Long-Term Oil Price Forecasting

ASIA PACIFIC ENERGY RESEARCH CENTRE

Annual Conference, Advisory Board Meeting and Joint Symposium with IEEJ 2020

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General Introduction

THE WORLDS OF FINANCIAL AND ENERGY TRADING HAVE 'FUSED', RESULTING IN THE DEVELOPMENT OF A GIGANTIC $1.44 QUADRILLION GLOBAL MARKETPLACE.

IT IS A MARKET, FRAUGHT WITH UNCERTAINTY IN THE AFTERMATH OF THE CORONAVIRUS, AND INTERNATIONAL TRADE WARS. NOW, MORE THAN EVER, THE GLOBAL POWER AND GAS INDUSTRIES HAVE BEEN EXPOSED TO ECONOMIC UNCERTAINTY, AND REGULATORY CONCERNS.

SOURCE: HTTPS://WWW.INVESTOPEDIA.COM/ASK/ANSWERS/052715/HOW-BIG-DERIVATIVES-MARKET.ASP

BIG OIL
The oil market is bigger than all raw metal markets combined

Oil $1,720B

The global market for oil was 94 million barrels per day in 2015.

This puts the oil market at $1.7 trillion per year with today's prices - far more than all raw metals combined!

Molybdenum $5B
Zinc $34B
Copper $91B
$3B Lithium
$4B Uranium
Manganese $30B
$5B Rare Earths
Aluminum $90B
Lead $22B
$15B Graphite
Nickel $21B
Tin $7B
Iron $115B
Gold $170B
Titanium $14B
Silver $20B
$8B Platinum
$6B Palladium

The largest metal market by tonnage is iron ore.
China alone consumes 1 billion tonnes per year mostly to produce steel.

The world's largest metal market by dollar value is gold.
The physical market is worth $170 billion per year at today's spot price.

SOURCES: Infomine, EIA, World Gold Council, Johnson Matthey, Cameco, Benchmark Minerals

visualcapitalist.com

"Diminishing returns are opposed by increasing knowledge, both of the earth's crust and of methods of extraction and use. The price of oil, like that of any mineral, is the uncertain fluctuating result of the conflict."

Morris A. Adleman The Economics of Petroleum Supply, 1993

"Oil Industry 'Sleepwalking into crisis' - former Shell chairman Lord Oxburgh says that diminishing resources could push price of crude to $150 a barrel'

Independent, 17th September 2007
Brent @ $78.00 Prices rose to $142.00 in July 2008

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"Oil ruled the 20th century; the shortage of oil will rule the 21st. There is now no doubt about the rising trend of oil prices."

William Rees Mogg, The Times, 16th July 2007 Brent @ $78.00 Prices have fallen to $56.55 in February 2020

More than one Oil Price

**Basis and Differentials:** More than One Oil Price Around the World

No Perfect Benchmark – Regional dynamics (supply/demand) and various other issues impact each benchmark

Primary Pricing Factors:
Crude Quality – API Gravity (light/medium/heavy), sulfur, refined product yield, cost to process
Geography and Transportation – cost of transporting the marginal barrel to its end-market
(Key crude oil benchmarks)

| Light |
| Medium |
| Heavy |

| ANS |
| Alaska |
| API: 31.9 |
| Sulfur: 0.93% |
| $110.16 |

Syncrude	WCS
Alberta	Alberta
API: 33	API: 20.3
Sulfur: 0.05%	Sulfur: 3.43%
$106.86	$84.41

Bakken (MN)	WTI
Clearbrook	Cushing, OK
API: 39	API: 38.7
Sulfur: 0.18%	Sulfur: 0.45%
$98.76	$103.90

LLS	Mars	Maya
US Gulf	US Gulf	US Gulf
API: 36.4	API: 28.9	API: 20.5
Sulfur: 0.13%	Sulfur: 2.05%	Sulfur: 3.13%
$105.51	$100.26	$94.79

| Brent |
| North Sea |
| API: 37.9 |
| Sulfur: 0.45% |
| $109.60 |

| Saharan Bl |
| Algeria |
| API: 37.9 |
| Sulfur: 0.45% |
| $109.60 |

| Urals (Med) |
| Russia |
| API: 31.6 |
| Sulfur: 1.3% |
| $109.28 |

Daqing	ESPO
China	Russia
API: 32.2	API: 34.5
Sulfur: 0.11%	Sulfur: 0.62%
$112.47	$112.08

| Tapis |
| Malaysia |
| API: 44.6 |
| Sulfur: 0.03% |
| $116.16 |

Arab X-Lt	Arab Lt	Arab Heavy
Saudi Arabia	Saudi Arabia	Saudi Arabia
API: 38.4	API: 32.5	API: 27
Sulfur: 1.16%	Sulfur: 1.8%	Sulfur: 2.8%
$110.13	$108.18	$103.43

Oman	Dubai
Oman	UAE
API: 33	API: 30.4
Sulfur: 1.11%	Sulfur: 2.13%
$109.98	$106.63

| Cerro Negro |
| Venezuela |
| API: 16 |
| Sulfur: 3.34% |
| $96.34 |

Qua Ibo	Bonny Lt
Nigeria	Nigeria
API: 35.2	API: 38.2
Sulfur: 0.12%	Sulfur: 0.15%
$110.13	$109.98

| Forcados |
| Nigeria |
| API: 31 |
| Sulfur: 0.3% |
| $111.49 |

| Cabinda |
| Angola |
| API: 32.5 |
| Sulfur: 0.13% |
| $107.49 |

Minas	Duri
Indonesia	Indonesia
API: 34	API: 20.8
Sulfur: 0.09%	Sulfur: 0.2%
$114.74	$107.04

Top 10 Crude Oil Producing Country
Latest pricing data as of April 16,2014

Source: Bloomberg, Morgan Stanley Commodity Research

Morgan Stanley

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What Drives Crude Oil Prices?

The three factors affecting crude oil are:

- Supply,
    - supply is predicted from past production data and reserve data
- Demand,
    - demand forecasts are usually made from GDP, exchange rates and domestic prices and
- Future Supply
    - Reserves, and Inventories

Source: https://www.eia.gov/finance/markets/crudeoil/, September 12, 2020

Methods of Forecasting Crude Oil Prices

Quantitative Methods
- Econometric Models
  - Time Series Models
  - Financial Models
  - Structural Models
- Non-Standard Methods
  - Artificial Neural Networks
  - Support Vector Machines

Qualitative Methods
- Delphi Method
- Belief Networks
- Fuzzy Logic
- Expert Systems

Source: Behmiri and Manso, 2013, Crude Oil Price Forecasting Techmiques: A Comprenensive Review of Literature,. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2275428, September 12, 2020

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Methods of Forecasting Crude Oil Prices

What is Artificial Neural Networks?

A neural network is a group of connected I/O units where each connection has a weight associated with its computer programs. It helps you to build predictive models from large databases. This model builds upon the human nervous system. It helps you to conduct image understanding, human learning, computer speech, etc.

What is Backpropagation?

Back-propagation is the essence of neural net training. It is the method of fine-tuning the weights of a neural net based on the error rate obtained in the previous epoch (i.e., iteration). Proper tuning of the weights allows you to reduce error rates and to make the model reliable by increasing its generalization.

Backpropagation is a short form for "backward propagation of errors." It is a standard method of training artificial neural networks. This method helps to calculate the gradient of a loss function with respects to all the weights in the network.

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Methods of Forecasting Crude Oil Prices

What is Backpropagation?

1. Inputs X, arrive through the preconnected path

2. Input is modeled using real weights W.

3. The weights are usually randomly selected.

4. Calculate the output for every neuron from the input layer, to the hidden layers, to the output layer.

5. Calculate the error in the outputs

Error= Actual Output – Desired Output

5. Travel back from the output layer to the hidden layer to adjust the weights such that the error is decreased.
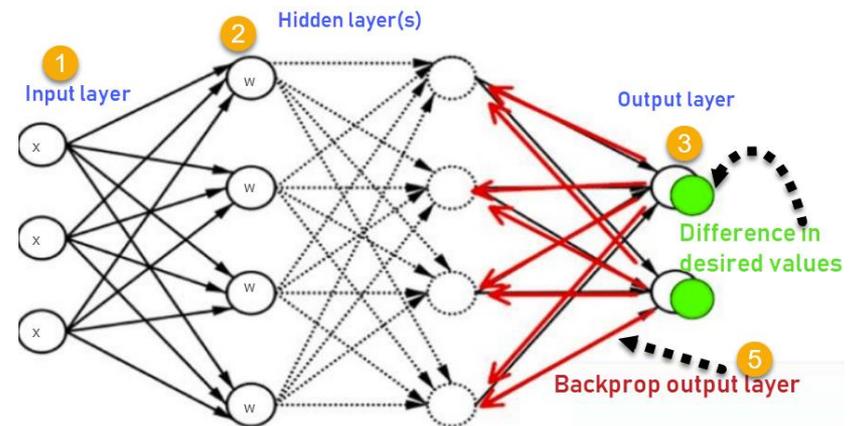
A quick look at some of the results….

Financial Models

Forward curves have certainly not been excellent predictors of spot prices.

It's also easy to see that the forward curves at any point in time often share a relatively consistent slope, which is primarily due to some of the factors listed above, and does not represent a true spot price forecast.

This especially apparent throughout 2015, where the forward curves moved down in a parallel fashion as spot prices fell throughout the year.

WTI Spot Oil Price & Futures (USD/bbl)
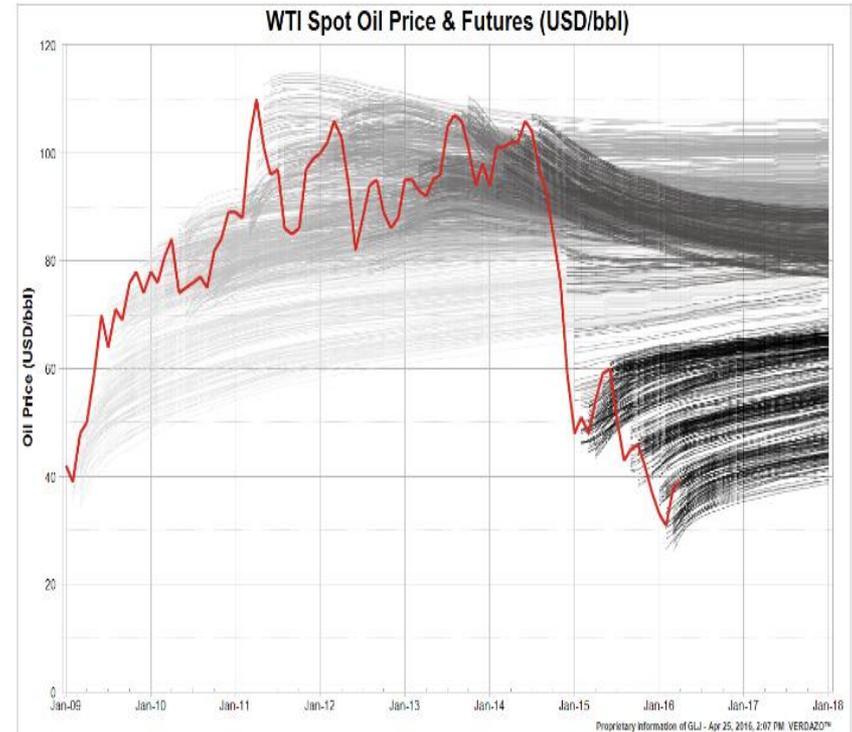
Sources: https://www.investopedia.com/ask/answers/062315/how-are-commodity-spot-prices-different-futures-prices.asp, https://www.verdazo.com/blog/forward-curves-are-a-poor-predictor-of-future-spot-prices/Husky Energy Market View 2020.

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A quick look at some of the results....

Artificial Neural Networks vs Financial Models

In this example a single hidden layer BP neural network model was established to train WTI oil prices from 2003 to 2015, and forecast the 2016 oil price.

Similarly, an ARIMA model was fitted to WTI oil prices from 2003 to 2015, and used to forecast the 2016 oil price

The main factors influencing WTI for both models:
1. world crude oil demand,
2. the world crude oil supply,
3. the U.S. Cushing crude oil inventory and
4. the US dollar index.
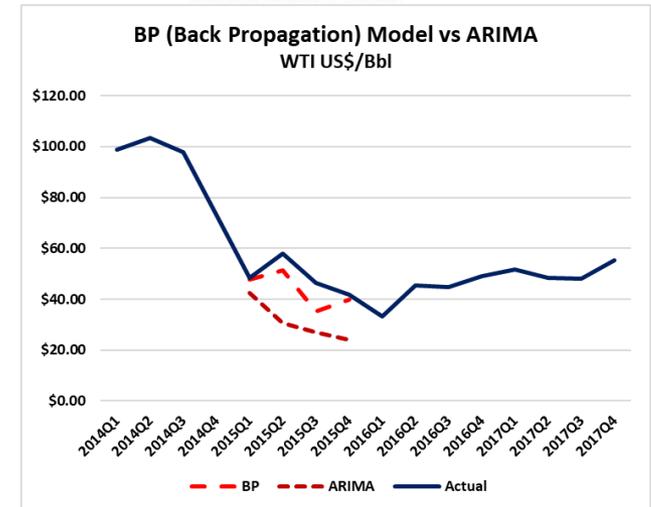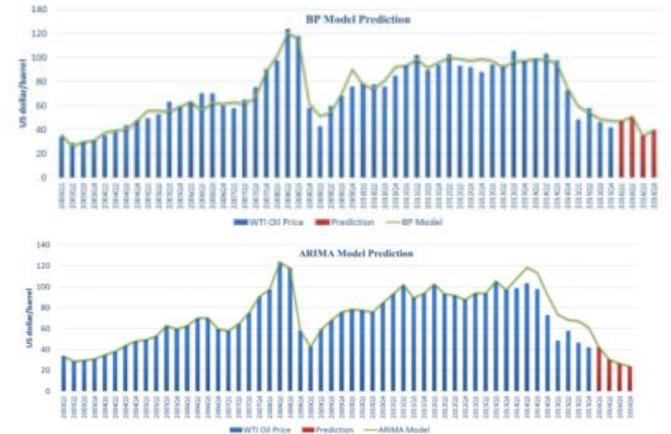
A quick look at some of the results….

Belief Networks

Despite their underlying sophistication, belief networks are conceptually simple. Any directed acyclic graph in which:

(i)   nodes represent individual variables, items, characteristics, or knowledge sources,

(ii) arcs demonstrate influence among the nodes, and

(iii) functions associated with the arcs indicate the nature of that influence,

qualifies as a belief network.

The oldest, simplest, and best understood networks - decision trees - have been studied extensively in many settings, including financial forecasting .

Belief Network Forecast of Oil Prices
WTI US$/Bbl

- - - Belief Network 1989 Data
—— Belief Netgwork updated with July 1990 data
—— Actual
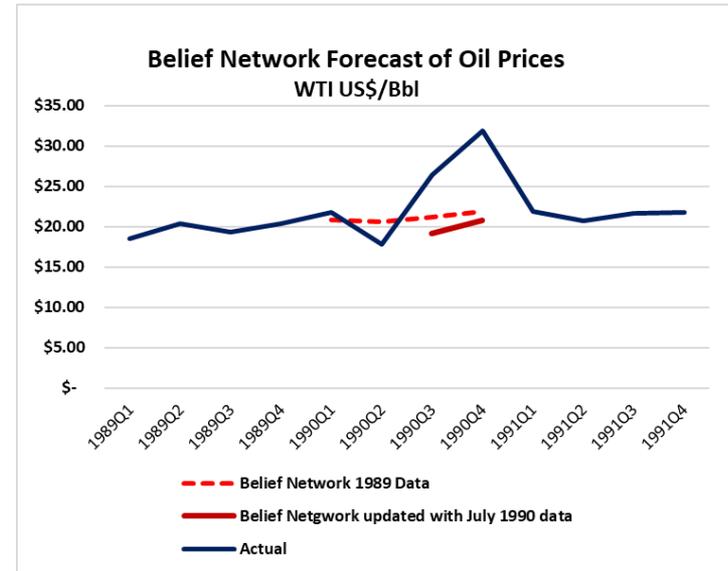
Historical Variables for 1989 used in the base case:
- Demand
- US Production
- Other Non OPEC production
- Normal Inventory Change

Exogenous Variables used in the base case:
- World GDP growth
- Gas tax increase
- Delta Inventory
- Core OPEC capacity
- Non-Core OPEC

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Source: Abramson, B,and Finizza A., Using Belief Networks to Forecast Oil Prides, International Journal of Forecasting, (7) , 1991.

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A quick look at some of the results....

Structural Models

CERI World Oil Market Model

The CERI WOMM consists of two primary components:

(i) World Oil Demand Model
  (i) Bottom up methodology
  (ii) Forecast the demand for petroleum products given local product prices and economic growth rates
(ii) World Oil Supply Model.
  (i) Drilling activity sub-model
  (ii) Reserve additions sub-model
  (iii) Production sub-model
  (iv) Cost sub-model

Battle for Market Share:

World Oil Market Projections, 1995 - 2010

Jennifer I. Considine   Anthony E. Reinsch

Canadian Energy Research Institute

Study No. 65
September 1995
ISBN 1-896091-08-3

The motivation was to provide an integrated forecast of either:
1) World Oil Prices given OPEC production, or
2) OPEC production given a desired level of world oil prices.

Source: After the Crisis: World Oil Market Projections 1991-2006, CERI August, 1991.

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A quick look at some of the results….
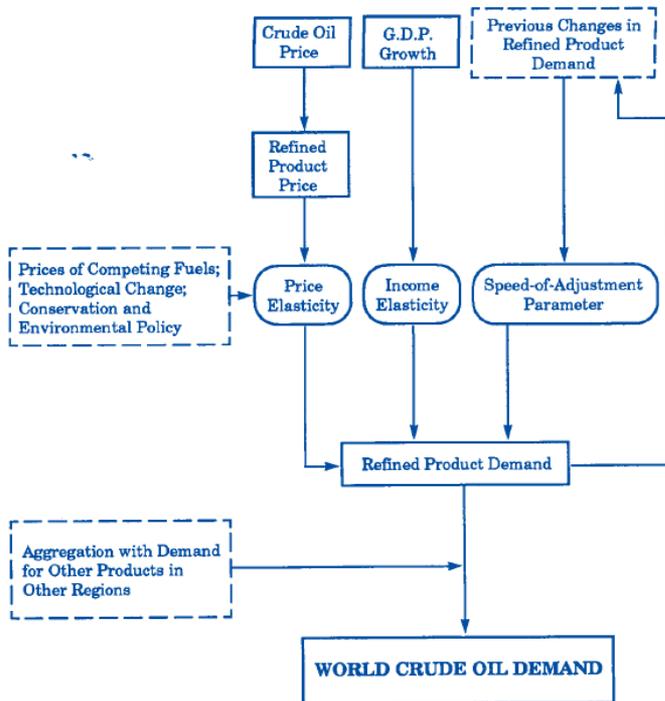
**Structural Models**

CERI World Oil Market Model
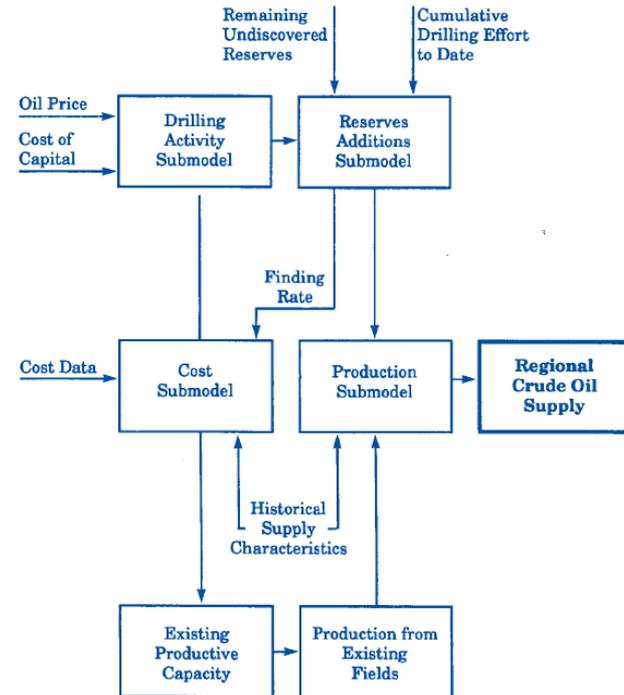
Source: After the Crisis: World Oil Market Projections 1991-2006, CERI August, 1991.

# A quick look at some of the results….

Structural Models

CERI World Oil Market Model

THE PRICE PROJECTION MODE OF THE WORLD OIL MARKET MODEL
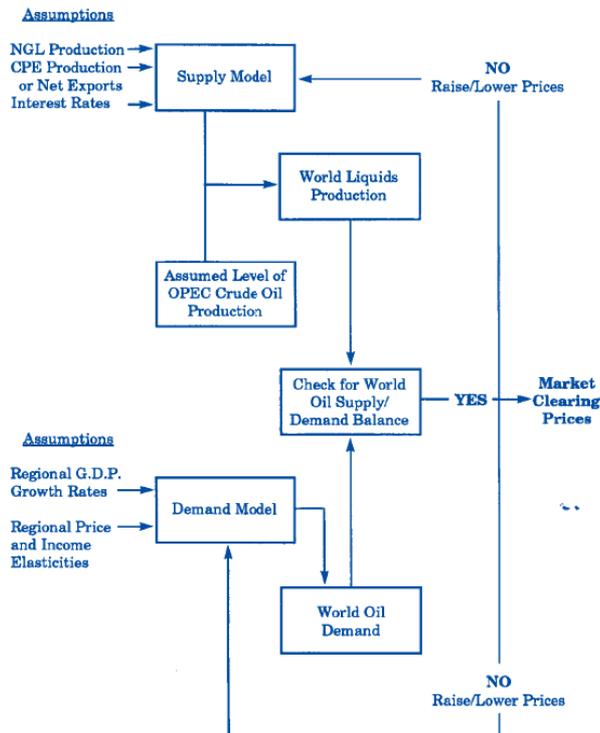
THE OPEC PRODUCTION MODE OF THE WORLD OIL MARKET MODEL
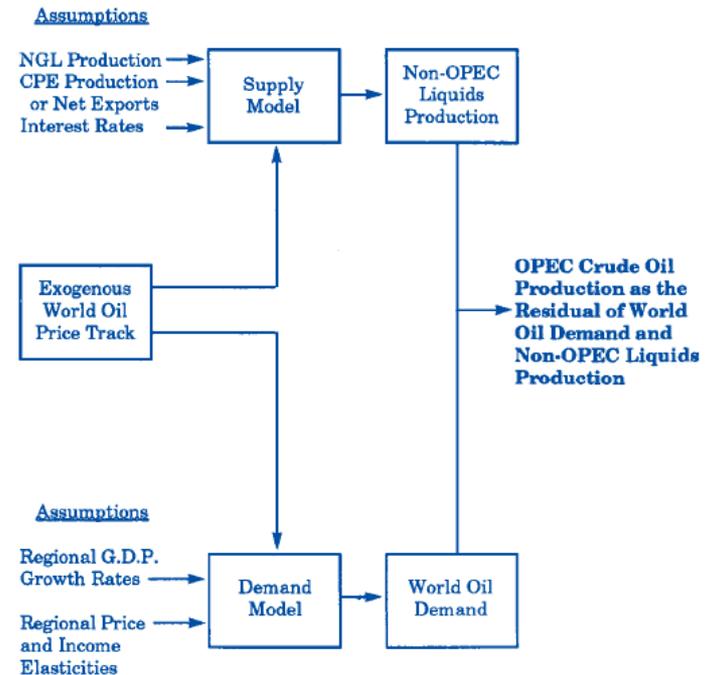
Source: After the Crisis: World Oil Market Projections 1991-2006, CERI August, 1991.

A quick look at some of the results….

Structural Models

CERI World Oil Market Model

Source: After the Crisis: World Oil Market Projections 1991-2006, CERI August, 1991.

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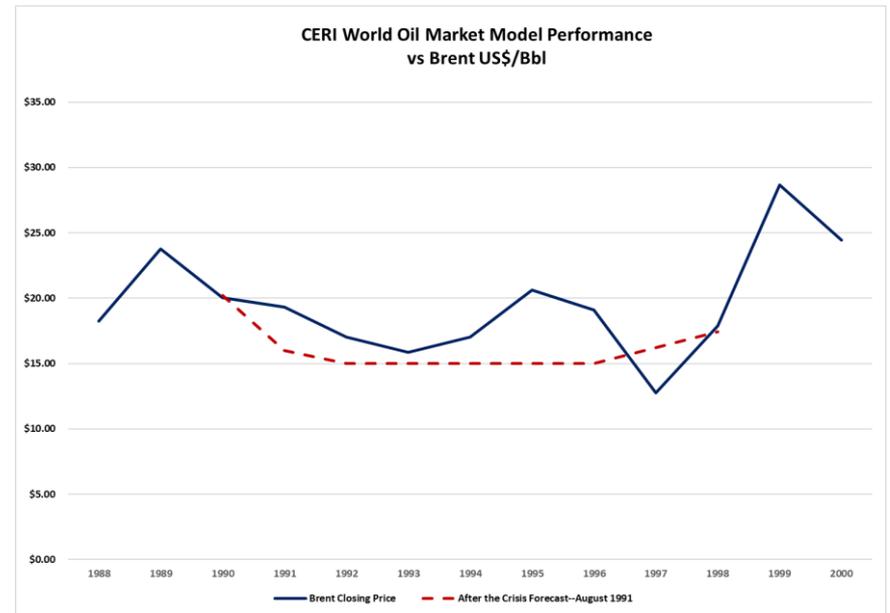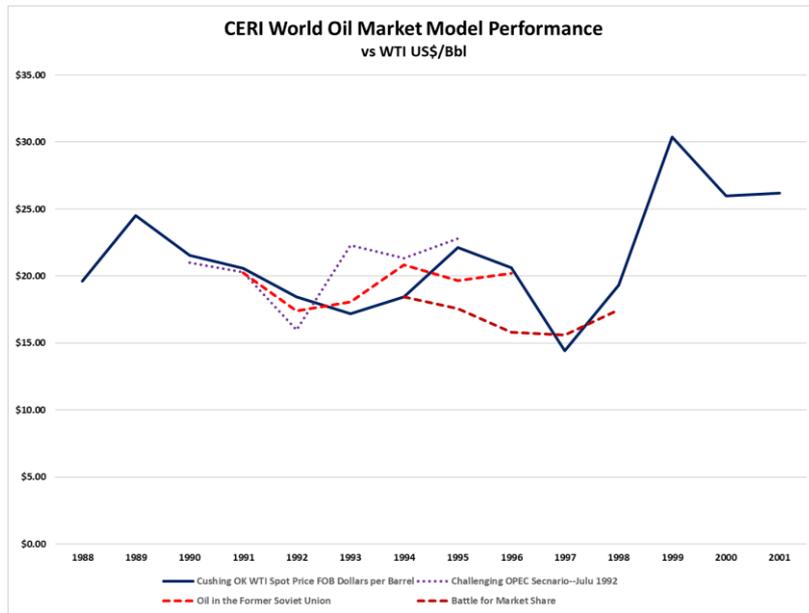
History of Crude Oil Prices

History of crude oil prices
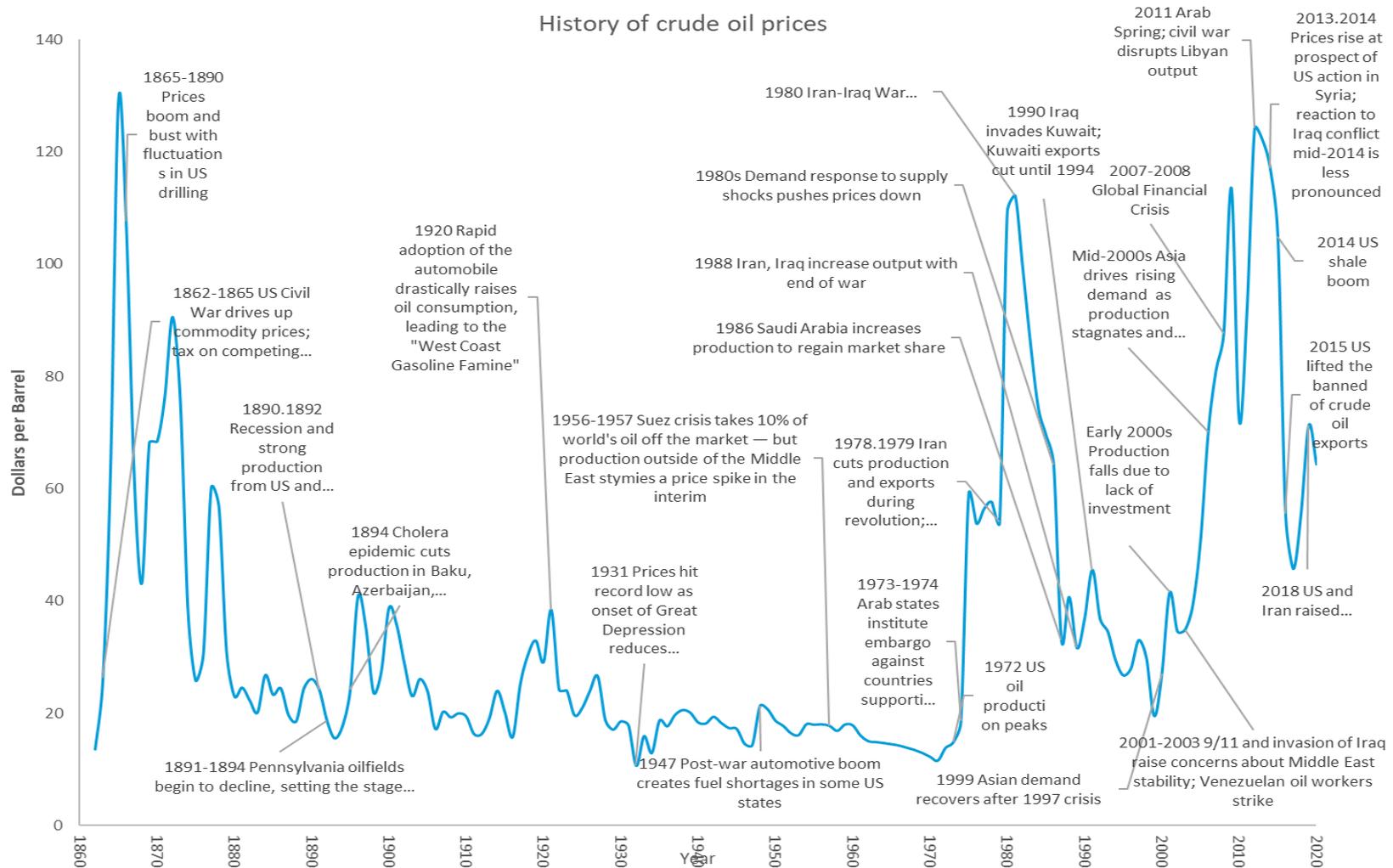
Data Sources and Management....

Sophisticated data sources and algorithms require new tools to forecast the real price of oil.

- First, even preliminary data often become available only with a lag. For example, it may take months for the first estimate of this month's global oil production to be released.

- Second, the initial data releases are continuously revised. It takes successive data revisions until we know, to the best of our ability, the true level of oil production in the current month. Little is known about the nature of these revisions in oil market data or about how data revisions and delays in data availability affect the out-of-sample accuracy of oil price forecasts.
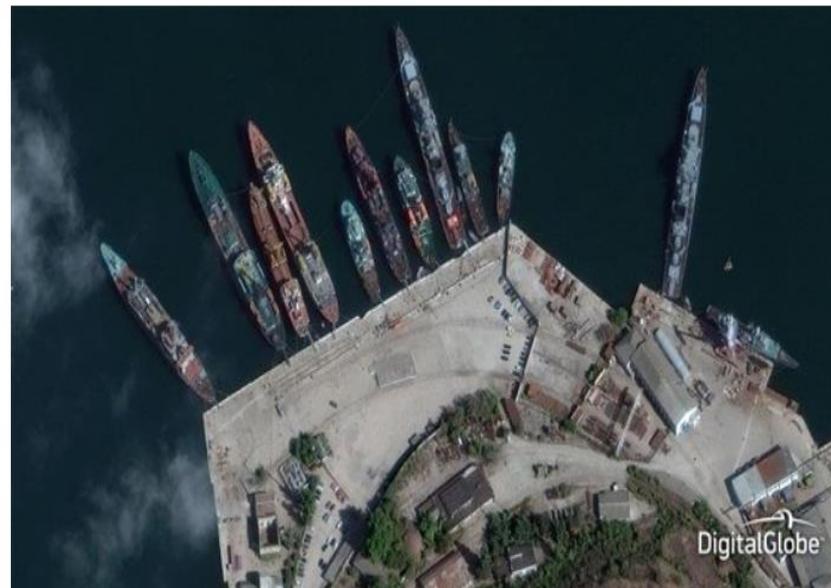

Image shared by Digital Globe now MDA, taken by Worldview-3, which shows cars near the dock as well as the material sitting on the decks of ships in the Crimean port of Sevastopol.

Source: https://voxeu.org/article/forecasting-oil-prices-real-time, September 13, 2020.

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Data Sources and Management….

Economics

Insights into macro-level economic trends:

- Country risk scores
- Predictive analytics of geopolitical risk
- Individual economist estimates

Energy

Specialized insights into energy markets:

- Fixtures and cargo agreements
- Hydraulic fracturing, proppant and stimulation chemicals
- Oil storage capacity, sourced from satellites
- Natural gas flows
- Global vessel tracking

Alternative Data
Bloomberg Professional Services

Source: https://voxeu.org/article/forecasting-oil-prices-real-time, September 13, 2020.

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Questions
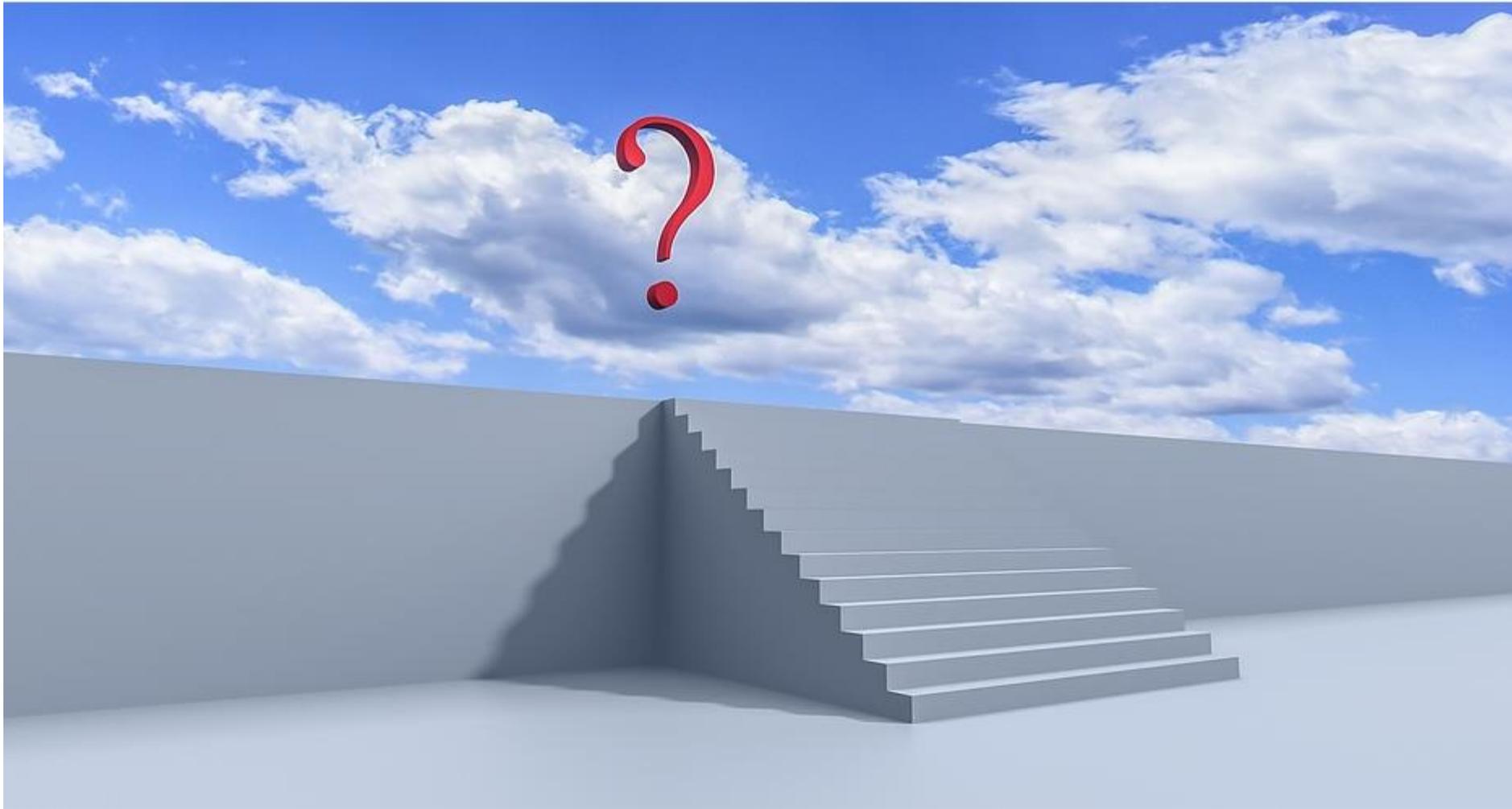
# What Constitutes a World Oil Shock?

Little is known about the actual quantitative value, or cost to society, of oil price shocks.

The potential consequences of any specific political or economic disturbance are unclear and would appear to depend on the market conditions existing at the time of forecast, and the exact nature of the supply shock.

Coronaviruses?
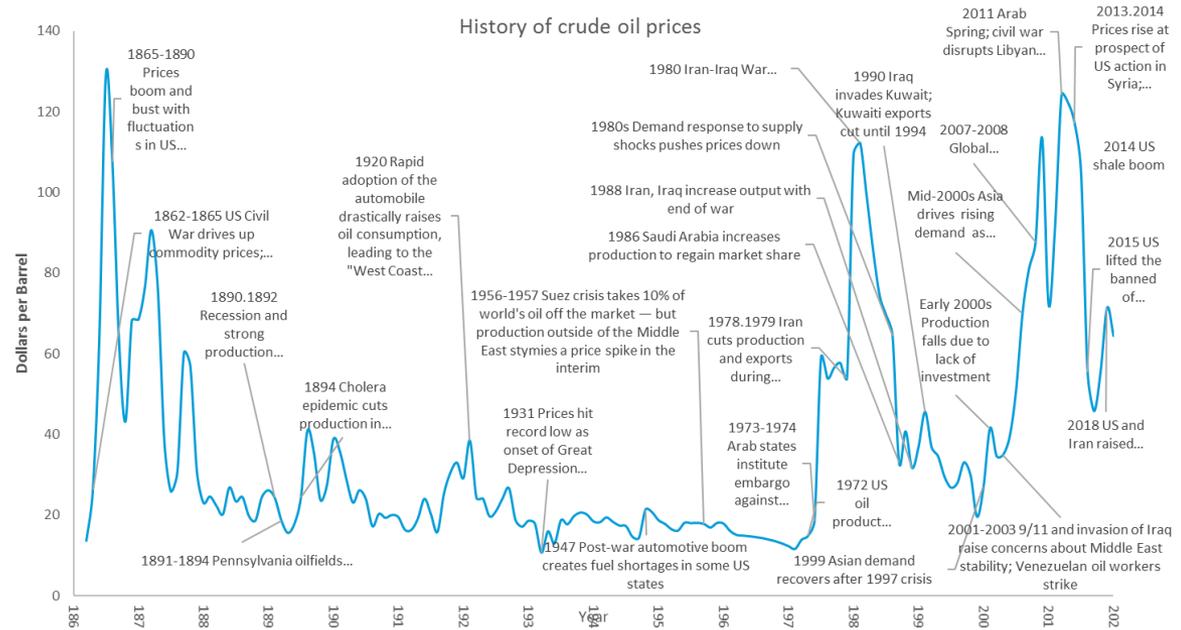
History of crude oil prices

What Constitutes a World Oil Shock?

In fact, the source of market disturbance, and state of the market at the time of analysis are significant factors in the determination of the real consequences of an oil price shock.

Surplus inventories and a significant reduction in crude oil prices can lead to a decline in the value of oil producing assets, depressed economic activity, even social unrest in producing nations.

Ample conflicts, little response
Brent crude oil prices, $/bbl

- Ukraine/Russia conflict
- IS/Iraq conflict
- Israel/Hamas conflict

Anti-government protests in Ukraine turn fatal.

Russia issues deadline for Ukrainan surrender of Crimea.

Crimean residents vote overwhelmingly to join Russia in referendum.

Ukrainian presidential election.

IS militants move across Syrian border into Iraq's Anbar province, seizing Fallujah.

IS launches recent round of offensives.

IS seizes Mosul.

Three Israeli youths go missing in the West Bank.

Battle for Iraq's largest refinery, Baiji; Obama says US is prepared to send up to 300 military advisers to Iraq.

IS declares a caliphate in Iraq and Syria.

Malaysian Airlines jet shot down; Israel launches ground operation in Gaza.

Youths' bodies found; Israeli leaders blame Hamas.

A Palestinian youth is killed in Jerusalem.

Israel launches first major offensive into Gaza since 2012.

Egyptian ceasefire proposal fails.

Source: Goldman Sachs Global Investment Research, various news sources.

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