CHAPTER 11
Capital Budgeting
Decision Methods

- Payback
- Net present value (NPV)
- Internal rate of return (IRR)
- Modified internal rate of return (MIRR)

What is capital budgeting?

- Analysis of potential additions to fixed assets.

- Long-term decisions; involve large expenditures.

- Very important to firm’s future.
1. Generate ideas.
2. Estimate the CFs (inflows and outflows).
3. Assess the riskiness of the CFs.
4. Determine the project cost of capital.
5. Find NPV, IRR, and/or MIRR.
6. Accept if NPV > 0.

**Capital Budgeting Steps:**

- Projects are **independent** if the cash flows of one are not affected by the acceptance of the other.
- Projects are **mutually exclusive** if acceptance of one “precludes” acceptance of the other.

**What is the difference between independent and mutually exclusive projects?**
What is the difference between normal and non-normal projects?

- Projects are **normal** if they have outflows or costs in the first year(s) followed by a series of inflows.

- Projects are **non-normal** if one or more outflows occur after the inflows have begun.

Cash flow data we will use for example:

<table>
<thead>
<tr>
<th>Year</th>
<th>CF</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>-$150</td>
</tr>
<tr>
<td>1</td>
<td>15</td>
</tr>
<tr>
<td>2</td>
<td>90</td>
</tr>
<tr>
<td>3</td>
<td>120</td>
</tr>
</tbody>
</table>
What is the payback period?

- The expected number of years required to recover a project’s cost, i.e. how long will it take to get our money back?

What is the rationale for the payback period?

It is a type of “breakeven” analysis. It tells us when the project will break even in a cash flow sense.

Payback for Project

<table>
<thead>
<tr>
<th>Year</th>
<th>CF (_t)</th>
<th>Cumulative CF</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>-150</td>
<td>-150</td>
</tr>
<tr>
<td>1</td>
<td>15</td>
<td>-135</td>
</tr>
<tr>
<td>2</td>
<td>90</td>
<td>-45</td>
</tr>
<tr>
<td>3</td>
<td>120</td>
<td>75</td>
</tr>
</tbody>
</table>

Payback = 2 + 45/120 = 2.375 years
Strengths of Payback:

1. Indication of a project’s risk and liquidity.
2. Easy to calculate and understand.

Weaknesses:

1. Ignores time value of money.
2. Ignores CF’s occurring after payback.

Should we look at payback?

- Some firms do calculate payback and give it some weight in capital budgeting decisions.

- It’s not the primary criterion; rather it is used as one measure of a project’s liquidity and riskiness.
**Discounted payback period**

- Uses discounted cash flows rather than raw CFs.

<table>
<thead>
<tr>
<th>t</th>
<th>0</th>
<th>10%</th>
<th>1</th>
<th>2</th>
<th>2.7</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>CF&lt;sub&gt;t&lt;/sub&gt;</td>
<td>-100</td>
<td>10</td>
<td>60</td>
<td>80</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PV of CF&lt;sub&gt;t&lt;/sub&gt;</td>
<td>-100</td>
<td>9.09</td>
<td>49.59</td>
<td>60.11</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cumulative</td>
<td>-100</td>
<td>-90.91</td>
<td>-41.32</td>
<td>18.79</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Disc Payback = \( 2 + \frac{41.32}{60.11} = 2.7 \) years

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**Net Present Value (NPV)**

\[
\text{NPV} = \sum_{t=0}^{n} \frac{\text{CF}_t}{(1+k)^t}
\]

OR:

\[
\text{NPV} = \sum_{t=1}^{n} \frac{\text{CF}_t}{(1+k)^t} - \text{CF}_0
\]
NPV in words:

- NPV = PV of future CFs discounted at the firm’s cost of capital MINUS the initial outlay
- NPV = the change in shareholder wealth if the project is accepted

What is the project’s NPV?

<table>
<thead>
<tr>
<th>Year</th>
<th>Cash Flow</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>-150</td>
</tr>
<tr>
<td>1</td>
<td>13.64</td>
</tr>
<tr>
<td>2</td>
<td>74.38</td>
</tr>
<tr>
<td>3</td>
<td>90.16</td>
</tr>
<tr>
<td></td>
<td>120</td>
</tr>
</tbody>
</table>

28.18 = NPV
### Calculator Solution

**Uneven cash flow problem:**

<table>
<thead>
<tr>
<th>Year</th>
<th>Cash Flow (CF)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>-150</td>
</tr>
<tr>
<td>1</td>
<td>15</td>
</tr>
<tr>
<td>2</td>
<td>90</td>
</tr>
<tr>
<td>3</td>
<td>120</td>
</tr>
<tr>
<td>4</td>
<td>10</td>
</tr>
</tbody>
</table>

\[ \text{NPV} = \sum \frac{CF_i}{(1 + I)^n} \]

\[ \text{NPV} = \frac{-150}{1} + \frac{15}{1.1} + \frac{90}{1.1^2} + \frac{120}{1.1^3} + \frac{10}{1.1^4} = $28.18 = \text{NPV} \]

### Rationale for NPV method?

- **NPV** = PV inflows - PV costs = Net gain in wealth
- Accept project if NPV \( \geq 0 \)
- Choose between mutually exclusive projects on the basis of higher positive NPV. Adds most to value.
Internal Rate of Return (IRR)

IRR is the discount rate which forces the NPV to equal zero:

\[ \sum_{t=0}^{n} \frac{CF_t}{(1+IRR)^t} = 0 \]

Internal Rate of Return (IRR)

IRR is the discount rate which forces the present value of future CFs to equal the initial outlay:

\[ \sum_{t=1}^{n} \frac{CF_t}{(1+IRR)^t} = \text{Initial Outlay} \]
What is the project’s IRR?

Enter in cash flows:

\[
\begin{align*}
&\text{CF}_0 & \text{CF}_1 & \text{CF}_2 & \text{CF}_3 & \text{IRR} \\
&-150 & 15 & 90 & 120 & = 18.126\% \\
\end{align*}
\]

Internal rate of return rationale:

If IRR = k,
the project cash flows just meet the investors’ required return.

If IRR > k
return is beyond what shareholders expected.
**IRR acceptance criteria:**

- If projects are independent,
  - **accept** all projects with $\text{IRR} \geq k$
  - **reject** all projects with $\text{IRR} < k$

**NPV and IRR always lead to the same accept/reject decision for any independent project.**

- $\text{IRR} > k$ and $\text{NPV} > 0$ **ACCEPT**
- $\text{IRR} < k$ and $\text{NPV} < 0$ **REJECT**
NPV and IRR can rank “acceptable” projects differently which can lead to conflicting choices for mutually exclusive projects.

Timing differences:
A project with faster payback provides more CF in early years for reinvestment.

Size (scale) differences:
Smaller project frees up funds at $t = 0$ for investment. The higher the opportunity cost, the more valuable these funds are.

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**Problems with IRR:**

- Lack of unique solution: Projects with non-normal CFs can have more than one IRR.

- Reinvestment rate: IRR assumes that future CFs can be reinvested at the same rate of return for the current project.
NPV

- Always has a unique solution.

- Assumes reinvestment at the opportunity cost (firm’s cost of capital).

Reinvestment rate assumptions

- Reinvestment at the opportunity cost, \( k \), is more realistic, since it only implies that the firm exists. Any higher reinvestment rate implies that the future projects meet that return.

- NPV should be used to choose between mutually exclusive projects.
BUT, Managers like rates - they can visualize IRR better than NPV. Can we give them a better IRR?

YES. The Modified Internal Rate of Return (MIRR) is the discount rate which causes the PV of a project’s terminal value (TV) to equal the PV of its costs.

Modified Internal Rate of Return (MIRR)

The MIRR is always unique.

Also, the TV is found by compounding inflows at the opportunity cost of capital, so the MIRR assumes cash inflows are reinvested at the firm’s cost of capital (as in NPV).
MIRR Formula

\[ \sum_{t=0}^{n} \frac{\text{COF}_t}{(1+k)^t} = \frac{\sum_{t=0}^{n} \text{CIF}_t(1+k)^{n-t}}{(1+\text{MIRR})^n} \]

COF = cash outflows  
CIF = cash inflows

MIRR for project (k = 10%)  

\[ 0 \quad 10\% \quad 1 \quad 2 \quad 3 \]

\[ -150 \quad 15 \quad 90 \quad 120 \]

PV of outflows  
TV of inflows  
$150 = \frac{$237.15}{(1+\text{MIRR})^3}$  
MIRR = 16.5%
Step 1: Calculate the present value of all negative CFs (using the cost of capital as the interest rate).

Step 2: Calculate the future value of all positive CFs as of the end of the project (using the cost of capital as the interest rate). First, get PV and use it to calculate FV.

Step 3: Find the interest rate (MIRR) that equates the future value from 2 with the present value from 1.

### MIRR Calculation Steps:

1. Separate negative and positive CFs.
2. Calculate the present value of all negative CFs.
3. Calculate the future value of all positive CFs.
4. Find the interest rate (MIRR) that equates the future value from step 2 with the present value from step 1.

### Example:
Your firm’s cost of capital is 10% and it is considering a project with the following CFs. What is the project’s MIRR?

<table>
<thead>
<tr>
<th>Year</th>
<th>CFs</th>
<th>Step1</th>
<th>Step2</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>-100,000</td>
<td>-100,000</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>20,000</td>
<td>0</td>
<td>20,000</td>
</tr>
<tr>
<td>2</td>
<td>40,000</td>
<td>0</td>
<td>40,000</td>
</tr>
<tr>
<td>3</td>
<td>-35,000</td>
<td>-35,000</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>80,000</td>
<td>0</td>
<td>80,000</td>
</tr>
<tr>
<td>5</td>
<td>70,000</td>
<td>0</td>
<td>70,000</td>
</tr>
<tr>
<td>6</td>
<td>-10,000</td>
<td>-10,000</td>
<td>0</td>
</tr>
</tbody>
</table>
Step 1: PV(-)

\[
\begin{align*}
CF_0 &= -100000 \\
CF_1 &= 0 \\
CF_2 &= 0 \\
CF_3 &= -35000 \\
CF_4 &= 0 \\
CF_5 &= 0 \\
CF_6 &= -10000 \\
I &= 10 \\
\text{NPV} &= -131,940.76
\end{align*}
\]

Step 2a: PV(+)

\[
\begin{align*}
CF_0 &= 0 \\
CF_1 &= 20000 \\
CF_2 &= 40000 \\
CF_3 &= 0 \\
CF_4 &= 80000 \\
CF_5 &= 70000 \\
CF_6 &= 0 \\
I &= 10 \\
\text{NPV} &= 149,345.24
\end{align*}
\]
Step 2b: FV(+)

N = number of years in project
I = cost of capital
PV = present value of positive cash flows

\[
\begin{array}{cccc}
N & I & PV & *FV* \\
6 & 10 & 149345.24 & 264574.20 \\
\end{array}
\]

Step 3: MIRR

N = number of years in project
PV = present value of negative cash flows
FV = future value of positive cash flows

\[
\begin{array}{cccc}
N & *I* & PV & FV \\
6 & 12.295 & -131940.76 & 264574.20 \\
\end{array}
\]

MIRR
NO. MIRR does not always lead to the same decision as NPV for mutually exclusive projects. Small projects often have a higher MIRR, but a lower NPV than larger projects.

NPV remains the conceptually best decision rule.