Unanswered Questions:
Our Energy Models

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June 2020
The Impossibility of Energy Models! And Forecasts?

Peter Drucker, “We must start out with the conclusion that forecasting is not respectable and not worthwhile beyond the shortest periods. Long range planning is necessary precisely because we cannot forecast.”

Nonlinear changes, Feedback loops...Scenarios and surprises

Robert Merton, sociologist, developed the concept of unanticipated or unintended consequences of social action, 1936 article ‘The Unanticipated Consequences of Purposive Social Action’
Price Volatility: boom and bust
Uncertainty & Variance ➔ Supply: Demand and Price

Many models do not work: surprises, disruptive technologies, politics
Whys of Price Volatility

Shocks, behavior, games, changed expectations, partial equilibrium, or what?

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<th>Supply: Demand</th>
<th>Stagflation</th>
<th>IR up recession</th>
<th>New fields on</th>
<th>Asian FX crisis</th>
<th>Asian growth, demand</th>
<th>Financial crisis</th>
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<td>OPEC, Russia, Saudi, China</td>
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<td>Adelman market structure; early IEA, oil embargo,</td>
<td>Macro general / partial equilibrium, Shell scenarios</td>
<td>Shocks, surprises, Killian, Hamilton Price expectation</td>
<td>More surprises; speculation...</td>
<td>VAR models supply &amp; demand shocks</td>
<td>Market structure change – Russia, Saudi, Shale</td>
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</table>
Price West Texas Intermediate crude oil (WTI Inflation adjusted, log scale)
The current price of WTI 03, 2020 is $37.29
1. Supply curves: peak oil

Hubbert's "idealized" production model

\[ x = \frac{e^{-t}}{(1 + e^{-t})^2} = \frac{1}{2 + 2 \cosh t} \]

The actual curve of each oil region differs from this theoretical graph, but more-or-less follows this pattern. There are also differences between on-shore and off-shore profiles.

Before oil can be consumed, it first needs to be located.

Phaster thoughts: its been said "What goes up, must come down; so hope for the best, but prepare for the worst!"
2. Oligopoly competition: cost curves and production
3. General Equilibrium Macro Structure:

Supply \geq< Demand

IEA, EIA, OPEC, Shell

→ huge data gathering and estimation
Growing demand for liquid fuels in emerging economies...

Demand

Supply

Mb/d

2016
OECD
Non-OECD

2016
Non-OPEC decline
Non-OPEC growth
OPEC

Fuels: Oil

bp

Change Investing

Demand from ‘Emerging Economies’
4. VAR: shocks/surprises ➔ swing producers
5. Heterogeneous Oil & Gas AGENTS – invest / produce differently

MENA Countries
- Unlimited low cost supply
- Stable opaque governance
- Respond to market surprises
- Sometimes critical budget balance
- Few constraints, except location

Non OPEC producers
- Mature variable cost supplier
- Markets close to supply chain
- Competitive market players
- Some win and some lose
- Profits, finance, value matter

Russia and CIS
- Large diversified O&G supply
- Close to market, Many not
- Politics and finance barriers
- Who manages JV projects & complicated supply chains

Off-Shore
- Large high cost fields
- Long lead times, long life
- Many partners, less risk
- Stable supply to markets
- Cash flow matters

US Shale
- Low cost and short timeframes
- Price & Quantity

Heterogeneous Oil & Gas AGENTS
Global oil demand forecasts vary widely

Uncertainties in policy choices, economic outlook, technology shifts, and resource estimates lead to large variations in oil demand forecasts.

- **EIA (low oil price)**
- **IEEJ (ref. case)**
- **EIA (ref.)**
- **OPEC (ref. case)**
- **EIA (high oil price)**
- **BP**
- **IEA (new policy)**

Oil Demand (MMbbl/d)

<table>
<thead>
<tr>
<th>Year</th>
<th>Oil Demand (MMbbl/d)</th>
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<tr>
<td>1990</td>
<td>60</td>
</tr>
<tr>
<td>1995</td>
<td>70</td>
</tr>
<tr>
<td>2000</td>
<td>80</td>
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<td>2005</td>
<td>90</td>
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<tr>
<td>2010</td>
<td>100</td>
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<tr>
<td>2018</td>
<td>110</td>
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<tr>
<td>2020</td>
<td>120</td>
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<tr>
<td>2025</td>
<td>130</td>
</tr>
<tr>
<td>2030</td>
<td>140</td>
</tr>
<tr>
<td>2035</td>
<td>150</td>
</tr>
<tr>
<td>2040</td>
<td>160</td>
</tr>
</tbody>
</table>

Natural decline from existing fields and fields under development.

- **IEA (sustainable dev.)**
- **OPEC (ref. case)**
- **EIA (ref.)**
- **EIA (low oil price)**
- **IEA (new policy)**
- **IEA (high oil price)**
- **BP**
- **Shell (sky)**
Agents are different
(productivity and investment cycles)
Agent Based Model (ABM): Dynamic & non-linear

Probabilistic Investment and production

- MAY Invest IF
  - Price high / moving average of expected oil prices
  - Supply / Demand tight (or oversupply)
  - Low Breakeven point (costs) → higher NPV

- Agents have different probability of investing base upon x, y, z...

- Agents with different breakeven points / costs

- HETEROGENEOUS Investment decisions / production → Oil supply ≤ Oil demand
Decision time for investment - heterogeneity
Breakeven costs by region – RED Invest, Blue No
Regional NPV reversion to mean, logs
Response of investment (y axis) to ma-of-prices (x axis) and ma-of-supply / demand-balance (z-axis).

An intuitive way to see this is to examine the corners:

- at high prices all investment is high (yellow),
- at low prices investment is med in undersupplied markets (green) and
- low in oversupplied (blue)
Who invests? and where? What energy mix?
6. Market Analysts:
Uncertain economy, politics, prices, and Company cash flows NPV value

\[
ENPV = \left( \sum_{t=0}^{N} \left( C_0 + \frac{C_t}{(1+D)^t} \right) \right) \times P_{1-n}
\]

**EXPECTED NPV**

*Expected Net Present Value Analysis aggregates a range of scenarios into one valuation incorporating time value of money and the probability of various outcomes.*
Heterogeneous frameworks: **Boom-Bust**

**OUR questions -- USING All Our Tools:**

*Forecasting is not respectable and not worthwhile*

**Our frameworks**
1. Hoteling – peak oil
2. Market structure – Adelman
3. Partial Equilibrium – scenarios
4. VAR and shocks
5. ABM – agents matter
6. Market analysts – NPV
7. All our tools

**Our Questions**
- What supply – fields
- Oligopolist game theory
- Supply changes – what if
- Demand/supply – swing producer
- Agents shift paths – non linearity
- Returns and investment
- WHAT IF
Ingres & Pollack:
MANY Pictures of our Energy Worlds & Future