Petroleum economic modelling in general

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The Bridge Group AS
Why economic modeling

• Economic models are mainly used for the following four reasons:
  
  – Investment decisions
  – Budgeting
  – Annual reports
  – Risk analysis to understand the risk elements within the business and within individual projects (sensitivities).
Investment Decisions

- Petroleum investments are
  - capital intensive
  - irreversible
  - high risk/uncertainty

- Investment decisions today are only unfolded in the uncertain future for both company and government
Modeling = Predicting

• Petroleum project modelling is based on
  – knowledge of fundamental elements in technology and economics
  – empiric data
  – and a bit of artistry
Warning

• All modeling is imperfect.
  – It is always a simplification of reality
  – Depends on quality of input

• The challenge is to assess the weaknesses and discover flaws
Resource Rent
Allocation of revenues from Production

After Johnston (1995)

Bonuses
Royalties
Prod. Sharing
Taxes
Gov. Participation
Activities and cash flow

Income
Costs

Pre-license | Exploration | Development | Production | Production Rehab. | Abandonment

Contract award
PDO

Government

Lead Time

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Input to cash flow models

- Production curve
- Oil/gas price
- Capex
- Opex
- Fiscal regime
- Discount rate

\[
\begin{align*}
\text{Gross revenue} & = \text{Production curve} \\
\text{Net revenue} & = \text{Oil/gas price} + \text{Capex} + \text{Opex} + \text{Fiscal regime} + \text{Discount rate}
\end{align*}
\]
Production curve

Volume

Build-up

Plateau

Decline

Time

Cutoff
Factors determining production

- No of wells
- Plateau factor (%)
- Production rate per well
- Plateau production rate
- Remaining oil/gas at start decline
- Decline rate (%)
- Cut off rate
Gas Production

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Gas Production

- Non Assoc. Gas [Million scf/d]
- Condensate [Thousand bbl/d]
Statfjord Oil - Norway

Oil Production - Statfjord, Norway
560 million Sm3 (3520 Million bbl)
Ula oil - Norway

Oil Production - Ula, Norway
80 million Sm3 (503 Million bbl)
Oseberg Oil - Norway

Oil Production - Oseberg Field, Norway
350 million Sm3 (2200 million bbl)

Years

0.0 % 10.0 % 20.0 % 30.0 % 40.0 % 50.0 % 60.0 % 70.0 % 80.0 % 90.0 % 100.0 %

Million Sm3

0.0 5.0 10.0 15.0 20.0 25.0 30.0 35.0

Oil Production

PR percentage


39.2 % 70.5 %
Frigg Gas - Norway

Gas Production - Frigg Field, Norway
116 billion Sm3 (4.1 TCF)

Yearly Gas Production and P/R percentage

- Gas Production
- P/R percentage

- 1979: 29.8%
- 1982: 63.9%

Million Sm3

0 0.2 0.4 0.6 0.8 1 1.2
0 2 4 6 8 10 12

Years


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## Rules of thumb - 1

<table>
<thead>
<tr>
<th>TECHNICAL ASPECTS</th>
<th>Rule of Thumb</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak production/total reserves</td>
<td>10-12%</td>
</tr>
<tr>
<td>Decline rate</td>
<td>10-12%</td>
</tr>
</tbody>
</table>
Lead Time

Lead time for fields on the Norwegian shelf

Years from discovery to production

Year of discovery

- Cod
- Eldfisk
- Tor
- Albuskjell
- Frigg
- Edda
- Statfjord
- Murchison
- Valhall
- Ula
- Troll I
- Brage
- Sleipner Øst
- Lille Frigg
- Statfjord Øst
- Statfjord Nord
- Troll II
- Snorre
- Gullfaks
- Gyda
- Veslefrikk
- Tannmeliton
- Oseberg
- Gyda Sør
- Gulffaks Vest
- Embla
- Gyda Sør
- Gulffaks Vest
- Loke
- Draugen
- Heidrun
- Frøy
- Tordis
- Yme
- Øst Frigg
- Hod
- Øst Frigg
- Heimdal
- Gugne
- Sleipner Vest
- Sleipner Øst
- Hald Øst Frigg

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Exercise - Production

• Construct a production curve for an oil field with 300 million barrels recoverable reserves which will be produced over 20 years. Lead time is 5 years and cut off rate is 10,000 bopd (Use Excel)
Input to cash flow models

- Production curve
- Oil/gas price
- Capex
- Opex
- Fiscal regime
- Discount rate

\[
\begin{aligned}
\text{Gross revenue} & \quad & \text{Net revenue} \\
\{ & & \\
& & \\
& & \\
& & \\
& & \\
& & \\
\}
\end{aligned}
\]
Input to cash flow models

- Production curve
- Oil/gas price
- Capex
- Opex
- Fiscal regime
- Discount rate

\[
\begin{align*}
\text{Gross revenue} & \quad \{ \text{Production curve, Oil/gas price, Capex, Opex, Fiscal regime, Discount rate} \\
\text{Net revenue} & \quad \{ \text{Gross revenue} \}
\end{align*}
\]
Expenditures = Cost

• Capital expenditure
  – Wells
  – Constructions - Facilities
  – Pipelines

• Operating expenditures
  – The cost of running the operations
    • Fixed Opex
    • Variable Opex
Capex and Opex

Years

Million USD

TOTAL CAPEX [Million USD, inflated]
Variable Opex
TOTAL OPEX [Million USD, inflated]
## Well cost - Asia

### Averages

<table>
<thead>
<tr>
<th>Field size</th>
<th>Exploration</th>
<th>Appraisal</th>
<th>Development/operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>bbl</td>
<td>Sm3</td>
<td>Well cost</td>
<td>No. of wells</td>
</tr>
<tr>
<td>10</td>
<td>1.6</td>
<td>6.9</td>
<td>1.14</td>
</tr>
<tr>
<td>25</td>
<td>4.0</td>
<td>7.43</td>
<td>1.31</td>
</tr>
<tr>
<td>50</td>
<td>7.9</td>
<td>7.43</td>
<td>1.31</td>
</tr>
<tr>
<td>125</td>
<td>19.9</td>
<td>7.43</td>
<td>1.31</td>
</tr>
<tr>
<td>250</td>
<td>39.7</td>
<td>7.43</td>
<td>1.31</td>
</tr>
<tr>
<td>500</td>
<td>79.5</td>
<td>7.43</td>
<td>1.31</td>
</tr>
<tr>
<td>160.00</td>
<td>25.44</td>
<td>7.34</td>
<td>1.29</td>
</tr>
</tbody>
</table>
Opex (usd/bbl)
(Norwegian fields 1998)

Average 4.4
## Facility Cost Estimates

<table>
<thead>
<tr>
<th>Component</th>
<th>Unit Cost ($MM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exploration Well</td>
<td>3-4</td>
</tr>
<tr>
<td>Appraisal Well</td>
<td>2-4</td>
</tr>
<tr>
<td>Development</td>
<td>1.5</td>
</tr>
<tr>
<td>CPP</td>
<td>300-500</td>
</tr>
<tr>
<td>WP (4 legs) + Sealines</td>
<td>13 - 18</td>
</tr>
<tr>
<td>LQ</td>
<td>40-60 (100 - 200 POB)</td>
</tr>
<tr>
<td>FSO 1 MMbbl</td>
<td>100</td>
</tr>
<tr>
<td>Booster Compressor</td>
<td>0.4-0.5</td>
</tr>
</tbody>
</table>

| Pipeline 16 "                            | 0.4 MM$ / km    |
| Pipeline 24 "                            | 0.6 MM$ / km    |

Ref. Anon Punnahitanon, PPM
Yearly opex as % of total capex
(Norwegian fields 1998)

Yearly opex as % of total capex

Fields

0.00 % 0.10 % 0.20 % 0.30 % 0.40 % 0.50 % 0.60 % 0.70 %

0 10 20 30 40 50 60

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Model checks

• Several checks of the results should be performed
  – Royalty % per year
  – Profit share % per year
  – Production plot
  – Capex and Opex plot
  – Depreciation plot
### Rules of thumb -2

<table>
<thead>
<tr>
<th>BASIC ASSUMPTIONS</th>
<th>Rule of Thumb</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capex/bbl</td>
<td>3-5 usd</td>
</tr>
<tr>
<td>Capex as % of Gross Revenue</td>
<td>10-20%</td>
</tr>
<tr>
<td>Opex/bbl</td>
<td>3-5 usd</td>
</tr>
<tr>
<td>Opex/peak year as % of total Capex</td>
<td>4-8%</td>
</tr>
</tbody>
</table>
Input to cash flow models

- Production curve
- Oil/gas price
- Capex
- Opex
- Fiscal regime
- Discount rate

\[ \text{Gross revenue} \]
\[ \text{Net revenue} \]
Share, take and profit margin

- Gross project revenue: 100
- Royalty: 0
- Net project revenue: 100
- Total cost: -40
- Profit basis (Operating income): 60
- Taxes: 35
- Net after tax income: 25

- Contractor take: 42% (25/60)
- Contractor profit margin: 25% (25/100)
- Contractor share: 65% (25+40/100)

Government take: 58% (35/60)
The Government Choice

Petroleum Fiscal Arrangements

Concessionary Systems
- Norway
- United Kingdom
- Pakistan
- Tunisia
- New Zealand

Contractual Systems

Service Contracts
- Limited usage

Pure Service Contracts
- Argentina
- Brazil
- Venezuela
- The Philippines

Risk Service Contracts
- Angola
- Indonesia
- India
- Nigeria
- Gabon

Production Sharing Contracts
Elements in a PSC

- Work Commitment
- Bonus Payment
- Royalties
- Cost Recovery (Cost Oil)
- Profit Oil
- Government participation
- Domestic Market Obligation
- Ring fencing
Indonesia- PSC (4th Gen.)
Mother of all PSCs

• (85/15 Split)
  – Royalty: 0%
  – FTP split 20%
  – Cost Oil: 100%
  – Profit Oil: 28.8462%
  – Tax Rate: 48%

• Effects
  – The split does not change with the level of cost
  – Effective Gov. take is 85%
FTP

- Calculated from Gross Revenue
- Works as a modified Royalty
- Can cause premature abandonment
NPV formula (end year)

\[
NPV = \sum_{n=0}^{n} \left( \frac{F_n}{(1 + i)^n} \right)
\]

\[
= F_0 + \frac{F_1}{(1 + i)^1} + \frac{F_2}{(1 + i)^2} + \cdots + \frac{F_n}{(1 + i)^n}
\]

...where:

- \( F_n \) - the net income in year \( n \)
- \( i \) - discount rate
- \( n \) - total numbers of years (project duration)
Time value of money

- Cash flow
- Cumulative cashflow
- Inflation corrected
- + Value of time corrected

Current Values
Real Values
Discounted Values

Million USD

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## Present Value

<table>
<thead>
<tr>
<th>Year</th>
<th>Cash Flow</th>
<th>NPV 5%</th>
<th>NPV 10%</th>
<th>NPV 15%</th>
<th>NPV 20%</th>
</tr>
</thead>
<tbody>
<tr>
<td>2003</td>
<td>-200</td>
<td>-200.0</td>
<td>-200.0</td>
<td>-200.0</td>
<td>-200.0</td>
</tr>
<tr>
<td>2004</td>
<td>-50</td>
<td>-47.6</td>
<td>-45.5</td>
<td>-43.5</td>
<td>-41.7</td>
</tr>
<tr>
<td>2005</td>
<td>10</td>
<td>9.1</td>
<td>8.3</td>
<td>7.6</td>
<td>6.9</td>
</tr>
<tr>
<td>2006</td>
<td>100</td>
<td>86.4</td>
<td>75.1</td>
<td>65.8</td>
<td>57.9</td>
</tr>
<tr>
<td>2007</td>
<td>100</td>
<td>82.3</td>
<td>68.3</td>
<td>57.2</td>
<td>48.2</td>
</tr>
<tr>
<td>2008</td>
<td>200</td>
<td>156.7</td>
<td>124.2</td>
<td>99.4</td>
<td>80.4</td>
</tr>
<tr>
<td>SUM</td>
<td>160</td>
<td>86.8</td>
<td>30.4</td>
<td>-13.6</td>
<td>-48.3</td>
</tr>
</tbody>
</table>
Present Value - IRR

![Graph showing present value and internal rate of return (IRR)]
Expected Monetary Value

- EMV = Expected Monetary Value
- R = Reward = Net Present Value (NPV)
- SP = Success Probability
- RC = Risk Capital = Bonuses, Dry Hole Cost, G&G etc.
EMV - Example

• Assumptions
  • NPV = 120 million USD
  • RC = 15 million USD
  • SP = 22%

• EMV = (R*SP) - (RC*(1-SP))
• EMV = (120*0.22) - (15*(1-0.22))
• EMV = 14.7 million USD

  – Break even SP = 12.5% (EMV=0)
EMV curve

- Reward (NPV)
- Break even POS
- Calculated EMV
- Risk capital
- Calculated POS

Probability of Success (%) vs. Million USD

- EMV curve

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Synonyms

• Net present value (NPV)  
  • Present value  
  • Discounted cash flow  
  • Present value profit (PVP)  
  • Present worth (PW)

• Internal rate of return (IRR)  
  • Rate of return (ROR)  
  • Profit investment ratio (P/I ratio)  
  • Return on investments (ROI)

• Expected monetary value  
  • Expected value  
  • Risked value
Basic assumptions

• Start Year
• Oil Price
  – Starting value
  – Escalation
  – Model
• Inflation
• Discount rate and year
• Depreciation rules
GeoX Demonstration

• The structure and functionality of GeoX
  – Prospect Analysis
  – Discovery Analysis
  – Full Cycle Analysis