Learning objectives

- Explain the purpose and importance of capital budgeting
- Determine whether a new project should be accepted using the following rules:
  - net present value (NPV)
  - internal rate of return (IRR)
  - profitability index (PI)
  - payback period (PBP)
- Explain which decision rule should be used to maximize shareholder wealth

Example

You are contemplating the purchase of a rental property. The property consists of 12 apartments, each of which fetches a rent of $600 per month.

The cost of maintaining the entire property is $1,800 per month.

The effective monthly discount rate is 1%.

The property has an economic life of ten years and can be sold for $500,000 at the end of its life.

1. What is the maximum that you would pay for this property?
2. What if the owner is selling for $500,000?

The Net Present Value (NPV)

Write down the CF stream
- cash inflows are positive
- cash outflows are negative

Use the risk adjusted cost of capital to calculate

\[ NPV = PV \text{ (CF stream)} \]

Note: we say "net" present value because we subtract the PV of cash outflows (costs, investment) from the PV of cash inflows (benefits).

The Net Present Value (NPV) rule

The goal of capital budgeting:
Find a decision rule that will maximize shareholder wealth

The NPV rule:

- **Accept project if NPV > 0**
- If we accept a project with NPV > 0 → increase shareholder wealth
- If we accept a project with NPV < 0 → decrease shareholder wealth
Assumptions

Assumption 1 (magnitude preference): all else equal, investors prefer to have more money rather than less.

Assumption 2 (timing preference): all else equal, investors prefer to get the money sooner (today) rather than later (in the future).

Assumption 3 (risk preference): all else equal, investors prefer a safe CF to a risky CF (they are risk-averse).

Assumption 4 (management’s goal): The primary goal of the firm’s management is to maximize shareholder wealth.

Good Capital Budgeting Decision Rules

Criterion 1: Does the NPV rule consider ALL CFs?
Criterion 2: Does the NPV rule consider CFs timing?
Criterion 3: Does the NPV rule consider CFs riskiness?
Criterion 4: Is the NPV rule consistent with management’s primary goal - maximizing shareholders wealth?

Profitability Index (PI)

Write down the CF stream:
- cash inflows
- cash outflows (investment)

Use the risk adjusted cost of capital to calculate:

NPV = \( PV(cash\ inflows) - PV(cash\ outflows) \)

\[ PI = \frac{PV(cash\ inflows)}{PV(cash\ outflows)} \]

Note that PI is a ratio while NPV is a difference.

The Profitability Index (PI) rule

(PI (ratio) rule intuition: look for projects with

\( PV(cash\ inflows) > PV(cash\ outflows) \)

\[ PI = \frac{PV(cash\ inflows)}{PV(cash\ outflows)} \]

If PI > 1 \( \Rightarrow \) Accept project
If PI = 1 \( \Rightarrow \) indifference
If PI < 1 \( \Rightarrow \) Reject project

The Net Present Value (NPV) rule

NPV (difference) rule intuition: look for projects with

\( PV(cash\ inflows) > PV(cash\ outflows) \)

\[ NPV = PV(cash\ inflows) - PV(cash\ outflows) \]

If NPV > 0 \( \Rightarrow \) Accept project
If NPV = 0 \( \Rightarrow \) indifference
If NPV < 0 \( \Rightarrow \) Reject project

Example - apply NPV and PI

You are contemplating the purchase of a rental property. The property consists of 12 apartments, each of which fetches a rent of $600 per month. The cost of maintaining the entire property is $1,800 per month. The effective monthly discount rate is 1%. The property has an economic life of ten years and can be sold for $500,000 at the end of its life.

1. What is the maximum that you would pay for this property?
2. What if the owner is selling for $500,000?
Consider the mutually exclusive projects A and B.

<table>
<thead>
<tr>
<th>Project</th>
<th>PV(inflows)</th>
<th>PV(outflows)</th>
<th>PI</th>
<th>NPV</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>$110,000</td>
<td>$100,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>$315,000</td>
<td>$300,000</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

NPV(A) __ NPV(B) \(\Rightarrow\) Choose project ____

PI(A) __ PV(B) \(\Rightarrow\) Choose Project ____

Which rule should we use?

The Internal Rate of Return (IRR)

Write down the CF stream (cash inflows and cash outflows (investment)).

Set NPV = 0 and solve for the cost of capital \(r\):

\[
NPV = \frac{CF_0}{(1 + IRR)^0} + \frac{CF_1}{(1 + IRR)^1} + \frac{CF_2}{(1 + IRR)^2} + \cdots + \frac{CF_T}{(1 + IRR)^T} = 0
\]

Note: use a trial-and-error algorithm to find IRR.

If NPV>0 then we used \(r < IRR\)
If NPV=0 then we used \(r = IRR\)
If NPV<0 then we used \(r > IRR\)

Example - apply IRR

You are contemplating the purchase of a rental property. The property consists of 12 apartments, each of which fetches a rent of $600 per month.

The cost of maintaining the entire property is $1,800 per month.

The effective monthly discount rate is 1%.

The property has an economic life of ten years and can be sold for $500,000 at the end of its life.

1. Calculate IRR if the owner is selling for $500,000
2. Compare IRR to the cost of capital and decide whether to accept / reject the project.

The Internal Rate of Return (IRR) rule

IRR is a yield - what we earn, on average, per year. Compare the IRR to the required (risk-adjusted) rate of return:

If IRR > required risk-adjusted return
\(\Rightarrow\) Accept project
If IRR = required risk-adjusted return
\(\Rightarrow\) Indifference
If IRR < required risk-adjusted return
\(\Rightarrow\) Reject project

NPV and IRR (conventional projects)
Textbook application: NPV & IRR

A firm considers an investment of $1,200 in a project that yields cash flows of $500 in the first year, $600 in the second year and $700 in the third year.

The annual risk adjusted cost of capital is 10%.

Compute the project NPV and IRR and decide whether to accept or reject.

Apply the NPV, IRR and PI rules

Assume the following CF stream and an annual risk adjusted cost of capital of 11%.

Compute the NPV, IRR, PI and decide whether the project should be accepted or rejected.

<table>
<thead>
<tr>
<th>Date</th>
<th>t=0</th>
<th>t=1</th>
<th>t=2</th>
<th>t=3</th>
<th>t=4</th>
<th>T=5</th>
</tr>
</thead>
<tbody>
<tr>
<td>CF</td>
<td>-1,000</td>
<td>400</td>
<td>400</td>
<td>400</td>
<td>500</td>
<td>500</td>
</tr>
</tbody>
</table>

Example

A five-year project, if taken, will require an initial investment of $120,000. The expected end-of-year cash inflows are as follows:

<table>
<thead>
<tr>
<th>Date</th>
<th>t=0</th>
<th>t=1</th>
<th>t=2</th>
<th>t=3</th>
<th>t=4</th>
<th>T=5</th>
</tr>
</thead>
<tbody>
<tr>
<td>CF</td>
<td>30,000</td>
<td>42,000</td>
<td>42,000</td>
<td>28,000</td>
<td>12,000</td>
<td></td>
</tr>
</tbody>
</table>

If the appropriate cost of capital for this project is 11%, which of the following is a correct decision?

a. Reject the project because NPV = -$30,507, which is less than 0
b. Reject the project because IRR is 10.04%, which is less than the cost of capital, 11%
c. Both a and b are correct
d. Accept the project because IRR is positive
e. None of the above

Textbook Example

The firm’s cost of capital for the following project is 12%.

The project will require an initial investment of $6 million and generate cash flows of $750,000 per year for ever.

Compute the NPV, IRR and PI of the project.

IRR technical problems: Example 1

Consider a project that yields (pays) a cash flow of $120 on date t=0 and requires an outflow (investment) of $100 to be paid on date t=1. The discount rate is 10%.

Calculate the NPV and IRR and decide whether to accept / reject.

IRR technical problems: Example 2

Consider the following project cash flows:

<table>
<thead>
<tr>
<th>Date</th>
<th>t=0</th>
<th>t=1</th>
<th>t=2</th>
</tr>
</thead>
<tbody>
<tr>
<td>CF</td>
<td>-400</td>
<td>2,500</td>
<td>3,000</td>
</tr>
</tbody>
</table>

Suppose the discount rate is 70%. Verify that NPV = $32.53

What about the IRR?
**NPV and the required rate of return**

Figure 11.3: Project NPV profile. Cash flows at $t=0, 1, 2$ are $-400$, $2,500$, $-3,000$.

**IRR and Conventional Projects**

Conventional project:
1. Starts with an investment: outflows, one or more negative CFs
2. Ends with inflows, positive CFs
3. There is only one sign change - only one transition from negative to positive CFs

**IRR and Unconventional Projects**

Unconventional project:
1. May start with a positive CF rather than an investment (outflow, negative CF)
2. May end with negative CFs - outflows, not inflows
3. There may be more than one sign change - more than one transition from negative to positive CFs or positive to negative CFs

If the project is not conventional the IRR rule has to be modified. Use the NPV rule!

**Example: scale differences**

Consider the mutually exclusive projects A and B

<table>
<thead>
<tr>
<th>Date</th>
<th>$t=0$</th>
<th>$t=1$</th>
<th>$t=2$</th>
<th>$t=3$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$CF(A)$</td>
<td>-$1,000,000$</td>
<td>$400,000$</td>
<td>$400,000$</td>
<td>$400,000$</td>
</tr>
<tr>
<td>$CF(B)$</td>
<td>-$1$</td>
<td>$0.4$</td>
<td>$0.4$</td>
<td>$0.5$</td>
</tr>
</tbody>
</table>

NPV(A) __ NPV(B)  Choose project ____
IRR(A) __ IRR(B)  Choose Project ____
PI(A) __ PV(B)  Choose Project ____

Which rule should we use?

**Good Capital Budgeting Decision Rules**

**Criterion 1:** Does the IRR rule consider ALL CFs?

**Criterion 2:** Does the IRR rule consider CFs timing?

**Criterion 3:** Does the IRR rule consider CFs riskiness?

**Criterion 4:** Is the IRR rule consistent with management's primary goal - maximizing shareholders wealth? + technical problems if the project is not conventional

**The Pay-Back Period (PBP)**

The payback period for a project is the length of time it takes to get your initial investment back. It is the time from the initial cash outflow to the time when the project's cash inflows add up to the initial cash outflow.

Example: if the initial investment is $100,000 and the project's CF stream is as follows, PBP = ______

<table>
<thead>
<tr>
<th>Date</th>
<th>$t=1$</th>
<th>$t=2$</th>
<th>$t=3$</th>
<th>$t=4$</th>
<th>$t=5$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$CF$</td>
<td>30,000</td>
<td>42,000</td>
<td>42,000</td>
<td>28,000</td>
<td>12,000</td>
</tr>
<tr>
<td>ACC. CF</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The Pay-Back Period (PBP) rule

Firms usually specify an arbitrary number of periods (t) as the maximum time-to-payback. The PBP decision rule is:

- If PBP < t → Accept project
- If PBP = t → Indifference
- If PBP > t → Reject project

Textbook example: PBP

Calculate the payback period for the following projects, which project will you accept if you require a maximum of 3 years to payback?

<table>
<thead>
<tr>
<th>Date</th>
<th>t=0</th>
<th>t=1</th>
<th>t=2</th>
<th>t=3</th>
<th>t=4</th>
<th>T=5</th>
</tr>
</thead>
<tbody>
<tr>
<td>CF(A)</td>
<td>-9,000</td>
<td>2,000</td>
<td>3,000</td>
<td>4,000</td>
<td>5,000</td>
<td>6,000</td>
</tr>
<tr>
<td>CF(B)</td>
<td>-11,000</td>
<td>2,000</td>
<td>3,000</td>
<td>4,000</td>
<td>5,000</td>
<td>6,000</td>
</tr>
</tbody>
</table>

Example: PBP compared with NPV

Assume the firm uses two years as the critical number of periods to payback and the cost of capital is 10%. Calculate the NPV and PBP for the two projects.

<table>
<thead>
<tr>
<th>Date</th>
<th>t=0</th>
<th>t=1</th>
<th>t=2</th>
<th>t=3</th>
<th>T=3</th>
</tr>
</thead>
<tbody>
<tr>
<td>CF(A)</td>
<td>-1,000</td>
<td>500</td>
<td>510</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>CF(B)</td>
<td>-1,000</td>
<td>0</td>
<td>0</td>
<td>99,000,000</td>
<td></td>
</tr>
</tbody>
</table>

NPV(A) __ NPV(B) → Choose project ____
PBP(A) __ PBP(B) → Choose Project ____
Which rule should we use?

Good Capital Budgeting Decision Rules

Criterion 1:
Does the PBP rule consider ALL CFs?

Criterion 2:
Does the PBP rule consider CFs timing?

Criterion 3:
Does the PBP rule consider CFs riskiness?

Criterion 4:
Is the PBP rule consistent with management's primary goal - maximizing shareholders wealth?

The Discounted Pay-Back Period (DPBP)

The discounted payback period for a project is the length of time it takes to get your initial investment back in terms of discounted future CFs.

Example: if the initial investment is $100,000, the cost of capital is 2% and the project's CF stream is as follows, DPBP = _______

<table>
<thead>
<tr>
<th>Date</th>
<th>t=1</th>
<th>t=2</th>
<th>t=3</th>
<th>t=4</th>
<th>T=5</th>
</tr>
</thead>
<tbody>
<tr>
<td>CF</td>
<td>30,000</td>
<td>42,000</td>
<td>42,000</td>
<td>28,000</td>
<td>12,000</td>
</tr>
<tr>
<td>PV(CF)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ACC PV(CF)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The Discounted Pay-Back Period rule

Firm usually specify an arbitrary number of periods (t) as the maximum time-to-discounted-payback. The Discounted PBP decision rule they is:

- If Discounted PBP < t → Accept project
- If Discounted PBP = t → Indifference
- If Discounted PBP > t → Reject project
Discounted PBP example

Suppose that the discount rate is 10%. Project A has the following cash flows. Find A's discounted PBP.

<table>
<thead>
<tr>
<th>Date</th>
<th>t=1</th>
<th>t=2</th>
<th>t=3</th>
<th>t=4</th>
</tr>
</thead>
<tbody>
<tr>
<td>CF</td>
<td>-9,000</td>
<td>3,000</td>
<td>6,000</td>
<td>9,000</td>
</tr>
<tr>
<td>PV(CF)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ACC. PV(CF)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Good Capital Budgeting Decision Rules

Criterion 1: Does the Discounted PBP rule consider ALL CFs?
Criterion 2: Does the Discounted PBP rule consider CFs timing?
Criterion 3: Does the Discounted PBP rule consider CFs riskiness?
Criterion 4: Is the Discounted PBP rule consistent with management’s primary goal - maximizing shareholders wealth?

Why the PBP criterion exists?

- PBP is widely used by corporations
- It is used as a secondary project selection criterion

Example: the firm may require a project to have (1) positive NPV first and also (2) satisfy some payback criterion.

Summary 1: Description

<table>
<thead>
<tr>
<th>Rule</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>NPV</td>
<td>[ NPV = PV(CF \text{ stream}) = PV(\text{cash inflows}) - PV(\text{cash outflows}) ]</td>
</tr>
<tr>
<td>IRR</td>
<td>The cost of capital, ( r ), that makes ( NPV = 0 )</td>
</tr>
<tr>
<td>PI</td>
<td>[ PI = \frac{PV(\text{cash inflows})}{PV(\text{cash outflows})} ]</td>
</tr>
<tr>
<td>D. PBP</td>
<td>The time it take to get your initial investment back, in terms of discounted future CFs</td>
</tr>
</tbody>
</table>

Summary 2: Rules

<table>
<thead>
<tr>
<th>Rule</th>
<th>Accept project if</th>
<th>Reject project if</th>
</tr>
</thead>
<tbody>
<tr>
<td>NPV</td>
<td>( NPV &gt; 0 )</td>
<td>( NPV &lt; 0 )</td>
</tr>
<tr>
<td>IRR</td>
<td>IRR &gt; cost of capital, ( r )</td>
<td>IRR &lt; cost of capital, ( r )</td>
</tr>
<tr>
<td>PI</td>
<td>PI &gt; 1</td>
<td>PI &lt; 1</td>
</tr>
<tr>
<td>D. PBP</td>
<td>D. PBP &lt; # of years (arbitrary number)</td>
<td>D. PBP &gt; # of years (arbitrary number)</td>
</tr>
</tbody>
</table>

Summary 2: Rule quality

<table>
<thead>
<tr>
<th>Criterion \ Rule</th>
<th>NPV</th>
<th>IRR</th>
<th>PI</th>
<th>Disc. PBP</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Does the rule consider ALL CFs?</td>
<td>☺</td>
<td>☺</td>
<td>☺</td>
<td>X</td>
</tr>
<tr>
<td>2. Does the rule consider CFs timing?</td>
<td>☺</td>
<td>☺</td>
<td>☺</td>
<td>☺</td>
</tr>
<tr>
<td>3. Does the rule consider CFs riskiness?</td>
<td>☺</td>
<td>☺</td>
<td>☺</td>
<td>☺</td>
</tr>
<tr>
<td>4. Is the rule consistent with maximizing shareholders wealth?</td>
<td>☺</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>