

Lecture 3

Financial markets & instruments

Financial instruments and pricing

Fall 2019

Financial markets & instruments

- ❖ General overview (taxonomy)
- ❖ Basic exchange trading rules
- ❖ Derivative Instruments

Financial markets: overview

- ❖ The **financial market** is a broad term describing any marketplace where trading of securities including equities, bonds, currencies and derivatives occur. Some financial markets are small with little activity, while some financial markets like the New York Stock Exchange (NYSE) trade trillions of dollars of securities daily. ([from Investopedia](#))
- ❖ In fact financial instruments include not only “**securities**” (e.g. shares and bonds) but also a variety of “**transactions / contracts**” (e.g. deposits, loans, most derivatives*)
- ❖ In general** one can classify financial markets by looking at the following features:
 - Types / categories of traded instruments (Interest Rate / Credit / Fixed Income, Equities, Currencies, Commodities, ...)
 - Centralization / regulations /supervision (Exchanges vs OTC vs private markets)
 - Types of transactions (spot / cash vs derivatives)
 - Dominating categories of investors (wholesale vs retail)
 -

* In some countries, e.g. in Poland, derivative contracts are legally treated as “securities”

** The proposed taxonomy is not unique, and various market segments may overlap

Financial markets

❖ The financial markets are large and securities including stocks and bonds are traded on Stock Exchange (NYSE).

❖ In fact financial institutions offer also a variety of “trading” services.

❖ In general** one can distinguish:

- Types / categories of instruments: Stocks, Bonds, Currencies, Commodity futures, Options, Derivatives
- Centralization / regionalization
- Types of transactions: spot, forward, derivatives
- Dominating categories: Equity, Fixed Income, Commodities
-

* In some countries, e.g. in Poland, there is no separate Stock Exchange.

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❖ (Stock / Commodity / Derivatives) Exchanges

- Highly **regulated** (both by law and by internal regulations about trading / pricing / settlement rules & conventions), **supervised** (e.g. by Securities and Exchanges Commission (US), Komisja Nadzoru Finansowego (PL)) and **centralized markets** (< 100 Exchanges globally).
- Usually very **transparent** (all transactions are registered, order book and trading data is (usually) publicly available) and **liquid** markets.
- Investors place **orders** which enter the order book and are executed according to strict rules
- Trading was originally done “manually” (“**Open Outcry**” system based on “**market makers**” acting on physical “floor”). Now most of the exchanges enable **electronic trading**
- Most exchanges offer both **spot/cash** and (**standardized !**) **derivative** transactions and a variety of securities / instruments to choose from
- **Fixed trading hours:** “**sessions**” (e.g. NYSE Core Session 9:30 am - 4:00 pm EST)
- Settlement done through specialized **Central Clearing Houses**, being parts of the exchange or independent: lower transaction and counterparty risks



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Financial markets

- ❖ The **financial markets** are markets for financial securities including stocks, bonds, derivatives, etc. Small vs. large markets: New York Stock Exchange (NYSE) vs. Nasdaq
- ❖ In fact financial institutions also offer a variety of “trading services”
- ❖ In general** one can distinguish:

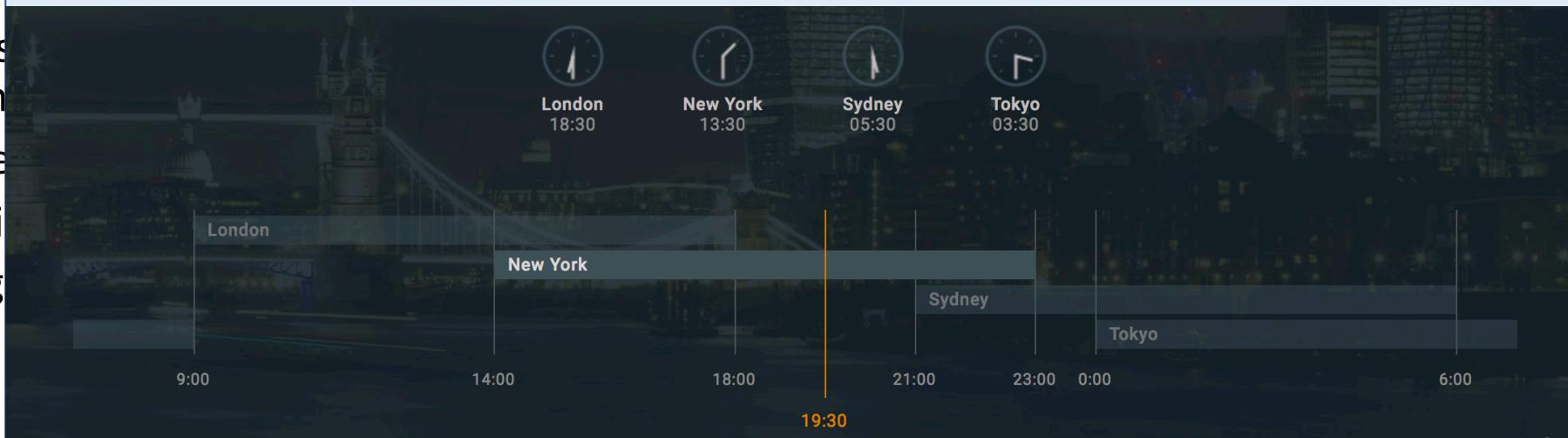
- Types / categories of financial instruments: Currencies, Commodities, Bonds, Stocks, Derivatives, etc.
- Centralization / regionalization
- Types of transaction: spot, forward, futures, options, swaps, etc.
- Dominating categories: equities, bonds, derivatives, etc.
-

* In some countries, e.g. in Poland, there is no separate stock exchange; the market is organized by the National Bank.

** The proposed taxonomy is not unique, and various market segments may overlap

❖ Over-The-Counter (OTC):

- Less but still supervised and (mainly internally: e.g. ISDA) regulated local markets organized by **banks / securities firms**
- Much less transparent: transaction data are usually not published or are much less detailed, no public access to orders flow, transaction volumes, etc., usually only some information on **BID – ASK** prices quoted by **market-makers** (bank dealers)
- Trading mostly based on **electronic platforms** (e.g. REUTERS, BLOOMBERG terminals) or “**by phone**”
- **24/24h markets** (except from weekends and holidays)
- Settlement mainly through local **Banks** or **Transfer Agents**: bigger transaction and counterparty risk



Financial markets: overview

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Financial markets

- ❖ The financial markets are markets for securities including stocks, bonds, and derivatives. The Stock Exchange (NYSE) is one example.
 - ❖ In fact financial institutions also provide a variety of “trading” services.
 - ❖ In general** one can distinguish:
 - Types / categories of assets traded: Currencies, Commodities, Bonds, Stocks, Derivatives
 - Centralization / regulation
 - Types of transactions
 - Dominating categories of participants
 -
- * In some countries, e.g. in the USA, there are no separate financial markets, but rather a single market for all types of assets.
- ** The proposed taxonomy is not unique, and various market segments may overlap.
- ❖ **Cash transactions:** immediate, i.e. within a few working days, settlement (usually on the **SPOT** date)
 - ❖ **Derivatives** (PL: **instrumenty pochodne, derywaty(wy)**) are transactions with all details and the price agreed upon now but with final settlement in the future, they comprise both (**standardized !**) **Exchange traded derivatives** (mainly Futures and Options) and (less or non-standardized) **OTC derivatives** (mainly Forwards, SWAPS and Options)
 - **Forward / Future:** a contract between two counterparties to buy or to sell an asset at a specified future time at a price agreed upon today, called the delivery / forward price
 - **SWAP:** a contract in which two counterparties exchange streams of cash flows. These streams are called the legs of the swap. The swap agreement defines the dates when the cash flows are to be paid.
 - **Option:** a contract which gives the option buyer the right to demand from the option seller some future obligation (e.g. to sell or buy some asset in the future). The option seller has to accept the decision of the option buyer (whether he wants to “exercise” the option or not). All the details of the future obligation are agreed upon today. In exchange for having the right the option buyer pays the option price.
 - ❖ **Derivative markets** became, in a sense, “**bigger**” than cash markets: the total nominal value of all open positions in derivatives is estimated at **\$ 500 – 600 trillion**, roughly **twice the value of all “cash” instruments**

Financial markets: overview

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Financial markets

- ❖ The financial markets are large and complex. Securities including stocks, bonds, and derivatives are traded on various markets. The New York Stock Exchange (NYSE) is one of the largest in the world.
- ❖ In fact financial institutions are involved in a variety of “trading” activities.
- ❖ In general** one can distinguish:
 - Types / categories of assets traded (e.g. Currencies, Commodities, Bonds, Stocks, Derivatives)
 - Centralization / regionalization
 - Types of transactions (Wholesale vs. Retail)
 - Dominating categories of investors
 -

* In some countries, e.g. in Poland, there is no formal stock exchange.

** The proposed taxonomy is not unique, and various market segments may overlap.

❖ **Wholesale transactions:** a minimal value of a single transaction (“lot”) is typically large, usually from \$ 100 000 to \$ 1 million. Transactions mainly done by professional institutional investors who trade mostly OTC or on specialized Exchanges

- Governments
- Central Banks
- Commercial and Investment Banks
- Insurance companies
- Large corporations
- Mutual / Investment / Pension Funds / Asset Managers
- “Big” professional private investors

❖ **Retail transactions***: much smaller value of a single trade. Transactions done by less- or non-professional investors, mainly on Exchanges or by intermediary of banks / brokers

- Smaller companies
- Private individuals

* Recent advances in technology make financial markets much more accessible to small investors (e.g. through regulated FOREX BROKERS)

Financial markets: overview

Financial Markets

Money markets

- Interest rate markets providing short-term (< 1Y) borrowing and liquidity for the financial system

Capital markets

- Interest rate or equity markets providing medium and longterm (>1Y) financing

FOReign EXchange

- Currency markets enabling worldwide trade and linking other financial markets globally

Commodity markets

- Trading in standardized raw or primary products including metals, energy and agriculture goods

Other markets

- Cryptocurrency
- Weather
- Energy
- Art
- ...

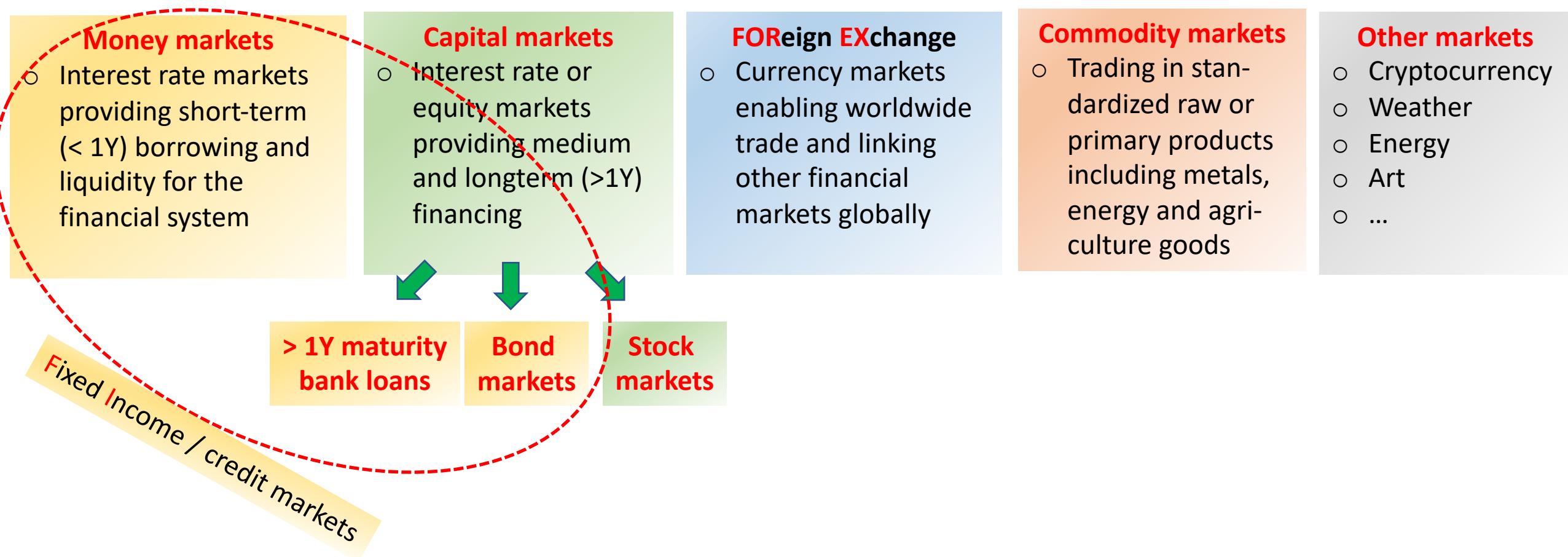


> 1Y maturity
bank loans

Bond
markets

Stock
markets

Financial markets: overview



Fixed Income / Credit markets

❖ MONEY MARKETS (estimated global size < \$ 10 trillion, i.e. 10×10^{12})

- Short-term interest rate markets providing borrowing and liquidity for the financial system. These are mainly wholesale OTC markets – Interbank lending is the core of trading (important role of Central Banks)
- Main spot instruments:
 - ✓ FED Funds (O/N loans between US banks to finance reserves kept in FED, target FF rate)
 - ✓ Eurodollar deposits (USD Interbank deposits made outside US)
 - ✓ Interbank deposits - reference rates are benchmarks for other interest rate instruments and have huge impact on the whole economy: LIBOR (11:00 GMT: \$, €, £, JP¥, CHF from 1d to 1Y) and EURIBOR (11:00 CET from 1w to 1Y) are just reference rates ! (e.g. WIBOR/WIBID are transactional)
 - ✓ REPOS (repurchase agreement in which government securities, usually T-Bills, are simultaneously sold and bought back shortly afterwards, usually the following day)
 - ✓ T-Bills / CentralBank Bills
 - ✓ ST loans to non-banking customers (in US: „prime rate” = r% for best clients)
 - ✓ Other: ST deposits, Certificates of Deposit (ST deposits with fixed r%), Bank acceptances (official documents pledging bank deposits), Commercial Paper (ST Corporate Bonds), Asset Backed Securities (mortgage, credit-cards, auto-loans, Collateralized Debt Obligations)

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- ## Other markets
- Cryptocurrency
 - Weather
 - Energy
 - Art
 - ...

Fixed Income / Credit markets

❖ BOND MARKETS (estimated global size around \$ 100 trillion, ~50% in US)

- Mainly OTC (wholesale) but also some Exchanges (more retail)
- Spot instruments already discussed (see Lecture 2)

❖ MEDIUM & LONGTERM LOANS (estimated global size around \$ 120 trillion)

- Spot instruments already discussed (see Lecture 1)

❖ MAIN INTEREST RATE AND CREDIT DERIVATIVES

- Forward Rate Agreements (**FRA**): OTC traded, non-deliverable forwards for short term interest rate, usually a benchmark Interbank offered rate (-IBOR)
- Interest Rate Swaps (**IRS**): OTC traded swaps usually on ST floating interest (-IBOR) vs fixed rate, e.g. Overnight Index Swap (**OIS**) or 3M \$ LIBOR vs fixed \$ rate
- Interest Rate Futures: Exchange traded standardized contracts for ST interest rate, usually -IBOR
- Bond Futures: Exchange traded standardized contracts, usually for some benchmark Treasury bonds (investors who sell the futures can choose the cheapest-to-deliver bond)
- Bond / ST interest rate options: can be both OTC or Exchange traded and of various types, e.g. interest rate **CAPs** and **FLOORs**, ...
- Credit Default Swaps (**CDS**): in fact a kind of an **option** securing over the default / credit risk

markets

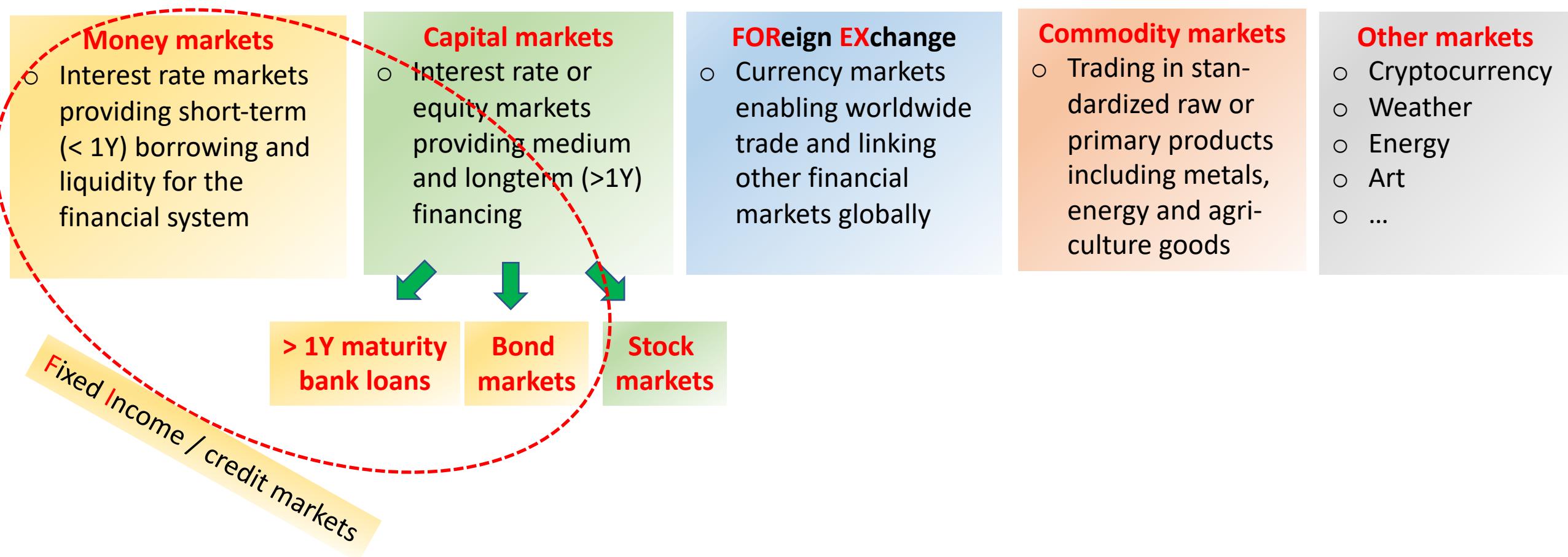
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Other markets

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- ...

Financial markets: overview

Financial Markets



Stock markets

❖ STOCK MARKETS (estimated global market capitalization around \$ 75 trillion*)

- These are mainly Stock Exchanges

- ✓ There are only ~60 Stock Exchanges worldwide,
- ✓ Only ~15 with Market Cap. > \$ 1 trillion
- ✓ Two biggest ones are: NYSE (~30% global Market Cap.) & NASDAQ (~15% global M. Cap.)

Stock exchange	Country	Market Cap. (\$ bn)	Monthly Vol. (\$ bn)
New York Stock Exchange	US	24,220	1,452
NASDAQ	US	11,860	1,262
Japan Exchange Group	Japan	6,288	481
Shanghai Stock Exchange	China	5,023	536
Euronext**	EU	4,649	174
London Stock Exchange Group	UK, Italy	4,596	219
Hong Kong Stock Exchange	Hong Kong	4,443	182
Shenzhen Stock Exchange	China	3,547	763
Deutsche Börse	Germany	2,339	140
Bombay Stock Exchange	India	2,298	210

Source: World Federation of Exchanges, as of April 2018.

**Euronext is in fact a part of the NYSE group

* For comparison worldwide GDP is ~\$ 80 trillion

Other markets

- Cryptocurrency
- Weather
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More
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Fixed In...

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❖ MAIN SPOT INSTRUMENTS

- Shares
- Exchange Traded Funds (ETFs): usually follow some stock exchange / sector / other index
- Margin buying: buying shares on credit (leveraged trades)
- Short selling: selling borrowed shares in order to buy them back when prices fall

❖ MAIN DERIVATIVES

- Futures and options on Stock Indices (e.g. DJIA, S&P500, NASDAQ, ...)
- Options (and Futures) on individual shares
- The World's biggest (equity and other) derivatives exchange in the CME Group (from US), comprising the Chicago Mercantile Exchange (CME), the Chicago Board of Trade (CBOT), the New York Mercantile Exchange (NYMEX) and the Commodity Exchange (COMEX)

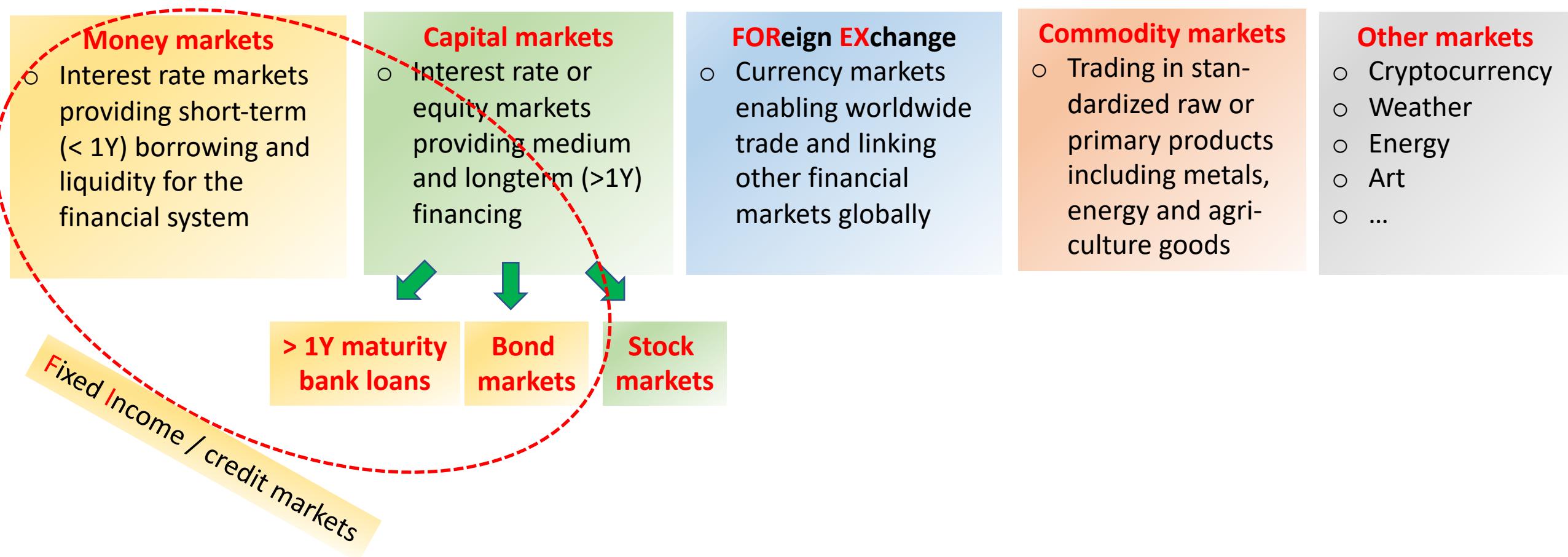
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Financial markets: overview



Foreign Exchange

❖ FOREIGN EXCHANGE

- Currency exchange is in general the most liquid financial market, with daily turnover around \$ 5 trillion (one order of magnitude more than all stock exchanges)
- FOREX is in ~95% OTC operating 24/24h and dominated by big wholesale investors, usually banks, acting through FOREX dealers located mostly in the UK (~40% of transactions), US (~20% of transactions), Singapore, Japan and Hong-Kong

❖ MAIN SPOT INSTRUMENTS (SPOT trades account for ~30% of volume)

- Currencies are always exchanged in **pairs**, i.e. one currency vs another currency
- The most liquid pairs are: EURUSD (~23%), USDJPY (~18%) and GBPUSD (~9%)

USD (US\$)	EUR (€)	JPY (¥)	GBP (£)	AUD (A\$)	CAD (C\$)	CHF (Fr)	CNY (元)	SEK (kr)	NZD (NZ\$)
87.6%	31.4%	21.6%	12.8%	6.9%	5.1%	4.8%	4.0%	2.2%	2.1%

Source BIS, as of April 2016. NOTE: as currencies trade in pairs the total sum for all currencies is 200% !

- A quote „EUR/USD” (or „EURUSD”): means the amount of USD we pay / receive **for 1 EUR** (the EUR is here called the “**base currency**”). The standard base currencies are (in order): EUR, GBP, AUD, NZD, USD, CAD, CHF, JPY (so we e.g. have EURUSD not USDEUR, as EUR has “priority”).
- Other currencies, e.g. PLN are quoted to base currencies, e.g. EURPLN or EURHRK (no direct quotes of HRKPLN) but one can compute the “**cross rate**”: HRKPLN = EURPLN / EURHRK

Money market
Interest rate market providing short-term (< 1Y) borrowing liquidity for the financial system

Fixed Income / credit

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❖ MAIN DERIVATIVE INSTRUMENTS (~70% of volume)

- **FX Swaps**: currencies are simultaneously exchanged now and exchanged back in the future
- **FX Forwards**: OTC forwards for major currency pairs (including **Non-Deliverable Forwards**)
- **FX options**: mainly OTC options for major currency pairs
- **(Cross-)currency (Interest Rate) Swaps** (CIRS, XCS): a mixture of Interest Rate Swap and FX Swap – one exchanges a stream of nominal and interest payments in one currency vs nominal and interest payments in other currency
- **FX Futures**: Exchange traded standardized contracts for major / local currency pairs

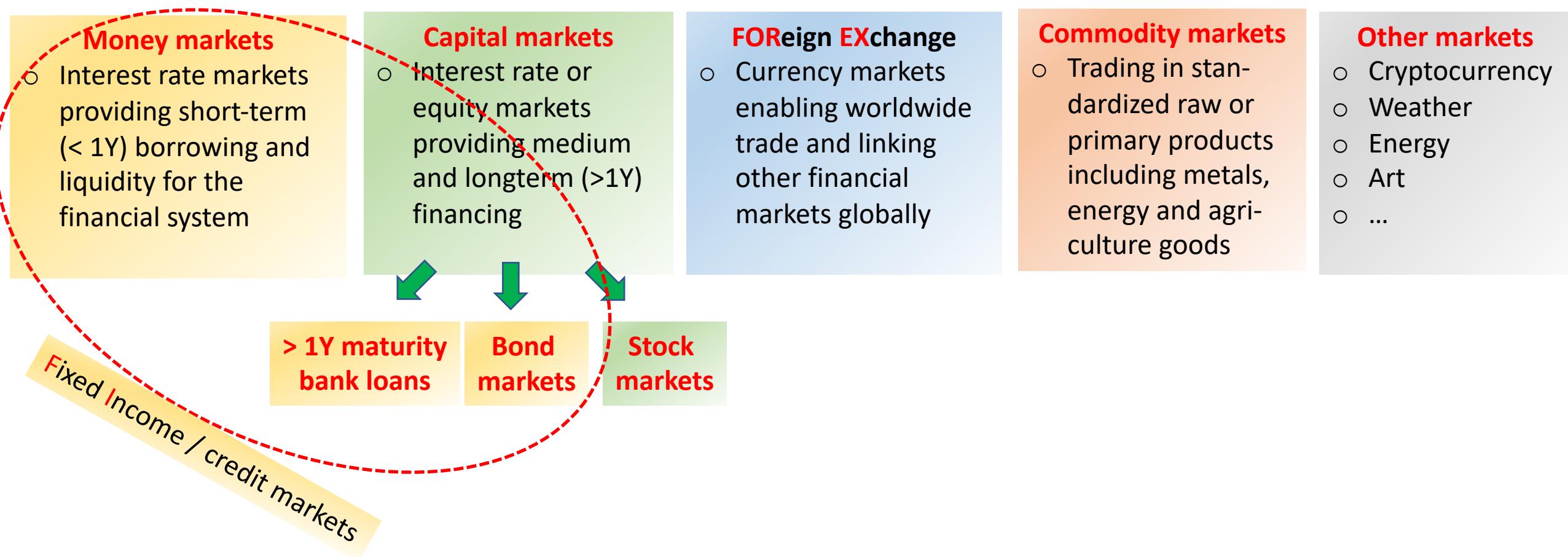
Money markets
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Fixed Income / credit

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Financial markets: overview

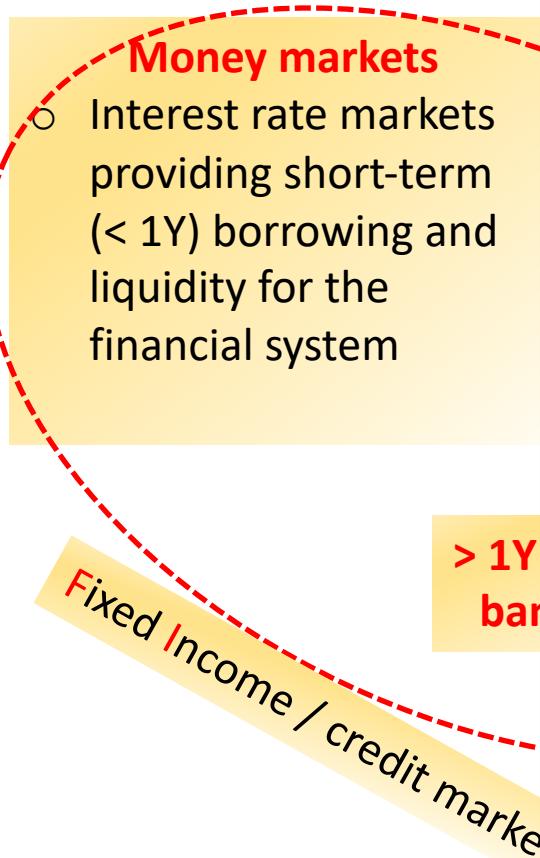
Financial Markets



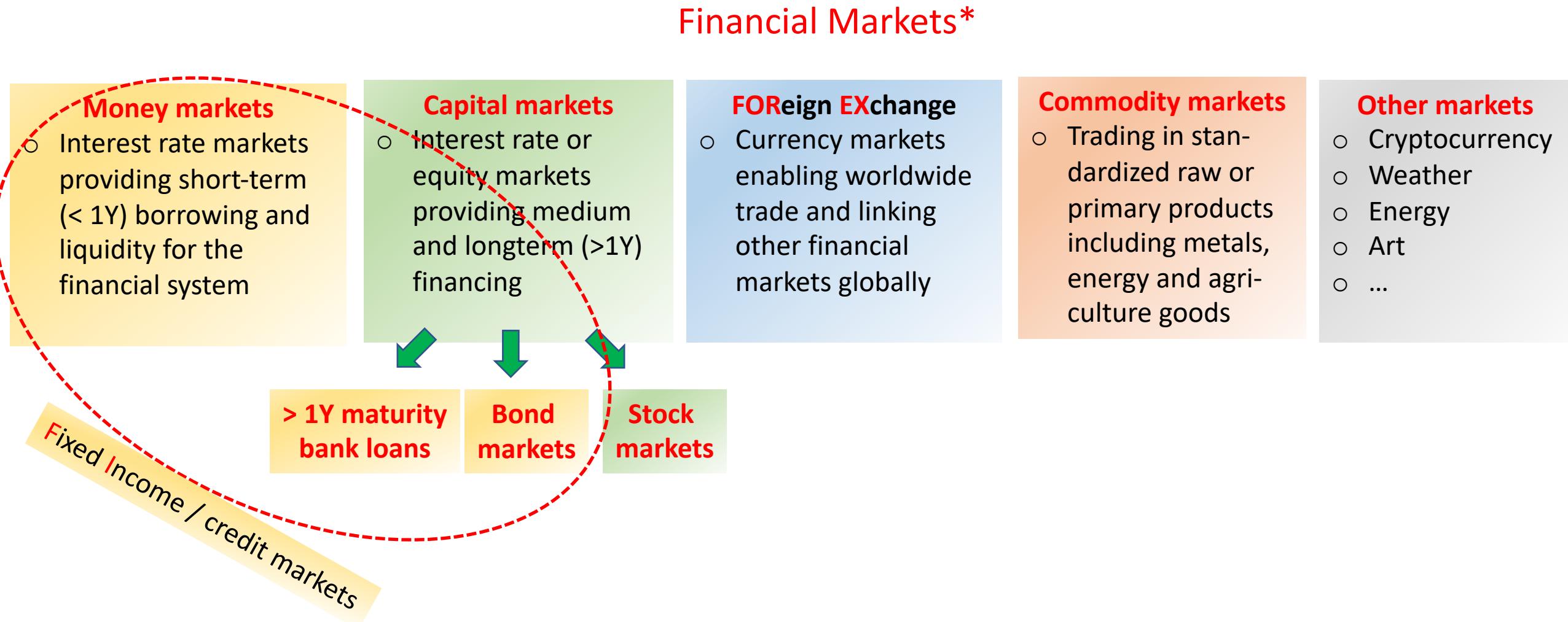
Commodity markets

❖ COMMODITY MARKETS

- Mostly Exchange traded Futures and Options for standardized raw or agricultural products including:
 - ✓ **Agricultural goods:** grains (corn, rice, wheat), cocoa, coffee, sugar, cotton, livestock (hogs, cattles)
 - ✓ **Energy goods:** crude oil (WTI, Brent), natural gas
 - ✓ **Industrial metals:** copper, zinc, lead, aluminium
 - ✓ **Precious metals:** gold, silver, platinum
- The World's biggest commodity and derivatives Exchange is the **CME Group** (from US), comprising the Chicago Mercantile Exchange (**CME**), the Chicago Board of Trade (**CBOT**), the New York Mercantile Exchange (**NYMEX**) and the Commodity Exchange (**COMEX**)



Financial markets: overview



*Nice visualization of various markets' size: <http://money.visualcapitalist.com/worlds-money-markets-one-visualization-2017/>

Financial markets & instruments

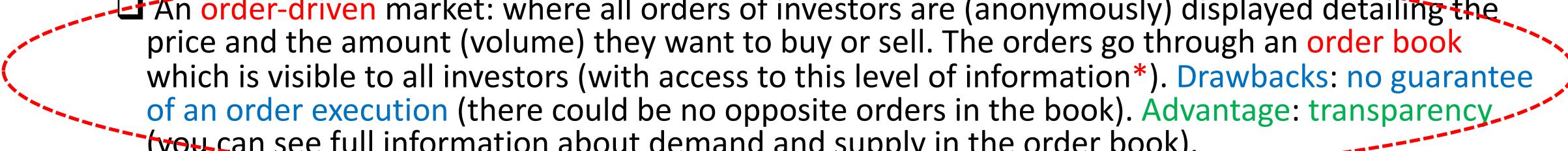
- ❖ General overview (taxonomy)
- ❖ Basic exchange trading rules
- ❖ Derivative Instruments

Exchange trading: types of markets

- ❖ (Stock / commodity / derivatives) **Exchanges** are highly organized and regulated markets. A lot of trading rules apply both by law and by internal regulations.
- ❖ In fact there are two types of markets
 - A **quote-driven** market: where designated **market makers** constantly quote BID and ASK prices at which they are ready to fill investors' orders. The role of the market maker is to accept the SELL / BUY order if it meets the BID / ASK price they quote. Of course they will adjust the quotes depending on the demand and supply on the market. **Drawback**: these markets are **less transparent** (you usually only see the best BID/ ASK prices of market makers and you don't see orders from investors, unless you are a market maker). **Advantage**: these markets are potentially **more liquid** as market makers have obligation to quote BID / ASK prices which are transactional (a guarantee of an order execution if it meets the quote).
 - An **order-driven** market: where all orders of investors are (anonymously) displayed detailing the price and the amount (volume) they want to buy or sell. The orders go through an **order book** which is visible to all investors (with access to this level of information*). **Drawbacks**: **no guarantee of an order execution** (there could be no opposite orders in the book). **Advantage**: **transparency** (you can see full information about demand and supply in the order book).
 - There are also “**hybrid**” markets (e.g. NYSE), where part of trading goes through the market makers (usually the “**Open Outcry**” system) and part is order-driven (usually **electronic** systems)

* Usually one has to pay for access to the order book data depending on the level of information he wants to get.

Exchange trading: types of markets

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Exchange trading: trading systems

- ❖ In the following we will discuss trading rules on the example of the **Warsaw Stock Exchange (WSE)** ([Giełda Papierów Wartościowych w Warszawie, GPW](#)) which is an electronic order-driven market* *Except from some structured instruments traded in the MM system
- ❖ WSE uses a modern trading system called **UTP (Universal Trading Platform)** designed by [NYSE Technologies](#), which is also used in major world's exchanges, e.g. [NYSE](#) and [EURONEXT](#). Similar trading rules / types of orders apply in other exchanges (there can be some minor differences, e.g. other orders' types, detailed regulations, ...)
- ❖ WSE trading is done in one of two systems
 - Continuous trading:** for most instruments market is open during the [trading session](#) and prices may change in any time depending on incoming orders
 - Fixing:** less liquid instruments have prices established only twice a day (at 11:00 and 15:00) during the single-price “[fixing](#)” auction

Before opening (8:30 – 8:45 or 9:00)	CONTINUOUS TRADING (prices change) (8:45 or 9:00 - 16:50)	Before closing (16:50 – 17:00)	TRADING „AT LAST” (@ fixed price) (17:00 – 17:05)
Opening auction (fixing)			Closing auction (fixing)

- Fixing:** less liquid instruments have prices established only twice a day (at 11:00 and 15:00) during the single-price “[fixing](#)” auction

Exchange trading: fixing

- ❖ The **opening / closing / fixing** price is calculated in such a way that* (in order !):
 - the volume of transactions at the fixing is maximized
 - the volume of unexecuted orders is minimized
 - a change from the last reference price is minimized (e.g. the previous closing for the opening price)
- ❖ Example: order book at the opening fixing, previous close was 10.00 PLN, price tick = 0.10 PLN

Buy orders		XYZ shares	Sell orders	
volume	Price limit		Price limit	volume
20	MO (PKC)	BEST ORDER	MO (PKC)	5
25	11.00		9.70	5
10	10.20		9.90	15
3	9.90		10.20	20
2	9.70		10.90	10
-	-		11.00	10
-	-	WORST ORDER	-	-

The best BUY order → The best SELL order

* The price is additionally „quantized” (min tick size) and it must stay within the static / dynamical daily price change limits

Exchange trading: fixing

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- ❖ Example: order book at the opening fixing, previous close was 10.00 PLN, price tick = 0.10 PLN

Buy orders		XYZ shares Price limit	Sell orders	
	volume		volume	
The best BUY order	20	MO (PKC)	-	
	25	11.00	10	
	0	10.90	10	
	10	10.20	20	
	3	9.90	15	
	2	9.70	5	
	-	MO (PKC)	5	

- ❖ We rearrange the order book such that the (sorted) buy / sell prices match

* The price is additionally „quantized” (min tick size) and it must stay within the static / dynamical daily price change limits

Exchange trading: fixing

- ❖ The **opening / closing / fixing** price is calculated in such a way that* (in order !):
 - the volume of transactions at the fixing is maximized
 - the volume of unexecuted orders is minimized
 - a change from the last reference price is minimized (e.g. the previous closing for the opening price)
- ❖ Example: order book at the opening fixing, previous close was 10.00 PLN, price tick = 0.10 PLN

Buy orders		XYZ shares Price limit	Sell orders	
Total volume	volume		volume	Total Volume
20	20	MO (PKC)	-	
45	25	11.00	10	65
45	0	10.90	10	55
55	10	10.20	20	45
58	3	9.90	15	25
60	2	9.70	5	10
	-	MO (PKC)	5	

The best BUY order → ↓ The best SELL order ← 5

- ❖ We rearrange the order book such that the (sorted) buy / sell prices match

* The price is additionally „quantized” ([min tick size](#)) and it must stay within the static / dynamical [daily price change limits](#)

Exchange trading: fixing

- ❖ The **opening / closing / fixing** price is calculated in such a way that* (in order !):
 - the volume of transactions at the fixing is maximized
 - the volume of unexecuted orders is minimized
 - a change from the last reference price is minimized (e.g. the previous closing for the opening price)
- ❖ Example: order book at the opening fixing, previous close was 10.00 PLN, price tick = 0.10 PLN

Buy orders		XYZ shares Price limit MO (PKC)	Sell orders	
Total volume	volume		volume	Total Volume
20	20	11.00	-	
45	25	10.90	10	65
55	0	10.20	10	55
58	10	9.90	20	45
60	3	9.70	15	25
	-	MO (PKC)	5	10
			5	5

Tot. Vol @ 11.00 = 45
 Vol unexecuted=65-45=20

Tot. Vol @ 10.90 = 45
 Vol unexecuted=55-45=10

$\Delta\text{price} = 0.90 \text{ PLN}$

This price wins using all 3 (ordered) conditions !!!

Tot. Vol @ 10.20= 45
 Vol unexecuted=55-45=10
 $\Delta\text{price} = 0.20 \text{ PLN}$

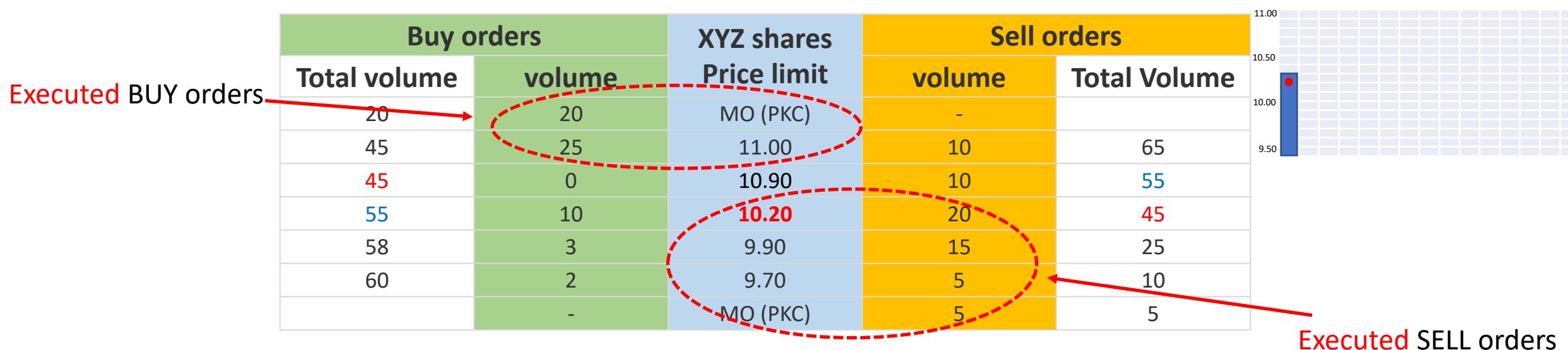
Tot. Vol @ 9.90 = 25
 (even though the Δprice is min. the Vol. cond. wins)

- ❖ The price is set @ **10.20 PLN**

* The price is additionally „quantized” (min tick size) and it must stay within the static / dynamical daily price change limits

Exchange trading: fixing

- ❖ The **opening / closing / fixing** price is calculated in such a way that* (in order !):
 - the volume of transactions at the fixing is maximized
 - the volume of unexecuted orders is minimized
 - a change from the last reference price is minimized (e.g. the previous closing for the opening price)
- ❖ Example: order book at the opening fixing, previous close was 10.00 PLN, price tick = 0.10 PLN



- ❖ The price is set @ **10.20 PLN**: 45 shares change hands and **continuous trading starts**

* The price is additionally „quantized” (**min tick size**) and it must stay within the static / dynamical **daily price change limits**

Exchange trading: fixing

- ❖ The **opening / closing / fixing** price is calculated in such a way that* (in order !):
 - the volume of transactions at the fixing is maximized
 - the volume of unexecuted orders is minimized
 - a change from the last reference price is minimized (e.g. the previous closing for the opening price)
- ❖ Example: order book at the opening fixing, previous close was 10.00 PLN, price tick = 0.10 PLN



- ❖ Order book after the opening: **unexecuted / partly-executed orders remain in the book**

* The price is additionally „quantized” ([min tick size](#)) and it must stay within the static / dynamical [daily price change limits](#)

Exchange trading: continuous trading

❖ After the **opening** price is fixed, **continuous trading** starts

- orders inflow to the order book at any time
- if an order meets the matching opposing order(s) in the book then it is executed immediately
- if there is no matching order(s) (or the order is executed partly) then it stays in the book

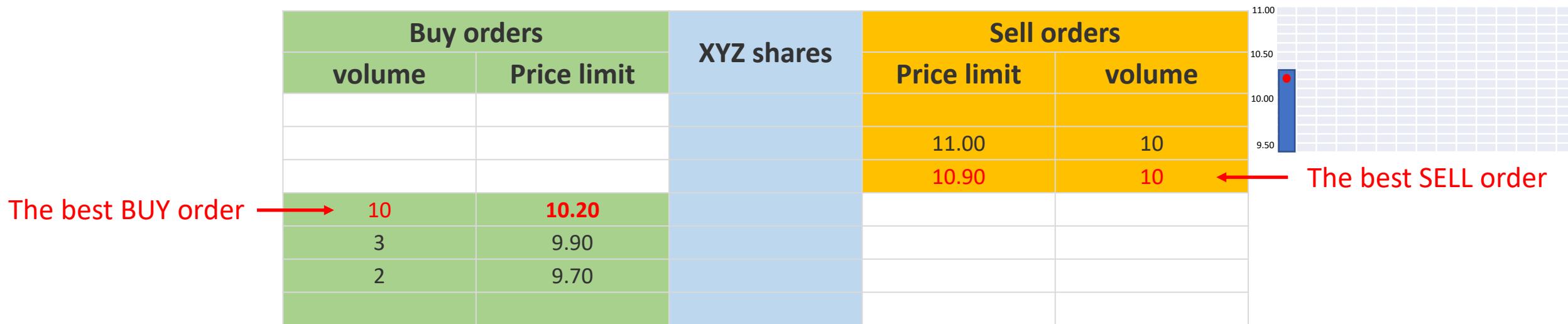


❖ Order book after the opening: **unexecuted / partly-executed orders remain in the book**

* The price is additionally „quantized” ([min tick size](#)) and it must stay within the static / dynamical [daily price change limits](#)

Exchange trading: continuous trading

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- ❖ **NOTE:** We rearrange the order book such that it looks like in “real life” trader screen



- ❖ Order book after the opening: **unexecuted / partly-executed orders remain in the book**

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Exchange trading: continuous trading

- ❖ After the **opening** price is fixed, **continuous trading** starts
 - orders inflow to the order book at any time
 - if an order meets the matching opposing order(s) in the book then it is executed immediately
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- ❖ **NOTE:** We rearrange the order book such that it looks like in “real life” trader screen



- ❖ Order book after the opening: **unexecuted / partly-executed orders remain in the book**

* The price is additionally „quantized” ([min tick size](#)) and it must stay within the static / dynamical [daily price change limits](#)

Exchange trading: orders' types

❖ WSE orders' types:

- ❑ **Limit order**: order quoting a price beyond which the order may not be executed (MAX bid price for BUY orders or the MIN offer price for SELL orders)

❖ Example: **BUY LIMIT 10 shares @ 9.50 PLN**

The order appears
in the book



- ❖ Last price: PLN 10.20, last Volume: 45 shares, total Volume: 45 shares

Exchange trading: orders' types

❖ WSE orders' types:

- ❑ **Limit order**: order quoting a price beyond which the order may not be executed (MAX bid price for BUY orders or the MIN offer price for SELL orders)

❖ Example: SELL LIMIT 20 shares @ 10.90 PLN



- ❖ Last price: PLN 10.20, last Volume: 45 shares, total Volume: 45 shares

Exchange trading: orders' types

❖ WSE orders' types:

- ❑ **Limit order**: order quoting a price beyond which the order may not be executed (MAX bid price for BUY orders or the MIN offer price for SELL orders)

❖ Example: **BUY LIMIT 15 shares @ 10.90 PLN**

The order meets
the **SELL 30 @ 10.90**



- ❖ Last price: PLN **10.20**, last Volume: **45** shares, total Volume: **45** shares

Exchange trading: orders' types

❖ WSE orders' types:

- ❑ **Limit order**: order quoting a price beyond which the order may not be executed (MAX bid price for BUY orders or the MIN offer price for SELL orders)

❖ Example: **BUY LIMIT 15 shares @ 10.90 PLN**

The order **is executed @ 10.90**, the previous **SELL order 20 @ 10.90** is executed in part (only 5 shares are sold as other sell orders @ 10.90 have priority)



- ❖ Last price: PLN **10.90**, last Volume: **15 shares**, total Volume: **60 shares**

Exchange trading: orders' types

❖ WSE orders' types:

- ❑ **Limit order**: order quoting a price beyond which the order may not be executed (MAX bid price for BUY orders or the MIN offer price for SELL orders)

❖ Example: **SELL LIMIT 10 shares @ 9.50 PLN**



- ❖ Last price: PLN 10.90, last Volume: 15 shares, total Volume: 60 shares

Exchange trading: orders' types

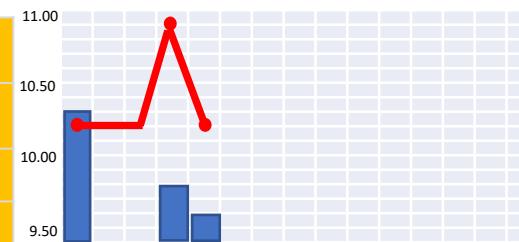
❖ WSE orders' types:

- ❑ **Limit order**: order quoting a price beyond which the order may not be executed (MAX bid price for BUY orders or the MIN offer price for SELL orders)

❖ Example: **SELL LIMIT 10 shares @ 9.50 PLN**

BUY 3 @ 9.90 becomes the best BID

Buy orders		XYZ shares	Sell orders	
volume	Price limit		Price limit	volume
3	9.90	BEST ORDER	10.90	15
2	9.70		11.00	10
10	9.50			



The SELL order meets the **BUY 10 @ 10.20** (the best BID for 10 shares \geq LIMIT !) and both are **executed @ 10.20**

❖ Last price: PLN **10.20**, last Volume: **10 shares**, total Volume: **70 shares**

Exchange trading: orders' types

❖ WSE orders' types:

- ❑ **Limit order**: order quoting a price beyond which the order may not be executed (MAX bid price for BUY orders or the MIN offer price for SELL orders)

❖ Example: SELL LIMIT 10 shares @ 9.60 PLN



❖ Last price: PLN 10.20, last Volume: 10 shares, total Volume: 70 shares

Exchange trading: orders' types

❖ WSE orders' types:

- ❑ **Limit order**: order quoting a price beyond which the order may not be executed (MAX bid price for BUY orders or the MIN offer price for SELL orders)

❖ Example: SELL LIMIT 10 shares @ 9.60 PLN



❖ Last price: PLN 9.70, last Volume: 5 shares, total Volume: 75 shares

Exchange trading: orders' types

❖ WSE orders' types:

- ❑ Market Order (PKC): no limit price, it is executed at the best possible prices of opposite orders

❖ Example: BUY 10 shares @ MO (PKC)

The BUY MO order meets
the **SELL 5 @ 9.60**
and **SELL 15 @ 10.90**
(the best ASKs !)

Buy orders		XYZ shares	Sell orders	
volume	Price limit		Price limit	volume
10	9.50		9.60	5
			10.90	15
			11.00	10

A red arrow points from the 'BEST ORDER' in the Buy orders section to the 'SELL 5 @ 9.60' in the Sell orders section. A red arrow also points from the 'WORST ORDER' in the Buy orders section to the 'SELL 15 @ 10.90' in the Sell orders section.



- ❖ Last price: PLN **9.70**, last Volume: **5** shares, total Volume: **75** shares

Exchange trading: orders' types

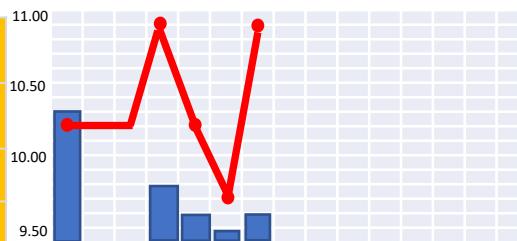
❖ WSE orders' types:

- ❑ Market Order (PKC): no limit price, it is executed at the best possible prices of opposite orders

❖ Example: BUY 10 shares @ MO (PKC)

The MO is executed as:
5 @ 9.60 + 5 @ 10.90
(The ASK @ 10.90 is
partly executed and the
rest of it stays in the
book)

Buy orders		XYZ shares	Sell orders	
volume	Price limit		Price limit	volume
10	9.50	BEST ORDER	10.90	10
			11.00	10



- ❖ Last price: PLN 10.90, last Volume: 10 shares, total Volume: 85 shares

Exchange trading: orders' types

❖ WSE orders' types:

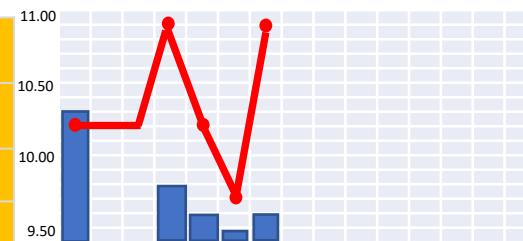
- ❑ Market Order (PKC): no limit price, it is executed at the best possible prices of opposite orders
- ❑ Market To Limit order (PCR): is executed at the best opposite price, unexecuted part becomes a limit order at that price

❖ Example: BUY 20 shares @ MTL (PCR)

The BUY MTL order meets
the SELL 10 @ 10.90
(only the 1st best ASK!)

Buy orders		XYZ shares	Sell orders	
volume	Price limit		Price limit	volume
10	9.50	BEST ORDER	10.90	10
			11.00	10

A red arrow points from the 'BEST ORDER' row in the Sell orders section to the 'WORST ORDER' row in the Buy orders section.



❖ Last price: PLN 10.90, last Volume: 10 shares, total Volume: 85 shares

Exchange trading: orders' types

❖ WSE orders' types:

- ❑ Market Order (PKC): no limit price, it is executed at the best possible prices of opposite orders
- ❑ Market To Limit order (PCR): is executed at the best opposite price, unexecuted part becomes a limit order at that price

❖ Example: BUY 20 shares @ MTL (PCR)

The MTL is executed as:
10 @ 10.90, the remaining
part becomes: BUY 10 @
10.90 (the price of the
previous 1st best ASK!)

Buy orders		XYZ shares	Sell orders	
volume	Price limit		Price limit	volume
10	10.90	BEST ORDER	11.00	10
10	9.50	WORST ORDER		



❖ Last price: PLN 10.90, last Volume: 10 shares, total Volume: 95 shares

Exchange trading: orders' types

❖ WSE orders' types:

- **STOP order**: includes a stop price and either a limit price at which the order is executed (**stop limit order**) or instructions to execute the order as MO (**stop loss order**). The order is activated (appears in the book) when the stop price is crossed. The stop price must be higher for BUY orders and lower for SELL orders than the last trade price.

❖ Example: **STOP SELL (activation = 9.50 PLN) 5 shares @ MO (stop loss)**



- ❖ It will appear in the book only if the price drops to or below PLN 9.50

Exchange trading: orders' types

❖ WSE orders' types:

- **STOP order**: includes a stop price and either a limit price at which the order is executed (**stop limit order**) or instructions to execute the order as MO (**stop loss order**). The order is activated (appears in the book) when the stop price is crossed. The stop price must be higher for BUY orders and lower for SELL orders than the last trade price.

❖ Example: STOP SELL (activation = 9.50 PLN) 5 shares @ MO (stop loss)



- ❖ It will appear in the book only if the price drops to or below PLN 9.50
e.g. an order **SELL 12 shares @ MO**

Exchange trading: orders' types

❖ WSE orders' types:

- **STOP order**: includes a stop price and either a limit price at which the order is executed (**stop limit order**) or instructions to execute the order as MO (**stop loss order**). The order is activated (appears in the book) when the stop price is crossed. The stop price must be higher for BUY orders and lower for SELL orders than the last trade price.

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Exchange trading: orders' types

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❖ Example: STOP SELL (activation = 9.50 PLN) 5 shares @ MO (stop loss)



- ❖ It will appear in the book only if the price drops to or below PLN 9.50

e.g. an order SELL 12 shares @ MO will trigger the above stop loss order, which then becomes SELL 5 shares @ MO

Exchange trading: orders' types

❖ WSE orders' types:

- **STOP order**: includes a stop price and either a limit price at which the order is executed (**stop limit order**) or instructions to execute the order as MO (**stop loss order**). The order is activated (appears in the book) when the stop price is crossed. The stop price must be higher for BUY orders and lower for SELL orders than the last trade price.

❖ Example: STOP SELL (activation = 9.50 PLN) 5 shares @ MO (stop loss)



- ❖ It will appear in the book only if the price drops to or below PLN 9.50

e.g. an order SELL 12 shares @ MO will trigger the above stop loss order, which then becomes SELL 5 shares @ MO

Exchange trading: orders' types

❖ WSE orders' types:

- ❑ **PEG order**: order with a limit price which automatically becomes equal to the limit price of the best order on the same side of the order book. It may also have additional max BID limit (for BUY orders) or min ASK limit (for SELL orders)

❖ Example: **BUY PEG 15 shares (with max BID limit = 10.00 PLN)**



Exchange trading: orders' types

❖ WSE orders' types:

- **PEG order**: order with a limit price which automatically becomes equal to the limit price of the best order on the same side of the order book. It may also have additional max BID limit (for BUY orders) or min ASK limit (for SELL orders)

❖ Example: **BUY PEG 15 shares (with max BID limit = 10.00 PLN)**



- ❖ It will appear in the book at the price of the best BUY order (@ 9.50 PLN)

Exchange trading: orders' types

❖ WSE orders' types:

- **PEG order**: order with a limit price which automatically becomes equal to the limit price of the best order on the same side of the order book. It may also have additional max BID limit (for BUY orders) or min ASK limit (for SELL orders)

❖ Example: BUY PEG 15 shares (with max BID limit = 10.00 PLN)



- ❖ It will appear in the book at the price of the best BUY order (@ 9.50 PLN)
e.g. an order **BUY LIMIT 10 shares @ 9.80 PLN** will automatically move the **BUY PEG** price higher

Exchange trading: orders' types

❖ WSE orders' types:

- **PEG order**: order with a limit price which automatically becomes equal to the limit price of the best order on the same side of the order book. It may also have additional max BID limit (for BUY orders) or min ASK limit (for SELL orders)

❖ Example: BUY PEG 15 shares (with **max BID limit = 10.00 PLN**)



- ❖ It will appear in the book at the price of the best BUY order (@ 9.50 PLN)

BUT an order **BUY LIMIT 5 shares @ 10.20 PLN** will move the **BUY PEG price only to the max BID limit (10 PLN)**

Exchange trading: orders' types

❖ WSE orders' types (summary):*

- LIMIT** order
- Market Order (MO, PKC)**
- Market To Limit order (MTL, PCR)**
- STOP Limit** order
- STOP Loss** order
- PEG** order

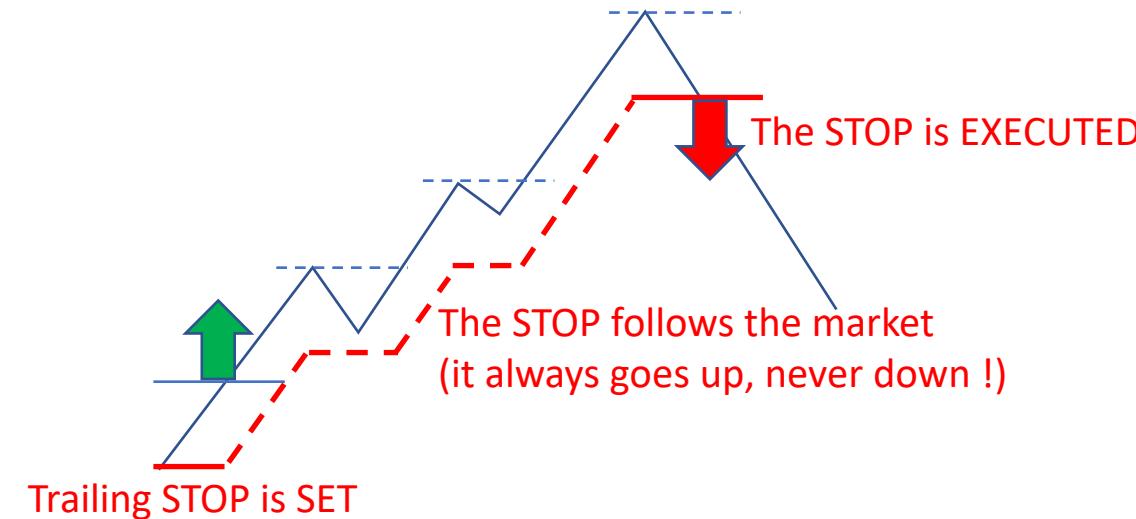
*Orders may have additional provisions:

- Max. validity (“Day”, “Good Till Date”, “Good Till Cancel”, “Good Till Time”, “Valid for Auction (fixing)”, “Valid for Closing”).
 - „Fill-and-Kill” (unexecuted part is void), „Fill-or-Kill” (void if not fully executed), Min. Quantity (void if not reached), „Iceberg” (partly hidden), „Cross”
 - There are also some special types of orders used for large packages or error correction which go outside the usual market.
- For details see e.g.: https://www.gpw.pl/pub/files/PDF/regulacje/SZOG_en.pdf

Exchange trading: orders' types

❖ WSE orders' types (summary):

- LIMIT** order
- Market Order (MO, PKC)**
- Market To Limit order (MTL, PCR)**
- STOP Limit** order
- STOP Loss** order
- PEG** order



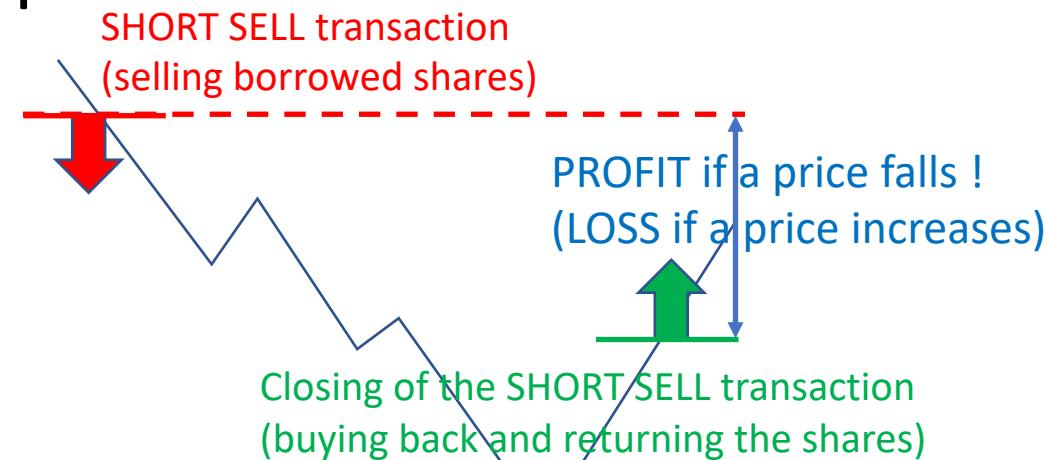
❖ Brokers can offer additional types of orders (which are then converted to WSE orders)

- Trailing STOP** order: the limit of the stop order is automatically adjusted depending on the current market price or the current BID/ASK price. For the SELL Trailing STOP the stop price will always go up (never down) following rising market prices. For the BUY Trailing STOP the stop price will follow decreasing market prices. This way investors can automatically take advantage of an upward/downward trend and make sure their positions will be safely closed (with a small loss or a profit) if the market turns

Exchange trading: orders' types

❖ WSE orders' types (summary):

- LIMIT** order
- Market Order (MO, PKC)**
- Market To Limit order (MTL, PCR)**
- STOP Limit** order
- STOP Loss** order
- PEG** order



❖ Brokers can offer additional types of orders (which are then converted to WSE orders)

- SHORT SELLING***: **sale of a security** that the seller has **borrowed** (usually from a broker). A **short seller profits if a security's price declines**: he sells to open the **short position** and expects to buy it back later at a lower price and will keep the difference as a gain. This can be usually done as a standard type of transaction, i.e. borrowing is “hidden” behind the SS order. The seller (as he is the borrower) usually pays some special fee and/or interest and he has to pay back all inflows from the borrowed securities (e.g. dividends or coupons). The cash received from a SS transaction is usually blocked on the account together with some additional amount (the **margin**) which guarantees that the short-seller will be able to buy back and return the borrowed securities if the price increases.

60

*Up to mid 2015 SHORT SELLING was regulated by the WSE (special marking of SS orders). Now it is up to brokers who need to obey EU regulations.

Exchange trading: orders' types

❖ WSE orders' types (summary):

- LIMIT** order
- Market Order (MO, PKC)**
- Market To Limit order (MTL, PCR)**
- STOP Limit** order
- STOP Loss** order
- PEG** order

the „leverage” =
 $= 1 / \text{margin rate} =$
 $= 1 / 10\%$

Example:

An investor pays only **1000 PLN** cash as a **margin** and he borrows 9000 PLN from a broker and buys 100 XYZ shares @ 100 PLN (**value of the shares is 10 000 PLN**)

- If the price increases by 5% (to 105 PLN) the shares will be worth 10 500 PLN and the investor can realize 500 PLN profit (the rate of return is $5\% \times 10 = 50\%$)
- If prices drop by 5% the investor will incur a 50% loss !

❖ Brokers can offer additional types of orders (which are then converted to WSE orders)

- MARGIN BUYING**: the purchase of an asset by using **leverage** and borrowing the balance from a bank or broker. Investor borrows money in order to **buy more securities**. Buying on **margin** refers to the initial payment made to the broker for the asset being purchased, e.g. 10% margin (initial payment) and 90% financed. The purchased securities constitute a **collateral** for the borrowed funds. If prices go down and thus the investor's stake falls below some limit the broker can sell the securities and pay back the loan. Margin buying is an example of a **leveraged trade**: an investor takes all profits / loses which depend on the total value of purchased securities which is much more than the investor's stake (**profits / losses are multiplied** by using external funds)

Exchange trading: orders' types

❖ WSE orders' types (summary):

- LIMIT** order
- Market Order (MO, PKC)**
- Market To Limit order (MTL, PCR)**
- STOP Limit** order
- STOP Loss** order
- PEG** order

❖ Brokers can offer additional types of orders (which are then converted to WSE orders)

- Trailing STOP**
- SHORT SELLING**
- MARGIN BUYING**
- ...

Financial markets & instruments

- ❖ General overview (taxonomy)
- ❖ Basic exchange trading rules
- ❖ Derivative Instruments

Forward

❖ We start with a simple example of an **equity forward*** (forward on N “XYZ” shares):

- The forward is an **OTC** transaction between the **BUYER** and the **SELLER** in which they agree to **trade the “underlying asset”** (e.g. N “XYZ” shares) **at some future date T at the guaranteed price X** . The date T and the price X are agreed upon now (at the moment of “signing” the forward contract)
- The **BUYER** of the forward (he has the, so called, “**LONG POSITION**”) has an **obligation to BUY** (i.e. to pay for) N “XYZ” **shares** at the future date T at the guaranteed price X
- The **SELLER** of the forward (he has the, so called, “**SHORT POSITION**”) has an **obligation to SELL** (i.e. to deliver) the **shares** at the above date T , at price X
- **No cash flow is paid now:** in this sense **the price of the forward is ZERO !** All CF (the payment for the shares) will be done in the future at maturity T .** \Rightarrow theoretically ∞ leverage (if **speculation!**)
- By trading forwards the parties **FIX** the future price @ X so forwards can be used to **hedge** against the market price risk ! (BUYER can hedge against rising prices and SELLER against falling prices)

❖ Notation:

- the future date (maturity / expiration / expiry): T
- the agreed price (the exercise / forward price*): X
- the number of shares (the “**multiplier**”): N
- the “XYZ” share price: $S(t)$

*In fact, OTC equity forwards are rarely traded.

One can instead have Exchange traded equity futures.

As the current price is zero, the BUYER / SELLER can theoretically trade ∞ many contracts, but he will then have problems to pay / deliver in the future \Rightarrow **counterparty transaction limits !!!

*In some notations the Forward exercise price is denoted: F

Forward

❖ The situation / risk of the **BUYER** and the **SELLER** is completely symmetric

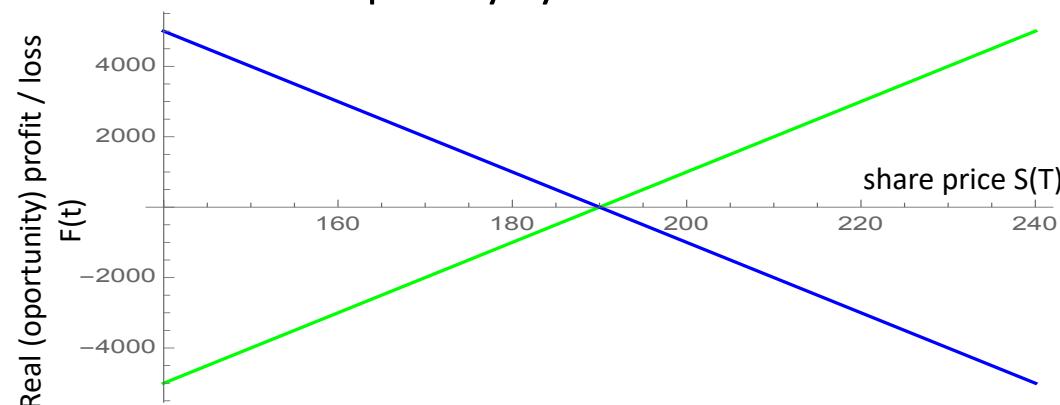
- The **BUYER** has risk that the future share price $S(T)$ will be lower than the agreed exercise price X
 - If (at date T) he immediately sell the shares @ price $S(T)$ he has bought @ price X , he will earn:

$$F(T) = N(S(T) - X)$$
 - If $S(T) > X \Rightarrow F(T) > 0$ and the **BUYER** will make a **profit**
 - If $S(T) < X \Rightarrow F(T) < 0$ and the **BUYER** will incur a **loss**
 - If (at date T) the **BUYER** keeps the shares he will anyway make (the opportunity) profit / incur (the opportunity) loss $F(T)$ as instead of BUYING shares in a forward contract @ price X he could wait until date T and buy shares @ price $S(T)$
 - So **LONG POSITION** in a forward turns out to be **profitable if future price $S(T) > X$** and unprofitable if future price $S(T) < X$
- The **SELLER** has risk that the future share price $S(T)$ will be higher than the agreed exercise price X
 - If (at date T) he buys the shares @ price $S(T)$ he has to deliver @ price X , he will earn:

$$-F(T) = N(X - S(T))$$
 - If $S(T) > X \Rightarrow F(T) > 0$ and the **SELLER** will incur a **loss**
 - If $S(T) < X \Rightarrow F(T) < 0$ and the **SELLER** will make a **profit**
 - If (at date T) the **SELLER** sells the shares he already has in his portfolio, he will anyway incur (the opportunity) loss / make (the opportunity) profit $-F(T)$ as instead of SELLING shares in a forward contract @ price X he could wait until date T and sell shares @ price $S(T)$
 - So **SHORT POSITION** in a forward turns out to be **profitable if future price $S(T) < X$** and unprofitable if future price $S(T) > X$

Forward: Example

- ❖ Today (22nd Nov 2019) we BUY equity forward for 100 Apple shares @ \$ 190 with delivery on 20th Dec 2019.
 - On the 20th Dec 2019 we pay for the shares $100 \times \$190 = \$19\,000$ independent of the share price $S(T)$
 - We can immediately sell the received shares at the stock exchange at the market price $S(T)$
 - If $S(T) > \$190$, e.g. $S(T) = \$210 \Rightarrow$ we will make a profit $F(T) = 100 \times (\$210 - \$190) = \$2\,000$
 - If $S(T) < \$190$, e.g. $S(T) = \$150 \Rightarrow$ we will incur a loss $F(T) = 100 \times (\$150 - \$190) = -\$4\,000$
 - If we want to keep the shares (bought @ \$190) we will anyway have (the opportunity) profit / loss
 - If $S(T) > \$190$, e.g. $S(T) = \$210 \Rightarrow$ we could pay for the shares \$210 instead of \$190 so we actually buy the shares cheaper than the current market price and we make the opportunity profit of \$2 000
 - If $S(T) < \$190$, e.g. $S(T) = \$150 \Rightarrow$ we could pay for the shares \$150 instead of \$190 so we actually buy the shares more expensive than the current market price and we incur the opportunity loss of -\$4 000
 - The situation of the SELLER is completely symmetric !



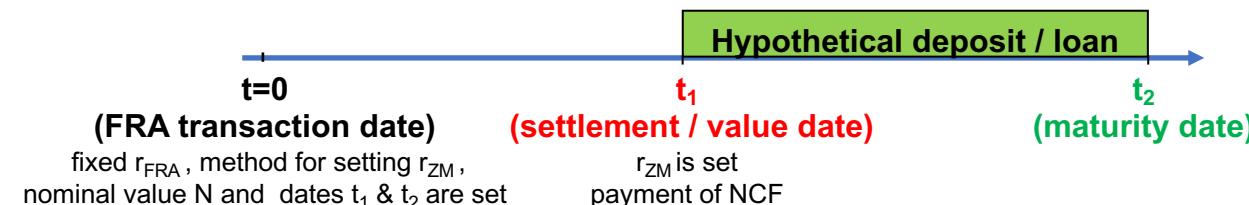
Non-Deliverable Forward (NDF)

- ❖ Instead of the forward with physical delivery (i.e. cash vs shares) one may choose the Non-Deliverable Forward (NDF), where the difference between the future share price $S(T)$ and the agreed exercise price X is payed at maturity in cash.
 - The BUYER of NDF (**long position**) will RECEIVE and the SELLER of NDF (**short position**) will PAY the CF equal to the “**PAYOUT function**”:
- $F(T) = N (S(T) - X)$
- NOTE: payoff $F(T)$ is the CF !, so if $F(T) > 0$ the SELLER pays to the BUYER, and if $F(T) < 0$ the BUYER pays to the SELLER (symmetric risk !)
 - From our earlier discussion **NDF is financially equivalent to the forward** with physical delivery:^{*}
 - If the BUYER of the usual forward (i.e. with physical delivery) sells the shares just after the delivery he will anyway make a profit equal $F(T)$
 - If the SELLER of the usual forward (i.e. with physical delivery) buys the shares just before the delivery he will anyway make a profit equal $-F(T)$
 - If the BUYER of NDF wants to get physical shares he can buy them on the market, where he pays: $N \times S(T)$, and from NDF he gets: $N \times (S(T) - X)$, so he effectively PAYS: $N \times X$ for the shares independent of $S(T)$, exactly as in the case of the usual forward
 - If the SELLER of NDF wants to sell physical shares he can sell them on the market, where he gets: $N \times S(T)$, and from NDF he pays: $N \times (S(T) - X)$, so he effectively GETS: $N \times X$ for the shares, exactly as in the case of the usual forward

*Here we disregard transaction costs, delivery / settlement risk, etc.

Forward Rate Agreement (FRA)

- ❖ Forward Rate Agreement (**FRA**) is the NDF for future interest rates. The parties fix the (FRA) rate of future (hypothetical) deposits / loans of nominal value N.



- The “deposit” / “loan” starts in a **fixed time $t_1 > 0$** (the **value / fixing date / the settlement date***) and ends in a **fixed time $t_2 > t_1$** (the **maturity date**). **like X in Equity Forward**
- The **FRA BUYER**** pays interest using **fixed rate**: the **FRA rate r_{FRA}** (set on the transaction date $t=0$) and receives interest using the (future, currently unknown) floating rate: **r_{ZM}** **like S(T) in Equity Forward**
- The **FRA SELLER**** pays interest using **floating rate**: **r_{ZM}** and receives interest using **fixed rate**: **r_{FRA}**
- On the **value date (t_1 NOT t_2 !!!)** the **floating rate r_{ZM} is set** by looking at the interest rate of deposits / loans for the (t_2-t_1) period. The method of setting (“fixing”) the rate **i_{ZM}** is detailed in the FRA contract, it is usually **some reference “–BOR” rate** (e.g. WIBOR, LIBOR, EURIBOR, ...).
- On the **settlement date (t_1 NOT t_2 !!!)** the parties exchange interests or (in practice) they compensate and the **FRA BUYER receives** / the **FRA SELLER pays the NET CF** (can be negative !):

*Usually r_{ZM} is set on „value date” but FRA is „settled”,
i.e. NCF is paid on SPOT = „value” + 2 days

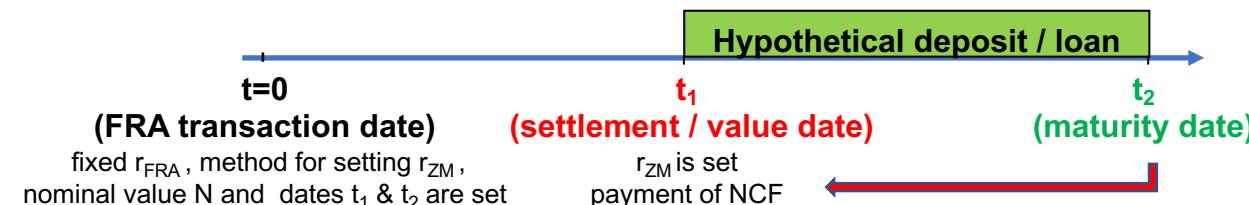
**The terminology: FRA BUYER (LONG) / FRA SELLER (SHORT)
is rarely used, and there is controversy which party is „BUY” / „SELL”

$$NCF = \frac{N (r_{ZM} - r_{FRA}) DCF_{t_2-t_1}}{1 + r_{ZM} DCF_{t_2-t_1}}$$

the Day Count Factor used for r_{ZM} ,
e.g. $DCF_{t_2-t_1} = (t_2 - t_1)/365$

Forward Rate Agreement (FRA)

- ❖ Forward Rate Agreement (**FRA**) is the NDF for future interest rates. The parties fix the (FRA) rate of future (hypothetical) deposits / loans of nominal value N.



$$NCF = \frac{N (r_{ZM} - r_{FRA}) DCF_{t_2-t_1}}{1 + r_{ZM} DCF_{t_2-t_1}}$$

Discount Factor !

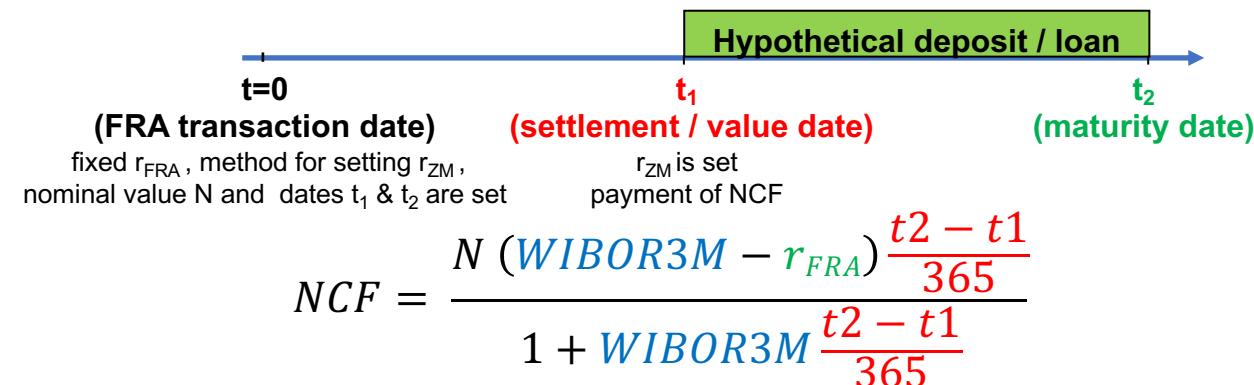
- ❑ The reason for using this formula is simply because **interest is payed “upfront”** (of the hypothetical future deposit / loan), i.e. **on the settlement date t_1 NOT the maturity date t_2** , therefore **the NET difference of interest has to be discounted from t_2 to t_1**

- ❑ Quoting terminology:

- ❑ “ $t_1 \times t_2$ ” FRA (where t_1 and t_2 are in (integer) months !), means a FRA with settlement t_1 and maturity t_2 , e.g. “1 x 4” FRA is a hypothetical (4-1 = 3 month) future deposit/loan settled in 1 month and ending in 4 months
- ❑ **FRA BID:** price (r_{FRA}) at which one can immediately SELL the FRA (make hypothetical future deposit), profit if $r_{ZM} < r_{FRA}$
- ❑ **FRA ASK:** price (r_{FRA}) at which one can immediately BUY the FRA (take hypothetical future loan), profit if $r_{ZM} > r_{FRA}$

Forward Rate Agreement (FRA): Example

- ❖ Forward Rate Agreement (**FRA**) is the NDF for future interest rates. The parties fix the (FRA) rate of future (hypothetical) deposits / loans of nominal value N .

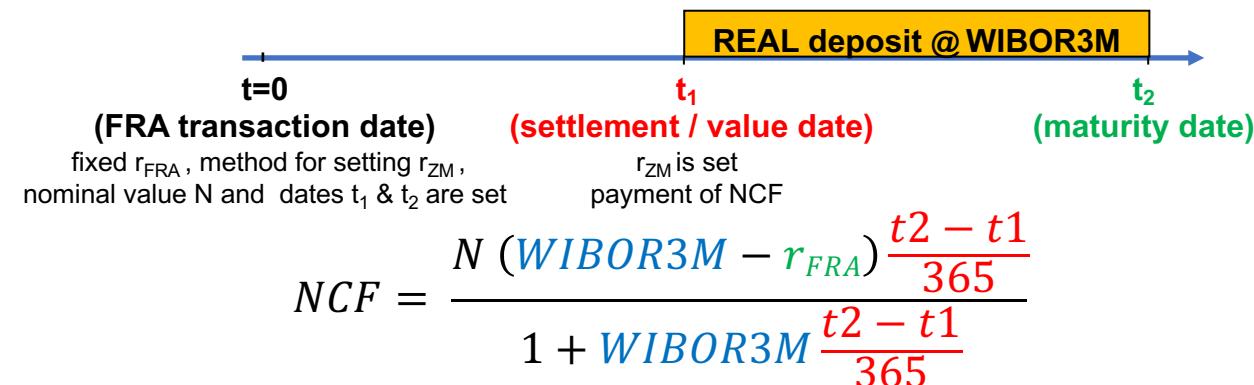


- ❑ As other Forwards, FRA can be used for **speculation**: you **BUY FRA** (pay fixed r_{FRA} , receive float r_{ZM}) when **you expect rates will go up**, and you **SELL FRA** (pay float r_{ZM} , receive fixed r_{FRA}) when **you expect rates will go down**
- ❑ **Example**: the “1x4” FRA in PLN settled against WIBOR3M traded on **20th Nov 2019** @ **1.75% - 1.77%** the **value date** is **20th Dec 2019** and the **maturity** is **20th Mar 2020** ($t_2 - t_1 = 91$ days)
 - Investor “A” expects 3MWIBOR will go up and he **BUYS** $N = 10$ mln PLN FRA @ $r_{FRA} = 1.77\%$
 - On **20th Dec 2019** (the value date) the **WIBOR3M is fixed @ 1.90%**: “A” will **EARN**:

$$NCF = \text{PLN } 10 \text{ mln} \times (1.90\% - 1.77\%) \times 91/365 / (1 + 1.90\% \times 91/365) = \text{PLN } 3\,225.82$$
 - If on **20th Dec 2019** the **WIBOR3M is fixed @ 1.70%** “A” will **LOSE**: $NCF = -1\,737.84$ PLN

Forward Rate Agreement (FRA): Example

- ❖ Forward Rate Agreement (**FRA**) is the NDF for future interest rates. The parties fix the (FRA) rate of future (hypothetical) deposits / loans of nominal value N.



- ❑ As other Forwards, FRA can be also used to **hedge against (short-term) interest rate risk**. Using FRA one may fix **REAL future deposit / loan rate**. If you are planning **future loan** and want to fix the rate now you **BUY FRA**. If you are planning **future deposit** and want to fix the rate now you **SELL FRA**.
- ❑ **Example:** the “1x4” FRA in PLN settled against WIBOR3M traded on **20th Nov 2019** @ 1.75% - 1.77% the **value date** is **20th Dec 2019** and the **maturity** is **20th Mar 2020** ($t_2 - t_1 = 91$ days)
 - Investor “B” plans to make a **REAL 3M deposit: $N = 1$ mln @ WIBOR3M in 1 month** (on **20th Dec 2019**) and is afraid that 3MWIBOR will go down so he **SELLS** $N = 1$ mln PLN FRA @ $r_{FRA} = 1.75\%$
 - On **20th Dec 2019** (the value date) the **WIBOR3M is fixed @ $r_{ZM}\%$** .
 - “B” **pays NCF** (he is **FRA SHORT**) and **makes the REAL deposit for $(N - NCF) = 1$ mln - NCF @ $r_{ZM}\%$** !
 - On **20th Mar 2020**, “B” **receives:** $(N - NCF)(1 + r_{ZM} \cdot 91/365) = N(1 + r_{ZM} \cdot 91/365) - N(r_{ZM} - r_{FRA}) \cdot 91/365 = 1$ mln $(1 + 1.75\% \cdot 91/365)$

Deposit rate is fixed @ r_{FRA}
independent of r_{ZM} !!!

Futures

- ❖ Futures are **standardized exchange traded forwards**
- ❖ All contract details (except from the exercise price X) is regulated by the exchange. The “standard” describes:
 - The **underlying asset** (e.g. KGHM shares, WIG20 index, EURPLN, WIBOR 3M, short term T-bonds (precise definition of which bonds can be delivered), ...)
 - The **multiplier**: N
 - **Delivery/Expiration month** (codes (Jan – Dec): F,G,H,J,K,M,N,Q,U,V,X,Z) and **day** (e.g. 3rd Friday of the Delivery Month): T
 - **Settlement method**: cash settlement or physical delivery
 - For cash settled futures: the **way of calculating the final settlement price**: S(T) (e.g. the average price from last hour of trading of the WIG20 index at the expiration day T)
 - The **quotation method** (e.g. share price, index points, EUR price per 100 PLN !, 100 – interest rate !, clean price of the bonds per 100 PLN nominal)
 - ...
- Investors **trade @ the exercise price**: X is set by the BUY / SELL orders (the market)

*For details see e.g.: <https://www.gpw.pl/opcje-standardy-warunki-obrotu>

Futures: Open Interest

- ❖ Futures are standardized exchange traded forwards
- ❖ The advantage of exchange trading and standardization is (usually) high liquidity and ease of closing the BUY / SELL side of the contract before maturity
- ❖ The LONG / SHORT position can be easily closed before maturity by making an opposite transaction on the market (conversely to OTC forwards one is not forced to close the position with the same counterparty) – the LONG and SHORT positions are treated independently and are secured by the Exchange / Central Clearing House
- ❖ The number of currently (active) open contracts is reported: Open Interest (OI)
(always: Total # LONGs = Total # SHORTs = OI)
- ❖ Example: assume that a new futures contract (e.g. new expiry date) just started to trade (OI=0)
 - A BUY order for 50 futures of Investor "A" meets the SELL order of Investor "B" ⇒ "A" is 50 futures "long" and "B" is 50 futures "short" (# LONGs = # SHORTs = OI = 50 ↑)
 - Investor "A" SELLS 20 futures which are BOUGHT by investor "C" ⇒ "A" is 30 long, "B" is 50 short and "C" is 20 long (# LONGs = # SHORTs = OI = 50)
 - Investor "B" BUYS 25 futures, which are SOLD by investor "C" ⇒ "A" is 30 long, "B" is 25 short and "C" is 5 short (# LONGs = # SHORTs = OI = 30 ↓)

Futures: Margins & Marking-to-market

- ❖ Futures are **standardized exchange traded forwards**
- ❖ As futures are traded between (anonymous) counterparties there must be automated mechanisms ensuring that investors will meet their obligations. These are based on **collateral**:
 - Margin deposits**
 - When a BUY or a SELL order is placed (symmetric risk!) some cash amount is blocked on the investor's account, it is called the **initial margin**
 - The margin is usually a **small fraction** (e.g. 10%) of the **nominal value** of a contract ($N \times X$) \Rightarrow one can open much bigger nominal position than the cash balance of the account: **leverage !!!**
 - Margins are blocked only when the net investor's position increases, the money is freed just after the position is closed (if net position decreases the margin is lowered accordingly)
 - Marking-to-market**
 - In the end of each trading day the **Daily Settlement Price** (DSP is usually the futures daily CLOSE price) is announced by the Exchange
 - The investor's cash account is credited / debited as if he closed all open positions @ DSP: **current daily profits / losses are added to / subtracted from the cash account**
 - If the cash balance falls below some level (the **maintenance margin**, e.g. 7%) the investor is called (the "**margin call**") to deposit additional funds (**up to the initial margin level**). The investor should deposit the funds before next day opening or all open positions will be closed.⁷⁴

Futures: Margins & Marking-to-market

- ❖ Futures are standardized exchange traded forwards
- ❖ As futures are traded between (anonymous) counterparties there must be automated mechanisms ensuring that investors will meet their obligations. These are based on collateral:
- ❖ Example: assume the initial margin level of 10% and the maintenance margin level of 7%. Let's trade the FW20Z1920 (Futures contracts on the WIG20 index expiring in Dec 2019 with multiplier 20 PLN) listed on the Warsaw Stock Exchange (GPW). We put 10 000 PLN on our cash account.
 - We BUY 1 contracts @ 2160 (nominal value: $1 \times 2160 \times 20 \text{ PLN} = 43\,200 \text{ PLN}$): the initial margin of $10\% \times 43\,200 \text{ PLN} = 4\,320 \text{ PLN}$ is blocked (the total account balance is still 10 000 PLN so we have free balance of $10\,000 \text{ PLN} - 4\,320 \text{ PLN} = 5\,680 \text{ PLN}$: this can be withdrawn or used for other trades)
 - We BUY 1 more contract @ 2160: the blocked margin is increased to $2 \times 4320 \text{ PLN} = 8\,640 \text{ PLN}$
 - We SELL 1 contract @ 2165 (we have a profit of $+1 \times (2165 - 2160) \times 20 \text{ PLN} = +100 \text{ PLN}$ on 1 closed long position: this will be added to the account balance in the end of the day), our net open position decreases: $+2 \rightarrow +1$ and the blocked margin decreases from 8 640 PLN to 4 320 PLN
 - We SELL 3 contracts @ 2158 (we have a loss of $+1 \times (2158 - 2160) \times 20 \text{ PLN} = -40 \text{ PLN}$: this will be subtracted from the account in the end of the day), our (absolute) net open position increases: $+1 \rightarrow -2$ and the blocked margin increases from 4320 PLN to 8632 PLN ($10\% \times 2 \times 2158 \times 20 \text{ PLN}$)

Futures: Margins & Marking-to-market

- ❖ Futures are standardized exchange traded forwards
- ❖ As futures are traded between (anonymous) counterparties there must be automated mechanisms ensuring that investors will meet their obligations. These are based on collateral:
- ❖ Example: assume the initial margin level of 10% and the maintenance margin level of 7%. Let's trade the FW20Z1920 (Futures contracts on the WIG20 index expiring in Dec 2019 with multiplier 20 PLN) listed on the Warsaw Stock Exchange (GPW). We put 10 000 PLN on our cash account.
 - The trading session ends and the Daily Settlement Price (the CLOSE price) is 2150
 - The realized profits / loses: +100 PLN -40 PLN are added to our cash account ⇒ Δbalance: +60 PLN
 - The open positions (-2 @ 2158) are marked-to-market: $-2 \times (2150 - 2158) \times 20 \text{ PLN} = +320 \text{ PLN}$
⇒ we earned +320 PLN as we have SHORT position and the price has dropped !
 - The total balance of the account has increased to: $10\,000 \text{ PLN} + 60 \text{ PLN} + 320 \text{ PLN} = 10\,380 \text{ PLN}$
(the blocked margin is now $10\% \times 2 \times 2150 \times 20 \text{ PLN} = 8\,600 \text{ PLN}$)
 - On the next trading day we BUY 4 contracts @ 2165 (we have a loss of $-2 \times (2165 - 2150) \times 20 \text{ PLN} = -600 \text{ PLN}$), our (absolute) net open position is unchanged: $-2 \rightarrow +2$ and the blocked margin remains (almost) unchanged 8 600 PLN → 8 660 PLN ($10\% \times 2 \times 2165 \times 20 \text{ PLN}$)

Last DSP (NOT 2158) !!!

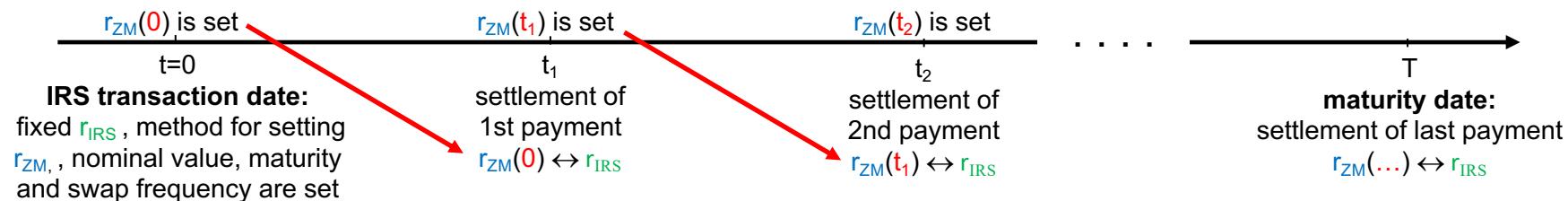
(P/L accumulate on daily basis)

Futures: Margins & Marking-to-market

- ❖ Futures are **standardized exchange traded forwards**
- ❖ As futures are traded between (anonymous) counterparties there must be automated mechanisms ensuring that investors will meet their obligations. These are based on **collateral**:
- ❖ Example: assume the **initial margin level of 10%** and the **maintenance margin level of 7%**. Let's trade the **FW20Z1920** (**Futures contracts on the WIG20 index expiring in Dec 2019** with multiplier 20 PLN) listed on the Warsaw Stock Exchange (GPW). We put 10 000 PLN on our cash account.
 - The next trading session ends and the **Daily Settlement Price** (the CLOSE price) is **2100**
 - The **realized daily profits / loses**: -600 PLN are added to our cash account $\Rightarrow \Delta\text{balance} = -600 \text{ PLN}$
 - The **open positions (+2 @ 2165)** are **marked-to-market**: $+2 \times (2100 - 2165) \times 20 \text{ PLN} = -2\,600 \text{ PLN}$
 \Rightarrow we lost -2 600 PLN as we have LONG position and the price has dropped !
 - The **total balance of the account is now**: 10 380 PLN (prev. bal.) - 600 PLN - 2 600 PLN = **7 180 PLN**
 (**the balance drops below the initial margin**: $10\% \times 2 \times 2100 \times 20 \text{ PLN} = 8\,400 \text{ PLN}$ but still is above the **maintenance margin**: $7\% \times 2 \times 2100 \times 20 \text{ PLN} = 5\,880 \text{ PLN}$) Last DSP (NOT 2165 !!!)
 - The following day **DSP** falls to **2050** and the open positions **(+2 @ 2100)** are **marked-to-market**:
 $+2 \times (2050 - 2100) \times 20 \text{ PLN} = -2\,000 \text{ PLN}$ \Rightarrow the **balance falls to**: 7 180 PLN - 2 000 PLN = **5 180 PLN**
 which is **BELOW the MAINTENANCE MARGIN** ($7\% \times 2 \times 2050 \times 20 \text{ PLN} = 5\,740 \text{ PLN}$) \Rightarrow we receive the "margin call" and we must make up the balance to the **INITIAL MARGIN** ($10\% \times 2 \times 2050 \times 20 \text{ PLN} = 8\,200 \text{ PLN}$) or our positions will be closed by the broker @ the next opening !

Interest Rate SWAP (IRS)

- ❖ Interest Rate SWAP (IRS) is an OTC contract in which the parties **exchange (“swap”)** future streams of interest payments (called the “legs” of IRS) computed on the nominal value N of the swap. One leg is usually calculated using **fixed interest rate r_{IRS}** while the other leg is based on **floating interest rate r_{ZM}** .*



- The **IRS BUYER**** pays interest using **fixed rate**: the **IRS rate r_{IRS}** (set on the transaction date $t=0$) and receives interest using the (future, currently unknown) floating rate: r_{ZM}
- The **IRS SELLER**** pays interest using **floating rate**: r_{ZM} and receives interest using **fixed rate**: r_{IRS}
- In contrast to FRA, **in IRS the parties exchange interest** payments (in practice net CF is paid by one of the parties) **many times** during the life of the IRS
- The **floating interest rate r_{ZM}** (some “-BOR” rate) is usually **set (fixed) in the beginning of each interest rate period** but the **payment of net CF (swap of interest)** is made **in the end of the interest rate period (conversely to FRA !)**. The r_{ZM} for the 1st period is known in $t=0$ (it is the current “-BOR”)

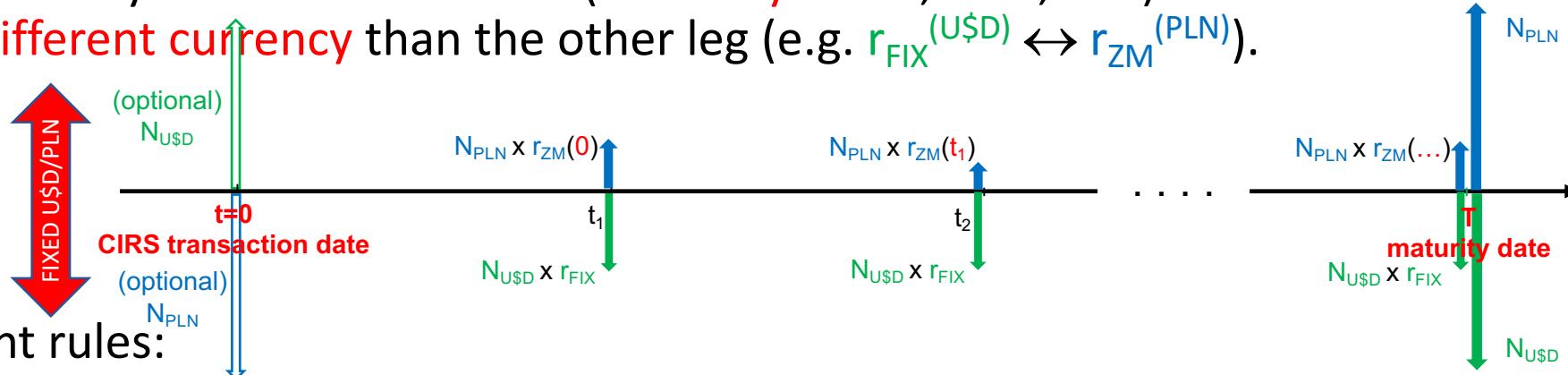
$$NCF(t_i) = N (r_{ZM}(t_{i-1}) - r_{IRS}) DCF_{t_i-t_{i-1}}$$

*Sometimes one floating rate is exchanged vs other floating rate (e.g. WIBOR3M vs WIBOR6M) – this is called the „basis SWAP”

**The terminology: IRS BUYER (LONG) / IRS SELLER (SHORT) is rarely used, and there is controversy which party is „BUY” / „SELL”

Cross-currency Interest Rate SWAP (CIRS,XCS)

- ❖ Cross-currency Interest Rate SWAP (Currency SWAP, CIRS, XCS) is similar to IRS but one leg is paid in different currency than the other leg (e.g. $r_{\text{FIX}}^{(\text{U\$D})} \leftrightarrow r_{\text{ZM}}^{(\text{PLN})}$).



- ❖ Important rules:

- All payments are exchanged (swapped) using the same currency exchange rate (it is just the ($t=0$) spot exchange rate). E.g. if the spot U\\$D/PLN rate is 3.75 than one party will pay fixed interest $r_{\text{FIX}}^{(\text{U\$D})}$ on, say, $N_{\text{U\$D}} = \text{U\$D } 1 \text{ million}$ and the other party will pay floating interest $r_{\text{ZM}}^{(\text{PLN})}$ (WIBOR) on $N_{\text{PLN}} = N_{\text{U\$D}} \times \text{U\$D/PLN} = \text{PLN } 3.75 \text{ million}$!
- On maturity (T) the parties must exchange the nominals of the CIRS transaction at the prefixed exchange rate ! (e.g. the party paying interest in U\\$D will also pay $N_{\text{U\$D}} = \text{U\$D } 1 \text{ M}$, the party paying interest in PLN will also pay $N_{\text{PLN}} = \text{PLN } 3.75 \text{ M}$, independent on the future U\\$D/PLN rate in T).
- On the transaction date ($t=0$) the parties usually (but not obligatorily) exchange initial nominal payments (e.g., the party paying future interest in U\\$D will receive $N_{\text{U\$D}} = \text{U\$D } 1 \text{ M}$, the party paying future interest in PLN will receive $N_{\text{PLN}} = \text{PLN } 3.75 \text{ M}$).

Options

- ❖ An **option** is a derivative instrument/contract which gives the **option buyer** (also called the “**option holder**” as he has the **LONG option position**) the **right** to demand from the **option seller** (also called the “**option writer**” as he has the **SHORT option position**) some future obligation.
 - The **buyer has the right but NOT obligation** to “**exercise**” the option ! The **seller** has to accept the decision of the option buyer !
 - All the details of the future obligation, time at which the option can be exercised, etc. are fixed today (in $t=0$).
 - In exchange for having the right (but not the obligation) **the option buyer pays (in $t=0$) to the option seller the option price** (also called the “**premium**”).
- ❖ The simplest „standard” („**plain vanilla**”) options:
 - „**CALL option**” which gives the option buyer **right to BUY** the “**underlying asset**” (e.g. shares / commodities / bonds/...) in future
 - „**PUT option**”, which gives the option buyer **right to SELL** the “**underlying asset**” in future
 - Option types: the „**European**” calls or puts can be exercised only at maturity, additionally „**American**” Calls or Puts can be also exercised at any time before maturity (the „**early exercise**”).*
 - At the option transaction date ($t=0$) all the details of the option contract are set. They include: **option type** (c, C, p, P), description (and **multiplier**) of the „**underlying asset**”, the future price at which the option **BUYER** has right to buy (“**CALL**”) or sell (“**PUT**”) (the „**exercise/strike price**” X) and the maturity of the option (the “**expiration date/expiry**” T).

* „**Bermudan options**” can be exercised on predetermined dates, usually one day each month.

Options

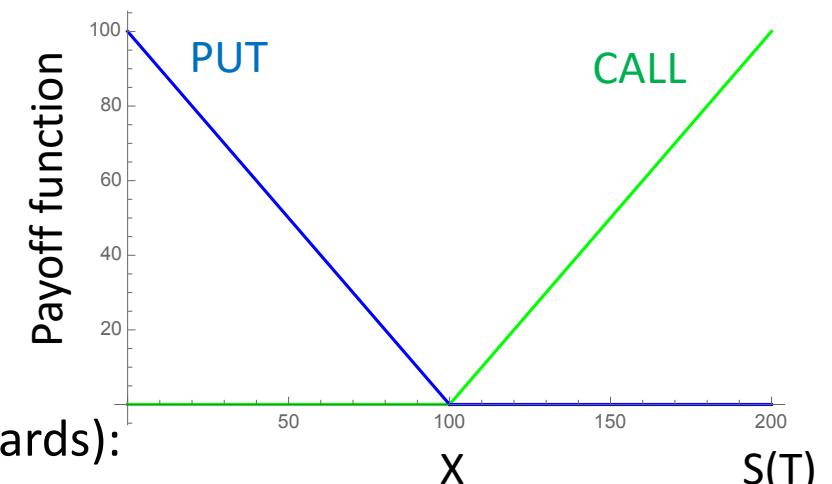
❖ Let's introduce the following **notation**:

- $S(t)$ – the „underlying asset” (e.g. Share) price in time t , $S(0) = S$
- X - the **eXercise price***
- T - expiration date
- $c(t)$ - European “**call**” option value/price at time t ,
 $c(0) = c$ is the premium paid in $t=0$
- $p(t)$ - European “**put**” option value/price, $p(0) = p$
- $C(t)$ - American “**Call**” option value/price, $C(0) = C$
- $P(t)$ - American “**Put**” option value/price $P(0) = P$

❖ The **value of the option at expiration T** is (recall discussion of Forwards):

- $c(T) = C(T) = \max(S(T) - X ; 0)$
- $p(T) = P(T) = \max(X - S(T) ; 0)$

❖ These are also “**payoff functions**” (always paid by option SELLER to option BUYER**) of options settled in cash (i.e. with no physical delivery)



* In the literature the exercise price is sometimes denoted: K

****Assymmetric risk !** But in exchange of option price (premium) which is always paid by the option BUYER to the option SELLER !

Options

- ❖ Standard options may have **various names**: e.g. **caps / floors** (which are in fact a series of ST Interest Rate options with unified X: e.g. the cap BUYER receives the difference between „-BOR” rate and X every period the „-BOR” exceeds X), **straddle / strangle** (simultaneous investment in call and put options with the same / different X), ...
- ❖ Options may be based on **“risk-symmetric” derivatives**: e.g. **options on futures, swaptions**
- ❖ Options can be **OTC or Exchange traded ***
- ❖ There are various types of **„EXOTIC” options:**
 - Non-standard payoff**: e.g. **binary**: $(B(T) = \Theta(S(T)-X))$, **asset-or-nothing** ($A(T) = S(T) \Theta(S(T)-X)$), ...
 - Payoff dependent on trajectory {S(t)}**: e.g. **Asian** (average price), **lookback** (max / min price), **barrier** (knock-out, knock-in, ...), **cumulative** (payoff depends on how much time $S(t)$ was above/below X), ...
 - Options on options („compound” options)**
 - Options dependent on future events**: e.g. **forward-start** (X is set at future time t as $X=S(t)$, $t < T$), **chooser** (at future time t the buyer may choose if the option is call or put with maturity at T), ...
 - Options on portfolios of assets**: e.g. **spread** (payoff depends on a price difference of two assets), **basket** (e.g. on value of a portfolio with constant weights, index options), **rainbow** (payoff depends on the best / worst asset(s) from the portfolio), ...
 - Options on assets priced in foreign currency**: e.g. **composite** (X in one currency, $S(T)$ in other), **quanto** (both X and $S(T)$ in foreign currency, but payoff in domestic currency at fixed FX rate), ...
 - **

* Exchange-traded options are standardized (~ as Futures), usually only SHORTs require margin (in LONGs one pays premium)

**Human creativeness is infinite ;)

Summary

