CHAPTER 10

Risk and Refinements in Capital Budgeting

LEARNING GOALS

- **LG1** Understand the importance of explicitly recognizing risk in the analysis of capital budgeting projects.
- **LG2** Discuss breakeven cash inflow, sensitivity and scenario analysis, and simulation as behavioral approaches for dealing with risk.
- **LG3** Discuss the unique risks that multinational companies face.
- **LG4** Describe the determination and use of risk-adjusted discount rates (RADRs), portfolio effects, and the practical aspects of RADRs.
- **LG5** Recognize the problem caused by unequal-lived mutually exclusive projects and the use of annualized net present values (ANPVs) to resolve it.
- **LG6** Explain the role of real options and the objective of, and basic approaches to, project selection under capital rationing.

Across the Disciplines WHY THIS CHAPTER MATTERS TO YOU

Accounting: You need to understand the risk caused by the variability of cash flows, how to compare projects with unequal lives, and how to measure project returns when capital must be rationed.

Information systems: You need to understand how risk is incorporated into capital budgeting techniques, and how those techniques may be refined in the face of special circumstances, in order to design decision modules that help analyze proposed capital projects.

Management: You need to understand behavioral approaches for dealing with risk, including international risk, in capital budgeting decisions; how to refine capital budgeting techniques when projects have unequal lives or when capital must be rationed; and how to recognize real options embedded in capital projects.

Marketing: You need to understand how the risk of proposed projects is measured in capital budgeting, how mutually exclusive projects with unequal lives will be evaluated, what real options may be embedded in proposed projects and how those options may affect project implementation, and how projects will be evaluated when capital must be rationed.

Operations: You need to understand how proposals for the acquisition of new equipment and plants will be evaluated by the firm's decision makers, especially projects that are risky, have unequal lives, or may need to be abandoned or slowed, or when capital is limited.

BESTFOODS

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 ways to incorporate the risks and rewards of its foreign investments into project 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 Stern Stewart, developers of the economic value added (EVA®) model, 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. In this chapter we'll look at other techniques that companies use to incorporate risk into the capital budgeting process.

LG1 10.1 Introduction to Risk in Capital Budgeting

The capital budgeting techniques introduced in Chapter 9 were applied in an environment we assumed to be certain. All of the projects' relevant cash flows, developed using techniques presented in Chapter 8, were assumed to have the same level of risk as the firm. In other words, all mutually exclusive projects were equally risky, and the acceptance of any project would not change the firm's overall risk. In actuality, these situations are rare—project cash flows typically have different levels of risk, and the acceptance of a project generally does affect the firm's overall risk, though often in a minor way. We begin this chapter by relaxing the assumptions of a certain environment and equal-risk projects, in order to focus on the incorporation of risk into the capital budgeting decision process.

For convenience, in this chapter, we continue the Bennett Company example that was used in Chapter 9. The relevant cash flows and NPVs for Bennett Company's two mutually exclusive projects—A and B—are summarized in Table 10.1.

In the following three sections, we use the basic risk concepts presented in Chapter 5 to demonstrate behavioral approaches for dealing with risk, international risk considerations, and the use of risk-adjusted discount rates to explicitly recognize risk in the analysis of capital budgeting projects.

Review Question

10–1 Are most mutually exclusive capital budgeting projects equally risky? How can the acceptance of a project change a firm's overall risk?

TABLE 10.1 Relevant Cash Flows and NPVs for Bennett Company's Projects

	Project A	Project B
A. Relevant Cash Flows		
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
B. Decision Technique		
NPV @ 10% cost of capital[a]	$11,071	$10,924

[a]From Figure 9.2 on page 402; calculated using a financial calculator.

LG2 10.2 Behavioral Approaches for Dealing with Risk

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: risk and cash inflows, sensitivity and scenario analysis, and simulation. In a later section, we consider a popular approach that explicitly recognizes risk.

Risk and Cash Inflows

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

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 < 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. Therefore, to assess the risk of a proposed capital expenditure, the analyst needs to evaluate the probability that the cash inflows will be large enough to provide for project acceptance.

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. For either project to be acceptable according to the net present value technique, its NPV must be greater than zero. If we let CF equal the annual cash inflow and let CF_0 equal the initial investment, the following condition must be met for projects with annuity cash inflows, such as A and B, to be acceptable.

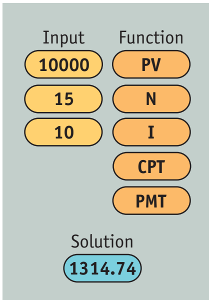
$$\text{NPV} = [CF \times (PVIFA_{k,n})] - CF_0 > \$0 \tag{10.1}$$

breakeven cash inflow
The minimum level of cash inflow necessary for a project to be acceptable, that is, NPV > $0.

By substituting $k = 10\%$, $n = 15$ years, and $CF_0 = \$10{,}000$, we can find the **breakeven cash inflow**—the minimum level of cash inflow necessary for Treadwell's projects to be acceptable.

Table Use The present value interest factor for an ordinary annuity at 10% for 15 years ($PVIFA_{10\%,15\text{yrs}}$) found in Table A–4 is 7.606. Substituting this value and the initial investment (CF_0) of $10,000 into Equation 10.1 and solving for the breakeven cash inflow (CF), we get

$$[CF \times (PVIFA_{10\%,15\text{yrs}})] - \$10{,}000 > \$0$$
$$CF \times (7.606) > \$10{,}000$$
$$CF > \frac{\$10{,}000}{7.606} = \underline{\underline{\$1{,}314.75}}$$



Calculator Use Recognizing that the initial investment (CF_0) is the present value (PV), we can use the calculator inputs shown at the left to find the breakeven cash inflow (CF), which is an ordinary annuity (PMT).

Spreadsheet Use The breakeven cash inflow also can be calculated as shown on the following Excel spreadsheet.

	A	B
1	**BREAKEVEN CASH INFLOW**	
2	Cost of capital	10%
3	Number of years	15
4	Initial investment	$10,000
5	Breakeven cash inflow	$1,314.74

Entry in Cell B5 is =PMT(B2,B3,–B4).
The minus sign appears before B4 because the initial investment is a cash outflow.

The table, calculator, and spreadsheet values indicate that for the projects to be acceptable, they must have annual cash inflows of at least $1,315. Given this breakeven level of cash inflows, the risk of each project could be assessed by determining the probability that the project's cash inflows will equal or exceed this breakeven level. The various statistical techniques that would determine that probability are covered in more advanced courses.[1] For now, we can simply assume that such a statistical analysis results in the following:

Probability of $CF_A > \$1{,}315 \rightarrow 100\%$
Probability of $CF_B > \$1{,}315 \rightarrow 65\%$

Because project A is certain (100% probability) to have a positive net present value, whereas there is only a 65% chance that project B will have a positive NPV, project A is less risky than project B. Of course, the expected level of annual cash inflow and NPV associated with each project must be evaluated in view of the firm's risk preference before the preferred project is selected.

The example clearly identifies risk as it is related to the chance that a project is acceptable, but it does not address the issue of cash flow variability. Even though project B has a greater chance of loss than project A, it might result in higher potential NPVs. Recall from Chapters 5 through 7 that it is the *combination* of risk and return that determines value. Similarly, the worth of a capital expenditure and its impact on the firm's value must be viewed in light of both risk and return. The analyst must therefore consider the *variability* of cash inflows and NPVs to assess project risk and return fully.

Sensitivity 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 possi-

1. Normal distributions are commonly used to develop the concept of the probability of success—that is, of a project having a positive NPV. The reader interested in learning more about this technique should see any second- or MBA-level managerial finance text.

In Practice

FOCUS ON e-FINANCE Putting the "R" Back into ROI

Ever since the economy faltered in late 2001, information technology (IT) managers have faced increased pressure to measure returns on technology investments and to show higher ROIs and faster project implementation. Managers must justify projects, proving that they support strategic business goals, and then track progress against expectations. Another key trend: Companies are moving IT approvals to more senior levels of management in order to evaluate better the projects' overall impact on the company's business.

In a poll of *Computerworld's* "Premier 100" IT companies, almost half of the respondents said they do not perform ROI analysis on proposed IT projects. For the 43 percent who calculate potential paybacks, nonfinancial, "soft" factors are an important part of the analysis. The chief information officer (CIO) may consider certain projects—for example, business-to-business (B2B) commerce—essential to the company's future.

Methods and metrics to assess ROI vary among companies. Illinois communications equipment maker **Tellabs Inc**. established a stringent proposal-and-approval process for IT projects. This formal analysis now includes project comparisons. Another important change is accountability. "In the past, we haven't gone back and done measurements after a project went live to see how much we did save or how much we didn't," says Cathie Kozik, CIO and senior vice president.

Tyco Capital, a New Jersey financial services company, takes a different approach. To reduce risk and boost returns, CIO Robert Plante divides large projects into smaller phases and measures ROI along the way, not just on the total project. This "plan, do, test, react" process enables the company to test the waters to make sure that new projects will be successful. "We're not going in with guns blazing, but reducing scale to reduce risk and size out [IT] investments appropriately," Plante says. For example, installation of a customer relationship management (CRM) application took 18 months. Before the company started each new phase, previous phases had to show positive ROIs.

Sources: Adapted from Gary H. Anthes, "Premier 100: ROI for IT Projects Necessary, But Not Easy," *Computerworld* (May 23, 2001), downloaded from *www.computerworld.com;* Julia King, "ROI: Make It Bigger, Better, Faster," *Computerworld* (January 1, 2002), downloaded from *www.computerworld.com;* Thornton A. May, "Return on Rebellion," *Computerworld* (May 14, 2001), downloaded from *www.computerworld.com.*

ble 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 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 Continuing with Treadwell Tire Company, assume that the 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 10.2. 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.

TABLE 10.2 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[a]	
Outcome		
Pessimistic	$1,409	−$10,000
Most likely	5,212	5,212
Optimistic	9,015	20,424
Range	$7,606	$30,424

[a]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.

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 computers and spreadsheets has greatly enhanced the use of both scenario and sensitivity analysis.

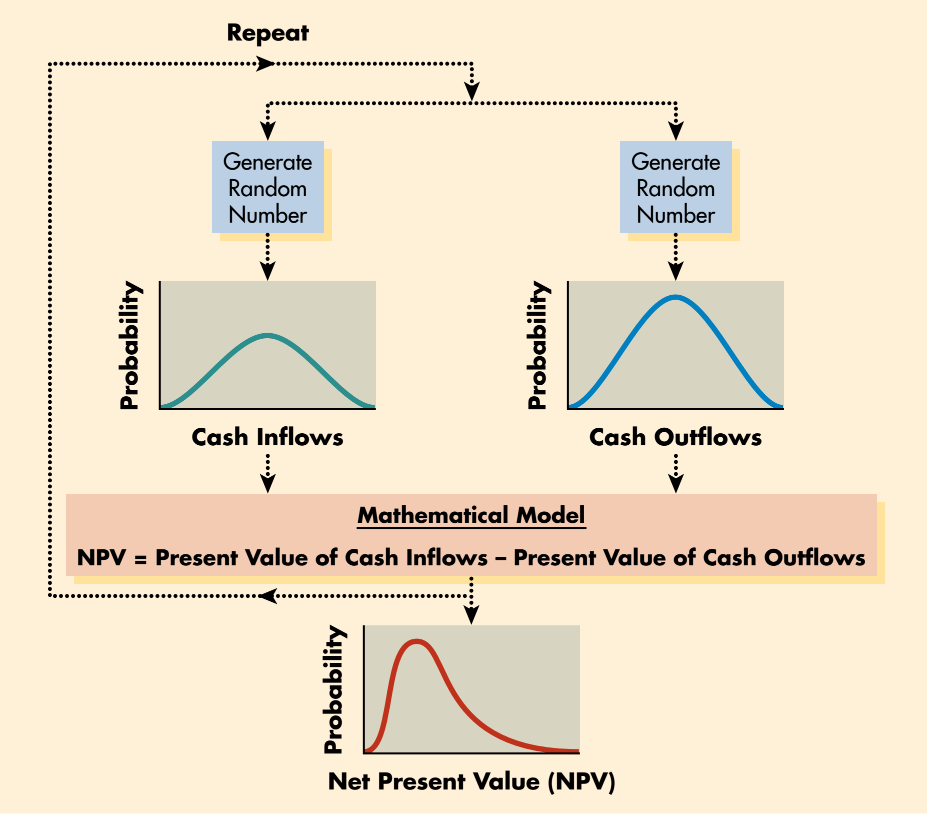
Simulation

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 10.1 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.

FIGURE 10.1

NPV Simulation
Flowchart of a net present value simulation



By repeating this process perhaps a thousand times, managers can create a probability distribution of net present values.

Although only gross cash inflows and cash outflows are simulated in Figure 10.1, 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 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.

Hint These behavioral approaches may seem a bit imprecise to one who has not used them. But repeated use and an "after-the-fact" review of previous analyses improve the accuracy of the users.

Review Questions

10–2 Define *risk* in terms of the cash inflows from a capital budgeting project. How can determination of the *breakeven cash inflow* be used to gauge project risk?

10–3 Describe how each of the following behavioral approaches can be used to deal with project risk: (**a**) sensitivity analysis, (**b**) scenario analysis, and (**c**) simulation.

LG3 10.3 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 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 Question

10–4 Briefly explain how the following items affect 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 a strict financial viewpoint.

LG4 10.4 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.[2] 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 portfolio effects of project analysis as well as the practical aspects of the risk-adjusted discount rate.

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:[3]

$$\text{NPV} = \sum_{t=1}^{n} \frac{CF_t}{(1+\text{RADR})^t} - CF_0 \qquad (10.2)$$

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

3. The risk-adjusted discount rate approach can be applied in using the internal rate of return as well as the net present value. When the IRR is used, the risk-adjusted discount rate becomes the cutoff rate that must be exceeded by the IRR for the project to be accepted. When NPV is used, the projected cash inflows are merely discounted at the risk-adjusted discount rate.

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. Because the logic underlying the use of RADRs is closely linked to the capital asset pricing model (CAPM) developed in Chapter 5, here we review CAPM and discuss its use in finding RADRs.

Review of CAPM

In Chapter 5, the *capital asset pricing model (CAPM)* was used to link the *relevant* risk and return for all assets traded in *efficient markets*. In the development of the CAPM, the *total risk* of an asset was defined as

$$\text{Total risk} = \text{Nondiversifiable risk} + \text{Diversifiable risk} \qquad (10.3)$$

For assets traded in an efficient market, the *diversifiable risk,* which results from uncontrollable or random events, can be eliminated through diversification. The relevant risk is therefore the *nondiversifiable risk*—the risk for which owners of these assets are rewarded. Nondiversifiable risk for securities is commonly measured by using *beta,* which is an index of the degree of movement of an asset's return in response to a change in the market return.

Using beta, b_j, to measure the relevant risk of any asset *j,* the CAPM is

$$k_j = R_F + [b_j \times (k_m - R_F)] \qquad (10.4)$$

where

k_j = required return on asset *j*
R_F = risk-free rate of return
b_j = beta coefficient for asset *j*
k_m = return on the market portfolio of assets

In Chapter 5, we demonstrated that the required return on any asset could be determined by substituting values of R_F, b_j, and k_m into the CAPM—Equation 10.4. Any security that is expected to earn in excess of its required return would be acceptable, and those that are expected to earn an inferior return would be rejected.

Using CAPM to Find RADRs

If we assume for a moment that real corporate assets such as computers, machine tools, and special-purpose machinery are traded in efficient markets, the CAPM can be redefined as noted in Equation 10.5:

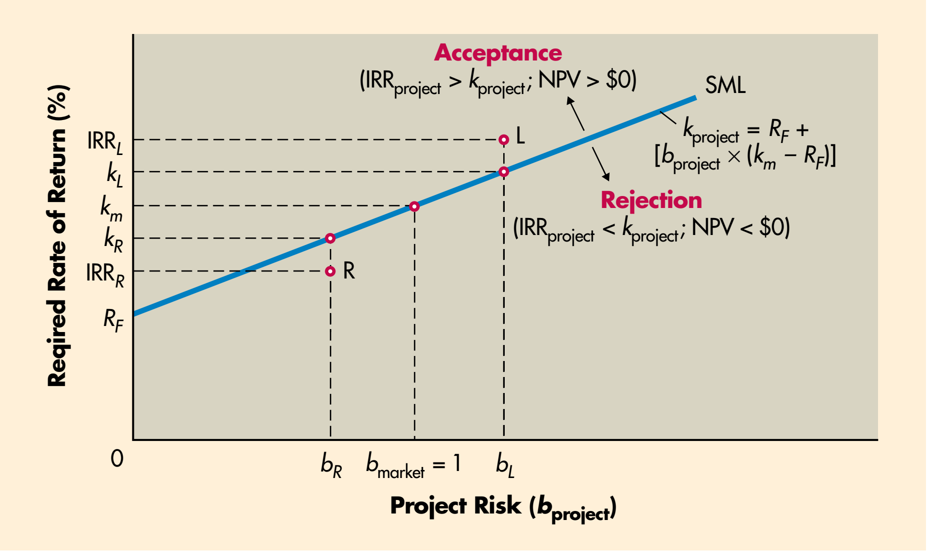
$$k_{\text{project } j} = R_F + [b_{\text{project } j} \times (k_m - R_F)] \qquad (10.5)$$

The *security market line* (SML)—the graphical depiction of the CAPM—is shown for Equation 10.5 in Figure 10.2. Any project having an IRR above the SML would be acceptable, because its IRR would exceed the required return, k_{project}; any project with an IRR below k_{project} would be rejected. In terms of NPV, any

FIGURE 10.2

CAPM and SML

CAPM and SML in capital budgeting decision making



project falling above the SML would have a positive NPV, and any project falling below the SML would have a negative NPV.[4]

EXAMPLE

Two projects, L and R, are shown in Figure 10.2. Project L has a beta, b_L, and generates an internal rate of return, IRR_L. The required return for a project with risk b_L is k_L. Because project L generates a return greater than that required ($IRR_L > k_L$), project L is acceptable. Project L will have a positive NPV when its cash inflows are discounted at its required return, k_L. Project R, on the other hand, generates an IRR below that required for its risk, b_R ($IRR_R < k_R$). This project will have a negative NPV when its cash inflows are discounted at its required return, k_R. Project R should be rejected.

Applying RADRs

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 10.2 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,

4. As noted earlier, whenever the IRR is above the cost of capital or required return ($IRR > k$), the NPV is positive, and whenever the IRR is below the cost of capital or required return ($IRR < k$), the NPV is negative. Because by definition the IRR is the discount rate that causes NPV to equal zero and the IRR and NPV always agree on accept–reject decisions, the relationship noted in Figure 10.2 logically follows.

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 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 in part A of Table 10.1, 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.

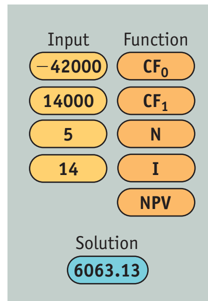
	Risk index	Required return (RADR)
	0.0	6% (risk-free rate, R_F)
	0.2	7
	0.4	8
	0.6	9
	0.8	10
Project B →	1.0	11
	1.2	12
	1.4	13
Project A →	1.6	14
	1.8	16
	2.0	18

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 10.3. The results clearly show that project B in 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 part B of Table 10.1, 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 10.3.

Project A



Project B

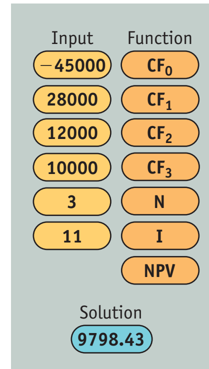
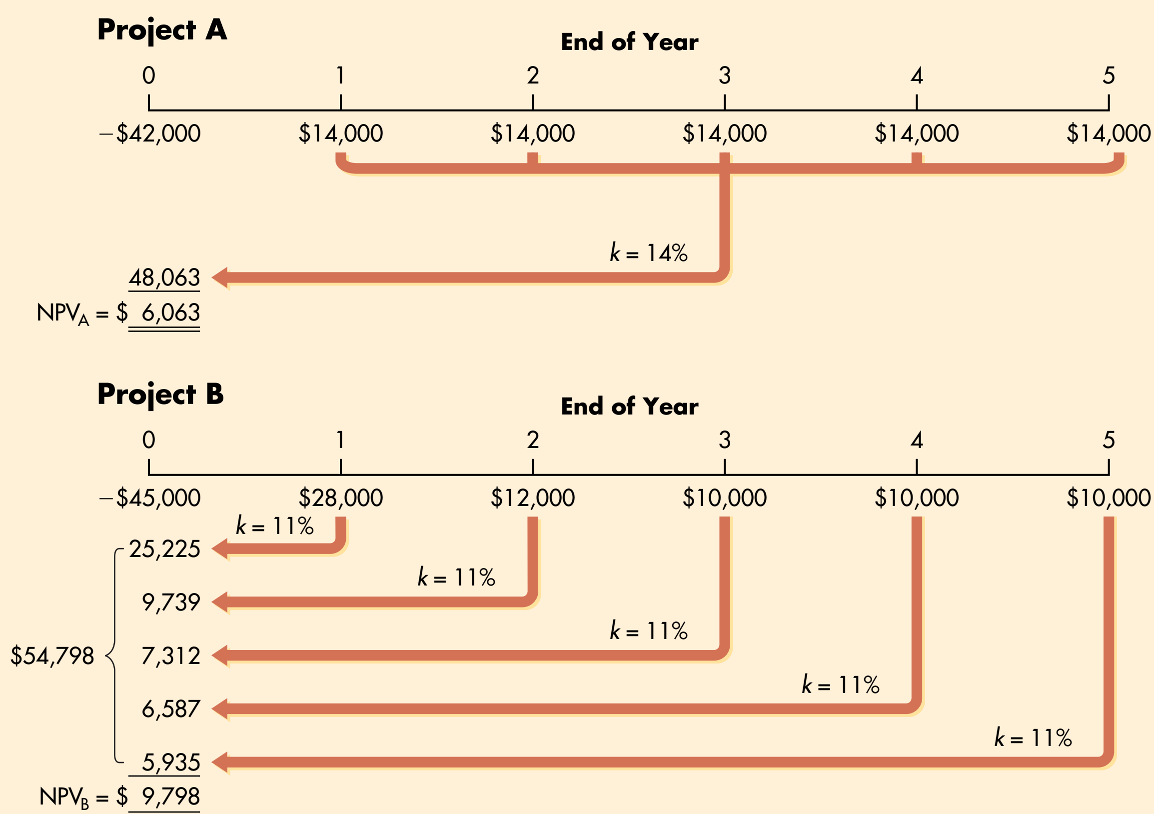


FIGURE 10.3 **Calculation of NPVs for Bennett Company's Capital Expenditure Alternatives using RADRs**

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	ANALYSIS OF PROJECTS USING RISK-ADJUSTED DISCOUNT RATES			
2	Year	Cash Inflow	Present Value	Formulas for Calculated Values in Column C
3	Project A			
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	Project 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).

Portfolio Effects

As noted in Chapter 5, because investors are not rewarded for taking diversifiable risk, they should hold a diversified portfolio of securities. Because a business firm can be viewed as a portfolio of assets, is it similarly important that the firm maintain a diversified portfolio of assets?

It seems logical that by holding a diversified portfolio the firm could reduce the variability of its cash flows. By combining two projects with negatively correlated cash inflows, the firm could reduce the combined cash inflow variability—and therefore the risk.

Are firms rewarded for diversifying risk in this fashion? If they are, the value of the firm could be enhanced through diversification into other lines of business. Surprisingly, the value of the stock of firms whose shares are traded publicly in an efficient marketplace is generally *not* affected by diversification. In other words, diversification is not normally rewarded and therefore is generally not necessary.

Why are firms not rewarded for diversification? Because investors themselves can diversify by holding securities in a variety of firms; they do not need the firm

In Practice

FOCUS ON PRACTICE Brand Ad-vantages

Advertising has always been an easy target for cost cutting when times are tough, because few companies can reliably track or predict the return on investment (ROI) for such spending. This is changing, however, as consultants and financial and marketing managers develop quantitative methodologies to measure returns from advertising and brand communications. Here are two different approaches to this capital budgeting dilemma.

Isolating advertising's contribution to revenues is much harder than analyzing increased volume or revenue from other types of capital expenditures, especially for manufacturers. Because it considers strong brands critical to differentiating itself from the competition, **General Mills'** Big G cereal division has developed a way to measure brand value and advertising effectiveness. Big G's analysts look at such factors as the brand's historical performance, market research on previous advertising effectiveness, and growth versus the competition. Then the company determines how much money to allocate to brand-specific advertising. "We look at each specific brand to determine the income for each," says Keith Woodward, vice president of finance. "There has to be an opportunity for growth, or else we won't invest." After the ad campaigns start, revenue and market data are tracked to measure performance.

The consulting firm **Interbrand** offers its clients proprietary ROI techniques that use net present value (NPV) analysis to value brands on the basis of their future earning power. After determining what percentage of overall revenues the brand generates, Interbrand develops earnings projections for that business segment and subtracts a charge that represents the cost of tangible assets. The remaining income is the economic value derived from intangibles (patents, customer lists, the brand). Interbrand uses qualitative techniques such as market research and interviews to separate the brand's value from the other intangibles. Finally, Interbrand considers seven factors—among them market leadership, stability, and global and cross-cultural reach—to develop a risk-adjusted discount rate to calculate the NPV of the brand's projected earnings stream.

Sources: Adapted from "Best Global Brands: The 100 Top Brands," *Business Week* (August 6, 2001), p. 60; and Kris Frieswick, "ROI: New Brand Day," *CFO.com* (November 28, 2001), downloaded from *www.cfo.com.*

to do it for them. And investors can diversify more readily—they can make transactions more easily and at a lower cost because of the greater availability of information and trading mechanisms.

Of course, if a firm acquires a new line of business and its cash flows tend to respond more to changing economic conditions (that is, greater nondiversifiable risk), greater returns would be expected. If, for the additional risk, the firm earned a return in excess of that required ($IRR > k$), the value of the firm could be enhanced. Also, other benefits, such as increased cash, greater borrowing capacity, guaranteed availability of raw materials, and so forth, could result from and therefore justify diversification, in spite of any immediate impact on cash flow.

Although a strict theoretical view supports the use of a technique that relies on the CAPM framework, the presence of market imperfections causes the market for real corporate assets to be inefficient. The relative inefficiency of this market, coupled with difficulties associated with measurement of nondiversifiable project risk and its relationship to return, tend to favor the use of total risk to evaluate capital budgeting projects. Therefore, the use of *total risk* as an approximation for the relevant risk does tend to have widespread practical appeal.

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,[5] 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.

Hint **The use of risk classes is consistent with the concept that risk-averse investors require a greater return for greater risks. In order to increase shareholders' wealth—and hence warrant acceptance—risky projects must earn greater returns.**

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 10.3. 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.

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 10.3. Bennett classified as lower-risk those projects that tend to involve routine replacement or

TABLE 10.3 Bennett Company's Risk Classes and RADRs

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

[a]This RADR is actually the firm's cost of capital, which is discussed in detail in Chapter 11. 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.

5. Recall that although NPV was the theoretically preferred evaluation technique, IRR was more popular in actual business practice because of the general preference of businesspeople for rates of return rather than pure dollar returns. The popularity of RADRs is therefore consistent with the preference for IRR over NPV.

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.[6] The NPV of project A at 14% was calculated in Figure 10.3 to be $6,063, and the NPV for project B at a 10% RADR was shown in Table 10.1 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 preferences shown in Table 10.1, where differing risks of projects A and B were not taken into account.

Review Questions

10–5 Describe the basic procedures involved in using *risk-adjusted discount rates (RADRs)*. How is this approach related to the *capital asset pricing model (CAPM)?*

10–6 Explain why a firm whose stock is actively traded in the securities markets need not concern itself with diversification. In spite of this, how is the risk of capital budgeting projects frequently measured? Why?

10–7 How are risk classes often used to apply RADRs?

LG5 LG6

10.5 Capital Budgeting Refinements

Refinements must often be made in the analysis of capital budgeting projects to accommodate special circumstances. These adjustments permit the relaxation of certain simplifying assumptions presented earlier. Three areas in which special forms of analysis are frequently needed are (1) comparison of mutually exclusive projects having unequal lives, (2) recognition of real options, and (3) capital rationing caused by a binding budget constraint.

Comparing Projects with Unequal Lives

The financial manager must often select the best of a group of unequal-lived projects. If the projects are independent, the length of the project lives is not critical. But when unequal-lived projects are mutually exclusive, the impact of differing lives must be considered because the projects do not provide service over comparable time periods. This is especially important when continuing service is needed from the project under consideration. The discussions that follow assume that the unequal-lived, mutually exclusive projects being compared *are ongoing*. If they were not, the project with the highest NPV would be selected.

6. Note that the 10% RADR for project B using the risk classes in Table 10.3 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.

The Problem

A simple example will demonstrate the basic problem of noncomparability caused by the need to select the best of a group of mutually exclusive projects with differing usable lives.

EXAMPLE

The AT Company, a regional cable television company, is evaluating two projects, X and Y. The relevant cash flows for each project are given in the following table. The applicable cost of capital for use in evaluating these equally risky projects is 10%.

	Project X	Project Y
Initial investment	$70,000	$85,000
Year	**Annual cash inflows**	
1	$28,000	$35,000
2	33,000	30,000
3	38,000	25,000
4	—	20,000
5	—	15,000
6	—	10,000

Table Use The net present value of each project at the 10% cost of capital is calculated by finding the present value of each cash inflow, summing them, and subtracting the initial investment from the sum of the present values.

$$\begin{aligned} NPV_X &= [\$28{,}000 \times (0.909)] + [\$33{,}000 \times (0.826)] + [\$38{,}000 \times (0.751)] - \$70{,}000 \\ &= (\$25{,}452 + \$27{,}258 + \$28{,}538) - \$70{,}000 \\ &= \$81{,}248 - \$70{,}000 \\ &= \underline{\underline{\$11{,}248}} \end{aligned}$$

$$\begin{aligned} NPV_Y &= [\$35{,}000 \times (0.909)] + [\$30{,}000 \times (0.826)] + [\$25{,}000 \times (0.751)] \\ &\quad + [\$20{,}000 \times (0.683)] + [\$15{,}000 \times (0.621)] + [\$10{,}000 \times (0.564)] - \$85{,}000 \\ &= (\$31{,}815 + \$24{,}780 + \$18{,}775 + \$13{,}660 + \$9{,}315 + \$5{,}640) - \$85{,}000 \\ &= \$103{,}985 - \$85{,}000 \\ &= \underline{\underline{\$18{,}985}} \end{aligned}$$

The NPV for project X is $11,248; that for project Y is $18,985.

Project X

Input	Function
−70000	CF_0
28000	CF_1
33000	CF_2
38000	CF_3
10	I
	NPV
Solution	11277.24

Project Y

Input	Function
−85000	CF_0
35000	CF_1
30000	CF_2
25000	CF_3
20000	CF_4
15000	CF_5
10000	CF_6
10	I
	NPV
Solution	19013.27

Calculator Use Employing the preprogrammed NPV function in a financial calculator, we use the keystrokes shown at the left for project X and for project Y to find their respective NPVs of $11,277.24 and $19,013.27.

Spreadsheet Use Comparison of the net present values of two projects with unequal lives also can be calculated as shown on the following Excel spreadsheet.

	A	B	C
1	COMPARISON OF NET PRESENT VALUES OF TWO PROJECTS WITH UNEQUAL LIVES		
2		Cost of Capital	10%
3		Year-End Cash Flows	
4	Year	Project X	Project Y
5	0	$ (70,000)	$ (85,000)
6	1	$ 28,000	$ 35,000
7	2	$ 33,000	$ 30,000
8	3	$ 38,000	$ 25,000
9	4		$ 20,000
10	5		$ 15,000
11	6		$ 10,000
12	NPV	$ 11,277.24	$ 19,013.27
13	Choice of Project		Project Y

Entry in Cell B12 is
=NPV(C2,B6:B11)+B5.
Copy the entry in Cell B12 to Cell C12.
Entry in Cell C13 is =IF(B12>=C12,B4,C4).

Ignoring the differences in project lives, we can see that both projects are acceptable (both NPVs are greater than zero) and that project Y is preferred over project X. If the projects were independent and only one could be accepted, project Y—with the larger NPV—would be preferred. On the other hand, if the projects were mutually exclusive, their differing lives would have to be considered. Project Y provides 3 more years of service than project X.

The analysis in the above example is incomplete if the projects are mutually exclusive (which will be our assumption throughout the remaining discussions). To compare these unequal-lived, mutually exclusive projects correctly, we must consider the differing lives in the analysis; an incorrect decision could result from simply using NPV to select the better project. Although a number of approaches are available for dealing with unequal lives, here we present the most efficient technique—the annualized net present value (ANPV) approach.

Annualized Net Present Value (ANPV) Approach

annualized net present value (ANPV) approach
An approach to evaluating unequal-lived projects that converts the net present value of unequal-lived, mutually exclusive projects into an equivalent annual amount (in NPV terms).

The **annualized net present value (ANPV) approach** converts the net present value of unequal-lived projects into an equivalent annual amount (in NPV terms) that can be used to select the best project.[7] This net present value based approach can be applied to unequal-lived, mutually exclusive projects by using the following steps:

Step 1 Calculate the net present value of each project j, NPV_j, over its life, n_j, using the appropriate cost of capital, k.

7. The theory underlying this as well as other approaches for comparing projects with unequal lives assumes that each project can be replaced in the future for the same initial investment and that each will provide the same expected future cash inflows. Although changing technology and inflation will affect the initial investment and expected cash inflows, the lack of specific attention to them does not detract from the usefulness of this technique.

Step 2 Divide the net present value of each project having a positive NPV by the present value interest factor for an annuity at the given cost of capital and the project's life to get the annualized net present value for each project *j*, $ANPV_j$, as shown below:

$$ANPV_j = \frac{NPV_j}{PVIFA_{k,n_j}} \tag{10.6}$$

Step 3 Select the project that has the highest ANPV.

EXAMPLE By using the AT Company data presented earlier for projects X and Y, we can apply the three-step ANPV approach as follows:

Step 1 The net present values of projects X and Y discounted at 10%—as calculated in the preceding example for a single purchase of each asset—are

NPV_X = \$11,248 (calculator/spreadsheet value = \$11,277.24)

NPV_Y = \$18,985 (calculator/spreadsheet value = \$19,013.27)

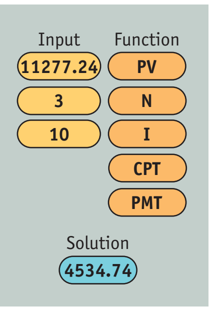
Step 2 **Table Use** Calculate the annualized net present value for each project by applying Equation 10.6 to the NPVs.

$$ANPV_X = \frac{\$11{,}248}{PVIFA_{10\%,3yrs}} = \frac{\$11{,}248}{2.487} = \underline{\underline{\$4{,}523}}$$

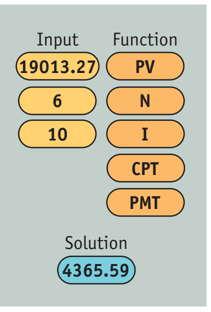
$$ANPV_Y = \frac{\$18{,}985}{PVIFA_{10\%,6yrs}} = \frac{\$18{,}985}{4.355} = \underline{\underline{\$4{,}359}}$$

Calculator Use The keystrokes required to find the ANPV on a financial calculator are identical to those demonstrated in Chapter 4 for finding the annual payments on an installment loan. These keystrokes are shown below for project X and for project Y. The resulting ANPVs for projects X and Y are \$4,534.74 and \$4,365.59, respectively.

Project X



Project Y



Spreadsheet Use Comparison of the annualized net present values of two projects with unequal lives also can be calculated as shown on the following Excel spreadsheet.

	A	B	C
1	COMPARISON OF ANNUALIZED NET PRESENT VALUES OF TWO PROJECTS WITH UNEQUAL LIVES		
2	Cost of Capital		10%
3		Year-End Cash Flows	
4	Year	Project X	Project Y
5	0	$ (70,000)	$ (85,000)
6	1	$ 28,000	$ 35,000
7	2	$ 33,000	$ 30,000
8	3	$ 38,000	$ 25,000
9	4		$ 20,000
10	5		$ 15,000
11	6		$ 10,000
12	NPV	$ 11,277.24	$ 19,013.27
13	ANPV	$ 4,534.74	$ 4,365.59
14	Choice of project		Project X

Entry in Cell B12 is =NPV(C2,B6:B11)+B5.
Copy the entry in Cell B12 to Cell C12.
Entry in Cell B13 is =B12/PV(C2,3,–1).
Entry in Cell C13 is =C12/PV(C2,6,–1).
Entry in Cell C14 is =IF(B13>=C13,B4,C4)

Step 3 Reviewing the ANPVs calculated in Step 2, we can see that project X would be preferred over project Y. Given that projects X and Y are mutually exclusive, project X would be the recommended project because it provides the higher annualized net present value.

Recognizing Real Options

The procedures described in Chapters 8 and 9 and thus far in this chapter suggest that to make capital budgeting decisions, we must (1) estimate relevant cash flows, (2) apply an appropriate decision technique such as NPV or IRR to those cash flows, and (3) recognize and adjust the decision technique for project risk. 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*.

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.*

Some of the more common types of real options—abandonment, flexibility, growth, and timing—are briefly described in Table 10.4. It should be clear from their descriptions that each of these types of options could be embedded in a

TABLE 10.4 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.

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 10.7.

$$NPV_{strategic} = NPV_{traditional} + \text{Value of real options} \qquad (10.7)$$

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 Table 10.1) finds no real options embedded in project A 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.

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

Substituting the \$1,500 real options value along with the traditional NPV of \$10,924 for project B (from Table 10.1) into Equation 10.7, we get the strategic NPV for project B.

$$NPV_{strategic} = \$10{,}924 + \$1{,}500 = \underline{\underline{\$12{,}424}}$$

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 ($NPV_{traditional} <$ \$0) to become acceptable ($NPV_{strategic} >$ \$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.

Capital Rationing

Hint Because everyone in the firm knows that long-term funds are rationed and they want a portion of them, there is *intense competition* for those funds. This competition increases the need for the firm to be objective and proficient in its analysis. Knowing how to use the techniques discussed in this chapter to justify your needs will help you get your share of the available long-term funds.

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, here 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 11, 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 10.4 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. 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.

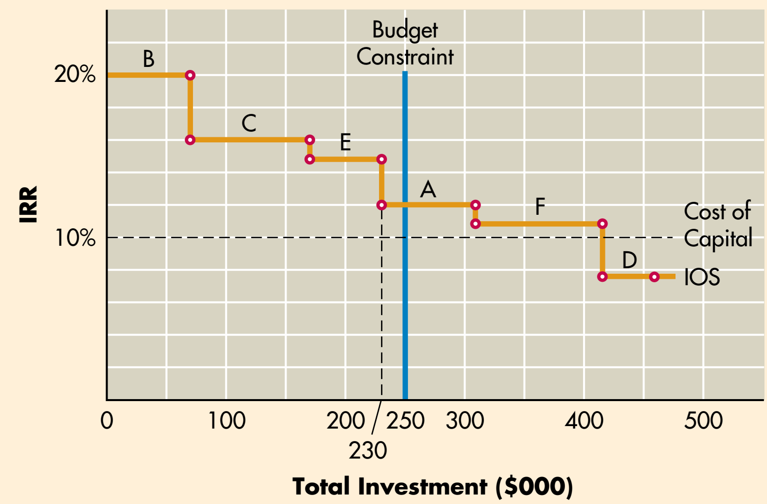
net present value approach
An approach to capital rationing that is based on the use of present values to determine the group of projects that will maximize owners' wealth.

Net Present Value Approach

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*

FIGURE 10.4

Investment Opportunities Schedule
Investment opportunities schedule (IOS) for Tate Company 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 10.5 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

TABLE 10.5 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	Cutoff point
D	40,000	8	36,000	(IRR < 10%)

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 ($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

10–8 Explain why a mere comparison of the NPVs of unequal-lived, ongoing, mutually exclusive projects is inappropriate. Describe the *annualized net present value (ANPV)* approach for comparing unequal-lived, mutually exclusive projects.

10–9 What are *real options?* What are some major types of real options?

10–10 What is the difference between the *strategic NPV* and the *traditional NPV?* Do they always result in the same accept–reject decisions?

10–11 What is *capital rationing?* In theory, should capital rationing exist? Why does it frequently occur in practice?

10–12 Compare and contrast the *internal rate of return approach* and the *net present value approach* to capital rationing. Which is better? Why?

SUMMARY

FOCUS ON VALUE

Not all capital budgeting projects have the same level of risk as the firm's existing portfolio of projects. In addition, mutually exclusive projects often possess differing levels of risk. The financial manager must therefore adjust projects for differences in risk when evaluating their acceptability. Without such adjustment, management could mistakenly accept projects that destroy shareholder value or could reject projects that create shareholder value. To ensure that neither of these outcomes occurs, the financial manager must make sure that only those projects that create shareholder value are recommended.

Risk-adjusted discounts rates (RADRs) provide a mechanism for adjusting the discount rate so that it is consistent with the risk–return preferences of market participants and thereby accepting only value-creating projects. Procedures for comparing projects with unequal lives, 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. These procedures, along with risk-adjustment 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 **Understand the importance of explicitly recognizing risk in the analysis of capital budgeting projects.** The cash flows associated with capital budgeting projects typically have different levels of risk, and the acceptance of a project generally affects the firm's overall risk. Thus it is important to incorporate risk considerations in capital budgeting. Various behavioral approaches can be used to get a "feel" for the level of project risk, whereas other approaches explicitly recognize project risk in the analysis of capital budgeting projects.

LG2 **Discuss breakeven cash inflow, sensitivity and scenario analysis, and simulation as behavioral approaches for dealing with risk.** Risk in capital budgeting is the chance that a project will prove unacceptable or, more formally, the degree of variability of cash flows. Finding the breakeven cash inflow and assessing the probability that it will be realized make up one behavioral approach that is used to assess the chance of success. Sensitivity analysis and scenario analysis are also behavioral approaches for dealing with project risk to capture the variability of cash inflows and NPVs. Simulation is a statistically based 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.

LG3 **Discuss the unique risks that multinational companies face.** 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 issues.

LG4 **Describe the determination and use of risk-adjusted discount rates (RADRs), portfolio effects, and the practical aspects of RADRs.** The risk of a project whose initial investment is known with certainty is embodied in the present value of its cash inflows, using NPV. Two opportunities to adjust the present value of cash inflows for risk exist—adjust the cash inflows or adjust the discount rate. Because adjusting the cash inflows is highly subjective, adjusting discount rates is more popular. The RADRs use a market-based adjustment of the discount rate to calculate NPV. The RADR is closely linked to CAPM, but because real corporate assets are generally not traded in an efficient market, the CAPM cannot be applied directly to capital budgeting. Instead, firms develop some CAPM-type of relationship to link a project's risk to its required return, which is used as the discount rate. Often, for convenience, firms will rely on total risk as an approximation for relevant risk when estimating required project returns. RADRs are commonly used in practice, because decision makers prefer rates of return and find them easy to estimate and apply.

LG5 **Recognize the problem caused by unequal-lived mutually exclusive projects and the use of annualized net present values (ANPVs) to resolve it.** The problem in comparing unequal-lived mutually exclusive projects is that the projects do not provide service over comparable time periods. The annualized net present value (ANPV) approach is the most efficient method of comparing ongoing mutually exclusive projects that have unequal usable lives. It converts the NPV of each unequal-lived project into an equivalent annual amount—its ANPV. The ANPV can be calculated using financial tables by dividing each project's NPV by the present value interest factor for an annuity at the given cost of capital and project life. Alternatively, it can be calculated using a financial calculator—the keystrokes are identical to those used to find the annual payment on an installment loan—or spreadsheet. The project with the highest ANPV is best.

LG6 **Explain the role of real options and the objective of, and basic approaches to, project selection 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 affects 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 exists when firms have more acceptable independent projects than they can fund. Although, in theory, capital rationing should not exist, in practice it commonly occurs. Its objective is to select from all acceptable projects the group that provides the highest overall net present value and does not require more dollars than are budgeted. The two basic approaches for choosing projects under capital rationing are the internal rate of return approach and the net present value approach. The NPV approach better achieves the objective of using the budget to generate the highest present value of inflows.

SELF-TEST PROBLEM (Solution in Appendix B)

LG4 **ST 10–1** **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

a. 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.

b. Use NPV to evaluate the projects, using *risk-adjusted discount rates* (*RADRs*) to account for risk.
c. Compare, contrast, and explain your findings in parts **a** and **b.**

PROBLEMS

LG1 **10–1 Recognizing risk** Caradine Corp., a media services firm with net earnings of $3,200,000 in the last year, is considering several projects.

Project	Initial Investment	Details
A	$ 35,000	Replace existing office furnishings.
B	500,000	Purchase digital film-editing equipment for use with several existing accounts.
C	450,000	Develop proposal to bid for a $2,000,000 per year 10-year contract with the U.S. Navy, not now an account.
D	685,000	Purchase the exclusive rights to market a quality educational television program in syndication to local markets in the European Union, a part of the firm's existing business activities.

The media services business is cyclical and highly competitive. The board of directors has asked you, as chief financial officer, to
a. Evaluate the risk of each proposed project and rank it "low," "medium," or "high."
b. Comment on why you chose each ranking.

LG2 **10–2 Breakeven cash inflows** Etsitty Arts, Inc., a leading producer of fine cast silver jewelry, is considering the purchase of new casting equipment that will allow it to expand the product line into award plaques. The proposed initial investment is $35,000. The company expects that the equipment will produce steady income throughout its 12-year life.
a. If Etsitty requires a 14% return on its investment, what minimum yearly cash inflow will be necessary for the company to go forward with this project?
b. How would the minimum yearly cash inflow change if the company required a 10% return on its investment?

LG2 **10–3 Breakeven cash inflows and risk** Pueblo Enterprises is considering investing in either of two mutually exclusive projects, X and Y. Project X requires an initial investment of $30,000; project Y requires $40,000. Each project's cash inflows are 5-year annuities; project X's inflows are $10,000 per year; project Y's are $15,000. The firm has unlimited funds and, in the absence of risk differences, accepts the project with the highest NPV. The cost of capital is 15%.
a. Find the NPV for each project. Are the projects acceptable?
b. Find the *breakeven cash inflow* for each project.

c. The firm has estimated the probabilities of achieving various ranges of cash inflows for the two projects, as shown in the following table. What is the probability that each project will achieve the breakeven cash inflow found in part **b**?

	Probability of achieving cash inflow in given range	
Range of cash inflow	Project X	Project Y
\$0 to \$5,000	0%	5%
\$5,000 to \$7,500	10	10
\$7,500 to \$10,000	60	15
\$10,000 to \$12,500	25	25
\$12,500 to \$15,000	5	20
\$15,000 to \$20,000	0	15
Above \$20,000	0	10

d. Which project is more risky? Which project has the potentially higher NPV? Discuss the risk-return tradeoffs of the two projects.

e. If the firm wished to minimize losses (that is, NPV < \$0), which project would you recommend? Which would you recommend if the goal, instead, was achieving the higher NPV?

LG2 **10–4 Basic sensitivity analysis** Murdock Paints 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

a. Determine the *range* of annual cash inflows for each of the two projects.

b. 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.

c. Do parts **a** and **b** provide consistent views of the two projects? Explain.

d. Which project do you recommend? Why?

LG2 **10–5 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 uses 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

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

LG2 10–6 **Simulation** Ogden Corporation has compiled the following information on a capital expenditure proposal:
(1) 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.

LG4 10–7 **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*:

$$\text{RADR}_j = R_F + [RI_j \times (k - R_F)]$$

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?

LG4 10–8 **Risk-adjusted discount rates—Tabular** After a careful evaluation of investment alternatives and opportunities, Masters School Supplies 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.

a. Evaluate the projects using *risk-adjusted discount rates*.

b. Discuss your findings in part **a,** and recommend the preferred project.

LG4 **10–9 Risk-adjusted rates of return using CAPM** Centennial Catering, Inc., is considering two mutually exclusive investments. The company wishes to use a risk-adjusted rate of return in its analysis. Centennial's cost of capital (similar to the market return in CAPM) is 12%, and the current risk-free rate of return is 7%. Cash flows associated with the two projects are as follows:

	Project X	Project Y
Initial investment (CF_0)	$70,000	$78,000
Year (t)	Cash inflows (CF_t)	
1	$30,000	$22,000
2	30,000	32,000
3	30,000	38,000
4	30,000	46,000

a. Use a risk-adjusted rate of return approach to calculate the net present value of each project, given that Project X has a RADR factor of 1.20 and Project Y has a RADR factor of 1.40. The RADR factors are similar to project betas. (Use Equation 10.5 to calculate the required project return for each.)

b. Discuss your findings in part **a,** and recommend the preferred project.

LG4 **10–10 Risk classes and RADR** Moses Manufacturing 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

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

LG5 **10–11 Unequal lives—ANPV approach** Evans Industries wishes to select the best of three possible machines, each of which is expected to satisfy the firm's ongoing need for additional aluminum-extrusion capacity. The three machines—A, B, and C—are equally risky. The firm plans to use a 12% cost of capital to evaluate each of them. The initial investment and annual cash inflows over the life of each machine are shown in the following table.

	Machine A	Machine B	Machine C
Initial investment (CF_0)	**\$92,000**	**\$65,000**	**\$100,500**
Year (t)	**Cash inflows (CF_t)**		
1	\$12,000	\$10,000	\$30,000
2	12,000	20,000	30,000
3	12,000	30,000	30,000
4	12,000	40,000	30,000
5	12,000	—	30,000
6	12,000	—	—

a. Calculate the NPV for each machine over its life. Rank the machines in descending order on the basis of NPV.
b. Use the *annualized net present value (ANPV)* approach to evaluate and rank the machines in descending order on the basis of ANPV.
c. Compare and contrast your findings in parts **a** and **b.** Which machine would you recommend that the firm acquire? Why?

LG5 **10–12 Unequal lives—ANPV approach** Portland Products is considering the purchase of one of three mutually exclusive projects for increasing production efficiency. The firm plans to use a 14% cost of capital to evaluate these equal-risk projects. The initial investment and annual cash inflows over the life of each project are shown in the following table.

	Project X	Project Y	Project Z
Initial investment (CF_0)	$78,000	$52,000	$66,000
Year (t)	Cash inflows (CF_t)		
1	$17,000	$28,000	$15,000
2	25,000	38,000	15,000
3	33,000	—	15,000
4	41,000	—	15,000
5	—	—	15,000
6	—	—	15,000
7	—	—	15,000
8	—	—	15,000

a. Calculate the NPV for each project over its life. Rank the projects in descending order on the basis of NPV.
b. Use the *annualized net present value (ANPV)* approach to evaluate and rank the projects in descending order on the basis of ANPV.
c. Compare and contrast your findings in parts **a** and **b.** Which project would you recommend that the firm purchase? Why?

LG5 **10–13 Unequal lives—ANPV approach** JBL Co. has designed a new conveyor system. Management must choose among three alternative courses of action: (1) The firm can sell the design outright to another corporation with payment over 2 years. (2) It can license the design to another manufacturer for a period of 5 years, its likely product life. (3) It can manufacture and market the system itself. The company has a cost of capital of 12%. Cash flows associated with each alternative are as follows:

Alternative	Sell	License	Manufacture
Initial investment (CF_0)	$200,000	$200,000	$450,000
Year (t)	Cash inflows (CF_t)		
1	$200,000	$250,000	$200,000
2	250,000	100,000	250,000
3	—	80,000	200,000
4	—	60,000	200,000
5	—	40,000	200,000
6	—	—	200,000

a. Calculate the net present value of each alternative and rank the alternatives on the basis of NPV.
b. Calculate the *annualized net present value (ANPV)* of each alternative and rank them accordingly.
c. Why is ANPV preferred over NPV when ranking projects with unequal lives?

LG6 **10–14 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

$$NPV_{traditional} = -\$1{,}700 < \$0$$

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.

a. Use the information provided to calculate the strategic NPV, $NPV_{strategic}$, for Asor Products' proposed equipment expenditure.

b. Judging on the basis of your findings in part **a**, what action should Rene recommend to management with regard to the proposed equipment expenditures?

c. In general, how does this problem demonstrate the importance of considering real options when making capital budgeting decisions?

LG6 **10–15 Capital rationing—IRR and NPV approaches** Valley Corporation 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

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

LG6 **10–16 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

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

CHAPTER 10 CASE Evaluating Cherone Equipment's Risky Plans for Increasing Its Production Capacity

Cherone Equipment, a manufacturer of electronic fitness equipment, wishes to evaluate two alternative plans for increasing its production capacity to meet the rapidly growing demand for its key product—the Cardiocycle. After months of investigation and analysis, the firm has pruned the list of alternatives down to the following two plans, either of which would allow it to meet the forecast product demand.

Plan X Use current proven technology to expand the existing plant and semiautomated production line. This plan is viewed as only slightly more risky than the firm's current average level of risk.

Plan Y Install new, just-developed automatic production equipment in the existing plant to replace the current semiautomated production line. Because this plan eliminates the need to expand the plant, it is less expensive than Plan X, but it is believed to be far more risky because of the unproven nature of the technology.

Cherone, which routinely uses NPV to evaluate capital budgeting projects, has a cost of capital of 12%. Currently the risk-free rate of interest, R_F, is 9%. The firm has decided to evaluate the two plans over a 5-year time period, at the end of which each plan would be liquidated. The relevant cash flows associated with each plan are summarized in the accompanying table.

	Plan X	Plan Y
Initial investment (CF_0)	**\$2,700,000**	**\$2,100,000**
Year (t)	**Cash inflows (CF_t)**	
1	\$ 470,000	\$ 380,000
2	610,000	700,000
3	950,000	800,000
4	970,000	600,000
5	1,500,000	1,200,000

The firm has determined the risk-adjusted discount rate (RADR) applicable to each plan.

Plan	Risk-adjusted discount rate (RADR)
X	13%
Y	15%

Further analysis of the two plans has disclosed that each has a real option embedded within its cash flows.

Plan X Real Option—At the end of 3 years the firm could abandon this plan and then install the automatic equipment, which would then have a proven track record. This *abandonment option* is expected to add \$100,000 of NPV and has a 25% chance of being exercised.

Plan Y Real Option—Because plan Y does not require current expansion of the plant, it creates an improved opportunity for future plant expansion. This option allows the firm to grow its business into related areas more easily if business and economic conditions continue to improve. This *expansion option* is estimated to be worth \$500,000 of NPV and has a 20% chance of being exercised.

Required

a. Assuming that the two plans have the same risk as the firm, use the following capital budgeting techniques and the firm's cost of capital to evaluate their acceptability and relative ranking.
   (1) Net present value (NPV).
   (2) Internal rate of return (IRR).

b. Recognizing the differences in plan risk, use the NPV method, the risk-adjusted discount rates (RADRs), and the data given earlier to evaluate the acceptability and relative ranking of the two plans.

c. Compare and contrast your finding in parts **a** and **b.** Which plan would you recommend? Did explicit recognition of the risk differences of the plans affect this recommendation?

d. Use the real-options data given above for each plan to find the strategic NPV, $NPV_{strategic}$, for each plan.

e. Compare and contrast your findings in part **d** with those in part **b.** Did explicit recognition of the real options in each plan affect your recommendation?

f. Would your recommendations in parts **a, b,** and **d** be changed if the firm were operating under capital rationing? Explain.

WEB EXERCISE

Go to the Contingency Analysis Web site, *www.contingencyanalysis.com*. Scroll down the page and click **Fundamentals**. Then click on **Risk Intuition**.

1. Take the seven-question quiz. Were you surprised at the answers?

Return to the **Fundamentals** page and click on **Risk Measures**.

2. Describe the three categories of risk measures and how they could be used in capital budgeting analysis.

Scroll down the Risk Measures menu in the lower left frame and click on **Asset Liability Analysis.**

3. Why are statistical risk measures less satisfactory in determining asset risk?
4. Summarize the steps to analyze asset risk.
5. Using the following project description, explain how you would analyze the risk.

Purchase of Automated Equipment for a New Assembly Line	
Initial cost: $6,600,000	
Expected incremental cash inflows:	
Year 1	$1,280,000
Year 2	1,640,000
Year 3	1,820,000
Year 4	2,030,000
Year 5	2,450,000

6. What types of assumptions would you change to create new cash flows? Consider various market factors such as timing for project implementation, inflation, capital costs, and so forth.

Remember to check the book's Web site at

www.aw.com/gitman

for additional resources, including additional Web exercises.

INTEGRATIVE CASE 3

Lasting Impressions Company

Lasting Impressions (LI) Company is a medium-sized commercial printer of promotional advertising brochures, booklets, and other direct-mail pieces. The firm's major clients are New York– and Chicago-based ad agencies. The typical job is characterized by high quality and production runs of over 50,000 units. LI has not been able to compete effectively with larger printers because of its existing older, inefficient presses. The firm is currently having problems cost effectively meeting run length requirements as well as meeting quality standards.

The general manager has proposed the purchase of one of two large six-color presses designed for long, high-quality runs. The purchase of a new press would enable LI to reduce its cost of labor and therefore the price to the client, putting the firm in a more competitive position. The key financial characteristics of the old press and of the two proposed presses are summarized in what follows.

Old press Originally purchased 3 years ago at an installed cost of $400,000, it is being depreciated under MACRS using a 5-year recovery period. The old press has a remaining economic life of 5 years. It can be sold today to net $420,000 before taxes; if it is retained, it can be sold to net $150,000 before taxes at the end of 5 years.

Press A This highly automated press can be purchased for $830,000 and will require $40,000 in installation costs. It will be depreciated under MACRS using a 5-year recovery period. At the end of the 5 years, the machine could be sold to net $400,000 before taxes. If this machine is acquired, it is anticipated that the following current account changes would result.

Cash	+	$ 25,400
Accounts receivable	+	120,000
Inventories	−	20,000
Accounts payable	+	35,000

Press B This press is not as sophisticated as press A. It costs $640,000 and requires $20,000 in installation costs. It will be depreciated under MACRS using a 5-year recovery period. At the end of 5 years, it can be sold to net $330,000 before taxes. Acquisition of this press will have no effect on the firm's net working capital investment.

Table 1

Profits Before Depreciation and Taxes for Lasting Impressions Company's Presses

Year	Old press	Press A	Press B
1	$120,000	$250,000	$210,000
2	120,000	270,000	210,000
3	120,000	300,000	210,000
4	120,000	330,000	210,000
5	120,000	370,000	210,000

The firm estimates that its profits before depreciation and taxes with the old press and with press A or press B for each of the 5 years would be as shown in Table 1. The firm is subject to a 40% tax rate on both ordinary income and capital gains. The firm's cost of capital, *k,* applicable to the proposed replacement is 14%.

Required

a. For each of the two proposed replacement presses, determine:
- (1) Initial investment.
- (2) Operating cash inflows. (*Note:* Be sure to consider the depreciation in year 6.)
- (3) Terminal cash flow. (*Note:* This is at the end of year 5.)

b. Using the data developed in part **a,** find and depict on a time line the relevant cash flow stream associated with each of the two proposed replacement presses, assuming that each is terminated at the end of 5 years.

c. Using the data developed in part **b,** apply each of the following decision techniques:
- (1) Payback period. (*Note:* For year 5, use only the operating cash inflows—that is, exclude terminal cash flow—when making this calculation.)
- (2) Net present value (NPV).
- (3) Internal rate of return (IRR).

d. Draw net present value profiles for the two replacement presses on the same set of axes, and discuss conflicting rankings of the two presses, if any, resulting from use of NPV and IRR decision techniques.

e. Recommend which, if either, of the presses the firm should acquire if the firm has (1) unlimited funds or (2) capital rationing.

f. What is the impact on your recommendation of the fact that the operating cash inflows associated with press A are characterized as very risky in contrast to the low-risk operating cash inflows of press B?