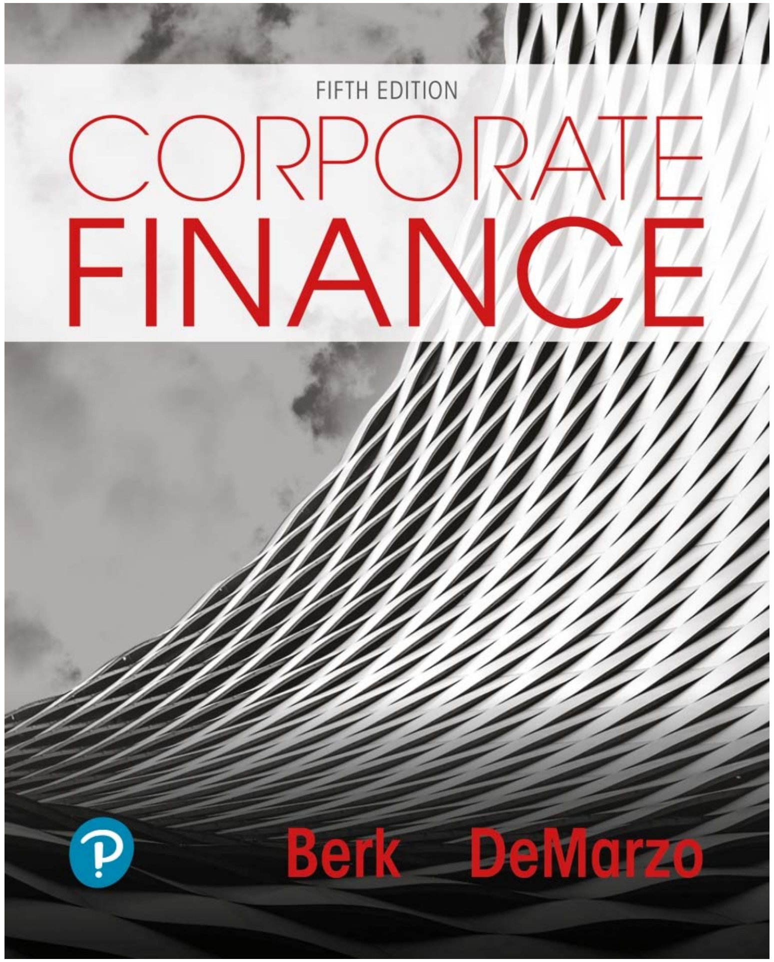
Corporate Finance

Fifth Edition



Chapter 7

Investment Decision Rules

Chapter Outline

Learning Objectives (1 of 2)

- Define net present value, payback period, internal rate of return, profitability index, and incremental IRR.
- Describe decision rules for each of the tools in objective 1, for both stand-alone and mutually exclusive projects.
- Given cash flows, compute the NPV, payback period, internal rate of return, and profitability index for a given project, and the incremental IRR for a pair of projects.

Learning Objectives (2 of 2)

- Compare each of the capital budgeting tools above, and tell why NPV always gives the correct decision.
- Discuss the reasons IRR can give a flawed decision.
- Describe situations in which profitability index cannot be used to make a decision.

7.1 NPV and Stand-Alone Projects

- Consider a take-it-or-leave-it investment decision involving a single, stand-alone project for Fredrick’s Feed and Farm (FFF).
  - The project costs $250 million and is expected to generate cash flows of $35 million per year, starting at the end of the first year and lasting forever.

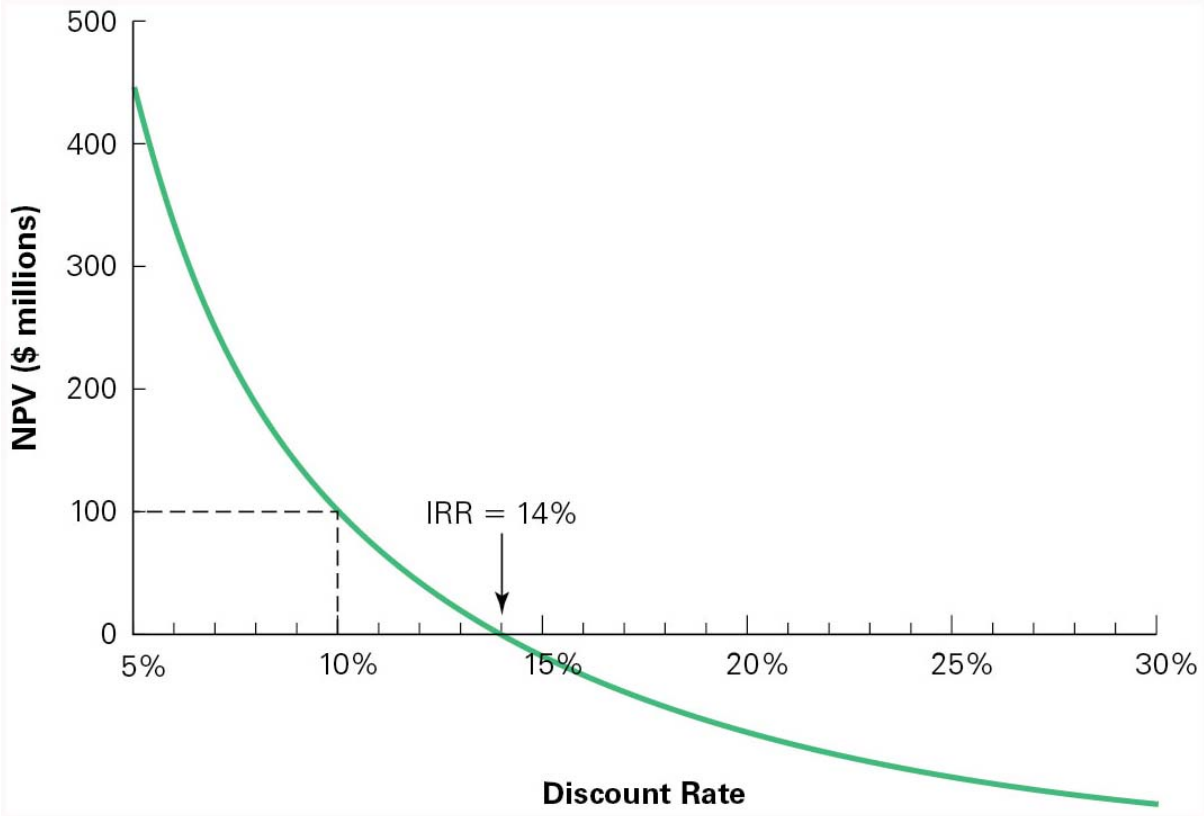
Applying the NPV Rule

- The NPV of the project is calculated as:

$$NPV = -250 + \frac{35}{r}$$

  – The NPV is dependent on the discount rate.

Figure 7.1 NPV of Fredrick's Fertilizer Project



If FFF's cost of capital is 10%, the NPV is $100 million, and they should undertake the investment

Alternative Rules Versus the NPV Rule

- Sometimes alternative investment rules may give the same answer as the NPV rule, but at other times they may disagree.
  - **When the rules conflict, the NPV decision rule should be followed.**

7.2 The Internal Rate of Return Rule (1 of 2)

- **Internal Rate of Return (IRR) Investment Rule**
  - Take any investment where the IRR exceeds the cost of capital
  - Turn down any investment whose IRR is less than the cost of capital

7.2 The Internal Rate of Return Rule (2 of 2)

- The IRR Investment Rule will give the same answer as the NPV rule in many, but not all, situations.
- In general, the IRR rule works for a stand-alone project if all of the project's negative cash flows precede its positive cash flows.
  - In Figure 7.1, whenever the cost of capital is below the IRR of 14%, the project has a positive NPV, and you should undertake the investment.

Applying the IRR Rule (1 of 10)

- In other cases, the IRR rule may disagree with the NPV rule and thus be incorrect.
  - Situations where the IRR rule and NPV rule may be in conflict:
    - Delayed Investments
    - Nonexistent IRR
    - Multiple IRRs

Pitfall 1: Delayed Investments (1 of 3)

- Assume you have just retired as the CEO of a successful company. A major publisher has offered you a book deal. The publisher will pay you $1 million upfront if you agree to write a book about your experiences. You estimate that it will take three years to write the book. The time you spend writing will cause you to give up speaking engagements amounting to $500,000 per year. You estimate your opportunity cost to be 10%.

Pitfall 1: Delayed Investments (2 of 3)

- Should you accept the deal?
  - Calculate the IRR

	NPER	RATE	PV	PMT	FV	Excel Formula
Given	3		1,000,000	−500,000	0	
Solve for 1		23.38%				=RATE(3,500000,1000000,0)

  - The IRR is greater than the cost of capital
  - Thus, the IRR rule indicates you should accept the deal

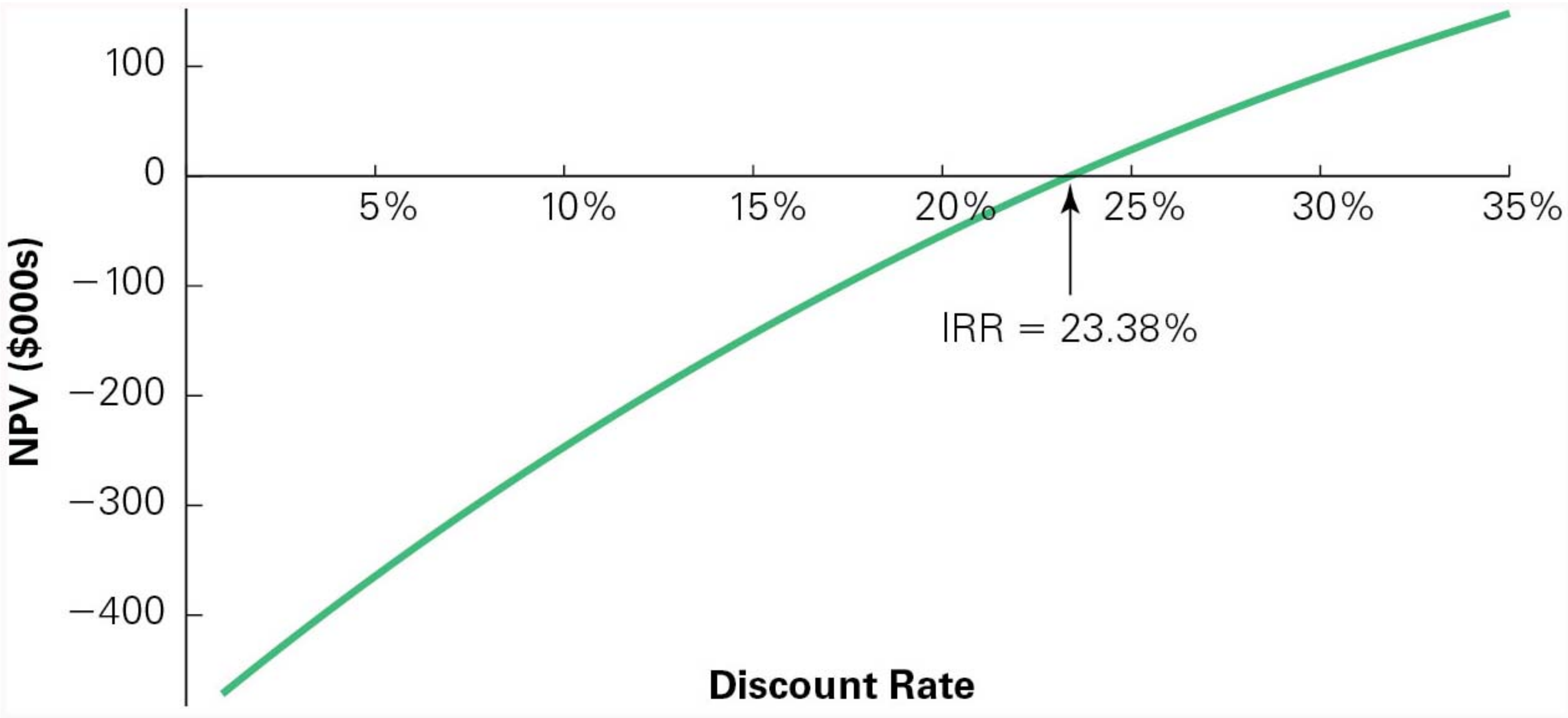
Pitfall 1: Delayed Investments (4 of 3)

- Should you accept the deal?

$$NPV = 1,000,000 - \frac{500,000}{1.1} - \frac{500,000}{1.1^2} - \frac{500,000}{1.1^3} = -\$243,426$$

- Since the NPV is negative, the NPV rule indicates you should reject the deal.

Figure 7.2 NPV of Star's $1 Million Book Deal



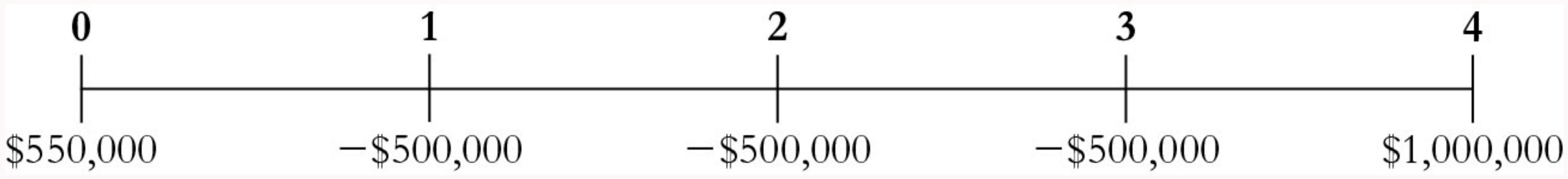
When the benefits of an investment occur before the costs, the NPV is an *increasing* function of the discount rate.

Pitfall 2: Multiple IRRs (1 of 4)

- Suppose Star informs the publisher that it needs to sweeten the deal before he will accept it. The publisher offers $550,000 advance and $1,000,000 in four years when the book is published.
- Should he accept or reject the new offer?

Pitfall 2: Multiple IRRs (2 of 4)

- The cash flows would now look like



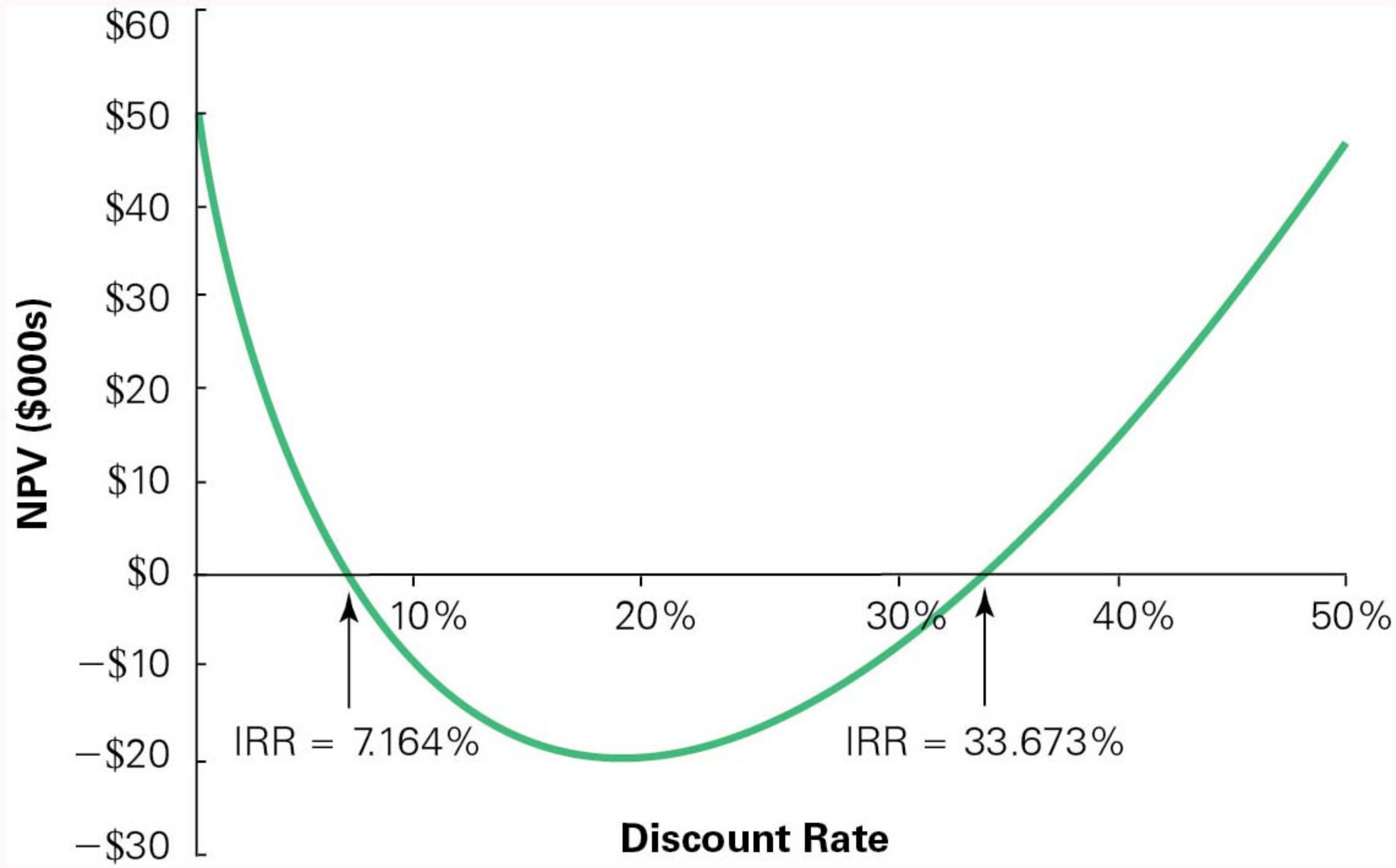
- The NPV is calculated as

$$NPV = 550,000 - \frac{500,000}{1+r} - \frac{500,000}{(1+r)^2} - \frac{500,000}{(1+r)^3} - \frac{1,000,000}{(1+r)^4}$$

Pitfall 2: Multiple IRRs (3 of 4)

- By setting the NPV equal to zero and solving for *r*, we find the IRR.
- In this case, there are two IRRs: 7.164% and 33.673%.
- Because there is more than one IRR, the IRR rule cannot be applied.

Figure 7.3 NPV of Star's Book Deal with Royalties



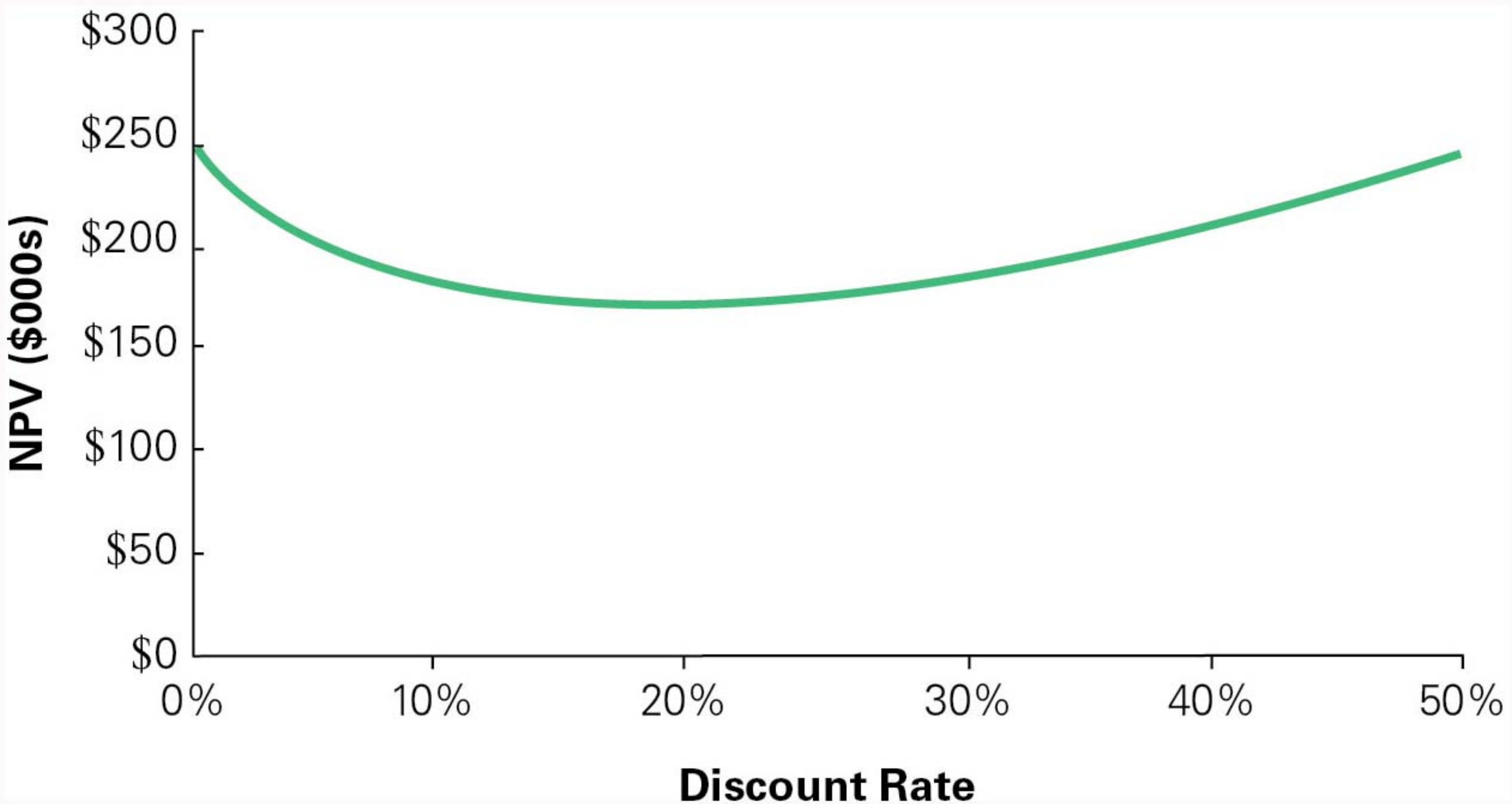
Pitfall 2: Multiple IRRs (4 of 4)

- As seen in Figure 7.3, between 7.164% and 33.673%, the book deal has a negative NPV.
- Since your opportunity cost of capital is 10%, you should reject the deal.

Pitfall 3: Nonexistent IRR

- Finally, Star is able to get the publisher to increase his advance to $750,000, in addition to the $1 million when the book is published in four years.
- With these cash flows, no IRR exists; there is no discount rate that makes NPV equal to zero.

Figure 7.4 NPV of Star's Final Offer



No IRR exists because the NPV is positive for all values of the discount rate. Thus the IRR rule cannot be used.

Common Mistake

- IRR Versus the IRR Rule
  - While the IRR rule has shortcomings for making investment decisions, the IRR itself remains useful. IRR measures the average return of the investment and the sensitivity of the NPV to any estimation error in the cost of capital.

Textbook Example 7.1 (1 of 2)

Problem with the IRR Rule

Problem

Consider projects with the following cash flows:

Project	0	1	2
A	−375	−300	900
B	−22,222	50,000	−28,000
C	400	400	−1,056
D	−4,300	10,000	−6,000

Which of these projects have an IRR close to 20%? For which of these projects is the IRR rule valid?

Textbook Example 7.1 (2 of 2)

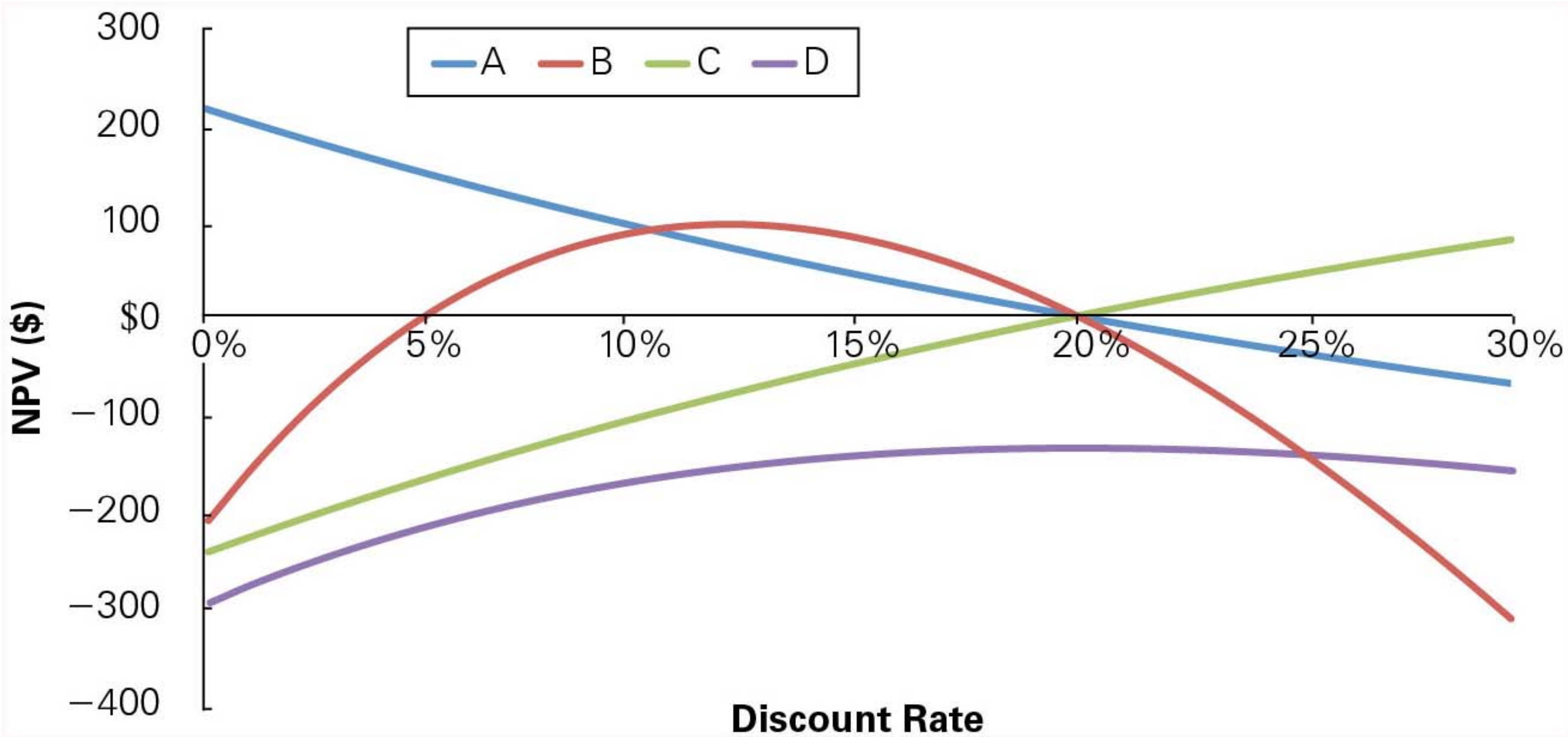
Solution

We plot the NPV profile for each project in Figure 7.5 from the NPV profiles, we can see that projects A, B, and C each have an IRR of approximately 20%, which project D has no IRR. Note also that project B has another IRR of 5%.

The IRR rule is valid only if the project has a positive NPV for every discount rate below the IRR. Thus, the IRR rule is only valid for project A. this project is the only one for which all the negative cash flows precede the positive ones.

NPVProfiles for Example 7.1

While the IRR Rule works for project A, it fails for each of the other projects.



7.3 The Payback Rule (1 of 2)

- The **payback period** is amount of time it takes to recover or pay back the initial investment.
- If the payback period is less than a pre-specified length of time, you accept the project.
- Otherwise, you reject the project.
  - The payback rule is used by many companies because of its simplicity.

Textbook Example 7.2 (1 of 2)

The payback Rule

Problem

Assume Fredrick's requires all projects to have a payback period of five years or less. Would the firm undertake the fertilizer project under this rule?

Textbook Example 7.2 (2 of 2)

Solution

Recall that the project requires an initial investment of $250 million, and will generate $35 million per year. The sum of the cash flows from year 1 to year 5 is $35 × 5 = $175 million, which will not cover the initial investment of $250 million. In fact, it will not be until year 8 that the initial investment will be paid back ($35 × 8 = $280 million). Because the payback period for this project exceeds five years, Fredrick's will reject the project.

The Payback Rule (2 of 2)

- Pitfalls
  - Ignores the project's cost of capital and time value of money
  - Ignores cash flows after the payback period
  - Relies on an ad hoc decision criterion

7.4 Choosing between Projects

- Mutually Exclusive Projects
  - When you must choose only one project among several possible projects, the choice is mutually exclusive.
  - NPV Rule
    - Select the project with the highest NPV
  - IRR Rule
    - Selecting the project with the highest IRR may lead to mistakes

Textbook Example 7.3 (1 of 2)

NPV and Mutually Exclusive Projects

Problem

A small commercial property is for sale near your university. Given its location, you believe a student – oriented business would be very successful there. You have researched several possibilities and come up with the following cash flow estimates (including the cost of purchasing the property). Which investment should you choose?

Project	Initial Investment	First-Year Cash Flow	Growth Rate	Cost of Capital
Book store	$300,000	$63,000	3.0%	8%
Coffee shop	$400,000	$80,000	3.0%	8%
Music store	$400,000	$104,000	0.0%	8%
Electronic store	$400,000	$100,000	3.0%	11%

Textbook Example 7.3 (2 of 2)

Solution

Assuming each business lasts indefinitely, we can compute the present value of the cash flows from each as a constant growth perpetuity. The NPV of each project is

$$NPV \text{ (Book Store)} = -300,000 + \frac{63,000}{8\% - 3\%} = \$960,000$$

$$NPV \text{ (Coffe Shop)} = -400,000 + \frac{80,000}{8\% - 3\%} = \$1,200,000$$

$$NPV \text{ (Music Store)} = -400,000 + \frac{104,000}{8\%} = \$900,000$$

$$NPV \text{ (Electronic Store)} = -400,000 + \frac{100,000}{11\% - 3\%} = \$850,000$$

Thus, all of the alternatives have a positive NPV. But, because we can only choose one, the coffee shop is the best alternative.

Alternative Example 7.3 (2 of 2)

- **Solution**
  - Assuming each business lasts indefinitely, we can compute the present value of the cash flows from each as a constant growth perpetuity. The NPV of each project is

$$NPV\text{ (Dating App)} = -\$250,000 + \frac{\$55,000}{7\% - 4\%} = \$1,583,333$$

$$NPV\text{ (Green Energy)} = -\$350,000 + \frac{\$75,000}{8\% - 4\%} = \$1,525,000$$

$$NPV\text{ (Water Purification)} = -\$400,000 + \frac{\$120,000}{8\% - 5\%} = \$2,600,000$$

$$NPV\text{ ("Smart" Clothes)} = -\$500,000 + \frac{\$125,000}{12\% - 8\%} = \$2,625,000$$

  - Thus, all of the alternatives have a positive NPV. But, because we can only choose one, the clothing store is the best alternative.

IRR Rule and Mutually Exclusive Investments (1 of 4)

- Differences in Scale
  - If a project's size is doubled, its NPV will double.
    - This is not the case with IRR.
  - Thus, the IRR rule cannot be used to compare projects of different scales.

IRR Rule and Mutually Exclusive Investments (2 of 4)

- Differences in Scale
  - Consider two of the projects from Example 7.3.

	Book store	Coffee shop
Initial Investment	$300,000	$400,000
Cash Flow $_{\text{year 1}}$	$363,000	$80,000
Annual Growth Rate	3%	3%
Cost of capital	8%	8%
IRR	**24%**	23%
NPV	$960,000	**$1,200,000**

IRR Rule and Mutually Exclusive Investments: Differences in Scale (cont'd)

- **Example 7.3, Differences in Scale:**
- IRR calculation:
  - Book Store: $$-300.000+\frac{63.000}{IRR-3\%}=0 \Rightarrow IRR=24\%$$
  - Coffee Shop: $$-400.000+\frac{80.000}{IRR-3\%}=0 \Rightarrow IRR=23\%$$

IRR Rule and Mutually Exclusive Investments: Timing of Cash Flows

- Another problem with the IRR is that it can be affected by changing the timing of the cash flows, even when the scale is the same.
  - IRR is a return, but the dollar value of earning a given return depends on how long the return is earned.
- Consider two projects. Both have the same initial scale **but different** horizon. Both have same IRR.

Jahr	0	1	2	3	4	5
Short-Term Project	−100	−150				
Long-Term Project	−100					$100 \times 1{,}50^5 = 759{,}375$

Calculating NPV and IRR

WACC = 10%

$$NPV_{Short-Term} = -100 + \frac{150}{1.1} = \$36.36$$

$$NPV_{Long-Term} = -100 + \frac{759.375}{1.1^5} = \$371.51$$

$$Short-Term: -100 + \frac{150}{1+IRR} = 0 \Rightarrow IRR = 50\%$$

$$Long-Term: -100 + \frac{759.375}{(1+IRR)^5} = 0$$

$$\frac{759.375}{100} = (1+IRR)^5$$

$$\sqrt[5]{7.59375} - 1 = IRR \Rightarrow IRR = 50\%$$

IRR Rule and Mutually Exclusive Investments (3 of 4)

- Timing of Cash Flows
  – Another problem with the IRR is that it can be affected by changing the timing of the cash flows, even when the scale is the same.
    - IRR is a return, but the dollar value of earning a given return depends on how long the return is earned.
  – Consider again the coffee shop and the music store investment in Example 7.3.
  – Both have the same initial scale and the same horizon.
  – The coffee shop has a lower IRR, but a higher NPV because of its higher growth rate.

IRR Rule and Mutually Exclusive Investments (4 of 4)

- Differences in Risk
  - An IRR that is attractive for a safe project need not be attractive for a riskier project.
  - Consider the investment in the electronics store from Example 7.3.
  - The IRR is higher than those of the other investment opportunities, yet the NPV is the lowest.
  - The higher cost of capital means a higher IRR is necessary to make the project attractive.

The Incremental IRR Rule (1 of 2)

- Incremental IRR Investment Rule
  - Apply the IRR rule to the difference between the cash flows of the two mutually exclusive alternatives (the increment to the cash flows of one investment over the other).
  - The incremental IRR tells us the discount rate at which it becomes profitable to switch from one project to the other.
  - Rule: Calculate difference in cash flows A – B. When Incr. IRR > WACC choose Project with lower IRR.
    When Incr. IRR < WACC choose Project with higher IRR.

Textbook Example 7.4 (1 of 4)

Using the Incremental IRR to Compare Alternatives

Problem

Your firm is considering overhauling its production plant. The engineering team has come up with two proposals, one for a minor overhaul and one for a major overhaul. The two options have the following cash flows(in millions of dollars):

Proposal	0	1	2	3
Major overhaul	−10	6	6	6
Minor overhaul	−50	25	25	25

What is the IRR of each proposal? What is the incremental IRR? If the cost of capital for both of these projects is 12%, what should your firm do?

Textbook Example 7.4 (2 of 4)

Solution

We can compute the IRR of each proposal using the annuity calculator. For the minor overhaul, the IRR is 36.3%:

	NPER	RATE	PV	PMT	FV	Excel Formula
Given	3		−10	6	0	
Solve for rate		**36.3%**				=RATE(3,6,−10,0)

For the major overhaul, the IRR is 23.4%:

	NPER	RATE	PV	PMT	FV	Excel Formula
Given	3		−50	25	0	
Solve for rate		**23.4%**				=RATE(3,25,−50,0)

Textbook Example 7.4 (3 of 4)

Which project is best? Because the projects have different scales, we cannot compare their IRRs directly. To compute the incremental IRR of switching from the minor overhaul to the major overhaul, we first compute the incremental cash flows:

Proposal	0	1	2	3
Major overhaul	−50	25	25	25
Less:Minor overhaul	−(−10)	−6	−6	−6
Incremental cash flow	−40	19	19	19

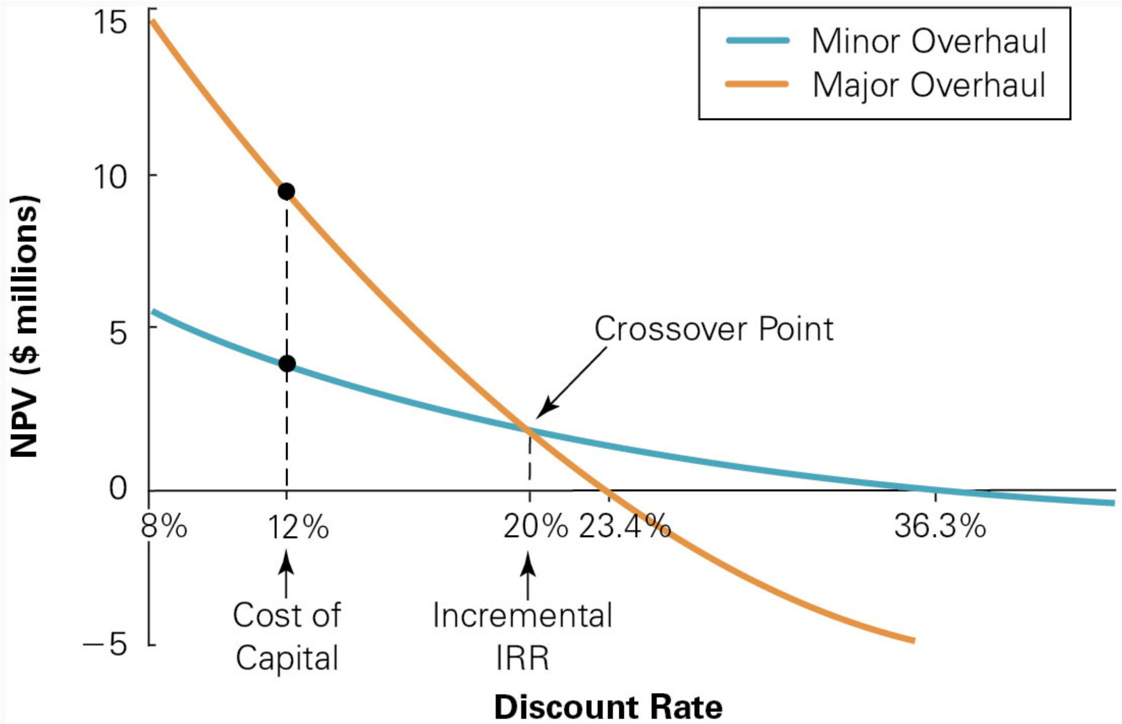
Textbook Example 7.4 (4 of 4)

These cash flows have an IRR of 20.0%

	NPER	RATE	PV	PMT	FV	Excel Formula
Given	3		−40	19	0	
Solve for Rate		20.0%				=RATE(3,19,−40,0)

Because the incremental IRR exceeds the 12% cost of capital, switching to the major overhaul looks attractive (i.e., its larger scale is sufficient to make up for its lower IRR). We can check this result using Figure 7.5, which shows the NPV profiles for each project. At the 12% cost of capital, the NPV of the major overhaul does indeed exceed that of the minor overhaul, despite its lower IRR. Note also that the incremental IRR determines the crossover point of the NPV profiles, the discount rate for which the best project choice switches from the major overhaul to minor one.

Figure 7.5 Comparison of Minor and Major Overhauls



In Example7.4, we can see that despite its lower IRR, the major overhaul has a higher NPV at the cost of capital of 12%. Note also that the incremental IRR of 20% determines the crossover point or discount rate at which the optimal decision changes.

The Incremental IRR Rule (2 of 2)

- Shortcomings of the Incremental IRR Rule
  - The incremental IRR may not exist.
  - Multiple incremental IRRs could exist.
  - The fact that the IRR exceeds the cost of capital for both projects does not imply that either project has a positive NPV.
  - When individual projects have different costs of capital, it is not obvious which cost of capital the incremental IRR should be compared to.

7.5 Project Selection with Resource Constraints

- Evaluation of Projects with Different Resource Constraints
  - Consider three possible projects with a $100 million budget constraint:

Table 7.1 Possible Projects for a $100 Million Budget

Project	NPV ($ millions)	Initial Investment ($ millions)	Profitability Index NPV /Investment
I	110	100	1.1
II	70	50	1.4
III	60	50	1.2

Profitability Index

- The **profitability index** can be used to identify the optimal combination of projects to undertake

$$\text{Profitability Index} = \frac{\text{Value Created}}{\text{Resource Consumed}} = \frac{NPV}{\text{Resource Consumed}}$$

  - From Table 7.1, we can see it is better to take projects II and III together and forgo project I.

Textbook Example 7.5 (1 of 3)

Profitability Index with a Human Resource Constraint

Problem

Your division at NetIt, a larger networking company, has put together a project proposal to develop a new home networking router. The excepted NPV of the project is $17.7 million, and the project will require 50 software engineers. NetIt has a total of 190 engineers available, and the router project must compete with the following other projects for these engineers:

Project	NPV ($ millions)	Engineering Headcount
Router	17.7	50
Project A	22.7	47
Project B	8.1	44
Project C	14.0	40
Project D	11.5	61
Project E	20.6	58
Project F	12.9	32
Total	107.5	332

How should NetIt prioritize these projects?

Textbook Example 7.5 (2 of 3)

Solution

The goal is to maximize the total NPV we can create with 190 engineers (at most). We compute the profitability index for each project using Engineering Headcount in the denominator, and then sort projects based on the index:

Project	NPV ($ millions)	Engineering Headcount(E H C)	Profitability Index (N P V per E H C)	Cumulative E H C Required
Project A	22.7	47	0.483	47
Project F	12.9	32	0.403	79
Project E	20.6	58	0.355	137
Router	17.7	50	0.354	187
Project C	14.0	40	0.350	
Project D	11.5	61	0.189	
Project B	8.1	44	0.184	

Textbook Example 7.5 (3 of 3)

We now assign the resource to the projects in descending order according to the profitability index. The final column shows the cumulative use of the resource as each project is taken on until the resource is used up. To maximize NPV within the constraint of 190 engineers. NetIt should choose the first four projects on the list. There is no other combination of projects that will create more value without using more engineers than we have. Note, however, that the resource constraint forces NetIt to forgo three otherwise valuable projects (C, D, and B) with a total NPV of $3.36 million.

Shortcomings of the Profitability Index (1 of 2)

- In some situations, the profitability Index does not give an accurate answer.
  - Suppose in Example 7.4 that NetIt has an additional small project with a NPV of only $120,000 that requires three engineers. The profitability index in this case is $\frac{0.12}{3} = 0.04$, so this project would appear at the bottom of the ranking. However, three of the 190 employees are not being used after the first four projects are selected. As a result, it would make sense to take on this project even though it would be ranked last.

Shortcomings of the Profitability Index (2 of 2)

- With multiple resource constraints, the profitability index can break down completely.

