Methods of Modeling World Oil Market using World Economic Dynamics (WED) Model
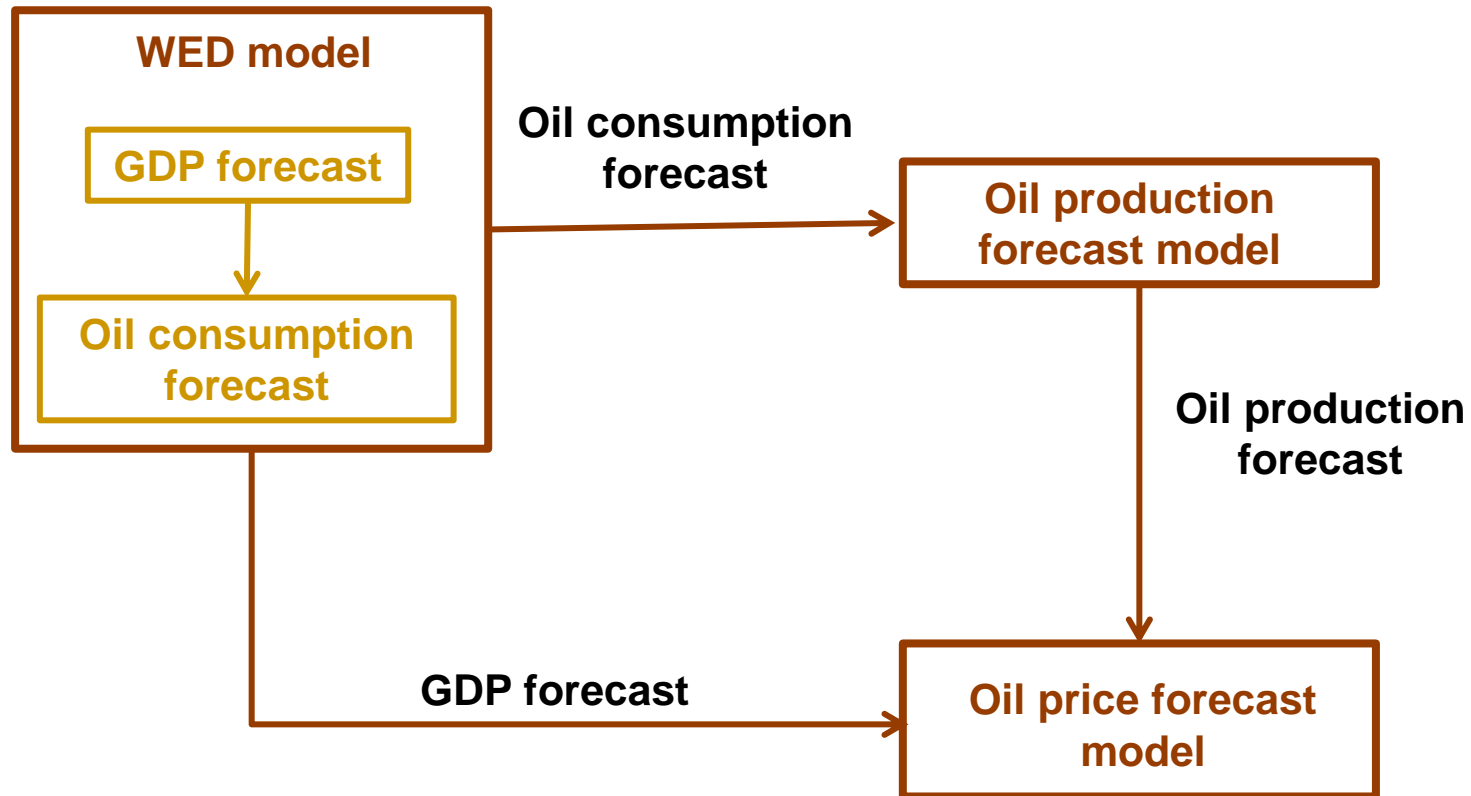
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General methodology
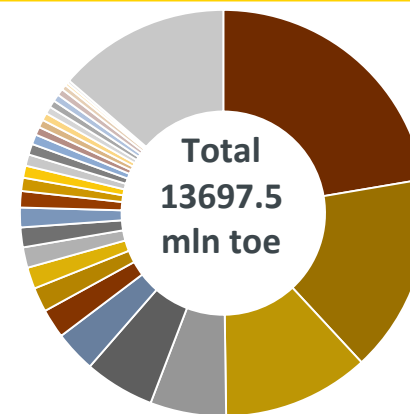
World Economic Dynamic (WED) model – brief introduction

▶ The model forecasts world economic development and world energy consumption

▶ It considers 27 countries and the European Union which:
- Made 87.2% of world's GDP (PPP 2011) in 2014
- Made 86.3% of world's primary energy consumption in 2014

▶ The main sources of data are: World Bank, International Monetary Fund, International Energy Agency

Structure of world's GDP (PPP 2011) in 2014

Total 102.8 thousand $ bln

World total energy consumption structure in 2014

Total 13697.5 mln toe
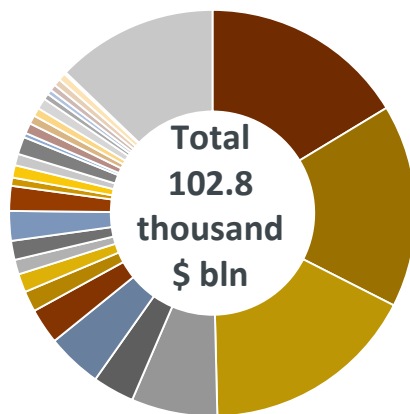
■ China	■ USA	■ EU	■ India	■ Russia	■ Japan
■ Brazil	■ Korea	■ Canada	■ Iran	■ Saudi Arabia	■ Indonesia
■ Mexico	■ South Africa	■ Australia	■ Thailand	■ Turkey	■ Ukraine
■ Pakistan	■ Malayzia	■ Argentina	■ Egypt	■ Vietnam	■ Kazakhstan
■ Venezuela	■ UAE	■ Colombia	■ Belarus	■ ROW	

World Economic Dynamic (WED) model – brief introduction

Economic module

Modeling and forecasting:

- Incremental capital-output ratio
- Gross fixed capital formation (% of GDP)
- GDP, PPP (2005 trillion $)
- Population (million people)
- GDP per capita (2005 thousand $)
- GDP per capita growth (annual %)
- GDP growth (annual %)

Energy module

Modeling and forecasting:

- Total primary energy consumption (Mtoe), includes: Oil, Gas, Coal, Nuclear power, Hydro power, Other renewables
- Primary energy consumption per thousand $ GDP (Mtoe)
- Primary energy consumption per capita (Mtoe)
- Electricity production (TWh)

WED model – GDP forecast

▶ GDP forecast is based on the forecast of two main factors:

- Gross fixed capital formation as % of GDP during period t ($CapF_t$)

- Incremental capital-output ratio defined as: $ICOR_t = \dfrac{CapF_t}{\dfrac{r_{GDP,\ t+1}}{r_{Pop,\ t+1}}}$

where $r_{GDP,\ t}$ - real GDP growth rates, $r_{Pop,\ t}$ - population growth rates

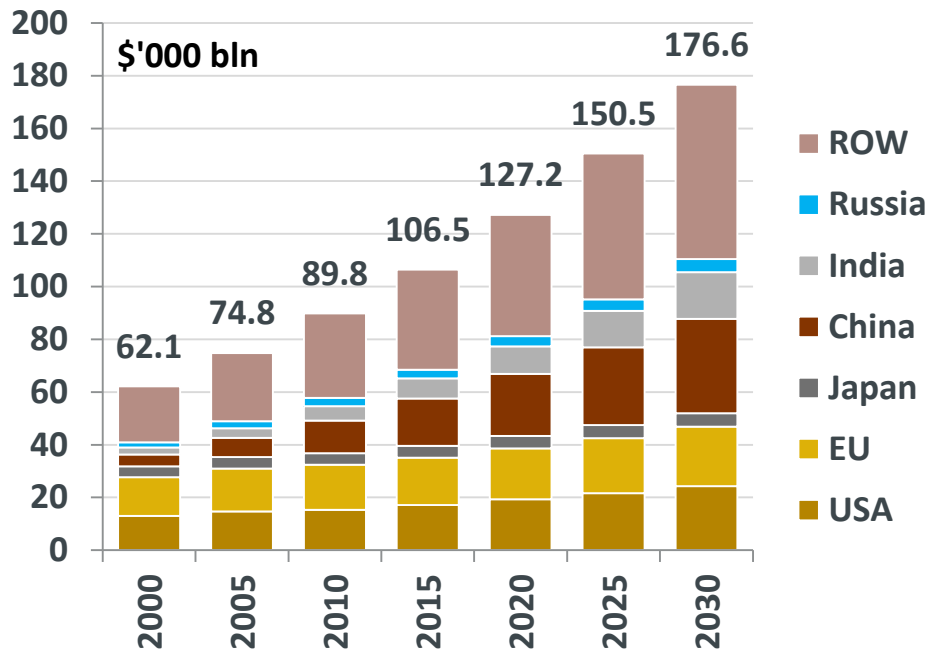▶ Both factors tend to reach US values on the forecast horizon (achieved by division the difference between country's and US' values by a fixed exogenous number)
(for US the 22% level for CapF is fixed in 2050)

▶ Having forecasted incremental capital-output ratio the future GDP growth rates can be estimated using UN population forecast*

World Population Prospects: The 2012 Revision (Medium fertility scenario)

WED model – GDP forecast

World's GDP forecast (PPP 2011)

$'000 bln

Legend: ROW, Russia, India, China, Japan, EU, USA

Values by year: 62.1 (2000), 74.8 (2005), 89.8 (2010), 106.5 (2015), 127.2 (2020), 150.5 (2025), 176.6 (2030)

▶ World's GDP rises to $176.6 thousand bln in 2030

▶ China's GDP will be the largest – $35.7 thousand bln in 2030 or 13.8% of world's GDP

▶ USA's GDP will be $24.3 thousand bln in 2030 (12.8% of worlds GDP), EU's – $22.6 thousand bln in 2030 (10.1%)

GDP CAGR forecast

	2015-2020	2021-2025	2026-2030
World	3.6%	3.4%	3.2%
USA	2.4%	2.4%	2.3%
EU	1.5%	1.6%	1.6%
Japan	0.7%	0.7%	0.8%
China	5.6%	4.5%	3.8%
India	6.6%	5.7%	5.1%
Russia	3.5%	2.4%	2.1%

▶ Rates of growth of the largest economies tend to decrease during the forecasting period
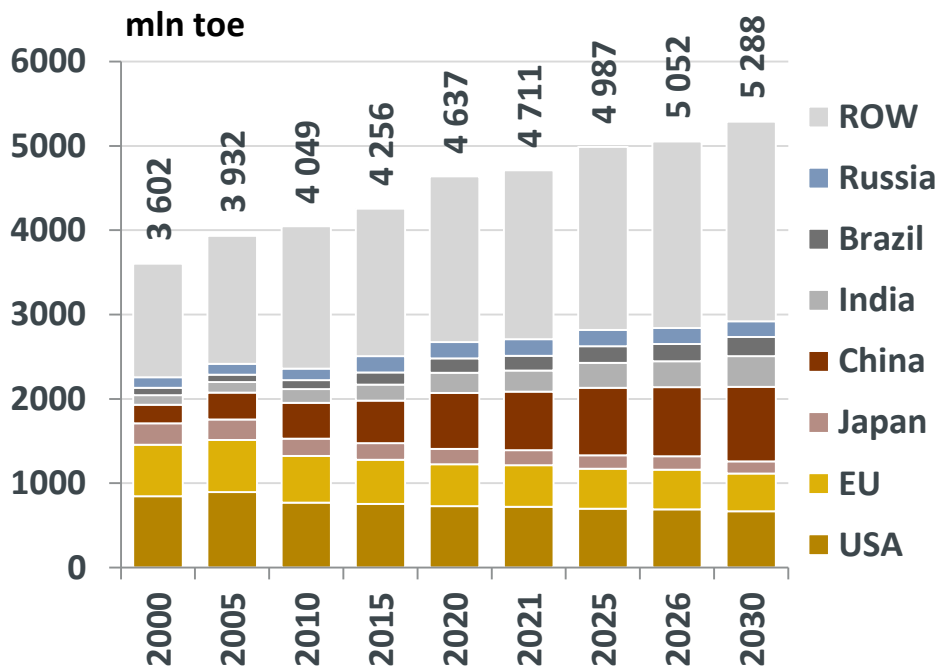
WED model – Petroleum liquids consumption forecast

- Number of cars was forecasted using Gompertz function: $\dfrac{Cars_t}{Pop_t} = ae^{be^{c\frac{GDP_t}{Pop_t}}}$

  where $Cars_t$ - number of cars at period t, Pop_t - population, a - constant, that defines the saturation level (exogenous), b and c - parameters of growth (both are negative)
- Only passenger cars and trucks were considered
- The oil products and all other energy sources consumption per car were calculated
- The difference between world's and a country's average consumption of oil and all energy sources per car were calculated. It was supposed that this difference tend to a country's expected value in future (for each country these values were defined by Rosneft technological experts team)
- The world's average consumption of oil and of all types of energy per car per 100 km tend to decrease with a constant rate of 2% per year
- The world's amount of other than oil energy sources consumption is tend to be 5% by 2050
- A very strong assumption was made: annual mileage is constant between countries and across the forecast period and equals 15 000 km for passenger cars (about 9320 miles) and 55 000 km for trucks (about 34 175 miles)
- Having made the forecasts of energy consumption per car (per 100 km), annual mileage, and the number of cars, the oil and all other energy future consumption can be estimated

Source: Data on amount of passenger cars and light and heavy trucks were get from IHS and International Organization of Motor Vehicle Manufacturers (OICA)

WED model – Liquids consumption forecast

World's liquids consumption forecast

mln toe

Bar chart values (total per year):
- 2000: 3 602
- 2005: 3 932
- 2010: 4 049
- 2015: 4 256
- 2020: 4 637
- 2021: 4 711
- 2025: 4 987
- 2026: 5 052
- 2030: 5 288

Legend: ROW, Russia, Brazil, India, China, Japan, EU, USA

- World's liquids consumption to rises to 5287.28 mln toe
- China's consumption will be the largest – 8882.7 mln toe in 2030 or 16.7% of world's consumption
- USA's consumption will be 666.2 mln toe in 2030 (12.6% of worlds liquids consumption), EU's – 448 mln toe in 2030 (8.5%)

Liquids consumption CAGR forecast

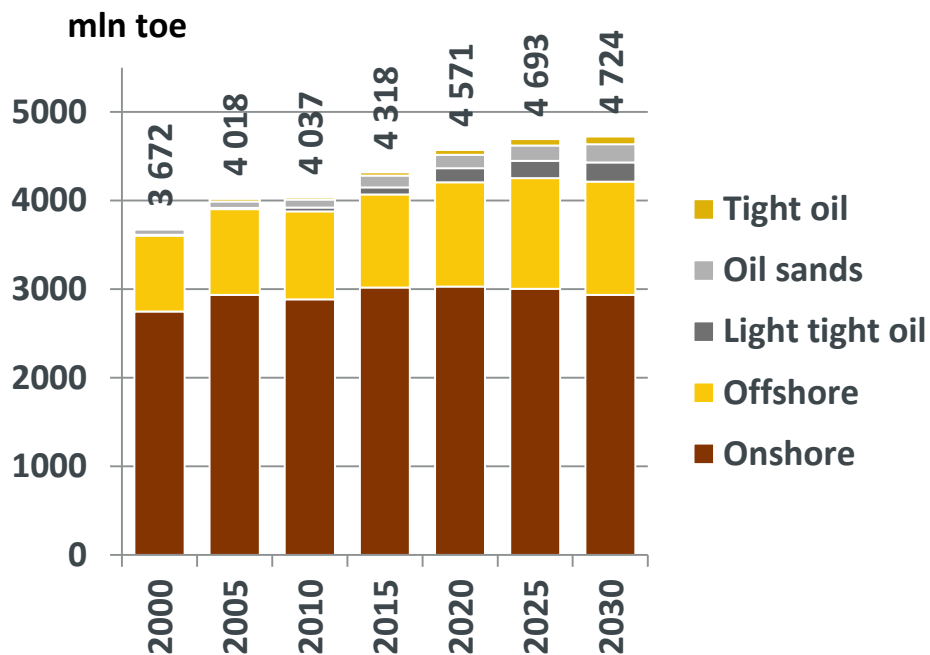|	2015-2020	2021-2025	2026-2030
World	1.7%	1.4%	1.1%
USA	-0.8%	-0.8%	-0.9%
EU	-0.9%	-1.0%	-1.1%
Japan	-1.9%	-2.3%	-2.4%
China	5.8%	3.5%	1.9%
India	4.5%	4.5%	4.3%
Russia	0.3%	-0.6%	-0.9%

- Rates of growth of liquids consumption tend to decrease during the forecasting period

Oil supply forecast

- Oil supply model includes huge amount of data: among all countries in consideration the data regarding volumes produced, current production volumes, reserves, types of oil's collectors and oil itself, breakeven prices for big developed and developing oil fields were collected and processed
- Forecast of oil and other liquids (NGL, and etc.) supply is based on:
  - Forecast of oil consumption (from WED)
  - Breakeven prices of oil production
  - Oil production curves (estimated for each type of oil/oil collector)
- For each country:
  - Oil data was sorted by breakeven price
  - Scenarios regarding future oil supply were made
- The model based on the following principles:
  - If country has enough oil to cover internal demand, then it will not import oil and may export the excess amounts
  - If country has not enough oil to cover internal demand – it will import it
  - On external market countries are compete by breakeven prices of oil production. Oil will be exported by the most economically effective countries.
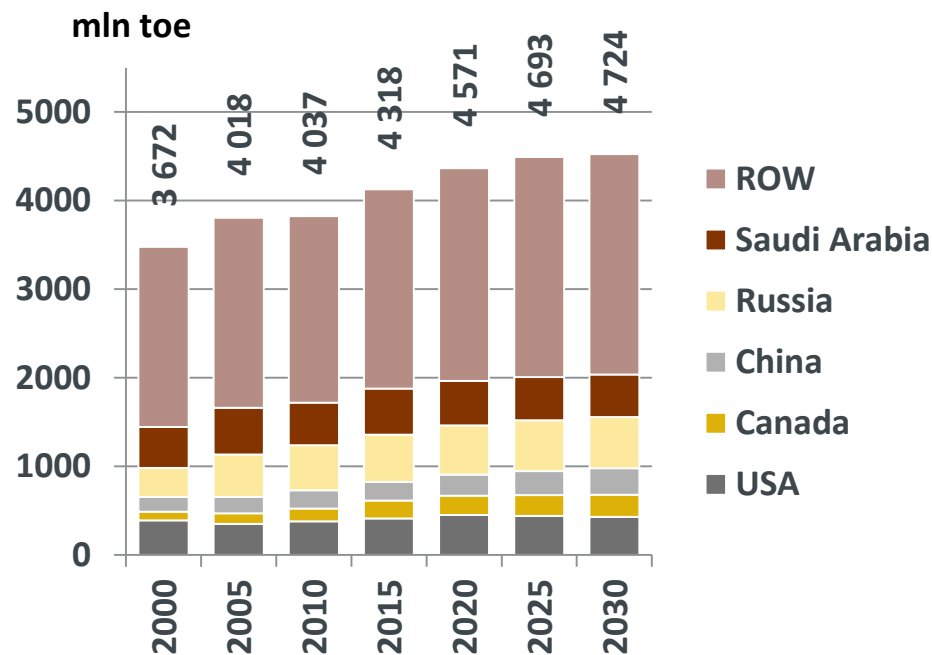
Oil production forecast

Structure of oil production by type of reserves

mln toe

Legend: Tight oil, Oil sands, Light tight oil, Offshore, Onshore

Years: 2000 (3 672), 2005 (4 018), 2010 (4 037), 2015 (4 318), 2020 (4 571), 2025 (4 693), 2030 (4 724)

▶ Onshore oil production share in world's oil production will be approximately 62%

▶ The most expensive oil production will be approximately 2% in2030

Structure of oil production by country

mln toe

Legend: ROW, Saudi Arabia, Russia, China, Canada, USA

Years: 2000 (3 672), 2005 (4 018), 2010 (4 037), 2015 (4 318), 2020 (4 571), 2025 (4 693), 2030 (4 724)

▶ USA will increase its oil production from 413.9 mln toe in 2015 to 430 mln toe after reaching 453 mln toe in 2020

▶ Russia and Saudi Arabia will still produce 12% and 10% of global oil production in 2030

Oil price forecast

- Oil price forecast model uses world's GDP forecast from WED and liquids production forecast from oil production model
- The oil price model based on:
  - World's GDP
  - Share of oil production in world's GDP: $OilShare_t = \dfrac{S_t P_t}{GDP_t}$

    where S_t - global supply of liquid fuels, P_t - Brent price, GDP_t - nominal GDP
 - Upstream full-cycle costs
  - World's inflation
- Lower and upper bounds of oil price are calculated. Lower bound defined as upstream full-cycle costs (approximately $50/b at 2014) which is changing with the rates of world's inflation. Upper bound was estimated using the formula of oil's share in world's GDP:
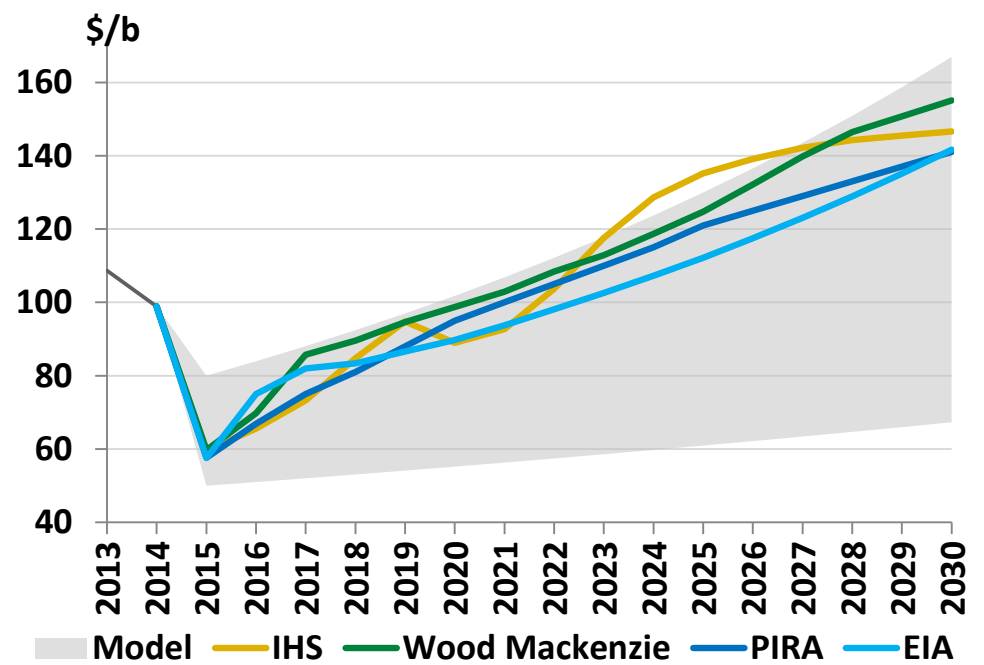
$$P_t = \frac{OilShare_t \, GDP_t}{S_t}$$

- The weighted average of upper and lower prices is defined by taking into account current economic situation and its possible development in future, global financial situation and so on

Oil price forecast

Oil price range

$/b

MAX · · · · · MIN —— Historical data
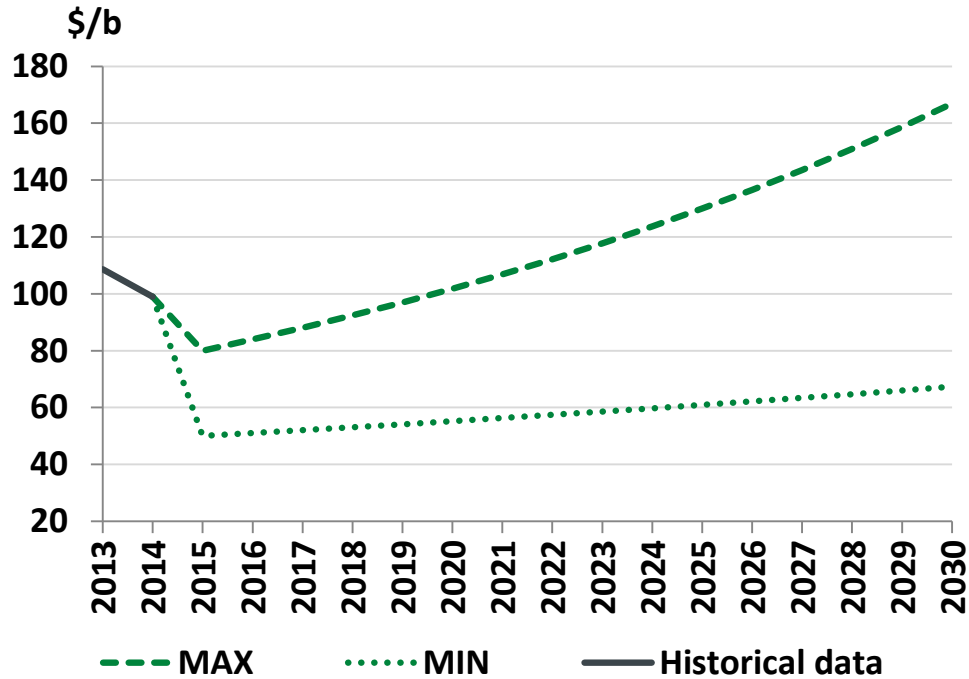
Other oil price forecasts
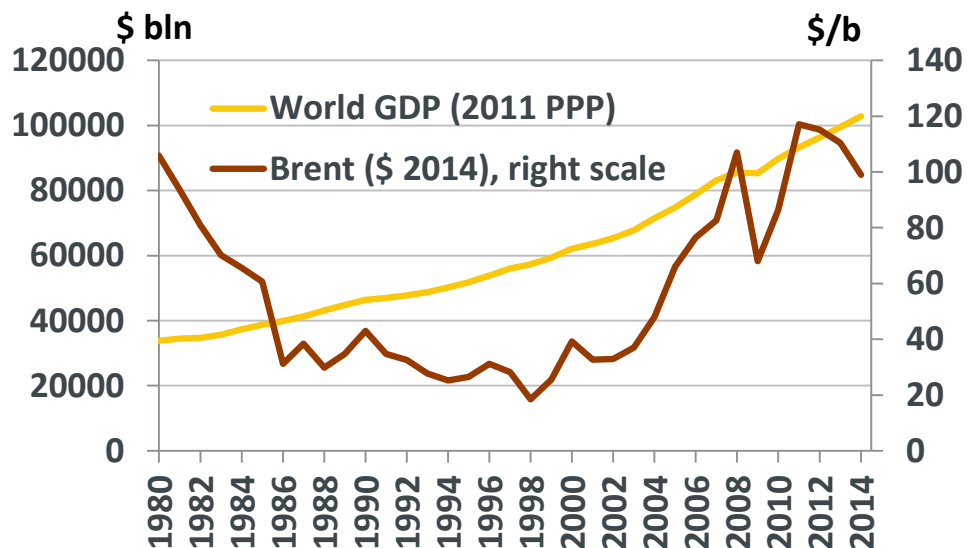
$/b

Model — IHS — Wood Mackenzie — PIRA — EIA

Conclusions

▶ The used method of forecasting world oil markets accounts only for fundamental factors

▶ Since it has very strong assumptions it has a lot of ways to improve it

▶ Possible ways of further work:
- Oil consumption and production balance
- Short-term factors such as speculative activity
- Better car statistics and number of cars forecast
- Modeling of oil consumptions by sectors other than transport
- Better forecast of fuels competition
- Backward linkages

Additional slides

Oil market – historical data

World's GDP and Brent price ($ 2014)

$ bln   **$/b**

Legend:
- World GDP (2011 PPP)
- Brent ($ 2014), right scale

World liquids consumption and production and Brent nominal price

mln toe   **$/b**

Legend:
- Consumption
- Production
- Brent (nominal), right scale

▶ During the 1986-2014 the world GDP rises by 2.6 times

▶ The Brent in constant prices rose by 3.2 times during the same period
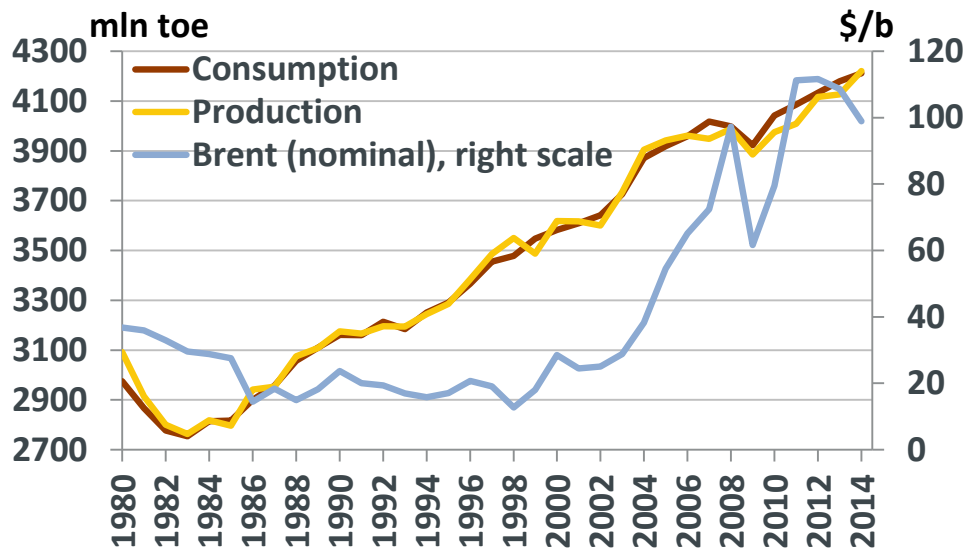
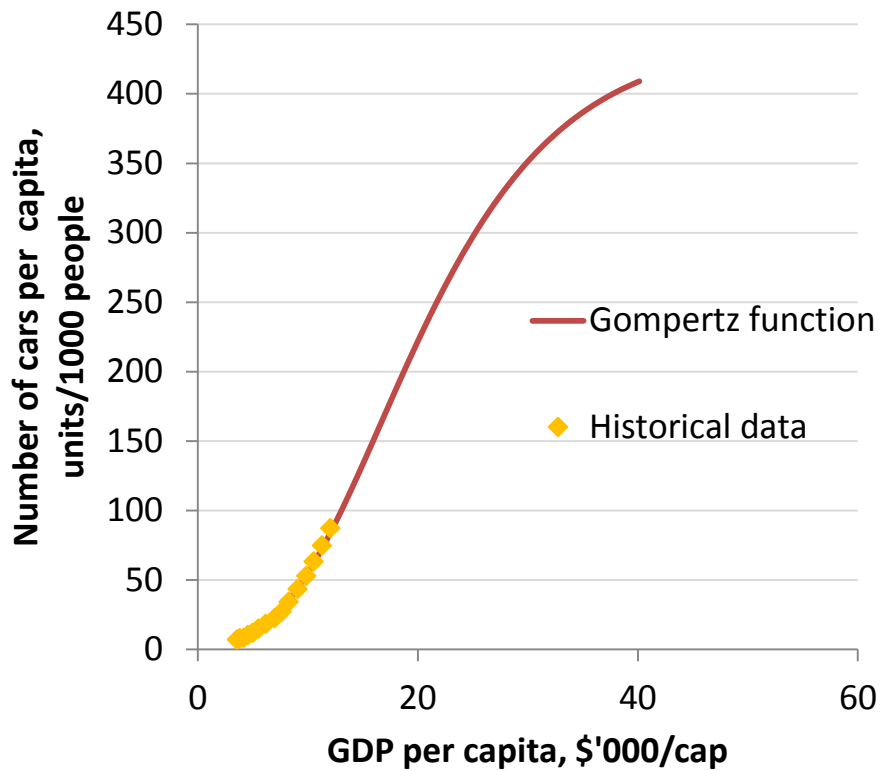▶ Both the world's petroleum liquids consumption and production rose by approximately 1.5 times during 1986-2014

▶ Brent nominal price rose by 6.9 times

The Gompertz function

China, passenger cars

World, passenger cars