Regulated Market, a Multilateral Trading Facility, or (within MiFID II) an Organized Trading Facility.

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As a result of the competition on latency, if you run a facility A faster by 2ms to your competitor B, you need to be at less than 2ms to B so that your customers can take profit of your speed.
$\Longrightarrow$ Exchanges concentrate in few datacenters. In Europe, most exchanges (LSE, Chi-X, BATS, Turquoise, Aquis, Euronext, etc.) are located at Basildon, close to London.

Major stock exchange groups (by market capitalization)

Rank	Stock Exchange	Country	Market Place	Creation
1	New York Stock Exchange	United States	New York	1792
2	NASDAQ	United States	New York	1971
3	Japan Exchange Group	Japan	Tokyo	1878
4	Shanghai Stock Exchange	China	Shanghai	1891
5	Euronext	European Union	Amsterdam, Brussels, Dublin, Lisbon, Paris	2000 (1602) (1801, 1793) (1769, 1639)
6	London Stock Exchange Group	United Kingdom, Italy	London, Milan	1698 1808
7	Hong Kong Stock Exchange	Hong Kong	Hong Kong	1891
8	Shenzhen Stock Exchange	China	Shenzhen	1987
9	Deutsche Börse	Germany	Frankfurt	1992
10	Bombay Stock Exchange	India	Mumbai	1875

Main ECN

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  - NYSE Arca grew out of the merger between the New York Stock Exchange (NYSE) and Archipelago, an early ECN from 1996. It facilitates electronic stock trading on major U.S. exchanges such as the NYSE and NASDAQ.

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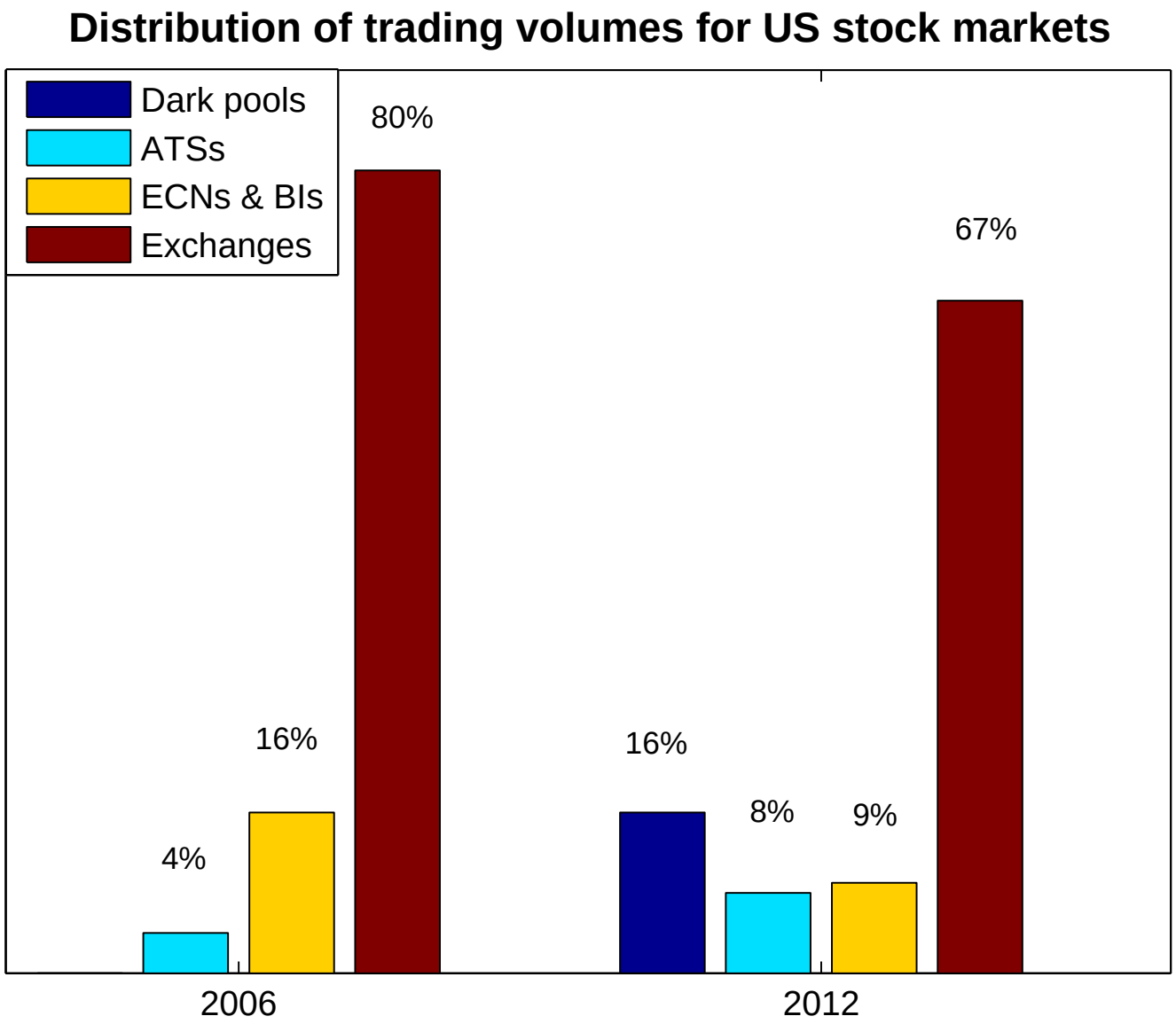
  - Turquoise was created by nine major investment banks in 2008. On 21 December 2009, the London Stock Exchange Group agreed to take a 60% stake in trading platform Turquoise, which had a 7% share of the market. Turquoise was merged with the LSE's trading facility Baikal Global.

Fragmentation : US markets 2006-2012



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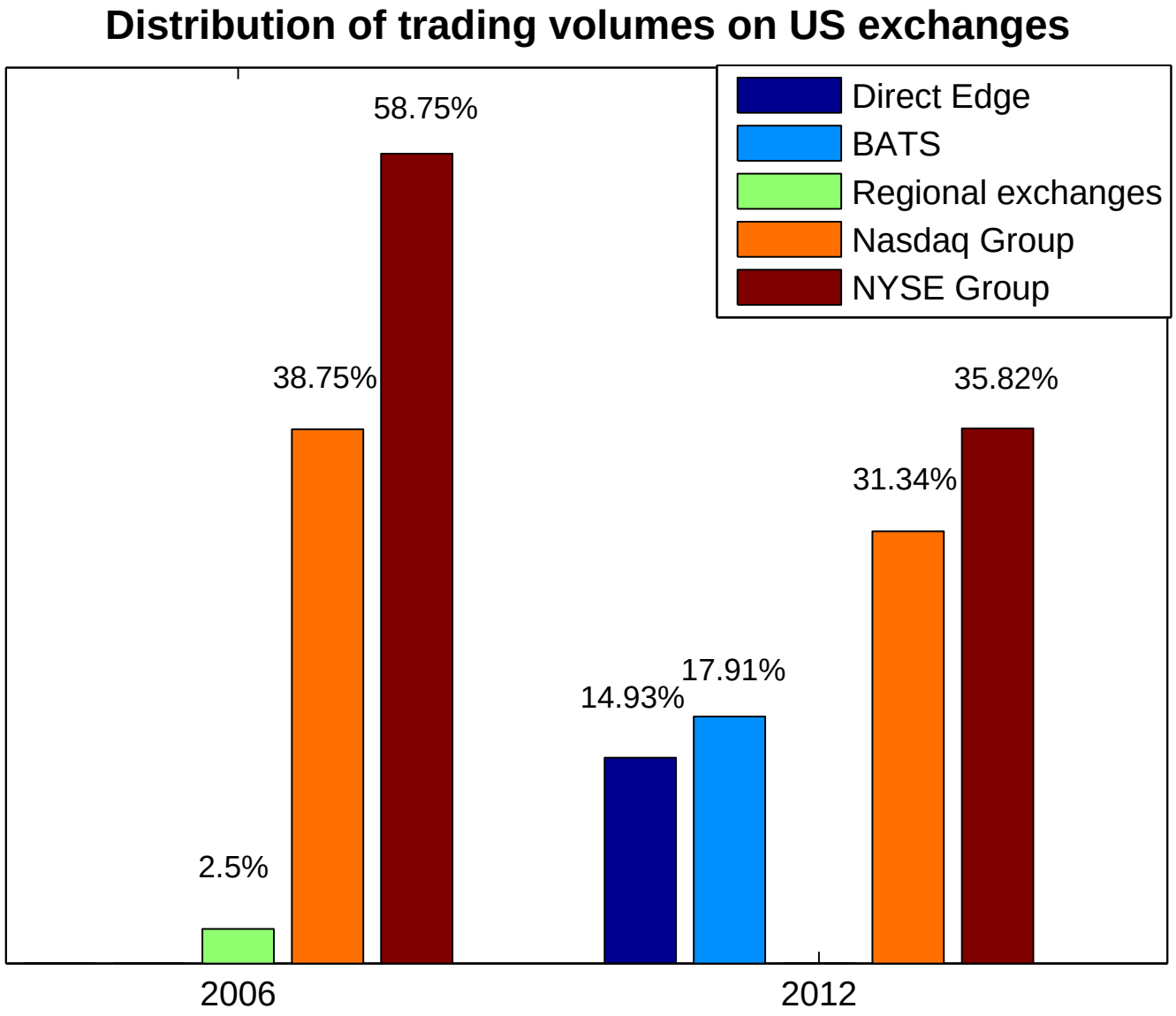
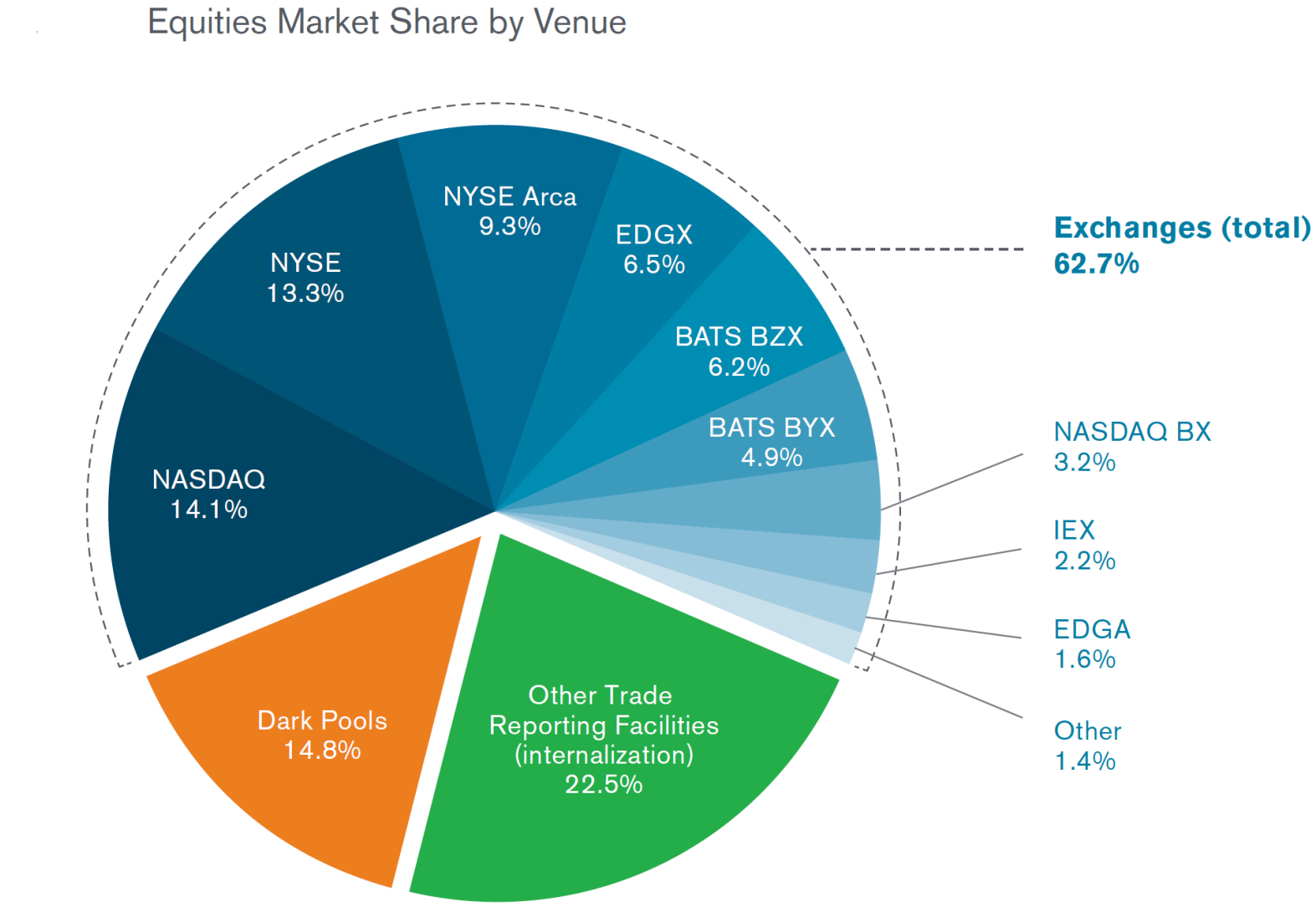
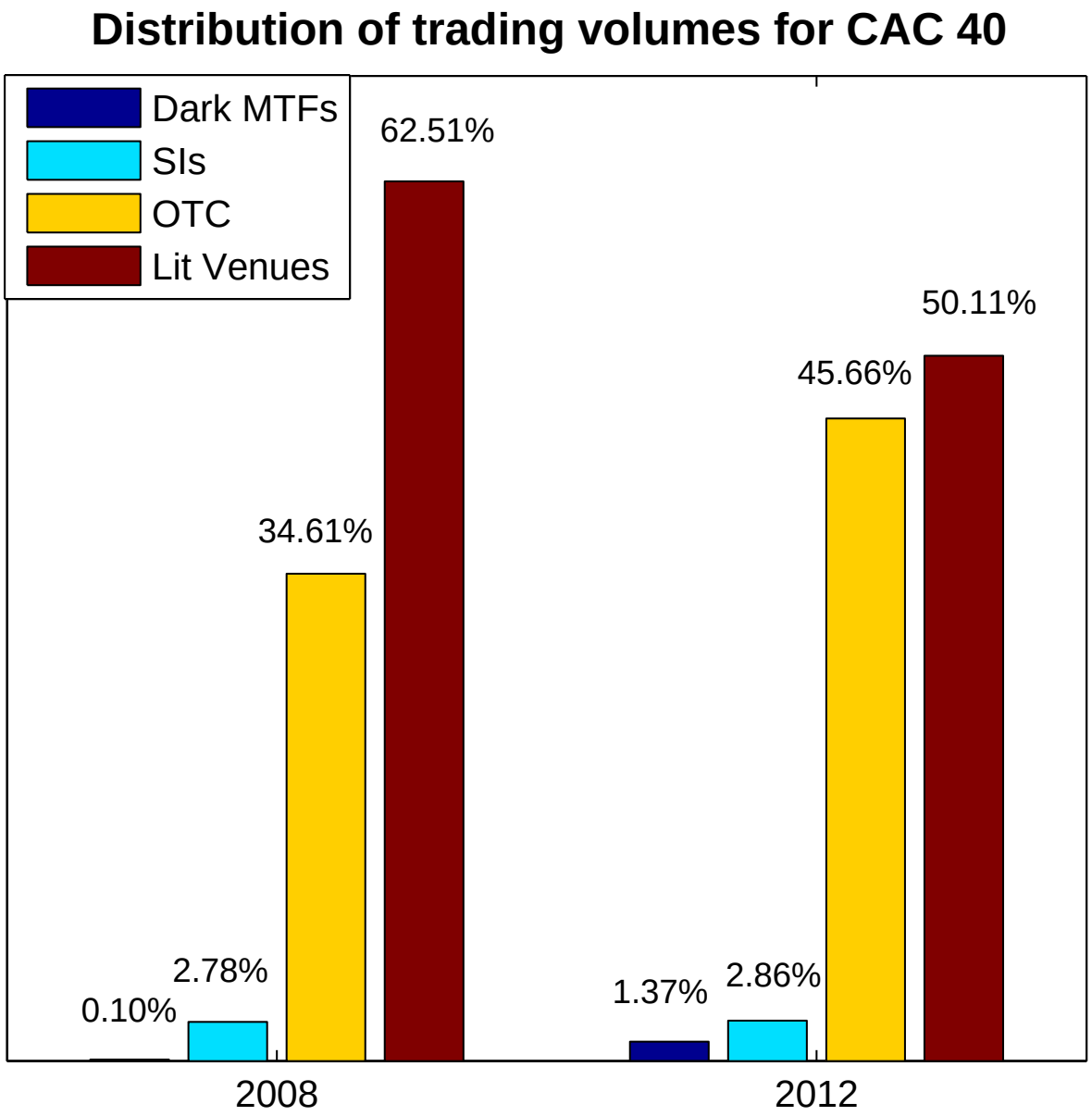


Fragmentation : US markets 2017



Source: Rosenblatt Securities, July 2017

Fragmentation : CAC 40 2008-2012



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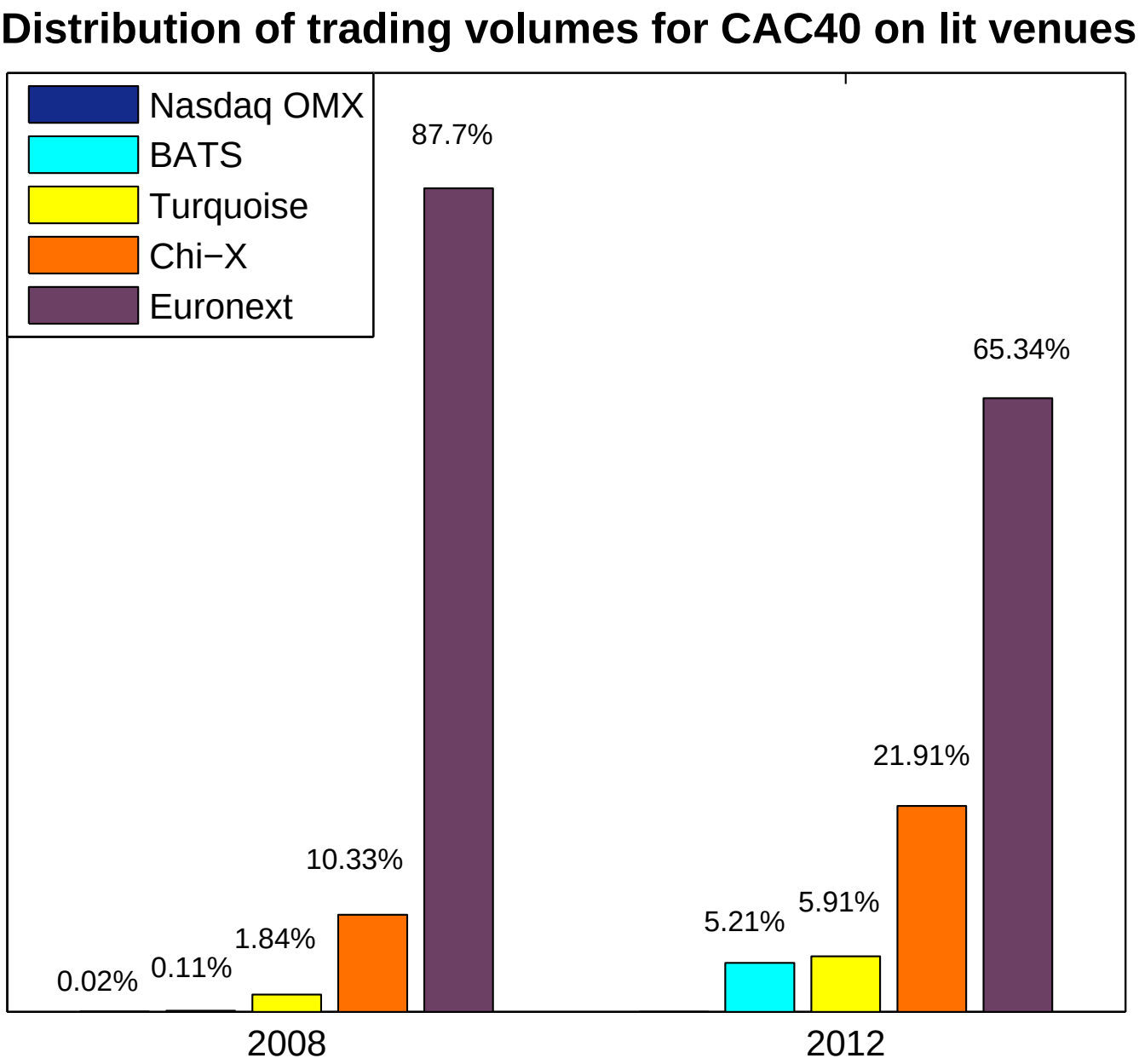
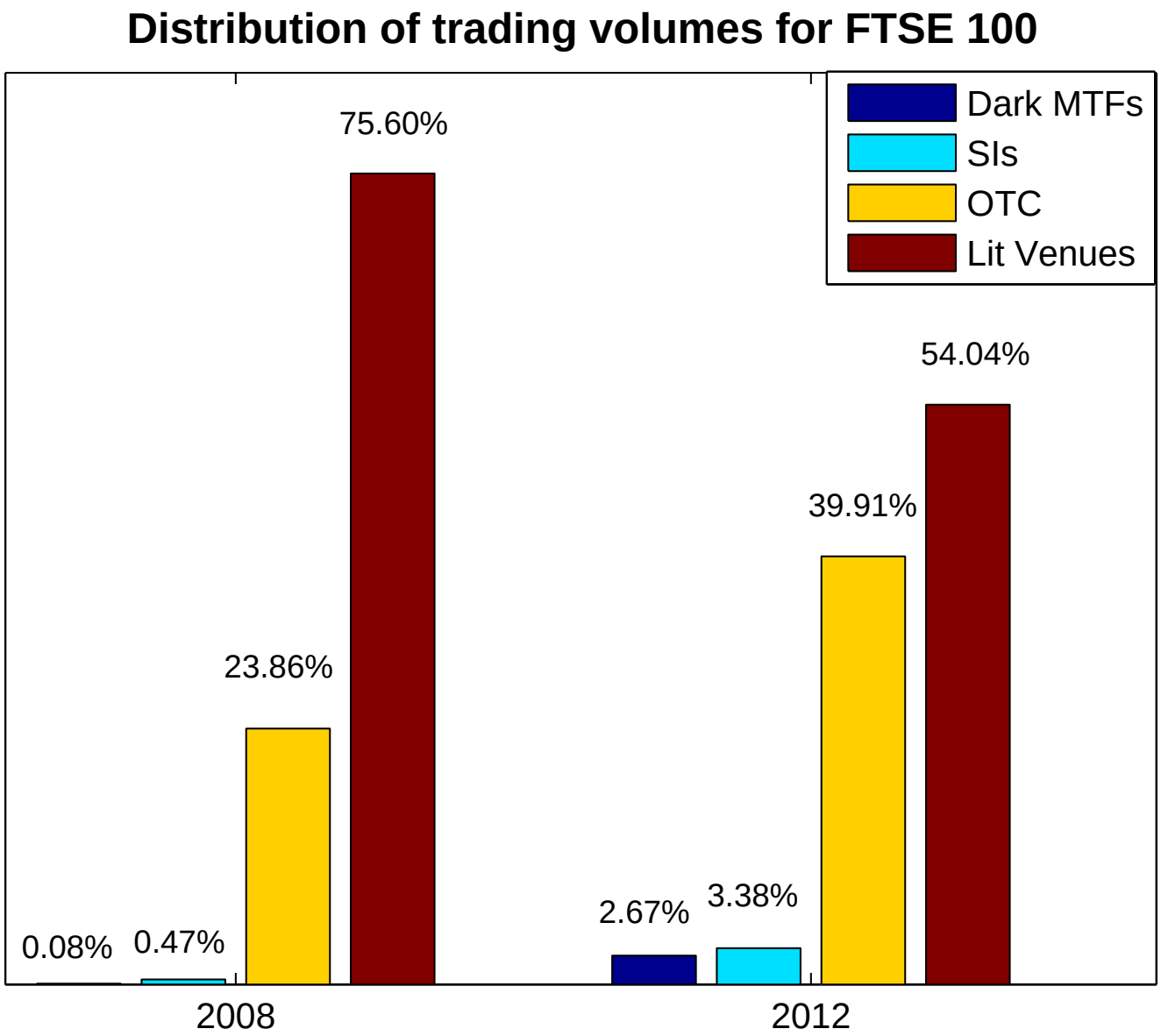


Fragmentation : FTSE 100 2008-2012



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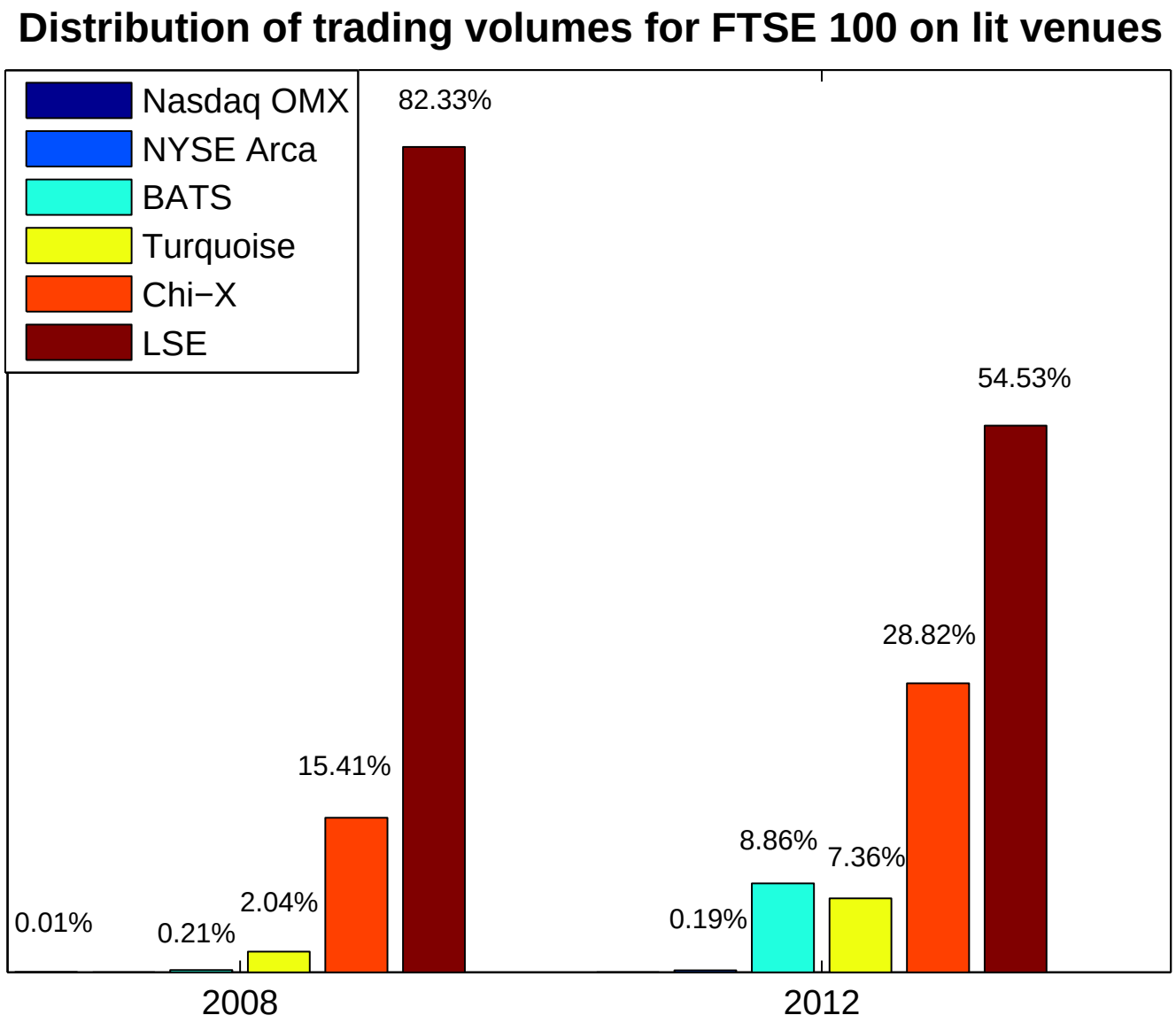
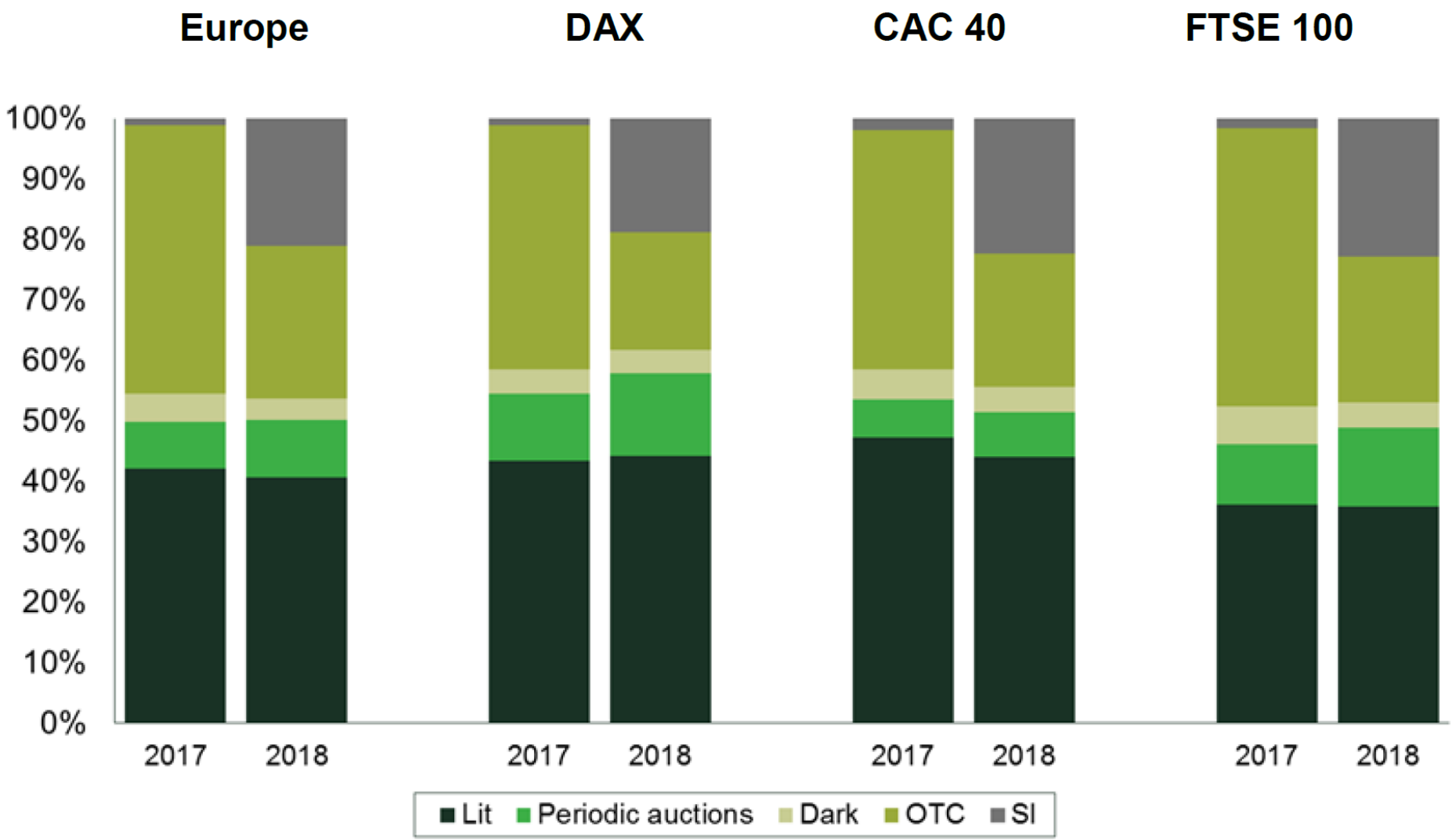
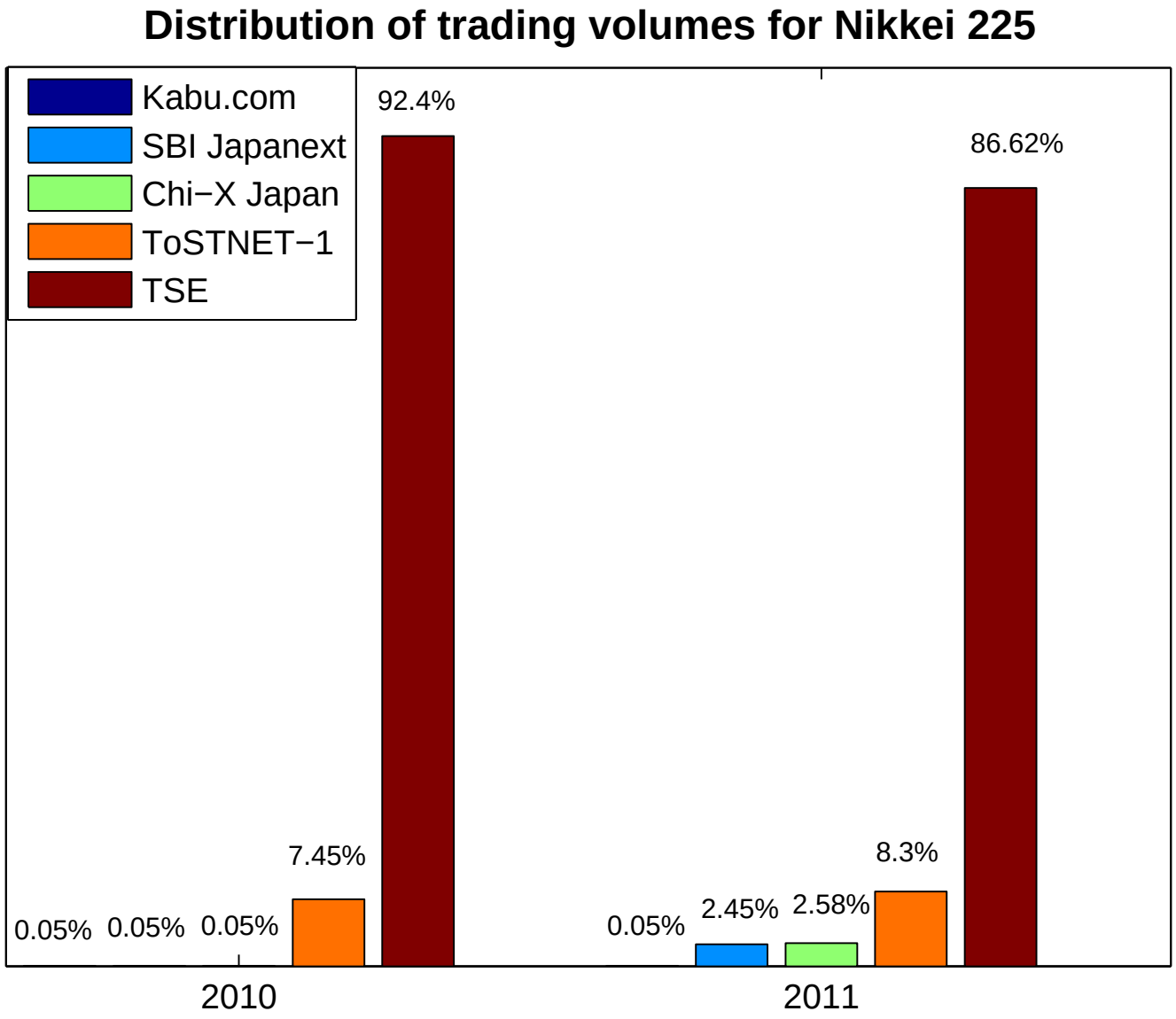


Fragmentation : Europe 2017-2018



Fragmentation : Nikkei 225 2010-2011



Outline

Financial markets as a biological system

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- Agents can change their strategies to enhance profit, and only the best ones remain: mutation and natural selection.
- When market rules change or new players come in, all agents need to adapt or die: invasions, evolutionary adaptation and extinction.

Description of financial agents

- **Retail banks**
  - They pay the depositors' savings at a lower interest rate.
  - They loan at a higher interest rate.
  - Their profit is the difference between both interest rates.
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- **Investment banks**
  - They sell financial instruments to investors: selling side.
  - They create new products under investors' demand.
  - Complex products require strong risk management policies: quants.
  - Profit made by volume and margin/prime over the hedging price of the product: flow trading.

- **Markets**
  - A market is where a buyer of an instrument meets a seller.
  - It can be an exchange or an over-the-counter (OTC) market.
  - A transaction in an exchange:
    - ★ Is done with listed or standard instruments, e.g. futures or listed options.
    - ★ Has a clearing house: clearing margins and daily settlements. $\Longrightarrow$ No counterparty or credit risk.
  - A transaction in an OTC market:
    - ★ Is done with any imaginable instrument, e.g. forwards or exotic options.
    - ★ But has no guarantee that the trading parts will honor the agreement. $\Longrightarrow$ Counterparty or credit risk.

- **Brokers**
  - They are middlemen: link between investors and financial markets.
  - In general they participate in exchanges, but they can also have OTC clients.
  - They charge a fee: fixed (account management) and/or per contract traded (unitary price or percentage of whole transaction).
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- **Market-makers**
  - They are agents who buy and sell assets in financial market.
  - They make firm quotes: once they show a price and a volume, they are bound to trade at those conditions if there is a willing counterparty. $\Rightarrow$ Liquidity providers.
  - Their buying (bid) price is smaller than their selling (ask) price. $\Rightarrow$ On each buy-and-sell transaction they earn the spread: the difference between the ask and the bid prices.

- **Small savers**
  - They put their money in retail banks, earning an interest rate.
  - If there is trust in the bank, savers leave their money inside; if there is no trust they withdraw their money.
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- **Qualified investors**
  - Legal persons (individuals) with more than 250K USD.
  - They are considered to have the same information and sophistication than any financial services provider $\Rightarrow$ less legal protection.
  - They can access complex investment strategies with higher return (but potentially higher risk).
  - They tend to search for high returns with a short- and middle-term investment horizon (less than 5 years).

- **Institutional investors**
  - They are legal entities (not individuals) with capital over 100M USD.
  - They are as sophisticated as qualified investors: access to all asset classes and investment strategies.
  - They have restrictions and controls due to law and internal mandates: pension funds, sovereign funds, insurers, reinsurers, etc.
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- **Asset management**
  - They are professionals of portfolio management (assets or baskets).
  - They invest on financial instruments on behalf of their clients: qualified investors, institutional investors.
  - In some cases, they can manage money from small investors via pooling, investment vehicles, etc.
  - They charge a fee on the amount of money invested in them or AUM (Assets Under Management).
  - Depending on their mandate they can use different strategies with different investment horizons.
  - They have risk management policies and can use different risk measures: Sharpe Ratio, Maximum Drawdown, Value-at-Risk (VaR), Expected Shortfall (CVaR), stress tests, Monte Carlo, etc.

- **Prop traders**
  - They speculate in capital markets with their own money. $\Rightarrow$ They have the highest exibility on investment strategies: derivatives (vanilla, exotic, structured), high-frequency trading, etc.
  - Before the Dodd-Frank reform, in particular the Volcker Rule:
    - ★ Big commercial banks used to have their own prop trading desks: dedicated teams speculating on behalf of the firm.
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    - ★ Now prop trading in banks is almost banned, but market-makers in banks are exonerated of the Volker rule.

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- **Arbitrageurs**
  - An arbitrage is to take advantage of a market inefficiency.
  - An arbitrageur is generally a speculator, but their role is to make markets more efficient. (ex: prices or mispricing arbitrage, venues or space arbitrage, time value or term-structure arbitrage, statistical arbitrage or stat arb).

- **Prime brokers.** Prime brokers or credit lines are the bankers of investment management firms. The services they offer are:
  - Borrow money to fund managers, so they can buy assets.
  - Borrow assets to fund managers, so they can short-sell them.
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- **Hedge funds**
  - They use sophisticated and innovative investment strategies (technical and financial knowledge above competitors, more rigorous risk management than traditional asset managers).
  - They are very active i.e. high turnover, unlike the classic buy-and-hold strategies.
  - They charge high fees, both on AUM and on performance, but they guarantee an absolute return. $\Rightarrow$ Very aggressive business model: only 50% survive after 3 years of launch.
  - Generally they are small and look for investment niches: small is beautiful.

Outline

Self-organised liquidity

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How do electronic markets work without dealers?

- It is the aggregate of liquidity providers that makes the market.
- But providers are not in obligation to place both ask and bid quotes $\Longrightarrow$ Self-organised liquidity: any trader can choose, at any instant of time, to either provide or consume liquidity.

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- When a dealer **consumes liquidity**, she sends a (buy or sell) market order for a given quantity. She buys (or sells) at the best selling (or buying) market price, i.e. the smallest (or biggest) available, and her order hits the ask (or bid) side.

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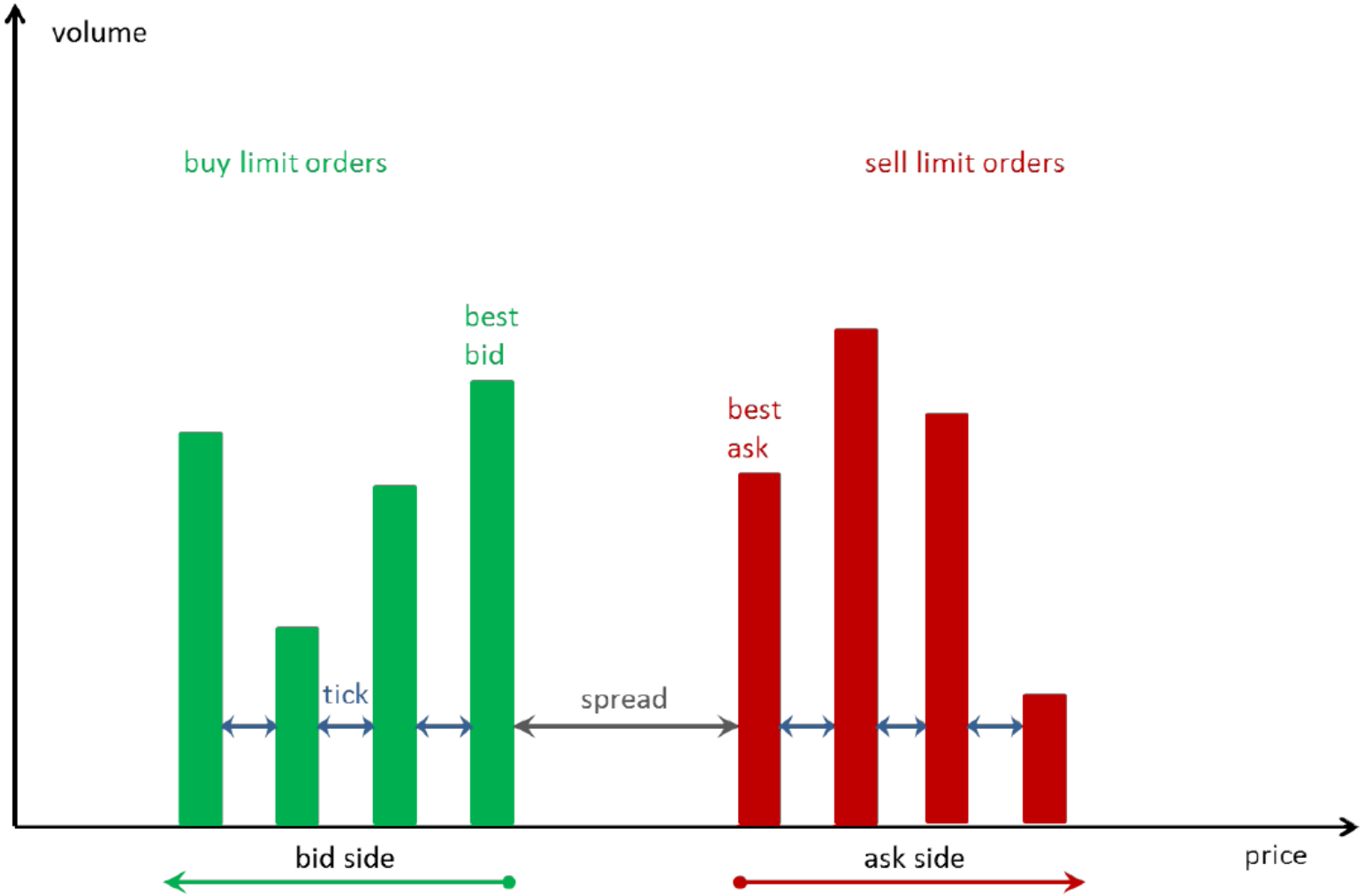
For **regulation**, stock markets have the **ID of every trader and every order**.

Example of LOB



Microstructure of the LOB

Priority : Most common is price/time priority.

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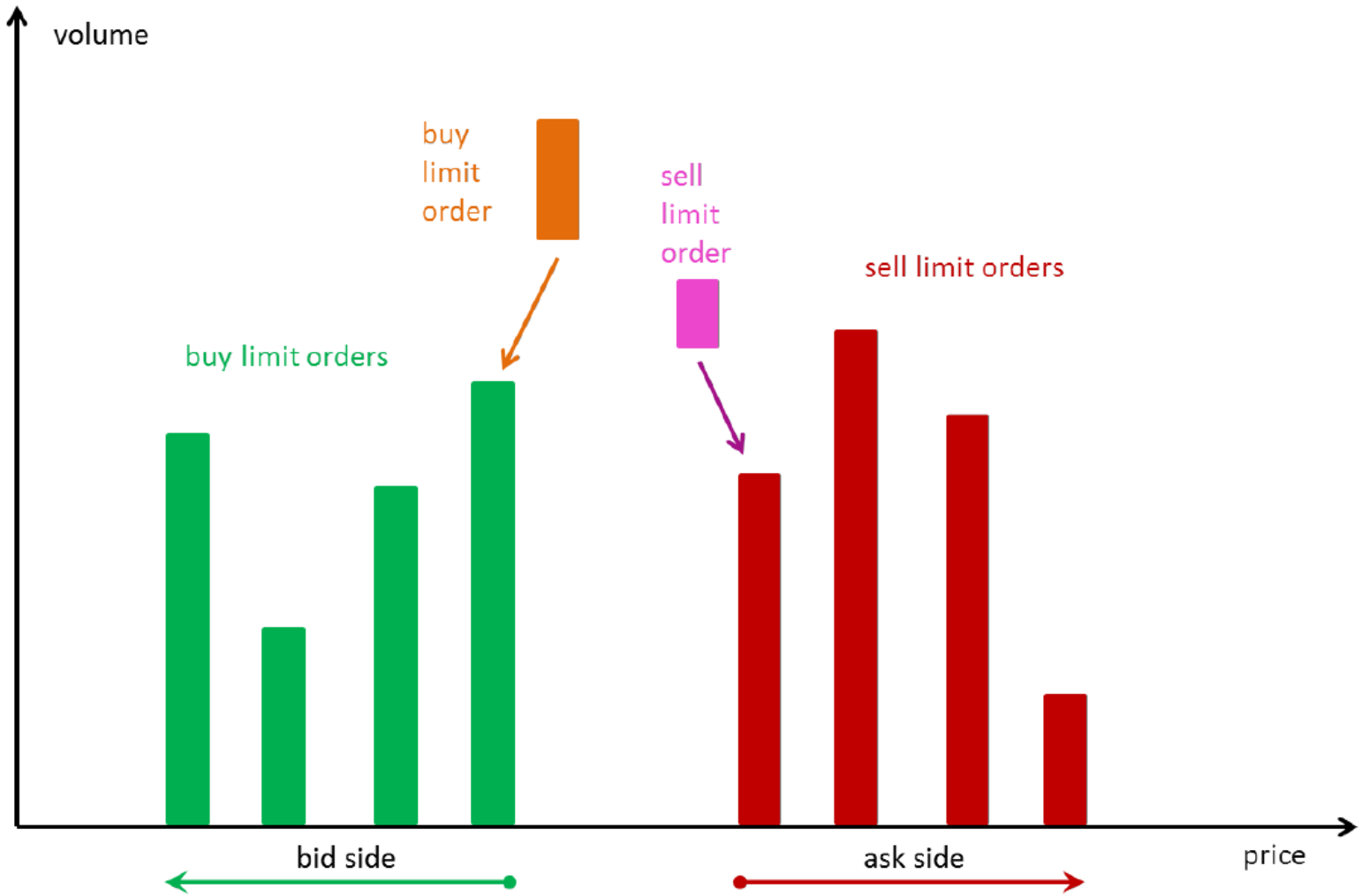
Spread : The difference between the best ask price and the best bid price.

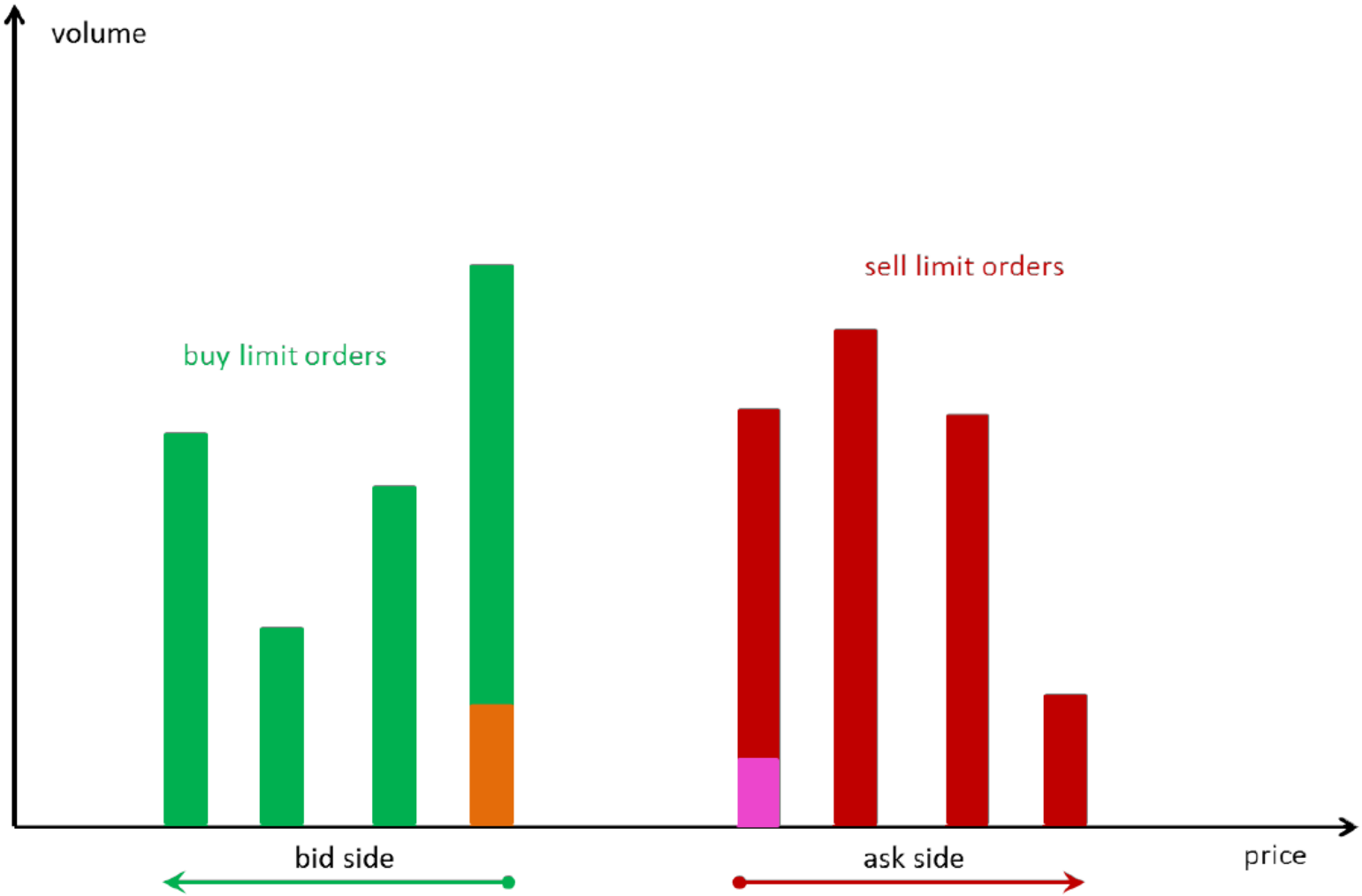
- It is the price of liquidity i.e. the expected gain of a dealer.
- It is a measure of liquidity: the more liquid the market, the smaller the spread.
- Highly liquid markets : spread $= 1$ tick.

Inserting LOs in the LOB I



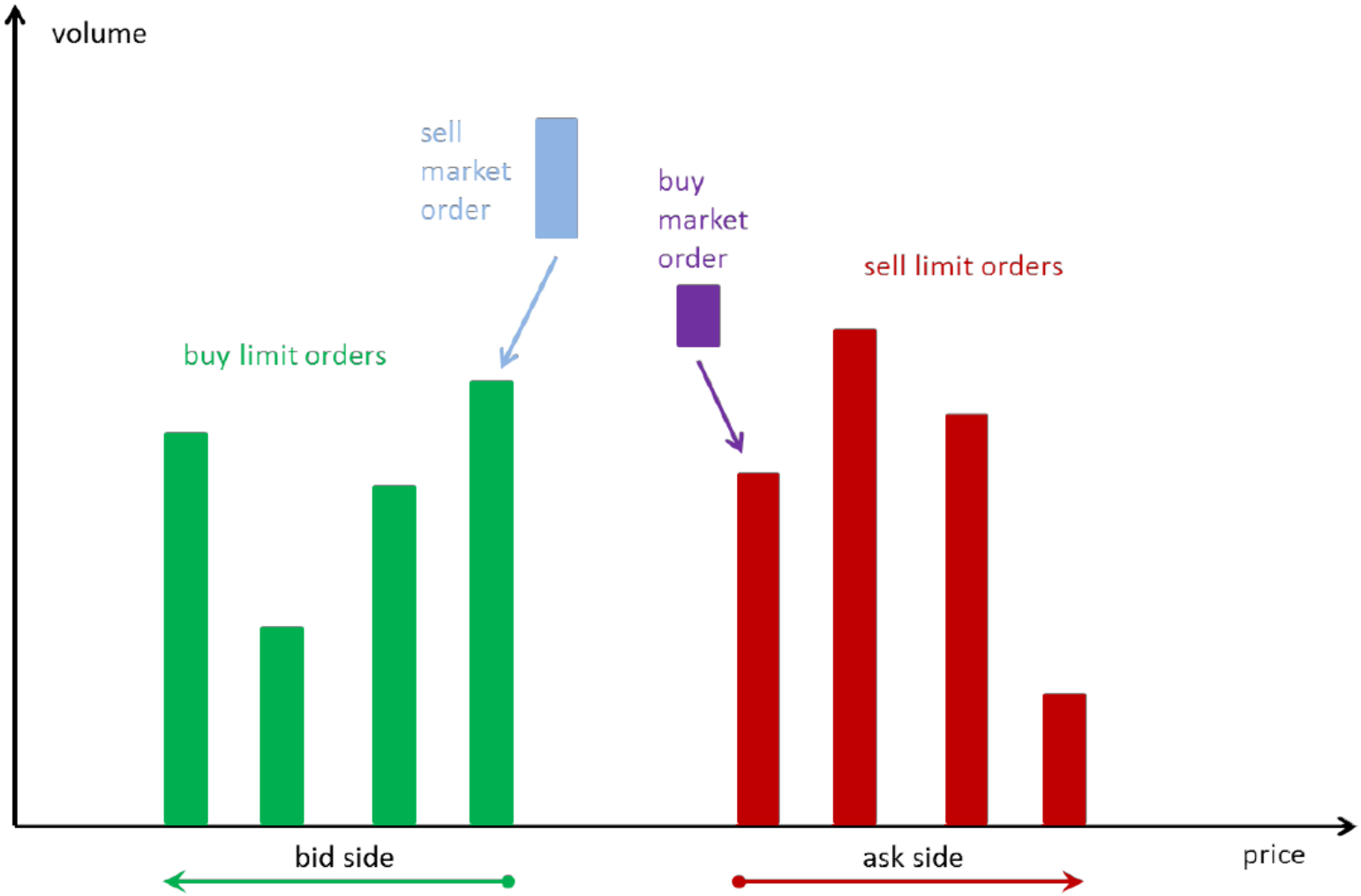
Incoming LOs: request to be inserted in the LOB.

Inserting LOs in the LOB II



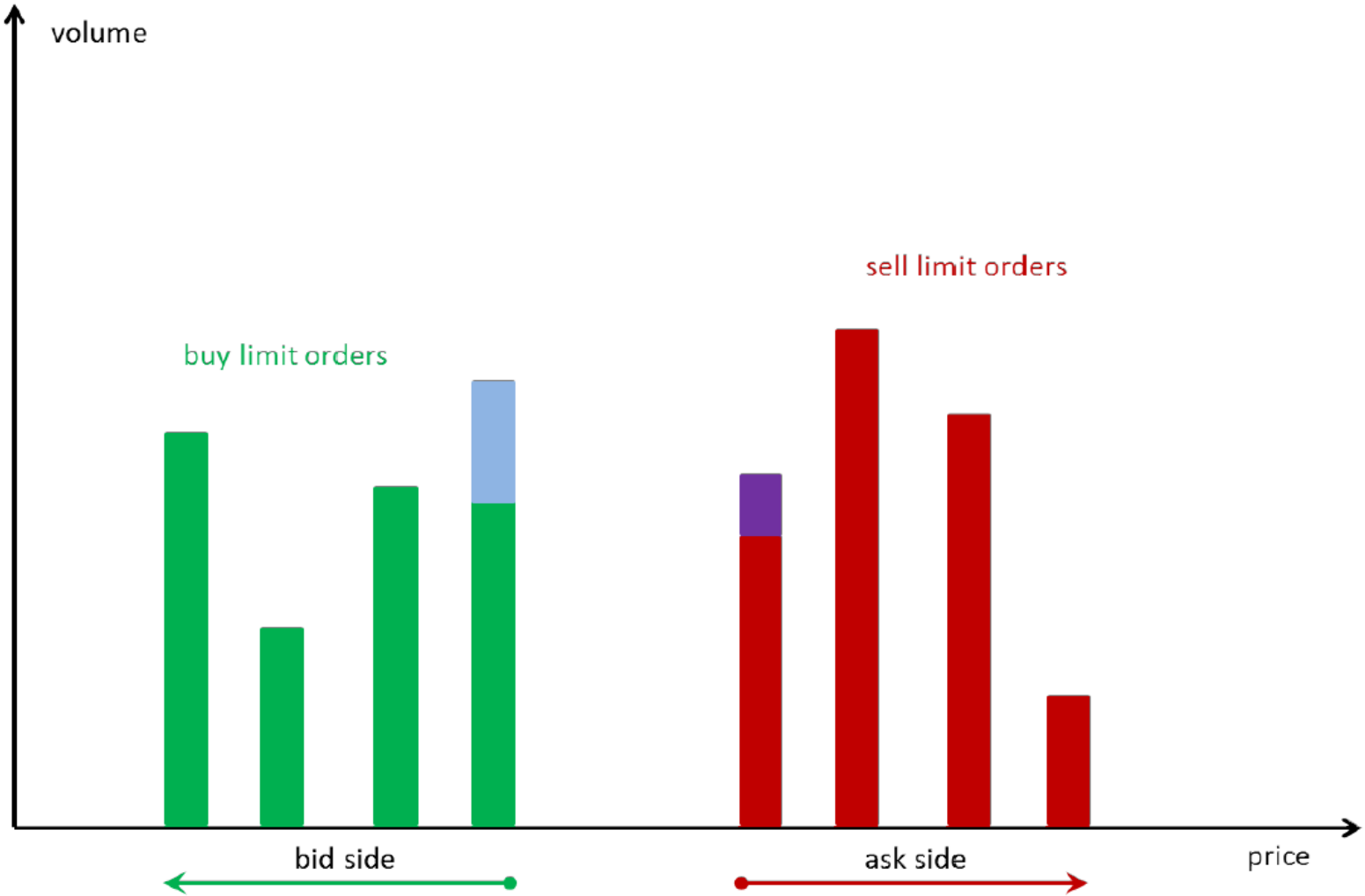
The newly inserted LOs are last in time priority.

Matching MOs vs LOs in the LOB I



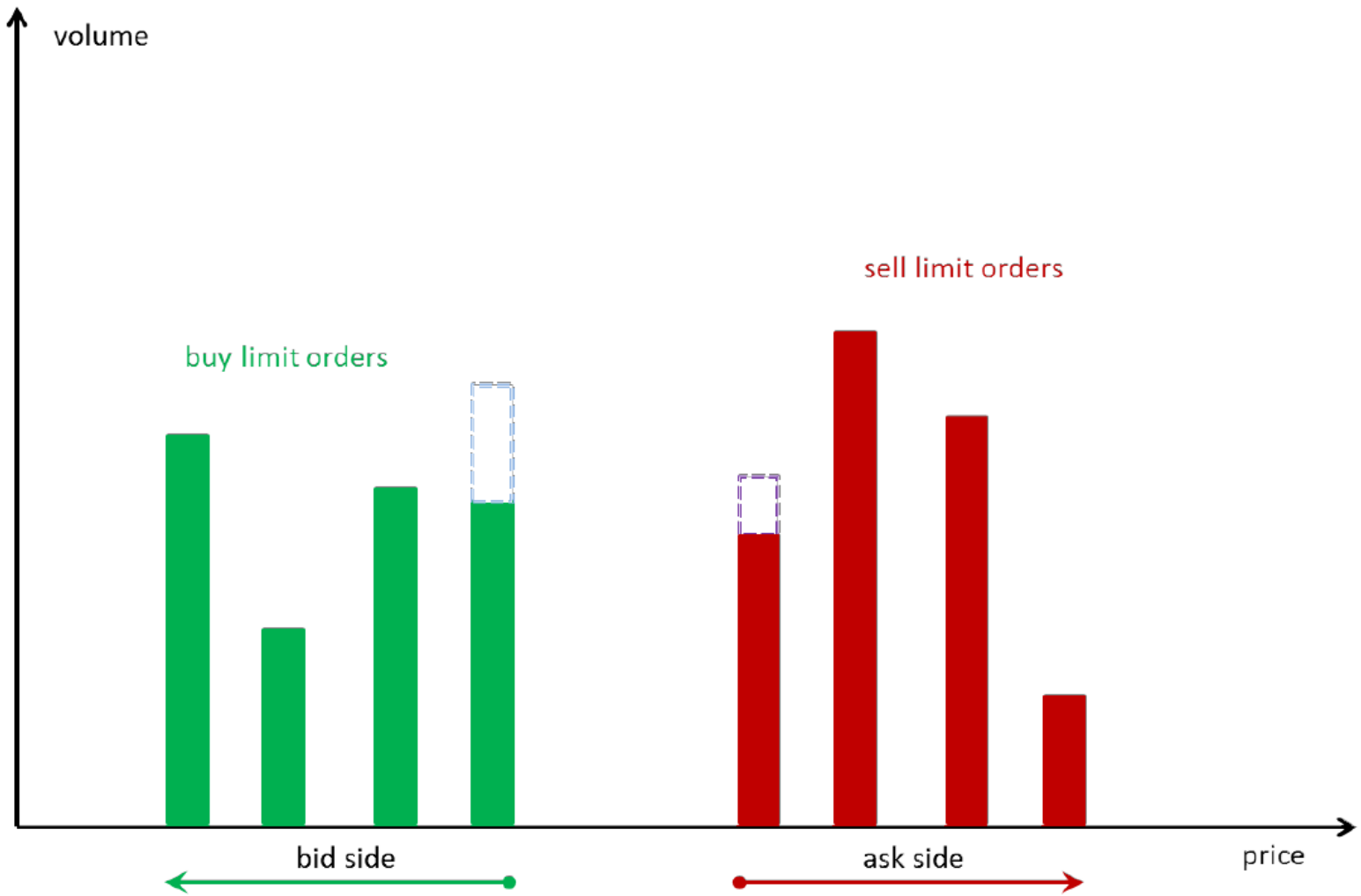
Incoming MOs: trading request at best market prices.

Matching MOs vs LOs in the LOB II



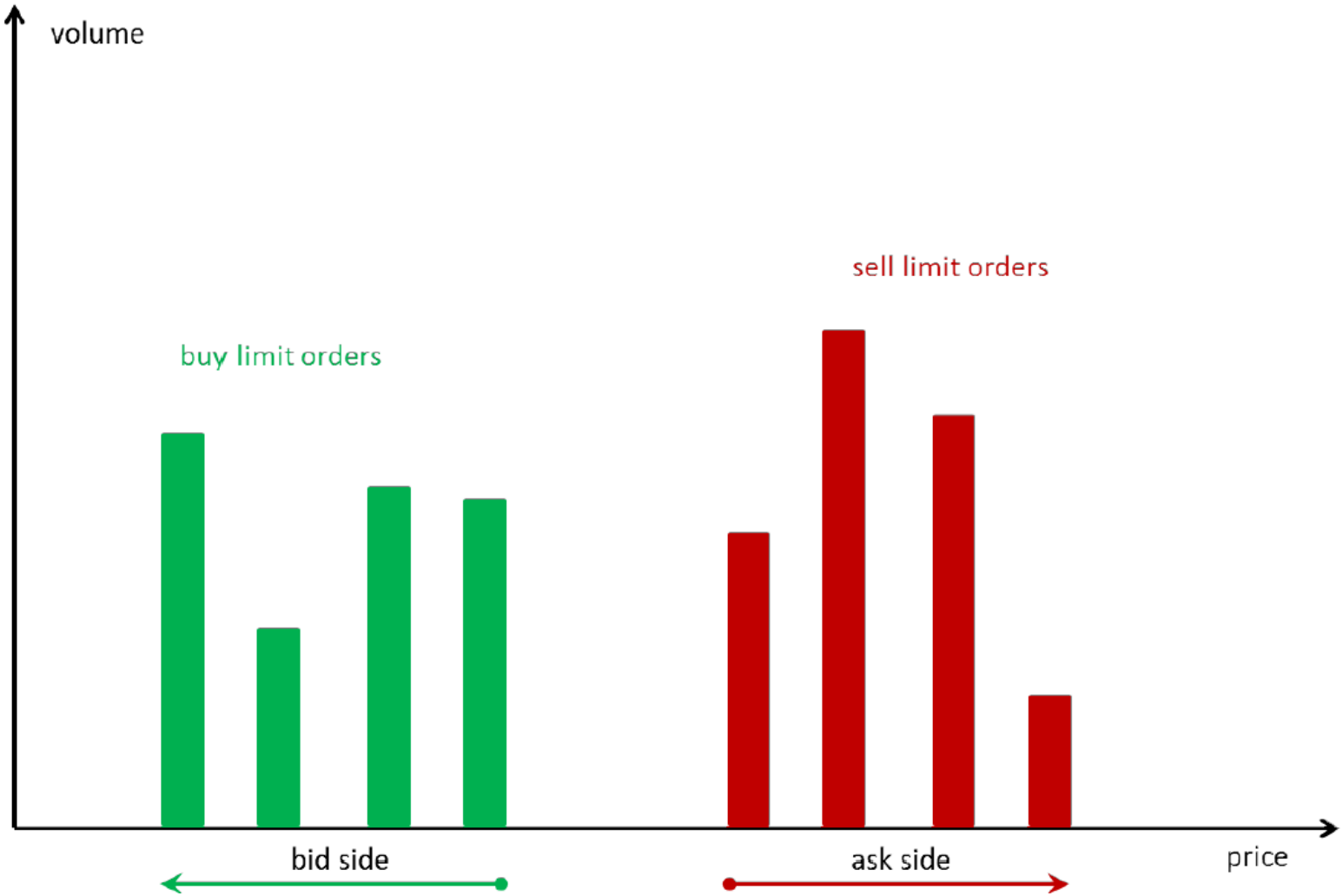
MOs are matched with LOs of highest priority price/time.

Matching MOs vs LOs in the LOB III



MOs consume some of the liquidity at the first limits.

Matching MOs vs LOs in the LOB IV



LOB after trades.

LO *vs* MO

- If a dealer trades via LO, she has a better price (she earns the spread), but delayed and uncertain execution (her LO sits passively on the LOB, waiting to be matched with a MO) $\Longrightarrow$ **Market risk and execution risk**.

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- If a dealer trades via MO, she has a worse price (she pays the spread), but immediate and certain execution : her MO hits the LOB and is matched vs the LOs at the best opposite price $\Longrightarrow$ **No market risk and no execution risk**.

Double Auction Mechanism

The double auction mechanism is dedicated to simultaneously: form an equilibrium price, disseminate information about the price.

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During the pre fixing phase (5 minutes) the buyers and the sellers are inserting orders for a quantity at a given price:

- bid order of 100 at 10 = agree to buy 100 shares at a price ≤ 10,
- ask order of 100 at 10 = agree to sell 100 shares at a price ≥ 10.
- At the end, the price is fixed by equalizing bid and ask cumulative order book functions (Walrassian equilibrium).

Walrassian equilibrium

Let $f^-_{LOB}(s)$ be the volume available in the order book by sellers (ask prices) at price s (resp. $f^+_{LOB}(s)$ for bids quantities). Define the **cumulative order book functions**:

$$F^+_{LOB}(S) = \int_{-\infty}^{S} f^+_{LOB}(s)ds, \quad F^-_{LOB}(S) = \int_{S}^{+\infty} f^-_{LOB}(s)ds.$$

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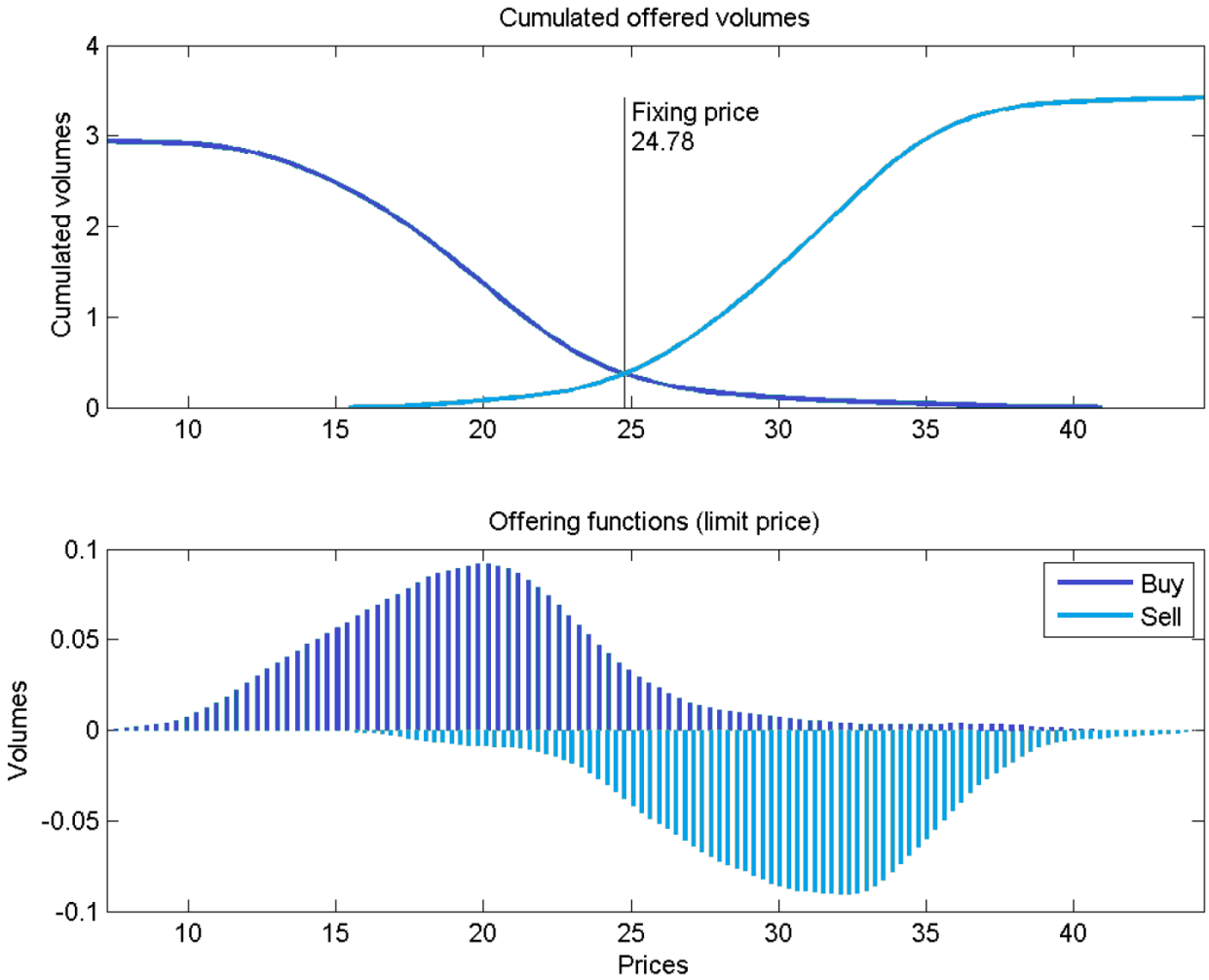
At the end of this pre-fixing phase, the price is fixed at a so called **Walrassian equilibrium** S^*, *i.e.* such that

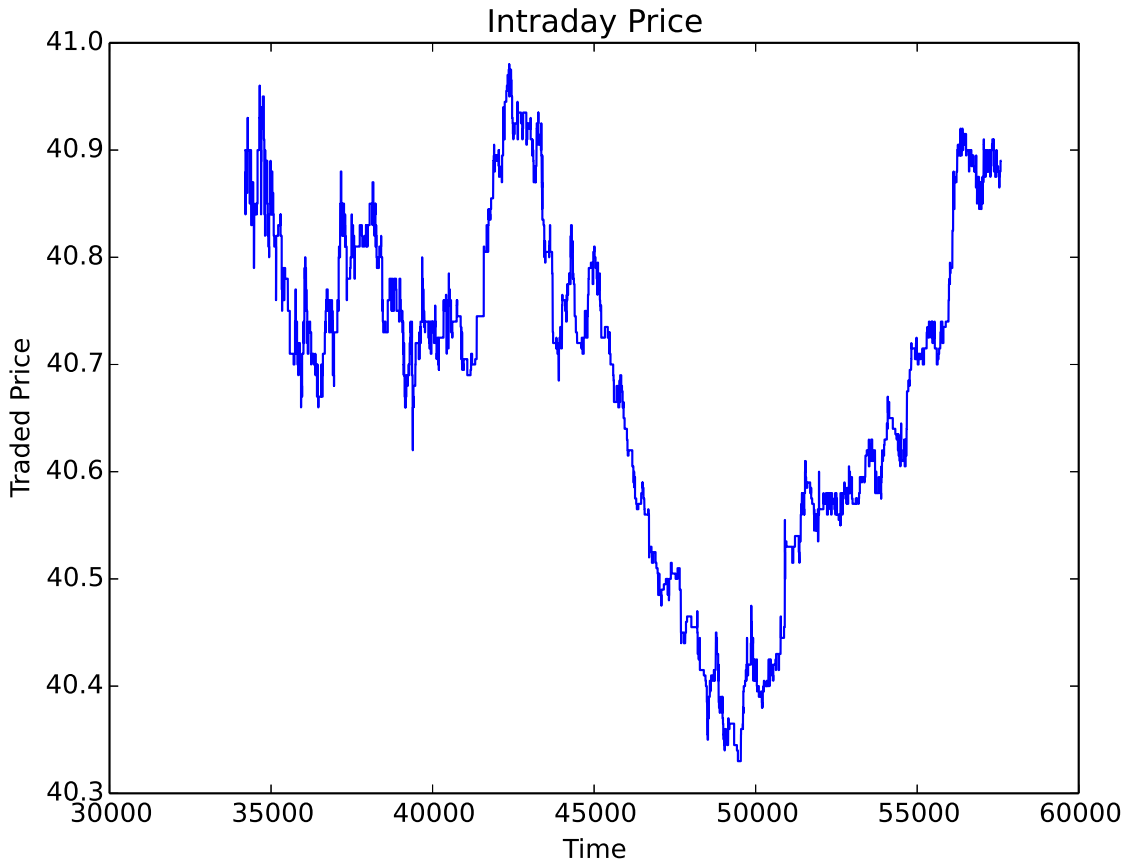
$$F^+_{LOB}(S^*) = F^-_{LOB}(S^*).$$

Fixing Auction



Outline

Stylized fact I : Traded price dynamics on the whole day



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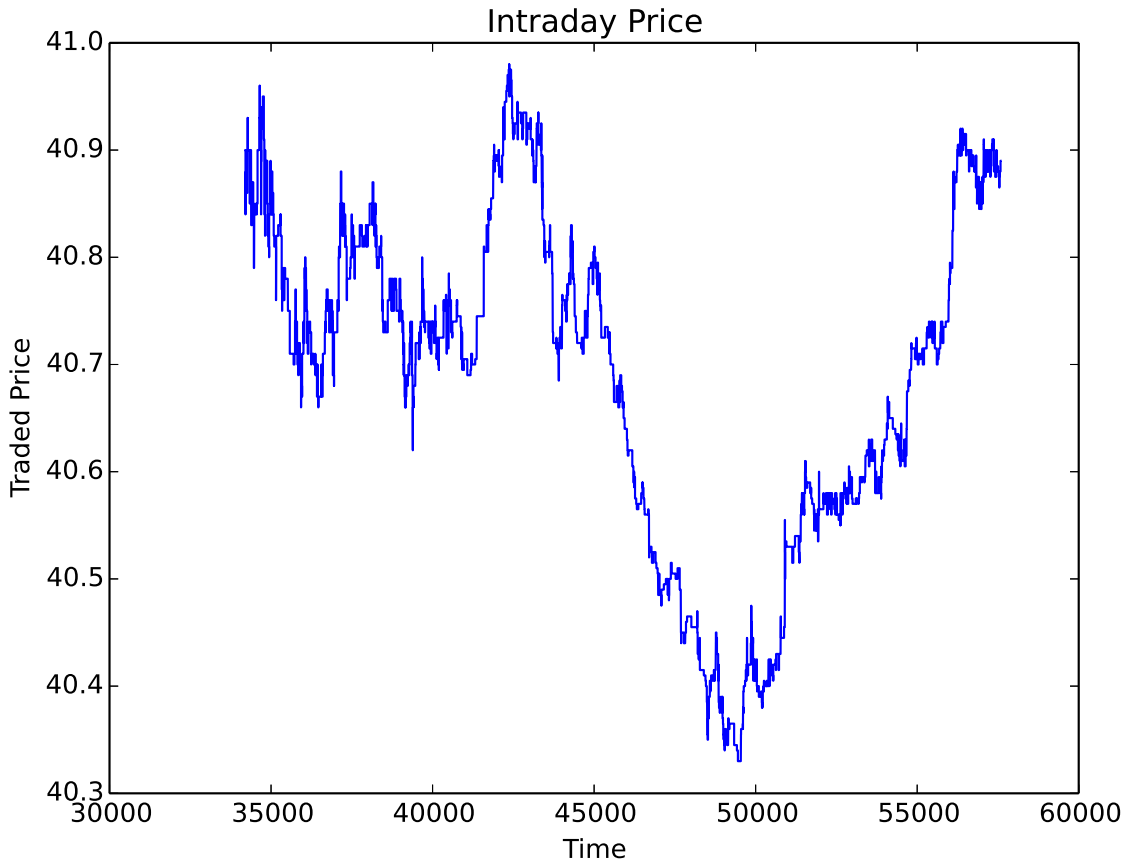

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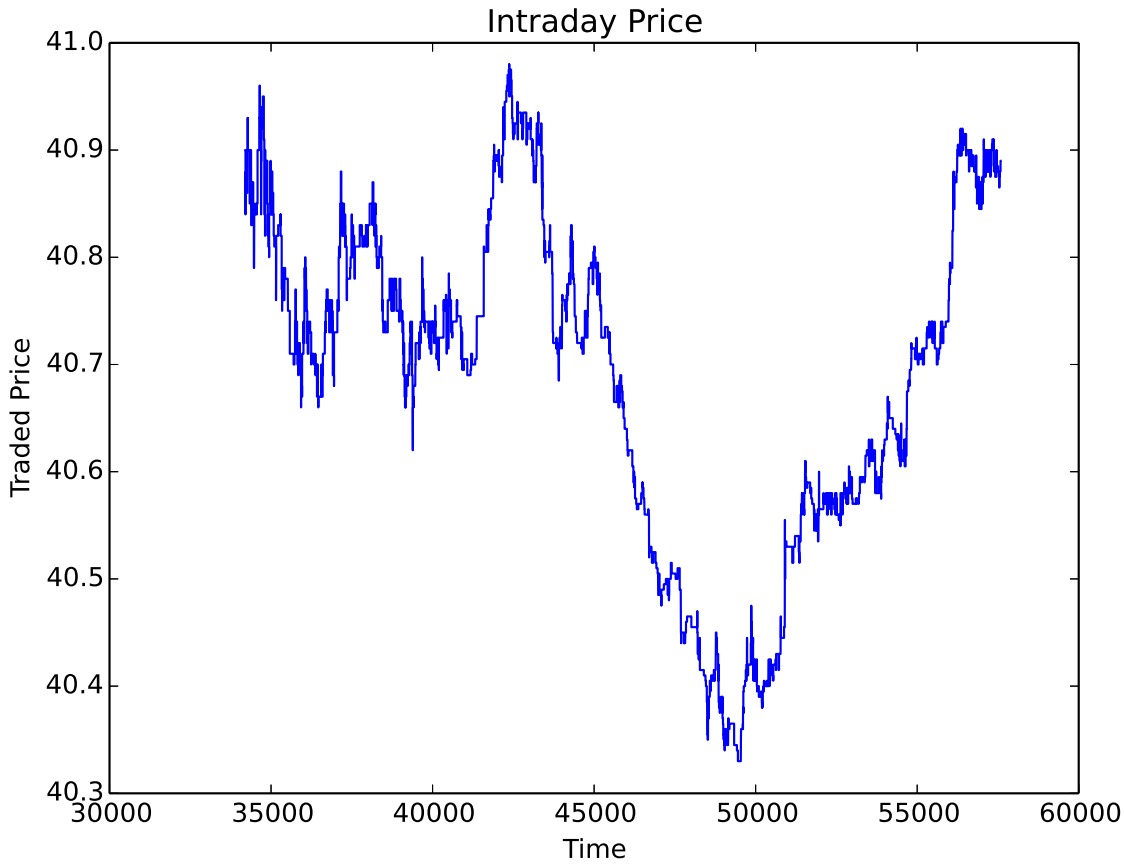

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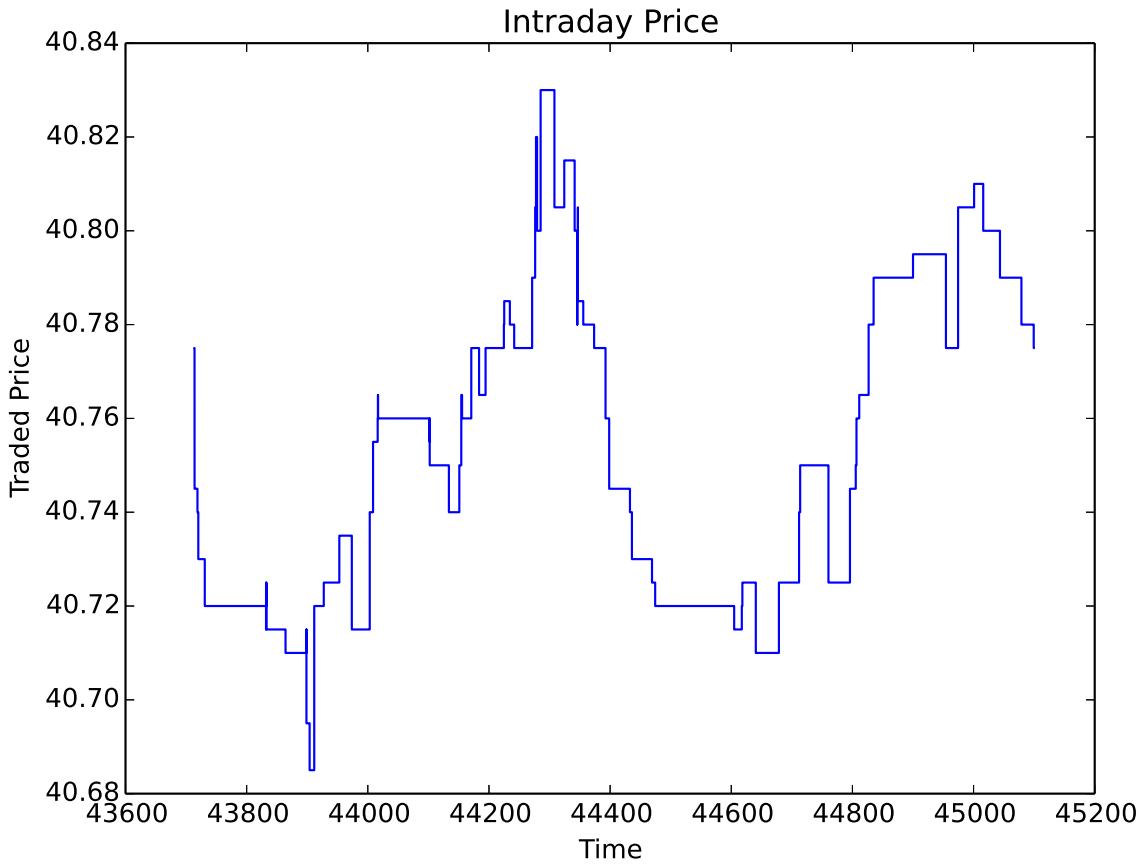
- The traded price is mean-reverting.

Stylized fact I : Traded price dynamics on 25 minutes



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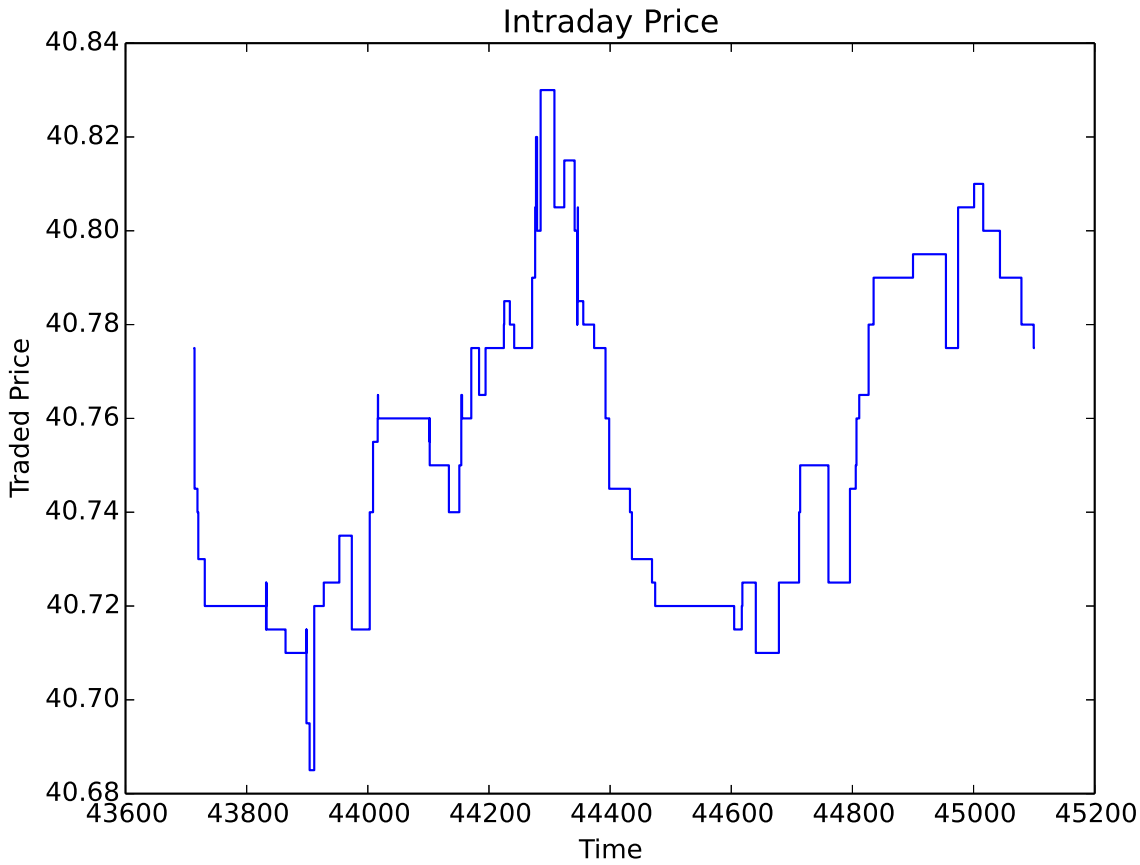

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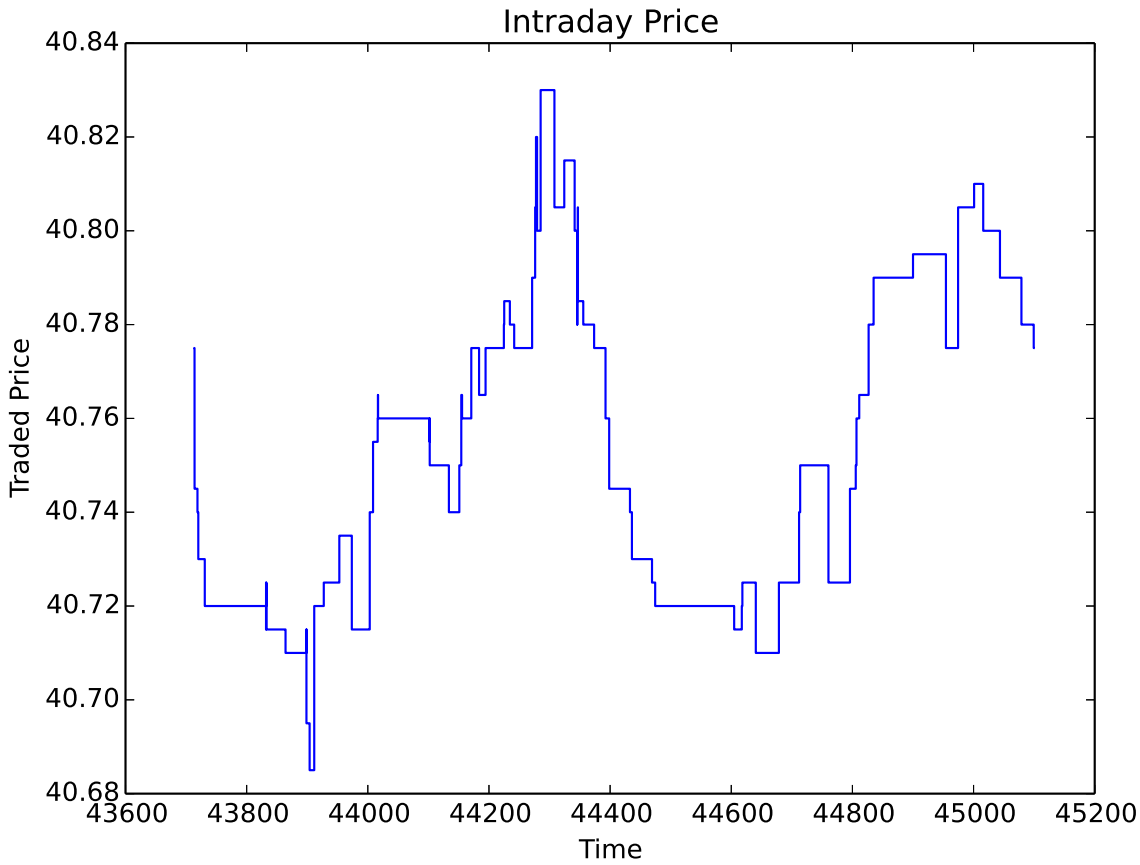

Alstom traded prices on February 1, 2011.

- In fact, it is not continuous, it evolves on a grid.
- The minimum price increment is called the tick whose size depends on the price level and the trading activity (since MiFID II).

Intraday patterns

- Intraday patterns are important, not only because they are critical for execution to a benchmark, but also because the concentration of trading in a specific time span during the day often reflects how informative the traded prices during this interval are.

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- There is an incentive, for both informed traders and liquidity traders, to time their trades to occur simultaneously.
- Furthermore, there are meeting points in terms of information, such as the opening or closing of some markets, that influence trading on other markets, or the release of important macroeconomic news at a predetermined time of day.

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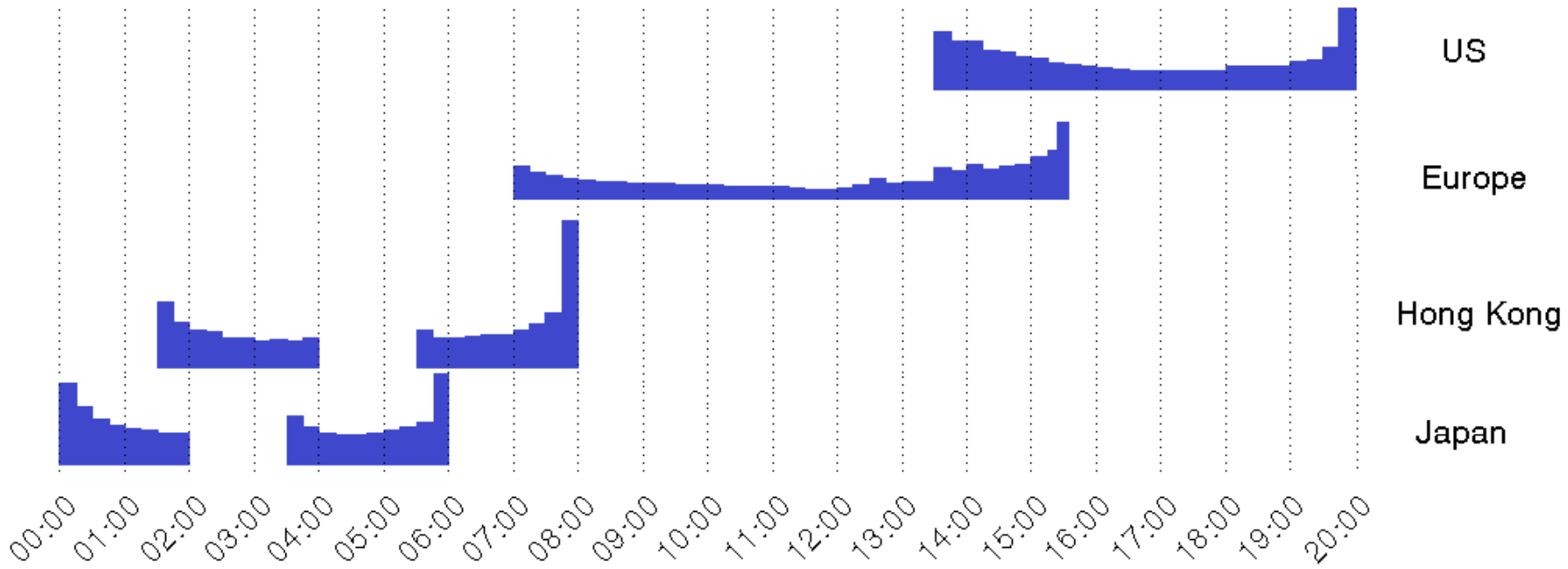
- The opening of another linked market;
- The release of news at a predetermined time of day on a regular basis (e.g. macroeconomic news or earnings announcements, which are often released before the opening);
- The way reference prices are computed, and whether a specific fixing phase is used especially for this purpose.

Volume Curves



Volumes curves and trading hours for exchanges of interest in GMT time to highlight overlapping across markets.

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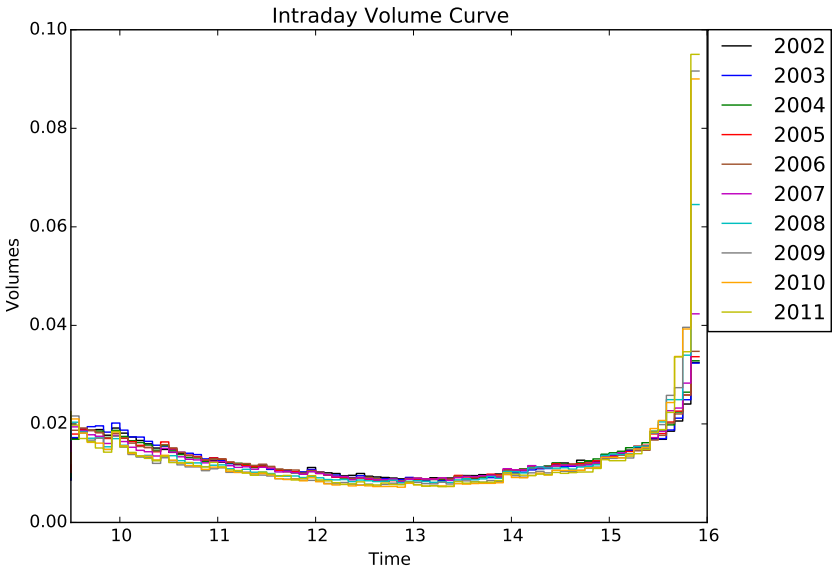
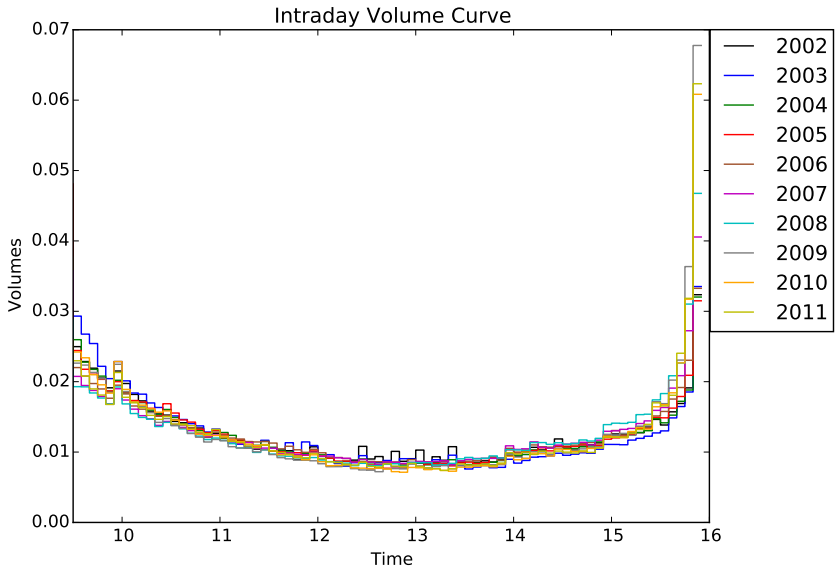
- This is the case for US opening on European markets and we will see these effects on the intraday curves.
- We recover the characteristic *U*-shape with an asymmetry between beginning and end of the day (more traded volume at the end because of inventory or intraday trading strategies).

Intraday Volume curve : US

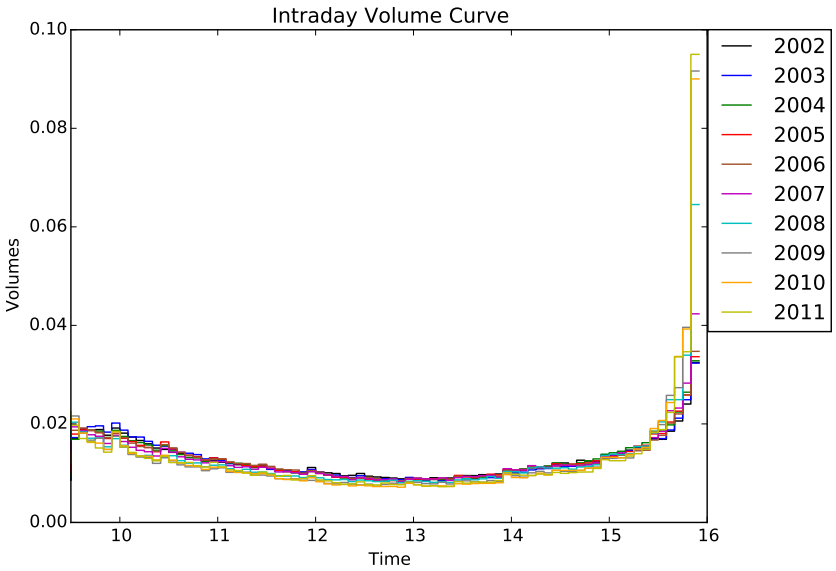


NYSE



NASDAQ

Intraday Volume curve : US



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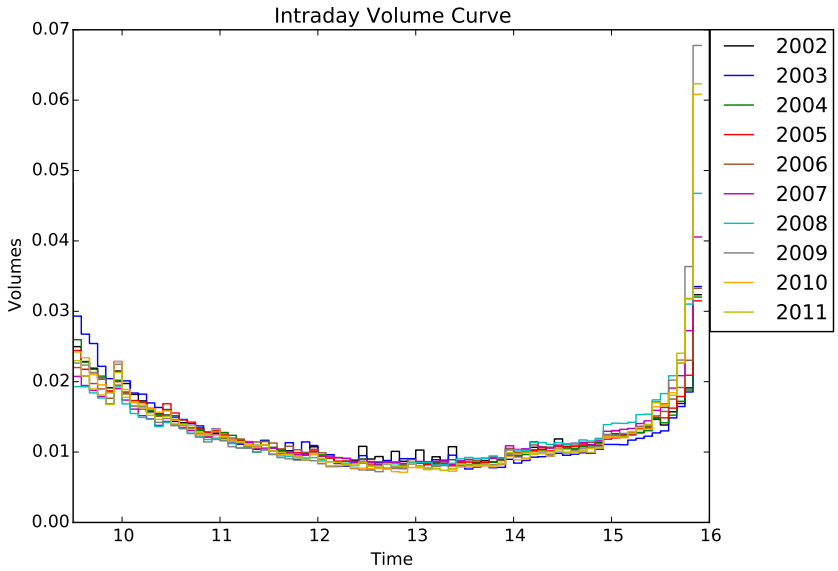
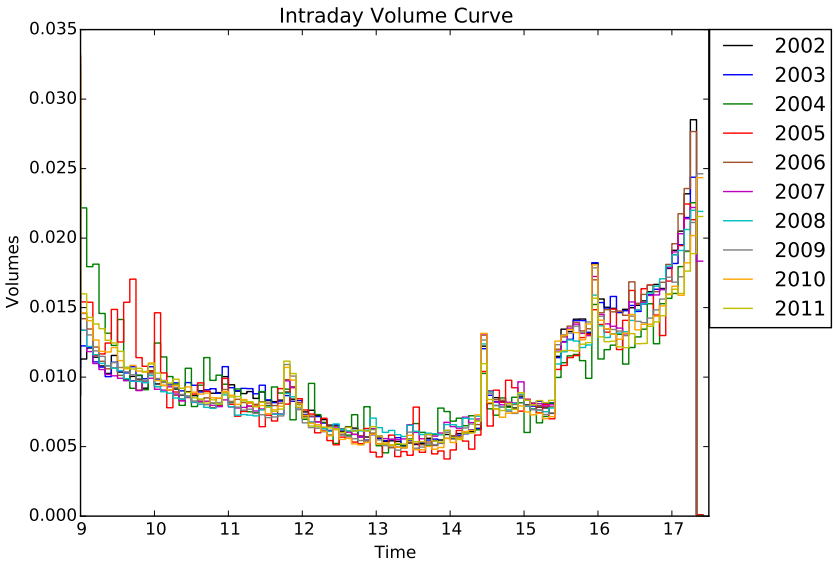


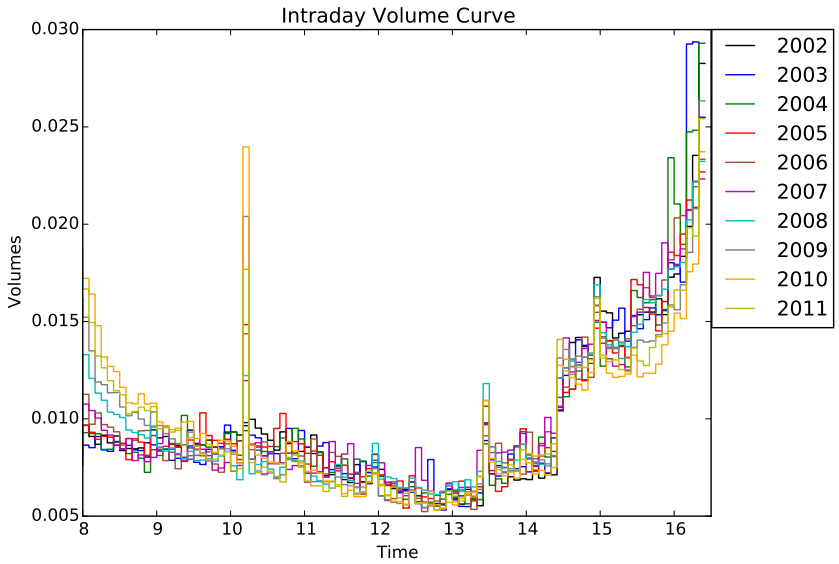
NASDAQ

The volume curve is very smooth with slight changes: less volume in the beginning of the day and more at the end that leads to a *J*-shape of the intraday volume curve (no market opening, size of US equity markets).

Intraday Volume curve : Europe

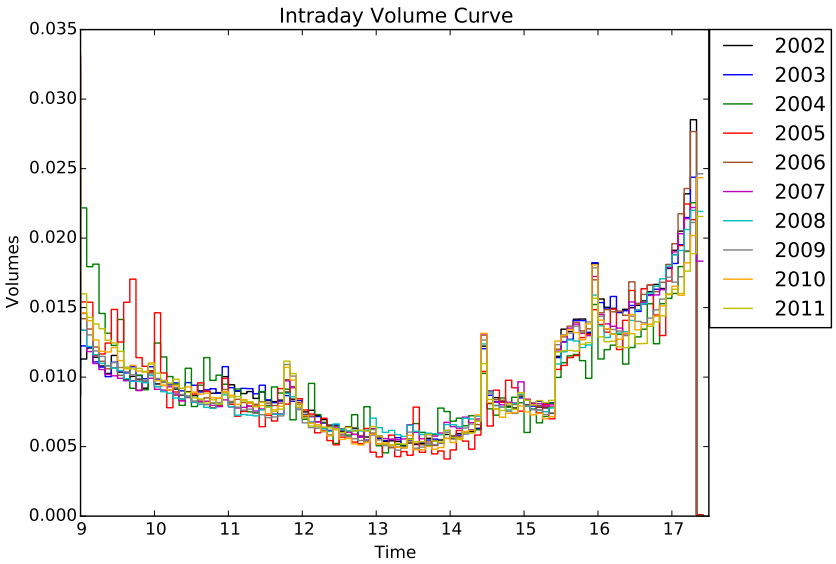


Euronext-Paris



LSE

Intraday Volume curve : Europe



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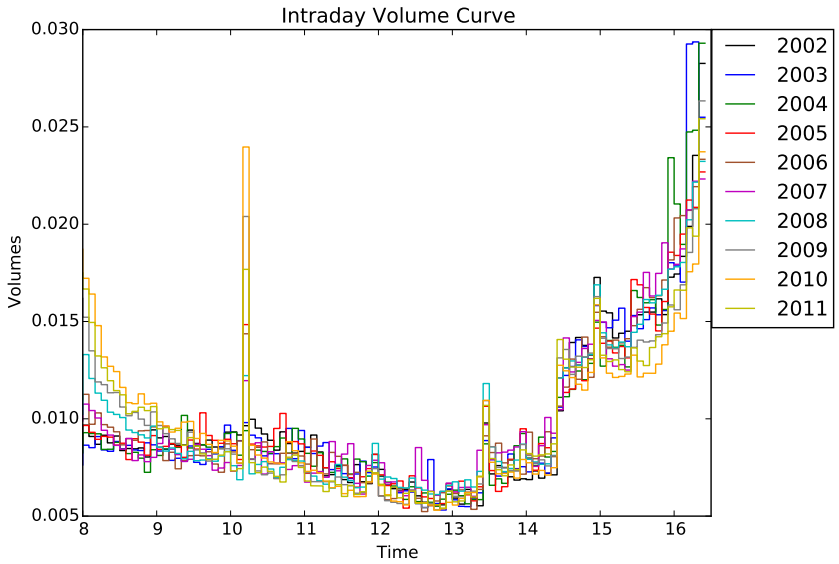
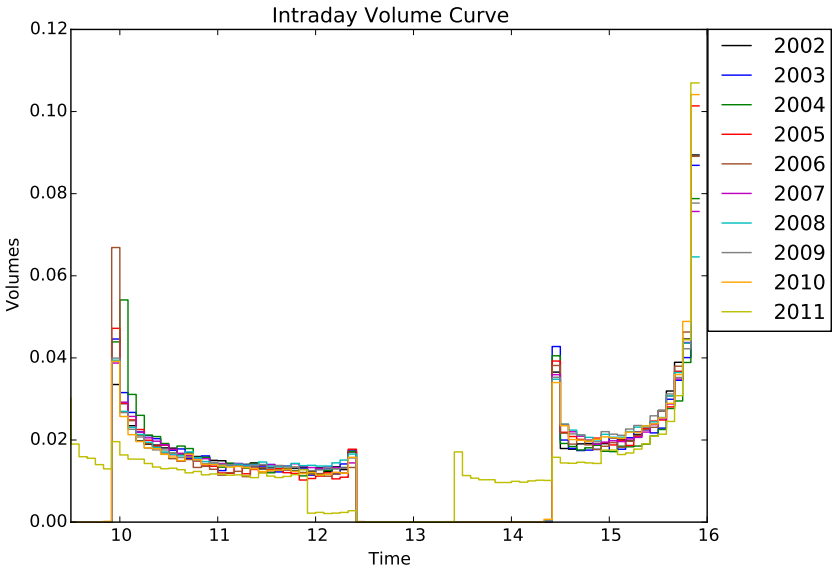


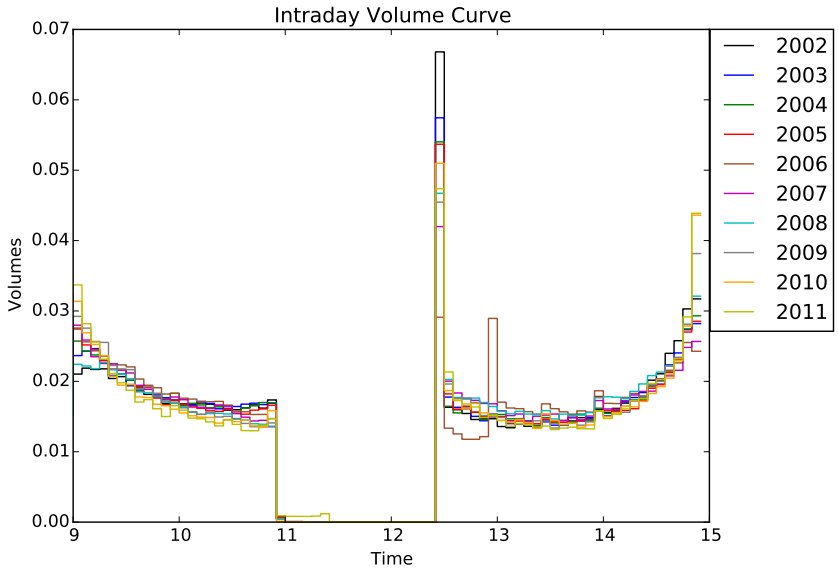
LSE

We observe some spikes that can be explain by the opening of US market, the US macroeconomic news, ECB (European Central Bank) macroeconomic news and the equity derivative expiries.

Intraday Volume curve : Asia



HKE



TSE

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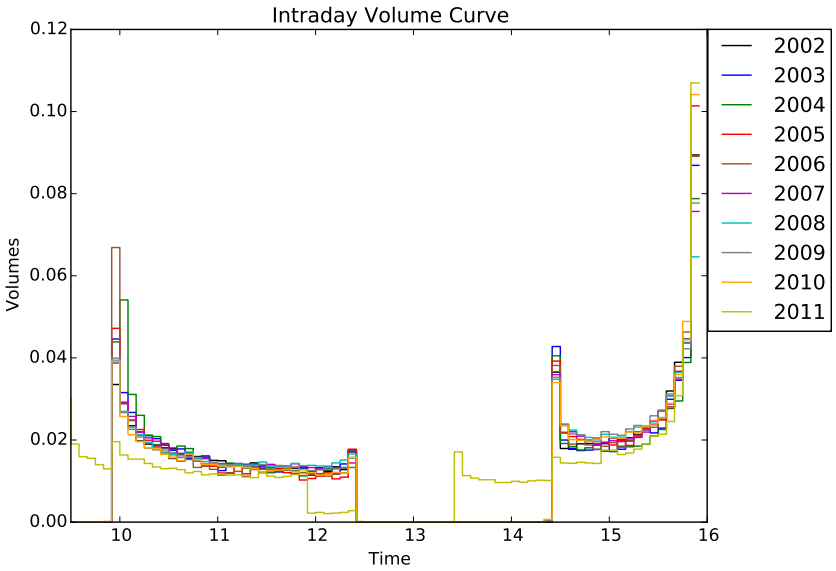

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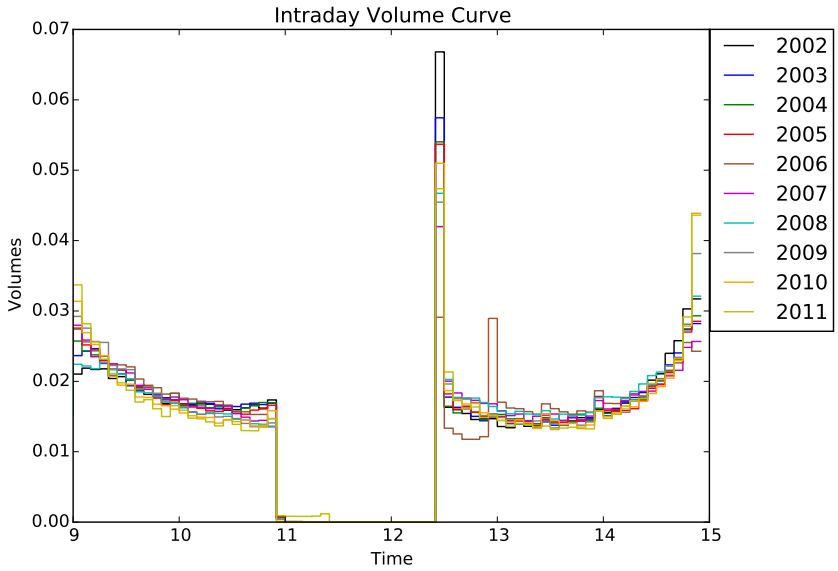

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We clearly see the lunch break and the beginning of the afternoon session (with a fixing at the beginning of the afternoon session for TSE which implied a huge volume). In 2006, TSE changes the beginning of the afternoon session to 1 p.m. (local time) and put it back at 12.30 in April.

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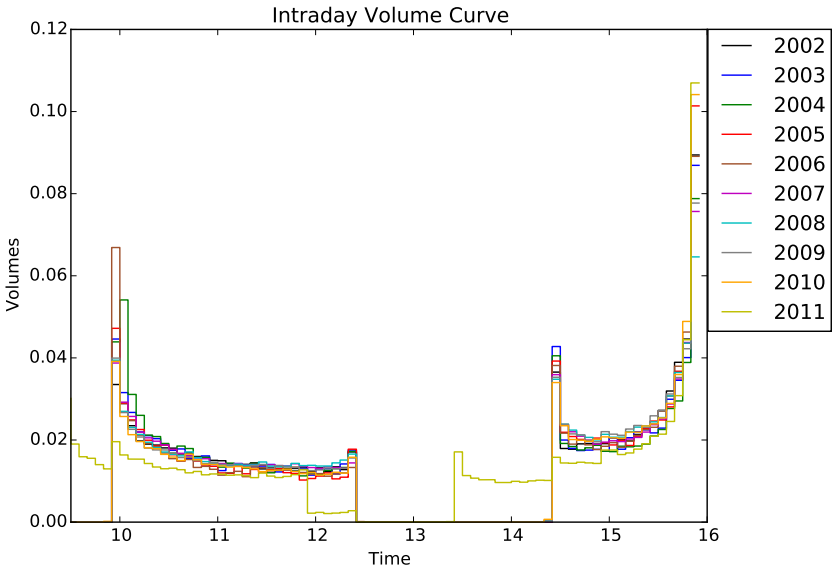

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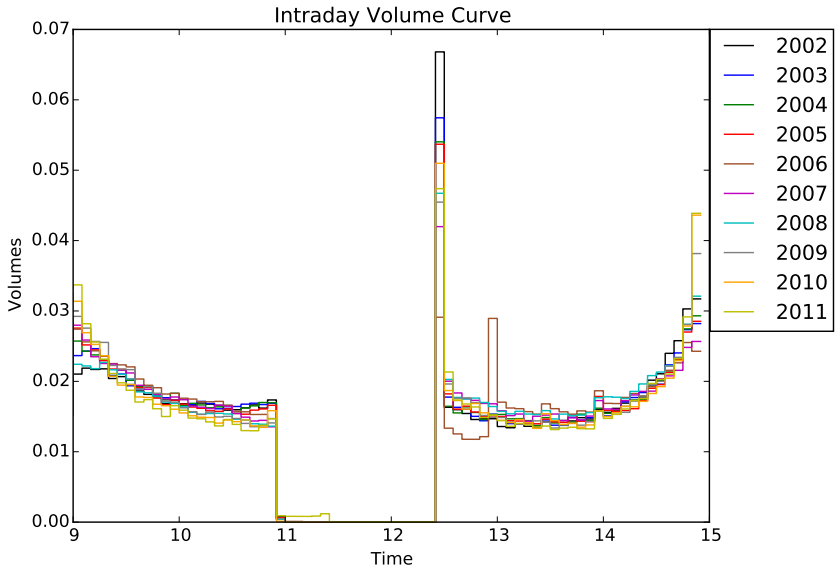

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For HKE, the volume curve is closer to a *J*-shape due to the effect of the computation od the reference price: 17% of the traded volume falls in the last 15-minute bucket and a quarter of this volume is concentrated in the very last minute (median of five prices observed every 15 seconds during the last minute of trading).

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The opening of US market happens at 9.30 a.m. (US eastern time, which converts into 3.30 p.m. for Euronext-Paris and 2.30 p.m. for LSE).

Macroeconomic News

- The Bureau of Labor Statistics releases a report on the employment situation in the US usually on the first Friday of the month at 8.30 a.m. (US eastern time).
  - Most popular indicator : change in non-farm payroll employment (number of jobs added or lost in the economy over the past month, not including jobs related to the farming sector).
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  - The composite index indicates whether manufacturing and the overall economy are growing or declining (only a portion of the economy is concerned).
- ECB publishes at 11 a.m. (Paris local time) some announcements: inflation rates, unemployment rates, retail sales, CPI (Consumer Price Index), PPI (Producer Price Index).

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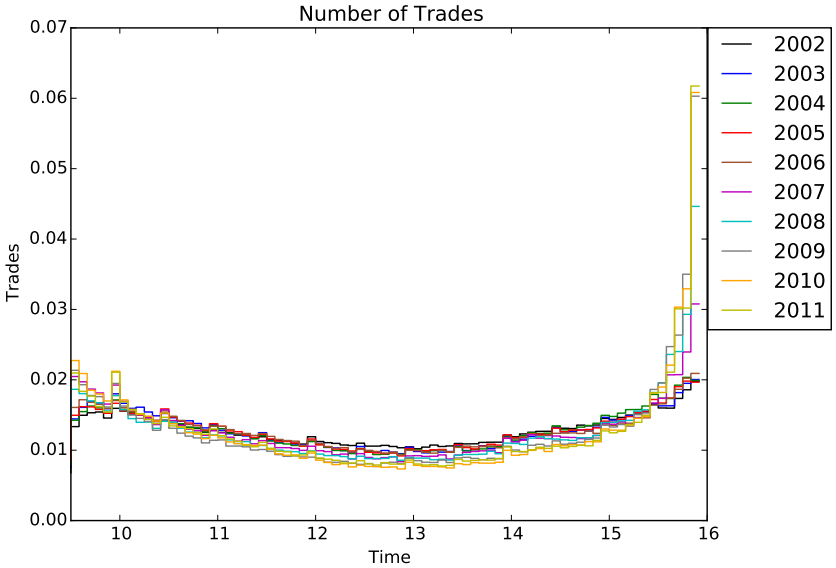
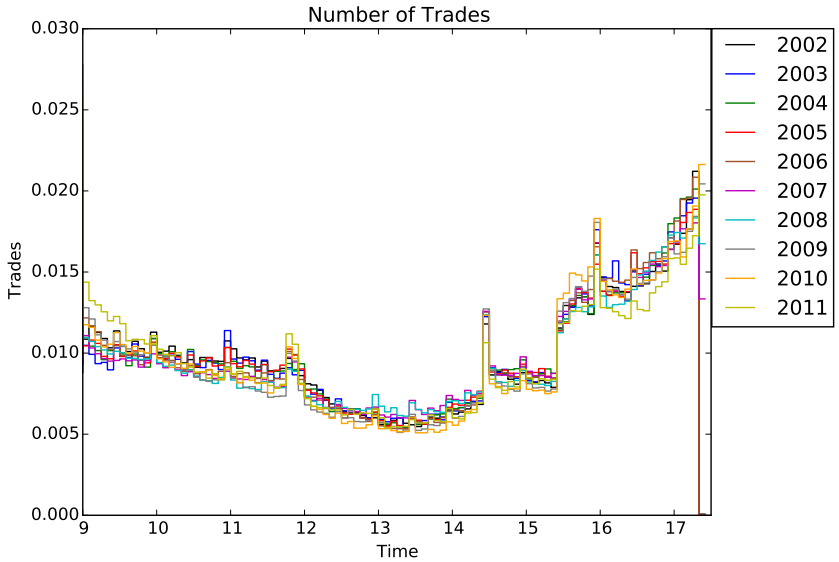
- The extra volume between 3.40 p.m. and 4.00 (Paris local time) that can be observed is due to CAC 40 derivatives, whose EDSP are computed on prices observed in this specific span of time. Equity derivatives expiries also have an effect on the volume traded at the closing fixing.

Number of trades



NYSE



Euronext-Paris

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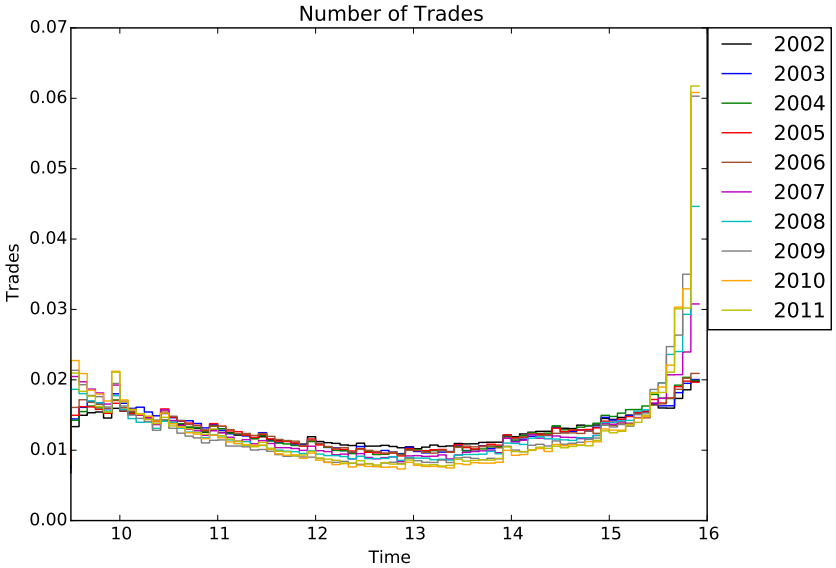

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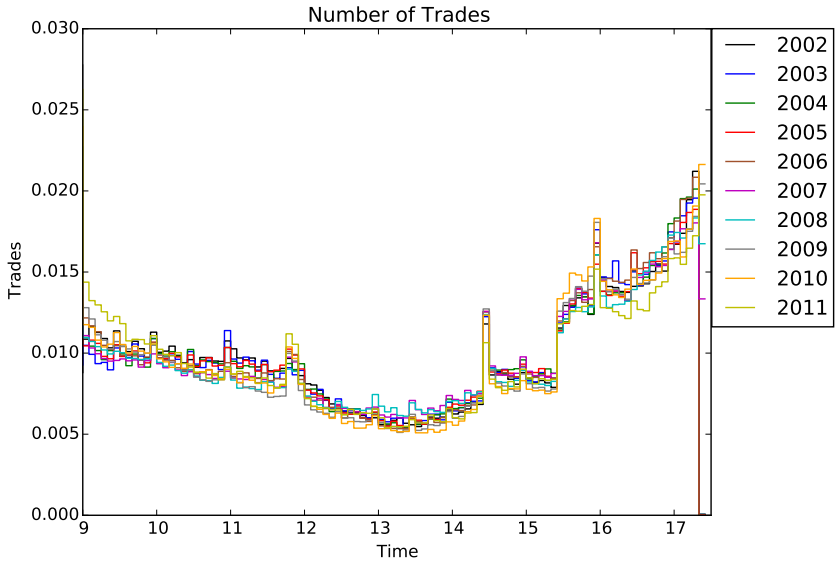
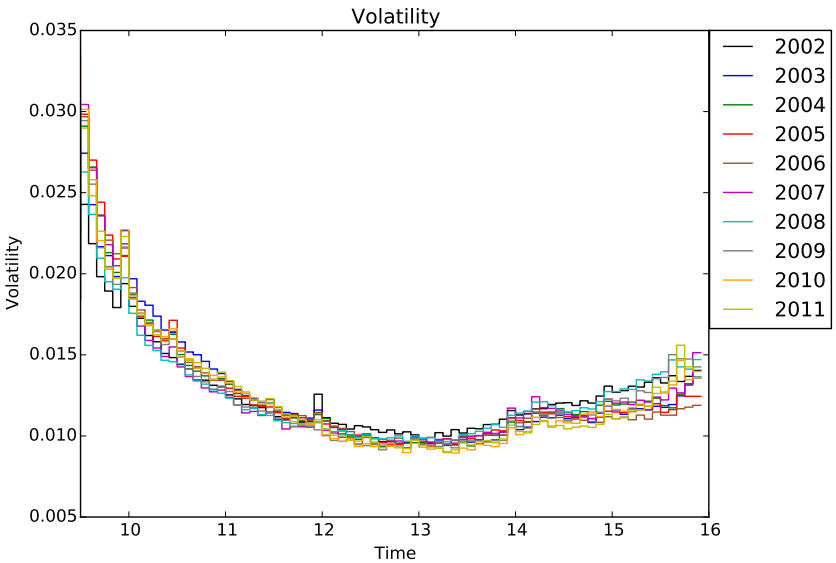


Euronext-Paris

The distribution of intraday trades is close a *U*-shape.

Volatility



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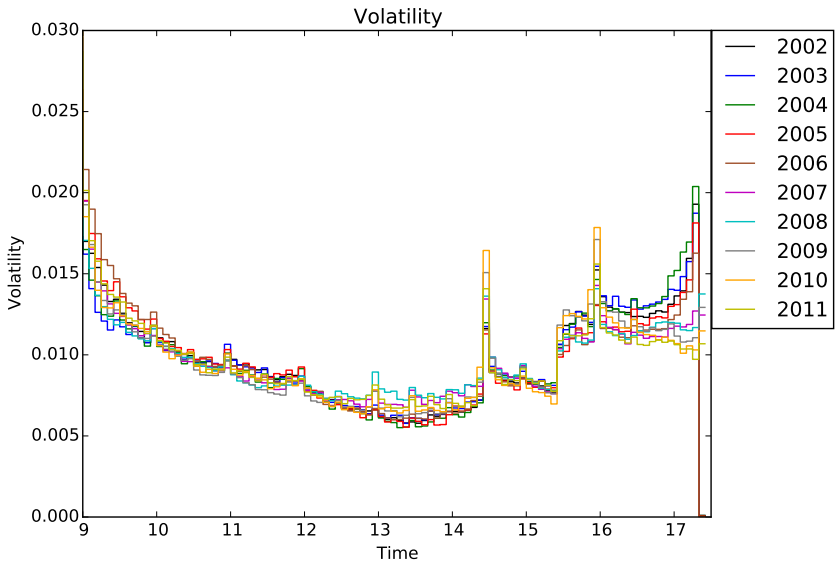

Euronext-Paris

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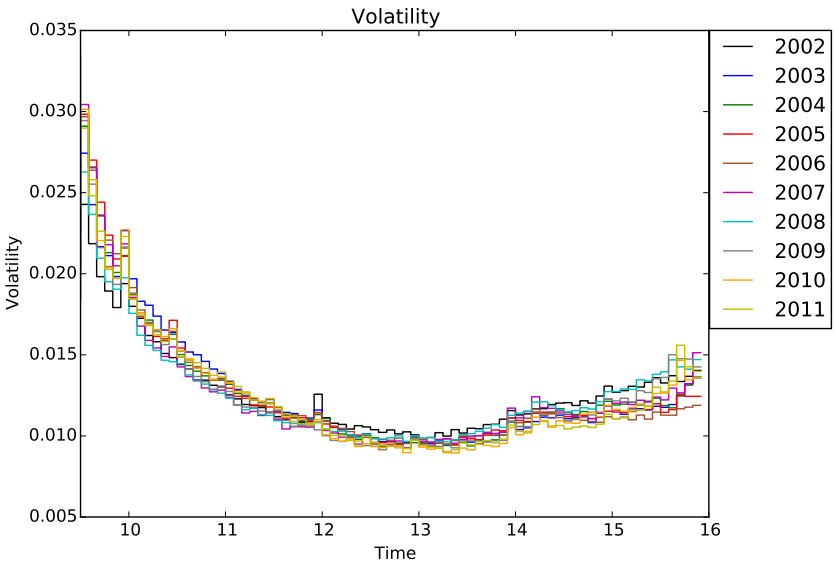

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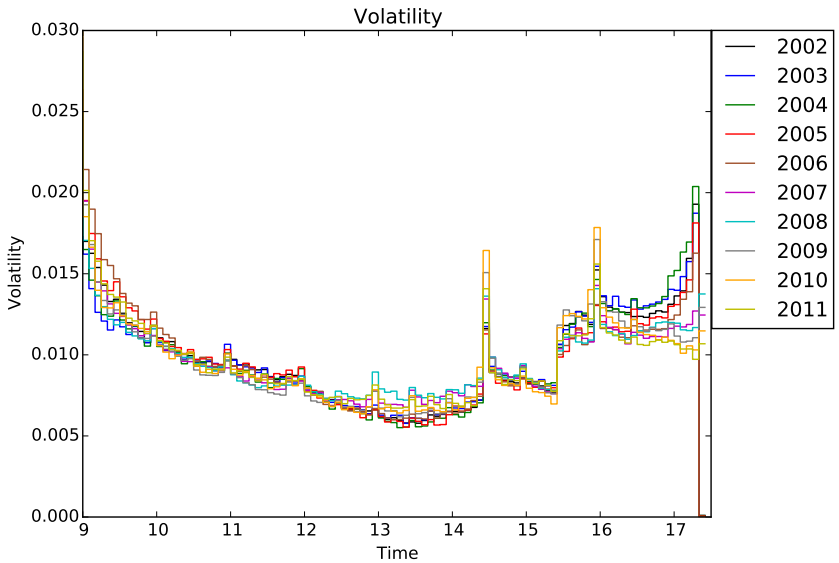
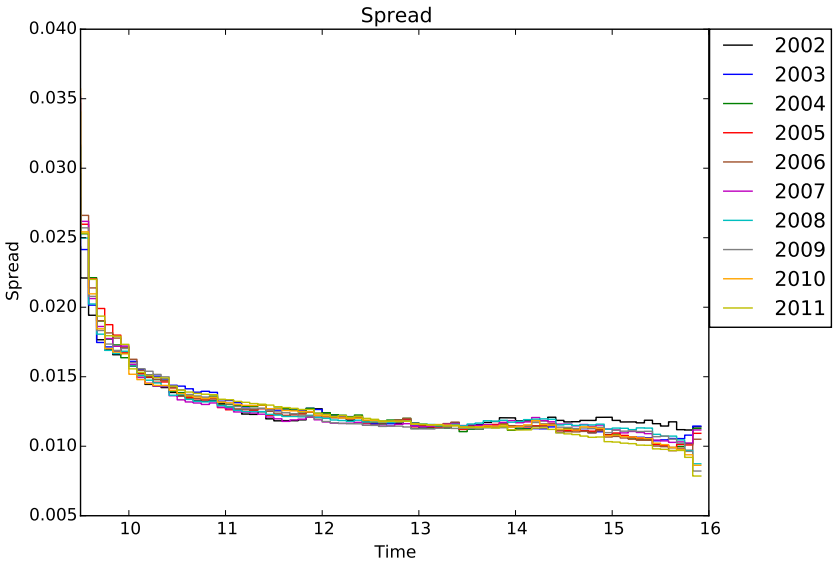


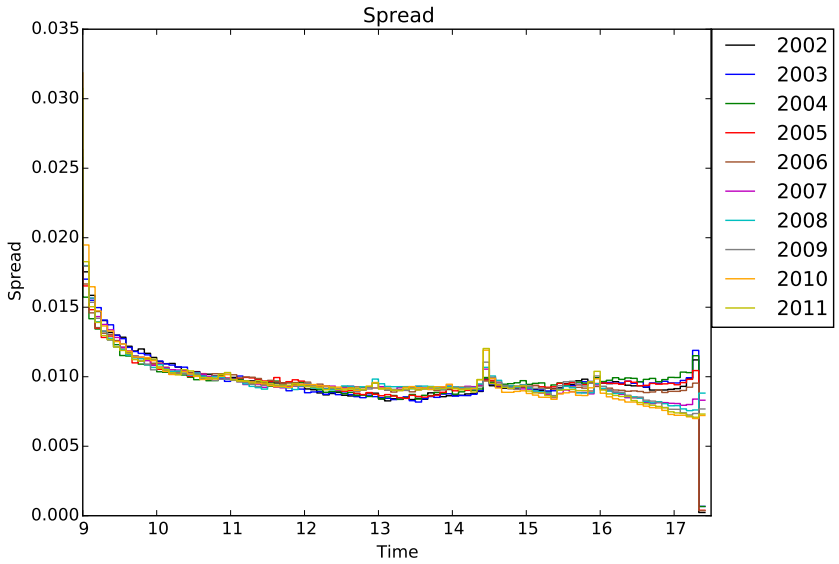
Euronext-Paris

The volatility looks like a *U*-shape, but on the contrary to the volume, it is higher at the beginning of the day than at the end.

Bid-ask spread

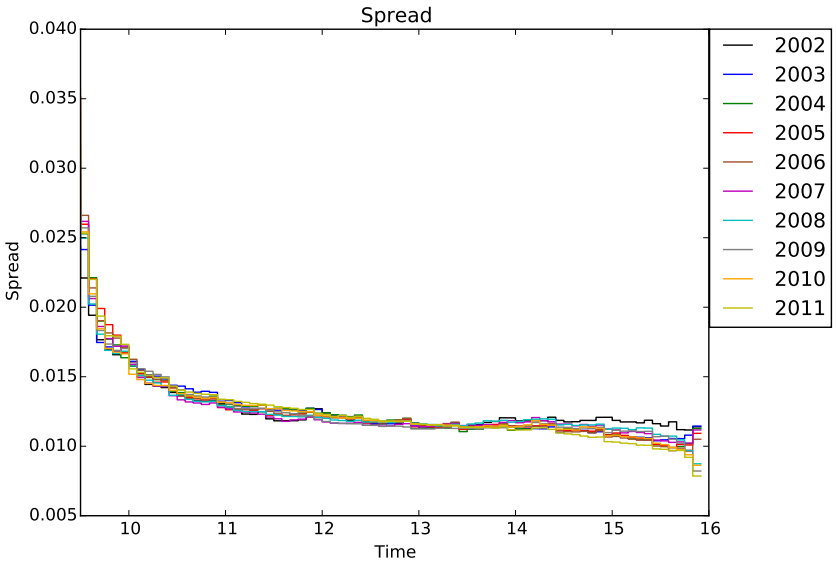


NYSE



Euronext-Paris

Bid-ask spread



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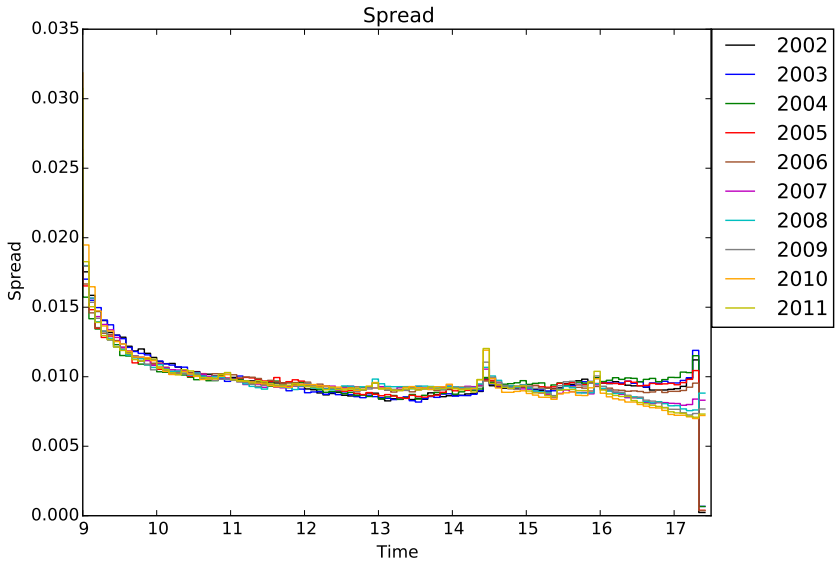
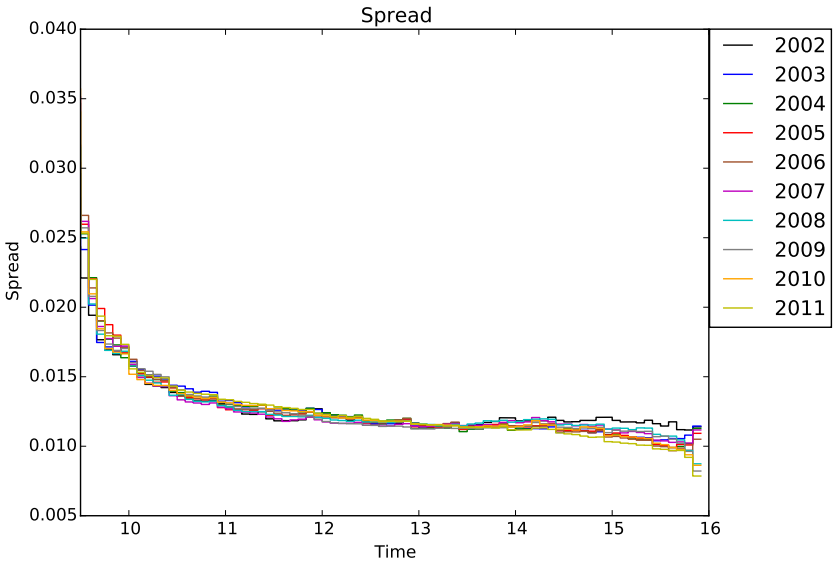


Euronext-Paris

The bid-ask spread has a *S*-shape with high spread at the opening, a decline, then a flat period in the middle of the day, and decreases at the end because of the increase in intraday volumes toward the close (market maker willing to liquidate passively their inventory explains the spread tightening observed before the close).

Bid-ask spread



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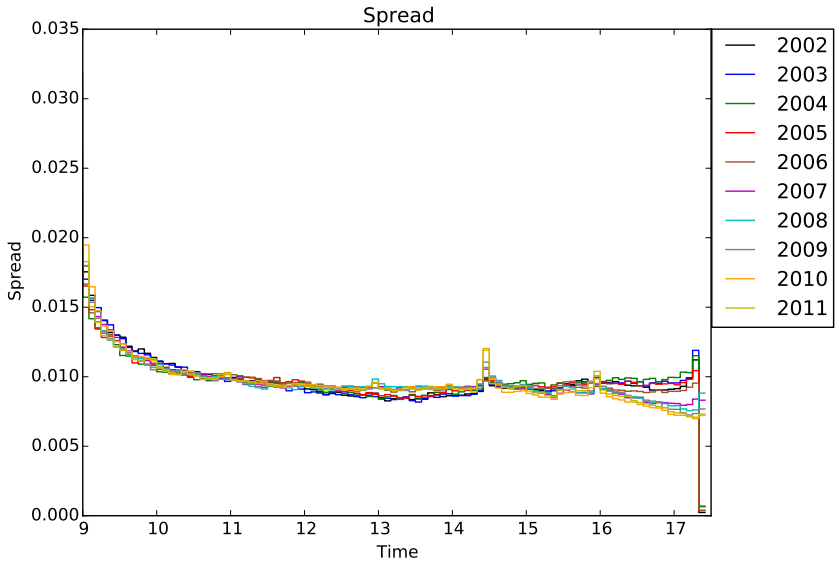
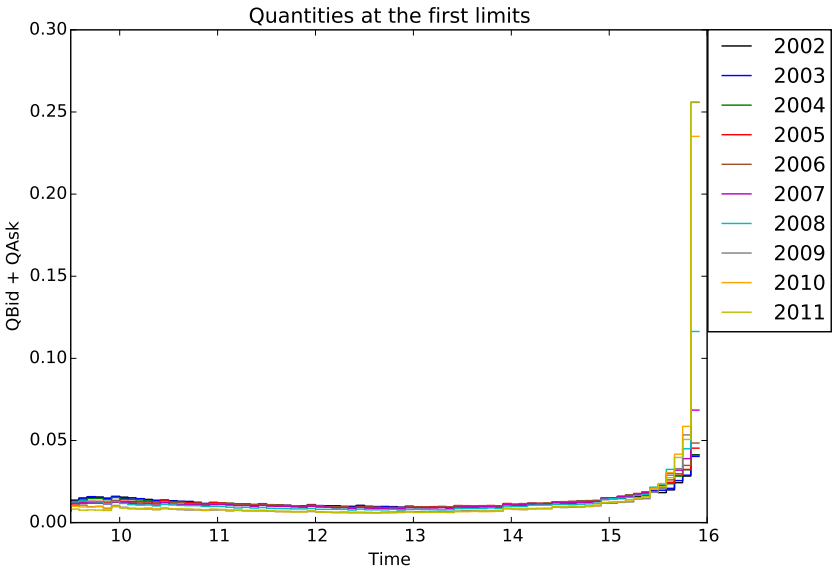


Euronext-Paris

The bid-ask spread has a *S*-shape with high spread at the opening, a decline, then a flat period in the middle of the day, and decreases at the end because of the increase in intraday volumes toward the close (market maker willing to liquidate passively their inventory explains the spread tightening observed before the close). With electronization (HFT with Reg NMS or MiFID), we observe a downturn in the bid-ask spread at both beginning and end of the day (more market activity) for all exchanges (and an upturn in the middle of the day).

Quantity at the best quotes



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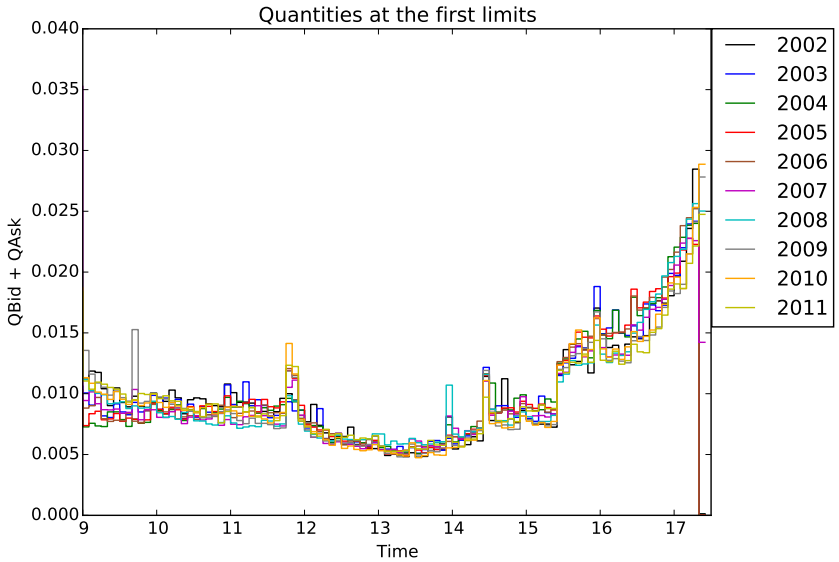

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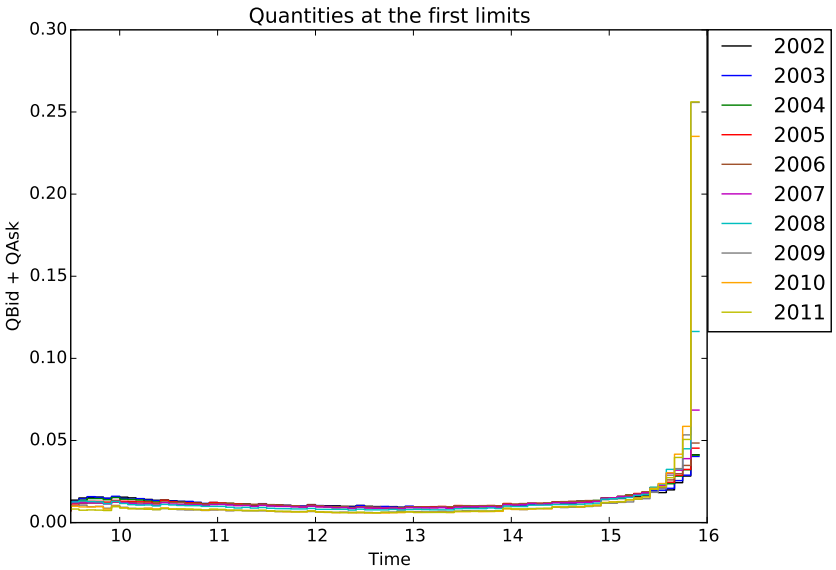
Quantity at the best quotes



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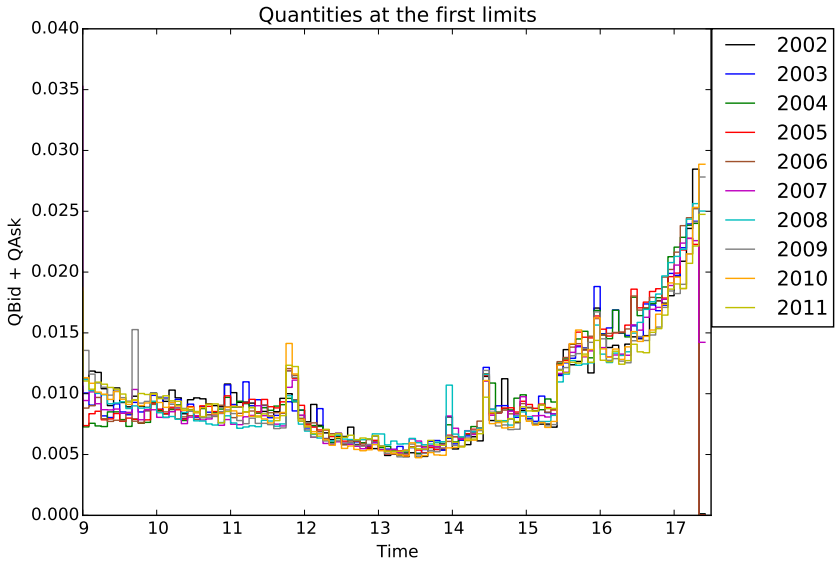
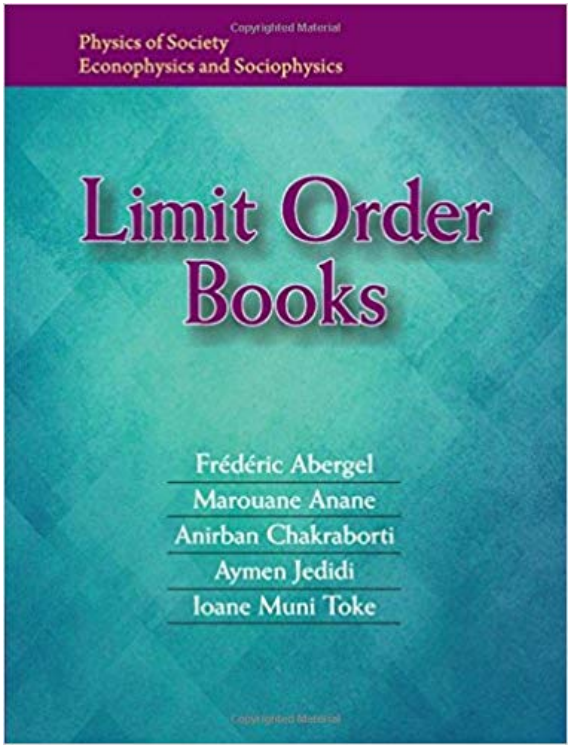


Euronext-Paris

We find again the *J*-shape.

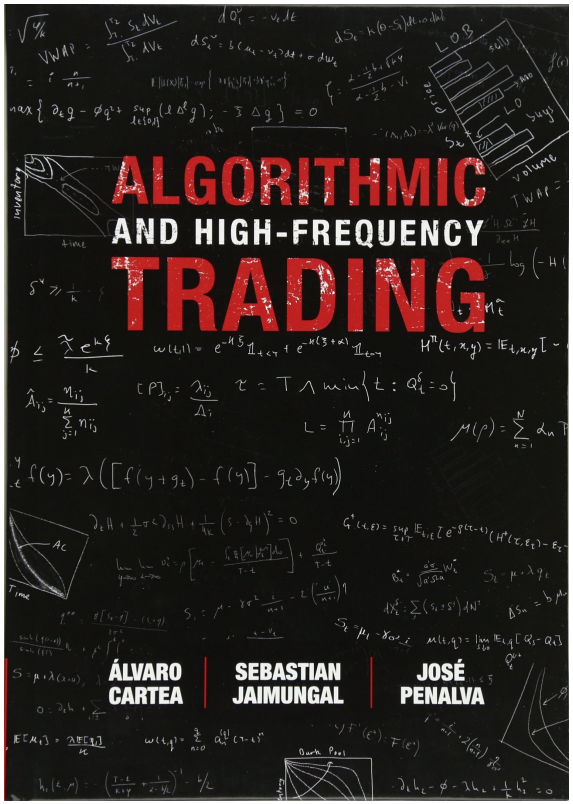
Books



Frédéric Abergel (BNP Paribas),
Marouane Anane (BNP Paribas),
Anirban
Chakraborti (Jawaharlal Nehru University),
Aymen Jedidi (HSBC Bank),
Ioane Muni Toke (CentraleSupélec).

Website

Books



Álvaro Cartea (University of Oxford),
Sebastian Jaimungal (University of Toronto),
José Penalva (Universidad Carlos III de Madrid).

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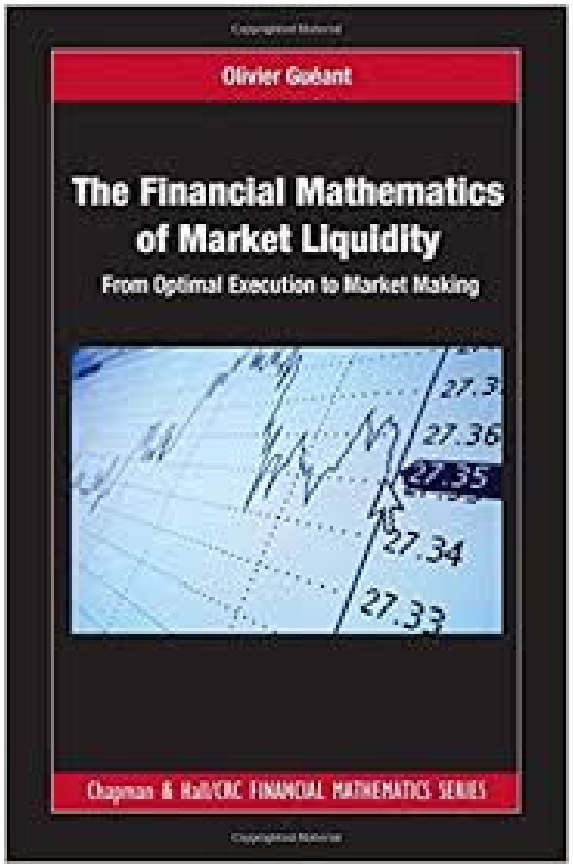
Books



Olivier Guéant (Université Paris 1).

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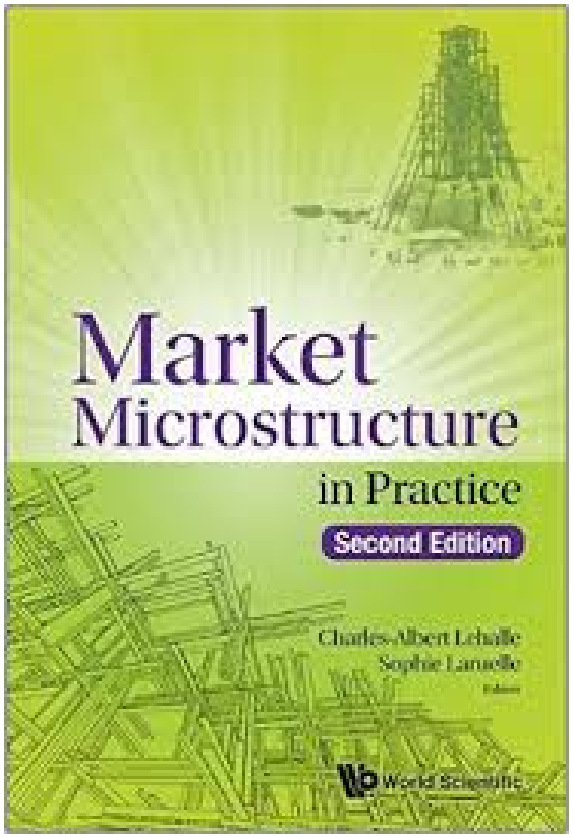
Books



Charles-Albert Lehalle (ADIA),
Sophie Laruelle (UPEC).

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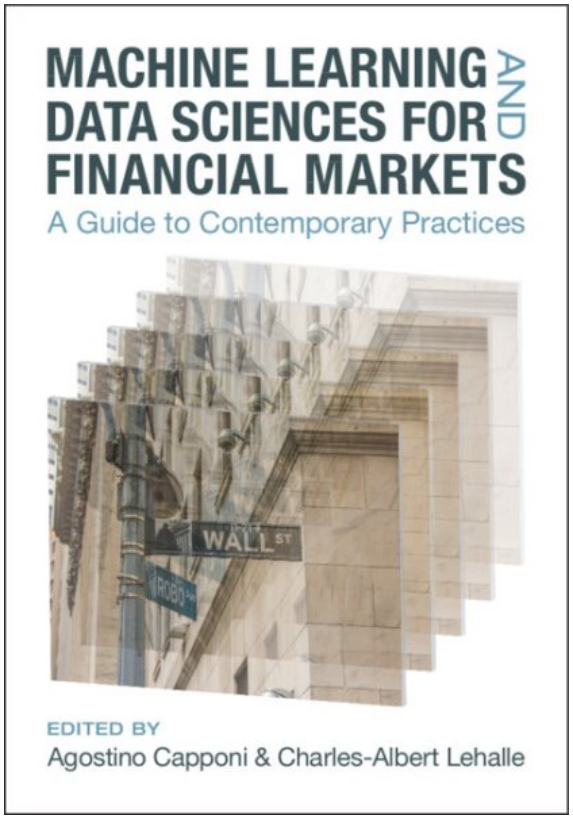
Books



Agostino Capponi (Columbia University), Charles-Albert Lehalle (ADIA).

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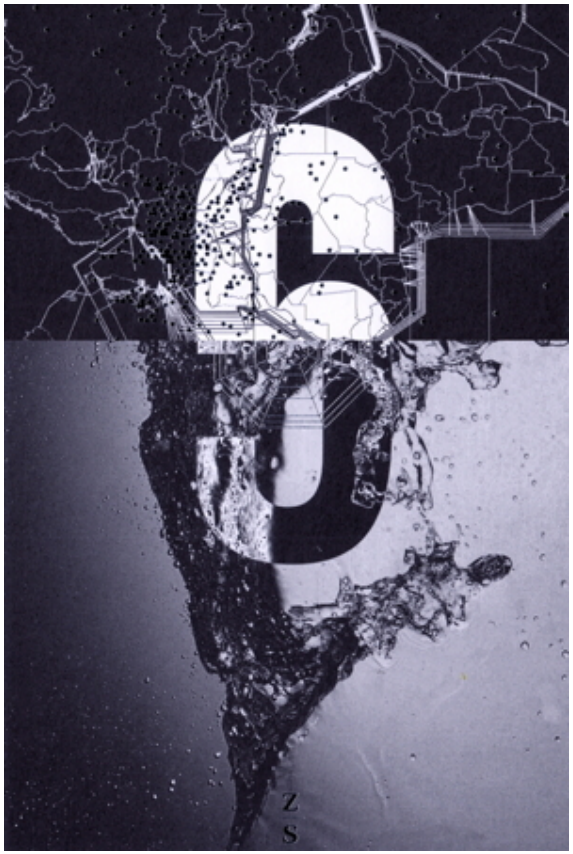
Books



Alexandre Laumonier

Website