

# Capital Budgeting Techniques: Certainty and Risk

## LEARNING GOALS

- LG1** Calculate, interpret, and evaluate the payback period.
- LG2** Apply net present value (NPV) and internal rate of return (IRR) to relevant cash flows to choose acceptable capital expenditures.
- LG3** Use net present value profiles to compare the NPV and IRR techniques in light of conflicting rankings.
- LG4** Discuss two additional considerations in capital budgeting—recognizing real options and choosing projects under capital rationing.
- LG5** Recognize sensitivity analysis and scenario analysis, decision trees, and simulation as behavioral approaches for dealing with project risk, and the unique risks that multinational companies face.
- LG6** Understand the calculation and practical aspects of risk-adjusted discount rates (RADRs).

## *Across the Disciplines* Why This Chapter Matters To You

**Accounting:** You need to understand capital budgeting techniques in order to develop good estimates of the relevant cash flows associated with a proposed capital expenditure and to appreciate how risk may affect the variability of cash flows.

**Information systems:** You need to understand capital budgeting techniques, including how risk is measured in those techniques, in order to design decision modules that help reduce the amount of work required in analyzing proposed capital projects.

**Management:** You need to understand capital budgeting techniques in order to understand the decision criteria used to accept or reject proposed projects; how to apply capital budgeting techniques when capital must be rationed; and behavioral and risk-adjustment approaches for dealing with risk, including international risk.

**Marketing:** You need to understand capital budgeting techniques in order to understand how proposals for new products and expansion of existing product lines will be evaluated by the firm's decision makers and how risk of proposed projects is treated in capital budgeting.

**Operations:** You need to understand capital budgeting techniques in order to understand how proposals for the acquisition of new equipment and plants will be evaluated by the firm's decision makers, especially when capital must be rationed.

*Firms use the relevant cash flows to make decisions about proposed capital expenditures. These decisions can be expressed in the form of project acceptance or rejection or of project rankings. A number of techniques are used in such decision making, some more sophisticated than others. These techniques are the topic of this chapter, wherein we describe the assumptions on which capital budgeting techniques are based, show how they are used in both certain and risky situations, and evaluate their strengths and weaknesses.*



## Capital Budgeting Techniques

When firms have developed relevant cash flows, as demonstrated in Chapter 8, they analyze them to assess whether a project is acceptable or to rank projects. A number of techniques are available for performing such analyses. The preferred approaches integrate time value procedures, risk and return considerations, and valuation concepts to select capital expenditures that are consistent with the firm's goal of maximizing owners' wealth. This section and the following one focus on the use of these techniques in an environment of certainty. Later in the chapter, we will look at capital budgeting under uncertain circumstances.

We will use one basic problem to illustrate all the techniques described in this chapter. The problem concerns Bennett Company, a medium-sized metal fabricator that is currently contemplating two projects: Project A requires an initial investment of \$42,000, project B an initial investment of \$45,000. The projected relevant operating cash inflows for the two projects are presented in Table 9.1 and depicted on the time lines in Figure 9.1.<sup>1</sup> The projects exhibit *conventional*

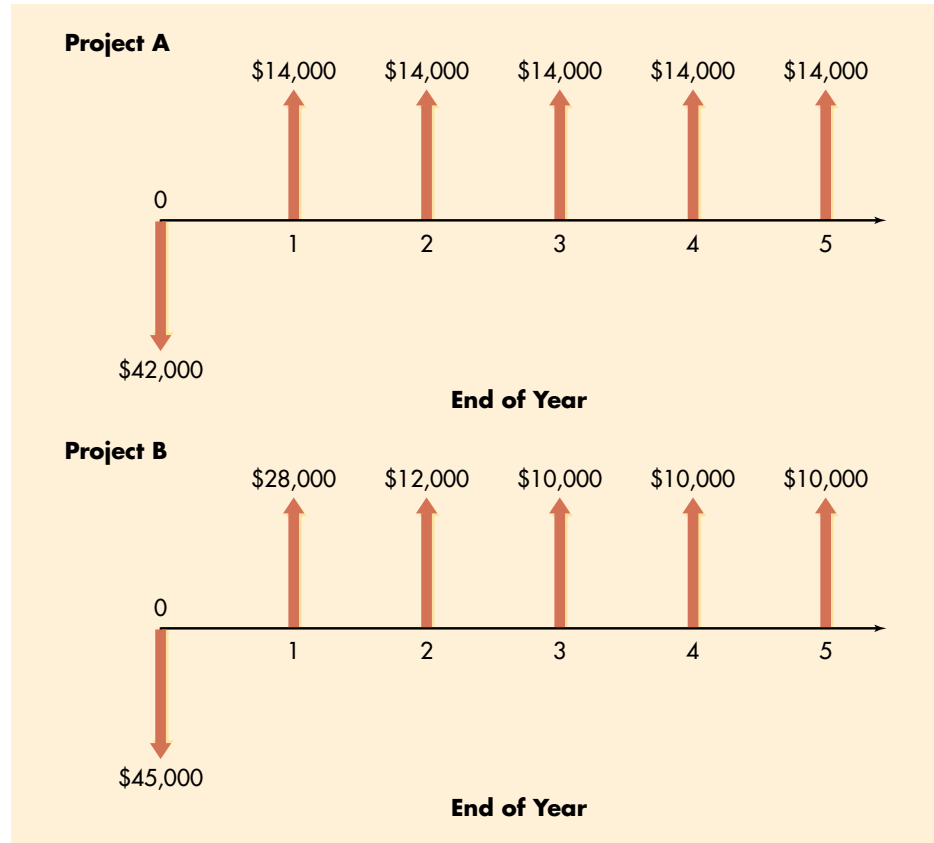
**TABLE 9.1** Capital Expenditure Data for Bennett Company

	Project A	Project B
Initial investment	\$42,000	\$45,000
Year	Operating cash inflows	
1	\$14,000	\$28,000
2	14,000	12,000
3	14,000	10,000
4	14,000	10,000
5	14,000	10,000

1. For simplification, these 5-year-lived projects with 5 years of cash inflows are used throughout this chapter. Projects with usable lives equal to the number of years of cash inflows are also included in the end-of-chapter problems. Recall from Chapter 8 that under current tax law, MACRS depreciation results in  $n + 1$  years of depreciation for an  $n$ -year class asset. This means that projects will commonly have at least 1 year of cash flow beyond their recovery period. In actual practice, the usable lives of projects (and the associated cash inflows) may differ significantly from their depreciable lives. Generally, under MACRS, usable lives are longer than depreciable lives.

**FIGURE 9.1****Bennett Company's  
Projects A and B**

Time lines depicting the  
conventional cash flows of  
projects A and B



*cash flow patterns*, which are assumed throughout the text. In addition, we initially assume that all projects' cash flows have the same level of risk, that projects being compared have equal usable lives, and that the firm has unlimited funds. Because very few decisions are actually made under such conditions, some of these simplifying assumptions are relaxed in later sections of this chapter. Here we begin with a look at the three most popular capital budgeting techniques: payback period, net present value, and internal rate of return.<sup>2</sup>

**payback period**

The amount of time required for a firm to recover its initial investment in a project, as calculated from cash inflows.

**Payback Period**

Payback periods are commonly used to evaluate proposed investments. The **payback period** is the amount of time required for the firm to recover its initial investment in a project, as calculated from *cash inflows*. In the case of an *annuity*,

2. Two other, closely related techniques that are sometimes used to evaluate capital budgeting projects are the *average (or accounting) rate of return (ARR)* and the *profitability index (PI)*. The ARR is an unsophisticated technique that is calculated by dividing a project's average profits after taxes by its average investment. Because it fails to consider cash flows and the time value of money, it is ignored here. The PI, sometimes called the *benefit-cost ratio*, is calculated by dividing the present value of cash inflows by the initial investment. This technique, which does consider the time value of money, is sometimes used as a starting point in the selection of projects under capital rationing; the more popular NPV and IRR methods are discussed here.

the payback period can be found by dividing the initial investment by the annual cash inflow. For a *mixed stream* of cash inflows, the yearly cash inflows must be accumulated until the initial investment is recovered. Although popular, the payback period is generally viewed as an *unsophisticated capital budgeting technique*, because it does not *explicitly* consider the time value of money.

### The Decision Criteria

When the payback period is used to make accept–reject decisions, the decision criteria are as follows:

- If the payback period is *less than* the maximum acceptable payback period, *accept* the project.
- If the payback period is *greater than* the maximum acceptable payback period, *reject* the project.

The length of the maximum acceptable payback period is determined by management. This value is set *subjectively* on the basis of a number of factors, including the type of project (expansion, replacement, renewal), the perceived risk of the project, and the perceived relationship between the payback period and the share value. It is simply a value that management feels, on average, will result in value-creating investment decisions.

**EXAMPLE ▼** We can calculate the payback period for Bennett Company’s projects A and B using the data in Table 9.1. For project A, which is an annuity, the payback period is 3.0 years (\$42,000 initial investment ÷ \$14,000 annual cash inflow). Because project B generates a mixed stream of cash inflows, the calculation of its payback period is not as clear-cut. In year 1, the firm will recover \$28,000 of its \$45,000 initial investment. By the end of year 2, \$40,000 (\$28,000 from year 1 + \$12,000 from year 2) will have been recovered. At the end of year 3, \$50,000 will have been recovered. Only 50% of the year 3 cash inflow of \$10,000 is needed to complete the payback of the initial \$45,000. The payback period for project B is therefore 2.5 years (2 years + 50% of year 3).

If Bennett’s maximum acceptable payback period were 2.75 years, project A would be rejected and project B would be accepted. If the maximum payback were 2.25 years, both projects would be rejected. If the projects were being ranked, B would be preferred over A, because it has a shorter payback period.

### Pros and Cons of Payback Periods

The payback period is widely used by large firms to evaluate small projects and by small firms to evaluate most projects. Its popularity results from its computational simplicity and intuitive appeal. It is also appealing in that it considers cash flows rather than accounting profits. By measuring how quickly the firm recovers its initial investment, the payback period also gives *implicit* consideration to the timing of cash flows and therefore to the time value of money. Because it can be viewed as a measure of *risk exposure*, many firms use the payback period as a decision criterion or as a supplement to other decision techniques. The longer the

firm must wait to recover its invested funds, the greater the possibility of a calamity. Therefore, the shorter the payback period, the lower the firm's exposure to such risk.

The major weakness of the payback period is that the appropriate payback period is merely a subjectively determined number. It cannot be specified in light of the wealth maximization goal because it is not based on discounting cash flows to determine whether they add to the firm's value. Instead, the appropriate payback period is simply the maximum acceptable period of time over which management decides that a project's cash flows must break even (that is, just equal the initial investment). A second weakness is that this approach fails to take *fully* into account the time factor in the value of money.<sup>3</sup> This weakness can be illustrated by an example.

### EXAMPLE ▼

DeYarman Enterprises, a small medical appliance manufacturer, is considering two mutually exclusive projects, which it has named projects Gold and Silver. The firm uses only the payback period to choose projects. The relevant cash flows and payback period for each project are given in Table 9.2. Both projects have 3-year payback periods, which would suggest that they are equally desirable. But comparison of the pattern of cash inflows over the first 3 years shows that more of the \$50,000 initial investment in project Silver is recovered sooner than is recovered for project Gold. For example, in year 1, \$40,000 of the \$50,000 invested in project Silver is recovered, whereas only \$5,000 of the \$50,000 investment in project Gold is recovered. Given the time value of money, project Silver would clearly be preferred over project Gold, in spite of the fact that they both have identical 3-year payback periods. The payback approach does not fully

**TABLE 9.2** Relevant Cash Flows and Payback Periods for DeYarman Enterprises' Projects

	Project Gold	Project Silver
Initial investment	\$50,000	\$50,000
Year	Operating cash inflows	
1	\$ 5,000	\$40,000
2	5,000	2,000
3	40,000	8,000
4	10,000	10,000
5	10,000	10,000
Payback period	3 years	3 years

3. To consider differences in timing *explicitly* in applying the payback method, the *present value payback period* is sometimes used. It is found by first calculating the present value of the cash inflows at the appropriate discount rate and then finding the payback period by using the present value of the cash inflows.

**TABLE 9.3** Calculation of the Payback Period for Rashid Company's Two Alternative Investment Projects

	Project X	Project Y
Initial investment	\$10,000	\$10,000
Year	Operating cash inflows	
1	\$5,000	\$3,000
2	5,000	4,000
3	1,000	3,000
4	100	4,000
5	100	3,000
Payback period	2 years	3 years

- account for the time value of money, which, if recognized, would cause project Silver to be preferred over project Gold.

A third weakness of payback is its failure to recognize cash flows that occur *after* the payback period.

**EXAMPLE** Rashid Company, a software developer, has two investment opportunities, X and Y. Data for X and Y are given in Table 9.3. The payback period for project X is 2 years; for project Y it is 3 years. Strict adherence to the payback approach suggests that project X is preferable to project Y. However, if we look beyond the payback period, we see that project X returns only an additional \$1,200 (\$1,000 in year 3 + \$100 in year 4 + \$100 in year 5), whereas project Y returns an additional \$7,000 (\$4,000 in year 4 + \$3,000 in year 5). On the basis of this information, project Y appears preferable to X. The payback approach ignored the cash inflows occurring after the end of the payback period.<sup>4</sup>

### Net Present Value (NPV)

Because *net present value (NPV)* gives explicit consideration to the time value of money, it is considered a *sophisticated capital budgeting technique*. All such techniques in one way or another discount the firm's cash flows at a specified rate.

4. To get around this weakness, some analysts add a desired dollar return to the initial investment and then calculate the payback period for the increased amount. For example, if the analyst wished to pay back the initial investment plus 20% for projects X and Y in Table 9.3, the amount to be recovered would be \$12,000 [ $\$10,000 + (0.20 \times \$10,000)$ ]. For project X, the payback period would be infinite because the \$12,000 would never be recovered; for project Y, the payback period would be 3.50 years [3 years +  $(\$2,000 \div \$4,000)$  years]. Clearly, project Y would be preferred.

**net present value (NPV)**

A sophisticated capital budgeting technique; found by subtracting a project's initial investment from the present value of its cash inflows discounted at a rate equal to the firm's cost of capital.

This rate—often called the *discount rate*, *required return*, *cost of capital*, or *opportunity cost*—is the minimum return that must be earned on a project to leave the firm's market value unchanged. In this chapter, we take this rate as a “given.” In Chapter 10 we will explore how it is calculated.

The **net present value (NPV)** is found by subtracting a project's initial investment ( $CF_0$ ) from the present value of its cash inflows ( $CF_t$ ) discounted at a rate equal to the firm's cost of capital ( $k$ ).

NPV = Present value of cash inflows – Initial investment

$$NPV = \sum_{t=1}^n \frac{CF_t}{(1+k)^t} - CF_0 \quad (9.1)$$

$$= \sum_{t=1}^n (CF_t \times PVIF_{k,t}) - CF_0 \quad (9.1a)$$

When NPV is used, both inflows and outflows are measured in terms of present dollars. Because we are dealing only with investments that have *conventional cash flow patterns*, the initial investment is automatically stated in terms of today's dollars. If it were not, the present value of a project would be found by subtracting the present value of outflows from the present value of inflows.

### The Decision Criteria

When NPV is used to make accept–reject decisions, the decision criteria are as follows:

- If the NPV is *greater than* \$0, *accept* the project.
- If the NPV is *less than* \$0, *reject* the project.

If the NPV is greater than \$0, the firm will earn a return greater than its cost of capital. Such action should enhance the market value of the firm and therefore the wealth of its owners.

### EXAMPLE ▼

We can illustrate the net present value (NPV) approach by using Bennett Company data presented in Table 9.1. If the firm has a 10% cost of capital, the net present values for projects A (an annuity) and B (a mixed stream) can be calculated as shown on the time lines in Figure 9.2. These calculations result in net present values for projects A and B of \$11,071 and \$10,924, respectively. Both projects are acceptable, because the net present value of each is greater than \$0. If the projects were being ranked, however, project A would be considered superior to B, because it has a higher net present value (\$11,071 versus \$10,924).

#### Project A

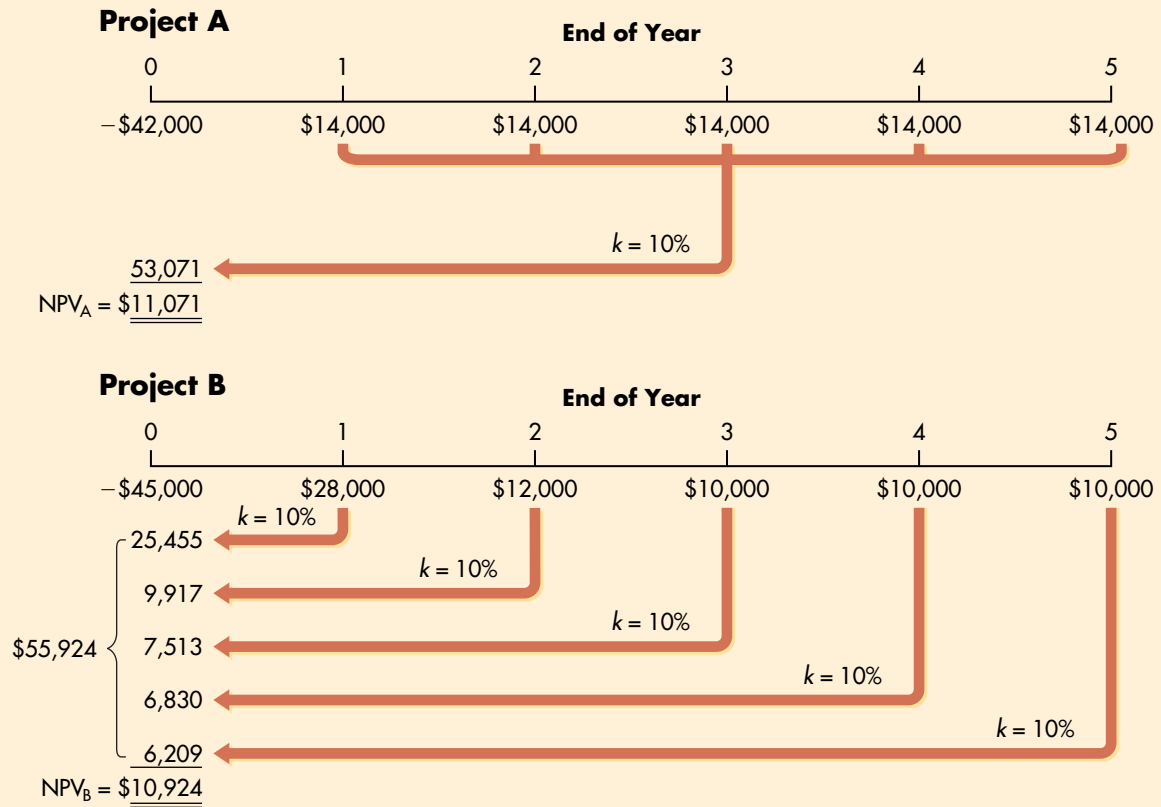
Input	Function
–42000	CF <sub>0</sub>
14000	CF <sub>1</sub>
5	N
10	I
	NPV
Solution	
11071.01	

#### Project B

Input	Function
–45000	CF <sub>0</sub>
28000	CF <sub>1</sub>
12000	CF <sub>2</sub>
10000	CF <sub>3</sub>
3	N
10	I
	NPV
Solution	
10924.40	

**Calculator Use** The preprogrammed NPV function in a financial calculator can be used to simplify the NPV calculation. The keystrokes for project A—the annuity—typically are as shown at left. Note that because project A is an annuity, only its first cash inflow,  $CF_1 = 14000$ , is input, followed by its frequency,  $N = 5$ .

**FIGURE 9.2** Calculation of NPVs for Bennett Company's Capital Expenditure Alternatives  
Time lines depicting the cash flows and NPV calculations for projects A and B



	A	B	C
1	<b>DETERMINING THE NET PRESENT VALUE</b>		
2	Firm's cost of capital		10%
3		Year-End Cash Flow	
4	Year	Project A	Project B
5	0	\$ (42,000)	\$ (45,000)
6	1	\$ 14,000	\$ 28,000
7	2	\$ 14,000	\$ 12,000
8	3	\$ 14,000	\$ 10,000
9	4	\$ 14,000	\$ 10,000
10	5	\$ 14,000	\$ 10,000
11	NPV	\$ 11,071	\$ 10,924
12	<b>Choice of project</b>		<b>Project A</b>

Entry in Cell B11 is  
=NPV(\$C\$2,B6:B10)+B5  
Copy the entry in Cell B11 to Cell C11.  
Entry in Cell C12 is IF(B11>C11,B4,C4).

The keystrokes for project B—the mixed stream—are as shown on page 346. Because the last three cash inflows for project B are the same ( $CF_3 = CF_4 = CF_5 = 10,000$ ), after inputting the first of these cash inflows,  $CF_3$ , we merely input its frequency,  $N = 3$ .

The calculated NPVs for projects A and B of \$11,071 and \$10,924, respectively, agree with the NPVs cited above.

**Spreadsheet Use** The NPVs can be calculated as shown on the Excel spreadsheet at the left.



**internal rate of return (IRR)**

A sophisticated capital budgeting technique; the discount rate that equates the NPV of an investment opportunity with \$0 (because the present value of cash inflows equals the initial investment); it is the compound annual rate of return that the firm will earn if it invests in the project and receives the given cash inflows.

## Internal Rate of Return (IRR)

The *internal rate of return (IRR)* is probably the most widely used *sophisticated capital budgeting technique*. However, it is considerably more difficult than NPV to calculate by hand. The **internal rate of return (IRR)** is the discount rate that equates the NPV of an investment opportunity with \$0 (because the present value of cash inflows equals the initial investment). It is the compound annual rate of return that the firm will earn if it invests in the project and receives the given cash inflows. Mathematically, the IRR is the value of  $k$  in Equation 9.1 that causes NPV to equal \$0.

$$\$0 = \sum_{t=1}^n \frac{CF_t}{(1 + IRR)^t} - CF_0 \quad (9.2)$$

$$\sum_{t=1}^n \frac{CF_t}{(1 + IRR)^t} = CF_0 \quad (9.2a)$$

## The Decision Criteria

When IRR is used to make accept–reject decisions, the decision criteria are as follows:

- If the IRR is *greater than* the cost of capital, *accept* the project.
- If the IRR is *less than* the cost of capital, *reject* the project.

These criteria guarantee that the firm earns at least its required return. Such an outcome should enhance the market value of the firm and therefore the wealth of its owners.

## Calculating the IRR



The actual calculation by hand of the IRR from Equation 9.2a is no easy chore. It involves a complex trial-and-error technique that is described and demonstrated on this text's Web site: [www.aw.com/gitman](http://www.aw.com/gitman). Fortunately, many financial calculators have a preprogrammed IRR function that can be used to simplify the IRR calculation. With these calculators, you merely punch in all cash flows just as if to calculate NPV and then depress **IRR** to find the internal rate of return. Computer software, including spreadsheets, is also available for simplifying these calculations. All NPV and IRR values presented in this and subsequent chapters are obtained by using these functions on a popular financial calculator.

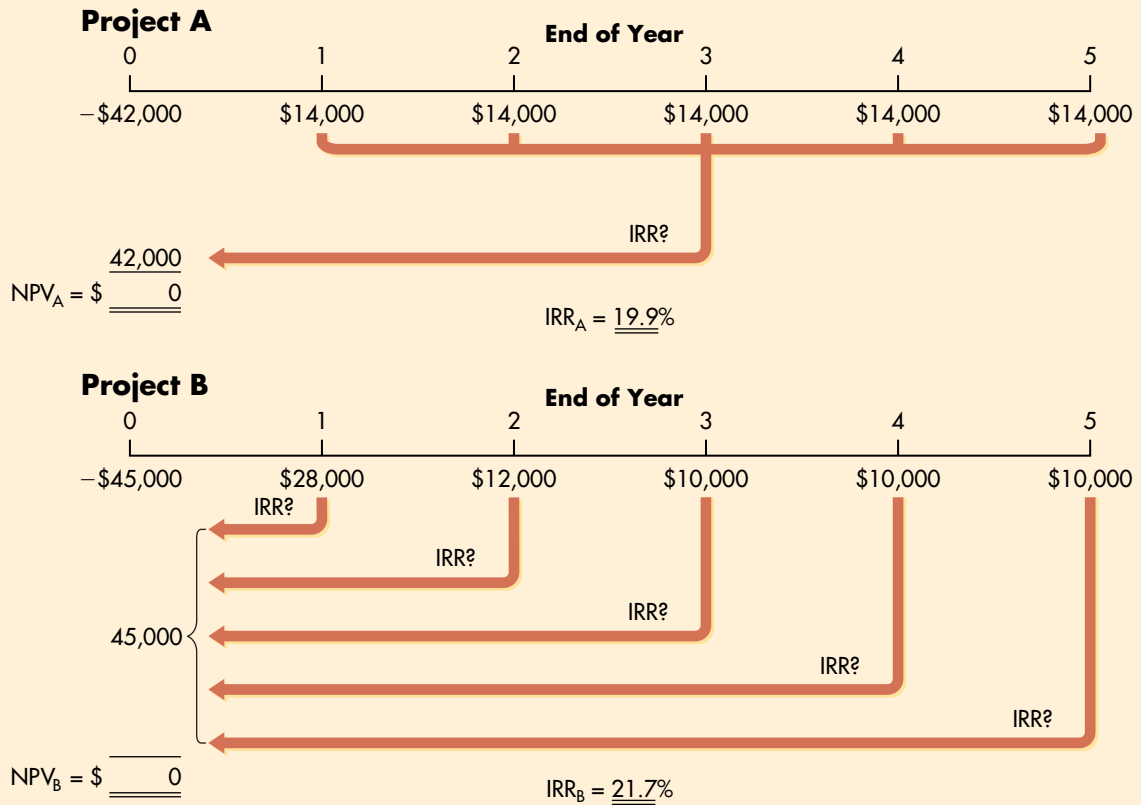
### EXAMPLE ▼

We can demonstrate the internal rate of return (IRR) approach using Bennett Company data presented in Table 9.1. Figure 9.3 uses time lines to depict the framework for finding the IRRs for Bennett's projects A and B, both of which have conventional cash flow patterns. It can be seen in the figure that the IRR is the unknown discount rate that causes the NPV just to equal \$0.

**Calculator Use** To find the IRR using the preprogrammed function in a financial calculator, the keystrokes for each project are the same as those shown on

**FIGURE 9.3** Calculation of IRRs for Bennett Company's Capital Expenditure Alternatives

Time lines depicting the cash flows and IRR calculations for projects A and B



	A	B	C
1	<b>DETERMINING THE INTERNAL RATE OF RETURN</b>		
2		Year-End Cash Flow	
3	Year	Project A	Project B
4	0	\$ (42,000)	\$ (45,000)
5	1	\$ 14,000	\$ 28,000
6	2	\$ 14,000	\$ 12,000
7	3	\$ 14,000	\$ 10,000
8	4	\$ 14,000	\$ 10,000
9	5	\$ 14,000	\$ 10,000
10	IRR	19.9%	21.7%
11	<b>Choice of Project</b>		<b>Project B</b>
	Entry in Cell B10 is =IRR(B4:B9).		
	Copy the entry in Cell B10 to Cell C10.		
	Entry in Cell C11 is =IF(B10>C10,B3,C3).		

page 346 for the NPV calculation, except that the last two NPV keystrokes (punching I and then NPV) are replaced by a single **IRR** keystroke.

Comparing the IRRs of projects A and B given in Figure 9.3 to Bennett Company's 10% cost of capital, we can see that both projects are acceptable because

$$IRR_A = 19.9\% > 10.0\% \text{ cost of capital}$$

$$IRR_B = 21.7\% > 10.0\% \text{ cost of capital}$$

Comparing the two projects' IRRs, we would prefer project B over project A because  $IRR_B = 21.7\% > IRR_A = 19.9\%$ . If these projects are mutually exclusive, the IRR decision technique would recommend project B.

**Spreadsheet Use** The internal rate of return also can be calculated as shown on the Excel spreadsheet at the left.

It is interesting to note in the preceding example that the IRR suggests that project B, which has an IRR of 21.7%, is preferable to project A, which has an IRR of 19.9%. This conflicts with the NPV rankings obtained in an earlier example. Such conflicts are not unusual. *There is no guarantee that NPV and IRR will rank projects in the same order. However, both methods should reach the same conclusion about the acceptability or nonacceptability of projects.*

### Review Questions

- 9-1 What is the *payback period*? How is it calculated? What weaknesses are commonly associated with the use of the payback period to evaluate a proposed investment?
- 9-2 How is the *net present value (NPV)* calculated for a project with a *conventional cash flow pattern*? What are the acceptance criteria for NPV?
- 9-3 What is the *internal rate of return (IRR)* on an investment? How is it determined? What are its acceptance criteria?



### Comparing NPV and IRR Techniques

To understand the differences between the NPV and IRR techniques and decision makers' preferences in their use, we need to look at net present value profiles, conflicting rankings, and the question of which approach is better.

### Net Present Value Profiles

**net present value profile**  
Graph that depicts a project's  
NPVs for various discount rates.

Projects can be compared graphically by constructing **net present value profiles** that depict the projects' NPVs for various discount rates. These profiles are useful in evaluating and comparing projects, especially when conflicting rankings exist. They are best demonstrated via an example.

#### EXAMPLE ▼

To prepare net present value profiles for Bennett Company's two projects, A and B, the first step is to develop a number of "discount rate–net present value" coordinates. Three coordinates can be easily obtained for each project; they are at discount rates of 0%, 10% (the cost of capital,  $k$ ), and the IRR. The net present value at a 0% discount rate is found by merely adding all the cash inflows and subtracting the initial investment. Using the data in Table 9.1 and Figure 9.1, we get

**For project A:**

$$(\$14,000 + \$14,000 + \$14,000 + \$14,000 + \$14,000) - \$42,000 = \$28,000$$

**For project B:**

$$(\$28,000 + \$12,000 + \$10,000 + \$10,000 + \$10,000) - \$45,000 = \$25,000$$

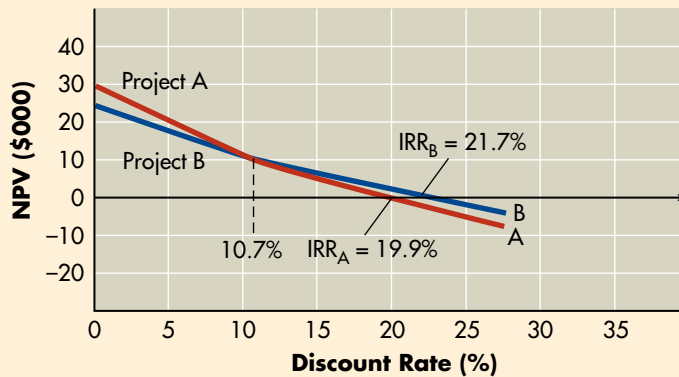
**TABLE 9.4** Discount-Rate–NPV Coordinates for Projects A and B

Discount rate	Net present value	
	Project A	Project B
0 %	\$28,000	\$25,000
10	11,071	10,924
19.9	0	—
21.7	—	0

**FIGURE 9.4**

### NPV Profiles

Net present value profiles for Bennett Company's projects A and B



The net present values for projects A and B at the 10% cost of capital are \$11,071 and \$10,924, respectively (from Figure 9.2). Because the IRR is the discount rate for which net present value equals zero, the IRRs (from Figure 9.3) of 19.9% for project A and 21.7% for project B result in \$0 NPVs. The three sets of coordinates for each of the projects are summarized in Table 9.4.

Plotting the data from Table 9.4 results in the net present value profiles for projects A and B shown in Figure 9.4. The figure indicates that for any discount rate less than approximately 10.7%, the NPV for project A is greater than the NPV for project B. Beyond this point, the NPV for project B is greater. Because the net present value profiles for projects A and B cross at a positive NPV, the IRRs for the projects cause conflicting rankings whenever they are compared to NPVs calculated at discount rates below 10.7%.

### Conflicting Rankings

Ranking is an important consideration when projects are mutually exclusive or when capital rationing is necessary. When projects are mutually exclusive, ranking enables the firm to determine which project is best from a financial standpoint.

**conflicting rankings**

Conflicts in the ranking given a project by NPV and IRR, resulting from differences in the magnitude and timing of cash flows.

**intermediate cash inflows**

Cash inflows received prior to the termination of a project.

When capital rationing is necessary, ranking projects will provide a logical starting point for determining what group of projects to accept. As we'll see, **conflicting rankings** using NPV and IRR result from *differences in the magnitude and timing of cash flows*.

The underlying cause of conflicting rankings is different implicit assumptions about the *reinvestment of intermediate cash inflows*—cash inflows received prior to the termination of a project. NPV assumes that intermediate cash inflows are reinvested at the cost of capital, whereas IRR assumes that intermediate cash inflows are invested at a rate equal to the project's IRR.<sup>5</sup>

In general, projects with similar-size investments and lower cash inflows in the early years tend to be preferred at lower discount rates. Projects that have higher cash inflows in the early years tend to be preferred at higher discount rates. Why? Because at high discount rates, later-year cash inflows tend to be severely penalized in present value terms. For example, at a high discount rate, say 20 percent, the present value of \$1 received at the end of 5 years is about 40 cents, whereas for \$1 received at the end of 15 years it is less than 7 cents. Clearly, at high discount rates a project's early-year cash inflows count most in terms of its NPV. Table 9.5 summarizes the preferences associated with extreme discount rates and dissimilar cash inflow patterns.

**EXAMPLE**

Bennett Company's projects A and B were found to have conflicting rankings at the firm's 10% cost of capital (as depicted in Figure 9.4). If we review each project's cash inflow pattern as presented in Table 9.1 and Figure 9.1, we see that although the projects require similar initial investments, they have dissimilar cash inflow patterns. Table 9.5 indicates that project B, which has higher early-year

**TABLE 9.5** Preferences Associated with Extreme Discount Rates and Dissimilar Cash Inflow Patterns

Discount rate	Cash inflow pattern	
	Lower early-year cash inflows	Higher early-year cash inflows
Low	Preferred	Not preferred
High	Not preferred	Preferred

5. To eliminate the reinvestment rate assumption of the IRR, some practitioners calculate the *modified internal rate of return (MIRR)*. The MIRR is found by converting each operating cash inflow to its future value measured at the end of the project's life and then summing the future values of all inflows to get the project's *terminal value*. Each future value is found by using the cost of capital, thereby eliminating the reinvestment rate criticism of the traditional IRR. The MIRR represents the discount rate that causes the terminal value just to equal the initial investment. Because it uses the cost of capital as the reinvestment rate, the MIRR is generally viewed as a better measure of a project's true profitability than the IRR. Although this technique is frequently used in commercial real estate valuation and is a preprogrammed function on some sophisticated financial calculators, its failure to resolve the issue of conflicting rankings and its theoretical inferiority to NPV have resulted in the MIRR receiving only limited attention and acceptance in the financial literature. For a thorough analysis of the arguments surrounding IRR and MIRR, see D. Anthony Plath and William F. Kennedy, "Teaching Return-Based Measures of Project Evaluation," *Financial Practice and Education* (Spring/Summer 1994), pp. 77–86.

cash inflows than project A, would be preferred over project A at higher discount rates. Figure 9.4 shows that this is in fact the case. At any discount rate in excess of 10.7%, project B's NPV is above that of project A. Clearly, the magnitude and timing of the projects' cash inflows do affect their rankings.

## Which Approach Is Better?

It is difficult to choose one approach over the other, because the theoretical and practical strengths of the approaches differ. It is therefore wise to view both NPV and IRR techniques in each of those dimensions.

### Theoretical View

*On a purely theoretical basis, NPV is the better approach to capital budgeting as a result of several factors. Most important is that the use of NPV implicitly assumes that any intermediate cash inflows generated by an investment are reinvested at the firm's cost of capital. The use of IRR assumes reinvestment at the often high rate specified by the IRR. Because the cost of capital tends to be a reasonable estimate of the rate at which the firm could actually reinvest intermediate cash inflows, the use of NPV, with its more conservative and realistic reinvestment rate, is in theory preferable.*

In addition, certain mathematical properties may cause a project with a non-conventional cash flow pattern to have zero or more than one *real* IRR; this problem does not occur with the NPV approach.

### Practical View

Evidence suggests that in spite of the theoretical superiority of NPV, *financial managers prefer to use IRR.*<sup>6</sup> The preference for IRR is due to the general disposition of businesspeople toward *rates of return* rather than actual *dollar returns*. Because interest rates, profitability, and so on are most often expressed as annual rates of return, the use of IRR makes sense to financial decision makers. They tend to find NPV less intuitive because it does not measure benefits *relative to the amount invested*. Because a variety of techniques are available for avoiding the pitfalls of the IRR, its widespread use does not imply a lack of sophistication on the part of financial decision makers.

## Review Questions

9–4 Do the net present value (NPV) and internal rate of return (IRR) always agree with respect to accept–reject decisions? With respect to ranking decisions? Explain.

6. For example, see Harold Bierman, Jr., "Capital Budgeting in 1992: A Survey," *Financial Management* (Autumn 1993), p. 24, and Lawrence J. Gitman and Charles E. Maxwell, "A Longitudinal Comparison of Capital Budgeting Techniques Used by Major U.S. Firms: 1986 versus 1976," *Journal of Applied Business Research* (Fall 1987), pp. 41–50, for discussions of evidence with respect to capital budgeting decision-making practices in major U.S. firms.

- 9–5 How is a *net present value profile* used to compare projects? What causes conflicts in the ranking of projects via net present value and internal rate of return?
- 9–6 Does the assumption concerning the reinvestment of intermediate cash inflow tend to favor NPV or IRR? In practice, which technique is preferred and why?



### Additional Considerations: Real Options and Capital Rationing

A couple of important issues that often confront the financial manager when making capital budgeting decisions are (1) the potential real options embedded in capital projects and (2) the availability of only limited funding for acceptable projects. Here we briefly consider each of these situations.

### Recognizing Real Options

The procedures described in Chapter 8 and thus far in this chapter suggest that to make capital budgeting decisions, we must (1) estimate relevant cash flows and (2) apply an appropriate decision technique such as NPV or IRR to those cash flows. Although this traditional procedure is believed to yield good decisions, a more *strategic approach* to these decisions has emerged in recent years. This more modern view considers any **real options**—opportunities that are embedded in capital projects (“real,” rather than financial, asset investments) that enable managers to alter their cash flows and risk in a way that affects project acceptability (NPV). Because these opportunities are more likely to exist in, and be more important to, large “strategic” capital budgeting projects, they are sometimes called *strategic options*.

Some of the more common types of real options—abandonment, flexibility, growth, and timing—are briefly described in Table 9.6. It should be clear from their descriptions that each of these types of options could be embedded in a capital budgeting decision and that explicit recognition of them would probably alter the cash flow and risk of a project and change its NPV.

By explicitly recognizing these options when making capital budgeting decisions, managers can make improved, more strategic decisions that consider in advance the economic impact of certain contingent actions on project cash flow and risk. The explicit recognition of real options embedded in capital budgeting projects will cause the project’s *strategic NPV* to differ from its *traditional NPV* as indicated by Equation 9.3.

$$\text{NPV}_{\text{strategic}} = \text{NPV}_{\text{traditional}} + \text{Value of real options} \quad (9.3)$$

Application of this relationship is illustrated in the following example.

#### EXAMPLE ▼

Assume that a strategic analysis of Bennett Company’s projects A and B (see cash flows and NPVs in Figure 9.2) finds no real options embedded in project A

#### real options

Opportunities that are embedded in capital projects that enable managers to alter their cash flows and risk in a way that affects project acceptability (NPV). Also called *strategic options*.

**TABLE 9.6 Major Types of Real Options**

Option type	Description
Abandonment option	The option to abandon or terminate a project prior to the end of its planned life. This option allows management to avoid or minimize losses on projects that turn bad. Explicitly recognizing the abandonment option when evaluating a project often increases its NPV.
Flexibility option	The option to incorporate flexibility into the firm's operations, particularly production. It generally includes the opportunity to design the production process to accept multiple inputs, use flexible production technology to create a variety of outputs by reconfiguring the same plant and equipment, and purchase and retain excess capacity in capital-intensive industries subject to wide swings in output demand and long lead time in building new capacity from scratch. Recognition of this option embedded in a capital expenditure should increase the NPV of the project.
Growth option	The option to develop follow-on projects, expand markets, expand or retool plants, and so on, that would not be possible without implementation of the project that is being evaluated. If a project being considered has the measurable potential to open new doors if successful, then recognition of the cash flows from such opportunities should be included in the initial decision process. Growth opportunities embedded in a project often increase the NPV of the project in which they are embedded.
Timing option	The option to determine when various actions with respect to a given project are taken. This option recognizes the firm's opportunity to delay acceptance of a project for one or more periods, to accelerate or slow the process of implementing a project in response to new information, or to shut down a project temporarily in response to changing product market conditions or competition. As in the case of the other types of options, the explicit recognition of timing opportunities can improve the NPV of a project that fails to recognize this option in an investment decision.

and two real options embedded in project B. The two real options in project B are as follows: (1) The project would have, during the first two years, some downtime that would result in unused production capacity that could be used to perform contract manufacturing for another firm, and (2) the project's computerized control system could, with some modification, control two other machines, thereby reducing labor cost, without affecting operation of the new project.

Bennett's management estimated the NPV of the contract manufacturing over the 2 years following implementation of project B to be \$1,500 and the NPV of the computer control sharing to be \$2,000. Management felt there was a 60% chance that the contract manufacturing option would be exercised and only a 30% chance that the computer control sharing option would be exercised.



The combined value of these two real options would be the sum of their expected values.

$$\begin{aligned}\text{Value of real options for project B} &= (0.60 \times \$1,500) + (0.30 \times \$2,000) \\ &= \$900 + \$600 = \$1,500\end{aligned}$$

Substituting the \$1,500 real options value along with the traditional NPV of \$10,924 for project B (from Figure 9.2) into Equation 9.3, we get the strategic NPV for project B.

$$\text{NPV}_{\text{strategic}} = \$10,924 + \$1,500 = \underline{\underline{\$12,424}}$$

Bennett Company's project B therefore has a strategic NPV of \$12,424, which is above its traditional NPV and now exceeds project A's NPV of \$11,071. Clearly, recognition of project B's real options improved its NPV (from \$10,924 to \$12,424) and causes it to be preferred over project A (NPV of \$12,424 for B > NPV of \$11,071 for A), which has no real options embedded in it.

It is important to realize that the recognition of attractive real options when determining NPV could cause an otherwise unacceptable project ( $\text{NPV}_{\text{traditional}} < \$0$ ) to become acceptable ( $\text{NPV}_{\text{strategic}} > \$0$ ). The failure to recognize the value of real options could therefore cause management to reject projects that are acceptable. Although doing so requires more strategic thinking and analysis, it is important for the financial manager to identify and incorporate real options in the NPV process. The procedures for doing this efficiently are emerging, and the use of the strategic NPV that incorporates real options is expected to become more commonplace in the future.

## Choosing Projects under Capital Rationing

Firms commonly operate under *capital rationing*—they have more acceptable independent projects than they can fund. *In theory*, capital rationing should not exist. Firms should accept all projects that have positive NPVs (or IRRs > the cost of capital). However, *in practice*, most firms operate under capital rationing. Generally, firms attempt to isolate and select the best acceptable projects subject to a capital expenditure budget set by management. Research has found that management internally imposes capital expenditure constraints to avoid what it deems to be “excessive” levels of new financing, particularly debt. Although failing to fund all acceptable independent projects is theoretically inconsistent with the goal of maximizing owner wealth, we will discuss capital rationing procedures because they are widely used in practice.

The objective of *capital rationing* is to select the group of projects that provides the *highest overall net present value* and does not require more dollars than are budgeted. As a prerequisite to capital rationing, the best of any mutually exclusive projects must be chosen and placed in the group of independent projects. Two basic approaches to project selection under capital rationing are discussed here.

**internal rate of return approach**

An approach to capital rationing that involves graphing project IRRs in descending order against the total dollar investment, to determine the group of acceptable projects.

**investment opportunities schedule (IOS)**

The graph that plots project IRRs in descending order against total dollar investment.

**Internal Rate of Return Approach**

The **internal rate of return approach** involves graphing project IRRs in descending order against the total dollar investment. This graph, which is discussed in more detail in Chapter 10, is called the **investment opportunities schedule (IOS)**. By drawing the cost-of-capital line and then imposing a budget constraint, the financial manager can determine the group of acceptable projects. The problem with this technique is that it does not guarantee the maximum dollar return to the firm. It merely provides a satisfactory solution to capital rationing problems.

**EXAMPLE ▼**

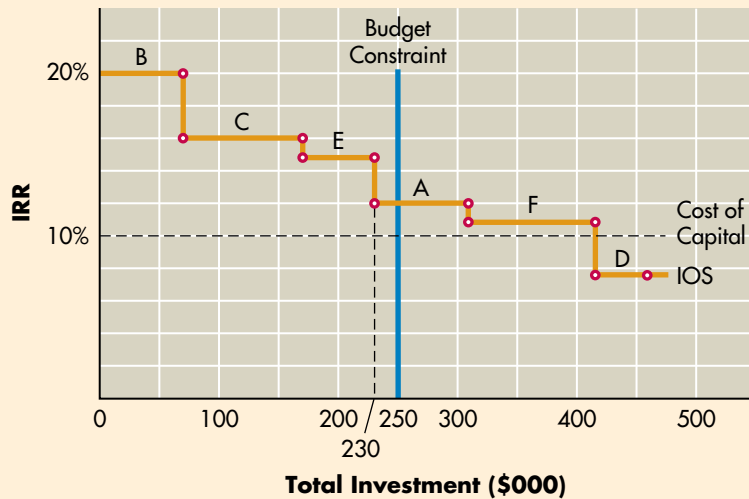
Tate Company, a fast-growing plastics company, is confronted with six projects competing for its fixed budget of \$250,000. The initial investment and IRR for each project are as follows:

Project	Initial investment	IRR
A	\$ 80,000	12%
B	70,000	20
C	100,000	16
D	40,000	8
E	60,000	15
F	110,000	11

The firm has a cost of capital of 10%. Figure 9.5 presents the IOS that results from ranking the six projects in descending order on the basis of their IRRs. According to the schedule, only projects B, C, and E should be accepted.

**FIGURE 9.5****Investment Opportunities Schedule**

Investment opportunities schedule (IOS) for Tate Company projects



Together they will absorb \$230,000 of the \$250,000 budget. Projects A and F are acceptable but cannot be chosen because of the budget constraint. Project D is not worthy of consideration; its IRR is less than the firm's 10% cost of capital.

The drawback of this approach is that there is no guarantee that the acceptance of projects B, C, and E will maximize *total dollar returns* and therefore owners' wealth.

### Net Present Value Approach

#### net present value approach

An approach to capital rationing that is based on the use of present values to determine the group of projects that will maximize owners' wealth.

The **net present value approach** is based on the use of present values to determine the group of projects that will maximize owners' wealth. It is implemented by ranking projects on the basis of IRRs and then evaluating the present value of the benefits from each potential project to determine *the combination of projects with the highest overall present value*. This is the same as maximizing net present value, in which the entire budget is viewed as the total initial investment. Any portion of the firm's budget that is not used does not increase the firm's value. At best, the unused money can be invested in marketable securities or returned to the owners in the form of cash dividends. In either case, the wealth of the owners is not likely to be enhanced.

#### EXAMPLE

The group of projects described in the preceding example is ranked in Table 9.7 on the basis of IRRs. The present value of the cash inflows associated with the projects is also included in the table. Projects B, C, and E, which together require \$230,000, yield a present value of \$336,000. However, if projects B, C, and A were implemented, the total budget of \$250,000 would be used, and the present value of the cash inflows would be \$357,000. This is greater than the return expected from selecting the projects on the basis of the highest IRRs. Implementing B, C, and A is preferable, because they maximize the present value for the given budget. *The firm's objective is to use its budget to generate the highest present value of inflows.* Assuming that any unused portion of the budget does not gain or lose money, the total NPV for projects B, C, and E would be \$106,000

**TABLE 9.7** Rankings for Tate Company Projects

Project	Initial investment	IRR	Present value of inflows at 10%	
B	\$ 70,000	20%	\$112,000	
C	100,000	16	145,000	
E	60,000	15	79,000	
A	80,000	12	100,000	
F	110,000	11	126,500	
D	40,000	8	36,000	Cutoff point (IRR < 10%)

- ... (\$336,000 – \$230,000), whereas for projects B, C, and A the total NPV would be \$107,000 (\$357,000 – \$250,000). Selection of projects B, C, and A will therefore maximize NPV.

### Review Questions

- 9–7 What are *real options*? What are some major types of real options?
- 9–8 What is the difference between the *strategic NPV* and the *traditional NPV*? Do they always result in the same accept–reject decisions?
- 9–9 What is *capital rationing*? In theory, should capital rationing exist? Why does it frequently occur in practice?
- 9–10 Compare and contrast the *internal rate of return approach* and the *net present value approach* to capital rationing. Which is better? Why?



**risk (in capital budgeting)**  
The chance that a project will prove unacceptable or, more formally, the degree of variability of cash flows.

### Behavioral Approaches for Dealing with Risk

In the context of capital budgeting, the term **risk** refers to the chance that a project will prove unacceptable—that is,  $NPV < \$0$  or  $IRR < \text{cost of capital}$ . More formally, risk in capital budgeting is the degree of variability of cash flows. Projects with a small chance of acceptability and a broad range of expected cash flows are more risky than projects that have a high chance of acceptability and a narrow range of expected cash flows.

In the conventional capital budgeting projects assumed here, risk stems almost entirely from *cash inflows*, because the initial investment is generally known with relative certainty. These inflows, of course, derive from a number of variables related to revenues, expenditures, and taxes. Examples include the level of sales, the cost of raw materials, labor rates, utility costs, and tax rates. We will concentrate on the risk in the cash inflows, but remember that this risk actually results from the interaction of these underlying variables.

*Behavioral approaches* can be used to get a “feel” for the level of project risk, whereas other approaches explicitly recognize project risk. Here we present a few behavioral approaches for dealing with risk in capital budgeting: sensitivity and scenario analysis, decision trees, and simulation. In addition, some international risk considerations are discussed.

### Sensitivity Analysis and Scenario Analysis

Two approaches for dealing with project risk to capture the variability of cash inflows and NPVs are sensitivity analysis and scenario analysis. As noted in Chapter 5, *sensitivity analysis* is a behavioral approach that uses several possible values for a given variable, such as cash inflows, to assess that variable’s impact on the firm’s return, measured here by NPV. This technique is often useful in getting a feel for the variability of return in response to changes in a key variable. In capital budgeting, one of the most common sensitivity approaches is to estimate

**TABLE 9.8** Sensitivity Analysis of Treadwell's Projects A and B

	Project A	Project B
Initial investment	\$10,000	\$10,000
Annual cash inflows		
Outcome		
Pessimistic	\$1,500	\$ 0
Most likely	2,000	2,000
Optimistic	2,500	4,000
Range	\$1,000	\$ 4,000
Net present values <sup>a</sup>		
Outcome		
Pessimistic	\$1,409	−\$10,000
Most likely	5,212	5,212
Optimistic	9,015	20,424
Range	\$7,606	\$30,424

<sup>a</sup>These values were calculated by using the corresponding annual cash inflows. A 10% cost of capital and a 15-year life for the annual cash inflows were used.

the NPVs associated with pessimistic (worst), most likely (expected), and optimistic (best) estimates of cash inflow. The *range* can be determined by subtracting the pessimistic-outcome NPV from the optimistic-outcome NPV.

**EXAMPLE ▼**

Treadwell Tire Company, a tire retailer with a 10% cost of capital, is considering investing in either of two mutually exclusive projects, A and B. Each requires a \$10,000 initial investment, and both are expected to provide equal annual cash inflows over their 15-year lives. The firm's financial manager made pessimistic, most likely, and optimistic estimates of the cash inflows for each project. The cash inflow estimates and resulting NPVs in each case are summarized in Table 9.8. Comparing the ranges of cash inflows (\$1,000 for project A and \$4,000 for B) and, more important, the ranges of NPVs (\$7,606 for project A and \$30,424 for B) makes it clear that project A is less risky than project B. Given that both projects have the same most likely NPV of \$5,212, the assumed risk-averse decision maker will take project A because it has less risk and no possibility of loss.

**scenario analysis**

A behavioral approach that evaluates the impact on the firm's return of simultaneous changes in a number of variables.

**Scenario analysis** is a behavioral approach similar to sensitivity analysis but broader in scope. It evaluates the impact on the firm's return of simultaneous changes in a *number of variables*, such as cash inflows, cash outflows, and the cost of capital. For example, the firm could evaluate the impact of both high inflation (scenario 1) and low inflation (scenario 2) on a project's NPV. Each scenario will affect the firm's cash inflows, cash outflows, and cost of capital, thereby resulting in different levels of NPV. The decision maker can use these

- NPV estimates to assess the risk involved with respect to the level of inflation. The widespread availability of computer and spreadsheets has greatly enhanced the use of both scenario and sensitivity analysis.

## Decision Trees

### decision trees

A behavioral approach that uses diagrams to map the various investment decision alternatives and payoffs, along with their probabilities of occurrence.

Decision trees are a behavioral approach that uses diagrams to map the various investment decision alternatives and payoffs, along with their probabilities of occurrence. Their name derives from their resemblance to the branches of a tree (see Figure 9.6). Decision trees rely on estimates of the probabilities associated with the outcomes (payoffs) of competing courses of action. The payoffs of each course of action are weighted by the associated probability; the weighted payoffs are summed; and the expected value of each course of action is then determined. The alternative that provides the highest expected value is preferred.

### EXAMPLE

Convoy, Inc., a manufacturer of picture frames, wishes to choose between two equally risky projects, I and J. To make this decision, Convoy's management has gathered the necessary data, which are depicted in the decision tree in Figure 9.6. Project I requires an initial investment of \$120,000; a resulting expected present value of cash inflows of \$130,000 is shown in column 4. Project I's expected net present value, which is calculated below the decision tree, is therefore \$10,000. The expected net present value of project J is determined in a similar fashion. Project J is preferred because it offers a higher NPV—\$15,000.

**FIGURE 9.6**

### Decision Tree for NPV

Decision Tree for Convoy, Inc.'s choice between projects I and J

	<u>Initial Investment (1)</u>	<u>Probability (2)</u>	<u>Present Value of Cash Inflow (Payoff) (3)</u>	<u>Weighted Present Value of Cash Inflow [(2) × (3)] (4)</u>
Decision: I or J?	\$120,000	.40	\$225,000	\$ 90,000
		.50	\$100,000	50,000
		.10	-\$100,000	-10,000
		Expected Present Value of Cash Inflows		<u>\$130,000</u>
	\$140,000	.30	\$280,000	\$ 84,000
		.40	\$200,000	80,000
		.30	-\$ 30,000	-9,000
		Expected Present Value of Cash Inflows		<u>\$155,000</u>
	Expected NPV <sub>I</sub> = \$130,000 - \$120,000 = \$10,000			
	Expected NPV <sub>J</sub> = \$155,000 - \$140,000 = \$15,000			
Because Expected NPV <sub>J</sub> > Expected NPV <sub>I</sub> , Choose J.				

## Simulation

### simulation

A statistics-based behavioral approach that applies predetermined probability distributions and random numbers to estimate risky outcomes.

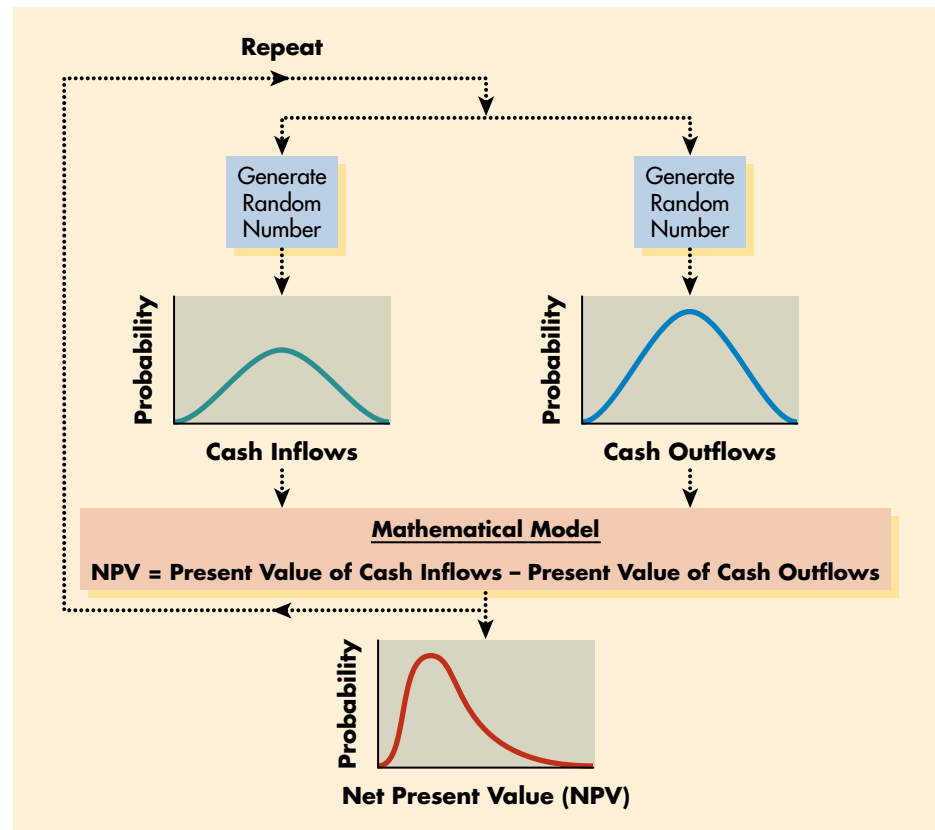
**Simulation** is a statistics-based behavioral approach that applies predetermined probability distributions and random numbers to estimate risky outcomes. By tying the various cash flow components together in a mathematical model and repeating the process numerous times, the financial manager can develop a probability distribution of project returns. Figure 9.7 presents a flowchart of the simulation of the net present value of a project. The process of generating random numbers and using the probability distributions for cash inflows and cash outflows enables the financial manager to determine values for each of these variables. Substituting these values into the mathematical model results in an NPV. By repeating this process perhaps a thousand times, one can create a probability distribution of net present values.

Although only gross cash inflows and cash outflows are simulated in Figure 9.7, more sophisticated simulations using individual inflow and outflow components, such as sales volume, sale price, raw material cost, labor cost, maintenance expense, and so on, are quite common. From the distribution of returns, the decision maker can determine not only the expected value of the return but also the probability of achieving or surpassing a given return. The use of computers has made the simulation approach feasible. The output of simulation provides an

**FIGURE 9.7**

### NPV Simulation

Flowchart of a net present value simulation



excellent basis for decision making, because it enables the decision maker to view a continuum of risk–return tradeoffs rather than a single-point estimate.

## International Risk Considerations

Although the basic techniques of capital budgeting are the same for multinational companies (MNCs) as for purely domestic firms, firms that operate in several countries face risks that are unique to the international arena. Two types of risk are particularly important: exchange rate risk and political risk.

**exchange rate risk**  
The danger that an unexpected change in the exchange rate between the dollar and the currency in which a project's cash flows are denominated will reduce the market value of that project's cash flow.

**Exchange rate risk** reflects the danger that an unexpected change in the exchange rate between the dollar and the currency in which a project's cash flows are denominated will reduce the market value of that project's cash flow. The dollar value of future cash inflows can be dramatically altered if the local currency depreciates against the dollar. In the short term, specific cash flows can be hedged by using financial instruments such as currency futures and options. Long-term exchange rate risk can best be minimized by financing the project, in whole or in part, in local currency.

**Political risk** is much harder to protect against. Once a foreign project is accepted, the foreign government can block the return of profits, seize the firm's assets, or otherwise interfere with a project's operation. The inability to manage political risk after the fact makes it even more important that managers account for political risks before making an investment. They can do so either by adjusting a project's expected cash inflows to account for the probability of political interference or by using risk-adjusted discount rates (discussed later in this chapter) in capital budgeting formulas. In general, it is much better to adjust individual project cash flows for political risk subjectively than to use a blanket adjustment for all projects.

In addition to unique risks that MNCs must face, several other special issues are relevant only for international capital budgeting. One of these special issues is *taxes*. Because only after-tax cash flows are relevant for capital budgeting, financial managers must carefully account for taxes paid to foreign governments on profits earned within their borders. They must also assess the impact of these tax payments on the parent company's U.S. tax liability.

**transfer prices**  
Prices that subsidiaries charge each other for the goods and services traded between them.

Another special issue in international capital budgeting is *transfer pricing*. Much of the international trade involving MNCs is, in reality, simply the shipment of goods and services from one of a parent company's subsidiaries to another subsidiary located abroad. The parent company therefore has great discretion in setting **transfer prices**, the prices that subsidiaries charge each other for the goods and services traded between them. The widespread use of transfer pricing in international trade makes capital budgeting in MNCs very difficult unless the transfer prices that are used accurately reflect actual costs and incremental cash flows.

Finally, MNCs often must approach international capital projects from a *strategic point of view*, rather than from a strictly financial perspective. For example, an MNC may feel compelled to invest in a country to ensure continued access, even if the project itself may not have a positive net present value. This motivation was important for Japanese automakers who set up assembly plants in the United States in the early 1980s. For much the same reason, U.S. investment in Europe surged during the years before the market integration of the European Community



## In Practice

## FOCUS ON PRACTICE Bestfoods' Recipe for Risk

With future volume growth in North America and Western Europe limited to 3 percent at most, executives at Bestfoods (now a unit of the Anglo-Dutch conglomerate Unilever) decided to look for more promising markets. Whereas other food manufacturers were hesitant to take the international plunge, Bestfoods took its popular brands, such as Hellman's/Best Foods, Knorr, Mazola, and Skippy, where the growth was—emerging markets like Latin America, where the company could grow at a rate of 15 percent a year. At the time it was acquired by Unilever, Bestfoods derived about 22 percent of its revenues outside the United States and Western Europe, producing mayonnaise, soups, and other foods for 110 different markets at 130 manufacturing plants worldwide.

Bestfoods' international expansion succeeded because the company developed methods to incorporate the risks and rewards of its foreign investments into proj-

ect analyses. These risks included exchange rate and political risks, as well as tax and legal considerations and strategic issues. First, it increased its familiarity with the foreign market by partnering with other companies whenever possible and by developing local management and experience. From this knowledge base, Bestfoods was willing to take calculated risks. Working with consultants, the company created its own analytical model to set discount rates for different markets.

Some companies attempt to quantify the risk of foreign projects by arbitrarily assigning a premium to the discount rate they use for domestic projects. Executives who rely on this subjective method may overestimate the costs of doing business overseas and rule out good projects. Unlike these companies, Bestfoods took the time to develop specific costs of capital for international markets. To incorporate the benefits of diversification for a multinational company

like Bestfoods, the company adapted the capital asset pricing model (CAPM). The model factors in elements of economic and political risk to obtain the country's risk premium and develops betas for each country on the basis of the local market's volatility and its correlation to the U.S. market. For example, the high volatility of Brazil's market has a low correlation to the U.S. market, so the country beta was .81. With the risk-free rates and country betas, Bestfoods could calculate local and global costs of capital. This more sophisticated approach gave Bestfoods the confidence to pursue an aggressive international strategy that increased shareholder value and resulted in Unilever offering a substantial premium to acquire the company.

*Sources:* Adapted from Andrew Osterland, "Lowering the Bar," *CFO* (August 1, 2002), downloaded from [www.cfo.com](http://www.cfo.com); Stanley Reed, "Unilever Restocks," *Business Week International* (August 6, 2001), downloaded from Electric Library, [ask.elibrary.com](http://ask.elibrary.com)

in 1992. MNCs often invest in production facilities in the home country of major rivals to deny these competitors an uncontested home market. MNCs also may feel compelled to invest in certain industries or countries to achieve a broad corporate objective such as completing a product line or diversifying raw material sources, even when the project's cash flows may not be sufficiently profitable.

## Review Questions

- 9–11 Define risk in terms of the cash inflows from a capital budgeting project. Briefly describe and compare the following behavioral approaches, explaining how each can be used to deal with project risk: (a) sensitivity analysis; (b) scenario analysis; (c) decision trees; and (d) simulation.
- 9–12 Briefly explain how each of the following considerations affects the capital budgeting decisions of multinational companies: (a) exchange rate risk; (b) political risk; (c) tax law differences; (d) transfer pricing; and (e) a strategic rather than strictly financial viewpoint.



## Risk-Adjusted Discount Rates

The approaches for dealing with risk that have been presented so far enable the financial manager to get a “feel” for project risk. Unfortunately, they do not explicitly recognize project risk. We will now illustrate the most popular risk-adjustment technique that employs the net present value (NPV) decision method.<sup>7</sup> The NPV decision rule of accepting only those projects with NPVs > \$0 will continue to hold. Close examination of the basic equation for NPV, Equation 9.1, should make it clear that because the initial investment ( $CF_0$ ) is known with certainty, a project’s risk is embodied in the present value of its cash inflows:

$$\sum_{t=1}^n \frac{CF_t}{(1+k)^t}$$

Two opportunities to adjust the present value of cash inflows for risk exist: (1) The cash inflows ( $CF_t$ ) can be adjusted, or (2) the discount rate ( $k$ ) can be adjusted. Adjusting the cash inflows is highly subjective, so here we describe the more popular process of adjusting the discount rate. In addition, we consider the practical aspects of risk-adjusted discount rates.

### Determining Risk-Adjusted Discount Rates (RADRs)

A popular approach for risk adjustment involves the use of *risk-adjusted discount rates* (RADRs). This approach uses Equation 9.1 but employs a risk-adjusted discount rate, as noted in the following expression:

$$NPV = \sum_{t=1}^n \frac{CF_t}{(1 + RADR)^t} - CF_0 \quad (9.4)$$

#### risk-adjusted discount rate (RADR)

The rate of return that must be earned on a given project to compensate the firm’s owners adequately—that is, to maintain or improve the firm’s share price.

The **risk-adjusted discount rate (RADR)** is the rate of return that must be earned on a given project to compensate the firm’s owners adequately—that is, to maintain or improve the firm’s share price. The higher the risk of a project, the higher the RADR, and therefore the lower the net present value for a given stream of cash inflows. The logic underlying the use of RADRs is closely linked to the capital asset pricing model (CAPM) developed in Chapter 5. Because the CAPM is based on an assumed efficient market, which does *not* exist for real corporate (nonfinancial) assets such as plant and equipment, the CAPM is not directly applicable in making capital budgeting decisions. Financial managers therefore assess the *total risk* of a project and use it to determine the risk-adjusted discount rate (RADR), which can be used in Equation 9.4 to find the NPV.

In order not to damage its market value, the firm must use the correct discount rate to evaluate a project. If a firm discounts a risky project’s cash inflows at too low a rate and accepts the project, the firm’s market price may drop as investors recognize that the firm itself has become more risky. On the other hand, if the firm discounts a project’s cash inflows at too high a rate, it will reject acceptable projects. Eventually the firm’s market price may drop, because

7. The IRR could just as well have been used, but because NPV is theoretically preferable, it is used instead.

investors who believe that the firm is being overly conservative will sell their stock, putting downward pressure on the firm's market value.

Unfortunately, there is no formal mechanism for linking total project risk to the level of required return. As a result, most firms subjectively determine the RADR by adjusting their existing required return. They adjust it up or down depending on whether the proposed project is more or less risky, respectively, than the average risk of the firm. This CAPM-type of approach provides a “rough estimate” of the project risk and required return because both the project risk measure and the linkage between risk and required return are estimates.

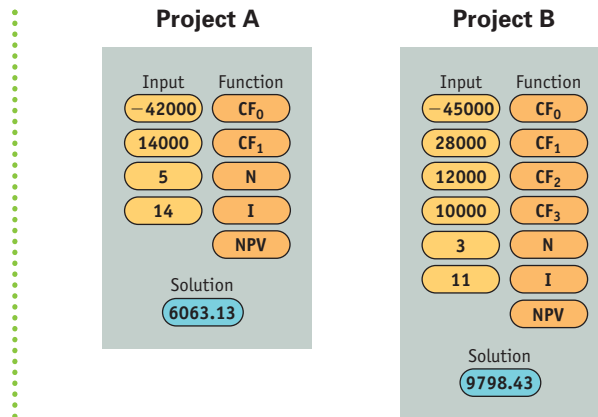
### EXAMPLE ▼

Bennett Company wishes to use the risk-adjusted discount rate approach to determine, according to NPV, whether to implement project A or project B. In addition to the data presented earlier, Bennett's management after much analysis assigned a “risk index” of 1.6 to project A and of 1.0 to project B. The risk index is merely a numerical scale used to classify project risk: Higher index values are assigned to higher-risk projects, and vice versa. The CAPM-type relationship used by the firm to link risk (measured by the risk index) and the required return (RADR) is shown in the following table.

	Risk index	Required return (RADR)
	0.0	6% (risk-free rate, $R_F$ )
	0.2	7
	0.4	8
	0.6	9
	0.8	10
Project B →	1.0	11
	1.2	12
	1.4	13
Project A →	1.6	14
	1.8	16
	2.0	18

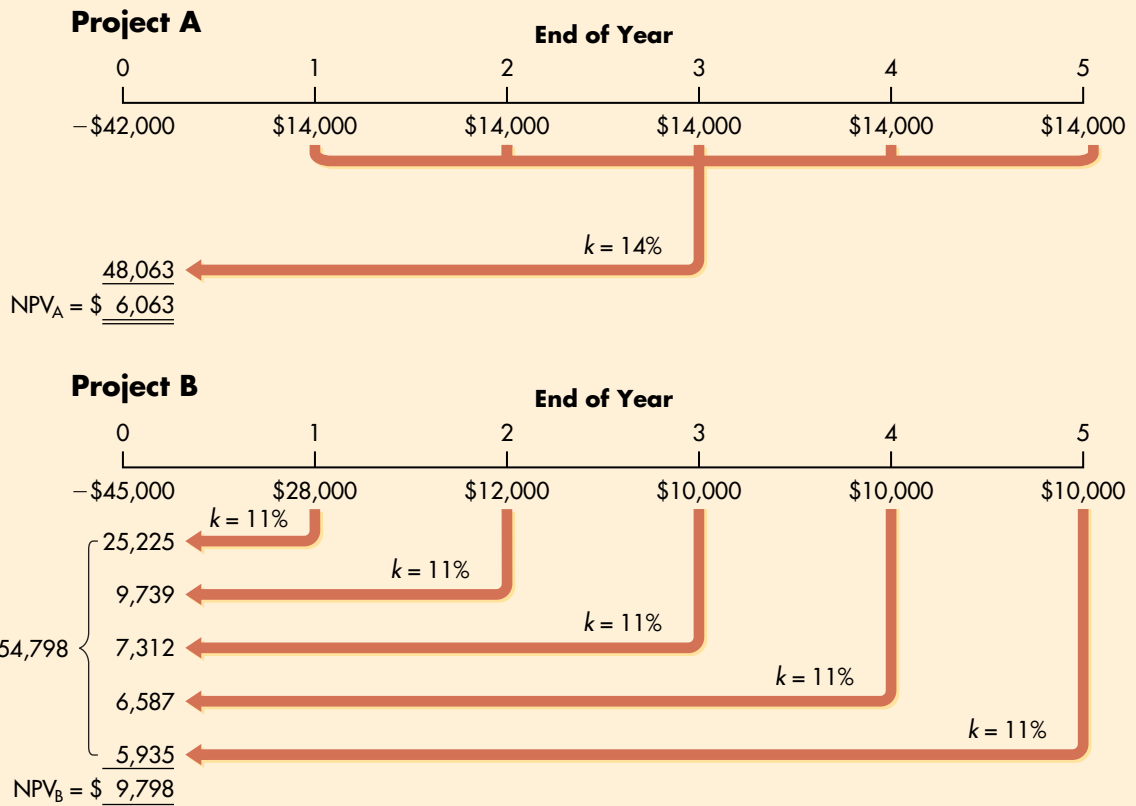
Because project A is riskier than project B, its RADR of 14% is greater than project B's 11%. The net present value of each project, calculated using its RADR, is found as shown on the time lines in Figure 9.8. The results clearly show that project B is preferable, because its risk-adjusted NPV of \$9,798 is greater than the \$6,063 risk-adjusted NPV for project A. As reflected by the NPVs in Figure 9.2, if the discount rates were not adjusted for risk, project A would be preferred to project B.

**Calculator Use** We can again use the preprogrammed NPV function in a financial calculator to simplify the NPV calculation. The keystrokes for project A—the annuity—typically are as shown at the top of the next page. The keystrokes for project B—the mixed stream—are also shown at the top of the next page. The calculated NPVs for projects A and B of \$6,063 and \$9,798, respectively, agree with those shown in Figure 9.8.



**FIGURE 9.8** Calculation of NPVs for Bennett Company's Capital Expenditure Alternatives using RADRs

Time lines depicting the cash flows and NPV calculations using RADRs for projects A and B



Note: When we use the risk indexes of 1.6 and 1.0 for projects A and B, respectively, along with the table in the middle of the preceding page, a risk-adjusted discount rate (RADR) of 14% results for project A and a RADR of 11% results for project B.

**Spreadsheet Use** Analysis of projects using risk-adjusted discount rates (RADRs) also can be calculated as shown on the following Excel spreadsheet.

	A	B	C	D
1	<b>ANALYSIS OF PROJECTS USING RISK-ADJUSTED DISCOUNT RATES</b>			
2	Year	Cash Inflow	Present Value	Formulas for Calculated Values in Column C
3	<b>Project A</b>			
4	1-5	\$ 14,000	\$48,063	=PV(C7,5,B4,0)
5	Initial Investment		\$42,000	
6	Net Present Value		\$ 6,063	C4-C5
7	Required Return (RADR)		14%	
8	<b>Project B</b>			
9	1	\$ 28,000	\$25,225	=PV(C17,A9,0,B9,0)
10	2	12,000	9,739	=PV(C17,A10,0,B10,0)
11	3	10,000	7,312	=PV(C17,A11,0,B11,0)
12	4	10,000	6,587	=PV(C17,A12,0,B12,0)
13	5	10,000	5,935	=PV(C17,A13,0,B13,0)
14	Present value		\$54,798	SUM(C9:C13) or NPV(C17,B9:B13)
15	Initial Investment		\$45,000	
16	Net Present Value		\$ 9,798	C14-C15
17	Required Return (RADR)		11%	
18	Choice of project	B		IF(C6>=C16,"A","B")
	The minus signs appear before the entries in Cells C4 and C9:C13 to convert the results to positive values.			

The usefulness of risk-adjusted discount rates should now be clear. The real difficulty lies in estimating project risk and linking it to the required return (RADR).

## RADRs in Practice

In spite of the appeal of total risk, RADRs are often used in practice. Their popularity stems from two facts: (1) They are consistent with the general disposition of financial decision makers toward rates of return, and (2) they are easily estimated and applied. The first reason is clearly a matter of personal preference, but the second is based on the computational convenience and well-developed procedures involved in the use of RADRs.

In practice, firms often establish a number of *risk classes*, with an RADR assigned to each. Each project is then subjectively placed in the appropriate risk class, and the corresponding RADR is used to evaluate it. This is sometimes done on a division-by-division basis, in which case each division has its own set of risk classes and associated RADRs, similar to those for Bennett Company in Table 9.9. The use of *divisional costs of capital* and associated risk classes enables a large multidivisional firm to incorporate differing levels of divisional risk into the capital budgeting process and still recognize differences in the levels of individual project risk.

**TABLE 9.9** Bennett Company's Risk Classes and RADRs

Risk class	Description	Risk-adjusted discount rate, RADR
I	<i>Below-average risk:</i> Projects with low risk. Typically involve routine replacement without renewal of existing activities.	8%
II	<i>Average risk:</i> Projects similar to those currently implemented. Typically involve replacement or renewal of existing activities.	10% <sup>a</sup>
III	<i>Above-average risk:</i> Projects with higher than normal, but not excessive, risk. Typically involve expansion of existing or similar activities.	14%
IV	<i>Highest risk:</i> Projects with very high risk. Typically involve expansion into new or unfamiliar activities.	20%

<sup>a</sup>This RADR is actually the firm's cost of capital, which is discussed in detail in Chapter 10. It represents the firm's required return on its existing portfolio of projects, which is assumed to be unchanged with acceptance of the "average risk" project.

**EXAMPLE ▼**

Assume that the management of Bennett Company decided to use risk classes to analyze projects and so placed each project in one of four risk classes according to its perceived risk. The classes ranged from I for the lowest-risk projects to IV for the highest-risk projects. Associated with each class was an RADR appropriate to the level of risk of projects in the class, as given in Table 9.9. Bennett classified as lower-risk those projects that tend to involve routine replacement or renewal activities; higher-risk projects involve expansion, often into new or unfamiliar activities.

The financial manager of Bennett has assigned project A to class III and project B to class II. The cash flows for project A would be evaluated using a 14% RADR, and project B's would be evaluated using a 10% RADR.<sup>8</sup> The NPV of project A at 14% was calculated in Figure 9.8 to be \$6,063, and the NPV for project B at a 10% RADR was shown in Figure 9.2 to be \$10,924. Clearly, with RADRs based on the use of risk classes, project B is preferred over project A. As noted earlier, this result is contrary to the preference shown in Figure 9.2, where differing risks of projects A and B were not taken into account.

**Review Questions**

- 9-13 Describe the logic involved in using *risk-adjusted discount rates* (RADRs). How is this approach related to the *capital asset pricing model* (CAPM)? Explain.
- 9-14 How are risk classes often used to apply RADRs?

8. Note that the 10% RADR for project B using the risk classes in Table 9.9 differs from the 11% RADR used in the preceding example for project B. This difference is attributable to the less precise nature of the use of risk classes.

# SUMMARY

## FOCUS ON VALUE

After estimating the relevant cash flows, the financial manager must apply appropriate decision techniques to assess whether the project creates value for shareholders. Net present value (NPV) and internal rate of return (IRR) are the generally preferred capital budgeting techniques. Both use the cost of capital as the required return needed to compensate shareholders for undertaking projects with the same risk as that of the firm. Both indicate whether a proposed investment creates or destroys shareholder value. NPV is the theoretically preferred approach, but IRR is preferred in practice because of its intuitive appeal.

Procedures for explicitly recognizing real options embedded in capital projects and procedures for selecting projects under capital rationing enable the financial manager to refine the capital budgeting process further. Not all capital budgeting projects have the same level of risk as the firm's existing portfolio of projects. The financial manager must therefore adjust projects for differences in risk when evaluating their acceptability. Risk-adjusted discount rates (RADRs) provide a mechanism for adjusting the discount rate in a manner consistent with the risk–return preferences of market participants and thereby accepting only value-creating projects. These techniques should enable the financial manager to make capital budgeting decisions that are consistent with the firm's goal of **maximizing stock price**.

## REVIEW OF LEARNING GOALS

**LG1** Calculate, interpret, and evaluate the **payback period**. The payback period measures the exact amount of time required for the firm to recover its initial investment from cash inflows. The formula and decision criterion for the payback period are summarized in Table 9.10. Shorter payback periods are preferred. In addition to its ease of calculation and simple intuitive appeal, the advantages of the payback period lie in its consideration of cash inflows, the implicit consideration given to timing, and its ability to measure risk exposure. Its weaknesses include its lack of linkage to the wealth maximization goal, failure to explicitly consider time value, and the fact that it ignores cash flows that occur after the payback period.

**LG2** Apply net present value (NPV) and internal rate of return (IRR) to relevant cash flows to choose **acceptable capital expenditures**. Sophisticated capital budgeting techniques use the cost of capital to consider the time factor in the value of money. Two such techniques are net present value (NPV) and internal rate of return (IRR). The key formulas and decision criteria for these techniques are summarized in Table 9.10. Both NPV and IRR provide the same accept–reject decisions but often provide conflicting ranks.

**LG3** Use net present value profiles to compare the **NPV and IRR techniques in light of conflicting rankings**. Net present value profiles are useful in comparing projects, especially when conflicting



**TABLE 9.10** Summary of Key Formulas/Definitions and Decision Criteria for Capital Budgeting Techniques

Technique	Formula/definition	Decision criteria
Payback period <sup>a</sup>	<p><i>For annuity:</i></p> $\frac{\text{Initial investment}}{\text{Annual cash inflow}}$ <p><i>For mixed stream:</i> Calculate cumulative cash inflows on year-to-year basis until the initial investment is recovered.</p>	<p><i>Accept</i> if &lt; maximum acceptable payback period.</p> <p><i>Reject</i> if &gt; maximum acceptable payback period.</p>
Net present value (NPV) <sup>b</sup>	Present value of cash inflows – Initial investment.	<p><i>Accept</i> if &gt; \$0.</p> <p><i>Reject</i> if &lt; \$0.</p>
Internal rate of return (IRR) <sup>b</sup>	The discount rate that causes NPV = \$0 (present value of cash inflows equals the initial investment).	<p><i>Accept</i> if &gt; the cost of capital.</p> <p><i>Reject</i> if &lt; the cost of capital.</p>

<sup>a</sup>Unsophisticated technique, because it does not give explicit consideration to the time value of money.

<sup>b</sup>Sophisticated technique, because it gives explicit consideration to the time value of money.

rankings exist between NPV and IRR. On a purely theoretical basis, NPV is preferred over IRR, because NPV assumes reinvestment of intermediate cash inflows at the cost of capital and is not subject to the mathematical problems that often arise when one is calculating IRRs for nonconventional cash flows. In practice, the IRR is more commonly used because it is consistent with the general preference toward rates of return.

**LG4** Discuss two additional considerations in capital budgeting—recognizing real options and choosing projects under capital rationing. By explicitly recognizing real options—opportunities that are embedded in capital projects and that allow managers to alter their cash flow and risk in a way that effects project acceptability (NPV)—the financial manager can find a project's strategic NPV. Some of the more common types of real options are abandonment, flexibility, growth, and timing options. The strategic NPV explicitly recognizes the value of real options and thereby improves the quality of the capital budgeting decision.

Capital rationing commonly occurs in practice. Its objective is to select from all acceptable projects the group that provides the highest overall net present value but does not require more dollars than are budgeted. Of the two basic approaches for choosing projects under capital rationing, the NPV approach better achieves the objective of using the budget to generate the highest present value of cash inflows.

**LG5** Recognize sensitivity analysis and scenario analysis, decision trees, and simulation as behavioral approaches for dealing with project risk, and the unique risks that multinational companies face. Risk in capital budgeting is concerned with either the chance that a project will prove unacceptable or, more formally, the degree of variability of cash flows. Sensitivity analysis and scenario analysis are two behavioral approaches for dealing with project risk to capture the variability of cash inflows and NPVs. A decision tree is a behavioral approach for dealing with risk that relies on estimates of probabilities associated with the outcomes of competing courses of action to determine the



expected values used to select a preferred action. Simulation is a statistics-based behavioral approach that results in a probability distribution of project returns. It usually requires a computer and allows the decision maker to understand the risk–return tradeoffs involved in a proposed investment.

Although the basic capital budgeting techniques are the same for multinational and purely domestic companies, firms that operate in several countries must also deal with both exchange rate and political risks, tax law differences, transfer pricing, and strategic rather than strictly financial considerations.



### Understand the calculation and practical aspects of risk-adjusted discount rates (RADRs).

The risk adjusted discount rate (RADR) technique involves a market-based adjustment of the discount rate used to calculate NPV. The RADR is closely linked to the CAPM, but because real corporate assets are generally not traded in an efficient market, the CAPM cannot be applied directly to capital budgeting. RADRs are commonly used in practice because decision makers prefer rates of return and find them easy to estimate and apply.

## SELF-TEST PROBLEMS (Solutions in Appendix B)



**ST 9–1 All techniques with NPV profile—Mutually exclusive projects** Fitch Industries is in the process of choosing the better of two equal-risk, mutually exclusive capital expenditure projects—M and N. The relevant cash flows for each project are shown in the following table. The firm’s cost of capital is 14%.

	Project M	Project N
Initial investment ( $CF_0$ )	\$28,500	\$27,000
Year ( $t$ )	Cash inflows ( $CF_t$ )	
1	\$10,000	\$11,000
2	10,000	10,000
3	10,000	9,000
4	10,000	8,000

- Calculate each project’s payback period.
- Calculate the net present value (NPV) for each project.
- Calculate the internal rate of return (IRR) for each project.
- Summarize the preferences dictated by each measure you calculated, and indicate which project you would recommend. Explain why.
- Draw the net present value profiles for these projects on the same set of axes, and explain the circumstances under which a conflict in rankings might exist.



**ST 9–2 Risk-adjusted discount rates** CBA Company is considering two mutually exclusive projects, A and B. The following table shows the CAPM-type relationship between a risk index and the required return (RADR) applicable to CBA Company.

Risk index	Required return (RADR)
0.0	7.0% (risk-free rate, $R_F$ )
0.2	8.0
0.4	9.0
0.6	10.0
0.8	11.0
1.0	12.0
1.2	13.0
1.4	14.0
1.6	15.0
1.8	16.0
2.0	17.0

Project data are shown as follows:

	Project A	Project B
Initial investment ( $CF_0$ )	\$15,000	\$20,000
Project life	3 years	3 years
Annual cash inflow ( $CF$ )	\$7,000	\$10,000
Risk index	0.4	1.8

- Ignoring any differences in risk and assuming that the firm's cost of capital is 10%, calculate the net present value (NPV) of each project.
- Use NPV to evaluate the projects, using *risk-adjusted discount rates (RADRs)* to account for risk.
- Compare, contrast, and explain your findings in parts a and b.

## PROBLEMS



**9-1 Payback period** Lee Corporation is considering a capital expenditure that requires an initial investment of \$42,000 and returns after-tax cash inflows of \$7,000 per year for 10 years. The firm has a maximum acceptable payback period of 8 years.

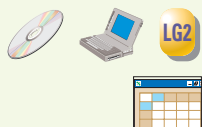
- Determine the payback period for this project.
- Should the company accept the project? Why or why not?



**9-2 Payback comparisons** Dallas Tool has a 5-year maximum acceptable payback period. The firm is considering the purchase of a new machine and must choose between two alternative ones. The first machine requires an initial investment of \$14,000 and generates annual after-tax cash inflows of \$3,000 for each of the next 7 years. The second machine requires an initial investment of \$21,000 and provides an annual cash inflow after taxes of \$4,000 for 20 years.

- Determine the payback period for each machine.

- b. Comment on the acceptability of the machines, assuming that they are independent projects.
- c. Which machine should the firm accept? Why?
- d. Do the machines in this problem illustrate any of the weaknesses of using payback? Discuss.



**9-3 NPV** Calculate the net present value (NPV) for the following 20-year projects. Comment on the acceptability of each. Assume that the firm has an opportunity cost of 14%.

- a. Initial investment is \$10,000; cash inflows are \$2,000 per year.
- b. Initial investment is \$25,000; cash inflows are \$3,000 per year.
- c. Initial investment is \$30,000; cash inflows are \$5,000 per year.



**9-4 NPV for varying costs of capital** Cheryl's Beauty Aids is evaluating a new fragrance-mixing machine. The machine requires an initial investment of \$24,000 and will generate after-tax cash inflows of \$5,000 per year for 8 years. For each of the costs of capital listed, (1) calculate the net present value (NPV), (2) indicate whether to accept or reject the machine, and (3) explain your decision.

- a. The cost of capital is 10%.
- b. The cost of capital is 12%.
- c. The cost of capital is 14%.



**9-5 Net present value—Independent projects** Using a 14% cost of capital, calculate the net present value for each of the independent projects shown in the following table, and indicate whether each is acceptable.

	Project A	Project B	Project C	Project D	Project E
Initial investment ( $CF_0$ )	\$26,000	\$500,000	\$170,000	\$950,000	\$80,000
Year ( $t$ )	Cash inflows ( $CF_t$ )				
1	\$4,000	\$100,000	\$20,000	\$230,000	\$ 0
2	4,000	120,000	19,000	230,000	0
3	4,000	140,000	18,000	230,000	0
4	4,000	160,000	17,000	230,000	20,000
5	4,000	180,000	16,000	230,000	30,000
6	4,000	200,000	15,000	230,000	0
7	4,000		14,000	230,000	50,000
8	4,000		13,000	230,000	60,000
9	4,000		12,000		70,000
10	4,000		11,000		



**9-6 NPV and maximum return** A firm can purchase a fixed asset for a \$13,000 initial investment. The asset generates an annual after-tax cash inflow of \$4,000 for 4 years.

- a. Determine the net present value (NPV) of the asset, assuming that the firm has a 10% cost of capital. Is the project acceptable?

- b. Determine the maximum required rate of return (closest whole-percentage rate) that the firm can have and still accept the asset. Discuss this finding in light of your response in part a.



**9–7 NPV—Mutually exclusive projects** Jackson Enterprises is considering the replacement of one of its old drill presses. Three alternative replacement presses are under consideration. The relevant cash flows associated with each are shown in the following table. The firm's cost of capital is 15%.

	Press A	Press B	Press C
Initial investment ( $CF_0$ )	\$85,000	\$60,000	\$130,000
Year ( $t$ )	Cash inflows ( $CF_t$ )		
1	\$18,000	\$12,000	\$50,000
2	18,000	14,000	30,000
3	18,000	16,000	20,000
4	18,000	18,000	20,000
5	18,000	20,000	20,000
6	18,000	25,000	30,000
7	18,000	—	40,000
8	18,000	—	50,000

- Calculate the net present value (NPV) of each press.
- Using NPV, evaluate the acceptability of each press.
- Rank the presses from best to worst using NPV.



**9–8 Payback and NPV** McAllister Products has three projects under consideration. The cash flows for each of them are shown in the following table. The firm has a 16% cost of capital.

	Project A	Project B	Project C
Initial investment ( $CF_0$ )	\$40,000	\$40,000	\$40,000
Year ( $t$ )	Cash inflows ( $CF_t$ )		
1	\$13,000	\$ 7,000	\$19,000
2	13,000	10,000	16,000
3	13,000	13,000	13,000
4	13,000	16,000	10,000
5	13,000	19,000	7,000

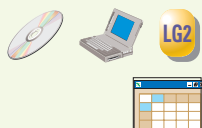
- Calculate each project's payback period. Which project is preferred according to this method?
- Calculate each project's net present value (NPV). Which project is preferred according to this method?

- c. Comment on your findings in parts a and b, and recommend the best project. Explain your recommendation.



- 9–9 Internal rate of return** For each of the projects shown in the following table, calculate the internal rate of return (IRR). Then indicate, for each project, the maximum cost of capital that the firm could have and still find the IRR acceptable.

	Project A	Project B	Project C	Project D
Initial investment ( $CF_0$ )	\$90,000	\$490,000	\$20,000	\$240,000
Year ( $t$ )	Cash inflows ( $CF_t$ )			
1	\$20,000	\$150,000	\$7,500	\$120,000
2	25,000	150,000	7,500	100,000
3	30,000	150,000	7,500	80,000
4	35,000	150,000	7,500	60,000
5	40,000	—	7,500	—



- 9–10 IRR—Mutually exclusive projects** Paulus Corporation is attempting to choose the better of two mutually exclusive projects for expanding the firm's warehouse capacity. The relevant cash flows for the projects are shown in the following table. The firm's cost of capital is 15%.

	Project X	Project Y
Initial investment ( $CF_0$ )	\$500,000	\$325,000
Year ( $t$ )	Cash inflows ( $CF_t$ )	
1	\$100,000	\$140,000
2	120,000	120,000
3	150,000	95,000
4	190,000	70,000
5	250,000	50,000

- Calculate the IRR to the nearest whole percent for each of the projects.
- Assess the acceptability of each project on the basis of the IRRs found in part a.
- Which project, on this basis, is preferred?



- 9–11 IRR, investment life, and cash inflows** Cincinnati Machine Tool (CMT) accepts projects earning more than the firm's 15% cost of capital. CMT is currently considering a 10-year project that provides annual cash inflows of \$10,000 and requires an initial investment of \$61,450. (*Note:* All amounts are after taxes.)
- Determine the IRR of this project. Is it acceptable?
  - Assuming that the cash inflows continue to be \$10,000 per year, how many *additional years* would the flows have to continue to make the project acceptable (that is, to make it have an IRR of 15%)?

- c. With the given life, initial investment, and cost of capital, what is the minimum annual cash inflow that the firm should accept?



**9–12 NPV and IRR** Lilo Manufacturing has prepared the following estimates for a long-term project it is considering. The initial investment is \$18,250, and the project is expected to yield after-tax cash inflows of \$4,000 per year for 7 years. The firm has a 10% cost of capital.

- Determine the net present value (NPV) for the project.
- Determine the internal rate of return (IRR) for the project.
- Would you recommend that the firm accept or reject the project? Explain your answer.



**9–13 Payback, NPV, and IRR** Bruce Reed Enterprises is attempting to evaluate the feasibility of investing \$95,000 in a piece of equipment that has a 5-year life. The firm has estimated the *cash inflows* associated with the proposal as shown in the following table. The firm has a 12% cost of capital.

Year ( $t$ )	Cash inflows ( $CF_t$ )
1	\$20,000
2	25,000
3	30,000
4	35,000
5	40,000

- Calculate the payback period for the proposed investment.
- Calculate the net present value (NPV) for the proposed investment.
- Calculate the internal rate of return (IRR), rounded to the nearest whole percent, for the proposed investment.
- Evaluate the acceptability of the proposed investment using NPV and IRR. What recommendation would you make relative to implementation of the project? Why?



**9–14 NPV, IRR, and NPV profiles** Candor Enterprises is considering two mutually exclusive projects. The firm, which has a 12% cost of capital, has estimated its cash flows as shown in the following table.

	Project A	Project B
Initial investment ( $CF_0$ )	\$130,000	\$85,000
Year ( $t$ )	Cash inflows ( $CF_t$ )	
1	\$25,000	\$40,000
2	35,000	35,000
3	45,000	30,000
4	50,000	10,000
5	55,000	5,000

- Calculate the NPV of each project, and assess its acceptability.
- Calculate the IRR for each project, and assess its acceptability.
- Draw the NPV profiles for both projects on the same set of axes.
- Evaluate and discuss the rankings of the two projects on the basis of your findings in parts a, b, and c.
- Explain your findings in part d in light of the pattern of cash inflows associated with each project.



**9–15 All techniques—mutually exclusive investment decision** Easi Chair Company is attempting to select the best of three mutually exclusive projects. The initial investment and after-tax cash inflows associated with these projects are shown in the following table.

Cash flows	Project A	Project B	Project C
Initial investment ( $CF_0$ )	\$60,000	\$100,000	\$110,000
Cash inflows ( $CF_t$ ), $t = 1$ to 5	\$20,000	\$ 31,500	\$ 32,500

- Calculate the payback period for each project.
- Calculate the net present value (NPV) of each project, assuming that the firm has a cost of capital equal to 13%.
- Calculate the internal rate of return (IRR) for each project.
- Draw the net present value profiles for these projects on the same set of axes, and discuss any conflict in ranking that may exist between NPV and IRR.
- Summarize the preferences dictated by each measure, and indicate which project you would recommend. Explain why.



**9–16 All techniques with NPV profile—Mutually exclusive projects** Projects A and B, of equal risk, are alternatives for expanding the Rosa Company's capacity. The firm's cost of capital is 13%. The cash flows for each project are shown in the following table.

	Project A	Project B
Initial investment ( $CF_0$ )	\$80,000	\$50,000
Year ( $t$ )	Cash inflows ( $CF_t$ )	
1	\$15,000	\$15,000
2	20,000	15,000
3	25,000	15,000
4	30,000	15,000
5	35,000	15,000

- Calculate each project's payback period.
- Calculate the net present value (NPV) for each project.
- Calculate the internal rate of return (IRR) for each project.
- Draw the net present value profiles for these projects on the same set of axes, and discuss any conflict in ranking that may exist between NPV and IRR.

- e. Summarize the preferences dictated by each measure, and indicate which project you would recommend. Explain why.



- 9-17 Integrative—Complete investment decision** Hot Springs Press is considering the purchase of a new printing press. The total installed cost of the press is \$2.2 million. This outlay would be partially offset by the sale of an existing press. The old press has zero book value, cost \$1 million 10 years ago, and can be sold currently for \$1.2 million before taxes. As a result of acquisition of the new press, sales in each of the next 5 years are expected to increase by \$1.6 million, but product costs (excluding depreciation) will represent 50% of sales. The new press will not affect the firm's net working capital requirements. The new press will be depreciated under MACRS using a 5-year recovery period (see Table 3.2 on page 89). The firm is subject to a 40% tax rate on both ordinary income and capital gains. Hot Spring Press's cost of capital is 11%. (*Note:* Assume that both the old and the new press will have terminal values of \$0 at the end of year 6.)
- Determine the initial investment required by the new press.
  - Determine the operating cash inflows attributable to the new press. (*Note:* Be sure to consider the depreciation in year 6.)
  - Determine the payback period.
  - Determine the net present value (NPV) and the internal rate of return (IRR) related to the proposed new press.
  - Make a recommendation to accept or reject the new press, and justify your answer.



- 9-18 Integrative—Investment decision** Holliday Manufacturing is considering the replacement of an existing machine. The new machine costs \$1.2 million and requires installation costs of \$150,000. The existing machine can be sold currently for \$185,000 before taxes. It is 2 years old, cost \$800,000 new, and has a \$384,000 book value and a remaining useful life of 5 years. It was being depreciated under MACRS using a 5-year recovery period (see Table 3.2 on page 89) and therefore has the final 4 years of depreciation remaining. If it is held until the end of 5 years, the machine's market value will be \$0. Over its 5-year life, the new machine should reduce operating costs by \$350,000 per year. The new machine will be depreciated under MACRS using a 5-year recovery period (see Table 3.2 on page 89). The new machine can be sold for \$200,000 net of removal and clean up costs at the end of 5 years. An increased investment in net working capital of \$25,000 will be needed to support operations if the new machine is acquired. Assume that the firm has adequate operating income against which to deduct any loss experienced on the sale of the existing machine. The firm has a 9% cost of capital and is subject to a 40% tax rate on both ordinary income and capital gains.
- Develop the relevant cash flows needed to analyze the proposed replacement.
  - Determine the net present value (NPV) of the proposal.
  - Determine the internal rate of return (IRR) of the proposal.
  - Make a recommendation to accept or reject the replacement proposal, and justify your answer.
  - What is the highest cost of capital that the firm could have and still accept the proposal? Explain.





**9–19 Real options and the strategic NPV** Jenny Rene, the CFO of Asor Products, Inc., has just completed an evaluation of a proposed capital expenditure for equipment that would expand the firm's manufacturing capacity. Using the traditional NPV methodology, she found the project unacceptable because

$$\text{NPV}_{\text{traditional}} = -\$1,700 < \$0$$

Before recommending rejection of the proposed project, she has decided to assess whether there might be real options embedded in the firm's cash flows. Her evaluation uncovered the following three options.

*Option 1: Abandonment*—The project could be abandoned at the end of 3 years, resulting in an addition to NPV of \$1,200.

*Option 2: Expansion*—If the projected outcomes occurred, an opportunity to expand the firm's product offerings further would occur at the end of 4 years. Exercise of this option is estimated to add \$3,000 to the project's NPV.

*Option 3: Delay*—Certain phases of the proposed project could be delayed if market and competitive conditions caused the firm's forecast revenues to develop more slowly than planned. Such a delay in implementation at that point has a NPV of \$10,000.

Rene estimated that there was a 25% chance that the abandonment option would need to be exercised, a 30% chance the expansion option would be exercised, and only a 10% chance that the implementation of certain phases of the project would have to be delayed.

- Use the information provided to calculate the strategic NPV,  $\text{NPV}_{\text{strategic}}$  for Asor Products' proposed equipment expenditure.
- Judging on the basis of your findings in part a, what action should Rene recommend to management with regard to the proposed equipment expenditures?
- In general, how does this problem demonstrate the importance of considering real options when making capital budgeting decisions?



**9–20 Capital rationing—IRR and NPV approaches** Bromley and Sons is attempting to select the best of a group of independent projects competing for the firm's fixed capital budget of \$4.5 million. The firm recognizes that any unused portion of this budget will earn less than its 15% cost of capital, thereby resulting in a present value of inflows that is less than the initial investment. The firm has summarized the key data to be used in selecting the best group of projects in the following table.

Project	Initial investment	IRR	Present value of inflows at 15%
A	\$5,000,000	17%	\$5,400,000
B	800,000	18	1,100,000
C	2,000,000	19	2,300,000
D	1,500,000	16	1,600,000
E	800,000	22	900,000
F	2,500,000	23	3,000,000
G	1,200,000	20	1,300,000

- Use the *internal rate of return (IRR) approach* to select the best group of projects.
- Use the *net present value (NPV) approach* to select the best group of projects.
- Compare, contrast, and discuss your findings in parts **a** and **b**.
- Which projects should the firm implement? Why?



**9-21 Capital rationing—NPV approach** A firm with a 13% cost of capital must select the optimal group of projects from those shown in the following table, given its capital budget of \$1 million.

Project	Initial investment	NPV at 13% cost of capital
A	\$300,000	\$ 84,000
B	200,000	10,000
C	100,000	25,000
D	900,000	90,000
E	500,000	70,000
F	100,000	50,000
G	800,000	160,000

- Calculate the *present value of cash inflows* associated with each project.
- Select the optimal group of projects, keeping in mind that unused funds are costly.



**9-22 Basic sensitivity analysis** Renaissance Pharmaceutical is in the process of evaluating two mutually exclusive additions to its processing capacity. The firm's financial analysts have developed pessimistic, most likely, and optimistic estimates of the annual cash inflows associated with each project. These estimates are shown in the following table.

	Project A	Project B
Initial investment ( $CF_0$ )	\$8,000	\$8,000
Outcome	Annual cash inflows ( $CF$ )	
Pessimistic	\$ 200	\$ 900
Most likely	1,000	1,000
Optimistic	1,800	1,100

- Determine the *range* of annual cash inflows for each of the two projects.
- Assume that the firm's cost of capital is 10% and that both projects have 20-year lives. Construct a table similar to this for the NPVs for each project. Include the *range* of NPVs for each project.
- Do parts **a** and **b** provide consistent views of the two projects? Explain.
- Which project do you recommend? Why?



- 9–23 Sensitivity analysis** James Secretarial Services is considering the purchase of one of two new personal computers, P and Q. Both are expected to provide benefits over a 10-year period, and each has a required investment of \$3,000. The firm has a 10% cost of capital. Management has constructed the following table of estimates of annual cash inflows for pessimistic, most likely, and optimistic results.

	Computer P	Computer Q
Initial investment ( $CF_0$ )	\$3,000	\$3,000
Outcome	Annual cash inflows ( $CF$ )	
Pessimistic	\$ 500	\$ 400
Most likely	750	750
Optimistic	1,000	1,200

- Determine the *range* of annual cash inflows for each of the two computers.
- Construct a table similar to this for the NPVs associated with each outcome for both computers.
- Find the *range* of NPVs, and subjectively compare the risks associated with purchasing these computers.



- 9–24 Decision trees** The Ouija Board-Games Company can bring out one of two new games this season. The *Signs Away* game has a higher initial cost but also a higher expected return. *Monopolistic Competition*, the alternative, has a slightly lower initial cost but also a lower expected return. The present values and probabilities associated with each game are listed in the table.

Game	Initial investment	Present value of cash inflows	Probabilities
<i>Signs Away</i>	\$140,000		1.00
		\$320,000	.30
		220,000	.50
		– 80,000	.20
<i>Monopolistic Competition</i>	\$120,000		1.00
		\$260,000	.20
		200,000	.45
		– 50,000	.35

- Construct a decision tree to analyze the games.
- Which game do you recommend (following a decision-tree analysis)?
- Has your analysis captured the differences in the risks associated with these games? Explain.



- 9–25 Simulation** Wales Castings has compiled the following information on a capital expenditure proposal:
- The projected cash *inflows* are normally distributed with a mean of \$36,000 and a standard deviation of \$9,000.

- (2) The projected cash *outflows* are normally distributed with a mean of \$30,000 and a standard deviation of \$6,000.
  - (3) The firm has an 11% cost of capital.
  - (4) The probability distributions of cash inflows and cash outflows are not expected to change over the project's 10-year life.
- a. Describe how the foregoing data can be used to develop a simulation model for finding the net present value of the project.
  - b. Discuss the advantages of using a simulation to evaluate the proposed project.



- 9-26 Risk-adjusted discount rates—Basic** Country Wallpapers is considering investing in one of three mutually exclusive projects, E, F, and G. The firm's cost of capital,  $k$ , is 15%, and the risk-free rate,  $R_F$ , is 10%. The firm has gathered the following basic cash flow and risk index data for each project.

	Project ( $j$ )		
	E	F	G
Initial investment ( $CF_0$ )	\$15,000	\$11,000	\$19,000
Year ( $t$ )	Cash inflows ( $CF_t$ )		
1	\$ 6,000	\$ 6,000	\$ 4,000
2	6,000	4,000	6,000
3	6,000	5,000	8,000
4	6,000	2,000	12,000
Risk index ( $RI_j$ )	1.80	1.00	0.60

- a. Find the net present value (NPV) of each project using the firm's cost of capital. Which project is preferred in this situation?
- b. The firm uses the following equation to determine the risk-adjusted discount rate,  $RADR_j$ , for each project  $j$ :

$$RADR_j = R_F + [RI_j \times (k - R_F)]$$

where

$R_F$  = risk-free rate of return

$RI_j$  = risk index for project  $j$

$k$  = cost of capital

Substitute each project's risk index into this equation to determine its RADR.

- c. Use the RADR for each project to determine its risk-adjusted NPV. Which project is preferable in this situation?
- d. Compare and discuss your findings in parts a and c. Which project do you recommend that the firm accept?



- 9-27 Risk-adjusted discount rates—Tabular** After a careful evaluation of investment alternatives and opportunities, Joely Company has developed a CAPM-type relationship linking a risk index to the required return (RADR), as shown in the following table.

Risk index	Required return (RADR)
0.0	7.0% (risk-free rate, $R_F$ )
0.2	8.0
0.4	9.0
0.6	10.0
0.8	11.0
1.0	12.0
1.2	13.0
1.4	14.0
1.6	15.0
1.8	16.0
2.0	17.0

The firm is considering two mutually exclusive projects, A and B. The following are the data the firm has been able to gather about the projects.

	Project A	Project B
Initial investment ( $CF_0$ )	\$20,000	\$30,000
Project life	5 years	5 years
Annual cash inflow ( $CF$ )	\$7,000	\$10,000
Risk index	0.2	1.4

All the firm's cash inflows have already been adjusted for taxes.

- Evaluate the projects using *risk-adjusted discount rates*.
- Discuss your findings in part a, and recommend the preferred project.



**9–28 Risk classes and RADR** Attila Industries is attempting to select the best of three mutually exclusive projects, X, Y, and Z. Though all the projects have 5-year lives, they possess differing degrees of risk. Project X is in class V, the highest-risk class; project Y is in class II, the below-average-risk class; and project Z is in class III, the average-risk class. The basic cash flow data for each project and the risk classes and risk-adjusted discount rates (RADRs) used by the firm are shown in the following tables.

	Project X	Project Y	Project Z
Initial investment ( $CF_0$ )	\$180,000	\$235,000	\$310,000
Year ( $t$ )	Cash inflows ( $CF_t$ )		
1	\$ 80,000	\$ 50,000	\$ 90,000
2	70,000	60,000	90,000
3	60,000	70,000	90,000
4	60,000	80,000	90,000
5	60,000	90,000	90,000

Risk Classes and RADRs		
Risk Class	Description	Risk-adjusted discount rate (RADR)
I	Lowest risk	10%
II	Below-average risk	13
III	Average risk	15
IV	Above-average risk	19
V	Highest risk	22

- Find the risk-adjusted NPV for each project.
- Which project, if any, would you recommend that the firm undertake?

## CHAPTER 9 CASE

### Making Norwich Tool's Lathe Investment Decision

Norwich Tool, a large machine shop, is considering replacing one of its lathes with either of two new lathes—lathe A or lathe B. Lathe A is a highly automated, computer-controlled lathe; lathe B is a less expensive lathe that uses standard technology. To analyze these alternatives, Mario Jackson, a financial analyst, prepared estimates of the initial investment and incremental (relevant) cash inflows associated with each lathe. These are shown in the following table.

	Lathe A	Lathe B
Initial investment ( $CF_0$ )	\$660,000	\$360,000
Year ( $t$ )	Cash inflows ( $CF_t$ )	
1	\$128,000	\$ 88,000
2	182,000	120,000
3	166,000	96,000
4	168,000	86,000
5	450,000	207,000

Note that Mario plans to analyze both lathes over a 5-year period. At the end of that time, the lathes would be sold, thus accounting for the large fifth-year cash inflows.

One of Mario's dilemmas centered on the risk of the two lathes. He believes that although the two lathes are equally risky, lathe A has a much higher chance of breakdown and repair because of its sophisticated and not fully proven solid-state electronic technology. Mario is unable to quantify this possibility effectively, so he decides to apply the firm's 13% cost of capital when analyzing the lathes. Norwich Tool requires all projects to have a maximum payback period of 4.0 years.

## Required



- a. Use the payback period to assess the acceptability and relative ranking of each lathe.
- b. Assuming equal risk, use the following sophisticated capital budgeting techniques to assess the acceptability and relative ranking of each lathe:
  - (1) Net present value (NPV).
  - (2) Internal rate of return (IRR).
- c. Summarize the preferences indicated by the techniques used in parts **a** and **b**, and indicate which lathe you recommend, if either, (1) if the firm has unlimited funds and (2) if the firm has capital rationing.
- d. Repeat part **b** assuming that Mario decides that because of its greater risk, lathe A's cash inflows should be evaluated by using a 15% cost of capital.
- e. What effect, if any, does recognition of lathe A's greater risk in part **d** have on our recommendation in part **c**?

## WEB EXERCISE



Go to the Web site [www.arachnoid.com/lutuspl/finance\\_old.html](http://www.arachnoid.com/lutuspl/finance_old.html). Page down to the portion of this screen that contains the financial calculator.

1. To determine the internal rate of return (IRR) of a project whose initial investment was \$5,000 and whose cash inflows are \$1,000 per year for the next 10 years, perform the steps outlined below. By entering various interest rates, you will eventually get a present value of \$5,000. When this happens you, have determined the IRR of the project.  
 To get started, into **PV**, enter 0; into **FV**, enter 0; into **np**, enter 1000; into **pmt**, enter 10; and then into **ir**, enter 8. Click on **Calculate PV**. This gives you a number much greater than \$5,000. Now change **ir** to 20 and then click on **Calculate PV**. Keeping changing the **ir** until **PV** = \$5,000, the same as the initial investment.
2. Try another project. The initial investment is \$10,000. The cash inflows are \$2,500 per year for the next 6 years. What is its IRR?
3. To calculate the IRR of an investment of \$3,000 with a single cash inflow of \$4,800 to be received exactly 3 years after the investment, do the following: Into **FV**, enter 4800; into **np**, enter 3; into **pmt**, enter 0; and then into **ir**, enter 8. Then click on **Calculate PV**. As before, keep changing **ir** until the **PV** is equal to the initial investment of \$3,000. What is this investment's IRR?

Remember to check the book's Web site at

[www.aw.com/gitman](http://www.aw.com/gitman)

for additional resources, including additional Web exercises.