Basic Commodities

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Books (Energy finance module)

- Market Description (Optional)
  - COMMODITIES DEMYSTIFIED: https://www.commoditiesdemystified.info/pdf/CommoditiesDemystified-en.pdf
  - Peterson, Paul E. Commodity Derivatives: A Guide for Future Practitioners. Routledge, 2018.
- Electricity Modelling
  - Benth, Fred Espen, Jurate Saltyte Benth, and Steen Koekebakker. Stochastic modelling of electricity and related markets. Vol. 11. World Scientific, 2008.

Commodities

- Physical commodities come in all shapes and sizes, but they also have certain characteristics in common:
  - They are delivered globally, including by sea, usually in bulk.
  - Economies of scale favor bulk delivery. The cost of transportation makes location a significant pricing factor.
  - Commodities with similar physical characteristics are exchangeable, but these are not standard items. Exchanging them may have an effect on price and quality.
  - There is no premium for branded goods. Pricing is determined by product quality and availability.
  - They can be stored for long, in some cases unlimited, periods.

Primary and secondary commodities

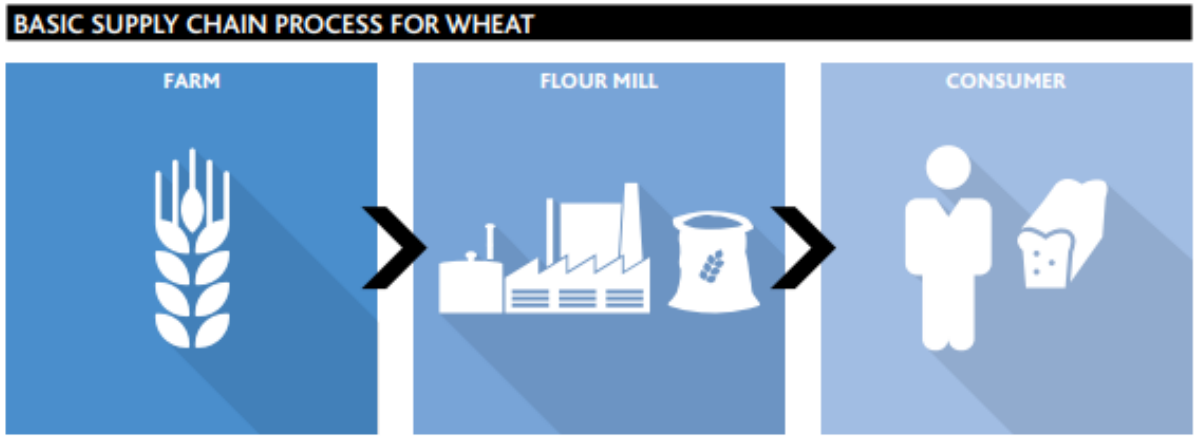
Primary commodities are either extracted or captured directly from natural resources. They come from farms, mines and wells. As natural products that come out of the ground, primary commodities are non-standard – their quality and characteristics vary widely.

Secondary commodities are produced from primary commodities to satisfy specific market needs. Crude oil is refined to make gasoline and other fuels; concentrates are smelted to produce metals. There may be minor variations in quality depending on how a secondary commodity is produced.

Global agricultural commodity production in 2017 (Million tonnes – mt)

Maize	Milk	Wheat	Dairy products	Soybeans	Roots/ tubers	Sugar	Fish	Poultry	Pigmeat
1,042.4	828.6	744.2	421.5	338.6	217.4	179.2	176.0	118.1	118.0

Source: OECD-FAO Agricultural Outlook (Edition 2017)



Agricultural commodities

Agricultural commodities

The prices of agricultural commodities, like all commodities, is determined by supply and demand. The United States Department of Agriculture publishes reports on inventories and production.

Stocks-to-use ratio. This is the ratio of the year-end inventory to the year's usage. Typically, it is between 20% and 40%. It has an impact on price volatility. As the ratio for a commodity becomes lower, the commodity's price becomes more sensitive to supply changes, so that the volatility increases.

There are reasons for supposing some level of mean reversion in agricultural prices. As prices decline, farmers find it less attractive to produce the commodity and supply decreases creating upward pressure on the price. Similarly, as the price of an agricultural commodity increases, farmers are more likely to devote resources to producing the commodity creating downward pressure on the price.

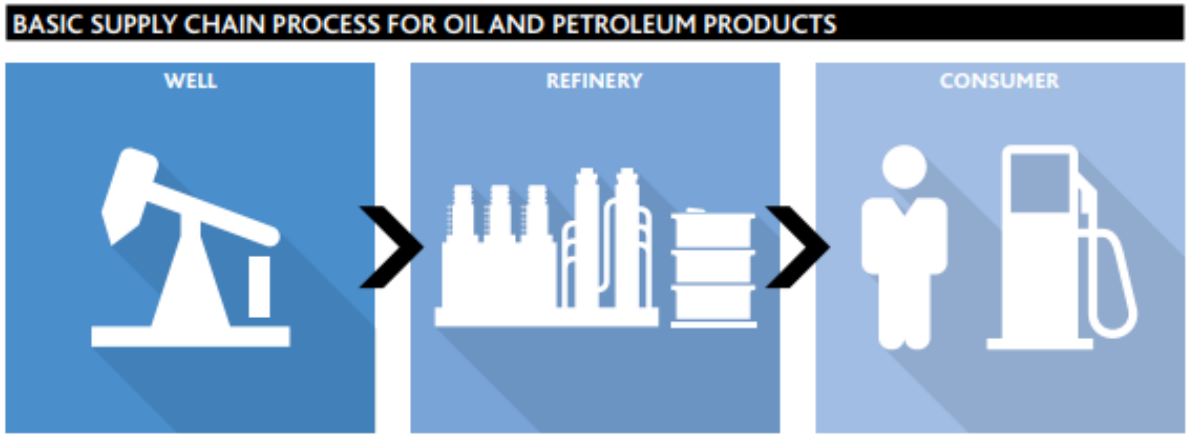
Prices of agricultural commodities tend to be seasonal, as storage is expensive and there is a limit to the length of time for which a product can be stored. Weather plays a key role in determining the price of many agricultural products. The volatility of the price of a commodity that is grown tends to be highest at pre-harvest times and then declines when the size of the crop is known.

Energy

World energy production 2016 (Million metric tonnes – mmt)

Coal	Crude oil	Natural gas	Nuclear	Hydro	Biofuels and waste	Other	Total
3730.89	4390.20	3034.95	679.65	349.22	1349.29	225.63	13759.83

Source: IEA World Energy Balances 2018 – https://webstore.iea.org/world-energy-balances-2018



Oil and petroleum market

At one time, the international oil majors (often described as "the Seven Sisters") exerted almost total control over the oil industry.

OPEC's (The Organization of the Petroleum Exporting Countries) wrested monopolistic control from the oil majors – a trend that continues to the present day.

The 1973 oil embargo was a vivid demonstration of the oil producers' ability to exert pressure by constraining supply. At the time of the embargo, OPEC controlled half of global crude production and 80 percent of proven reserve.

As markets developed, oil futures contracts were increasingly used to enable trading along the supply chain between producers and consumers. There are many grades of crude oil, reflecting variations in the gravity and the sulfur content. Two important benchmarks for pricing are Brent crude oil (which is sourced from the North Sea) and West Texas Intermediate (WTI) crude oil.

Natural Gas

The natural gas industry throughout the world went through a period of deregulation and the elimination of government monopolies in the 1980s and 1990s.

Suppliers are faced with the problem of meeting daily demand. A typical over-the-counter contract is for the delivery of a specified amount of natural gas at a roughly uniform rate over a 1-month period.

The seller of natural gas is usually responsible for moving the gas through pipelines to the specified location.

An interesting contract in electricity and natural gas markets is what is known as a swing option or take-and-pay option. In this contract, a minimum and maximum for the amount of power that must be purchased at a certain price by the option holder is specified for each day during a month and for the month in total.

Electricity

Electricity is an unusual commodity because it cannot easily be stored.

The maximum supply of electricity in a region at any moment is determined by the maximum capacity of all the electricity-producing plants in the region. In the United States there are 140 regions known as control areas.

The ability of one control area to sell power to another control area depends on the transmission capacity of the lines between the two areas.

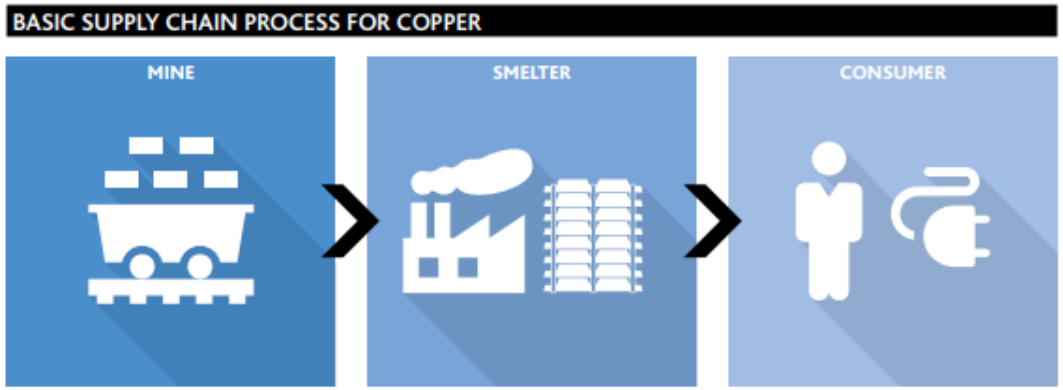
A major use of electricity is for air-conditioning systems. The demand for electricity, and therefore its price, is much greater in the summer months than in the winter months. The non-storability of electricity causes occasional very large movements in the spot price.

A typical contract (exchange-traded or over-the-counter) allows one side to receive a specified number of megawatt hours for a specified price at a specified location during a particular month.

Global major metal production in 2018

26 Fe	13 Al	29 Cu	30 Zn	82 Pb	28 Ni
Iron ore 1,645mmt	**Aluminium** 64mmt	**Copper** 24mmt	**Zinc** 12.5mmt	**Lead** 12.7mmt	**Nickel** 2.2mmt
Steel making	Transport, automotive, construction, packaging	Electronics, plumbing	Galvanising iron and steel and making brass	Batteries, alloys, radiation shielding	Stainless and specialty steels

Source: Trafigura research 2019



Metals

Metals

Metals have quite different characteristics from agricultural commodities. Their prices are unaffected by the weather and are not seasonal. They are extracted from the ground. They are divisible and are relatively easy to store.

Some metals, such as copper, are used almost entirely in the manufacture of goods and should be classified as consumption assets. Others, such as gold and silver, are held purely for investment as well as for consumption and should be classified as investment assets.

In the long term, the price of a metal is determined by trends in the extent to which a metal is used in different production processes and new sources of the metal that are found. Changes in exploration and extraction methods, geopolitics, cartels, and environmental regulation also have an impact. One potential source of supply for a metal is also recycling.

Minerals that are investment assets are not usually assumed to follow mean-reverting processes because a mean-reverting process would give rise to an arbitrage opportunity for the investor (metals are storable). For metals that are consumption assets, however, there may be some mean reversion due to changes in the consumption.

Metals and minerals

The pattern of the global metals trade has been transformed since the start of the millennium. The major destination countries for metals have shifted from West to East; primarily to China.

In the boom years before the global financial crisis of 2008-9, the spot price rose to twice the contract price. Some Chinese companies took this opportunity to buy contract ore and sell at spot prices to their fellow steel makers.

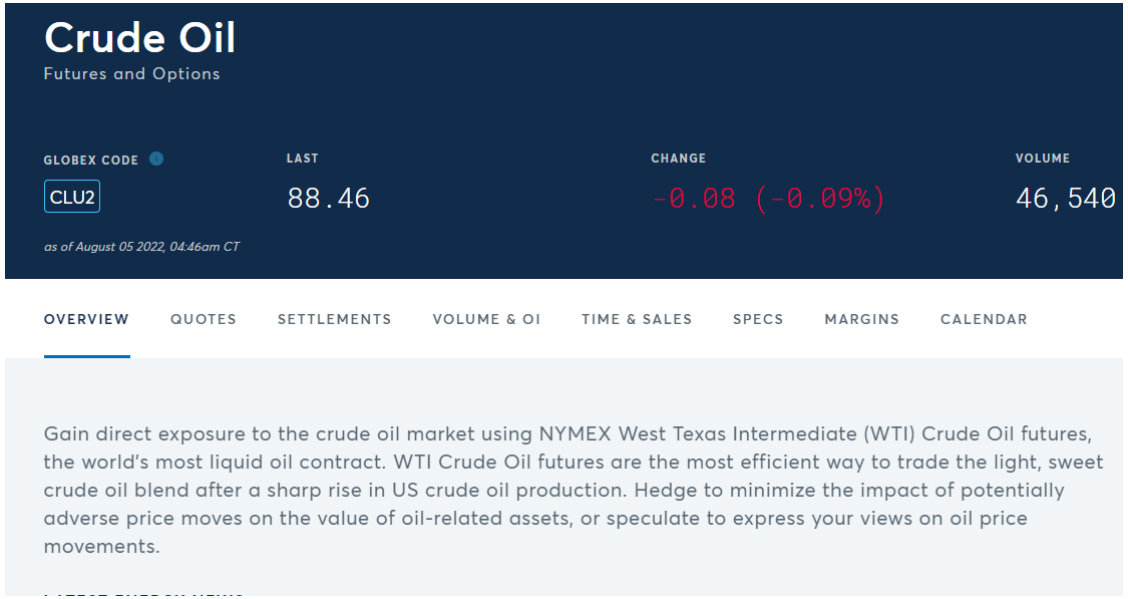
As the global financial crisis affected output, the spot price rapidly sank below the contract price and some of these firms reneged on contracts.

The Chicago Mercantile Exchange (now CME group)

- Born in the 1874 (Chicago butter and egg board).
- Most traded contract *Bellies.* Futures on frozen pork belly (least traded contracts on the CME today).
- The largest open interest in options and futures contracts of any futures exchange in the world.

The New York Mercantile Exchange (NYMEX)

- Born in the early 1880s (Butter and Cheese Exchange of New York).
- Futures trading in the energy complex: crude oil, gasoline, natural gas precious metals futures such as gold and silver.
- Merged in 2010 with CME group but contracts are still on the different exchange names (e.g. NYMEX light sweet crude oil).



IntercontinentalExchange (ICE)

- ICE was established May 2000, with the mission of transforming OTC trading.
- Facilitates over-the counter energy and commodity contracts. This simply means that there is no centralized location; all trading takes place in cyberspace.
- Facilitate trading in the softs complex (a commodity that is grown rather than mined: sugar, cocoa).

Trading: the central LOB

Bid quantity	*Price*	*Ask quantity*
	3.52	0
	3.5175	1
	3.5150	8
	3.5125	23
	3.51	61
	3.5075	112
	3.5050	89
	3.5025	12
35	3.50	
61	3.4975	
127	3.4950	
54	3.4925	
19	3.49	
13	3.4875	
5	3.4850	
2	3.4825	

Electronic trading: the matching engine

- The *matching engine* is the software that matches bids and offers at the same price.
  - First In, First Out (FIFO) – Strict price/time priority, so the earliest bid (or offer) at a particular price is the first to be matched with an incoming offer (or bid)
  - Pro Rata – Takes an equal share from each order at a particular price.
  - All or None (AON) – Matched with a single order for the same (or larger) quantity.

- What happens when a new ask order of 40 contract is delivered and these are the bid with the same price?
  - 10 contracts (oldest bid)
  - 50 contracts (second-oldest bid)
  - 11 contracts (third-oldest bid)
  - 4 contracts (fourth-oldest bid)
  - 5 contracts (fifth-oldest bid; also the newest bid)

Futures

- CME future contract definition: *A legally binding, standardized agreement to buy or sell a standardized commodity, specifying quantity and quality at a set price on a future date.*

1. Where: delivery location
2. When: delivery timing
3. What: the product quality or grade

Financially settled **vs** Phisical delivery.

Approximately 97% of futures contracts never result in physical delivery of the underlying commodity. Traders offset their holding prior to the expiration date.

Futures expiration

First notice day (prior to expiration of the corresponding futures contract) is the day in which the buyer of a futures contract can be called upon by the exchange to take delivery of the underlying commodity.

Delivery notice are usually sent in a first-in basis.

After notice, the trader can still instruct a broker to ‘retender’ the notice.

At expiration, the future price is set and the delivery process begins (or the contract is cash-settled).

Commodity Codes and Month Codes

- Commodity names were reduced to a single, unique letter called a *ticker symbol* or *commodity code* – for example, C for corn, O for oats, and W for wheat. Later on, as more futures contracts were added and the supply of single-letter codes was depleted, two-letter and eventually three-letter commodity codes.
- Expiration month names were designated by a single, unique letter. Last digit of the expiration year was added to distinguish between futures contracts expiring in the same month but different years. CLH4 for March 2024 crude oil futures.

Code	*Calendar month*	*Code*	*Calendar month*
F	January	N	July
G	February	Q	August
H	March	U	September
J	April	V	October
K	May	X	November
M	June	Z	December

Cost to Carry

- Prices in the cash and futures market differ from one another as a direct result of the disparity in the timing of delivery of the underlying product (storage and insurance costs).
- In normal market conditions, the cash price will be cheaper, and the future prices will be increasing with the expiry. This scenario is called contango.
- In case of short-term shortage, the contango can be reduced or reversed. This happens when the convenience yield (i.e. the utility in having the commodity) is higher than the cost of carry.

CRUDE OIL WTI - NYMEX

Month	Latest	Net	%
SEP2	88.42	-0.12	-0.14 %
OCT2	87.41	-0.15	-0.17 %
NOV2	86.64	-0.17	-0.20 %

Reverse contango: first 3 WTI NYMEX futures on the 05/07/2022.

Commoditisation

Metals may end up pretty much the same once they have been through the homogenizing process of smelting but raw materials and minerals can be very diverse.

With over 150 different grades of crude oil and oil products, searching out and matching sellers' products with buyers' preferences is a core competence for commodity traders.

Commoditisation

- Commodity trading is a bilateral business bringing buyers and sellers together in over-the-counter (OTC) deals.
- This cannot be done through centralized exchanges, electronic or otherwise, such as the oil futures market, because physical commodities vary widely in grade, quality and location, and the needs of those who use them are very diverse.
- Standardization is vital. Standardized futures contracts provide the market with benchmarks – such as Brent, WTI and Dubai – around which actual physical oil can be priced, at a premium or discount, according to quality, transport and location. Standardization also allows hedging.


WTI NYMEX
Very few people want to take delivery of oil in a small town (Cushing) in Oklahoma
Seattle
WASHINGTON
Portland
OREGON
MONTANA
IDAHO
WYOMING
NORTH DAKOTA
SOUTH DAKOTA
MINNESOTA
Minneapolis
WISCONSIN
MICHIGAN
Québec City
Ottawa
Montreal
Toronto
MAINE
VERMONT
NEW HAMPSHIRE
NEW YORK
MASSACHUSETTS
CT
RI
Chicago
IOWA
NEBRASKA
Salt Lake City
NEVADA
UTAH
Denver
United States
COLORADO
KANSAS
MISSOURI
St. Louis
ILLINOIS
INDIANA
OHIO
Indianapolis
PENNSYLVANIA
New York
Philadelphia
NJ
MARYLAND
DE
WEST VIRGINIA
KENTUCKY
VIRGINIA
Sacramento
San Francisco
San Jose
CALIFORNIA
Las Vegas
Albuquerque
OKLAHOMA
TENNESSEE
Nashville
NORTH CAROLINA
Charlotte
ARKANSAS
Atlanta
SOUTH CAROLINA
MISSISSIPPI
ALABAMA
Los Angeles
ARIZONA
NEW MEXICO
San Diego
Phoenix
Dallas
TEXAS
Ciudad Juárez
BAJA CALIFORNIA
SONORA
Austin
Houston
LOUISIANA
Jacksonville
CHIHUAHUA
San Antonio
Orlando
COAHUILA
FLORIDA
Miami
NUEVO LEON
Gulf of California
Gulf of Mexico
BAJA CALIFORNIA SUR
SINALOA
DURANGO
Monterrey
TAMAULIPAS
Mexico
The Bahamas
Havana
Google

Seasonality

Many commodities – crude oil and gold, for example – are produced and consumed continuously throughout the year, so the forward curve is relatively smooth. Other commodities are produced seasonally or consumed seasonally.

If a commodity is not storable, or cannot be stored without suffering quality loss (e.g. livestock or electricity) it has unique supply conditions at each point in time, so the price at one time is largely independent of the price at other times.

Leading Firms

The principal traders in agricultural products have a long lineage; Cargill for example started grain trading at the end of the American Civil War.

Vitol, Trasfigura, Mercuria, Gunvor and Noble are leading firms that specialize in energy, metals and minerals trading. Several major oil and mining companies are also active traders, as a sideline to their industrial activity

Trading and trasformation

Commodity traders are essentially logistics companies that use financial markets to fund their operations and hedge or limit the price risk involved.

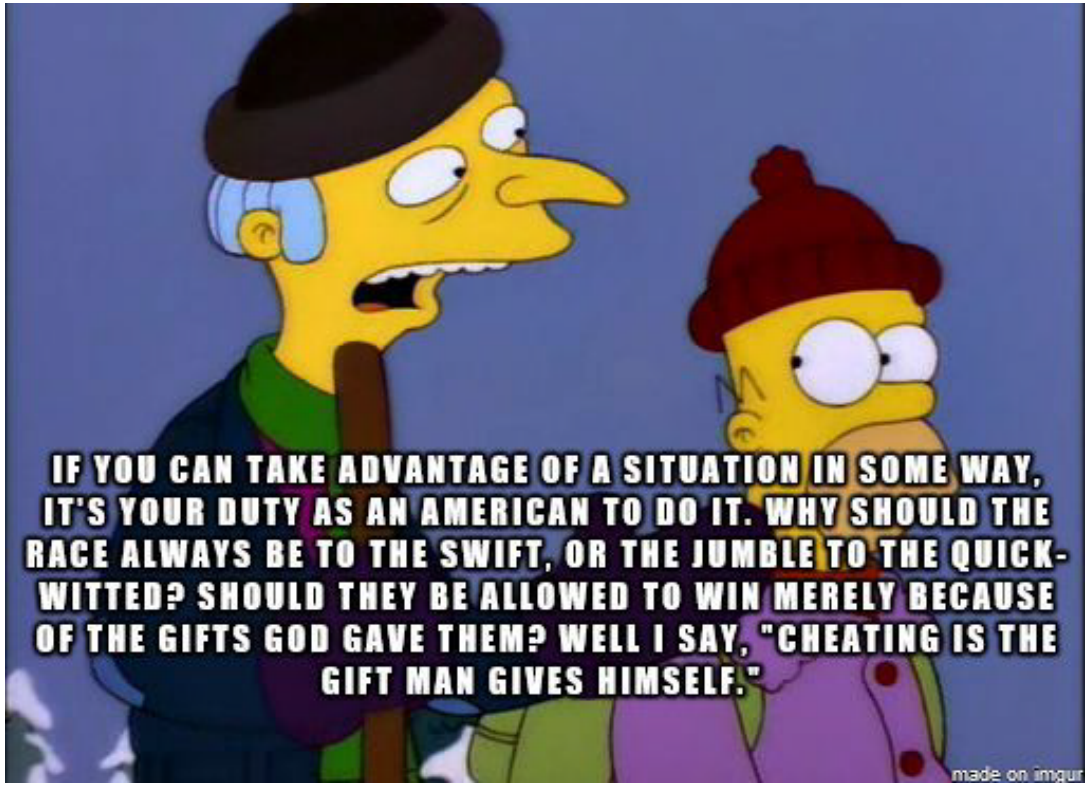
Transformation in space. Transporting commodities from where they are produced to where they are consumed.

Transformation in time. Commodity supply and demand are not always in sync. The demand for energy products fluctuates with the seasons.

Transformation in form. With the exception of those consumed directly in a power station, all commodities undergo some transformation before they can be consumed.

Spot/Future Arbitrage

If the price difference between the cash and futures prices of a commodity exceeds the cost to carry, traders will buy the undervalued (cash market commodity) and sell the overvalued (futures contract written on underlying commodity). **Not all market allow easy arbitrage.**



Physical arbitrage

Traders focus on spotting any gaps in the market, mispricing or dislocation in distribution. They monitor relative prices for different grades of a commodity (*the quality spread*), for the same commodity with different delivery locations (*the geographic spread*) and for different delivery dates (*the forward spread*).

Where they identify a mismatch, they can lock in profit by buying in the cheaper market and selling in the more expensive market.

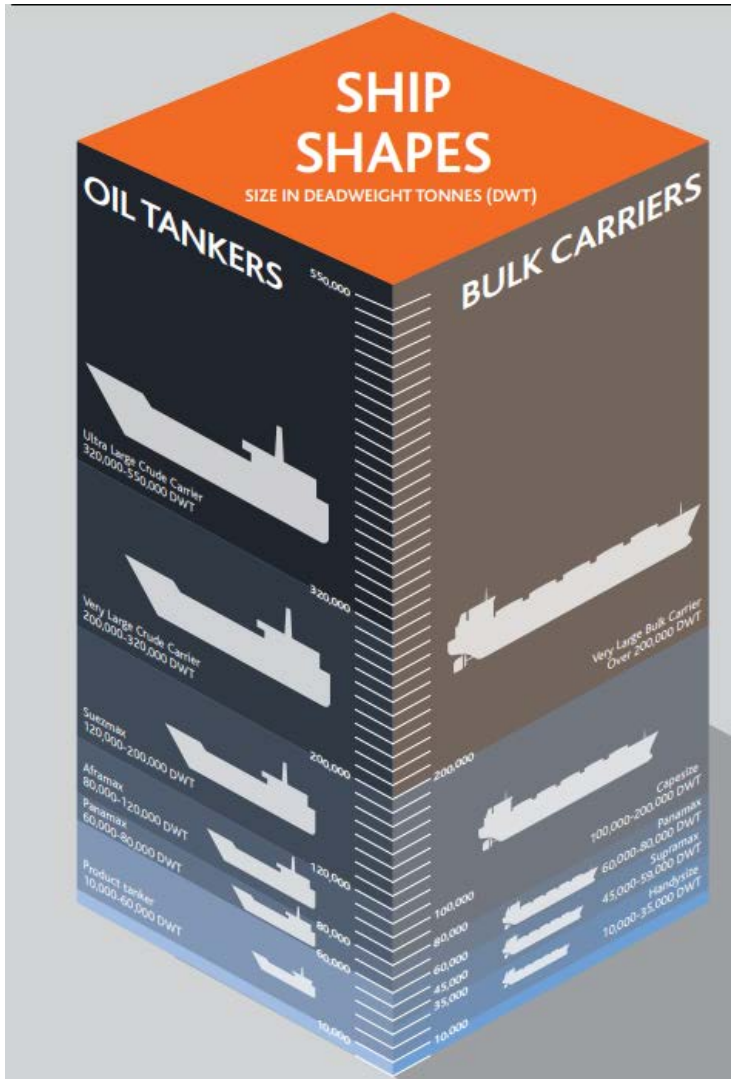
An arbitrage opportunity opens up when the value of transformation – the difference between the prices of the transformed and untransformed commodity – is more than the cost of making that transformation. For instance, in a contango market the forward price is higher than the spot price.

Transformation in space

- Many producers are found in remote locations, often in emerging economies. Traders need to deliver commodities to consumption centers on the other side of the world.
- Trading firms design (and own or rent) multimodal logistics systems to optimize economies of scale and reduce shipment costs.

Transformation in space

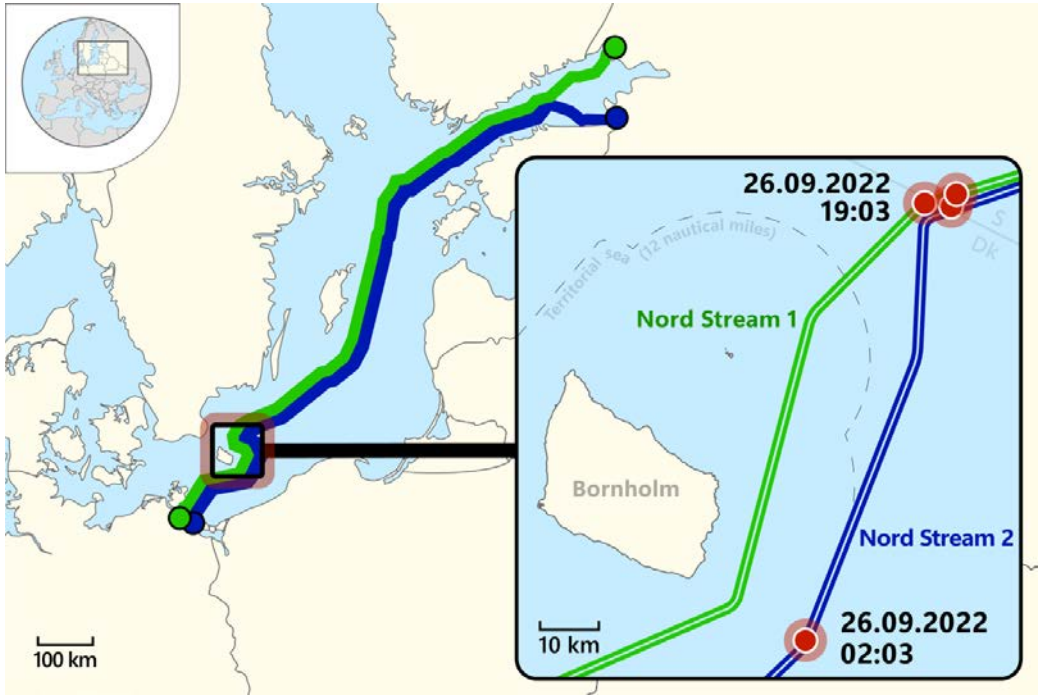
- Trading firm charter wet freight tankers to transport oil and petroleum products. Metals and minerals – dry freight – are transported in bulk carriers.
- **A time charter**: you pay for the daily hire, fuel and any parking fees, while the cost of maintenance, insurance and licensing is paid by the rental company. With a time charter the trading firm has direct control of the ship and can redirect it for exploiting arbitrage opportunities.
- **A voyage charter:** the charterer pays a metric tons freight rate for the cargo to be carried from point A to point B.
- Commodity trading firms normally operate shipping or freight desks (often freight desks make idle-time chartered vessels available to third parties).



Trasformation in space: the LNG case

- Gas, the greenest of the fossil fuels, is difficult to transport globally and that restricts its tradability.
- Russia, the most landlocked of major energy producers, delivers most of its gas by pipeline. Pipeline gas generally goes straight from the producer to the consumer, with no real role for intermediaries.
- LNG works by cooling natural gas to minus 162 degrees centigrade. This liquefies the gas and shrinks it to 1/600th of its gaseous volume. The liquid concentrate is transportable in purpose-built refrigerated tankers.

Nord stream pipelines



Trasformation in space: the LNG case

- Qatar is the global industry leader, but is now being joined by new exporters, chiefly Australia but also the US and countries in east Africa.
- A small but growing share of international LNG trade is taken by trading firms selling gas from a global portfolio and benefiting from arbitrage opportunities between the various regional import prices.

TRANSFORMATION IN TIME

- All major commodity traders own midstream infrastructure, including loading and offloading terminals at ports, and storage and blending facilities, which are also usually at ports.
- Supply and demand shocks in commodity markets can have many different causes, and they can occur at any time.
- Both supply and demand are price inelastic. Producers cannot easily open or close mines or wells; for consumers, commodities are typically seen as necessities.
- Commodity storage plays a vital economic role by helping to dampen volatility and bring markets back into balance.

TRANSFORMATION IN TIME

- Trading firms earn arbitrage profits by releasing or increasing inventories while simultaneously creating offsetting positions in futures markets.
- Trading firms gain a competitive advantage by maintaining inventories their own facilities.
- To execute arbitrage successfully, traders need instant access to their assets. Knowing this, facility owners may try to charge premium rates by, for example instituting delivery delays and enforcing an artificially high price for an ‘express’ service. Such hold-ups don’t occur if the firm executing the arbitrage also owns the storage facility.

BLENDING COMMODITIES: TRANSFORMATION IN FORM

- In metals and minerals markets, traders often combine materials from two or more mines to create commodities with the desired qualities synthetically.
- Arbitrage opportunities are fleeting. If a change in relative pricing between two grades of a commodity creates a blending opportunity the trader must be able to react swiftly to exploit that. Again, this shows the advantages of maintaining inventories their own facilities.

Managing flat price risk

- In a typical transaction, a trader will agree purchase and sale prices with two different counterparties to lock in a profit margin. Final prices are not fixed until the commodity is delivered.
- For crude, for instance, the purchase price might be set in advance at 50 basis points over the Brent index on the day the trader takes delivery (t) and the sale price at 150 basis points over Brent when the shipment is delivered (T).
- The risk on price can be mitigated by selling futures at t and buying them back at T (not complete hedge).

Managing basis risk

- The difference between the future price and the cash price is called basis.
- Basis risk arises because, in practice, the price behavior of a hedging instrument will never exactly correspond to that of the physical commodity.
- When trading firms buy and sell physical commodities they are acquiring specific assets at particular locations on precise dates. The physical nature of the asset makes it unique.
- A Brent futures contract, based on a notional specification of light North Sea oil delivered at a precise location, will never be an exact match for, say, a cargo of heavy Middle East crude.

Managing basis risk

- Both prices move roughly in tandem so basis risk is considerably lower than flat price risk. But because they are priced in linked but distinct markets, technical factors and supply and demand differences result in fluctuations in the differential between their prices.
- The global nature of the crude oil market makes global arbitrage, with oil cargoes circling the world seeking the best price, a profitable activity for traders.

A corn hedge example

At time 1 a processor need to buy corn at time 2. He has no possibility to store the corn.

	Cash	*Futures*
Time 1:	[Short at $3.50]	
Time 2:	Long at $4.50	
Gain (Loss):	−$1.00	
Net Price:		

If at time 1 it does nothing, he has an implicit short position. He close the position at time 1 by buying the cash corn. In this case it has a loss.

	Cash	*Futures*
Time 1:	[Short at $3.50]	Long at $3.50
Time 2:	Long at $4.50	Short at $4.50
Gain (Loss):	−$1.00	+$1.00
Net Price:	$4.50 actual cash purchase price − $1.00 futures gain = $3.50 net purchase price	

If the processor hedge its position with a future contract (off-setting its future position at time 2) it edges against changes in prices.

This is called a *perfect hedge* because the change in the futures price perfectly matches the change in the cash price. This rarely happens in practice, but the perfect hedge is useful for demonstration purposes.

A corn hedge example

- However, cash prices and future prices are rarely the same and rarely changes by the same amount, i.e. cash prices and future prices are not perfectly correlated. In our example,

	Cash	−	*Futures*	=	*Basis*
Time 1:	[Short at $3.50]		Long at $3.00		+$0.50
Time 2:	Long at $4.50		Short at $3.90		+$0.60
Gain (Loss):	−$1.00		+$0.90		−$0.10
Net Price:	$4.50 actual cash purchase price − $0.90 futures gain = $3.60 net purchase price				

A focus on the European Electricity and Natural Gas Markets

The electricity markets

As already mentioned, electricity markets are regional.

A difference in power between The Nord Pool (the Nordic power exchange) and the European Power Exchange (EEX) does not necessarily imply arbitrage.

Electricity is a flow commodity, it is useful for practical purposes only if it is delivered during a certain period of time.

All traded contracts guarantee a certain amount of power for a specified future time-period.

Electricity contracts with physical delivery

- Spikes and seasonality.
- This market are supervised by a transmission system operator (TSO). They manage the electricity infrastructure (Terna in Italy) by matching supply and demand.
- Two-settlement system: the contract for physical delivery are organized in two different markets:
  - The real time market (RT): is organized by the TSO for short-term upward or downward regulation.
  - The day ahead market (DA): is usually deregulated and is where most of the volume is traded

The real time market

- Bids in the RT market are submitted to the TSO and specify load and time-period for consumption. They can be posted or changed close to operational times (sightly different rules for different TSO).
- Bids can be for upward regulation (increase generation or reduced consumption) or downward regulation (decreased generation or increased consumption). Both supply and demand bids are posted stating prices and volume.
- TSO list bid of each hour in priority order according to price and this order is used to balance the power system for each hour.
- In case of a grid power deficit(upward regulation is applied) and the RT market price is set at the highest price of the considered bids.
- In case of a grid power surplus (downward regulation is applied) and the RT market price is the lowest price of the asks.

The day ahead market

- In the Nordic market Elspot is organized by Nord Pool. The UK Power Exchange and the EEX are also example of DA markets.
- On Elspot hourly power contracts are traded daily for physical delivery in the next day's 24-hour period (midnight to midnight).
- Each morning the players submit the bids for purchasing or selling a certain volume of electricity in the next days. Once the spot market is closed for bids, at noon each day, the DA price is derived for each hour of the next day.

Financial electricity contracts

- The basic exchange traded contract at Nord Pool are written on the average of hourly system prices over a specified delivery period. During the period contracts are settled in cash against the system price and hence, financial electricity contracts are swap. However, market jargon refers to these contract as electricity futures.
- Usually, futures contract use as reference price the DA price. As is common in the commodity word, market participants usually close their exposition before the delivery period.
- A future contract trading period is the time period the contract is available for trading. The time to maturity is usually replaced by the expression *time to delivery*.

Financial electricity contracts

- Since contracts are set against hourly DA prices the amount of electricity energy is $DP\ x\ 24\ MWh$, where *DP* is the delivery period. All contracts trade until the last trading day prior to the delivery period.
- To compare prices with different delivery periods prices are listed in terms of Euro per MWh.
- Quarterly contract were first introduced for the year 2005. In the first trading day of January each year four new quarterly contracts are listed (Q1, Q2, Q3 and Q4); the trading period last two years.
- A new yearly contract that trade for three years is also introduced.
- Every month a monthly contract is enlisted and a new one is introduced that trade for six months.
- Every week a weekly contract is introduced that trade for eight weeks.
- New daily contracts are introduced every Thursday.

Financial electricity contracts

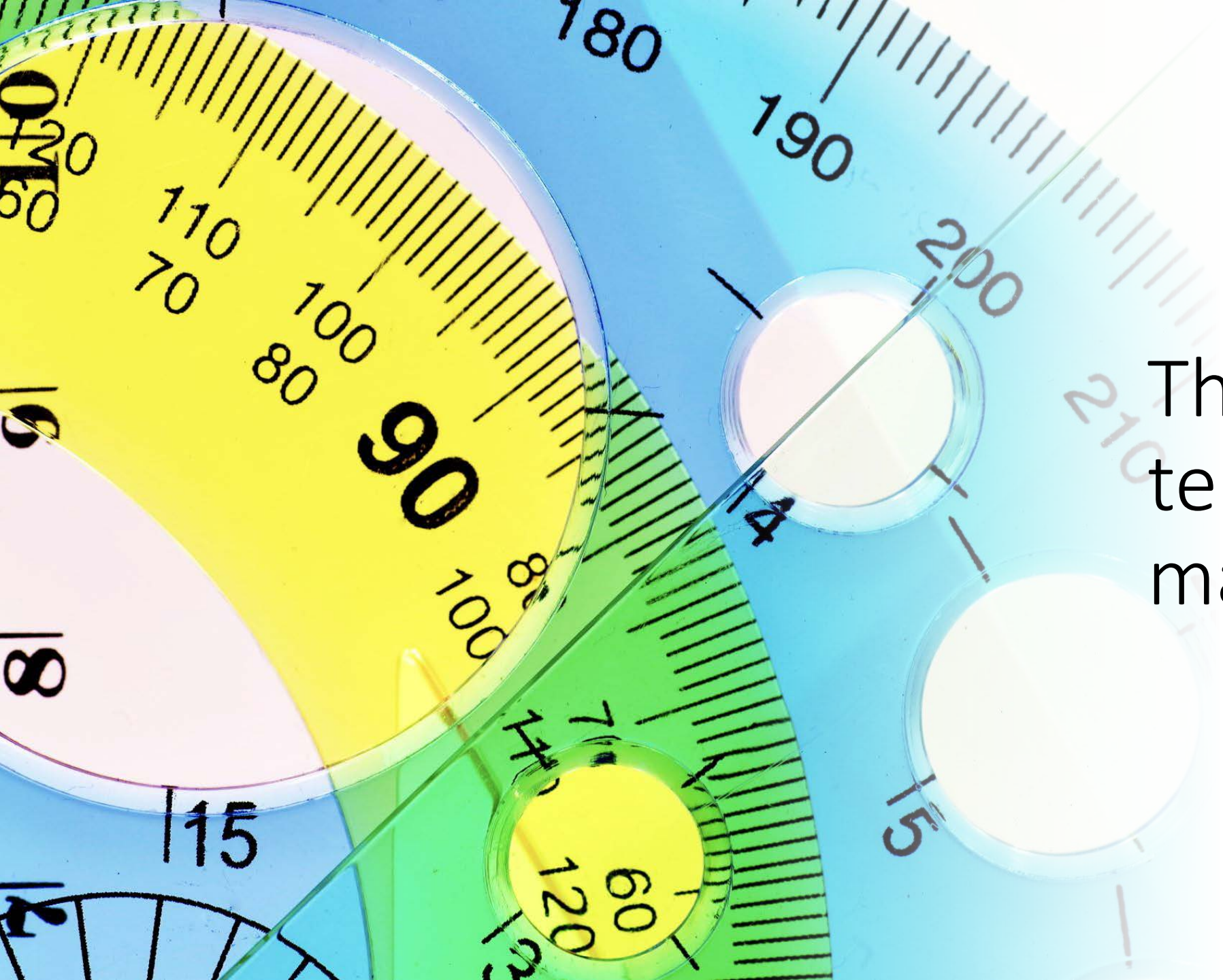
- Nord Pool financial market also include option contracts and Contracts for Differences:
  - European Call and put prices are written on the electricity futures contract. Exercise day is set as the third Thursday in the month before the delivery period of the underlying contract starts.
  - Contracts for Differences are defined as the area price minus the system price. CdFs are defined with the same delivery time as futures.

The gas market

- Gas prices are subject to spikes and seasonality
- Natural gas is important for heating and electricity.
- The gas markets are located around different hubs. Arrival points for gas trasportation and gas storage facility (e.g. Henry Hub in Louisiana and the Nacional Balancing system in the UK).
- The short-term delivery of natural gas is usually OTC (spot market). Futures, with characteristics very similar with the electricity market trade mostly OTC.
- Gas can be stored, but storage costs are high.

Financial Gas contracts

- Structured UK natural gas futures are traded. The contracts deliver gas at a fixed rate trhough NBP over a specific period of time.
- The delivery perioed are the first 10-12 consecutive months, 11-12 quarters and six seasons (summer season April to September and winter season October to March).
- Since no spot price is available the futures underlying is an index (for ICE gas futures the Heren NPB DA index is used as measurement of the spot price of Gas.
- Spark spread options are call and put written on the differences between electricity and gas future prices. These option are rater popular for risk management of a Gas powered power plant.



The temperature market

Temperature market

Close connection between commodity and weather (e.g. air condition and agricolture).

Market are clearly incomplete (no hedging using the underlying) and there are clear evidence of mean reversion (conservation of energy).

Typical contracts are written on some temperature measurement over a certain period of time (similar to delivery time of energy contracts). These contracts are called temperature futures.

CME organizes trade in future contracts based on four different temperature indices. These indices measure the aggregation of daily mean temperatures in US, European and Japanese cities.

Temperature market

- For US cities the constracts are written on the aggregated amount of heating-degree days (HDD) and cooling-degree days (CDD). The amount of CDD on a particular day is $CDD(t) = \max(T(t) - c, 0)$, where T is the average day temperature and c is the threshold of 18° C after which most air conditioning system are switched on in the US.
- The CDD futures are settled financially in terms of 20$ per unit. The contract can be specified as the accumulate CDD over a period of time.
- The HDD index measure the amount of degrees below the threshold c. H$DD(t) = \min(c - T(t), 0)$. The contracts are written in term of accumulated HDD over amount or a season in the cold part of the year.
- For European cities there is active trading of HDD contracts in winter season while in the summer season the underlying temperature index is the so-called cumulative average temperature (CAT).