Basic Petroleum Economics

Investment decisions

- Investment decisions are among the most important decisions that a company/government can take
  - capital intensive
  - irreversible
  - high risk/uncertainty
Decisions through the life-cycle of a petroleum project

In all these phases you have to take decisions.

Investment analysis is used as a managerial tool to take such decisions.

Objectives

- Basic knowledge and techniques for performing investment analysis
- Use the tools and concepts on petroleum investment projects
  - A field development project
  - An exploration project
- Be able to understand the concepts used and do the economic calculations needed in the case study.
Investment analysis

..main economic terms

- Investment analysis- main economic terms
  - Cash-flow
    - inflation
    - time value of money
    - uncertainty
  - Economic Decision Criteria
    - net present value
    - internal rate of return (IRR)
    - payback & maximum exposure

Main elements in economic investment analysis

Idea

Analysis

Establish a cash-flow prognosis
Nominal/real values
Discount the cash flow
Consider the uncertainties
Net Present Value

Investment decision

Invest

Drop

Wait
Cash-flow

..the starting point of an investment analysis

♦ What cash flow will be generated in & out?

♦ Why concerned about the cash flow?
  ♦ Investor invests $ today (out flow) hoping to harvest more $ in the future (inflow)

Cash-flow

Budgeting techniques are used to calculate the projects cash-flow for every year:

Year 1:

Income - costs = Net cash flow
Cash-flow

...over the life-time of the project

\[
\text{Income - costs} \quad = \quad \text{Net cash -flow}
\]

\[
\text{Income - costs} \quad = \quad \text{Net cash -flow}
\]

\[
\text{Income - costs} \quad = \quad \text{Net cash -flow}
\]

\[
\begin{array}{c}
\text{Year} \\
0 \quad 1 \quad 2 \\
\end{array}
\]

Cash-out-flow (costs)

Cash-in-flow (income)
Cash-flow

..comparing cash-flow elements over time

- We can’t simply add up inflow and outflow, due to
  - Inflation
  - Time Value of Money
  - Uncertainty

Cash-flow

..inflation

- As long as there is inflation, the consumers purchasing power (i.e. what you can buy) for 10$ will be reduced the later you receive the money.
- You could buy more for 10$ in 1960 than in 2004 - and probably more in 2004 than in 2010
- We adjust for inflation by using real values instead of current values
Cash-flow

..inflation - from current to real values (to deflate)

<table>
<thead>
<tr>
<th></th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current value</td>
<td>-1000$</td>
<td>212$</td>
<td>449$</td>
</tr>
<tr>
<td>Real 2004 value</td>
<td>-1000$</td>
<td>$212/(1+0.06)$</td>
<td>$449/(1+0.06)^2$</td>
</tr>
</tbody>
</table>

\[
\begin{align*}
\text{2004:} &\quad -1000$ \\
\text{2005:} &\quad 212/(1+0.06)$ \\
\text{2006:} &\quad 449/(1+0.06)^2 \\
\text{Current value:} &\quad -1000$ \\
\text{Real 2004 value:} &\quad = 200$ \\
\text{Real 2004 value:} &\quad = 400$
\end{align*}
\]

Cash-flow

Cash in-flow (income)  ..inflation

Cash out-flow (costs)
Even after you have adjusted for inflation, it is not correct to simply add up in-flow and out-flow of the project.

Assume the bank offers an interest rate equal to 5%.

<table>
<thead>
<tr>
<th></th>
<th>2004</th>
<th>2005</th>
</tr>
</thead>
<tbody>
<tr>
<td>Example 1</td>
<td>1$</td>
<td>1$5 cent</td>
</tr>
<tr>
<td>Example 2</td>
<td>92,5 cent</td>
<td>1$</td>
</tr>
</tbody>
</table>

Cash-flow

..Time value of Money – an example

Bank deposit: $100
Annual interest rate: 10%

After 1 year: $V_1 = 100 \times (1 + 0.10) = 110.0$
After 2 years: $V_2 = 110 \times (1 + 0.10) = 121.0$

After 3 years: $V_3 = 121 \times (1 + 0.10) = 133.1$

etc
Cash-flow

..Time value of Money – end value

\[ V_n = V_0 (1 + r)^n \]

- \( V_n \) = the amount of money we can take out of the bank after \( n \) years
- \( V_0 \) = the amount of money we put in the bank today
- \( r \) = a fixed interest rate in \% per year

Cash-flow

..Time value of Money – present value

\[ V_0 = \frac{V_n}{(1 + r)^n} \]

To calculate the present value is often called discounting
Cash-flow

..Time value of Money

Cash in-flow (income)

Cash out-flow (costs)

Cash-flow

..discounting a cash-flow - Net Present value - an example

1 Calculate separately the present value of all the cash-flow elements

<table>
<thead>
<tr>
<th>Time</th>
<th>0</th>
<th>1</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cash-flow</td>
<td>-100</td>
<td>80</td>
<td>70</td>
</tr>
</tbody>
</table>

Present value:

-100
75
62

80/(1.06)
70/(1.06)^2

interest rate is 6%

2 Add together the discounted cash-flow elements

-100 + 75 + 62 = 37

The net present value of the cash-flow of the project is 37
Cash-flow

..a summary

- Future in- and out-flow have to be discounted to be comparable.
- The present value of a project is the sum of discounted cash-flow elements.
- You have to use the rate of return of the best alternative use of money as the discount rate. Then the net present value means the increase in value by choosing this project instead of the best alternative.

Cash-flow

..uncertainty

- There is always some uncertainty in investment analysis. The future cash-flow can not be projected with certainty at the time of investment.
- As long as today is more certain than the future, there is a third reason to prefer money today instead of tomorrow - we are risk averse
Cash-flow

..uncertainty - risk premium

- Risk averse people will demand a compensation for taking risk - they want a risk-premium.
- You can express this by correcting the discount-rate

Cash-flow

..uncertainty - risk premium

- By investing in a diversified (varied) project portfolio, you can lower your total risk exposure
- Only the change of risk an individual project contribute to an investment portfolio is relevant for compensation.
Cash-flow
..uncertainty - risk premium – an example

- An oil company has estimated the following cash flow for an oil project:
- (-800, -900, 200, 130, 600 per year in 9 years, 400, 300, 50)
- Risk free discount rate is 7% but the company is very risk averse and want a risk premium of 10%.
- Calculate the NPV of the project.

\[
\begin{array}{cccc}
\text{Year} & \text{Real cash flow} & \text{Discounted 7\%} & \text{Discounted 17\%} \\
0 & -800 & -800 & -800 \\
1 & -900 & -841 & -769 \\
2 & 200 & 175 & 146 \\
3 & 130 & 106 & 81 \\
4 & 600 & 458 & 320 \\
5 & 600 & 428 & 274 \\
6 & 600 & 400 & 234 \\
7 & 600 & 374 & 200 \\
8 & 600 & 349 & 171 \\
9 & 600 & 326 & 146 \\
10 & 600 & 305 & 125 \\
11 & 600 & 285 & 107 \\
12 & 600 & 266 & 91 \\
13 & 400 & 166 & 52 \\
14 & 300 & 116 & 33 \\
15 & 50 & 18 & 5 \\
\end{array}
\]

NPV 4780 2131 415
Economic Decision Criteria

- In this part we will see how to use cash-flow and discounting to decide whether a project is economic or not.

1. Calculate separately the present value of all the cash-flow elements

<table>
<thead>
<tr>
<th>Time</th>
<th>0</th>
<th>1</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cash-flow</td>
<td>-100</td>
<td>80</td>
<td>70</td>
</tr>
</tbody>
</table>

Present value:

-100
75
62

Interest rate is 6%

2. Add together the discounted cash-flow elements

\[-100 + \frac{80}{1.06} + \frac{70}{1.06^2} = 37\]

The net present value of the cash-flow of the project is 37
The Net present value (NPV) concept says:

- Accept all projects with NPV > 0
- Drop all projects with NPV < 0
- If NPV = 0, we are indifferent between accepting or dropping the project

### Economic Decision Criteria

- Net Present Value – an example

**Discount rate: 10%**

<table>
<thead>
<tr>
<th>Project</th>
<th>Cash-flow</th>
<th>Present Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>(-200, 120, 140)</td>
<td>25</td>
</tr>
<tr>
<td>B</td>
<td>(-390, 270, 220)</td>
<td>37</td>
</tr>
<tr>
<td>C</td>
<td>(-600, 300, 350)</td>
<td>-38</td>
</tr>
</tbody>
</table>

The net present value concept:

- Accept project A
- Accept project B
- Drop project C
The discount rate that yields \( \text{NPV} = 0 \) defines the Internal Rate of Return (IRR)

- Accept all projects with IRR > discount factor
- Drop all projects with IRR < discount factor
- If IRR = discount factor we are indifferent

### Economic Decision Criteria

- **– Internal Rate of Return**

### Economic Decision Criteria

- **– Present Value Profile – an example**

<table>
<thead>
<tr>
<th>Discount rate (%)</th>
<th>Discounted cash-flow</th>
<th>Present Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>-200+120/(1.00)+140/(1.00)^2</td>
<td>60</td>
</tr>
<tr>
<td>5</td>
<td>-200+120/(1.05)+140/(1.05)^2</td>
<td>41</td>
</tr>
<tr>
<td>10</td>
<td>-200+120/(1.10)+140/(1.10)^2</td>
<td>25</td>
</tr>
<tr>
<td>15</td>
<td>-200+120/(1.15)+140/(1.15)^2</td>
<td>10</td>
</tr>
<tr>
<td>18.9</td>
<td>-200+120/(1.189)+140/(1.189)^2</td>
<td>0</td>
</tr>
<tr>
<td>20</td>
<td>-200+120/(1.20)+140/(1.20)^2</td>
<td>-3</td>
</tr>
<tr>
<td>25</td>
<td>-200+120/(1.25)+140/(1.25)^2</td>
<td>-14</td>
</tr>
</tbody>
</table>
Economic Decision Criteria

- Maximum Exposure
  - The maximum negative cash-flow on a project.

- Pay-back
  - The time required for an investment to generate sufficient cash-flow to recover the initial capital investment
Economic Decision Analysis

- The results and the quality of the economic analysis depends on
  - The quality of the cash-flow elements
  - If the discount rate reflects the best alternative value of the money

- Then NPV is the best suited decision criteria, and positive NPV means that the project is profitable.
  ➔ Go ahead with the investment!