Chapter 8 – Net Present Value and Other Investment Criteria

Topics Covered

- Net Present Value
- Other Investment Criteria
- Mutually Exclusive Projects
- Capital Rationing
What is capital budgeting?

- Capital budgeting is the process of evaluating specific investment decisions.
- Capital budgeting is the decision process that managers use to identify projects that add to the firm’s value.

Net Present Value

Net Present Value - Present value of cash flows minus initial investments.

Opportunity Cost of Capital - Expected rate of return given up by investing in a project
Net Present Value

Example

Q: Suppose we can invest $50 today & receive $60 later today. What is our increase in value?

A: Profit = - $50 + $60 = $10

<table>
<thead>
<tr>
<th>Initial Investment</th>
<th>Added Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$50</td>
<td>$10</td>
</tr>
</tbody>
</table>

Net Present Value

Example

Suppose we can invest $50 today and receive $60 in one year. What is our increase in value given a 10% expected return?

Profit = -50 + \( \frac{60}{1.10} \) = $4.55

This is the definition of NPV

<table>
<thead>
<tr>
<th>Initial Investment</th>
<th>Added Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$50</td>
<td>$4.55</td>
</tr>
</tbody>
</table>
Valuing an Office Building

**Step 1: Forecast cash flows**
- Cost of building = \( C_0 = 350,000 \)
- Sale price in Year 1 = \( C_1 = 400,000 \)

**Step 2: Estimate opportunity cost of capital**
If equally risky investments in the capital market offer a return of 7%, then
- Cost of capital = \( r = 7\% \)

**Step 3: Discount future cash flows**
\[
PV = \frac{C_1}{(1+r)} = \frac{400,000}{(1+0.07)} = 373,832
\]

**Step 4: Go ahead if PV of payoff exceeds investment**
\[
NPV = -350,000 + 373,832 = 23,832
\]
Risk and Present Value

- Higher risk projects require a higher rate of return
- Higher required rates of return cause lower PVs

\[
\text{PV of } C_1 = $400,000 \text{ at 7%} \\
\text{PV} = \frac{400,000}{1+.07} = 373,832
\]

\[
\text{PV of } C_1 = $400,000 \text{ at 12%} \\
\text{PV} = \frac{400,000}{1+.12} = 357,143
\]
Net Present Value

**NPV = PV - required investment**

\[
NPV = C_0 + \frac{C_t}{(1+r)^t}
\]

\[
NPV = C_0 + \frac{C_1}{(1+r)^1} + \frac{C_2}{(1+r)^2} + \ldots + \frac{C_t}{(1+r)^t}
\]

**Terminology**

- **C** = Cash Flow
- **t** = time period of the investment
- **r** = “opportunity cost of capital”

- The Cash Flow could be positive or negative at any time period.
Net Present Value Rule

Managers increase shareholders’ wealth by accepting all projects that are worth more than they cost.

Therefore, they should accept all projects with a positive net present value.

Net Present Value – Another Example

Example
You have the opportunity to purchase an office building. You have a tenant lined up that will generate $16,000 per year in cash flows for three years. At the end of three years you anticipate selling the building for $450,000. How much would you be willing to pay for the building?

Assume a 7% opportunity cost of capital
Net Present Value

Example - continued

If the building is being offered for sale at a price of $350,000, would you buy the building? If so, what is the added value generated by your purchase and management of the building?
Net Present Value

Example - continued

If the building is being offered for sale at a price of $350,000, would you buy the building? If so, what is the added value generated by your purchase and management of the building?

\[ NPV = -350,000 + \frac{16,000}{(1.07)^1} + \frac{16,000}{(1.07)^2} + \frac{466,000}{(1.07)^3} \]

\[ NPV = $59,323 \]

Net Present Value in Excel

- There are several ways to solve using Excel.
  - Find the Present Value of each cash flow individually (using PV) and sum them up (or treat it as an annuity if the payments are equal).
  - Or, use the NPV function, choosing all of the cash flows beginning with the cash flow in period 1. Later add in the (negative) cash outflow.
Assume you are presented with the following potential project. If the opportunity cost is 12%, what is the Net Present Value? Should you invest in this project?

<table>
<thead>
<tr>
<th>Year</th>
<th>Time</th>
<th>Cash Flow</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>0</td>
<td>(25,000.00)</td>
</tr>
<tr>
<td>2011</td>
<td>1</td>
<td>3,000.00</td>
</tr>
<tr>
<td>2012</td>
<td>2</td>
<td>3,000.00</td>
</tr>
<tr>
<td>2013</td>
<td>3</td>
<td>3,500.00</td>
</tr>
<tr>
<td>2014</td>
<td>4</td>
<td>3,500.00</td>
</tr>
<tr>
<td>2015</td>
<td>5</td>
<td>3,750.00</td>
</tr>
<tr>
<td>2016</td>
<td>6</td>
<td>3,750.00</td>
</tr>
<tr>
<td>2017</td>
<td>7</td>
<td>4,000.00</td>
</tr>
<tr>
<td>2018</td>
<td>8</td>
<td>4,000.00</td>
</tr>
<tr>
<td>2019</td>
<td>9</td>
<td>4,250.00</td>
</tr>
<tr>
<td>2020</td>
<td>10</td>
<td>4,350.00</td>
</tr>
<tr>
<td>2021</td>
<td>11</td>
<td>4,450.00</td>
</tr>
<tr>
<td>2022</td>
<td>12</td>
<td>4,550.00</td>
</tr>
<tr>
<td>2023</td>
<td>13</td>
<td>4,600.00</td>
</tr>
<tr>
<td>2024</td>
<td>14</td>
<td>4,750.00</td>
</tr>
<tr>
<td>2025</td>
<td>15</td>
<td>5,000.00</td>
</tr>
</tbody>
</table>

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.
Independent versus Mutually Exclusive Projects

If projects are independent, you would simply choose all projects with a positive NPV.

When you need to choose between mutually exclusive projects, the decision rule is simple. Calculate the NPV of each project, and, from those options that have a positive NPV, choose the one whose NPV is highest.

Payback Method

**Payback Period** - Time until cash flows recover the initial investment of the project.

- The *payback rule* specifies that a project be accepted if its payback period is less than the specified cutoff period. The following example will demonstrate the absurdity of this statement.
Payback Method

Example
The three project below are available. The company accepts all projects with a 2 year or less payback period. Show how this decision will impact our decision.

<table>
<thead>
<tr>
<th>Cash Flows</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project</td>
</tr>
<tr>
<td>A</td>
</tr>
<tr>
<td>B</td>
</tr>
<tr>
<td>C</td>
</tr>
</tbody>
</table>

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 Terminal Value.
2. Ignores CFs occurring after the payback period.
Another Example
Solve for Payback Period on this Project

\[
\begin{array}{c|cccc}
0 & 1 & 2 & 2.4 & 3 \\
\hline
\text{CF}_t & -100 & 10 & 60 & 100 \\
\text{Cumulative} & -100 & -90 & -30 & 0 \\
\end{array}
\]

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

Payback = Year before full recovery + 
(unrecovered cost at start of the next year) / (cash flow during the next year)

Discounted Payback: Uses discounted rather than raw CFs.

\[
\begin{array}{c|cccc}
0 & 10\% & 1 & 2 & 3 \\
\hline
\text{CF}_t & -100 & 10 & 60 & 80 \\
\text{PVCF}_t & -100 & 9.09 & 49.59 & 60.11 \\
\text{Cumulative} & -100 & -90.91 & -41.32 & 18.79 \\
\end{array}
\]

Discounted payback = 2 + \frac{41.32}{60.11} = 2.7 yrs

Recover invest. + cap. costs in 2.7 yrs.
Other Investment Criteria

**Internal Rate of Return (IRR)** - Discount rate at which NPV = 0.

**Rate of Return Rule** - Invest in any project offering a rate of return that is higher than the opportunity cost of capital.

If only one cash flow and one investment:

\[
\text{Rate of Return} = \frac{C_1 - \text{investment}}{\text{investment}}
\]

**Internal Rate of Return**

**Example**

You can purchase a building for $350,000. The investment will generate $16,000 in cash flows (i.e. rent) during the first three years. At the end of three years you will sell the building for $450,000. What is the IRR on this investment?
Internal Rate of Return

Example

You can purchase a building for $350,000. The investment will generate $16,000 in cash flows (i.e. rent) during the first three years. At the end of three years you will sell the building for $450,000. What is the IRR on this investment?

\[
0 = -350,000 + \frac{16,000}{(1 + IRR)} + \frac{16,000}{(1 + IRR)^2} + \frac{466,000}{(1 + IRR)^3}
\]

IRR = 12.96%

Internal Rate of Return

Calculating IRR by using a spreadsheet

<table>
<thead>
<tr>
<th>Year</th>
<th>Cash Flow</th>
<th>Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>(350,000.00)</td>
<td>IRR = 12.96% =IRR(B4:B7)</td>
</tr>
<tr>
<td>1</td>
<td>16,000.00</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>16,000.00</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>466,000.00</td>
<td></td>
</tr>
</tbody>
</table>
Pitfall 1 - Lending or Borrowing?

- Take an example:
- One project where you invest $100 today and receive $150 at the end of year 1. In the other project you borrow $100 today and return $150 at the end of year 1. What does IRR tell you? What does NPV tell you?
Internal Rate of Return

Pitfall 2 - Multiple Rates of Return
Certain cash flows can generate $NPV=0$ at two different discount rates (in the case of non-normal cash flows).

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.
Inflow (+) or Outflow (-) in Year

<table>
<thead>
<tr>
<th></th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>N</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-</td>
<td>N</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-</td>
<td>N</td>
<td></td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td>N</td>
<td>N</td>
<td></td>
</tr>
<tr>
<td>+</td>
<td></td>
<td>N</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-</td>
<td></td>
<td></td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
</tr>
</tbody>
</table>

Pavilion Project: NPV and IRR?

Using a Calculator, if you Enter CFs enter \( r = 10\% \).

\[
\text{NPV} = -386.78
\]

\[
\text{IRR} = \text{ERROR. Why?}
\]
Excel Solution

If you input 200% for the guess you will see the multiple IRR.

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td>35</td>
<td>Time</td>
<td>Cash Flow</td>
<td>Time</td>
<td>Cash Flow</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>-800</td>
<td>0</td>
<td>-800</td>
</tr>
<tr>
<td>36</td>
<td>1</td>
<td>5000</td>
<td>1</td>
<td>5000</td>
</tr>
<tr>
<td>37</td>
<td>2</td>
<td>-5000</td>
<td>2</td>
<td>-5000</td>
</tr>
<tr>
<td>39</td>
<td>Rate</td>
<td>10%</td>
<td>Rate</td>
<td>10%</td>
</tr>
<tr>
<td>40</td>
<td>NPV</td>
<td>($386.78)</td>
<td>NPV</td>
<td>($386.78)</td>
</tr>
<tr>
<td>41</td>
<td>IRR</td>
<td>25.00%</td>
<td>IRR</td>
<td>400.00%</td>
</tr>
</tbody>
</table>

Internal Rate of Return

Pitfall 3 - Mutually Exclusive Projects
- IRR sometimes ignores the magnitude of the project.
- The following two projects illustrate that problem.
Internal Rate of Return

**Example**

You have two proposals to choose between. The initial proposal has a cash flow that is different than the revised proposal. Using IRR, which do you prefer?

<table>
<thead>
<tr>
<th>Project</th>
<th>C₀</th>
<th>C₁</th>
<th>C₂</th>
<th>C₃</th>
<th>IRR</th>
<th>NPV@7%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Proposal</td>
<td>-350</td>
<td>400</td>
<td></td>
<td></td>
<td>14.29%</td>
<td>$ 24,000</td>
</tr>
<tr>
<td>Revised Proposal</td>
<td>-350</td>
<td>16</td>
<td>16</td>
<td>466</td>
<td>12.96%</td>
<td>$ 59,000</td>
</tr>
</tbody>
</table>

Project Interactions

When you need to choose between mutually exclusive projects, the decision rule is simple. Calculate the NPV of each project, and, from those options that have a positive NPV, choose the one whose NPV is highest.
Reinvestment Rate Assumptions

- NPV assumes that cash flows are reinvested at \( r \) (opportunity cost of capital).
- IRR assumes they are reinvested at IRR.
- Reinvesting 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 the opportunity cost.

Thus, MIRR assumes cash inflows are reinvested at opportunity cost.
MIRR Example

Excel Solution

<table>
<thead>
<tr>
<th>Time</th>
<th>Cash Flow</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>-100.0</td>
</tr>
<tr>
<td>1</td>
<td>10.0</td>
</tr>
<tr>
<td>2</td>
<td>60.0</td>
</tr>
<tr>
<td>3</td>
<td>80.0</td>
</tr>
<tr>
<td>29</td>
<td>Reinvestment Rate</td>
</tr>
<tr>
<td>29</td>
<td>IRR</td>
</tr>
<tr>
<td>30</td>
<td>MIRR</td>
</tr>
</tbody>
</table>

Use the MIRR function to find the discount rate. Reinvestment Rate is Opportunity Cost.
Why use MIRR versus IRR?

MIRR correctly assumes reinvestment at opportunity cost. MIRR also avoids the problem of multiple IRRs.

Managers like rate of return comparisons, and MIRR is better for this than IRR.

Other Investment Decisions

- Investment Timing
- Choosing between long and short-lived Equipment
- The Replacement Decision
Investment Timing

- Calculate NPV using the different scenarios. Whichever scenario gives you the highest NPV, is the one you should take.

For choosing between equipment and/or the replacement decision we use Equivalent Annual Annuity

**Equivalent Annual Annuity** - The cash flow per period with the same present value as the cost of buying and operating a machine.

Equivalent to solving for an Annuity Payment or using annuity factor table:

\[
\text{Equivalent annual annuity} = \frac{\text{present value of cash flows}}{\text{annuity factor}}
\]
Equivalent Annual Annuity

Example

Given the following costs of operating two machines and a 6% cost of capital, select the lower cost machine using equivalent annual annuity method.

<table>
<thead>
<tr>
<th>Mach</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>PV@6%</th>
<th>E.A.A.</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>-15</td>
<td>-4</td>
<td>-4</td>
<td>-4</td>
<td>-25.69</td>
<td>-9.61</td>
</tr>
<tr>
<td>G</td>
<td>-10</td>
<td>-6</td>
<td>-6</td>
<td></td>
<td>-21.00</td>
<td>-11.45</td>
</tr>
</tbody>
</table>

Capital Rationing

Capital Rationing - Limit set on the amount of funds available for investment.

Soft Rationing - Limits on available funds imposed by management.

Hard Rationing - Limits on available funds imposed by the unavailability of funds in the capital market.
Profitability Index

Profitability Index = \( \frac{NPV}{\text{Initial Investment}} \)

**Profitability Index**

Ratio of net present value to initial investment.

<table>
<thead>
<tr>
<th>Project</th>
<th>PV</th>
<th>Investment</th>
<th>NPV</th>
<th>Profitability Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>J</td>
<td>4</td>
<td>3</td>
<td>1</td>
<td>1/3 = .33</td>
</tr>
<tr>
<td>K</td>
<td>6</td>
<td>5</td>
<td>1</td>
<td>1/5 = .20</td>
</tr>
<tr>
<td>L</td>
<td>10</td>
<td>7</td>
<td>3</td>
<td>3/7 = .43</td>
</tr>
<tr>
<td>M</td>
<td>8</td>
<td>6</td>
<td>2</td>
<td>2/6 = .33</td>
</tr>
<tr>
<td>N</td>
<td>5</td>
<td>4</td>
<td>1</td>
<td>1/4 = .25</td>
</tr>
</tbody>
</table>
Capital Budgeting Techniques

<table>
<thead>
<tr>
<th>Investment Criterion</th>
<th>Percentage of Firms That Always or Almost Always Use Criterion</th>
<th>Average Score on 0-4 Scale (0 = never use; 4 = always use)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>All Firms</td>
</tr>
<tr>
<td>Internal rate of return</td>
<td>76</td>
<td>3.1</td>
</tr>
<tr>
<td>Net present value</td>
<td>75</td>
<td>3.1</td>
</tr>
<tr>
<td>Payback period</td>
<td>57</td>
<td>2.5</td>
</tr>
<tr>
<td>Profitability index</td>
<td>12</td>
<td>0.6</td>
</tr>
</tbody>
</table>


Try some Examples