
- Overview
- Methods
  - Payback, discounted payback
  - NPV
  - IRR, MIRR
  - Profitability Index
- Unequal lives
- Economic life

Steps in Capital Budgeting

- Estimate cash flows (inflows & outflows).
- Assess risk of cash flows.
- Determine $r = WACC$ for project.
- Evaluate cash flows.

What is the difference between independent and mutually exclusive projects?

Projects are:
- independent, if the cash flows of one are unaffected by the acceptance of the other.
- mutually exclusive, if the cash flows of one can be adversely impacted by the acceptance of the other.

What is the payback period?

The number of years required to recover a project’s cost, or how long does it take to get the business’s money back?

Payback for Project L (Long: Most CFs in out years)

<table>
<thead>
<tr>
<th>CF_t</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>2.4</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cumulative</td>
<td>-100</td>
<td>-90</td>
<td>-30</td>
<td>0</td>
<td>50</td>
</tr>
</tbody>
</table>

Payback$_L = 2 + \frac{30}{80} = 2.375$ years

Strengths of Payback:
1. Provides an indication of a project’s risk and liquidity.
2. Easy to calculate and understand.

Weaknesses of Payback:
1. Ignores the TVM.
2. Ignores CFs occurring after the payback period.
**Discounted Payback:** Uses discounted rather than raw CFs.

<table>
<thead>
<tr>
<th>$t$</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\text{CF}_t$</td>
<td>-100</td>
<td>9.09</td>
<td>49.59</td>
<td>60.11</td>
</tr>
<tr>
<td>$\text{PVCF}_t$</td>
<td>-100</td>
<td>-90.91</td>
<td>-41.32</td>
<td>18.79</td>
</tr>
<tr>
<td>Discounted payback</td>
<td>$2 + \frac{41.32}{60.11} = 2.7\text{ yrs}$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recover invest. + cap. costs in 2.7 yrs.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**NPV:** Sum of the PVs of inflows and outflows.

$$NPV = \sum_{t=0}^{n} \frac{\text{CF}_t}{(1+r)^t}$$

Cost often is $\text{CF}_0$ and is negative.

$$NPV = \sum_{t=0}^{n} \left[ \frac{\text{CF}_t}{(1+r)^t} - \text{CF}_0 \right]$$

**What's Project L's NPV?**

Project L:

<table>
<thead>
<tr>
<th>$t$</th>
<th>0</th>
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<th>2</th>
<th>3</th>
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<td>49.59</td>
<td>60.11</td>
</tr>
</tbody>
</table>

$$18.79 = NPV_L$$

**Rationale for the NPV Method**

$$NPV = \text{PV inflows} - \text{Cost} = \text{Net gain in wealth.}$$

Accept project if $NPV > 0$.

Choose between mutually exclusive projects on basis of higher NPV. Adds most value.

**Using NPV method, which project(s) should be accepted?**

- If Projects S and L are mutually exclusive, accept S because $NPV_S > NPV_L$.
- If S & L are independent, accept both; $NPV > 0$.

**Internal Rate of Return: IRR**

$$\text{IRR is the discount rate that forces PV inflows} = \text{cost}. \text{ This is the same as forcing NPV} = 0.$$
NPV: Enter \( r \), solve for NPV.
\[
\sum_{t=0}^{n} \frac{CF_t}{(1 + r)^t} = NPV.
\]

IRR: Enter NPV = 0, solve for IRR.
\[
\sum_{t=0}^{n} \frac{CF_t}{(1 + IRR)^t} = 0.
\]

What's Project L’s IRR?
\[
\begin{array}{c|c|c|c|c}
0 & 1 & 2 & 3 \\
\hline
-100.00 & 10 & 60 & 80 \\
\end{array}
\]
\[
\begin{array}{c|c|c|c}
PV_1 & PV_2 & PV_3 \\
\hline
\end{array}
\]

\[0 = NPV\]
Enter CFs in CFLO, then press IRR: \( IRR_L = 18.13\% \).

Decisions on Projects S and L per IRR
- If S and L are independent, accept both. IRRs > \( r = 10\% \).
- If S and L are mutually exclusive, accept S because IRR_S > IRR_L.

Reinvestment Rate Assumptions
- NPV assumes reinvest at \( r \) (opportunity cost of capital).
- IRR assumes reinvest at IRR_L.
- Reinvest at opportunity cost, \( r \), is more realistic, so NPV method is best. NPV should be used to choose between mutually exclusive projects.

Managers like rates—prefer IRR to NPV comparisons. Can we give them a better IRR?
Yes, MIRR is the discount rate which causes the PV of a project’s terminal value (TV) to equal the PV of costs. TV is found by compounding inflows at WACC.

Thus, MIRR assumes cash inflows are reinvested at WACC.
**Normal Cash Flow Project:**

Cost (negative CF) followed by a series of positive cash inflows. One change of signs.

**Nonnormal Cash Flow Project:**

Two or more changes of signs. Most common: Cost (negative CF), then string of positive CFs, then cost to close project. Nuclear power plant, strip mine.

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**Replacement Chain Approach**

<table>
<thead>
<tr>
<th></th>
<th>S</th>
<th>L</th>
</tr>
</thead>
<tbody>
<tr>
<td>$CF_0$</td>
<td>-100,000</td>
<td>-100,000</td>
</tr>
<tr>
<td>$CF_1$</td>
<td>60,000</td>
<td>33,500</td>
</tr>
<tr>
<td>$N_j$</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>$l$</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>NPV</td>
<td>4,132</td>
<td>6,190</td>
</tr>
</tbody>
</table>

NPV$_L$ > NPV$_S$. But is L better? Can’t say yet. Need to perform common life analysis.

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**If the cost to repeat S in two years rises to $105,000, which is best? (000s)**

<table>
<thead>
<tr>
<th></th>
<th>S</th>
<th>L</th>
</tr>
</thead>
<tbody>
<tr>
<td>$CF_0$</td>
<td>(100)</td>
<td>(105)</td>
</tr>
<tr>
<td>$CF_1$</td>
<td>60</td>
<td>60</td>
</tr>
<tr>
<td>$N_j$</td>
<td>60</td>
<td>60</td>
</tr>
<tr>
<td>$l$</td>
<td>60</td>
<td>60</td>
</tr>
<tr>
<td>NPV$_S$</td>
<td>$3,415$</td>
<td>NPV$_L$</td>
</tr>
</tbody>
</table>

Now choose L.
Consider another project with a 3-year life. If terminated prior to Year 3, the machinery will have positive salvage value.

<table>
<thead>
<tr>
<th>Year</th>
<th>CF</th>
<th>Salvage Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>($5,000)</td>
<td>$5,000</td>
</tr>
<tr>
<td>1</td>
<td>2,100</td>
<td>3,100</td>
</tr>
<tr>
<td>2</td>
<td>2,000</td>
<td>2,000</td>
</tr>
<tr>
<td>3</td>
<td>1,750</td>
<td>0</td>
</tr>
</tbody>
</table>

### CFs Under Each Alternative (000s)

<table>
<thead>
<tr>
<th></th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>No termination</td>
<td>(5)</td>
<td>2.1</td>
<td>2</td>
<td>1.75</td>
</tr>
<tr>
<td>Terminate 2 years</td>
<td>(5)</td>
<td>2.1</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Terminate 1 year</td>
<td>(5)</td>
<td>5.2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Assuming a 10% cost of capital, what is the project’s optimal, or economic life?

\[
\begin{align*}
\text{NPV}_{(0)} &= -$123. \\
\text{NPV}_{(2)} &= $215. \\
\text{NPV}_{(1)} &= -$273.
\end{align*}
\]

### Conclusions

- The project is acceptable only if operated for 2 years.
- A project’s engineering life does not always equal its economic life.

### Choosing the Optimal Capital Budget

- Finance theory says to accept all positive NPV projects.
- Two problems can occur when there is not enough internally generated cash to fund all positive NPV projects:
  - An increasing marginal cost of capital.
  - Capital rationing

### Increasing Marginal Cost of Capital

- Externally raised capital can have large flotation costs, which increase the cost of capital.
- Investors often perceive large capital budgets as being risky, which drives up the cost of capital.

(More...)
- If external funds will be raised, then the NPV of all projects should be estimated using this higher marginal cost of capital.

Capital Rationing

- Capital rationing occurs when a company chooses not to fund all positive NPV projects.
- The company typically sets an upper limit on the total amount of capital expenditures that it will make in the upcoming year.