



Algorithmic Trading

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Topics

1. **Market Macrostructure**
2. Market Microstructure
3. Algorithmic Trading Fundamentals
4. Algorithmic Execution
5. Algorithmic Market-Making
6. Algorithmic Investment
7. The Future of Algorithmic Trading

1. Market Macrostructure



I. The purpose of markets

- Markets bring together individuals or organizations interested in trading (e.g. buy or sell) financial instruments like stocks, bonds, etc
 - **Primary markets:** when the financial instruments are being created and sold for the first time to investors, e.g. governments issuing bonds, an initial public offering (IPO) of stock by a company
 - **Secondary markets:** when the financial instruments were already created in the past, and the purpose is to exchange them with other investors if they are not willing to wait until the financial instruments expires. Most of the trading activity in a given day happen in practice in secondary markets
- A key characteristic of markets is **liquidity**: how easy is to trade a certain financial instrument at a fair price in the secondary market.
 - Liquidity benefits investors since they can trade at better prices in secondary markets.
 - It also benefits the organisations that issue the instruments, since having a liquid secondary market makes a new instrument more attractive in a primary market, therefore commanding a higher issuing price

Liquidity and fair price determination

- The **fair price** of a financial instrument is the value that investors give to the instrument when removing all potential sources of friction in trading, i.e. it takes into account only characteristics of the instrument like future cash-flows, maturity, early redemption etc, but not commissions, fees, or premiums / discounts paid to trade with urgency for example
- Since fair prices depend on future economical conditions, which are **uncertain**, they are difficult to estimate independently. Markets help to determine fair prices by publishing information about past / current transactions, reflecting in practice what are the views that investors have on the value of the financial instrument at a given time
- Of course actual prices transacted in markets depend on liquidity, which makes the problem of liquidity and fair price determination a “**chicken or the egg**” one!
- Assuming that investors have already a view on fair price, a market is more liquid if they can trade at a price close to this estimation. This will depend on:
 - how big are the commissions / fees that the market charges for facilitating trading
 - having other investors willing to be on the other side of the trade. The bigger the volume of the transaction the more difficult to trade it at a fair price, requiring to pay a premium / discount to attract investors
 - How easy is in general for investors to estimate fair price: more complex instruments or instruments that are traded less often are more difficult to value, and such uncertainty usually has to be compensated with a premium / discount

II. What instruments are traded in financial markets?

Financial instruments are typically classified in the following asset classes:

1. Equity
 1. Shares in the capital of a company: stocks
2. Fixed Income
 1. Debt of corporates and governments: bonds
3. Foreign Exchange
 1. Currencies
4. Money Markets
 1. Short term funding instruments for banks, institutions and corporations
 2. Examples: Fed funds, commercial paper, repo, securities lending
5. Derivatives
 1. Contracts that derive their value from other assets (underlyings)
 2. Examples: futures, options, swaps, credit derivatives
6. Cryptocurrencies
 1. digital currencies in which transactions are verified and records maintained by a decentralized system using cryptography
 2. Examples: bitcoin, ether

III. Market participants: a classification

- **Liquidity takers** (“buy side”): investors (aka “clients”) who want to hold assets or convert them in cash. Types:
 - Institutional: banks, insurance companies, pensions, hedge funds, REITs, investment advisors, endowments, and mutual funds...
 - Corporations
 - Governments
 - Retail (“individuals”)
- **Liquidity providers** (“sell side”): since supply and demand from investors is not always matched, there is room for intermediaries that benefit from facilitating trading in the markets:
 - Dealers (aka “market makers”): by holding inventories and therefore being able to buy and sell at any time. They take risk. Examples:
 - Investment banks: J.P. Morgan, Citi, UBS, BBVA...
 - Non-bank liquidity providers: Citadel, Virtu, Jane Street, ...
 - Inter-dealer brokers: companies that build networks of buyers and sellers and connect them. They don’t take risk. Examples: ICAP, BGC, ...

IV. Market structures

Traditionally, the relevance of intermediaries (dealers) in facilitating trading has been so large that markets have been structured to accommodate their needs:

- **Inter-dealer markets:** markets where intermediaries trade with each other exclusively. They typically want to adjust the inventories in order to facilitate trading with investors (“clients”). Recently, they are allowing investors to participate directly in these markets using their membership (direct market access)
- **Dealer-to-client markets:** markets where intermediaries transact with investors
- **Alternative markets:** new market structures that are emerging recently that bypass the dealer / client segmentation in traditional markets. They tend to provide “all-to-all” trading, i.e. have intermediaries and investors trade in the same conditions

<i>Asset class</i>	<i>Inter-dealer</i>	<i>Dealer-to-client</i>	<i>Alternative</i>
Equities	Exchange	Single/Multi broker, DMA	ECN/MTF, ATS
Derivative (Listed)			
Other (ADR, ETF)			
Fixed income	OTC/IDB	Single/Multi broker	ECN, ATS
Foreign exchange			
Money markets			
Derivative (OTC)	OTC	OTC	

Table 3-1 Market structure across asset classes

Evolution of market structures

- Market structures evolve pushed by factors like standardisation, technology, regulation and competition. Roughly, we tend to see the following evolution:
 - **Single dealer to client:** the most primitive structure, where investors can only trade with intermediaries using specific channels facilitated by the dealer: phone, voice, chat, a dealer electronic platform, etc. Tends to happen in early stages of development of a market, or for products that are complex or niche
 - **Multi dealer to client:** competition tends to increase the number of intermediaries facilitating trading, and markets are created that connect clients with multiple dealers at the same time.
 - **Dealer to dealer:** as the interest in trading a certain instrument increases, and competition brings multiple dealers into facilitating trading, they tend to build inter-dealer markets to ensure they have enough inventories to trade with investors. As these markets tend to grow in relevance, some dealers tend to directly facilitate access to clients to directly trade in these markets using their membership (direct market access), effectively becoming all-to-all although clients cannot become members directly
 - **All to all:** recent regulations are trying to benefit investors (clients) by increasing competition. Alternative markets can now be created by private organisations where the traditional dealer / client segmentation is removed, therefore eliminating some of the costs to trade via intermediary fees. Those structures tend to emerge, though, only in most standardised / frequently traded instruments.

A. Inter-dealer markets

- Intermediaries (dealers) build markets to trade with each other in order to meet their client's requirements if they don't have enough inventory.
- A good inter-dealer market is vital to improve liquidity in the dealer-to-client markets
- More recently, dealers are allowing investors (dealers) to access directly to some of these markets (mostly exchanges) using their membership (direct market access)
- Typical market structures:
 - Exchanges
 - Inter-dealer broker networks

Exchanges

- Oldest and best known venue for trading
- *Marketplace where multiple third-parties bring together buying and selling interests in financial instruments*
- The operation of an Exchange is carried out exclusively by **authorised market operators and is not considered an investment service** (core difference with respect to ATS/MTF, see later)
- Trading mechanisms:
 - Traditionally floor-based open-outcry auctions
 - The majority are moving to electronic order books (“lit” order books, since the orders and trades are published to all the participant)
- Trading is carried out by members of the Exchange, who are normally specialised dealers or brokers.
 - However, in the last years investors have been able to access directly to Exchanges using Direct Market Access (DMA) through brokers
- Core functions:
 - Fair and orderly trading
 - Efficient dissemination of price information

Examples of Exchanges

Asset class	Exchange
Equities	U.S: New York Stock Exchange (NYSE), NASDAQ, BATS Europe: London Stock Exchange (LSE), Euronext, Deutsche Börse, Bolsas y Mercados Españoles (BME)
Fixed Income	Europe: LSE, Senaf, Eurex Cash
Money Markets	Europe : Eurex Repo
Derivatives	U.S.: Chicago Mercantile Exchange (CME), Chicago Board of Trade (CBOT), Chicago Board Options Exchange (CBOE) Europe: Eurex, London International Futures Exchange (Liffe), Mercado Español de Futuros Financieros (MEFF)

Inter-dealer broker networks

- Inter-dealer brokers (IDBs) are **specialist intermediaries that facilitate transactions between dealers in markets without Exchanges**
- For assets that generally trade over the counter (OTC)
- Trading mechanisms:
 - Phone, email, chat
 - Dedicated electronic trading platforms (most liquid products)
 - Some just aggregate dealer's quotes
 - Others have a full order book (“lit”) based-functionality
 - Some also aggregate voice-based OTC

Asset class	Platforms
Fixed Income	U.S (Treasuries): NEX BrokerTec, BGC, ICAP Europe: MTS Cash
Foreign Exchange	EBS Direct, Reuters
Money Markets	U.S.: NEX BrokerTec, BGC, ICAP Europe : MTS Repo, ICAP
Swaps	ICAP i-Swap, CME SwapStream, MTS Swaps
Credit Default Swaps	ICE Creditex, ICAP

B. Dealer-to-client markets

- **Markets where dealers and brokers provide liquidity to investors**
- Can be order-driven or quote-driven
- Single dealer-to-client or multi dealer-to-client
- Trading mechanisms:
 - Phone, email, chat
 - Electronic platforms

Asset class	Platforms
Equities	Broker or vendor OMSs
Fixed Income	Tradeweb, Bloomberg, MarketAxess, MTS BondVision
Foreign Exchange	Bank platforms, FX All, Currenex, State Street FX Connect
Money market	Tradeweb, Bloomberg
Swaps	Tradeweb, Bloomberg, CME
Credit Default Swaps	Tradeweb, MarketAxess

C. Alternative markets

- **Markets that are privately owned, operated for profits and less regulated than the exchanges.**
- Consequence of regulations like MiFID and reg-NMS that pushed for competition in financial markets
- They are bypassing the traditional dealer-to-dealer and dealer-to-client structures, becoming effectively all-to-all
- They are becoming increasingly important
- Mostly electronic, although some are voice-based
- Can be order-driven or quote-driven
- Typical structures:
 - Electronic Communication Networks
 - Dark Pools

Electronic Communication Networks (ECNs)

- **Very similar to Exchanges (but regulated differently)**
- Aggregate orders of liquidity providers typically in an order book (“lit”), which can be executed by liquidity takers
- Liquidity providers can be dealers, brokers, or other agents, that must be members of the ECN
- Typically for stocks and currencies

Asset class	Platforms
Equities	US: Bloomberg Tradebook, BATS BZX before becoming Exchange Europe: Turquoise, BATS Chi-X before becoming Exchange
Foreign Exchange	FXAll, Bloomberg Tradebook

Dark Pools

- **Opaque order-driven trading platform:** buy and sell orders are matched without being displayed publicly
- There are various matching mechanisms:
 - Full order-book matching but with hidden limit orders (“dark” order book)
 - Matching using another market midpoint as a reference (eg US NBBO)
 - “Pass through” orders: if not matched in dark pool, send to lit market
- Set up by owners of Exchanges, brokers, investment banks...
- Despite the polemic surround them:
 - They are useful to match large block trades
 - They are highly regulated

Asset class	Platforms
Equities	ITG POSIT, Instinet CBX, Liquidnet, Credit Suisse Crossfinder, UBS MTF
Foreign Exchange	Hotspot QT

Trends

- Accessibility: all-to-all markets
- Transparency: pushed by regulations like MiFID 2
- Electronic trading: voice replaced by computer platforms

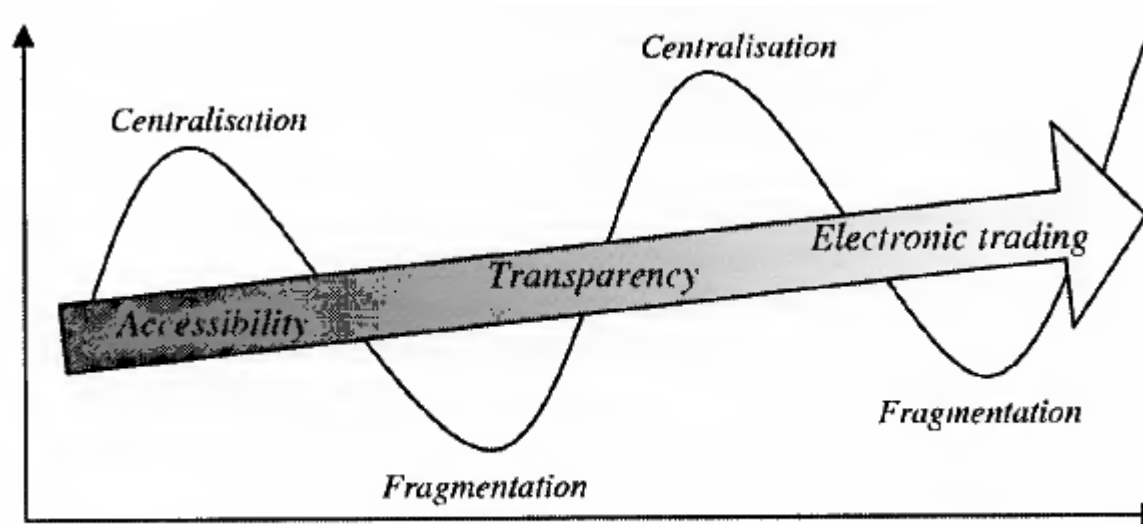


Figure 3-3 Common global market trends

Source: Johnson, B. (2010)

Market structure according to US regulation

- Market structure:
 - **Exchange trading venues**
 - **Alternative Trading Systems:** non-Exchange trading venues
 - Electronic Communication Networks
 - Call Markets
 - Crossing Networks
 - Dark Pools
- Additionally, we have (Dodd-Frank)
 - Swap Execution Facilities (SEFs): platform for financial swap trading that provides pre-trade information and a mechanism for executing swap transactions, including clearing
 - Examples: Bloomberg, 360T, CME, LCH, Eurex, ICAP, ICE, MarketAxess, Tradeweb, ...
 - Swaps: IRS and CDS
 - In European regulation there is no similar concept

Market structure according to European regulation (MiFID 2)

		Examples	DIFFERENCES
REGULATED MARKET - RM	“...means a multilateral system operated and/or managed by a market operator , which brings together multiple third-party buying and selling interests in financial instruments, in accordance with its non-discretionary rules , in a way that results in a contract...”	<i>Exchanges</i>	The main difference between an MTF and an RM is that RM is operated only by a market operator and a MTF could be operated by a market operator or an investment firm.
MULTILATERAL TRADING FACILITY - MTF	“...means a multilateral system operated by an investment firm or market operator , which brings together multiple third-party buying and selling interests in financial instruments, in accordance with non-discretionary rules , in a way that results in a contract...”	<i>Like USA's ATS ECN's , dealer-to-client networks, dark pools (MTFs exempted of pre-trade transparency – large in size waiver -)</i>	
ORGANISED TRADING FACILITIES - OTF	“...means a multilateral system which is not a RM or MTF and in which multiple third-party buying and selling interests in financial instruments are able to interact in the system in a way that results in a contract... Restricted to non-equities: bonds, structured finance products, derivatives...	<i>Similar in some aspects to USA's SEFs Broker-dealer networks</i>	The main difference between an MTF and an OTF is the fact that an OTF is not obliged to give an indiscriminate access to its services;
SYSTEMATIC INTERNALISER	“...means an investment firm which, on an organized, frequent, systematic and substantial basis , deals on own account by executing client orders outside a RM or an MTF or an OTF“.	<i>Dealers that match internally OTC orders</i>	SIs are not considered Trading Venues and are reserved for financial institutions that routinely use their own capital to trade in the markets.

V. Electronic Trading

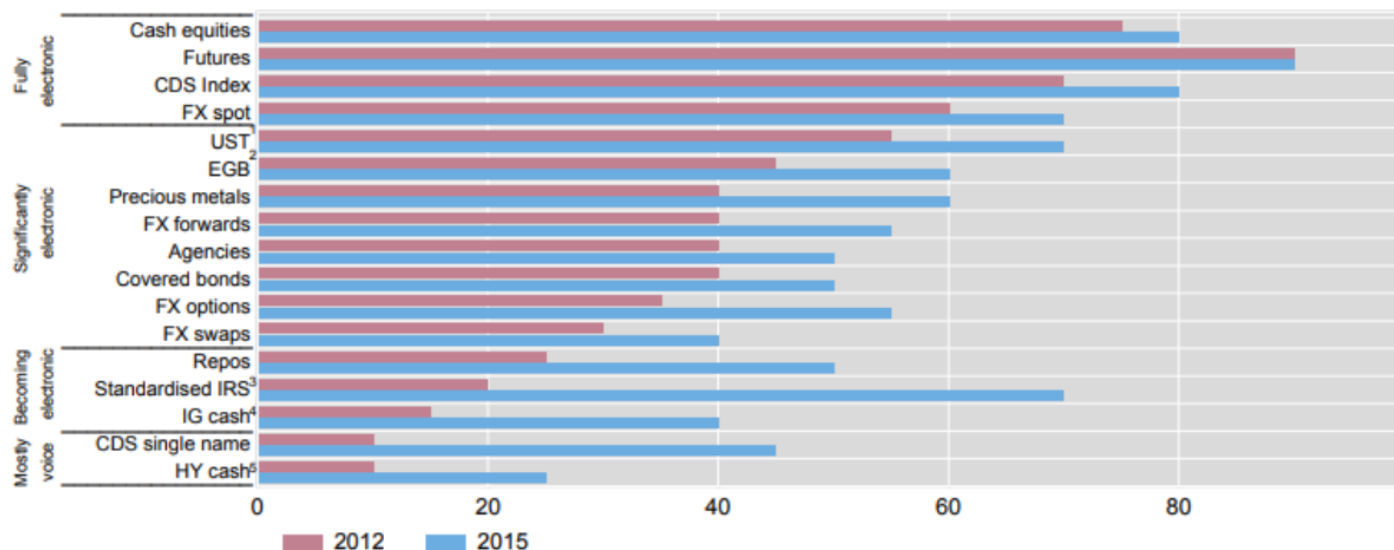
“Transfer of ownership of a financial instrument where the matching of the two counterparties in the negotiation or execution phase of the trade occurs through and electronic system“

(Source: BIS, 2016)

State of electronification in various asset classes

In per cent

Graph 3



¹ US Treasuries. ² European government bonds. ³ Standardised interest rate swaps. ⁴ Investment grade cash bonds. ⁵ High-yield cash bonds.

Sources: Greenwich Associates (2014); McKinsey & Company and Greenwich Associates (2013).

Key drivers of electronic trading

There are many forces that have promoted the adoption of electronic trading. The drivers can broadly be categorised under three headings: (i) technological evolution which lowers costs; (ii) market structure features that influence demand; and (iii) the regulatory framework contributing to changes in dealers' business models.

Technology. Technological innovations tend to reduce costs. A commonly cited benefit of electronic trading is that, if the electronic trading platform (ETP) is used on a sufficient scale, it can generate very low marginal and average trading costs. Recent innovations have also reduced the fixed cost of building new trading systems, which has lowered the entry barriers for new platform providers. However, the costs of adopting the technology may be high. ETPs can also lower the indirect costs of transacting by bringing down search costs. They can do this because they provide the capacity for increased transparency through the more efficient dissemination of market information to more market participants. Furthermore, ETPs can reduce search and transaction costs to the extent that they offer liquidity benefits via pooling transactions, reducing market segmentation and fragmentation and promoting competition among market participants.

Market structure features. The scalability for an ETP depends on the capacity of the technology (described above), but also on the size of the market and features of the market structure. For instance, there is greater potential for economies of scale to be realised for standardised products that are traded frequently or for a market with a large number and diverse range of investors. The usage of a particular ETP may also depend on its ancillary benefits, such as its capacity to provide solutions for clearing, settlement, risk management, and regulatory, reporting or market-making requirements.

Regulatory changes. The regulatory drivers of the usage of ETPs can be broadly divided into those that are directly concerned with the arrangements of trading venues and markets and those that may have an indirect impact on their usage. The former are broadly framed by principles outlined by IOSCO. The latter include some regulatory changes introduced since the financial crisis which have had the objective of ensuring that banks are not a source of liquidity contagion. Due to changes in the regulatory environment and in dealers' business models, the relative cost of providing intermediation services via electronic means, rather than voiced means, has changed. Due to a strong level of competition in many markets, dealers have been unable to fully pass on higher trading costs to clients. At the same time, the potential for them to withdraw from market-making activities is limited by client relationships and certain obligations, especially when acting as primary dealers. Consequently, dealers have scaled down high-cost market-making and increased their provision of lower cost structures by providing customers with a capacity to transact via electronic trading platforms.

Chronology

Table 1. Chronology.

2 MHz 0.64 MIPS	1970s:	US/Introduction of the NYSE's "designated order turnaround" system (DOT) that routed orders electronically to the floor.
16–40 MHz 5 MIPS	1980s:	Automation of index arbitrage and development of program trading.
	1986:	France/Introduction of the CAC trading system (fully-computerised matching engine).
233 MHz 100 MIPS	1990s:	US/Introduction of the Electronic Communication Networks.
	1992:	Initiation of the FIX protocol: International real-time exchange of information.
1.3–3.8 GHz 1700 MIPS	2000s:	US/Decimalisation of prices.
	June 2001:	Creation of the Committee of European Securities Regulators (CESR), which will be replaced by ESMA under MiFID II.
2.6–3.6 GHz 9000 MIPS	April 2004:	Adoption of the MiFID directive at the EU level.
	2005:	US/Rules promoting national market system are consolidated into RegNMS.
	June 2005:	US/BATS Trading is formed.

(Continued)

Table 1. (Continued)

2.4 GHz 22 000 MIPS	February 2006:	<i>Archipelago becomes NYSE Arca after the NYSE's buyout.</i>
	June 2006:	<i>NYSE (New York Stock Exchange) and Euronext merge to become NYSE Euronext.</i>
	July 2006:	Publication of implementing measures for MiFID.
3 GHz 2*22 000 MIPS	July 2007:	Launch of Chi-X Amsterdam and Chi-X London .
	August 2007:	One participant makes 80% of Chi-X Amsterdam's trades.¹
	September 2007:	The same participant reaches 15% of all Dutch trades and drives Chi-X's increase in market share in Amsterdam.
	November 2007:	Deadline for the industry to apply the directive. Launch of Chi-X Paris .
3.2 GHz 2*24 000 MIPS	August 2008:	Launch of Turquoise in Europe.
	October 2008:	US/ Knight Link is the No. 1 Dark Pool in share volume.
	November 2008:	Launch of BATS Trading Europe and Xetra Mid-Point .
2.93 GHz 76 383 MIPS	March 2009:	Market-making agreements on Turquoise expire. Its market share drops.
	May 2009:	Launch of Nasdaq OMX Europe .
	June 2009:	Tick war: BATS and Turquoise activate a gradual reduction in tick sizes, leading to a tacit agreement between exchanges under the FESE.
	July 2009:	A former Goldman Sachs programmer is arrested by the FBI with a USB key containing algorithmic trading codes.
	August 2009:	US/Flash orders appear on the Nasdaq Stock Exchange.
	October 2009:	Launch of NYSE ARCA Europe .
	November 2009:	Launch of Knight Link , first Systematic Internaliser in Europe.

(Continued)

Table 1. (Continued)

3.33 GHz 147 600 MIPS	January 2010:	Turquoise offers futures and options on Norwegian stocks and an index on Turquoise derivatives. US/The SEC sends a request for comments on market microstructure.
	April 2010:	The CESR also sends questions to participants on market microstructure.
	May 2010:	May 6th: Flash Crash.
	July 2010:	<i>Closure of Nasdaq OMX Europe.</i>
	September 2010:	Findings on the May 6th events are reported by the CFTC and the SEC.
	December 2010:	The European Commission launches a public consultation for the revision of MiFID (MiFID II). <i>BATS Global and Chi-X Europe enter exclusive merger talks.</i>
	February 2011:	End of the EC consultation. Regulatory change in Spain for Chi-X to get clearing and settlement. <i>Feb. 18th: London Stock Exchange and Turquoise merge. Deutsche Boerse and NYSE Euronext confirm advanced merger discussions.</i> Feb. 22nd: Outage on the Italian Stock Exchange. Feb. 25th: Outage on the London Stock Exchange.
3.33 GHz 147 600 MIPS	May 2011:	Markus Ferber appointed as rapporteur for MiFID II. His conclusions are to be presented to the ECON (European Parliament's Economic and Monetary Affairs Committee).
	June 2011:	June 13th and 15th: Outages on Chi-X. June 20th, 21st and 27th: Outages on NYSE Euronext.
	August 2011:	India/first regulatory approval for Smart Order Routing.
	September 2011:	Turquoise offers futures and options on the FTSE 100 index.
	October 2011:	Proposal for MiFID II is unveiled by the European Commission. It contains one directive, and one regulation.

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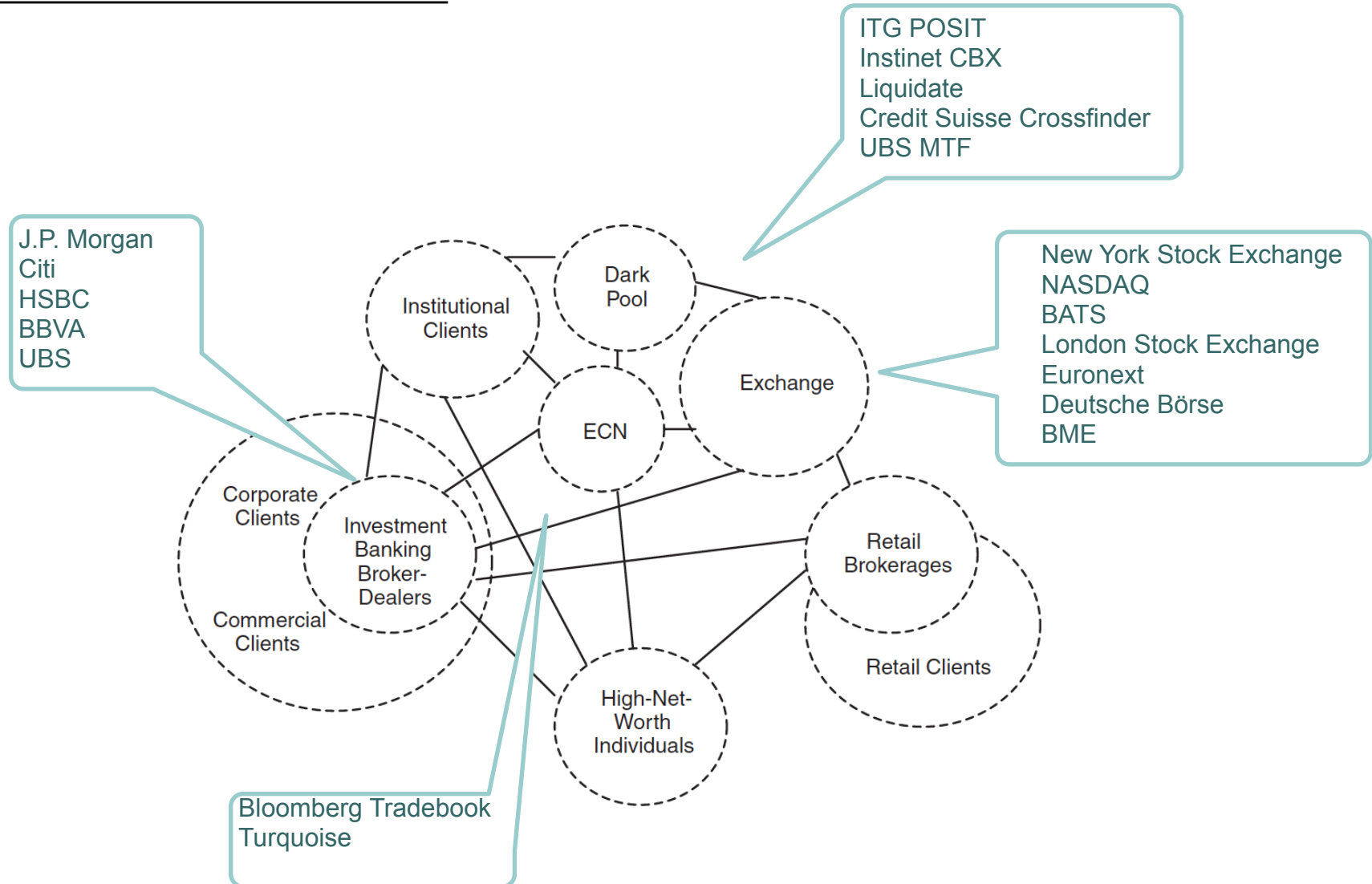
Table 1. (Continued)

November 2011:	<i>Final decision on the BATS-Chi-X merger from the UK Competition Commission. BATS Global and Chi-X Europe successfully closed their deal.</i>
April 2012:	ESMA guidelines issued for MiFID II. Both BATS and Chi-X Europe to launch fully interoperable clearing.
May 2012:	Amendment deadline for MiFID II.
July 2012:	ECON committee vote on MiFID II.
End of 2012:	Dialogue process to reach agreement on MiFID II.
January 2013:	Inter Continental Exchange (ICE) offer to buy Nyse-Euronext.
January 2014:	Earliest indicated implementation of MiFID II.

Source: *High-Frequency Trading and The New Market Makers*, A. Menkveld, 2011.

VI. Market structures across asset-classes

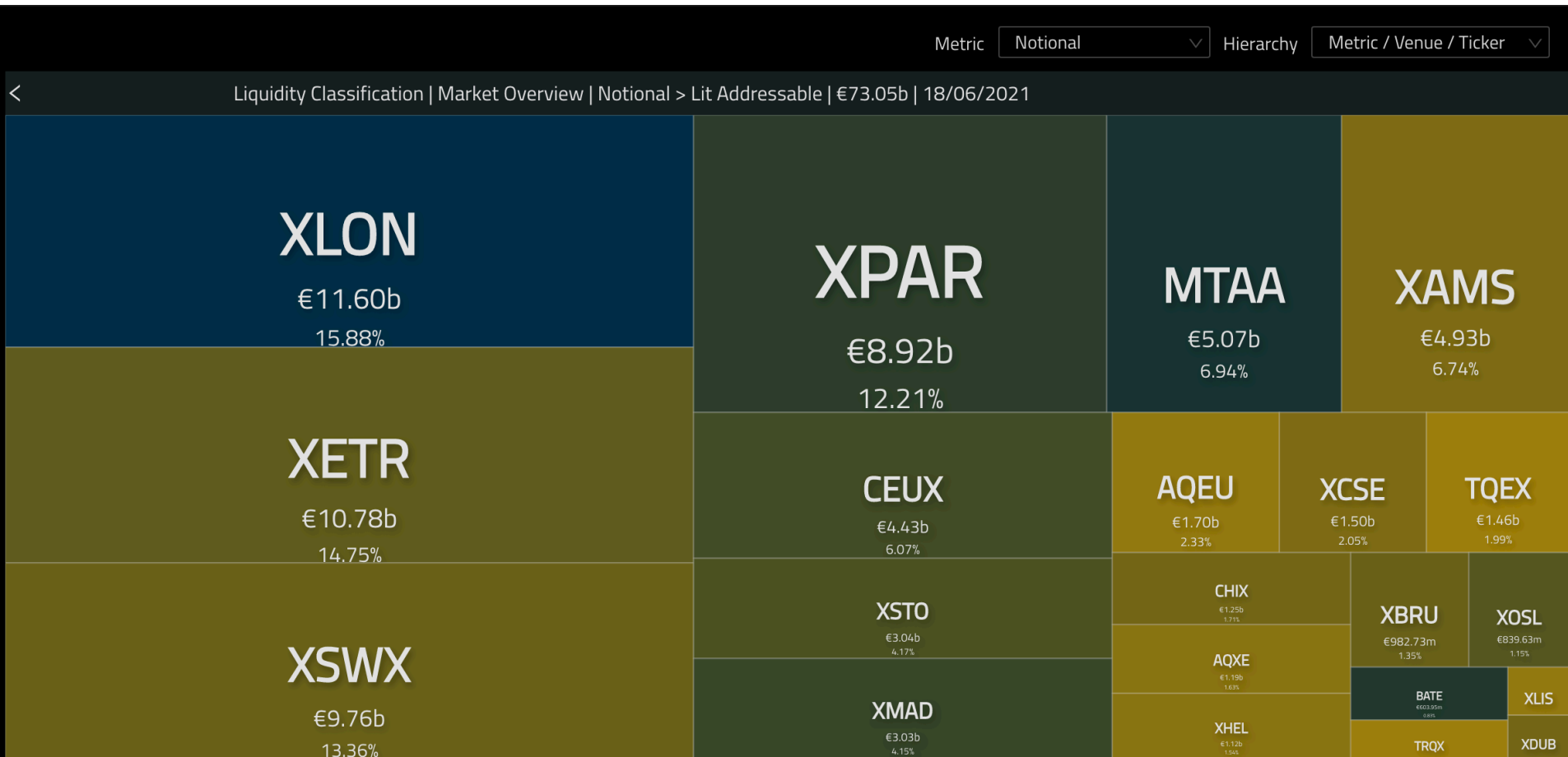
Equities market structure



Equities market structure

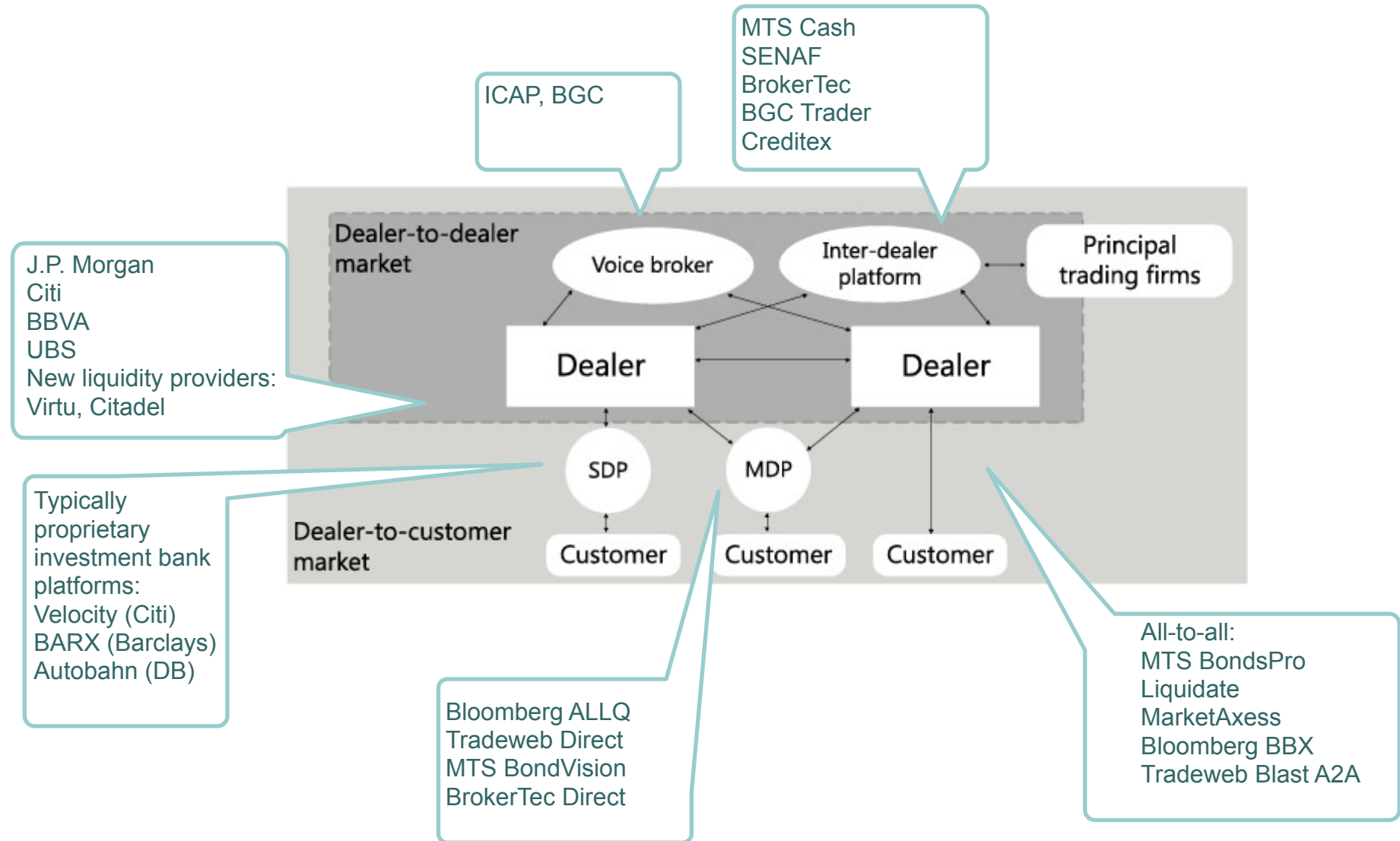
- Market structure **highly fragmented**, specially in the USA, although in Europe fragmentation is also increasing as a consequence of regulation pushing for competition between trading venues:
 - **USA**: Regulation NMS “National Market System” (2007)
 - **Europe**: MiFID I (2004, started 2007) only for Equities, MiFID II (2018) extends rules to other assets
- Both regulations **open competition to Exchanges** by allowing private companies to create their own markets (aka alternative trading systems in Reg NMS or multilateral trading facilities in MiFID)
- Most markets can only be accessed by specialised firms (brokers, dealers), that trade on behalf of clients or on their own account.
- **High degree of electronification** (around 80%), CLOBs being the most popular trading mechanism
- However **Direct Market Access (DMA) is becoming very popular**, where dealers or broker allow clients to trade directly in the markets using their infrastructure or their trading code.

Equities market structure (Europe):



Source: Platometrics (2022)

Fixed Income (cash) market structure

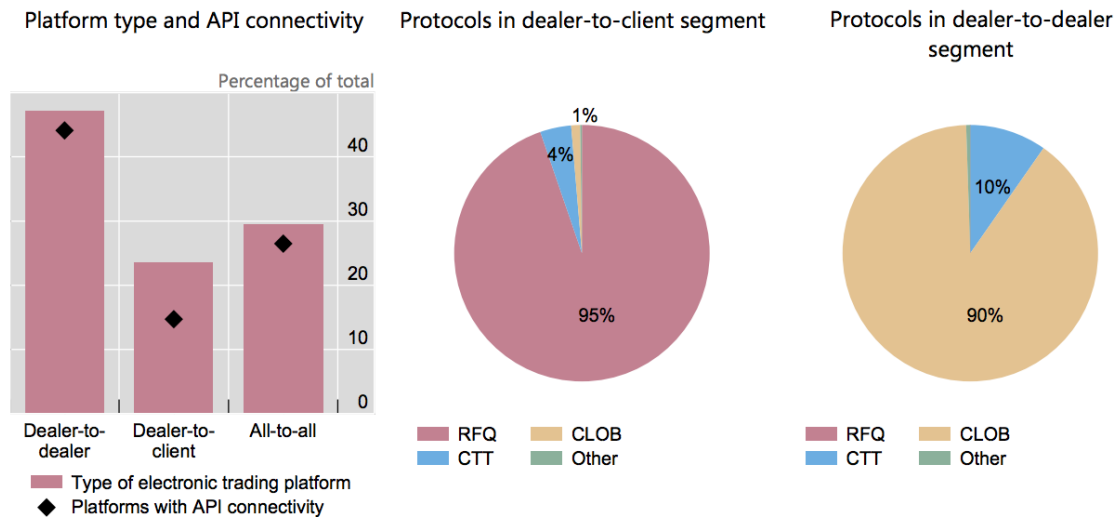


Fixed Income (cash) market structure

- Government Bonds: 60-70% electronic, CLOB inter-dealer, RfQ dealer-to-client
- Corporate Bonds: 30-40% electronic (the majority small trades), CLOB inter-dealer, RfQ dealer-to-client

Survey of electronic trading platforms and usage of trading protocols

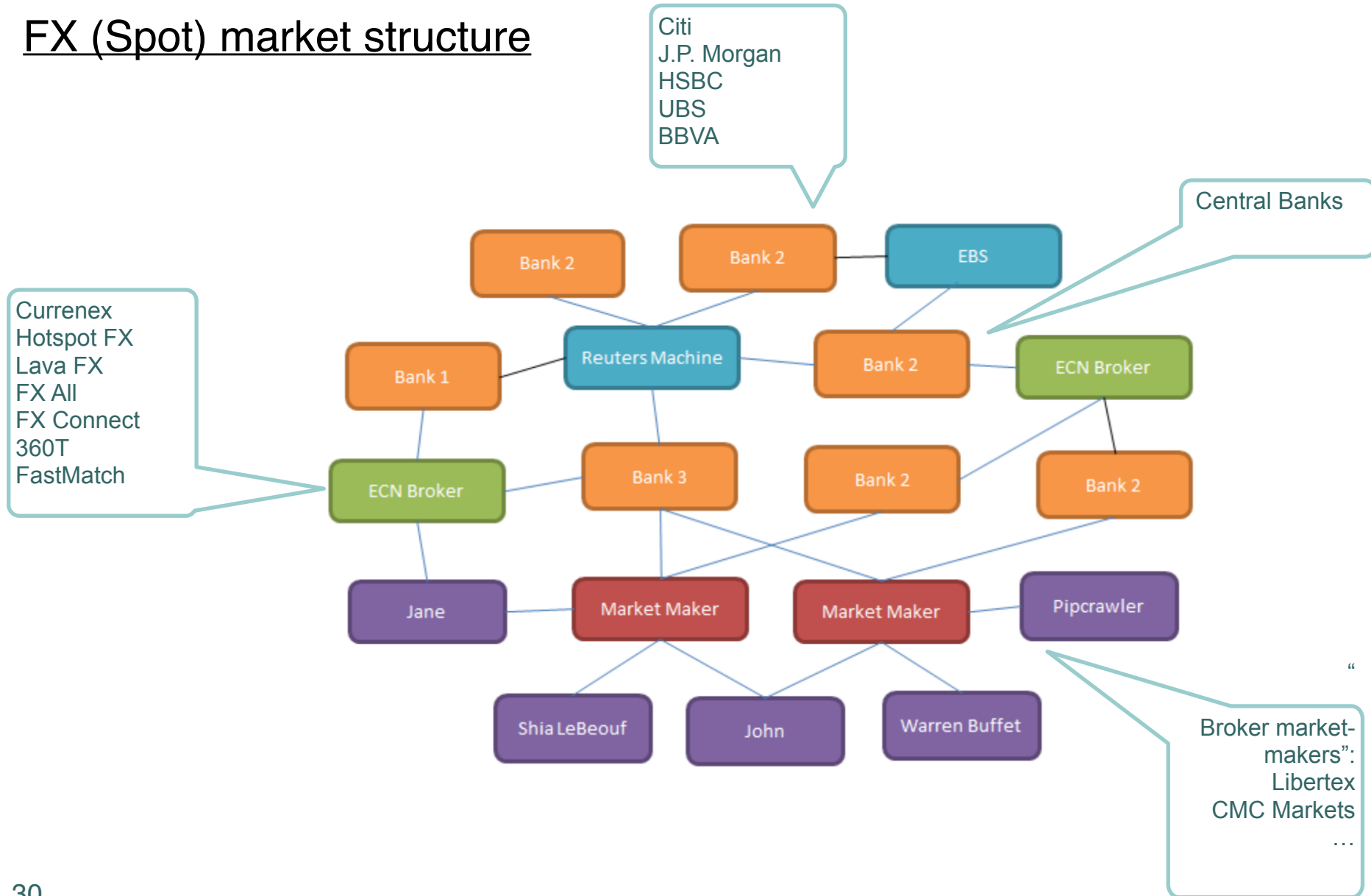
Graph 6



CLOB = central limit order book; CTT = click-to-trade; RFQ = request for quote (request for market).

Sources: Markets Committee survey of electronic trading platforms; BIS calculations.

FX (Spot) market structure



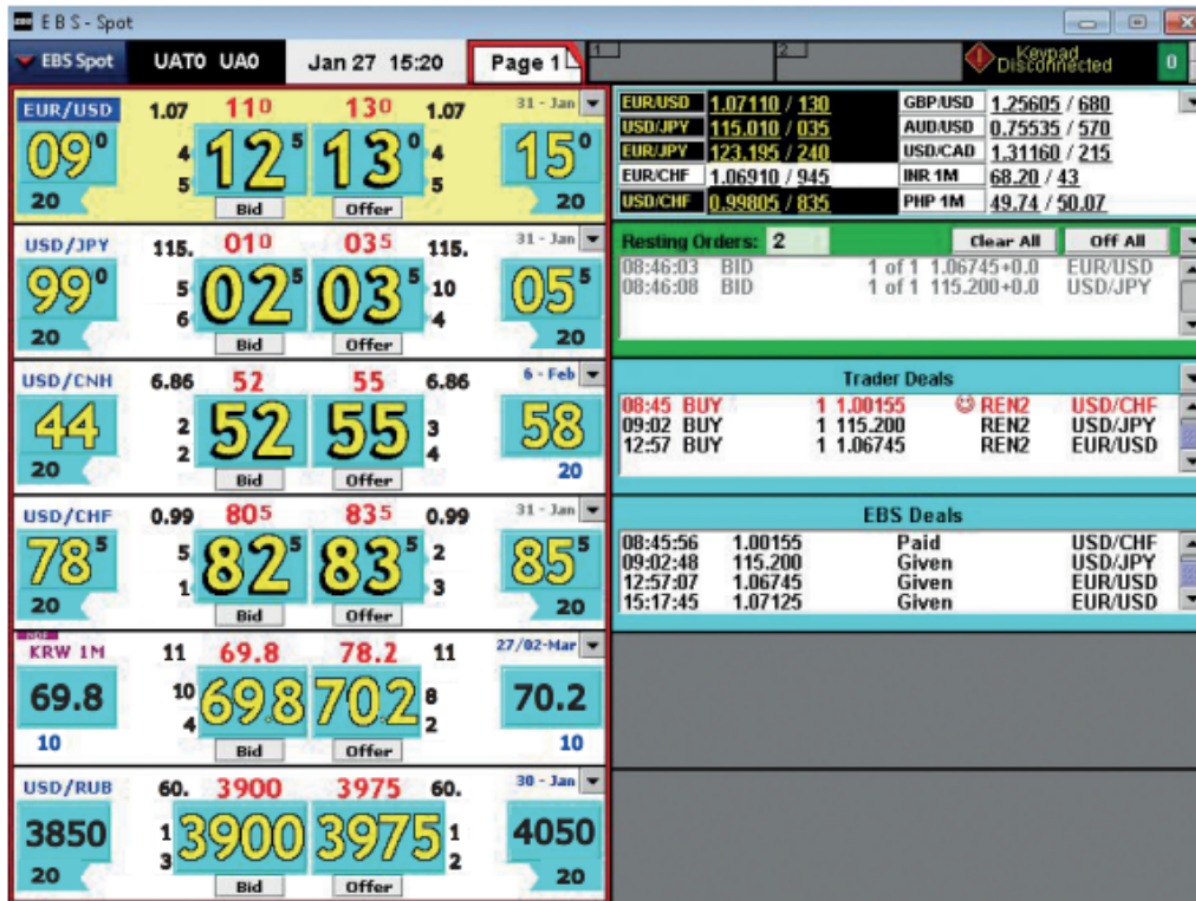
FX (Spot) market structure

- No centralised market, but a large network of liquidity providers, typically investment banks like J.P. Morgan, Citi, HSBC, UBS... which quote two-way executable prices in their single-dealer platforms
 - Citi: [Velocity](#), Deutsche Bank: [Autobahn](#), Barclays: [BARX](#), ...
- Since the 90's, two large multi-dealer electronic platforms are created which aggregate liquidity from the inter-dealer market, building CLOB-like structures:
 - [EBS](#) (now part of CME)
 - [Refinitiv FX Trading](#) (previously Thomson Reuters FX)

Both offer trading in the major currency pairs, but certain pairs are more liquid over EBS or Refinitiv. For instance, EURUSD is typically traded through EBS while GBPUSD is traded through Refinitiv

- The dealer-to-client market is dominated by two kind of players:
 - Electronic Communication Networks (ECNs) like [Refinitiv's FXall](#), [Currenex](#), Deutsche Boerse's 360T, ... which aggregate liquidity from the inter-dealer market
 - Broker Market-Makers: they operate with clients on own account, taking the opposite trade, which might or not try to match later in the inter-dealer market

FX (Spot) market structure



EBS Direct Screen

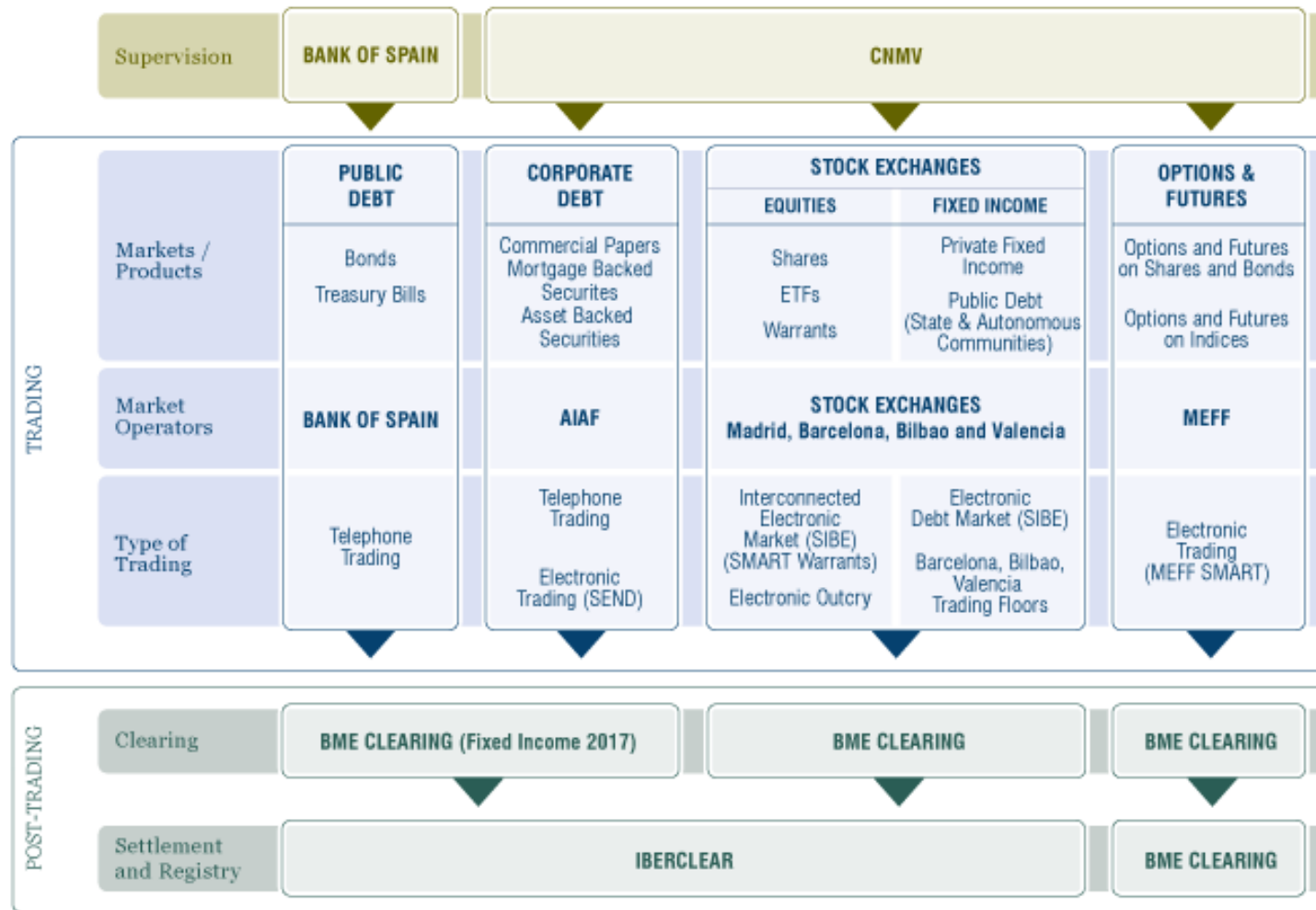
Derivatives market structure

- Derivatives are traded OTC or in Exchanges (listed derivatives)
- Listed derivatives are mostly standardised futures and options contracts. They are not as fungible, though, as cash equities or bonds
- Liquidity tends to concentrate across the largest Exchanges:
 - CME (Chicago Mercantile Exchange)
 - Korea Exchange
 - Eurex
 - CBOE (Chicago Board of Options Exchange)
 - Liffe (London International Financial Futures Exchange)
 - International Securities Exchange
- Clients can trade placing orders to brokers/dealers, using DMA or by electronic platforms like Bloomberg Tradebook, Tradeweb, 360T, FXall
- Electronification is high in listed derivatives, more than 80% of trades are done using electronic platforms
- Exchanges usually use CLOBs, dealer-to-client platforms RfQs, ECNs hybrid systems

Derivatives market structure

- Types of swaps: Interest Rate Swap (IRS), Credit Default Swap (CDS), Cross-Currency Swap (XCS), Total Return Swap (TRS)
- Swaps are one of the most important derivatives
- Swap markets show a strong separation between inter-dealer and dealer-to-client segments
- Electronification has been quicker in dealer-to-client markets, although inter-dealer markets have been catching up at a fast paced:
 - IRS: nowadays 60-70% electronic, mostly RfQ based
 - CDS: single-name 50% electronic, indices 80% electronic, mostly RfQ based
- Swap markets are mainly OTC, with a mixture of trading in single-dealer and multi-dealer platforms
 - Examples of dealer-to-client platforms: Bloomberg, Tradeweb, CME, BrokerTec
 - Examples of inter-dealer platforms: ICAP i-Swap, CME SwapStream, MTS Swaps for IRS; Creditex for CDS
- In USA, after Dodd-Frank, in order to trade swaps a platform must become a Swap Execution Facility (SEF), with no equivalent in Europe

Spanish securities market structure (regulated markets)



Cryptocurrencies market structure

- As per the end of 2022, the largest cryptocurrencies in capitalisation are:

#	Name	Price	1h %	24h %	7d %	Market Cap	Volume(24h)	Circulating Supply
☆ 1	Bitcoin BTC	\$18,923.25	▲ 0.02%	▼ 0.93%	▼ 4.63%	\$362,316,453,612	\$22,814,007,145 1,206,469 BTC	19,160,318 BTC
☆ 2	Ethereum ETH Buy	\$1,305.88	▼ 0.04%	▼ 2.79%	▼ 8.08%	\$159,994,149,579	\$10,582,591,689 8,103,973 ETH	122,520,869 ETH
☆ 3	Tether USDT Buy	\$1.00	▼ 0.00%	▲ 0.00%	▲ 0.01%	\$67,959,512,344	\$34,324,247,032 34,321,818,067 USDT	67,954,703,169 USDT
☆ 4	USD Coin USDC Buy	\$0.9999	▼ 0.00%	▼ 0.01%	▼ 0.00%	\$49,599,441,436	\$3,524,841,243 3,525,036,051 USDC	49,602,182,662 USDC
☆ 5	BNB BNB	\$275.00	▼ 0.30%	▼ 1.70%	▼ 0.70%	\$44,355,762,784	\$652,638,278 2,373,871 BNB	161,337,261 BNB

<https://coinmarketcap.com/>

- Trading of currency pairs happens mostly in Exchanges. There is a large amount of them (> 50) but trading is dominated by a dozen of the largest ones
- As per end of 2022, the top Exchanges are Binance, Coinbase and FTX
- Large Exchanges usually offer a CLOB (order-driven), broker services (quote-driven) and OTC Desks that allow users to trade bilaterally. Example: Coinbase has Coinbase Pro (formerly GDAX) as Exchange and also its own user-facing retail broker
- The biggest currency pairs traded are USD, JPY, EUR and KRW
- CBOE and CME offer since end 2017 futures on Bitcoin. ETFs on Bitcoin are available since October 2021 (ProShares ETF, tracks BTC futures not cash)