6. Capital budgeting: Decision criteria

- Recall that there are three main issues in corporate finance:
  - capital budgeting
  - capital structure
  - working capital management
- In this chapter we begin to look at the issue of capital budgeting.
- We will review some basic approaches to assessing potential investments.

Introduction

- Given limited resources, a firm must decide whether a particular investment is worth undertaking.
- There are various approaches to assessing potential investments:
  - Net present value
  - Internal rate of return
  - Payback rule
  - Discounted payback
  - Average accounting return
  - Profitability index
- Each has its own advantages and disadvantages.

Advanced topics

In future classes, we will also discuss some more advanced techniques related to capital budgeting:

- Scenario analysis
- Sensitivity analysis
- Monte Carlo simulation
- Break-even analysis
- Real options

Net present value

- Computing NPV:
  - Take all estimated cash flows for the investment (both costs and revenues)
  - Compute present value of each
  - Add them up
- Accept project if NPV is positive.
- This approach is also known as discounted cash flow valuation.
- The choice of discount rate can be used to adjust for risk
- Often regarded as the “best” approach.
Example NPV

Agroproducts Corp. is considering investing in a new fertilizer factory. Estimated cash flows for the project are as follows:

- Initial investment is $20,000
- Cash revenues are $20,000 per year
- Cash costs (including taxes) are $14,000 per year
- After 8 years, after-tax salvage value of factory is $2000

What is the NPV (use 15% discount rate)?

Is this a good investment?

---

Example — continued

<table>
<thead>
<tr>
<th>Year</th>
<th>Cash flow</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>-20,000</td>
</tr>
<tr>
<td>1</td>
<td>6,000</td>
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<tr>
<td>2</td>
<td>6,000</td>
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<td>8</td>
<td>8,000</td>
</tr>
</tbody>
</table>

NPV =

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Remarks

- Positive NPV means that accepting the project will add value to the firm and thus increase the wealth of the owners.
- Since the goal of the corporation is to increase owner wealth, NPV is a direct measure of how well this project will accomplish that goal.
- Once the cash flows and discount rate have been determined, the mechanical job of computing NPV is easy.
- The important (and difficult) part of the task is coming up with realistic estimates for the cash flows and an appropriate discount rate.

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In the real world ...

- Although NPV is a valuable tool, care must be exercised in its use, since there are many important factors that are difficult to quantify.
- Recall that in a perfectly competitive economy there should be no positive NPV projects!!
- Therefore, positive NPV projects must be predicated on some market imperfection.
- It is a good idea to try to identify the imperfection and think about how realistic the NPV projections are.

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Market imperfections
Examples of potentially exploitable market imperfections include:
• The firm has patents or proprietary technology (e.g., drug companies, software companies).
• First entrant into a market with a product meeting some previously unidentified need.
• Exceptionally well-organized, well-trained, or well-motivated work force.

Internal rate of return
The IRR is the discount rate at which NPV=0. Accept the project if the IRR is greater than some target.

Example:
Continuing the previous example, recall that the estimated cash flows are:

<table>
<thead>
<tr>
<th>Year</th>
<th>Cash flow</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>-20,000</td>
</tr>
<tr>
<td>1</td>
<td>6,000</td>
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<tr>
<td>2</td>
<td>6,000</td>
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<td>3</td>
<td>6,000</td>
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<td>6,000</td>
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<td>7</td>
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<tr>
<td>8</td>
<td>8,000</td>
</tr>
</tbody>
</table>

What is the IRR?

Advantages and disadvantages of IRR
• In many cases, the IRR will lead to the same decision as NPV.
• Many people find rates of return to be more intuitively useful.
• No need to specify a discount rate in advance.
• IRR is very popular in practice. Even more so than NPV.
But...
• If the cash flows are not “conventional” (i.e., first is negative and rest are all positive), then the IRR can be misleading.
• There is also a “mutually exclusive investments” problem.

Example: nonconventional cash flows
Think about a strip-mining project with following cash flows:
• initial investment is $60
• first year cash flow is $155
• second year cash flow is -$100 (clean-up)
If the target rate of return is 20%, should we accept this project?
(See figure on next slide).
Example — continued

- In this example, multiple solutions for the IRR are possible.

- But even worse, with a target rate of 20%, the IRR rule says this is an acceptable investment even though the NPV is negative!!

Discussion

- IRR can give misleading results if cash flows are nonconventional.
- NPV always gives the correct answer.

Mutually exclusive investments

- Consider the decision about which of two mutually exclusive investments to make. E.g., whether to build
  - hotel, or
  - a shopping center
  on a given piece of property.

- How should you decide which is better?

- The best solution is to choose the one with the largest NPV (but, note that this requires that we decide upon a discount rate).

- Could we also base the decision on which has the highest IRR?

Example — mutually exclusive investments

Suppose the cash flows are as follows:

<table>
<thead>
<tr>
<th>Year</th>
<th>Investment A</th>
<th>Investment B</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>-$100</td>
<td>-$100</td>
</tr>
<tr>
<td>1</td>
<td>50</td>
<td>20</td>
</tr>
<tr>
<td>2</td>
<td>40</td>
<td>40</td>
</tr>
<tr>
<td>3</td>
<td>40</td>
<td>50</td>
</tr>
<tr>
<td>4</td>
<td>30</td>
<td>60</td>
</tr>
</tbody>
</table>

- For which discount rates is A preferred? For which is B preferred?
- What is the IRR for each investment?
  (see figure on next slide).
• A has the higher IRR.

• But B is preferred (by NPV) if the discount rate is 11% or less.

Discussion

To get the correct solution:

• First decide on a discount rate.

• Then choose the project with highest NPV at that discount rate.

Crossover point

• The crossover point is the discount rate at which both projects return the same NPV.

• To find the crossover point, compute the IRR for the difference in cash flows between the two projects:

<table>
<thead>
<tr>
<th>Year</th>
<th>Investment A</th>
<th>Investment B</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>-$100</td>
<td>-$100</td>
<td>$0</td>
</tr>
<tr>
<td>1</td>
<td>50</td>
<td>20</td>
<td>30</td>
</tr>
<tr>
<td>2</td>
<td>40</td>
<td>40</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>40</td>
<td>50</td>
<td>-10</td>
</tr>
<tr>
<td>4</td>
<td>30</td>
<td>60</td>
<td>-30</td>
</tr>
</tbody>
</table>

Crossover point =

Modified internal rate of return (MIRR)

• The modified internal rate of return provides an approach to addressing the issue of nonconventional cash flows.

• The idea is to combine future cash flows, working backwards from the project’s termination date and discounting at the target discount rate until all cash flows (except the initial cost) are positive.
Example — MIRR

Let’s consider a project to build a toxic waste facility.

The estimated cash flows are:

- Initial investment is $60
- Cash flows of $50 per year are earned for the next 4 years.
- In year 5, a clean-up cost of $100 is incurred.

If the target rate of return is 20%, should we accept this project?

Solution: The cash flows look like this:

<table>
<thead>
<tr>
<th>Year</th>
<th>CF</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>-60</td>
</tr>
<tr>
<td>1</td>
<td>50</td>
</tr>
<tr>
<td>2</td>
<td>50</td>
</tr>
<tr>
<td>3</td>
<td>50</td>
</tr>
<tr>
<td>4</td>
<td>50</td>
</tr>
<tr>
<td>5</td>
<td>-100</td>
</tr>
</tbody>
</table>

Since the last cash flow is negative, we combine it with the preceding cash flow, discounting at 20%. I.e., we use

\[ CF_4 = 50 - \frac{-100}{1.20} = -33.33 \]

This is still negative, so we combine it with the previous year’s cash flow. I.e.,

\[ CF_3 = 50 - \frac{-33.33}{1.20} = -22.23 \]

Since this is positive, we can now compute the IRR as usual using these “modified” cash flows:

<table>
<thead>
<tr>
<th>Year</th>
<th>CF</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>-60</td>
</tr>
<tr>
<td>1</td>
<td>50</td>
</tr>
<tr>
<td>2</td>
<td>50</td>
</tr>
<tr>
<td>3</td>
<td>22.23</td>
</tr>
</tbody>
</table>

MIRR =

Discussion

- The MIRR is a sort of hybrid of the NPV and IRR.
- Since computing the MIRR requires the use of a target discount rate, it is usually more straightforward to just compute the NPV.

The payback rule

How many years until the cash flows equal or exceed the initial cost?

An investment is considered acceptable if the payback time is less than some target, e.g., 5 years.
Example

Continuing the previous example, recall that the cash flows are:

<table>
<thead>
<tr>
<th>Year</th>
<th>Cash flow</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>-20,000</td>
</tr>
<tr>
<td>1</td>
<td>6,000</td>
</tr>
<tr>
<td>2</td>
<td>6,000</td>
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<td>3</td>
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<td>4</td>
<td>6,000</td>
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<td>6,000</td>
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<td>6</td>
<td>6,000</td>
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<tr>
<td>7</td>
<td>6,000</td>
</tr>
<tr>
<td>8</td>
<td>8,000</td>
</tr>
</tbody>
</table>

What is the payback time?

If the target payback time is 5 years, is this a good investment?

Problems with the payback rule

- A project may have more than one payback time.
  - For example, a project with cash flows of -200, 100, -200, 200.
- Cash flows beyond the payback time are ignored.
  - For example, a project with cash flows of -1000, 400, 400, 400, 400, 2000.
  - What is the payback time?
  - Is this a good investment?
  - Can you think of an example of an investment that might have cash flows like this?
- Time value of money is ignored.
- No straightforward way to determine the target payback period?
- No easy way to adjust for risk.

Advantages of the payback rule

Despite the problems with this rule, it is commonly used, especially for small projects.

- Simple.
- Intuitive.
- Useful as a “rule of thumb”.
- Emphasis on short-term
  - Liquidity may be important
  - Longer-term cash flows are more uncertain

Example — health care industry

In the health care industry, technology is rapidly changing, some of the equipment tends to be extremely expensive, and the industry itself is increasingly competitive.

What this means is that, in many cases, an equipment purchase is complicated by the fact that, while the machine may be able to perform its function for, say 6 years or more, new and improved equipment is likely to be developed that will supersede the “old” equipment long before its useful life is over.

Demand from patients and physicians for “cutting edge technology” can drive a push for new investment.

In the face of such a situation, many hospital administrators focus on how long it will take to recoup the initial outlay, in addition to the NPV and IRR of the equipment.
Example — political instability

Firms that have operations in countries with volatile governments may also be concerned with quick paybacks. When there is always a possibility that the government may seize your assets, you want to make sure that you can recoup your investment as quickly as possible.

Discounted payback

Same as payback rule, except we use discounted cash flows.

Example

Consider the same project as previously. Recall that the estimated cash flows are:

- Initial investment is $20,000
- Cash revenues are $20,000 per year
- Cash costs (including taxes) are $14,000 per year
- After 8 years, after-tax salvage value of factory is $2000

What is the discounted payback time (use a discount rate of 10%)?

Based on this criterion, is this a good investment?

Example (continued)

<table>
<thead>
<tr>
<th>Year</th>
<th>Cash flow</th>
<th>Accumulated cash flow</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Undiscounted</td>
<td>Discounted</td>
</tr>
<tr>
<td>0</td>
<td>-20,000</td>
<td>-20,000</td>
</tr>
<tr>
<td>1</td>
<td>6000</td>
<td>5454.5</td>
</tr>
<tr>
<td>2</td>
<td>6000</td>
<td>4958.7</td>
</tr>
<tr>
<td>3</td>
<td>6000</td>
<td>4507.9</td>
</tr>
<tr>
<td>4</td>
<td>6000</td>
<td>4098.1</td>
</tr>
<tr>
<td>5</td>
<td>6000</td>
<td>3725.5</td>
</tr>
</tbody>
</table>

Discounted payback:

\[
4 + \frac{981}{3.81 + 2.745} = 4.26 \text{ years.}
\]
Advantages and disadvantages of discounted payback rule

Similar to payback rule, but
- Time value of money is now accounted for
- Simplicity is lost (need to decide on a discount rate)

---

Average accounting return

There are various ways of defining the AAR, depending on exactly how one defines the numerator and denominator, but we will use:

\[
\text{AAR} = \frac{\text{Average net income}}{\text{Average book value}}
\]

Accept the project if AAR is greater than some target, e.g., 15%

NOTE: For book value, we will use NWC + FA.

---

Example

XYZ Corp. is considering bringing out a new line of widgets. Given the following information, compute the AAR.

<table>
<thead>
<tr>
<th>Year</th>
<th>NWC  (thousand)</th>
<th>FA  (thousand)</th>
<th>BV  (thousand)</th>
<th>Sales  (thousand)</th>
<th>Costs  (thousand)</th>
<th>Depr  (thousand)</th>
<th>Ebit  (thousand)</th>
<th>Tax    (thousand)</th>
<th>NI     (thousand)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>3000</td>
<td>8000</td>
<td>11000</td>
<td>6000</td>
<td>3000</td>
<td>2000</td>
<td>1000</td>
<td>340</td>
<td>660</td>
</tr>
<tr>
<td>1</td>
<td>3000</td>
<td>6000</td>
<td>9000</td>
<td>6000</td>
<td>3000</td>
<td>2000</td>
<td>1000</td>
<td>340</td>
<td>660</td>
</tr>
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<td>2</td>
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<td>4000</td>
<td>7000</td>
<td>6000</td>
<td>3000</td>
<td>2000</td>
<td>1000</td>
<td>340</td>
<td>660</td>
</tr>
<tr>
<td>3</td>
<td>3000</td>
<td>2000</td>
<td>5000</td>
<td>6000</td>
<td>3000</td>
<td>2000</td>
<td>1000</td>
<td>340</td>
<td>660</td>
</tr>
<tr>
<td>4</td>
<td>3000</td>
<td>0</td>
<td>3000</td>
<td>6000</td>
<td>3000</td>
<td>2000</td>
<td>1000</td>
<td>340</td>
<td>660</td>
</tr>
</tbody>
</table>

\[
\text{Avg BV} = \frac{(11000 + 9000 + 7000 + 5000 + 3000)}{5} = 7000
\]
\[
\text{Avg NI} = \frac{660}{5} = 660
\]
\[
\text{AAR} = \frac{660}{7000} = 9.43\%
\]

---

Advantages and disadvantages of AAR

Disadvantages:
- The AAR is not a return in any meaningful economic sense and is thus not comparable to any other rate of return.
- Ignores time value of money.
- No easy way to determine appropriate target rate.
- Uses net income and book value rather than the more economically useful concepts of cash flow and market value.

Advantages:
- Uses accounting figures which may be readily available.
- Is the project-level equivalent to ROA, which is sometimes used as a measure of firm performance.
Profitability index

\[ \text{PI} = \frac{\text{PV of future cash flows}}{\text{Initial investment}} \]

Accept project if PI > 1.

- PI measures “Bang for the buck”.
- May be useful when resources are limited
  - are resources ever not limited?
  - short vs long-term constraints
- Usually (but not always) leads to same decisions as NPV.

Example — profitability index

Using the same cash flows as in previous examples and a discount rate of 15%, what is the profitability index of the project? Using this measure, should the project be accepted?

<table>
<thead>
<tr>
<th>Year</th>
<th>Cash flow</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>-20,000</td>
</tr>
<tr>
<td>1</td>
<td>6,000</td>
</tr>
<tr>
<td>2</td>
<td>6,000</td>
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<td>3</td>
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<td>7</td>
<td>6,000</td>
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<tr>
<td>8</td>
<td>8,000</td>
</tr>
</tbody>
</table>

\[ \text{PI} = \frac{\text{PV of future cash flows}}{\text{Initial investment}} \]

Discussion

- In practice, the world is complicated.
  - Cash flows are subject to considerable uncertainty.
  - Specific projects may have special factors that need to be taken into account
    - potential synergies with existing projects
    - strategic plan
    - reputation (e.g., environmental issues)
    - resource constraints
- It is often difficult to quantitatively assess the effects of uncertainty and special factors.
- Techniques used include:
  - Scenario analysis
  - Sensitivity analysis
  - Monte Carlo simulations
  - Break-even analysis
  - Real options

Note: We discuss these ideas briefly in later chapters. More thorough study will have to wait until more advanced courses.

Summary

If...

- cash flows are known with certainty
- there are no real options to be considered
- the appropriate discount rate is known
- increasing shareholder value is the sole basis of the decision rule
- there are no capital constraints

then...

NPV is the correct tool to use. In practice, these conditions are unlikely to be met, so alternative tools may be useful as well.
In the real world

Surveys indicate that few large firms employ the payback period and/or the AAR methods exclusively; rather, these techniques are used in conjunction with one or more of the DCF techniques.

On the other hand, anecdotal evidence suggests that many smaller firms rely more heavily on non-DCF approaches. Reasons for this include:

• small firms are more concerned about liquidity.
• small firms don't have direct access to the capital markets and therefore find it more difficult to estimate discount rates based on cost of capital.
• they may also have more difficulty raising funds, even for projects they assess as having positive NPV.
• some small firm decision-makers may be less aware of how to apply DCF approaches than their large firm counterparts.

—

And finally...

Remember that being able to punch a string of numbers into a calculator and come up with an NPV or whatever is a $10/hour skill.

The important skills are being able to:

• come up with the cash flows
• estimate the cost of capital
• assess relevant risks, uncertainties, and various special factors

These are the things you want to spend your energy thinking about.

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