World oil market

Jan Osička

W. Nordhaus: The „Bathtub“ view of the World oil market

The idea:

- Taps: Saudi Arabia, Russia, and other producers that introduce oil into the inventory
- Sinks: the United States,
  China, and other consumers
  drawing oil from the tub

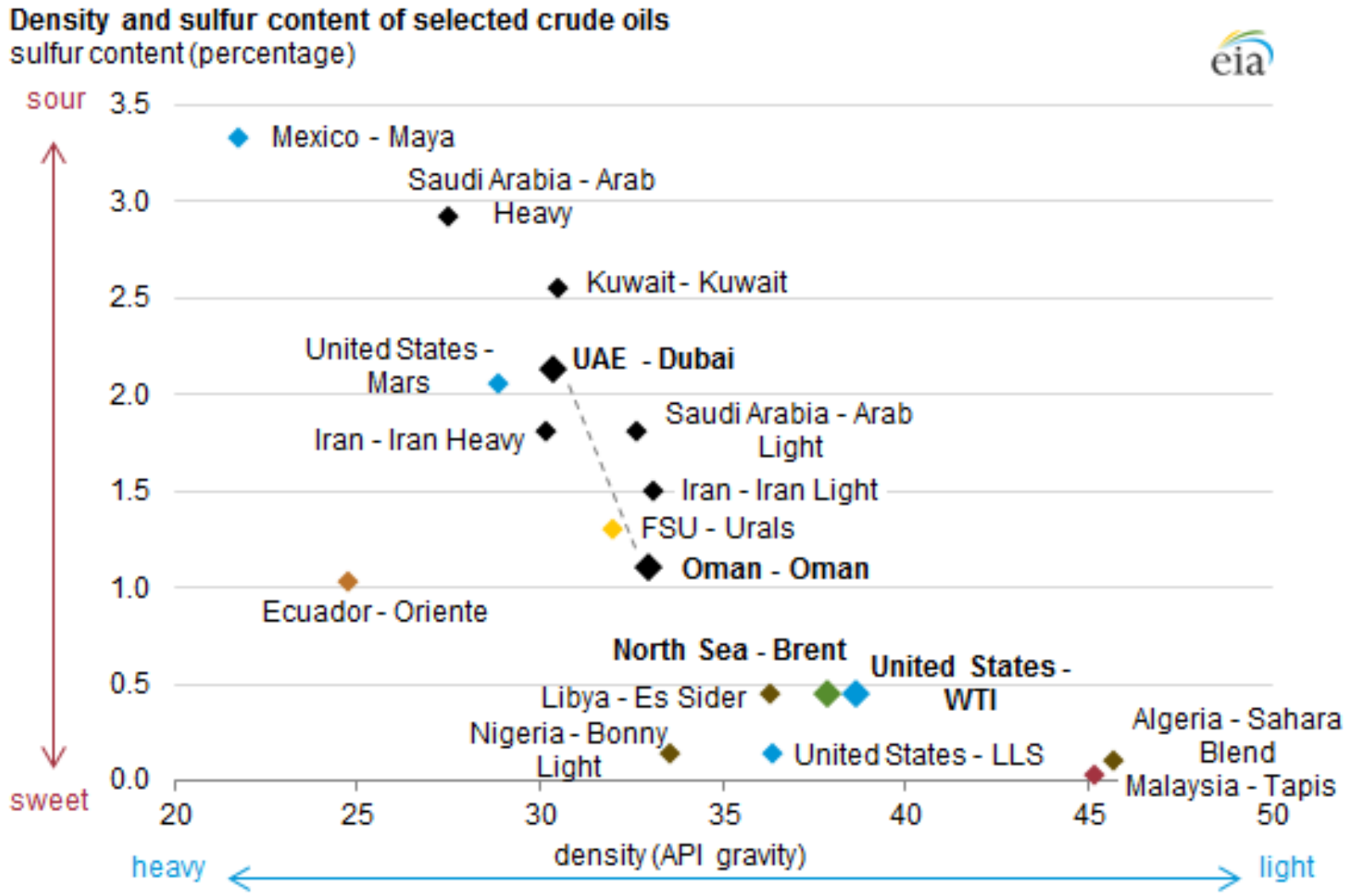
Assumptions:

- Oil is fungible
- Bilateral ties are irrelevant
- Single price regardless the source

The commodity

What is (traded) oil?

Oil crudes actually vary...



Oil benchmarks

Benchmark crude

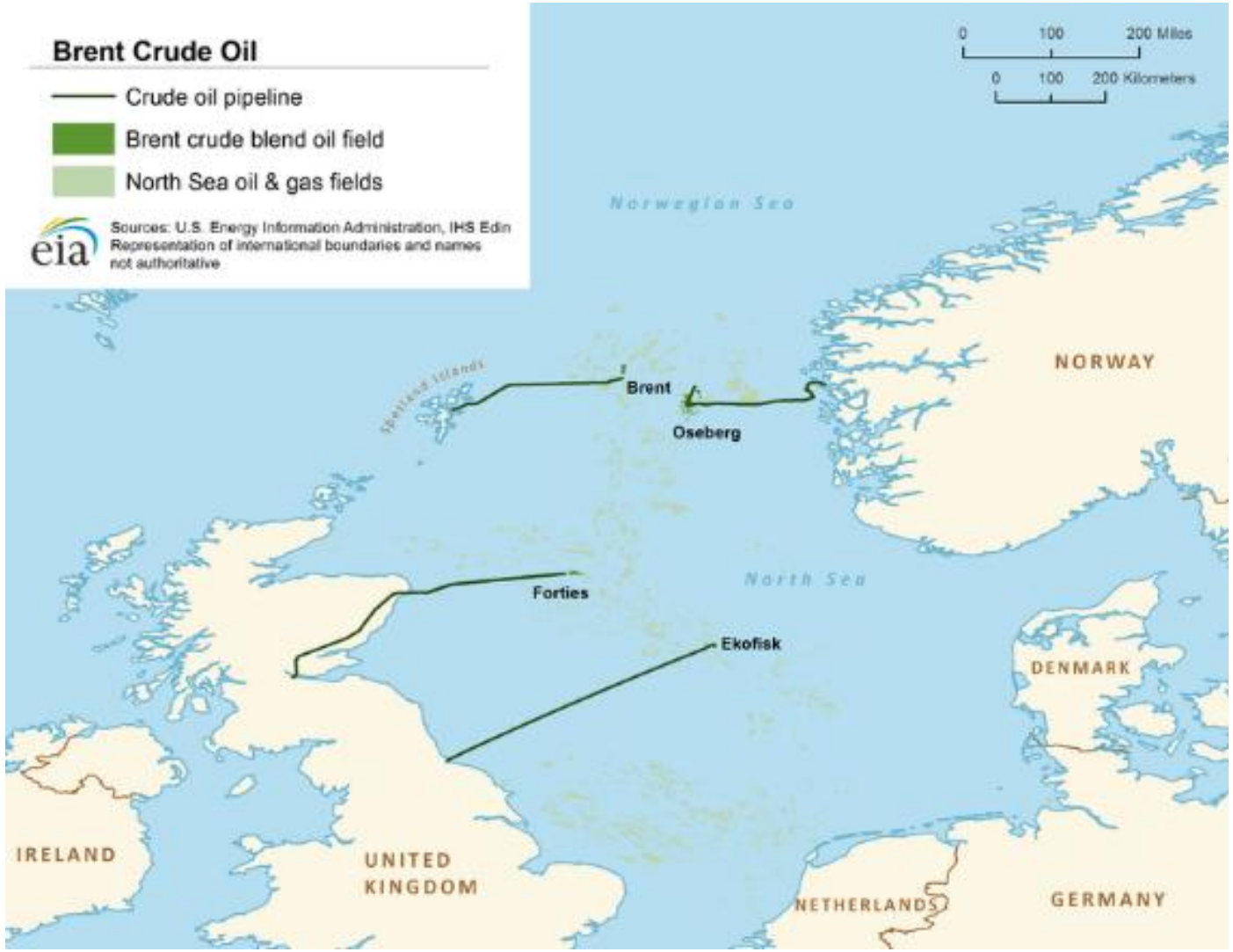
- Specific crude oil
- Widely and actively bought and sold
- To which other types of crude oil can be compared to determine a price by an agreed-upon differential

Oil benchmarks

Brent

- The most widely used global crude oil benchmark
- Include four North Sea streams:
  - Brent and Forties (offshore the United Kingdom)
  - Ekofisk and Oseberg (offshore Norway)
- 1 % of global production in 2013 (0.86 bpd)
- Benchmark for approx. 2/3 of global oil
- Light and sweet crude oil
  that is produced and traded in:
  - Europe
  - the Mediterranean and Africa
  - Australia
  - Asia (selectively)

Original source streams of Brent



West Texas Intermediate

- Light, sweet crude oil produced in the United States
- Priced at Cushing, Oklahoma
- Benchmark for other types of crude oil produced in the United States, such as:
  - Mars, a medium, sour crude produced in the Gulf of Mexico
  - Bakken, a light, sweet crude produced in North Dakota.
- WTI is also used as a benchmark for imported crude oil that is produced in:
  - Canada
  - Mexico
  - South America

Dubai/Oman

- Average price of Dubai and Oman crude, both of which are medium and sour
- Benchmark for crude oil produced in the Middle East (incl. Saudi Aramco) and exported to Asian markets.
- Dubai: steady decline in production down to 0.034 mbd (2013)
  => Omani oil (0.94 mbd in 2013) used to continue the benchmark

Table 1.1: OPEC Reference Basket and selected crudes, US$/b

	Oct 14	Nov 14	Change Nov/Oct	Year-to-date 2013	Year-to-date 2014
OPEC Reference Basket	**85.06**	**75.57**	**-9.49**	**105.72**	**99.57**
Arab Light	85.93	76.07	-9.86	106.40	100.47
Basrah Light	83.57	73.94	-9.63	103.47	97.70
Bonny Light	88.51	80.10	-8.41	111.21	104.15
Es Sider	86.31	78.90	-7.41	108.35	101.80
Girassol	86.78	78.68	-8.10	108.96	102.52
Iran Heavy	84.61	74.46	-10.15	105.46	99.49
Kuwait Export	83.99	74.04	-9.95	104.85	98.62
Marine	86.14	75.43	-10.71	105.11	99.67
Merey	76.17	68.42	-7.75	96.66	90.06
Murban	89.10	77.85	-11.25	107.95	102.76
Oriente	76.84	69.52	-7.32	97.84	90.29
Saharan Blend	87.61	79.60	-8.01	109.10	102.95
Other Crudes					
Brent	87.41	78.90	-8.51	108.44	102.33
Dubai	86.73	76.33	-10.40	105.25	99.96
Isthmus	85.40	79.04	-6.36	105.73	96.67
LLS	87.60	79.64	-7.96	107.73	100.13
Mars	83.57	75.76	-7.81	102.62	96.11
Minas	84.46	75.92	-8.54	107.50	102.13
Urals	86.63	78.92	-7.71	107.80	101.34
WTI	84.43	76.04	-8.39	97.98	96.26
Differentials					
Brent/WTI	2.98	2.86	-0.12	10.46	6.07
Brent/LLS	-0.19	-0.74	-0.55	0.71	2.20
Brent/Dubai	0.68	2.57	1.89	3.19	2.38

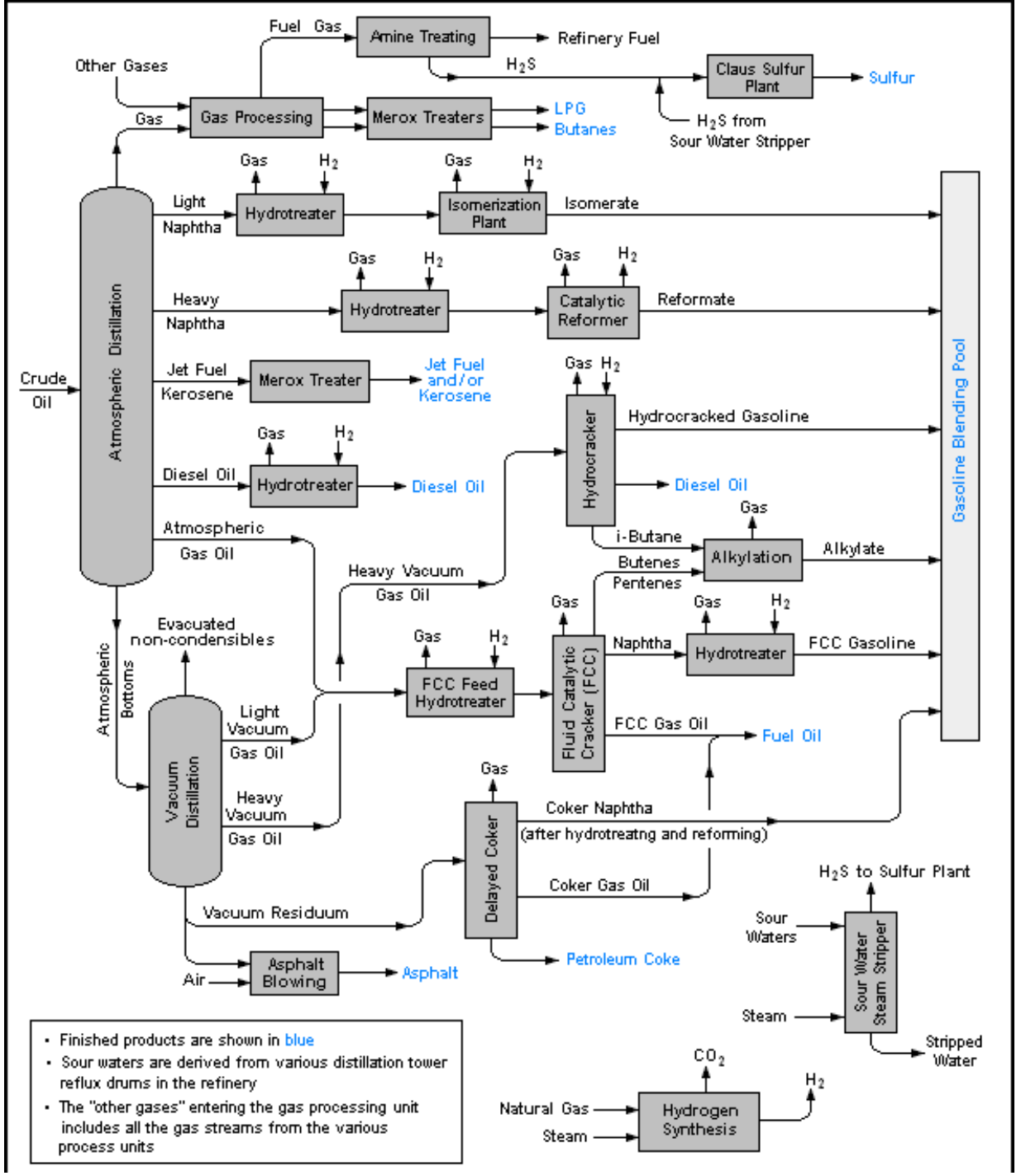
Differentials

... A benchmark is a type of crude oil to which other types of crude oil can be compared to determine a price by an agreed-upon differential...

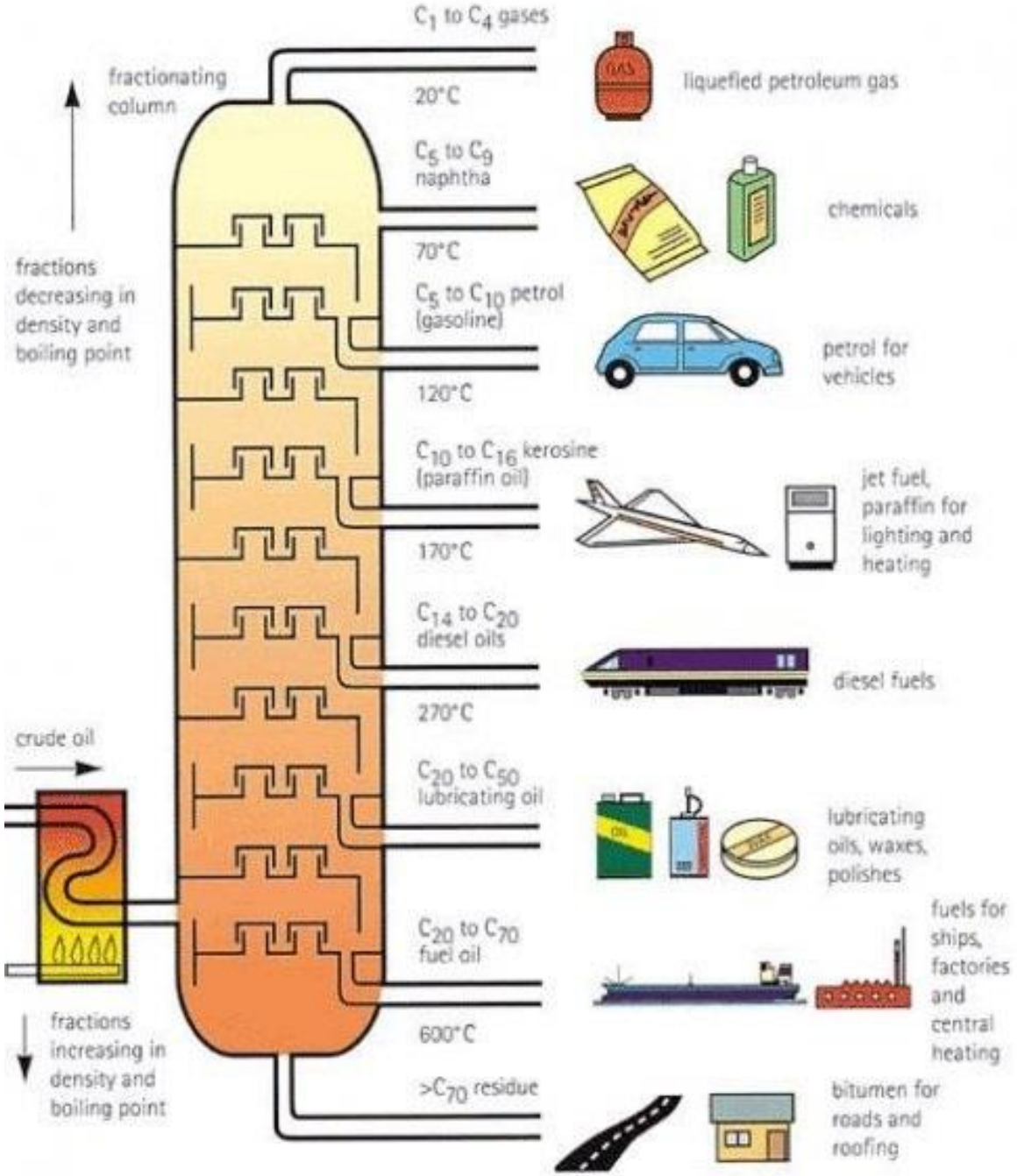
Differentials are determined by:

- Quality characteristics (API gravity or sulfur content).
- Transportation costs from production areas to refineries.
- Regional and global supply and demand conditions.

Oil quality


Fuel Gas
Amine Treating
Refinery Fuel
Other Gases
H_2S
Claus Sulfur Plant
Sulfur
Gas
Gas Processing
Merox Treaters
LPG
Butanes
H_2S from Sour Water Stripper
Gas
H_2
Light Naphtha
Hydrotreater
Isomerization Plant
Isomerate
Heavy Naphtha
Catalytic Reformer
Reformate
Crude Oil
Atmospheric Distillation
Jet Fuel Kerosene
Merox Treater
Jet Fuel and/or Kerosene
Diesel Oil
Hydrocracker
Hydrocracked Gasoline
Atmospheric Gas Oil
Heavy Vacuum Gas Oil
i-Butane
Butenes
Pentenes
Alkylation
Alkylate
Evacuated non-condensibles
Atmospheric Bottoms
Vacuum Distillation
Light Vacuum Gas Oil
Heavy Vacuum Gas Oil
FCC Feed Hydrotreater
Fluid Catalytic Cracker (FCC)
Naphtha
FCC Gasoline
FCC Gas Oil
Fuel Oil
Coker Naphtha (after hydrotreatng and reforming)
Delayed Coker
Coker Gas Oil
Vacuum Residuum
Petroleum Coke
Air
Asphalt Blowing
Asphalt
H_2S to Sulfur Plant
Sour Waters
Sour Water Steam Stripper
Steam
Stripped Water
CO_2
Natural Gas
Steam
Hydrogen Synthesis
Gasoline Blending Pool
• Finished products are shown in blue
• Sour waters are derived from various distillation tower reflux drums in the refinery
• The "other gases" entering the gas processing unit includes all the gas streams from the various process units

Oil quality

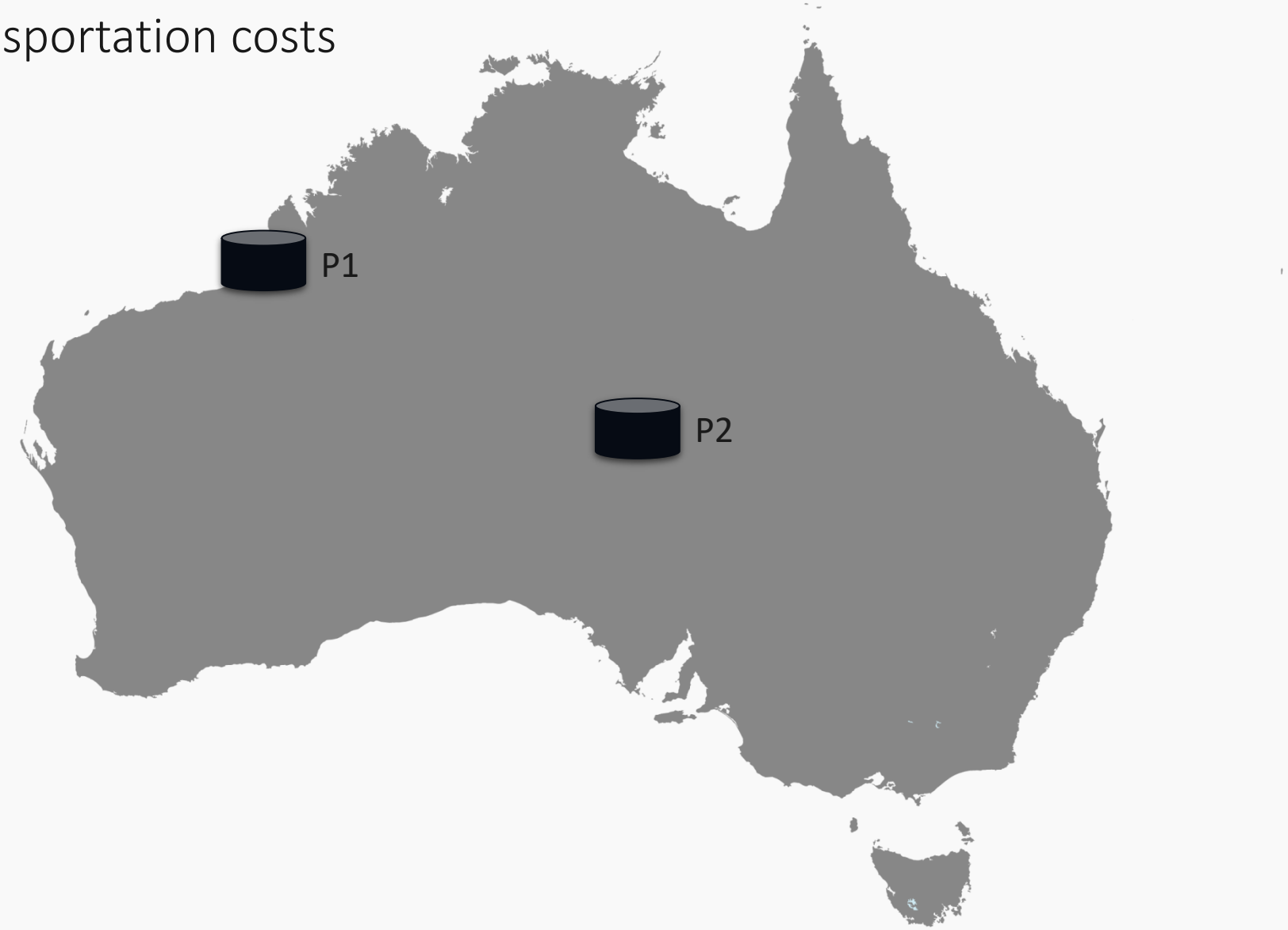

C_1 to C_4 gases
fractionating column
20°C
liquefied petroleum gas
C_5 to C_9 naphtha
chemicals
70°C
fractions decreasing in density and boiling point
C_5 to C_{10} petrol (gasoline)
petrol for vehicles
120°C
C_{10} to C_{16} kerosine (paraffin oil)
jet fuel, paraffin for lighting and heating
170°C
C_{14} to C_{20} diesel oils
diesel fuels
270°C
crude oil
C_{20} to C_{50} lubricating oil
lubricating oils, waxes, polishes
C_{20} to C_{70} fuel oil
fuels for ships, factories and central heating
600°C
fractions increasing in density and boiling point
>C_{70} residue
bitumen for roads and roofing

Oil quality

Refineries

- Calibrated to process a particular type of oil (sweet/sour, light/heavy)
- Processing different oil possible but at reduced efficiency => noncompetitiveness
- Re-calibration possible but at significant costs

Transportation costs



Transportation costs

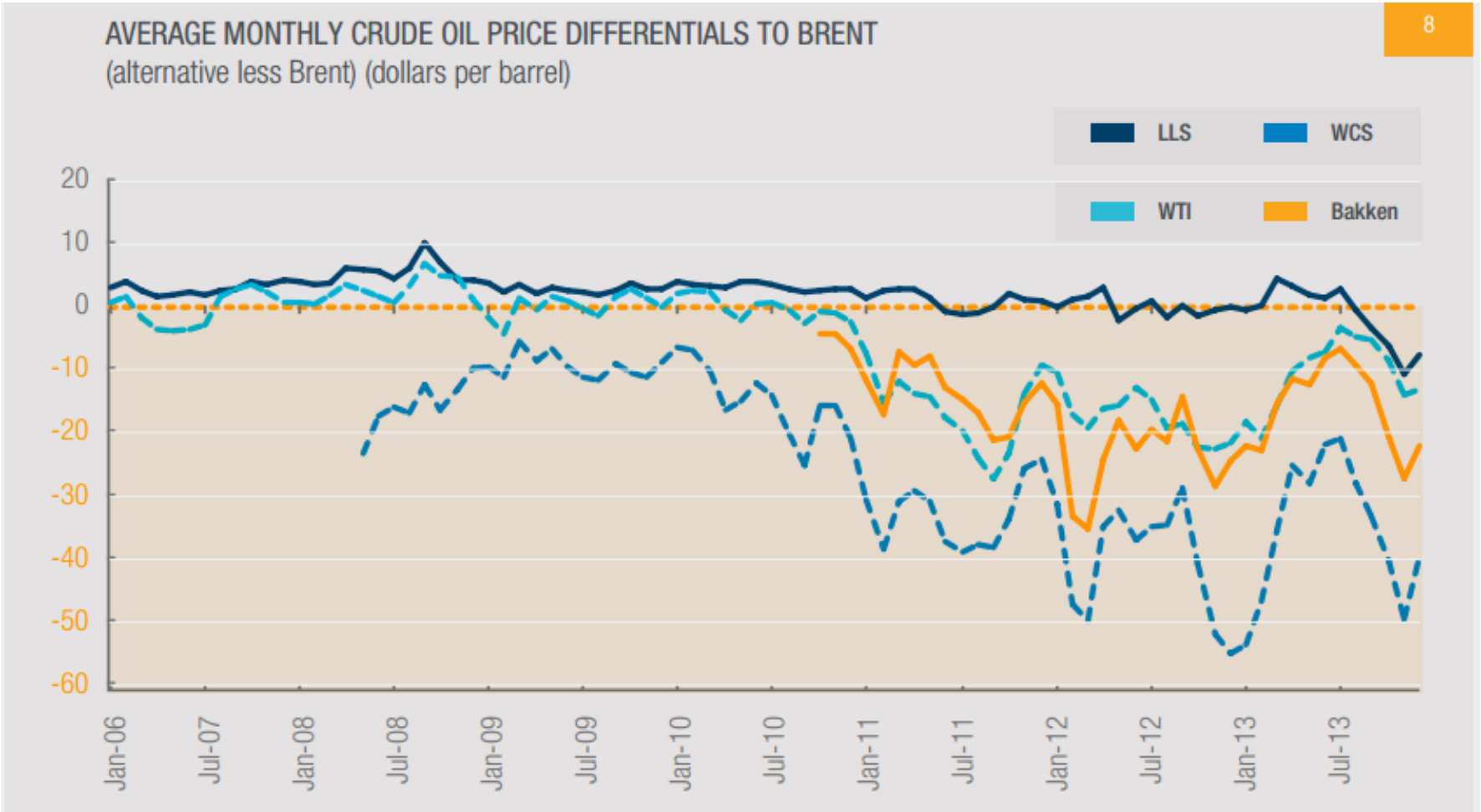
Onshore-produced and otherwise poorly accessible crudes tend to be cheaper than offshore and easily accessible onshore crudes

Transportation costs

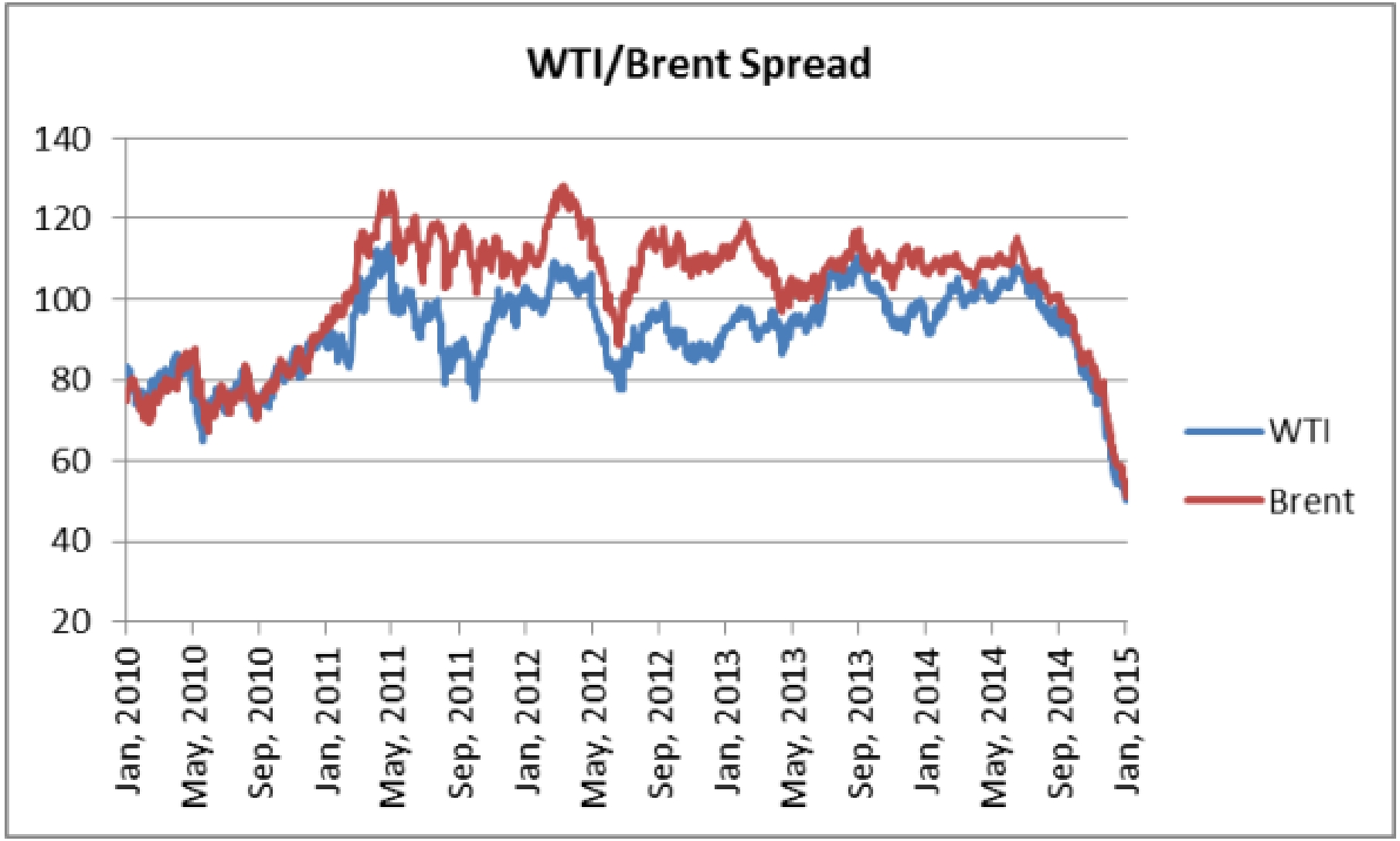
Onshore-produced and otherwise poorly accessible crudes tend to be cheaper than offshore and easily accessible onshore crudes

- To compensate for additional costs of transportation
- Transportation bottleneck foster „micro“ oil-to-oil competition

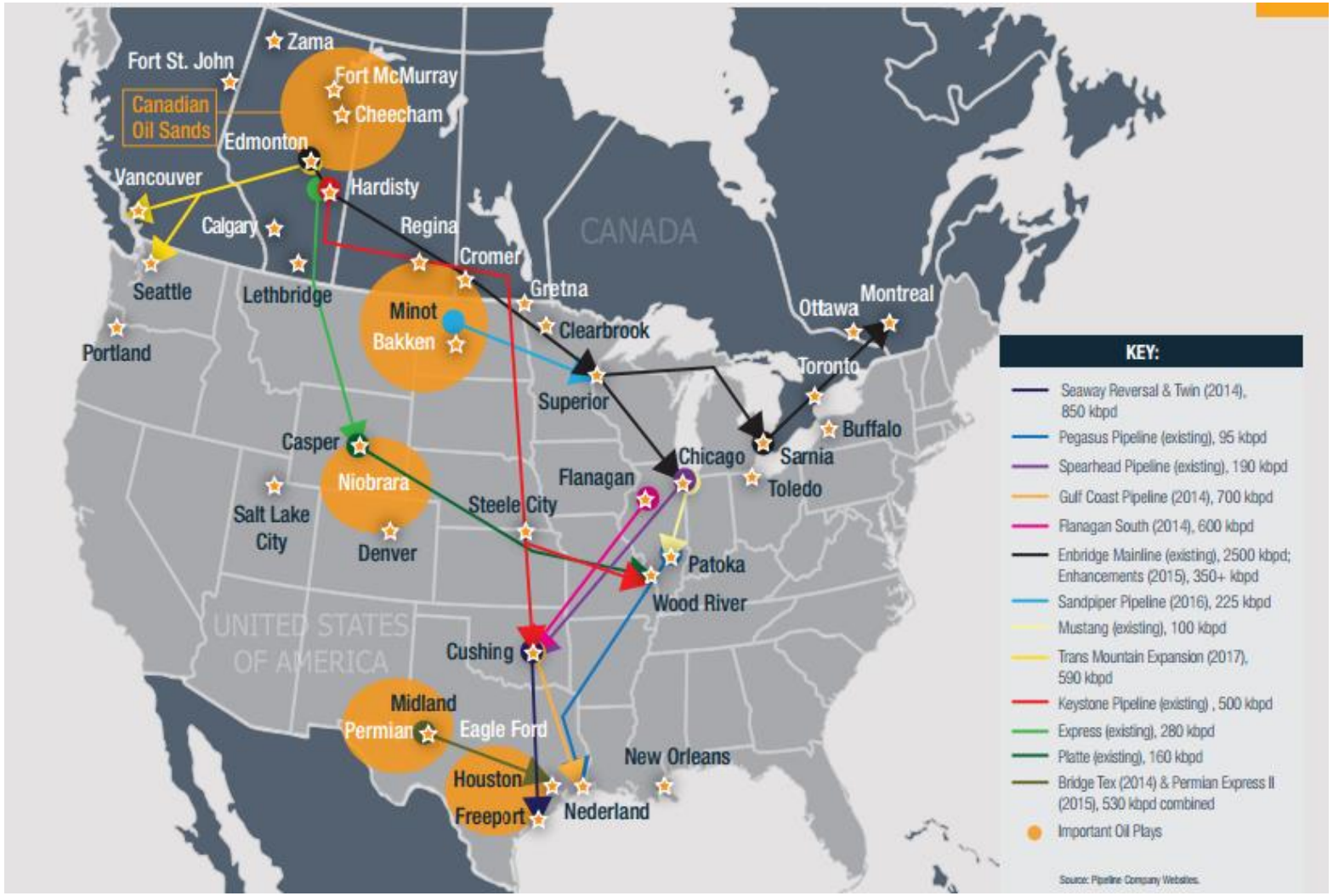
Regional supply/demand



Regional supply/demand



Regional supply/demand



How a specific crude becomes benchmark?

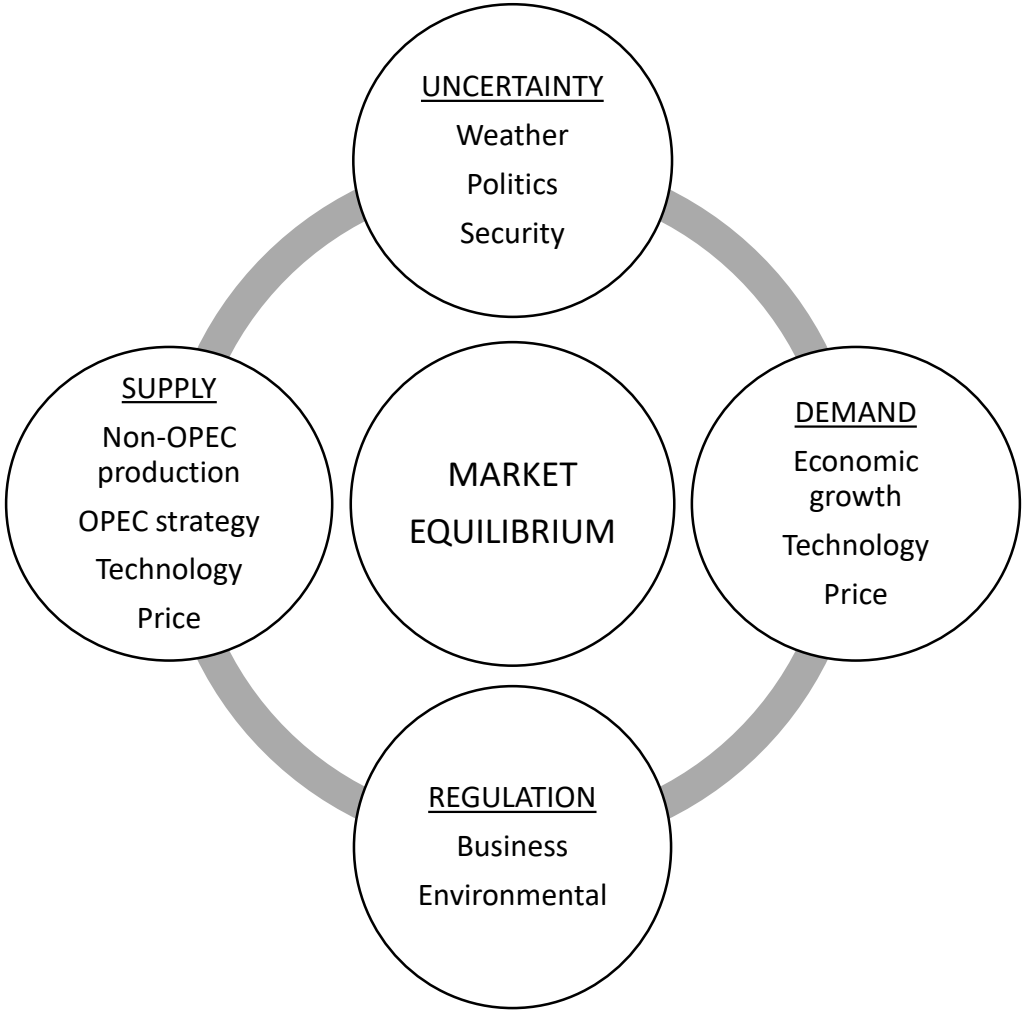
- Stable and ample production.
- Transparent, liquid market located in a geopolitically and financially stable region to encourage price discovery.
- Adequate storage to encourage market development.
- Delivery points at locations that allow arbitrage opportunities in world markets so that prices reflect global supply and demand.

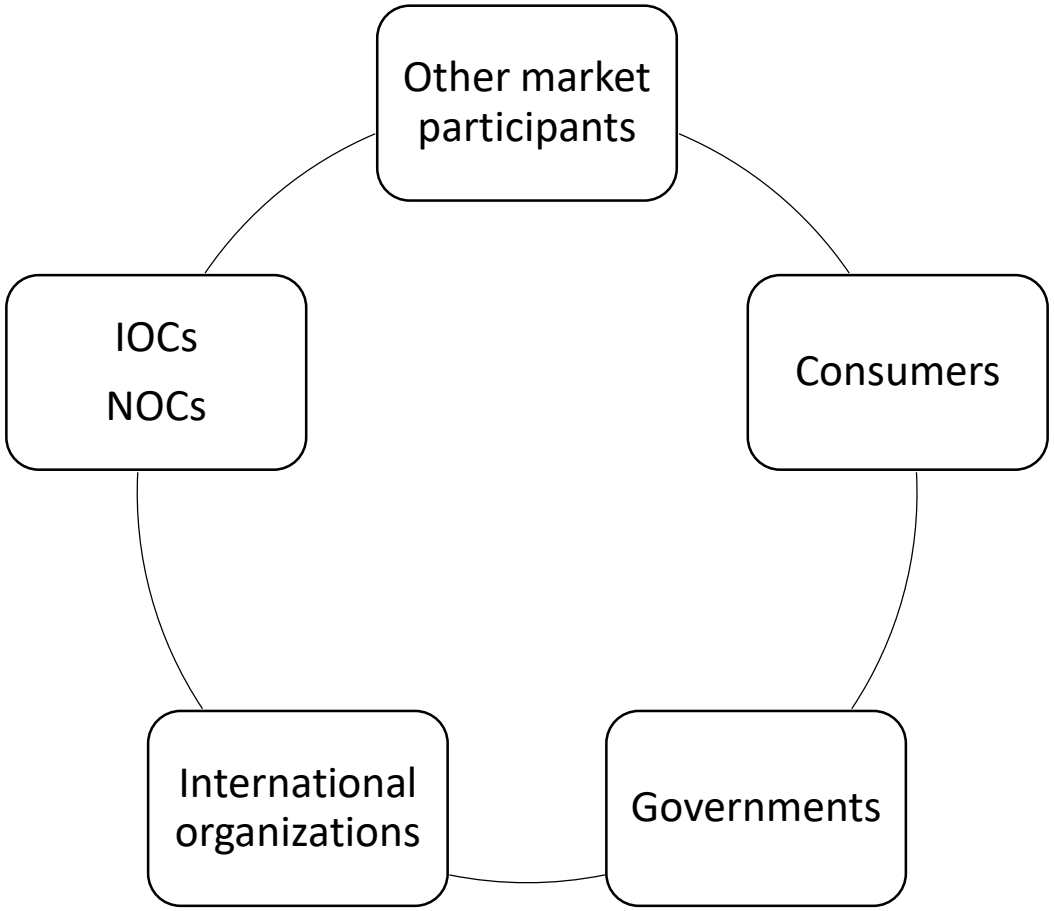
An oil bathtub?

- Individual crudes are interchangeable only at significant costs/loss of competitiveness
- Individual crudes are feedstock for production of the same products
- World oil market = set of very closely correlated benchmark/regional markets

The oil market: actors and structure

Market structure and actors



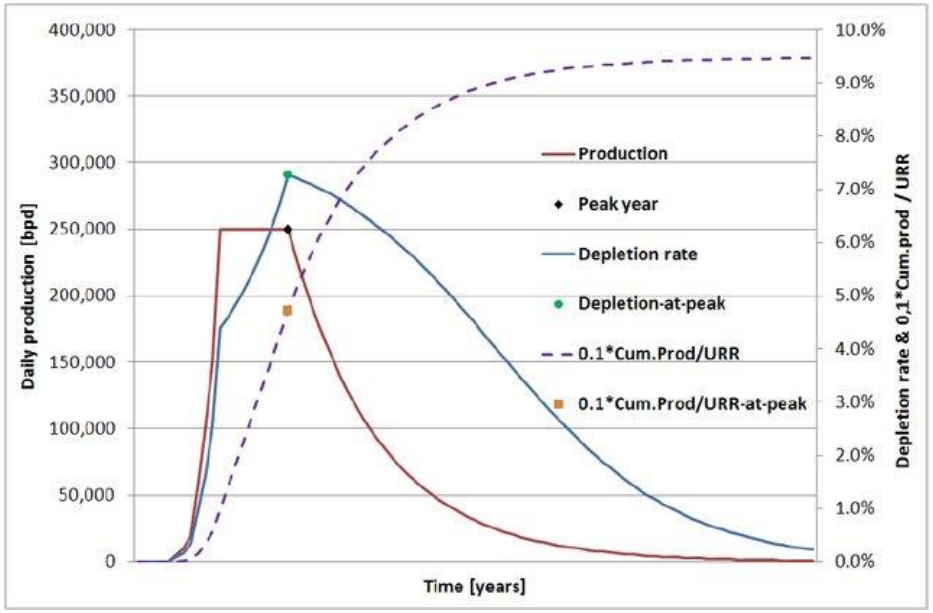


Rank	*Company*	*Country*	*State ownership (%)*	*Production (thousand barrels/day)*	*Proved reserves (million barrels)*
1	**Saudi Aramco**	**Saudi Arabia**	100	10,413	264,200
2	**NIOC**	**Iran**	100	4,401	138,400
3	Pemex	Mexico	100	3,474	12,187
4	CNPC	China	100	2,764	22,447
5	Exxon Mobil	US		2,616	11,074
6	**KPC**	**Kuwait**	100	2,600	101,500
7	**PDV**	**Venezuela**	100	2,570	99,377
8	BP	UK		2,414	10,073
9	**INOC**	**Iraq**	100	2,145	115,000
10	Rosneft	Russia	75.16	2,027	17,513
11	Petrobras	Brazil	32.2	1,918	9,581
12	Shell	UK/Netherlands		1,899	4,887
13	**Sonatrach**	**Algeria**	100	1,860	11,400
14	Chevron	US		1,783	7,523
15	ConocoPhillips	US		1,644	6,541
16	**Adnoc**	**UAE**	100	1,574	52,800
17	Lukoil	Russia		1,552	12,572
18	Total	France		1,509	5,778
19	**NNPC**	**Nigeria**	100	1,414	21,700
20	**Libya NOC**	**Libya**	100	1,368	30,700

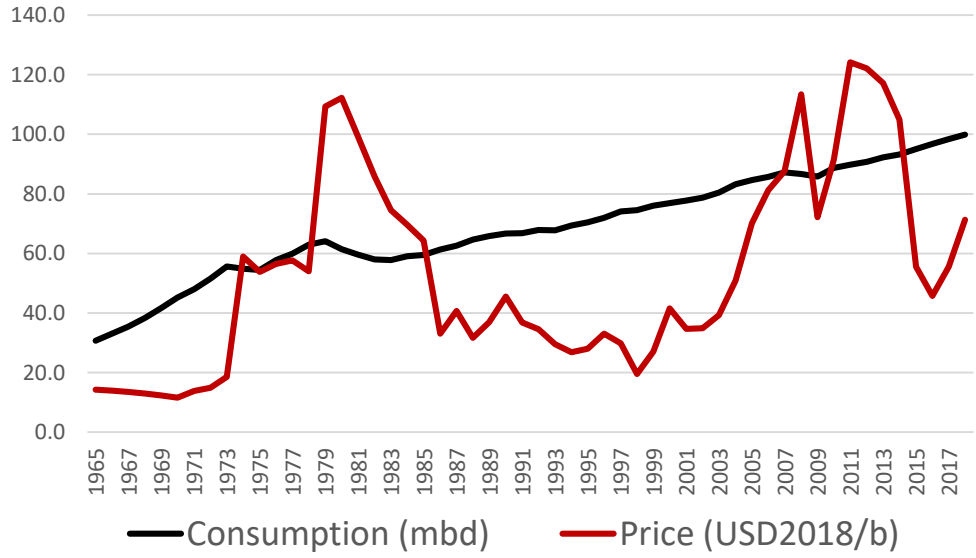
Source: Petroleum Intelligence Weekly, December 4, 2008.

Market fundamentals: what defines the oil market?

The Troll A platform



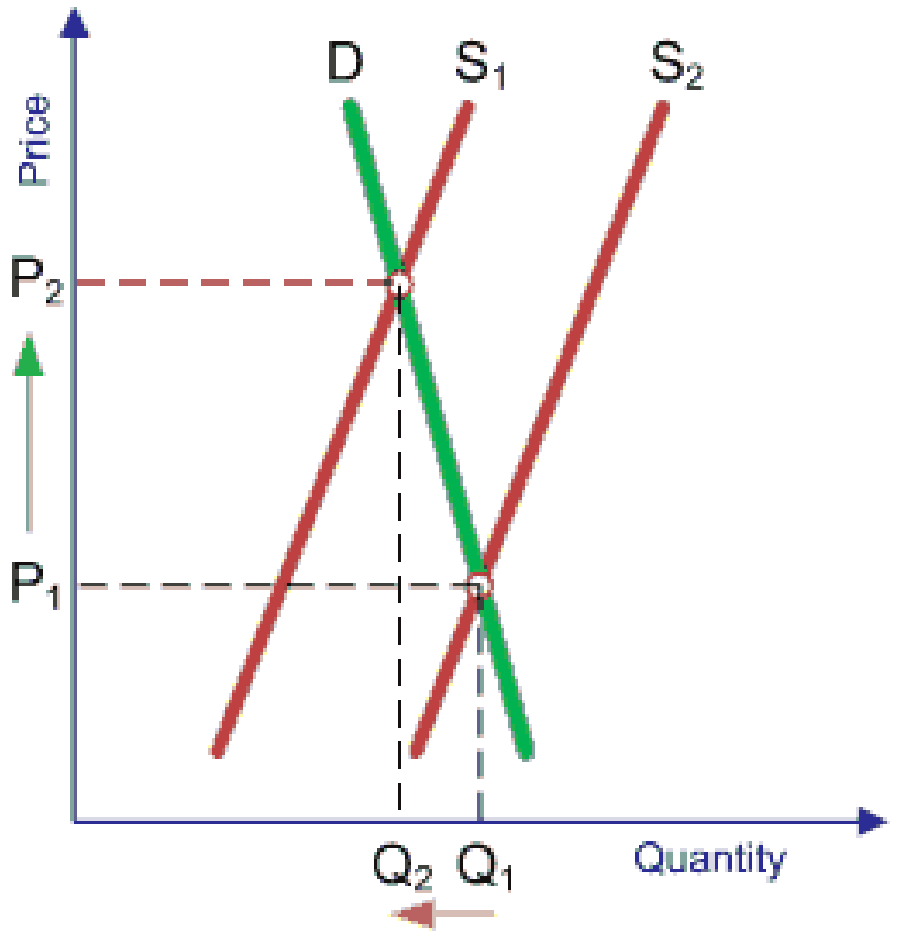
A typical oilfield production diagram



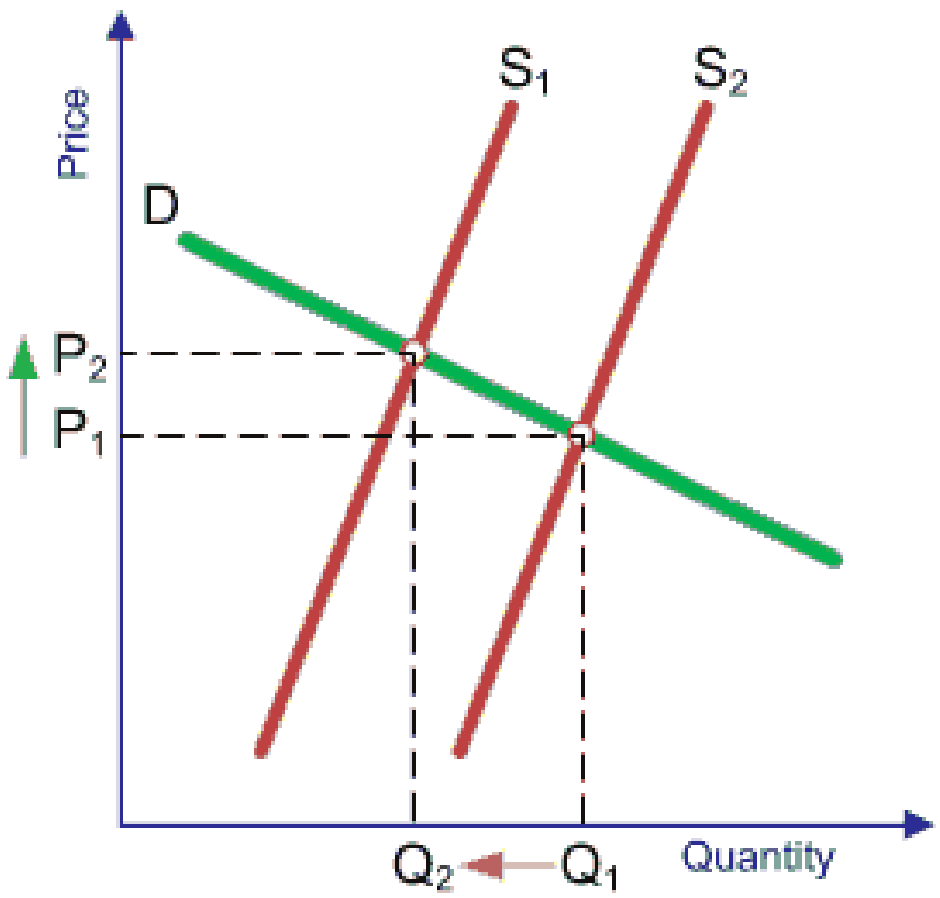
World oil consumption and price (since 1965)

Price elasticity

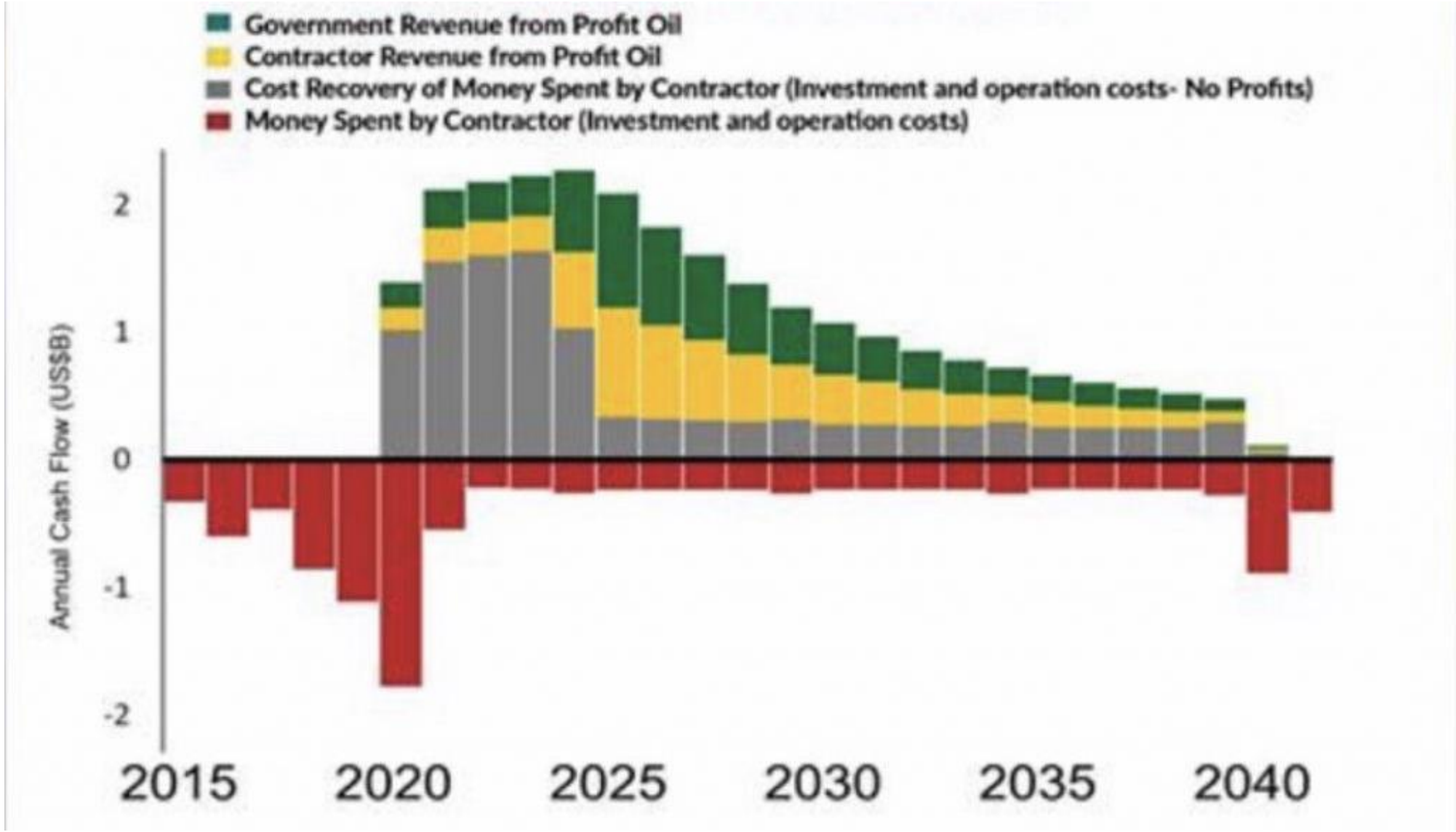
3.



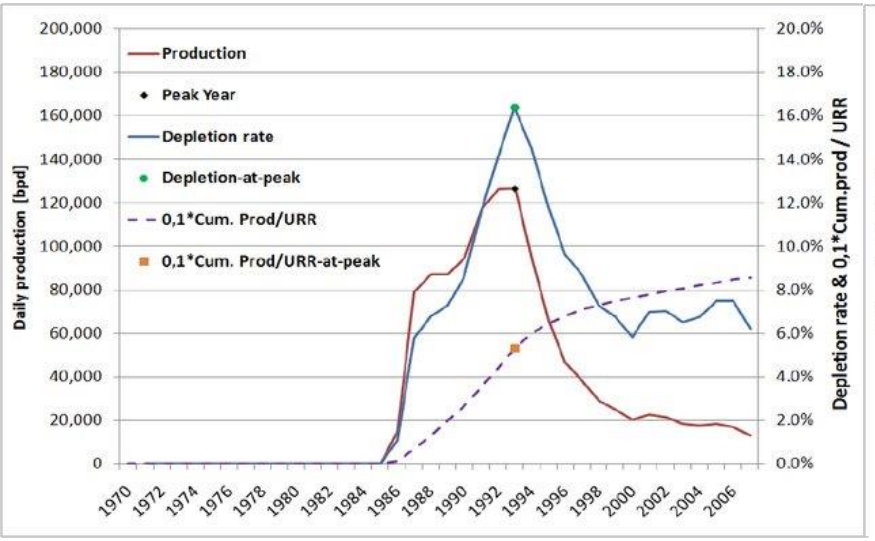
4.



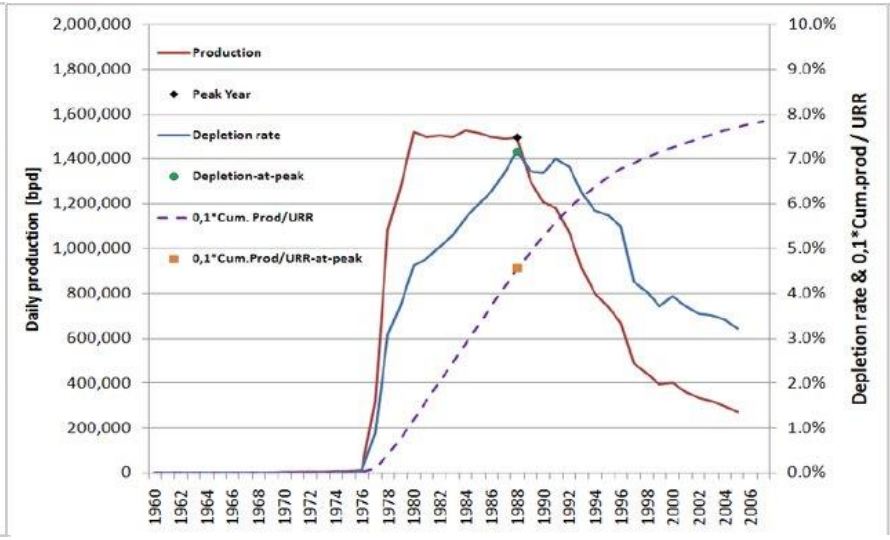
Long time horizonts



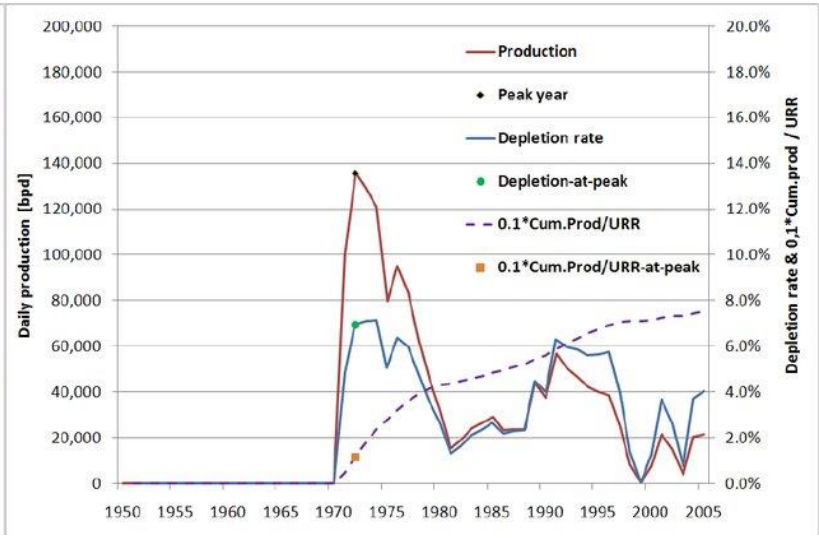
Long time horizonts



Ula (Norway)

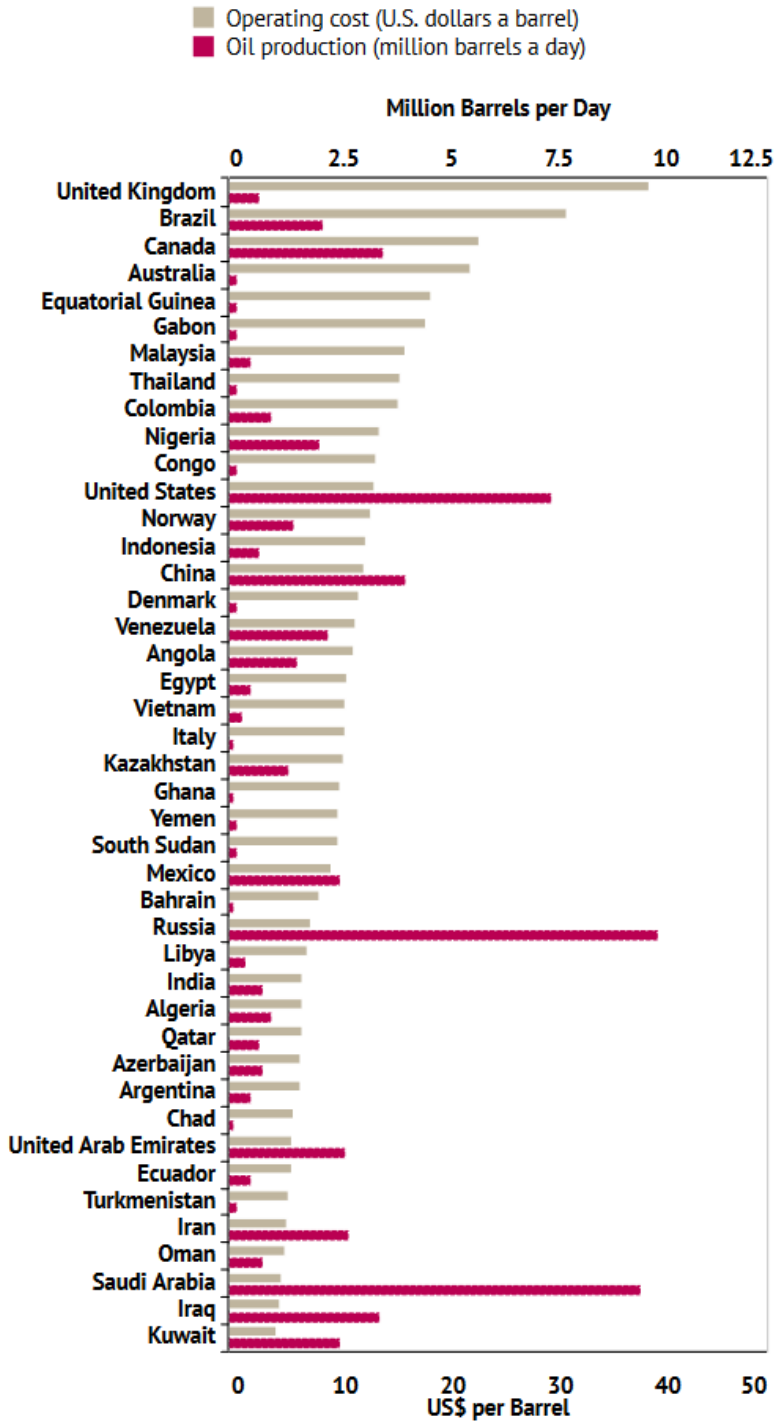


Prudhoe Bay (Alaska)



Jones Creek (Nigeria)

		Marginal Production Cost
		2014
Russia	Arctic	120.00
	Onshore	18.00
Europe	Biodiesel	110.00
	Ethanol	103.00
Canada	Sand	90.00
Brazil	Ethanol	66.00
	Offshore	80.00
United States	Deep-water	57.00
	Shale	73.00
Angola	Offshore	40.00
Ecuador	Total	20.00
Venezuela	Total	20.00
Kazakhstan	Total	16.00
Nigeria	Deep-water	30.00
	Onshore	15.00
Oman	Total	15.00
Qatar	Total	15.00
Iran	Total	15.00
Algeria	Total	15.00



Cost structure

Marginal costs

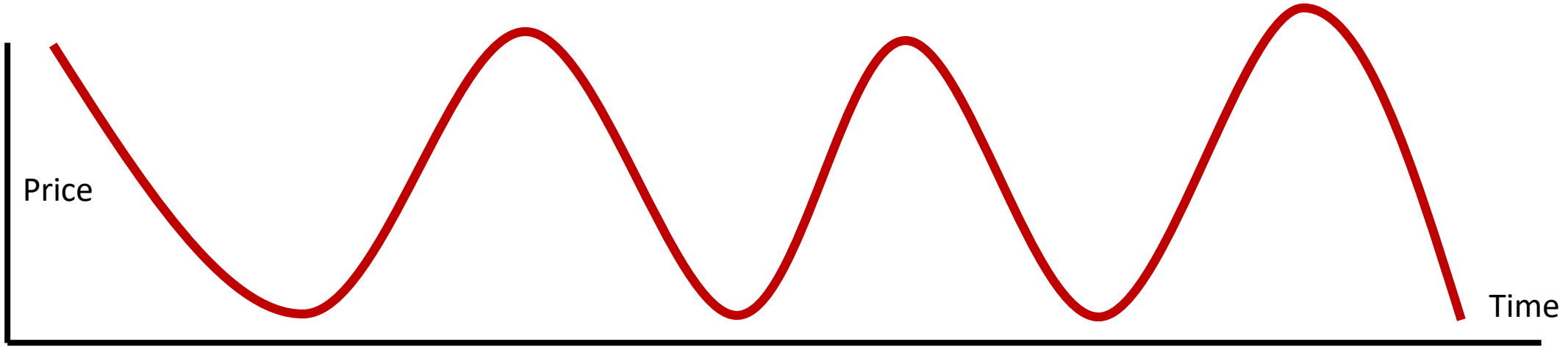
~15-120 $/b

Operational costs

~4-40 $/b

Long term: boom and bust

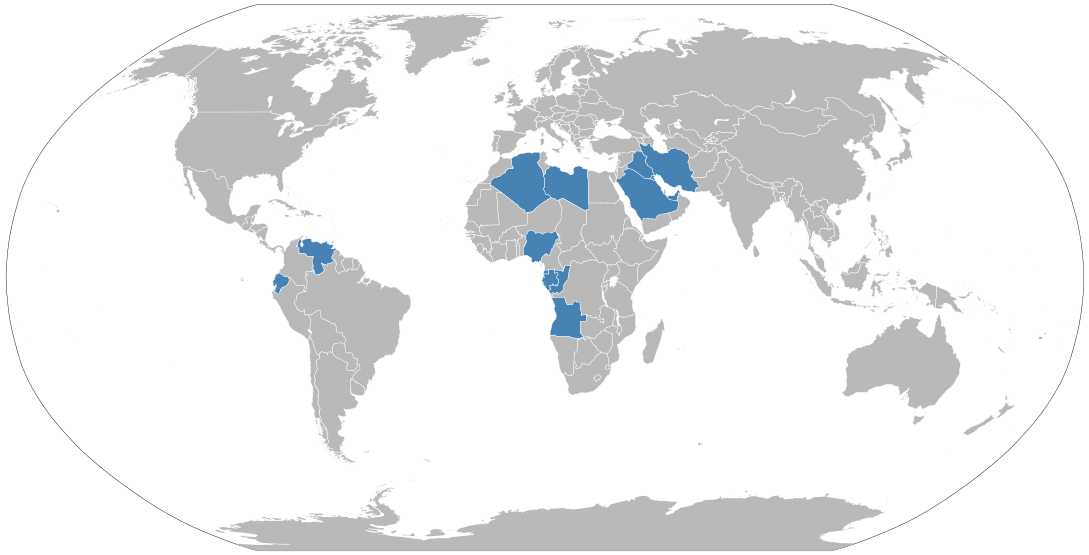
- Cost structure and long time horizons: maximizing revenues = maximizing production
- Correction: demand and (less so) supply are price elastic in the long run:
  - Demand: adjusted fuel consumption or switching to a different fuel
  - Supply: companies' cash flow improves/deteriorates, investment increases/decreases, new fields are/are not developed



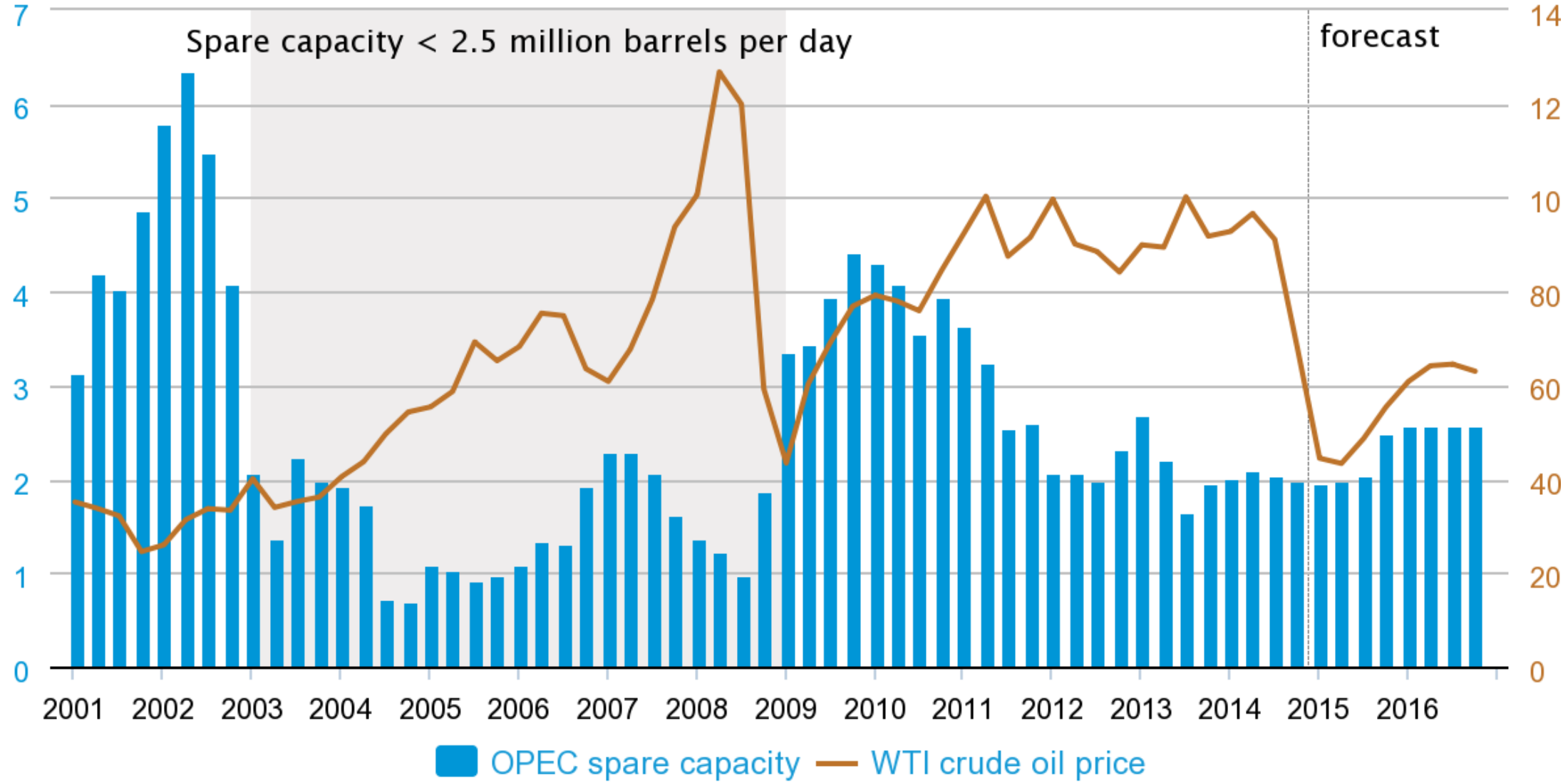
OPEC

Founded in 1960 in Baghdad, founding members Venezuela, Saudi Arabia, Iraq, Iran, Kuwait

- 80% of proven reservers
- 44% production
- Practically all spare production capacity



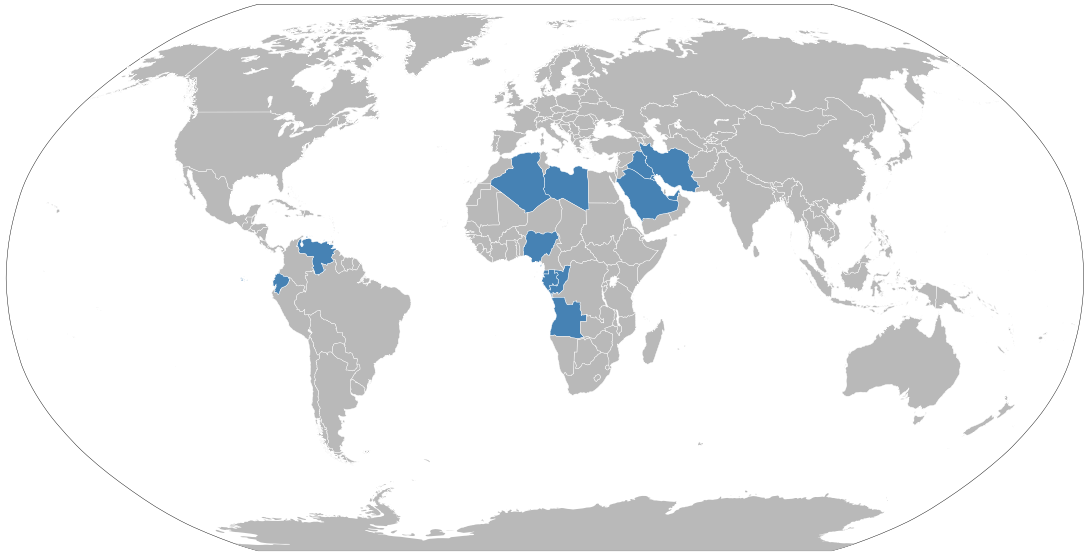
Spare capacity



OPEC

Regulates the supply via two means:

- Production quotas.
- Investments into new production capacities.



How cartels work? A coordination game

Imagine the following situation:

- Overall demand for oil is 6-14 barrels per day

- The price varies according to scarcity of oil:
  - At 6 bpd the price is high (20 USD/b)
  - At 14 bpd the price is low (4 USD/b)

- There are (only) two producers (P1 and P2)
  - Similar production and delivery costs
  - Wishing to maximize profits
    => adjusting production according to the price

How cartels work? A coordination game

Barrels	USD/b	P1‘s income	P2‘s income	Total income
6	20	3*20=60	3*20=60	120
7	18	4*18=72	3*18=54	126
8	16	4*16=64	4*16=64	128
9	14	5*14=70	4*14=56	126
10	12	5*12=60	5*12=60	120
11	10	6*10=60	5*10=50	110
12	8	6*8=48	6*8=48	96
13	6	7*6=42	6*6=36	78
14	4	7*4=28	7*4=28	56

How cartels work? A coordination game

Barrels	USD/b	P1‘s income	P2‘s income	Total income
6	20	3*20=60	3*20=60	120
7	18	4*18=72	3*18=54	126
8	**16**	**4*16=64**	**4*16=64**	**128 (cartel equilibrium)**
9	14	5*14=70	4*14=56	126
10	**12**	**5*12=60**	**5*12=60**	**120 (Nash equilibrium)**
11	10	6*10=60	5*10=50	110
12	8	6*8=48	6*8=48	96
13	6	7*6=42	6*6=36	78
14	4	7*4=28	7*4=28	56

The freeriding issue: prisoners‘ dilema

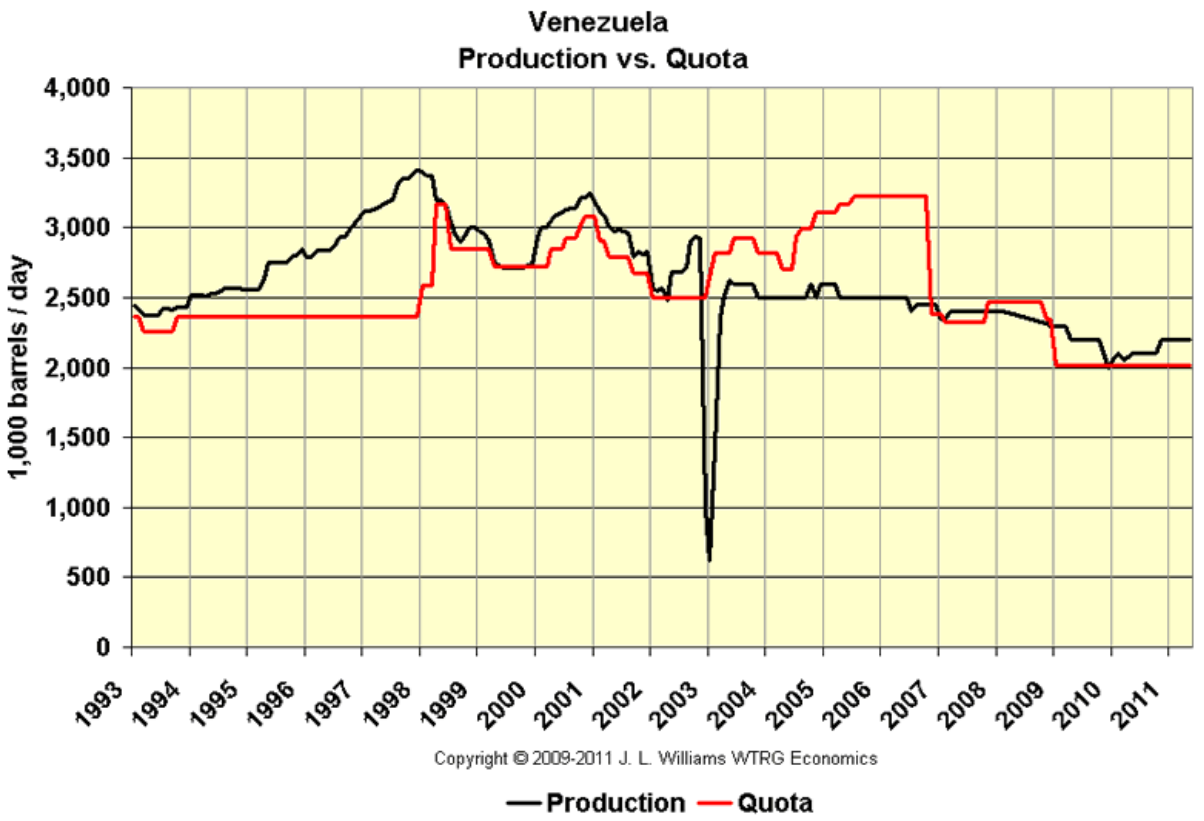
*"Mr. President, we are rapidly approaching a moment of truth both for ourselves as human beings and for the life of our nation. Now, truth is not always a pleasant thing. But it is necessary now to make a choice, to choose between two admittedly regrettable, but nevertheless *distinguishable*, postwar environments: one where you got twenty million people killed, and the other where you got a hundred and fifty million people killed.“*

General Buck Turgidson, (Dr. Strangelove)

http://www.youtube.com/watch?v=HgyjlqhiTV8

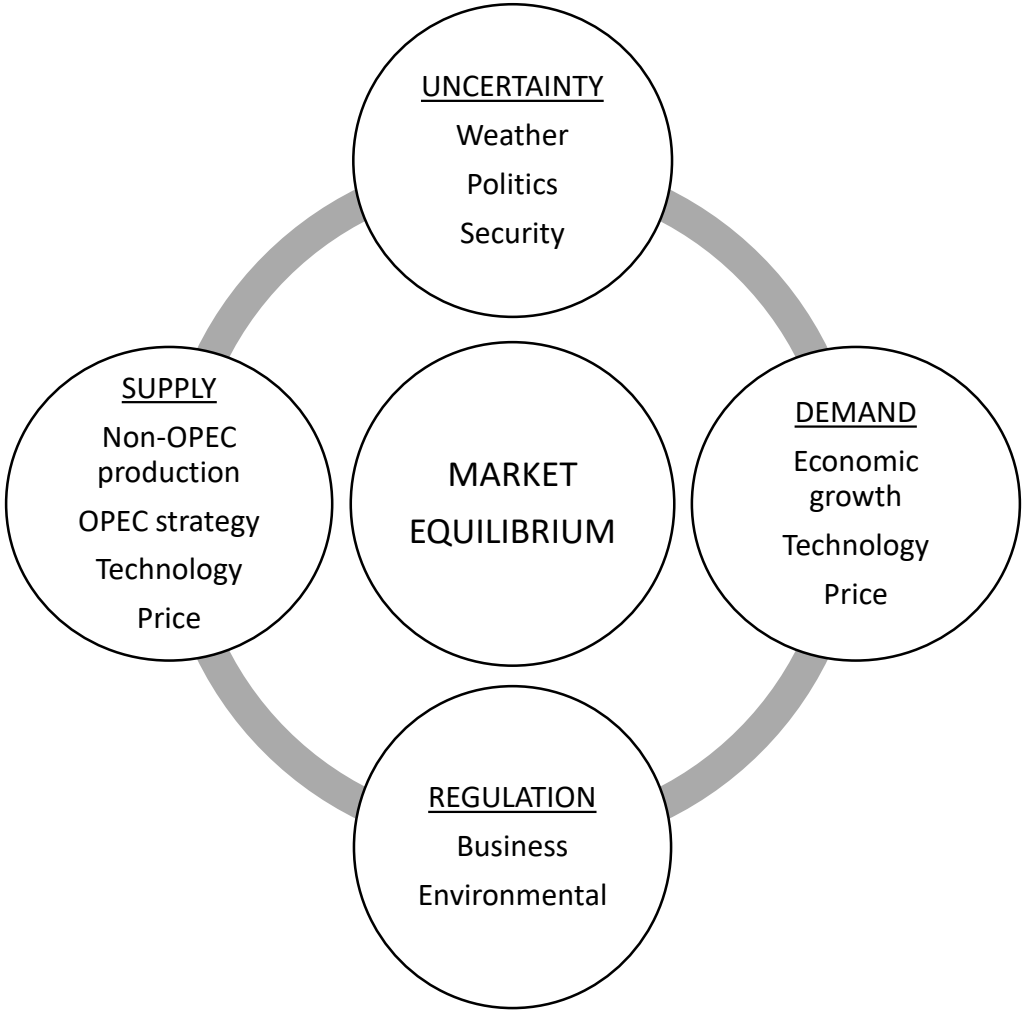
The freeriding issue: prisoners‘ dilema

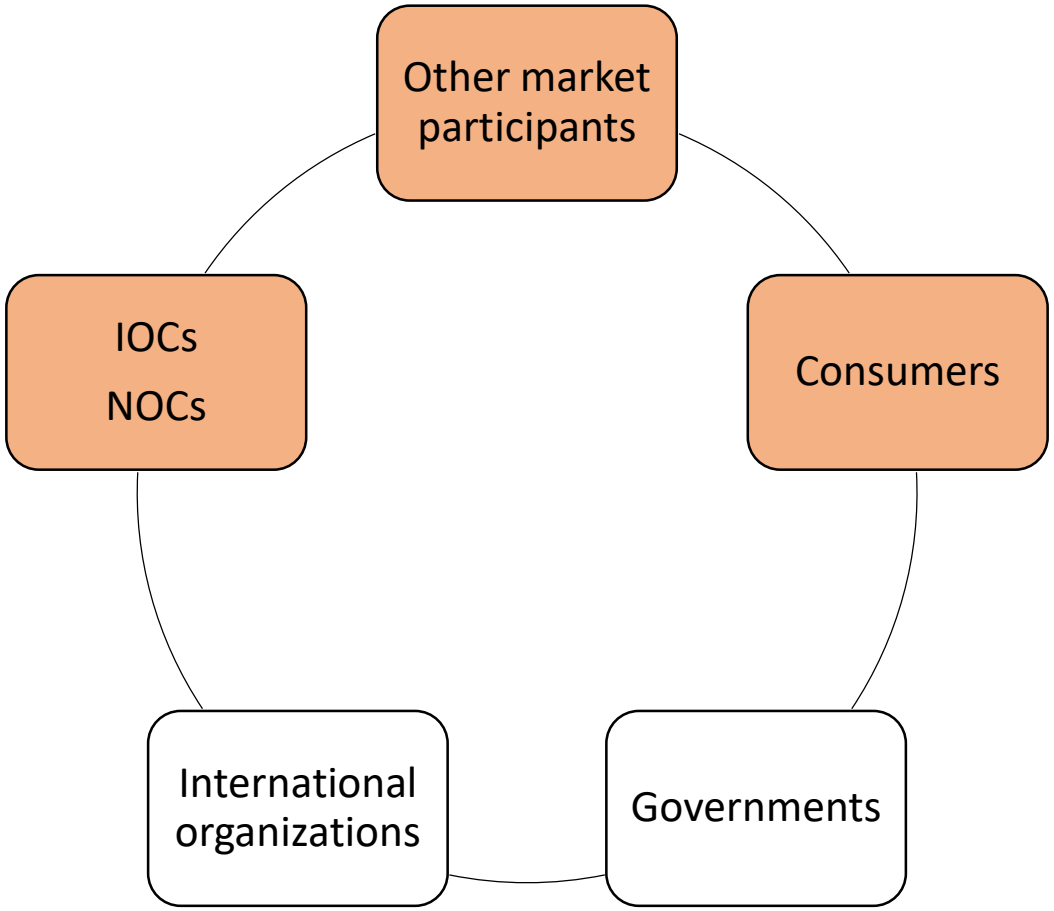
		P2	
		Does not increase	Increases
P1	Does not increase	64/64	56/70
	Increases	70/56	60/60



Trading oil

Market structure and actors





Trading oil

Physical delivery

🛢 ⇔ $

Financial delivery

$ ⇔ $ (🛢)

What is the ratio between daily traded physical and financial (paper) barrels?

Physical deliveries

Bilateral agreements (Over-the-counter)

- Term contracts of mostly one year
- Price set according to spot
- 90-95% physically traded volume

Spot market (hub trading, exchange trading)

- Balancing needs (surplus or missing barrels)
- Sets the price („marginal barrels“)
- 5-10% of volume

Financial deliveries

Bilateral agreements

- Term contracts of different lengths
- Price: spot +/- expectations
- Used for speculation and hedging

Types vary according to contract characteristics

- Futures
- Options
- Swaps
- Forwards

Financial deliveries

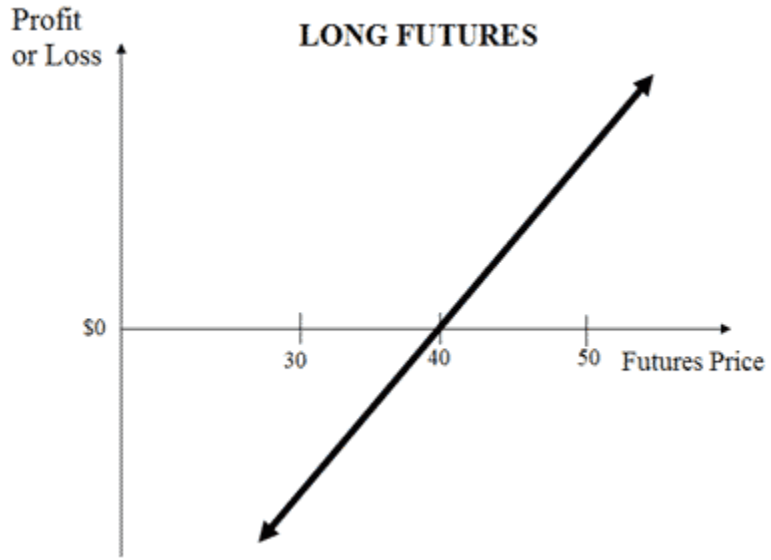
Futures

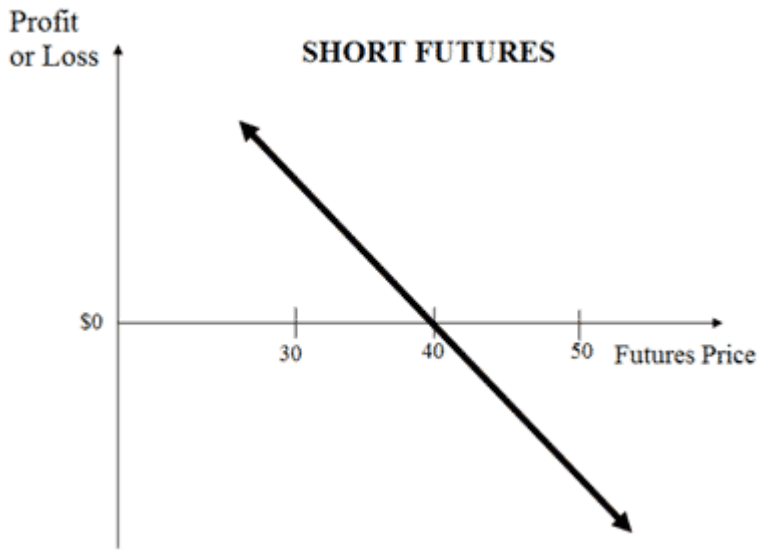
Futures

A financial contract obligating the buyer to purchase an asset (or the seller to sell an asset), such as a physical commodity or a financial instrument, at a predetermined future date and price.

- Underlying asset (oil)
- Type: long (buying) x short (selling)
- Date of settlement
- Price

Long and short position





Long futures: buying futures with expectation of price increase

Short futures: selling futures with expectation of price decline

Futures: physical and financial delivery

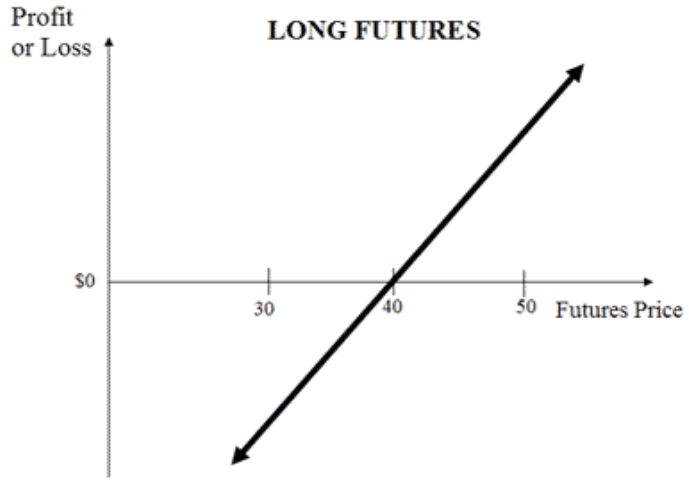
♦ Physical delivery		$ Financial delivery	
Selling physical barrels	♦ delivered: a barrel worth of P1	Selling financial barrels	$ paid: P1
	$ received: P0		$ received: P0
Buying physical barrels	$ paid: P0	Buying financial barrels	$ paid: P0
	♦ received: a barrel worth of P1		$ received: P1

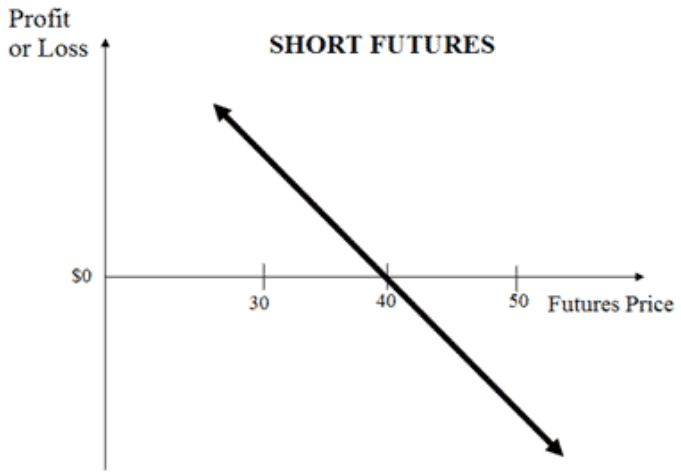
Note:

P0 = negotiated price

P1 = market price at the day of settlement

Speculation with futures





Example

- Time T0 (now), negotiated price P0 = $50
  - 1,000 barrels financial futures bought at $50 with settlement next June (T1)

- Time T1 (next June), oil price P1 = $45
  - Bought for $50 what is being now traded at $45 => lost $5 per barrel => lost 5,000 USD

- Time T1 (next June), oil price P1 = $55
  - Bought for $50 what is being now traded at $55 => gained $5 per barrel => gained 5,000 USD

Hedging with futures

♦ Physical delivery		$ Financial delivery	
Selling physical barrels	♦ delivered: a barrel worth of P1	Selling financial barrels	$ paid: P1
	$ received: P0		$ received: P0
Buying physical barrels	$ paid: P0	Buying financial barrels	$ paid: P0
	♦ received: a barrel worth of P1		$ received: P1

What are the balances of green and blue traders if:

(1) P0 = 50; P1 = 70

(2) P0 = 50; P1 = 30

Hedging with futures

Imagine the following oil buyer:

- Has invested in business the profitability of which depends on price of oil (i.e. a rafinery)
- Needs a stable oil price to plan the development of the business

=> Wishes to hedge against price fluctations, i.e. wishes the current (time T0) prices (P0) to last.

Will need 1,000 barrels of oil about this time next year (time T1, oil price P1)

Hedging with futures

Today (time T0, negotiated price P0 = 50 USD/b):

- The buyer enters a contract in which agrees to buy 1,000 **physical** barrels at $50 (P0) with delivery in time T1.

- At the same time sells 1,000 **financial** barrels at $50 (P0) with delivery in time T1

- In time T1, therefore, the buyer:
  - Will pay for the physical delivery amount equal to 1,000 x P0
  - Will get paid for financial delivery amount equal to 1,000 x P1

Hedging with futures

About this time next year (T1): The price went up to P1 = 70 USD/b

Settles the physical contract:

- Bought $70 worth barrels for $50 ... Balance: +20 x 1,000 = +20,000 USD

Settles the financial contract:

- Sold $70 worth barrels for $50 ... Balance: -20 x 1,000 = -20,000 USD

Total balance: 0 USD

=> The buyer got 1,000 barrels at $50 as desired.

Hedging with futures

About this time next year (T1): The price went down to P1 = 30 USD/b

Settles the physical contract:

- Bought $30 worth barrels for $50 ... Balance: -20 x 1,000 = -20,000 USD

Settles the financial contract:

- Sold $30 worth barrels for $50 ... Balance: +20 x 1,000 = +20,000 USD

Total balance: 0 USD

=> The buyer got 1,000 barrels at $50 as desired.

Hedging with futures

If the buyer was a seller:

T0: P0 = 50 USD/b
Agrees to deliver 1,000 physical barrels at 50 USD/b in T1
At 50 USD/b buys 1,000 financial barrels to receive what they are worth in T1 (P1)

T1: P1 = 70 USD/b
- Physical: Delivered $70 worth barrels at $50 ... Balance -20,000 USD
- Financial: Received $70 for what was bought for $50 ... Balance +20,000 USD

T1: P1 = 30 USD/b
- Physical: Delivered $30 worth barrels at $50 ... Balance +20,000 USD
- Financial: Received $30 for what was bought for $50 ... Balance -20,000 USD

Total balance: 0 USD

=> The seller sold 1,000 barrels at $50 as desired.

Options

Options

A financial derivative that represents a contract sold by one party (option writer) to another party (option holder). The contract offers the buyer the right, but not the obligation, to buy (call) or sell (put) a security or other financial asset at an agreed-upon price (the strike price) during a certain period of time or on a specific date (exercise date).

Option types

	Call option	Put option
Buyers	Right to buy stock if exercised	Right to sell stock if exercised
Sellers	Obligation to sell stock if assigned	Obligation to buy stock if assigned

- Underlying asset: oil
- Type: call (right to buy) x put (right to sell)
- Price: price of contract
- Strike price: oil price at which the right can be exercised
- Exercise date: when the contract expires

Hedging with options

	Call option	Put option
Buyers	Right to buy stock if exercised	Right to sell stock if exercised
Sellers	Obligation to sell stock if assigned	Obligation to buy stock if assigned

Example: oil purchasing hedging (oil purchaser = option buyer)

T0: oil price P0 = $50

- Buyer: bought call option for 1,000 barrels at $60 from Seller for 3 USD/b due to T1

T0.8 (between T0 and T1): oil price P1 = $70

- Buyer: exercises his right and gets $70 worth barrels for $60
  ... Balance: + 10,000 – 3,000 = + 7,000 USD

- Seller: sells $70 worth barrels for $60
  ... Balance: - 10,000 + 3,000 = - 7,000 USD

=> Hedging successful, major loss due to price spike prevented

	Call option	Put option
Buyers	Right to buy stock if exercised	Right to sell stock if exercised
Sellers	Obligation to sell stock if assigned	Obligation to buy stock if assigned

Example: oil purchasing hedging (oil purchaser = option buyer)

T0: oil price P0 = $50

- Buyer: bought call option for 1,000 barrels at strike price of $60 from Seller for 3 USD/b due to T1

T1: oil price P1 = $58

- Buyer: does not exercise his right (would get $58 worth barrels for $60)
  ... Balance: - 3,000 USD

- Seller: gains $3 per each barrel for selling unexercised option at $3
  ... Balance: + 3,000 USD

=> Hedging successful, major loss due to price spike prevented

	Call option	Put option
Buyers	Right to buy stock if exercised	Right to sell stock if exercised
Sellers	Obligation to sell stock if assigned	Obligation to buy stock if assigned

Example: oil selling hedging (oil seller = option buyer)

T0: oil price P0 = $50

- Buyer: bought put option for 1,000 barrels at strike price of $40 from Seller for 3 USD/b due to T1

T1: oil price P1 = $30

- Buyer: exercises his right and sells $30 for $40
  ... Balance: + 10,000 – 3,000 = + 7,000 USD

- Seller: buys $30 worth barrels for $40
  ... Balance: - 10,000 + 3,000 = - 7,000 USD

=> Hedging successful, major loss due to price decline prevented

	Call option	Put option
Buyers	Right to buy stock if exercised	Right to sell stock if exercised
Sellers	Obligation to sell stock if assigned	Obligation to buy stock if assigned

Example: oil selling hedging (oil seller = option buyer)

T0: oil price P0 = $50

- Buyer: bought put option for 1,000 barrels at strike price of $40 from Seller for 3 USD/b due to T1

T1: oil price P1 = $45

- Buyer: does not exercise his right (would sell $45 worth barrels for $40)
  ... Balance: - 3,000 USD

- Seller: gains $3 per each barrel for selling unexercised option at $3
  ... Balance: + 3,000 USD

=> Hedging successful, major loss due to price spike prevented

What is the ratio between daily traded physical and financial (paper) barrels?

Physical to financial trading

- Physical barrels: approx. 92 mbd (2014, EIA)
- Financial barrels: more than 1,000 mbd
  (2009, Congressional testimony by the commodities specialist Michael W. Masters)

=> At least 1:10