Basic Petroleum Economics
by Mari Kvaal

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 decisions**

- Investment decisions are among the most important decisions that a company/government can make
  - capital intensive
  - irreversible
  - high risk/uncertainty

**Decisions through the life-cycle of a petroleum project**

In all these phases you have to make decisions.

Investment analysis is used as a management tool when making such decisions.
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 forecast
Nominal/real values
Consider the uncertainties
Discount the cash flow
Net Present Value

Make a decision

Invest

Drop

Wait
Investment analysis

..main economic terms

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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 (outflow)
    - hoping to harvest more
    - $ in the future (inflow)
Cash flow

...annual cash flow

Budgeting techniques are used to calculate the project's cash flow for each year:

Year 1:

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

Cash flow

...over the lifetime of the project

\[
\begin{align*}
\text{Income} - \text{costs} &= \text{Net cash flow} \\
\text{Income} - \text{costs} &= \text{Net cash flow} \\
\text{Income} - \text{costs} &= \text{Net cash flow}
\end{align*}
\]
Cash flow

...an oil investment - the investment project’s cash flow

Cash inflow (income)

Cash outflow (costs)

August 2004
3rd PPM Philippines Case Study Workshop

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

<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>(\frac{212}{1+0.06})</td>
<td>(\frac{449}{(1+0.06)^2})</td>
</tr>
</tbody>
</table>

\[
\begin{align*}
2004 & = 200$ \\
2006 & = 400$
\end{align*}
\]

Expected inflation is 6 % per year
A friend asks to borrow $350 today and pay you back $400 in this way:

- $100 the year after and so on the next three years

If the inflation rate is 5% per year, is this a good deal?
### Cash flow

#### inflation - an example

<table>
<thead>
<tr>
<th></th>
<th>Nominal values</th>
<th>Real values</th>
</tr>
</thead>
<tbody>
<tr>
<td>This year</td>
<td>-350</td>
<td>-350</td>
</tr>
<tr>
<td>+1</td>
<td>100</td>
<td>95</td>
</tr>
<tr>
<td>+2</td>
<td>100</td>
<td>91</td>
</tr>
<tr>
<td>+3</td>
<td>100</td>
<td>86</td>
</tr>
<tr>
<td>+4</td>
<td>100</td>
<td>82</td>
</tr>
<tr>
<td>Sum</td>
<td>50</td>
<td>4</td>
</tr>
</tbody>
</table>

---

*...so far so good*

August 2004

3rd PPM Philippines Case Study Workshop
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
..Time value of Money

- Even after you have adjusted for inflation, it is not correct to simply add up inflow and outflow 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$5cent</td>
</tr>
<tr>
<td>Example 2</td>
<td>92,5cent</td>
<td>1$</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: \( V_2 = 110 \times (1 + 0.10) = 121.0 \)
\( = 100 \times (1 + 0.10) \times (1 + 0.10) \)
\( = 100 \times (1 + 0.10)^2 \)
\( = 121.0 \)
After 3 years: \( V_3 = 121 \times (1 + 0.10) = 133.1 \)
\( = 100 \times (1 + 0.10)^3 \)

etc

Cash flow

..Time value of Money – end value

\[ V_n = V_o \times (1 + r)^n \]
Cash flow

..Time value of Money

- Money received today is worth more than money received in the future:
  - Money today can immediately go to consumption or investment and so give an interest income
  - If you have to wait, you miss the interest income or you have to wait with your consumption

→ People are impatient

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
There is always some uncertainty in investment analysis. The future cash flow cannot 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.

By investing in a diversified (varied) project portfolio, you can lower your total risk exposure.

Only the change of risk an individual project contributes to an investment portfolio is relevant for compensation.
Risk averse companies will demand a compensation for taking risk - they want a risk-premium.

You can express this by correcting the discount-rate

Cash flow

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

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

To calculate the present value is often called discounting
Calculating the Present Value (PV) of an amount is the opposite operation of calculating the end-value.

\[
\begin{align*}
\text{Time} & : 0 & 1 & 2 \\
\text{Cash flow} & : -100 & 80 & 70 \\
\text{Present value} & : -100 & 80/1.06 & 70/(1.06)^2
\end{align*}
\]

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

- Discount rate – the rate used to determine the present worth of future value by discounting.

- The choice of discount rate reflects the cost of capital
  - Time Value of Money
  - Uncertainty

- Banks usually use the interest rate as a discount rate
### Cash flow

#### Net Present Value – an example

<table>
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<th>Real values</th>
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<td></td>
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- Net Present Value – an example

### Cash flow

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<td>89</td>
</tr>
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<td>91</td>
<td>79</td>
</tr>
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<td>+3</td>
<td>100</td>
<td>86</td>
<td>71</td>
</tr>
<tr>
<td>+4</td>
<td>100</td>
<td>82</td>
<td>63</td>
</tr>
<tr>
<td>Sum</td>
<td>50</td>
<td>4</td>
<td>-48</td>
</tr>
</tbody>
</table>
**Cash flow**

..a summary

- Future in- and outflow 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.

**Investment analysis**

..main economic terms

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

- In this part we will see how we can 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>
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<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 | 80/(1.06) | 70/(1.06)^2 |
| 75 | 62 | 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
Economic Decision Criteria

..Net Present Value

- The Net present value (NPV) concept says:
  - Accept all projects with NPV > 0
  - Reject all projects with NPV < 0
  - If NPV = 0, we are indifferent between accepting or rejecting 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
Economic Decision Criteria

Internal Rate of Return

- The discount rate that yields 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

If we go back to project A we have a real cash flow of (-200, 120, 140) million $. The net present value as a function of the discount rate, can be written as:

\[
NPV = -200 + \frac{120}{1+r} + \frac{140}{(1+r)^2}
\]

- If we put in different values for \( r \) we can come up with a present value profile
### 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.

The results and the quality of the economic analysis depend on:

- The quality of the cash flow elements
- Whether 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!