Oil prices
Volatility and prediction

JOHN KEMP
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(John Kemp is a Reuters market analyst. The views expressed are his own)

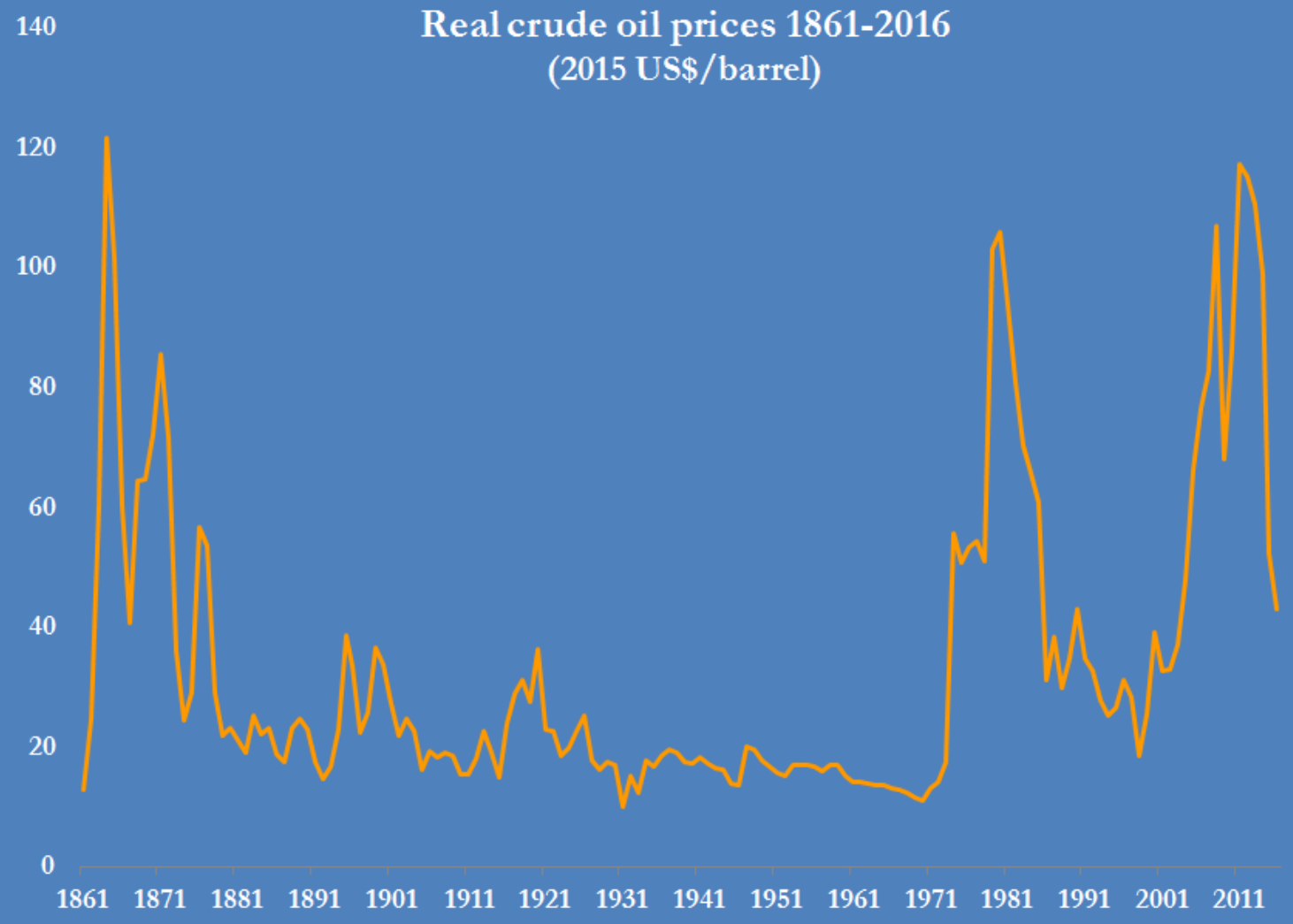
Questions

Why are oil prices so volatile?

Is it possible to forecast oil prices (and if so over what time horizon)?

Is it possible to stabilise oil prices (and if not what is the alternative)?

Oil prices are variable but changes are cyclical rather than random



Source: *BP Statistical Review of World Energy 2016,* Reuters calculations for 2016
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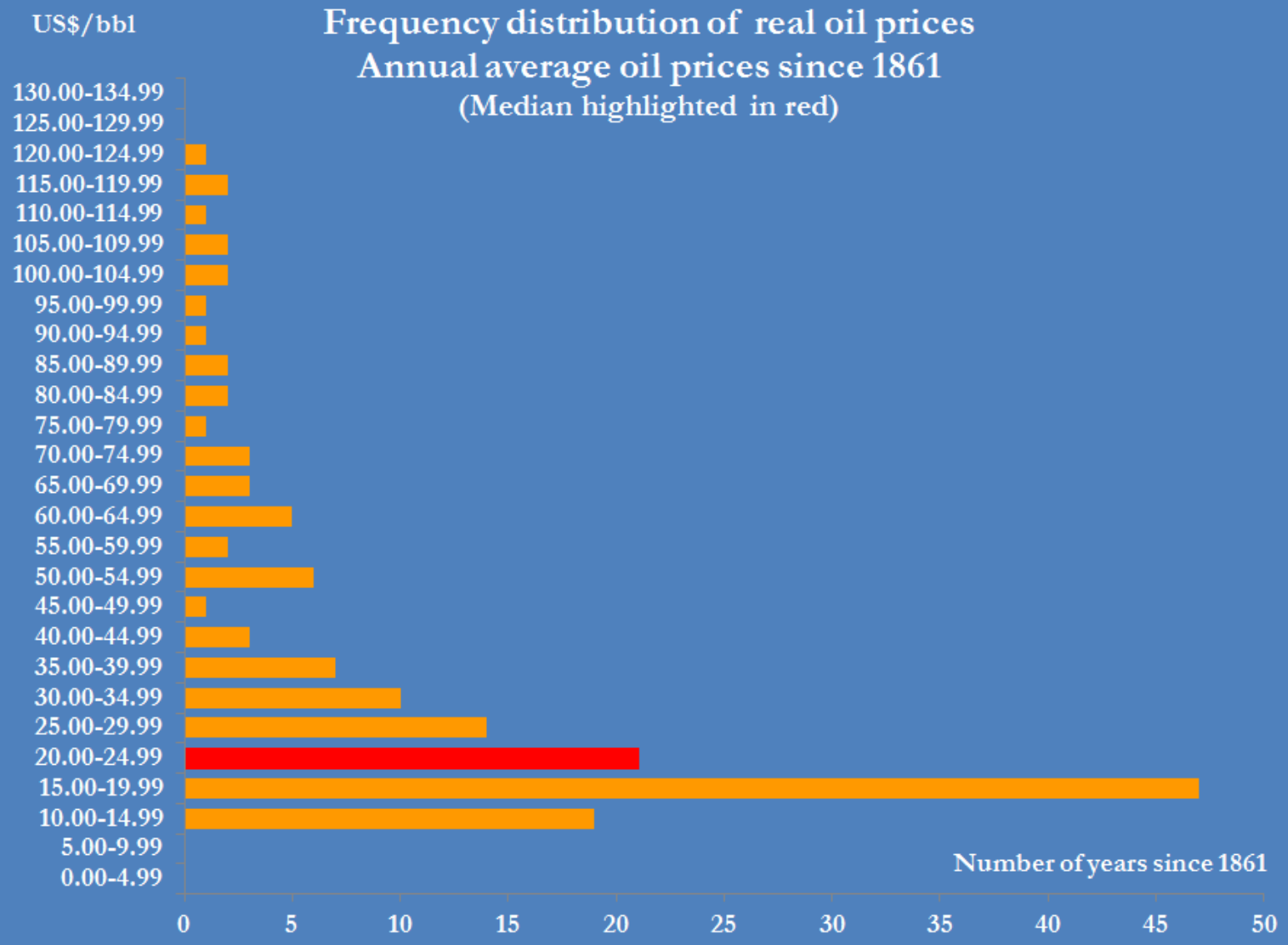
Have oil prices ever been in a stable equilibrium?



Source: *BP Statistical Review of World Energy*, 2016 and author calculations

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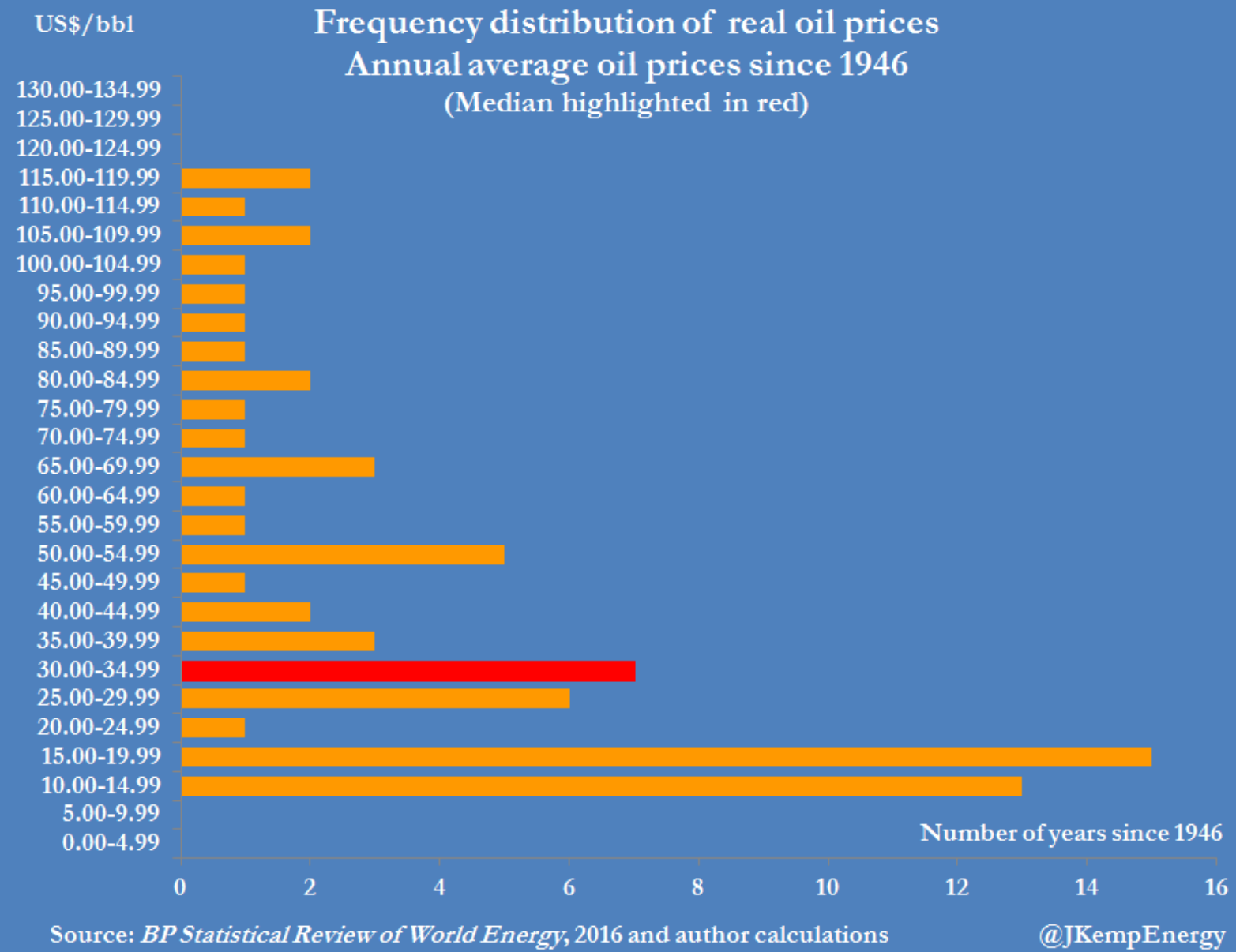
Distribution of real oil prices since Second World War



Source: *BP Statistical Review of World Energy*, 2016 and author calculations

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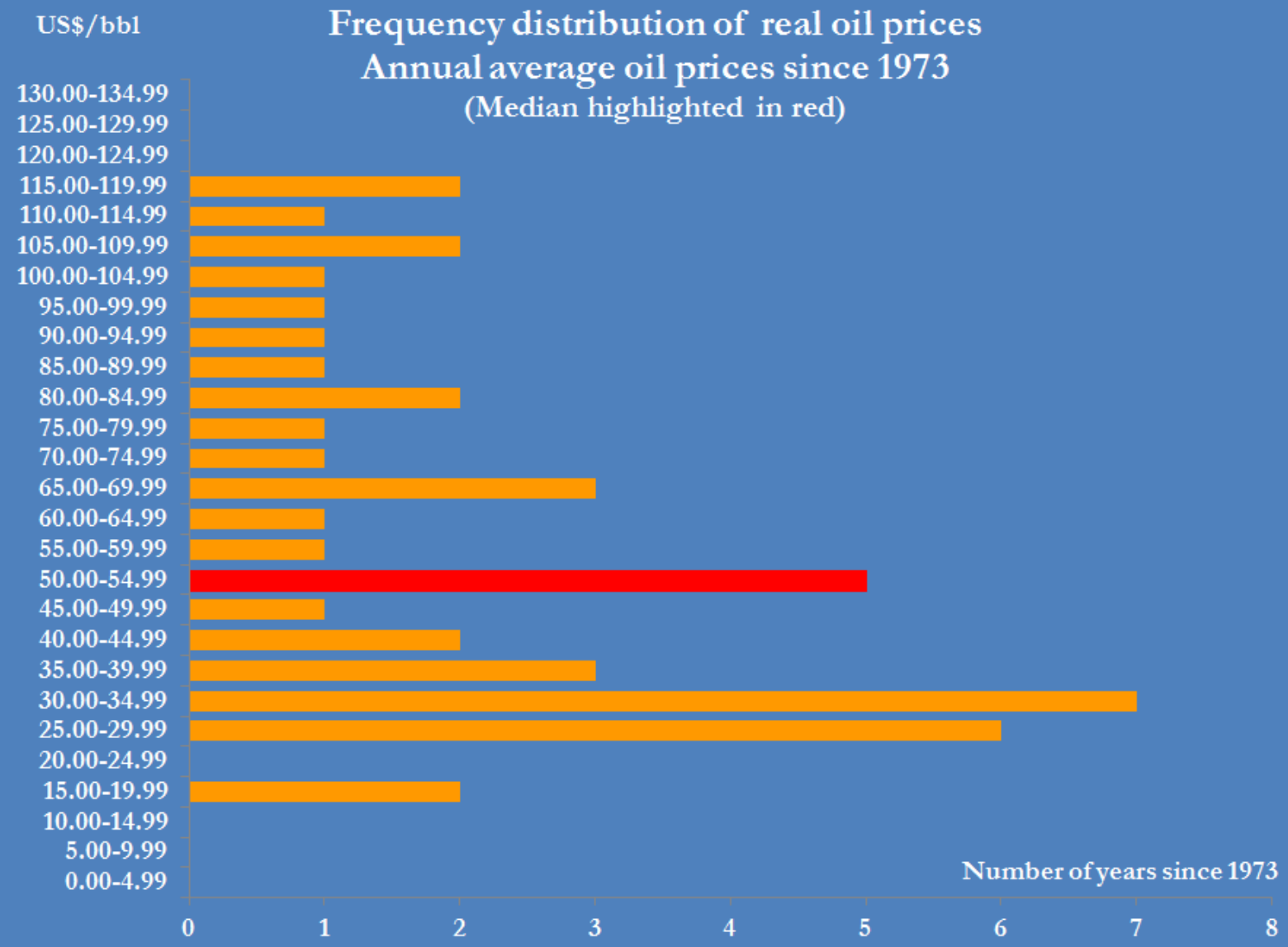
Distribution of real oil prices since the first oil shock in 1973



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History of the oil industry is one of continual boom and bust

"The problem of oil is that there is always too much or too little" (Oil: stabilization or conservation, Watkins, 1937)

"Hectic prosperity is followed all too swiftly by complete collapse" (Essentials of petroleum, Frankel, 1946)

"The basic feature of the petroleum industry ... that matters most is that it is not self-adjusting" (Frankel, 1946)

"The industry not being self-adjusting has an inherent tendency to extreme crises" (Frankel, 1946)

History of the oil industry is also one of attempts to tame the boom-bust cycle and stabilise prices without lasting success

Oil Creek Association (1861)

Petroleum Producers Association of Pennsylvania (1869)

Standard Oil (1870s-1910s)

Achnacarry /As-Is Agreement (1928)

Anglo-American Petroleum Agreement (1944)

Seven Sisters (1940s-1970s)

Texas Railroad Commission (1940s-1970s)

OPEC (1970s-2000s)

OPEC-plus (2010s-)

OPEC's founding statute committed it to price stabilization but it has had no more success than previous arrangements

"The Organization shall devise ways and means of ensuring the stabilization of prices in international oil markets with a view to eliminating harmful and unnecessary fluctuations"
(OPEC Statute, Art. 2B, 1960)

Volatility is THE defining characteristic of oil and other commodity prices

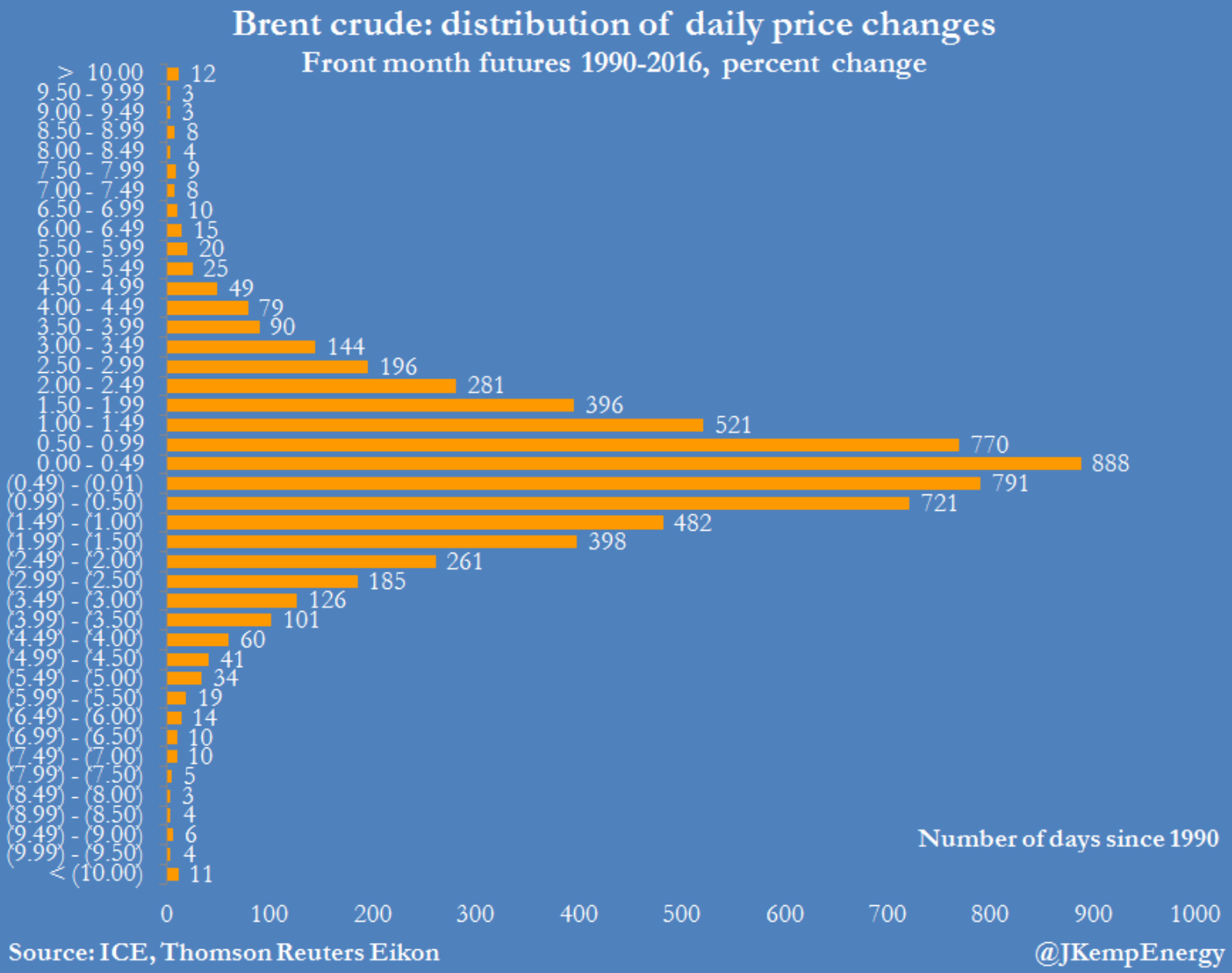
Oil prices are much more volatile than the price of manufactured goods or services (in this they resemble the price of other commodities)

Volatility is apparent at all time scales from the very short term (tick by tick and daily moves in futures prices) to the long term (years)

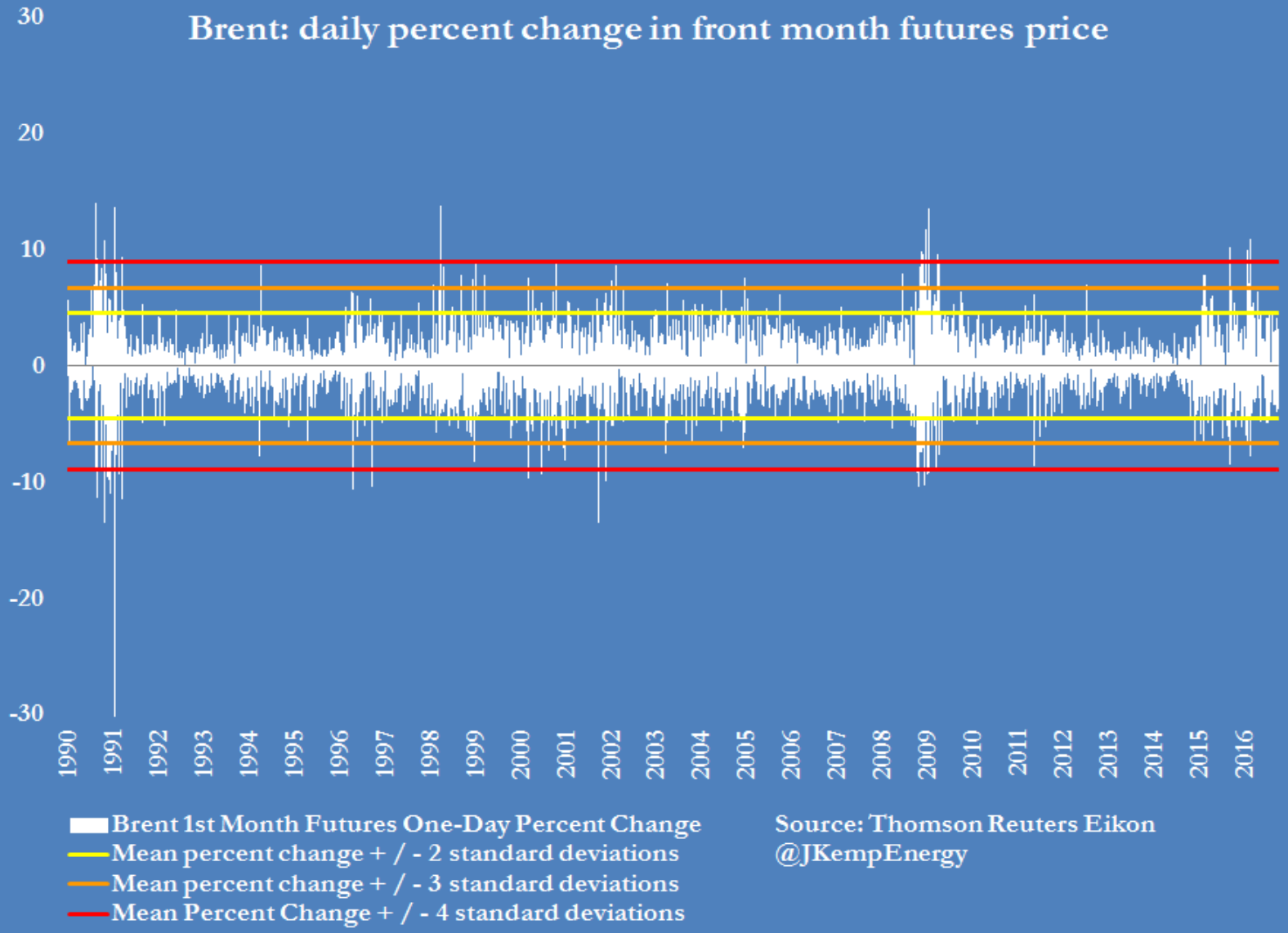
Price volatility is not an irritating incidental feature of oil markets that can be wished or managed away

Price volatility is a fundamental characteristic of the oil industry and oil markets

Daily price moves of +/- 5 percent or even 10 percent not uncommon



Oil prices are very volatile, but the "average" amount of volatility is itself volatile: the market alternates between calm and wild states



Multiple explanations for the volatility in oil prices (not exclusive)

Inflexibility of supply and demand in the short term (low price elasticity of supply and demand)

Backward-looking expectations about future prices coupled with lumpiness in capital investment (cobweb theories)

Positive and negative feedback mechanisms

Complex systems with chaotic behaviour

(1) Low price-elasticity: price changes have little impact on demand and production in the short run: the industry is not "self-adjusting"

Price elasticity of oil demand is low. Few substitutes for oil as a transport fuel or in petrochemicals (oil did have substitutes in the heating market but largely lost its place there after the oil shocks)

"On the demand side there exist few of the acknowledged automatic safeguards against rapid and extensive fluctuations in prices, which can easily be driven sky-high or knocked down to a fraction of the previous level without much relief from an expanding or narrowing market" (Frankel, 1946)

Price elasticity of oil supply is low . Oil is capital intensive. High ratio of fixed to variable costs in exploration, production, refining and marketing

Very large price moves needed to rebalance supply and demand

(2) Cobweb models: delays in adjusting production and investment coupled with backward-looking component in price expectations

Cyclical behaviour of oil prices can be explained by delays in adjusting production and investment (supply lags) combined with expectations about future prices based on current and past prices (adaptive expectations)

Oil investment held back during 2000-2008 by painful memories of the long slump in 1990s as well as lack of experienced personnel after 1990s layoffs

Boom 2010-2014 was based on the assumption oil prices would remain at high levels prevailing in 2010-2014 which led to investment in uneconomic plays

Changes in investment and production take a long time. Ten years or more to train an experienced driller or seismologist or bring a complex offshore field onstream

Layoffs from the 1990s are still impacting industry's skill base in 2010s

(3) Feedback mechanisms operate in oil markets and can delay as well as accelerate process of adjustment

Oil industry is characterised by a multiple feedback loops

Initial conditions  Outcomes

Negative feedback loops dampen impact of an initial change and are therefore stabilising and promote rapid return to "equilibrium"

Positive feedback loops amplify the impact of an initial change and are therefore destabilising and delay return to "equilibrium"

Feedback concept was popularised by communications experts at Bell Telephone Laboratory in the 1920s

Long (implicit) history in economics: Adam Smith's "invisible hand" and David Hume's "price-specie-flow" mechanism are both instances of negative feedback loops

Examples of feedback mechanisms acting on oil supply and demand

	Supply-side	Demand-side
Negative feedback mechanisms (promote return to balance)	Capital budgets Cash flow Equity finance Debt finance	Fuel switching Fuel efficiency Energy conservation policy GDP impact in oil-consuming countries
Positive feedback mechanisms (delay return to balance)	Producers' revenue needs Labour costs Raw material costs Services contract adjustments Fiscal terms (taxes and royalties)	GDP impact in oil-producing countries Fuel consumption within the oil industry (drilling, refining, transportation) Fuel consumption throughout the oil supply chain (service companies and other suppliers)

Feedback mechanisms have a complicated and dynamic impact on oil prices and markets

Feedback can introduce an element of non-linearity into oil prices which makes them hard to forecast over anything other than short time horizon

Small initial disturbances in supply or demand balance can trigger very large adjustments in supply-demand-prices

Feedback loops operate at different timescales, in some cases with a long lag, so the balance between them varies over time

Short term: positive feedback loops can dominate, adding to instability and delaying process of adjustment

Long term: negative feedback mechanisms must dominate (there are no instances where oil prices have risen/fallen without limit)

(4) Oil markets can be analysed as complex systems

Useful to think of oil industry and markets as a system

Systems can usually be analysed as a set of sub-systems

No such thing as "the oil market"

Series of closely related markets for crude, fuels, refining, oilfield services, engineering, construction, drilling equipment, skilled labour, raw materials etc

Many markets exhibit low price elasticity, decision-making and supply lags, backward-looking expectations and feedback loops

Each market is subject to its own feedback mechanisms, operating at difference speeds/timescales, with a constantly challenge balance

Balancing "the oil market" actually means balancing all of these markets simultaneously

Oil markets are complex systems and can exhibit chaotic behaviour

Complex systems can be defined as "large networks with no central control and simple rules of operation that give rise to complex collective behaviour, sophisticated information processing and adaptation via learning or evolution" (Complexity: a guided tour, Mitchell, 2009)

Complex systems can exhibit very dynamic and non-linear responses with small initial disturbances producing large changes in outcomes

Complex systems can exhibit chaotic behaviour where a small change in the initial conditions results in a disproportionately large change in outcomes

Complexity, non-linearity, feedback mechanisms and chaotic behaviour make oil prices very hard to forecast beyond the very short term

Stabilising oil markets is impossible in practice

Every attempt to stabilise oil markets has ultimately failed though some have achieved success for a while

Coordination problem #1: too many oil producers

Coordination problem #2: too many different markets

Coordination problem #3: too much information required

Forecasting current and future supply and demand conditions across so many markets (crude, fuels, refining, oilfield services, engineering, raw materials, experienced labour), reacting to unexpected shocks and anticipating all the feedback mechanisms is next to impossible

Oil markets solve the problem through price signals. Successful oil market stabiliser would need to collect vast amounts of accurate information and have an enormous amount of forecasting power and accuracy to substitute for them

Can we really forecast future oil prices? Probably not ...

In principle oil prices should be forecastable given accurate information about (a) current supply and demand, (b) an understanding of feedback and adjustment mechanisms, and (c) an ability to forecast or guess future shocks

In practice, oil price forecasts are severely hampered by:

Data collection and analysis problems

Poor understanding of price elasticities

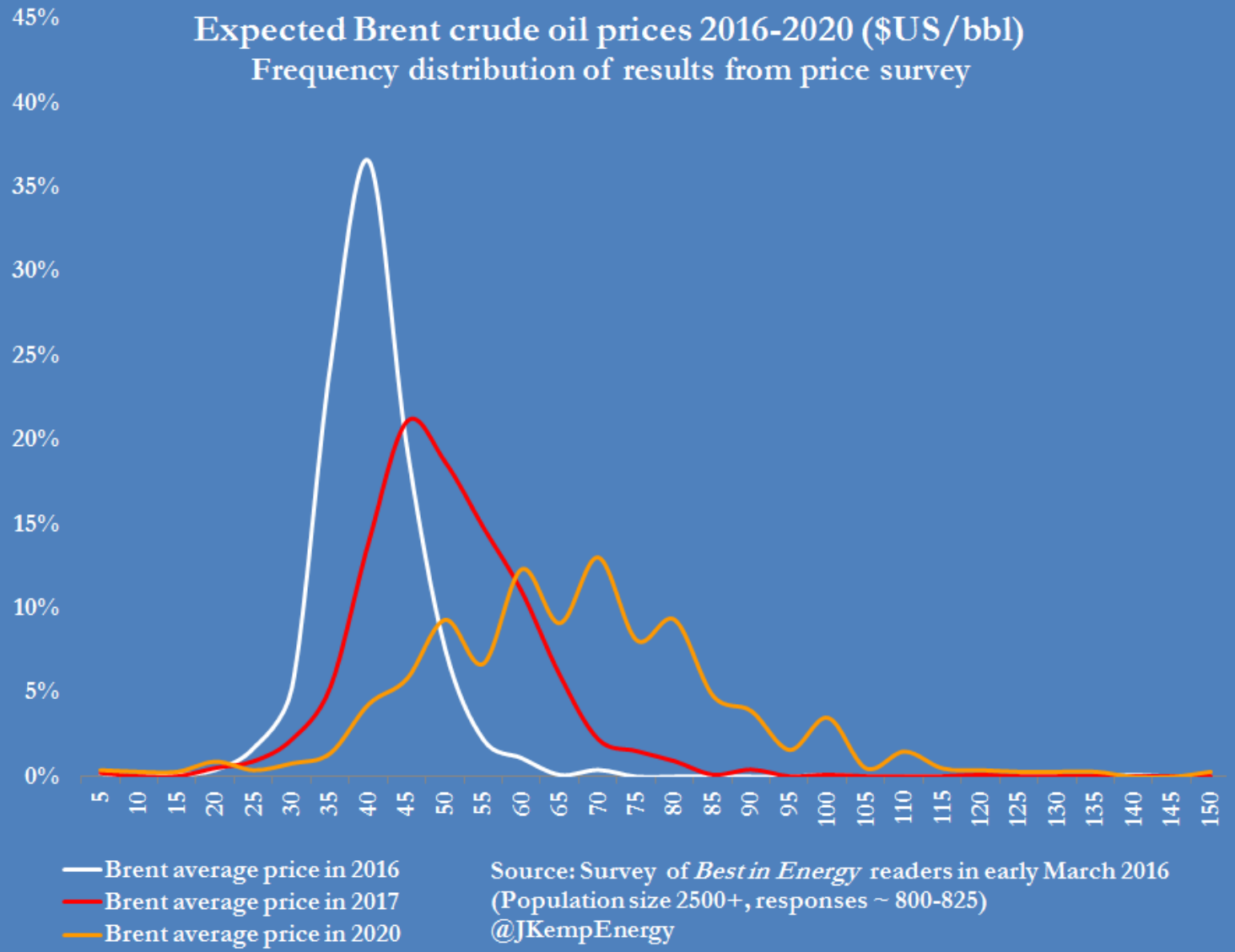
Behavioural changes

Non-linear responses

Feedback mechanisms

Macroeconomic cycle

Expectations about future oil prices (survey conducted in Mar 2016)
Forecasts become much more diverse over longer time horizons



Oil outlook survey 2016-2020

Survey sent to 2500+ recipients on daily best in energy circulation list

Full or partial responses from 830

Survey conducted between Mar 1 and Mar 6, 2016

Forecast	Number of respondents expecting avg. price of Brent in US$/bbl to be																			
Year	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
2016	2	0	1	3	14	44	202	303	162	63	18	9	1	3	0	0	0	0	0	1
2017	2	0	0	4	7	18	43	112	170	151	119	89	48	18	12	7	1	3	0	1
2018	2	1	1	2	4	15	19	62	76	115	89	136	88	79	41	37	14	8	1	7
2019	2	1	2	3	4	8	22	34	54	95	65	110	93	103	55	63	26	24	9	16
2020	3	2	2	7	3	6	11	34	46	74	53	98	72	103	64	74	38	31	13	28

Forecast	Number of respondents expecting avg. price of Brent in US$/bbl to be											
Year	105	110	115	120	125	130	135	140	145	150	155	160
2016	0	0	0	0	0	0	0	1	0	0	0	0
2017	0	0	0	1	0	0	0	0	0	0	0	0
2018	2	2	0	2	1	0	0	0	0	1	1	0
2019	3	2	1	4	0	1	0	1	0	1	0	0
2020	4	12	4	3	2	2	2	0	0	2	0	1

Response rate		
	Total Response	No Response
2016	827	3
2017	806	24
2018	806	24
2019	802	28
2020	794	36

Dispersion measures (US$/bbl)					
	2016	2017	2018	2019	2020
5th percentile	30	35	35	35	40
10th percentile	35	40	40	45	45
25th percentile	35	45	50	50	55
75th percentile	45	55	65	75	80
90th percentile	50	65	75	85	90
95th percentile	50	70	80	90	100
Standard deviation	7.9	11.2	15.7	17.4	20.2

Central tendency (US$/bbl)					
	2016	2017	2018	2019	2020
Mode	40	45	60	60	70
Median	40	50	60	65	65
Mean	40.4	50	58.4	63.3	67

Futures prices (U.S.$/bbl)					
	2016	2017	2018	2019	2020
Fut. strip (1 Mar 2016)		43.9	46.6	48.5	50.2

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Dealing with oil price volatility: better price forecasting or focus on flexibility and coping?

Exxon Mobil Chief Executive Rex Tillerson (2 March 2016):

"We've never been any good at predicting these [price] cycles, neither when they occur nor their duration. We don't spend a lot of time even trying.

"How the future is going to look, we take no particular view on it, other than to recognize that whatever it is today it will be different sometime in the future, and after that it will be different again.

"In my nearly 41 years [with Exxon], that's been my experience. I didn't learn anything about my ability to foresee that. I learned a lot about how you deal with it"

Conclusions

Volatility is an inherent characteristic of oil markets

- Low price elasticity of supply and demand
- Delays in adjusting investment and output
- Multiple feedback loops operating at various timescales
- Multiple markets that all adjust at different speeds
- Complex behaviour and chaos

Stabilisation efforts have repeatedly failed

- Too many producers
- Too many markets
- Too much data needed

Price forecasts deteriorate beyond very short term

- No evidence of successful multi-year prediction

Success in the oil business depends on building in flexibility, optionality and diversity