CHAPTER 11

Investment Decision Criteria

Chapter Outline

Principles P 1, P 2, P 3, and P 5 Applied

This chapter applies what we have learned from valuing stocks and bonds to the valuation of investments in production plants, new equipment, real estate, and any other asset that is likely to generate future profits. Our discussion of valuing investment opportunities relies on the first three basic principles of finance, along with the final principle: P Principle 1: **Money Has a Time Value**—the cash inflows and outflows from an investment opportunity are generally spread out over a number of years; thus, we need the time-value-of-money tools to make these cash flows that occur in different time periods comparable; P Principle 2: **There Is a Risk-Return Tradeoff**—different investment opportunities have different levels of risk, and as a result, the risk-return tradeoff becomes important when determining the rate to use to discount future cash flows; P Principle 3: **Cash Flows Are the Source of Value**—when evaluating investment opportunities, we will rely on the cash flows generated by the investment rather than accounting profits; and P Principle 5: **Individuals Respond to Incentives**—managers respond to incentives, and when their investment incentives are not properly aligned with those of the firm's stockholders, they may not make the investments that are consistent with increasing shareholder value.

Real Estate Investing

Suppose that you and your roommates rent a condo near campus and, at the end of your senior year, your landlord offers to sell you the condo for $90,000. If you bought the condo, you would make some minor repairs and sell it right away. Your father has agreed to loan you the money for the purchase and repairs. How would you decide whether to take your landlord up on the offer?

You estimate that it will cost $2,000 and take about three weeks to get the condo repainted and ready for sale. Given the demand for student housing in the area, you think that you will be able to sell it in a few days for $100,000, which represents a profit of $8,000. By completing this analysis, you've just determined the *net present value* of this project, which is the $8,000 increase in your wealth that results from the purchase and sale of the condo.

This scenario is not unlike many investment problems in the world of corporate finance. A firm's manager who is considering a new investment, such as the launch of a new product, first analyzes the costs involved. Next, the manager forecasts the future cash inflows expected throughout the life of the product. Our condo investment example assumed that there is only three weeks from purchase to sale, so we ignored the time value of money, which in most cases plays an important role. Hence, in the final step, the future cash flows of the investment must be discounted back to the present and then compared to the initial cash outlay to determine whether the investment is likely to create value for the investor. This will be the case if the present value of the cash inflows exceeds the initial cash outlay.

With the exception of the necessity of adjusting future cash flows for the time value of money, the analysis carried out by the manager is exactly what you would have done in analyzing the condo investment. Very simply, *a good investment is one that is worth more than it costs to make*. This observation is a good one to file away and come back to over and over as we go through the rest of this chapter. Throughout the chapter, we will be talking about the analysis of investment opportunities; the commonsense approach we will use is to compare the benefits we derive from the investment with the costs we incur in making it.

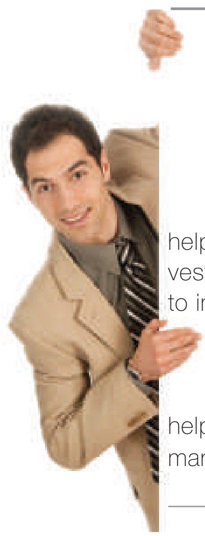
Capital budgeting is the term we use to refer to the process used to evaluate a firm's long-term investment opportunities. As part of this process, managers rely on four of the basic principles of finance:

- First, we value an investment opportunity by evaluating its expected cash flows, following P Principle 3: **Cash Flows Are the Source of Value**.
- Second, we discount all cash flows back to the present, taking into account P Principle 1: **Money Has a Time Value**.

- Next, we incorporate risk into the analysis by adjusting the discount rate used to calculate the present value of the project's future cash flows, bearing in mind Principle 2: **There Is a Risk-Return Tradeoff**. The term risk means that more things can happen than will happen, so the reward for assuming more *risk* is not a sure thing but simply a higher *expected* return.
- Finally, we must take into account Principle 5: **Individuals Respond to Incentives**. Managers respond to incentives, and when their incentives are not properly aligned with those of the firm's stockholders, they may not make investment decisions that are consistent with increasing shareholder value.

We begin this chapter with a look at the criteria managers use to determine if an investment opportunity—such as the condo investment or the product introduction—is a good investment. Our primary focus is on net present value, a measure of the value created by the investment. However, we also review other popular measures used in practice.

Regardless of Your Major…



"Making Personal Investment Decisions"

Over your career, you will be faced with investment opportunities that require some type of evaluation and analysis. Whether the decision is to purchase a piece of property that you hope to develop and resell or to start and run a business, capital-budgeting analysis will help you make the right decision. In the introduction, we described a very simple real estate investment opportunity. More typically, such an investment would require a substantial investment to improve the property, with renovations carried out over an extended period of time (perhaps as much as a year). Having completed the renovation, you might consider at least two alternatives: You could sell the property to someone else to rent and manage, or you could keep the property and manage the rentals yourself. The tools we develop in this chapter will help you evaluate the initial property investment as well as decide whether or not to keep and manage the property.

Your Turn: See Study Question 11–1.

11.1 An Overview of Capital Budgeting

In 1955, the Walt Disney Company (DIS) was largely a movie studio, but that all changed when the company decided to invest $17.5 million to build Disneyland in Anaheim, California. The decision to build the theme park was a major capital-budgeting decision for Disney and was so successful that the company later decided to open theme parks in Orlando, Tokyo, Paris, and Hong Kong. In retrospect, how important was this investment? Today, parks and resorts account for over 30 percent of Disney's revenue. There are three important lessons from the Disney theme park story:

Lesson 1: Capital-budgeting decisions are critical in defining a company's business. Had Disney not embarked on its theme park strategy, it would be a very different company today.

Lesson 2: Very large investments frequently consist of many smaller investment decisions that define a business strategy. Disney did not launch its theme parks in 1955 with a plan to invest $3.5 billion some 50 years later to build the Hong Kong site. Rather, the $3.5 billion investment in the Hong Kong Disneyland was the result of a series of smaller investments that led to the eventual decision to expand the franchise in Asia.

Lesson 3: **Successful investment choices lead to the development of managerial expertise and capabilities that influence the firm's choice of future investments.** Disney's early success with its theme park in California provided its managers with the expertise and confidence to replicate the theme park in Orlando and then internationally. This storehouse of talent and experience gives Disney a competitive edge on would-be competitors who might seek to enter the theme park business.

The Typical Capital-Budgeting Process

Although the capital-budgeting process can be long and complicated at many major corporations, we can sum up the typical capital-budgeting process at any firm in terms of two basic phases:

Phase 1: **The firm's management identifies promising investment opportunities.** These opportunities generally arise from ideas generated by the management and employees of the firm. Employees who work closely with the firm's customers (generally, the marketing department) or who run the firm's operations (the production management department) are often the idea generators.

Phase 2: **Once an investment opportunity has been identified, its value-creating potential—what some refer to as its *value proposition*—is thoroughly evaluated.** In very simple terms, a project's value proposition answers the following question: "How do we plan to make money?" It is at this stage that financial analysts enter the picture.

The logic of the two-phase process is very simple: Identify promising investment opportunities, and select those that offer an opportunity to create value for the firm's common stockholders.

What Are the Sources of Good Investment Projects?

Finding good investment projects can be a daunting task, particularly when the firm faces substantial competition from other firms that are also looking for similar investment opportunities. Recall from your introductory economics class that firms tend to be more profitable when they operate in markets that have less competition. So the search for good investments is largely a search for opportunities where the firm can exploit some competitive advantage over its competitors. For example, the firm may have a proprietary production process that uses fewer inputs and results in a lower cost of production.

As a general rule, good investments are most likely to be found in markets that are less competitive. These are markets where barriers to new entrants are sufficiently high that they keep out would-be competitors. For example, the strong brand reputation of the Frito-Lay products that results from an ongoing barrage of advertising makes it difficult for competing brands to enter the salty snack food category and, at the same time, makes it easier for Frito-Lay to introduce new products.

Types of Capital Investment Projects

Capital investment projects can be classified into one of three broad categories:

1. Revenue-enhancing investments
2. Cost-reducing investments
3. Mandatory investments that are a result of government mandates

Let's consider each of these briefly.

Revenue-Enhancing Investments

Investments that lead to higher revenues often involve the expansion of existing businesses, such as Apple's (APPL) decision to add the smaller Nano to its iPod products. Alternatively, when Apple originally decided to begin selling its iPod line of MP3 players, it created an entirely new line of business.

Larger firms have research and development (R&D) departments that search for ways to improve existing products and create new ones. These ideas may come from within the R&D department or be based on ideas from executives, sales personnel, or customers. The most common new investment projects might involve taking an existing product and selling it to a new market. That was the case when Kimberly-Clark (KMB), the manufacturer of Huggies, made its disposable diapers more waterproof and began marketing them as disposable swim pants called Little Swimmers. Similarly, the Sara Lee Corporation's (SLE) hosiery unit appealed to more customers when it introduced Sheer Energy pantyhose for support and Just My Size pantyhose aimed at larger-size customers.

Cost-Reducing Investments

The majority of a firm's capital expenditure proposals are aimed at reducing the cost of doing business. For example, Walmart (WMT) did not locate a regional distribution center in San Marcos, Texas, to expand firm revenues; the region was already populated with Walmart stores. Instead, the primary benefit of the distribution center came from lowering the cost of supporting stores within the region.

Other types of cost-reducing investments arise when equipment either wears out or becomes obsolete due to the development of new and improved equipment. For example, Intel's (INTC) semiconductor manufacturing plants (called "fabs") utilize equipment called handlers that move microprocessors from one processing station to another and test their functionality. Because the technology involved in the manufacture of these processors is always evolving, the handlers also change and evolve. This means that Intel is continually evaluating the replacement of existing equipment.

Mandated Investments

Companies frequently find that they must make capital investments to meet safety and environmental regulations. These investments are not revenue-producing or cost-reducing but are required for the company to continue doing business. An example is the scrubbers that are installed on the smokestacks of coal-fired power plants. The scrubbers reduce airborne emissions in order to meet government pollution guidelines.

Not all investments have sufficient potential for value creation to be undertaken, and we need some analytical tools or criteria to help us ferret out the most promising investments. In the pages that follow, we consider the most commonly used criteria for determining the desirability of alternative investment proposals. These include net present value (NPV), a closely related metric called the equivalent annual cost (EAC), the profitability index (PI), the internal rate of return (IRR), the modified internal rate of return (MIRR), the payback period, and the discounted payback period.

Before you move on to 11.2

Concept Check | 11.1

1. What does the term *capital budgeting* mean?
2. Describe the two-phase process typically involved in carrying out a capital-budgeting analysis.
3. What makes a capital-budgeting project a good one?
4. What are the three basic types of capital investment projects?

11.2 Net Present Value

In the introduction to this chapter, we described a simple investment opportunity involving the purchase and sale of a condo. The $8,000 difference between the $100,000 cash inflow from the sale of the condo and the $92,000 investment outlay (the $90,000 cost of buying the condo from your landlord plus $2,000 in painting and repair expenses) is the incremental effect of the investment on your personal wealth. Because both the inflow from the sale and the outflows related to buying and fixing up the condo were only three weeks apart, we ignored the time value of money and compared the inflows directly to the outflows. We determined that the investment is a sound undertaking because it can be sold for more than it cost.

The analysis of most investments requires us to also consider the time value of money. In other words, instead of simply calculating the profits of the investment, we must calculate the investment's *net present value*. The **net present value (NPV)** is the difference between the present values of the cash inflows and the cash outflows. As such, the NPV estimates the amount of wealth that the project creates. The NPV criterion simply states that an investment project should be accepted if the NPV of the project is positive and should be rejected if the NPV of the project is negative.[1]

Why Is the NPV the Right Criterion?

As we discussed in Chapter 1, one of the primary goals of a corporation is to improve the wealth of its shareholders. Because the NPV of an investment measures the impact of the investment opportunity on the value of the firm, it is the gold standard of criteria for evaluating new investment opportunities. However, the NPV is not the only investment criterion that is used. So in addition to describing how the NPV is used to evaluate investment projects, we will describe other criteria that are used in practice and compare each of them to the NPV criterion.

Calculating an Investment's NPV

Most investments that firms make are more complicated than the condo purchase and sale described previously. Firms typically make investments that involve spending cash today with the expectation of receiving cash over a period of several years. They may have a pretty good idea as to how much these investments will cost; however, the expected future cash flows are uncertain and must be discounted back to the present in order to estimate their value. Determining the appropriate discount rate, of what can be thought of as the required rate of return or cost of capital for an investment is not easy, and in Chapter 14, we will look more carefully at the calculation of this rate. In Chapter 12, we will delve into forecasting future cash flows that are based on pro forma or predicted financial statements.

The NPV of an investment proposal can be defined as follows:

$$\text{Net Present Value } (NPV) = \text{Cash Flow for Year 0 } (CF_0) + \frac{\text{Cash Flow for Year 1 } (CF_1)}{\left(1 + \text{Discount Rate } (k)\right)^1} + \frac{\text{Cash Flow for Year 2 } (CF_2)}{\left(1 + \text{Discount Rate } (k)\right)^2} + \cdots + \frac{\text{Cash Flow for Year } n \ (CF_n)}{\left(1 + \text{Discount Rate } (k)\right)^n} \quad \textbf{(11–1)}$$

Cost of making the investment = Initial cash flow (this is typically a cash outflow, taking on a negative value)

Present value of the investment's cash inflows = Present value of the project's future cash inflows

Once we calculate the NPV, we can make an informed decision about whether to accept or reject the project. Reflecting back on our first three principles, you can see that they are all reflected in the NPV: The project's cash flows are used to measure the benefits the project provides (P Principle 3: **Cash Flows Are the Source of Value**), the cash flows are discounted back to the present (P Principle 1: **Money Has a Time Value**), and the discount rate used to discount the cash flows back to the present reflects the risk in the future cash flows (P Principle 2: **There Is a Risk-Return Tradeoff**).

> ***NPV Decision Criterion:*** *If the NPV is greater than zero, the project will add value and should be accepted, but if the NPV is negative, the project should be rejected. If the project's NPV is exactly zero (which is highly unlikely), the project will neither create nor destroy value.*

[1] Note that projects that have a zero NPV earn the required rate of return used to discount the project cash flows and technically are acceptable investments. However, given that we are estimating future cash flows, it is not uncommon for firms to require an "NPV cushion" or a positive NPV. They accomplish this by adding a premium to the discount rate. We discuss this idea further in Chapter 14, where we discuss the determination of the required rate of return or cost of capital.

Tools of Financial Analysis—Net Present Value

Name of Tool	Formula	What It Tells You
Net present value (NPV)	$NPV = \text{Cash Flow for Year 0 } (CF_0) + \dfrac{\text{Cash Flow for Year 1 } (CF_1)}{\left(1 + \text{Discount Rate } (k)\right)^1} + \dfrac{\text{Cash Flow for Year 2 } (CF_2)}{\left(1 + \text{Discount Rate } (k)\right)^2} + \cdots + \dfrac{\text{Cash Flow for Year } n \ (CF_n)}{\left(1 + \text{Discount Rate } (k)\right)^n}$	• An estimate of the value added to shareholder wealth if an investment is undertaken. • In simple terms, the NPV represents the amount by which the value of the investment cash flows exceeds (or falls short of) the cost of making an investment. • Thus, a good project is one that costs less than the value of its future cash flows—that is, one with a positive NPV.

Independent Versus Mutually Exclusive Investment Projects

The settings in which capital-budgeting analysis is carried out can vary. For example, there are times when the firm is considering whether or not to make a single investment and other times when it needs to analyze multiple investment opportunities simultaneously. In the first case, the firm is evaluating what is referred to as an independent investment project. An **independent investment project** is one that stands alone and can be undertaken without influencing the acceptance or rejection of any other project. For example, a firm may be considering whether or not to construct a shipping and handling warehouse in central Kentucky. In the second case, the firm is considering a group of mutually exclusive projects. Accepting a **mutually exclusive project** prevents another project from being accepted. For example, a firm may be interested in investing in an accounting software system and has two viable choices. If the firm decides to take the first system, it cannot take the second system.

Evaluating an Independent Investment Opportunity

Project Long, evaluated in Checkpoint 11.1, demonstrates the use of the NPV to analyze an independent investment opportunity. Because the project is an independent investment opportunity, its analysis entails simply calculating its NPV to see if it is positive or not. If the NPV is positive, the investment opportunity adds value to the firm and should be undertaken.

Evaluating Mutually Exclusive Investment Opportunities

There are times when firms cannot undertake all positive-NPV projects. When this happens, the firm must choose the best project or set of projects from the set of positive-NPV investment opportunities it has before it. Because the firm cannot undertake all of the positive-NPV projects, they must be viewed as mutually exclusive. We will consider two such circumstances in which the firm is faced with choosing from among a set of mutually exclusive projects:

1. **Substitutes.** When a firm is analyzing two or more alternative investments and each performs the same function, the mutually exclusive alternatives are substitutes. For example, a new pizza restaurant needs to buy a pizza oven. The managers consider a number of alternatives, each of which, when viewed in isolation, has a positive NPV. However, they need only one oven. Therefore, when analyzing which particular oven to buy, the pizza restaurant's managers are choosing between mutually exclusive alternatives.
2. **Firm Constraints.** The second reason for mutually exclusive investment opportunities arises when the firm faces constraints that limit its ability to take every project that has a positive NPV. Here are some situations where such constraints arise:

- **Limited managerial time.** The managers may have three projects that look attractive. Although it might be possible to take on all three, the managers are very busy and feel that only one project can be properly implemented at any given time.
- **Limited financial capital.** The managers may be reluctant to issue new equity or to borrow substantial amounts of money from their bank, and as a result, they may need to ration the capital that is readily available. If available investment funds are

Checkpoint 11.1

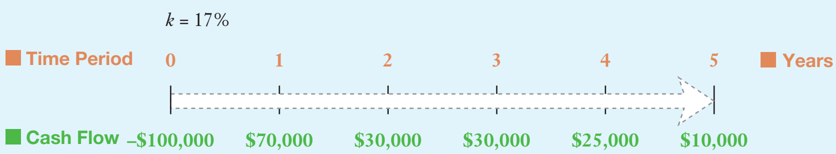
Calculating the Net Present Value for Project Long

Project Long requires an initial investment of $100,000 and is expected to generate cash flows of $70,000 in Year 1, $30,000 per year in Years 2 and 3, $25,000 in Year 4, and $10,000 in Year 5.

The discount rate (*k*) appropriate for calculating the NPV of Project Long is 17 percent. Is Project Long a good investment opportunity?

STEP 1: Picture the problem

Project Long requires an initial investment of $100,000 and is expected to produce the following cash flows over the next five years:



STEP 2: Decide on a solution strategy

Our strategy for analyzing whether this is a good investment opportunity involves first calculating the present value of the cash inflows and then comparing them to the amount of money invested, the initial cash outflow, to see if the difference or the NPV is positive. The NPV for Project Long is equal to the present value of the project's expected cash flows for Years 1 through 5 minus the initial cash outlay (CF_0). We can use Equation (11–1) to solve this problem. Thus, the first step in the solution is to calculate the present value of the future cash flows by discounting the cash flows using $k = 17\%$. Then, from this quantity we subtract the initial cash outlay of $100,000.

We can calculate this present value using the mathematics of discounted cash flow, a financial calculator, or a spreadsheet. We demonstrate all three methods here.

STEP 3: Solve

Using the Mathematical Formulas. Using Equation (11–1),

$$NPV = -\$100{,}000 + \frac{\$70{,}000}{(1+.17)^1} + \frac{\$30{,}000}{(1+.17)^2} + \frac{\$30{,}000}{(1+.17)^3} + \frac{\$25{,}000}{(1+.17)^4} + \frac{\$10{,}000}{(1+.17)^5}$$

Solving the equation, we get

$$\begin{aligned} NPV &= -\$100{,}000 + \$59{,}829 + \$21{,}915 + \$18{,}731 + \$13{,}341 + \$4{,}561 \\ &= -\$100{,}000 + \$118{,}378 \\ &= \$18{,}378 \end{aligned}$$

Using a Financial Calculator. Before using the CF button, make sure you clear your calculator by inputting CF; 2nd; CE/C.

Data and Key Input	Display
CF; –100,000; ENTER	CF0 = –100,000.00
↓; 70,000; ENTER	C01 = 70,000.00
↓; 1; ENTER	F01 = 1.00
↓; 30,000; ENTER	C02 = 30,000.00
↓; 2; ENTER	F02 = 2.00
↓; 25,000; ENTER	C03 = 25,000.00
↓; 1; ENTER	F03 = 1.00
↓; 10,000; ENTER	C04 = 10,000.00
↓; 1; ENTER	F04 = 1.00
NPV; 17; ENTER	I = 17
↓; CPT	NPV = 18,378

Using an Excel Spreadsheet. It should be noted that the NPV function in Excel does *not* compute the net present value that we want to calculate. Instead, the NPV function calculates the present value of a sequence of cash flows using a single discount rate. In addition, the NPV function assumes that the first cash flow argument is for one period in the future (i.e., Period 1), so you *do not* want to incorporate the initial cash flow (CF_0) in the NPV function—instead, use the NPV function to calculate the present value of the cash flows, and then adjust for the initial cash flow (CF_0), which is generally a negative number. Specifically, the inputs of the NPV function are the following for Project Long:

= NPV (discount rate, CF_1, CF_2, CF_3, CF_4, CF_5) + CF_0 or, with values entered, =

NPV (0.17,70000,30000,30000,25000,10000) − 100000 = $18,378

Type this formula into a cell in a spreadsheet.

And this answer will appear in the cell.

Thus, using the NPV function, we calculate the NPV of the investment to be $18,378.

STEP 4: Analyze

Project Long requires an initial investment of $100,000 and provides future cash flows that have a present value of $118,378. Consequently, the project cash flows are $18,378 more than the required investment. Because the project's future cash flows are worth more than the initial cash outlay required to make the investment, the project is an acceptable project.

STEP 5: Check yourself

Saber Electronics is considering providing specialty manufacturing services to defense contractors located in the Seattle, Washington, area. The initial outlay is $3 million, and management estimates that the firm might generate cash flows for Years 1 through 5 equal to $500,000, $750,000, $1,500,000, $2,000,000, and $2,000,000. Saber uses a 20 percent discount rate for projects of this type. Is this a good investment opportunity?

ANSWER: NPV = $573,817.

Your Turn: For more practice, do the NPV calculations for **Study Problems** 11–1, 11–6, 11–8, 11–12, 11–19, and 11–26 at the end of this chapter.

>> END Checkpoint 11.1

limited to a fixed dollar amount that is less than the total amount of money required to fund all positive-NPV projects, the firm will engage in **capital rationing**. This means that the managers will need to choose between alternative investments that all have positive NPVs.

In either of the above situations, one might think that the investment opportunity with the highest NPV should be chosen. This intuition is often correct, but there are some important exceptions. In particular, it is sometimes better to choose a project with a lower NPV if the life of the project is shorter. With a shorter payback, the firm ties up its capital for less time. Intuitively, one might think in terms of the NPV created per year as a metric for evaluating a project. One might also want to choose projects that require less managerial time and less capital.

Later in this chapter, we will describe popular alternative methods for evaluating investment projects in situations where firms must choose between mutually exclusive projects because capital is rationed. In the Appendices in MyLab Finance, we consider an example of a firm that must choose between two alternative investments that serve the same purpose.

Choosing Between Mutually Exclusive Investments

This section is relatively complex and can be skipped without loss of continuity. In fact, many students find the material to be somewhat easier if they return to it after finishing the chapter.

When comparing mutually exclusive investments that have the same useful life, we simply calculate the NPVs of the alternatives and choose the one with the higher NPV. However, it is often the case that mutually exclusive investments have different useful lives. For example, one alternative might last for 10 years, while the other lasts only 6 years. This often occurs when the firm is considering the replacement of a piece of equipment where the alternatives have different initial costs to purchase, different useful lives, and different annual costs of operations. The decision the firm must make is which alternative is most cost-effective.

Before we can decide which alternative to select, we must determine whether we will need this piece of equipment forever. That is, at the end of its useful life, will we buy another one? If not, we can simply compare alternatives with different lives by calculating the NPV of each alternative and choosing the piece of equipment with the higher NPV. However, if we expect this new piece of equipment to be replaced over and over again with a similar piece of equipment with the same NPV for each replication of the investment, then we must calculate the **equivalent annual cost (EAC)**. The EAC is sometimes referred to as the equivalent annual annuity (EAA). The EAC capital-budgeting technique provides an estimate of the annual cost of owning and operating the investment over its lifetime. We can then compare the EACs of two or more alternatives and select the most cost-effective alternative. The power of the EAC is that it incorporates the time value of money, the initial cash outlay, and the productive life of the investment all in a single number that can be compared across alternative investments.

The EAC of the equipment can be calculated as follows:

- First, we calculate the sum of the present values of the project's costs, including the project's initial cost and the costs the firm will incur to operate the equipment over its projected lifespan. Remember, in this case the revenues are the same for both of the alternatives we are considering, so the free cash flows for the alternative investments are all negative (thus the name *equivalent annual cost*).
- Next, we convert the present value of the costs into its annual equivalent, which is the EAC of the investment.

The EAC is simply the cost per year, and this is what we will use to compare the two alternatives because the revenues are the same, regardless of which alternative is chosen. You will notice that the calculations are the same as those we did earlier in Chapter 6 when we calculated the installment payment on a loan (PMT). In this case, the EAC is the payment (PMT) for an installment loan with the loan value amount (PV) equal to the present value of the project's costs. Thus, EAC can be calculated as follows:[2]

$$\text{Equivalent Annual Cost } (EAC) = \frac{PV \text{ of Costs}}{\text{Annuity Present Value Interest Factor}} = \frac{CF_0 + \dfrac{CF_1}{(1+k)^1} + \dfrac{CF_2}{(1+k)^2} + \cdots + \dfrac{CF_n}{(1+k)^n}}{\left(\dfrac{1}{k} - \dfrac{1}{k(1+k)^n}\right)} = \frac{NPV}{\left(\dfrac{1}{k} - \dfrac{1}{k(1+k)^n}\right)} \qquad \textbf{(11–2)}$$

We can also solve for EAC using a financial calculator as follows:

Enter	Number of Years	Discount Rate	PV of Costs		0
	N	I/Y	PV	PMT	FV
Solve for				EAC	

Step 1. Calculate the present value of the annual operating costs for the equipment over one life cycle of the project and add this sum to the initial cost of the equipment.

Step 2. Divide the present value of the costs (calculated in step 1) by the annuity present value interest factor (note the abbreviated formula for this present value interest factor found in Equation (11–2)). You can think of the numerator of Equation (11–2) as an amount of money that you might borrow to purchase a new car and the EAC as your annual car payment.

[2]This is the same formulation for the annuity present value interest factor used in Chapter 5, where the numerator has been divided by the denominator (k).

Checkpoint 11.2

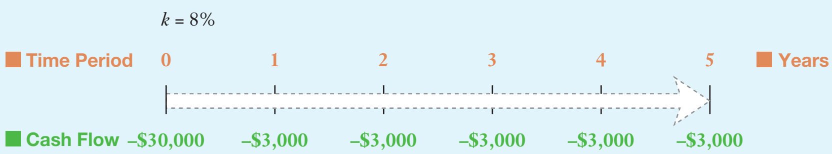
Calculating the Equivalent Annual Cost

Suppose your bottling plant needs a new bottle capper. You are considering two different capping machines that will perform equally well but that have different expected lives. The more expensive one costs \$30,000 to buy, requires a payment of \$3,000 per year for maintenance and operation expenses, and will last for five years. The cheaper model costs only \$22,000, requires operating and maintenance costs of \$4,000 per year, and lasts for only three years. Regardless of which machine you select, you intend to replace it at the end of its life with an identical machine with identical costs and operating performance characteristics. Because there is not a market for used cappers, there will be no salvage value associated with either machine. Let's also assume that the discount rate on both of these machines is 8 percent.

STEP 1: Picture the problem

You are considering two alternative pieces of equipment, one with a five-year life and one with a three-year life:

Project Long (Five-Year Life):



Project Short (Three-Year Life):

STEP 2: Decide on a solution strategy

The question we need to answer is which capping machine offers the lowest cost per year of operation. We can use a calculator to determine the EAC for each piece of equipment, which will tell us the cost per year for each alternative, and then choose the one with the lower cost.

STEP 3: Solve

Using the Mathematical Formulas. The present value of the costs of the five-year project can be calculated using a slightly modified version of Equation (11–1) (solving for PV of costs instead of NPV) as follows:

$$
\begin{aligned}
PV \text{ of Costs} &= CF_0 + \frac{CF_1}{(1+k)^1} + \frac{CF_2}{(1+k)^2} + \frac{CF_3}{(1+k)^3} + \frac{CF_4}{(1+k)^4} + \frac{CF_5}{(1+k)^5} \\
&= -\$30{,}000 + \frac{-\$3{,}000}{(1+.08)^1} + \frac{-\$3{,}000}{(1+.08)^2} + \frac{-\$3{,}000}{(1+.08)^3} + \frac{-\$3{,}000}{(1+.08)^4} + \frac{-\$3{,}000}{(1+.08)^5} \\
&= -\$41{,}978
\end{aligned}
$$

Similarly, for the three-year project we calculate the present value of the costs as follows:

$$
\begin{aligned}
PV \text{ of Costs} &= CF_0 + \frac{CF_1}{(1+k)^1} + \frac{CF_2}{(1+k)^2} + \frac{CF_3}{(1+k)^3} \\
&= -\$22{,}000 + \frac{-\$4{,}000}{(1+.08)^1} + \frac{-\$4{,}000}{(1+.08)^2} + \frac{-\$4{,}000}{(1+.08)^3} \\
&= -\$32{,}308
\end{aligned}
$$

Now that we have the present values of the projects' costs, we can compute the EAC for each, which is the annual cash flow that is equivalent to the present value of the costs. For the five-year project, the EAC is

$$
EAC_{\text{Long project}} = \frac{PV \text{ of Costs}}{\text{Annuity Present Value Interest Factor}} = \frac{-\$41{,}978}{\frac{1}{.08}\left(1 - \frac{1}{(1+.08)^5}\right)} = -\$10{,}514
$$

The three-year project's EAC can be computed in the same way:

$$EAC_{\text{Short project}} = \frac{PV \text{ of Costs}}{\text{Annuity Present Value Interest Factor}} = \frac{-\$32{,}308}{\frac{1}{.08}\left(1 - \frac{1}{(1+.08)^3}\right)} = -\$12{,}537$$

We are not going to go through the steps used to solve for EAC here because a financial calculator can be used to solve the problem quite easily.

Using a Financial Calculator. First, after clearing your calculator, calculate the present value of the cost for one life cycle of each project.

Project Long:

Data and Key Input	Display
CF; −30,000; ENTER	CF0 = −30,000.00
↓; −3,000; ENTER	C01 = −3,000.00
↓; 5; ENTER	F01 = 5.00
NPV; 8; ENTER	I = 8
↓ CPT	NPV = −41,978

Project Short:

Data and Key Input	Display
CF; –22,000; ENTER	CF0 = −22,000.00
↓; –4,000; ENTER	C01 = −2,000.00
↓; 3; ENTER	F01 = 3.00
NPV; 8; ENTER	I = 8
↓ CPT	NPV = −32,308

Note that the present values of the costs of both pieces of equipment are negative because we are calculating the present values of the costs.

Second, we calculate the values of the annuity payments over the project's life that would produce the same present values of the costs that you just calculated.

Project Long:

Enter	5	8.0	-41,978		0
	N	I/Y	PV	PMT	FV
Solve for				10,514	

$$EAC_{\text{Long project}} = -\$10{,}514$$

Project Short:

Enter	3	8.0	-32,308		0
	N	I/Y	PV	PMT	FV
Solve for				12,537	

$$EAC_{\text{Shotr project}} = -\$12{,}537$$

STEP 4: Analyze

We can see that the EAC associated with the longer-lived machine, –$10,514, is less than the EAC for the shorter-lived machine, –$12,537; thus, we should purchase the longer-lived machine. In effect, it is the less-expensive alternative even though it costs more to purchase originally. The reason this works out is that by spending the extra money required to buy the longer-lived machine, we do not have to repeat the purchase for five years; in contrast, the shorter-lived machine, although cheaper to purchase, must be replaced every three years. This is not always the case, however, as it depends on the cost of acquiring the longer-lived machine and the annual operating costs.

(11.2 CONTINUED >> ON NEXT PAGE)

The EAC decision criterion is generally applied to mutually exclusive projects where the only difference is in the length of life and the costs. Thus, with the EAC we ignore cash inflows because they are identical. However, if the mutually exclusive projects produce different cash inflows, we can still use this technique, but rather than calculating the present value of each project's costs (which would have a negative value), we calculate each project's NPV (which should have a positive value) and select the project with the highest EAC.

STEP 5: Check yourself

What is the EAC for a machine that costs $50,000, requires an annual payment of $6,000 for maintenance and operation, and lasts for six years? You may assume that the discount rate is 9 percent and that there will be no salvage value associated with the machine. In addition, you intend to replace this machine at the end of its life with an identical machine with identical costs.

ANSWER: EAC = –$17,146.

Your Turn: For more practice, do related **Study Problem** 11–4 at the end of this chapter. >> **END Checkpoint 11.2**

Tools of Financial Analysis—Equivalent Annual Cost (or Equivalent Annual Annuity)

Name of Tool	Formula	What It Tells You
Equivalent annual cost (EAC) or equivalent annual annuity (EAA)	$EAC = \dfrac{PV \text{ of All Cash Flows}}{\text{Annuity Present Value Interest Factor}} = \dfrac{CF_0 + \dfrac{CF_1}{(1+k)^1} + \dfrac{CF_2}{(1+k)^2} + \cdots + \dfrac{CF_n}{(1+k)^n}}{\left(\dfrac{1}{k} - \dfrac{1}{k(1+k)^n}\right)} = \dfrac{NPV}{\left(\dfrac{1}{k} - \dfrac{1}{k(1+k)^n}\right)}$	• An estimate of the annualized present value of a project's cash flows. • Where all project cash flows are negative, then the lower the EAC is, the less costly the project is to operate per year. • For a normal project with positive future cash flows, the EAC is the annualized NPV of the project. This metric is sometimes used to compare projects that have different initial costs and different useful lives.

Before you move on to 11.3

Concept Check | 11.2

1. Describe what the NPV tells the analyst about a new investment opportunity.
2. What is the equivalent annual cost (EAC) measure, and when should it be used?
3. What is capital rationing?

11.3 Other Investment Criteria

Although the NPV investment criterion makes the most sense in theory, in practice financial managers use a number of criteria to evaluate investment opportunities. Criteria that we explore in this section include the profitability index, internal rate of return, modified internal rate of return, and payback period.

Profitability Index

The **profitability index (PI)** is a cost-benefit ratio equal to the present value of an investment's future cash flows divided by its initial cost:[3]

$$\text{Profitability Index } (PI) = \left(\begin{array}{c}\text{Present Value of}\\ \text{Future Cash Flows}\end{array}\right) \div \left(\begin{array}{c}\text{Initial Cash}\\ \text{Outlay}\end{array}\right)$$

[3]While the initial outlay is a negative value because it is an outflow, we do not give it a negative sign in calculating the PI. Instead, the initial outlay is entered as a positive value, since we are interested only in the ratio of benefits to costs.

or

$$\text{Profitability Index } (PI) = \frac{\dfrac{\text{Cash Flow for Year 1 } (CF_1)}{\left(1 + \text{Discount Rate } (k)\right)^1} + \dfrac{\text{Cash Flow for Year 2 } (CF_2)}{\left(1 + \text{Discount Rate } (k)\right)^2} + \cdots + \dfrac{\text{Cash Flow for Year } n \ (CF_n)}{\left(1 + \text{Discount Rate } (k)\right)^n}}{\text{Initial Cash Outlay } (-CF_0)} \quad \textbf{(11–3)}$$

A PI greater than 1 indicates that the present value of the investment's future cash flows exceeds the cost of making the investment, so the investment should be accepted. For the condo investment we discussed in the introduction, the PI is equal to 1.087 = \$100,000/\$92,000.

Note that when computing the PI, we use a positive value for the initial cash outlay (CF_0). This is done so that the PI is a positive ratio. Technically, because the initial outlay for most investments is a cash outflow, the sign on this number is negative.

The PI is closely related to the NPV because it uses the same inputs: the present value of the project's future cash flows and the initial cash outlay. The PI is a ratio of these two quantities, and the NPV is the difference between them:

$$\text{Profitability Index } (PI) = \text{Present Value of Future Cash Flows} \div \text{Initial Cash Outlay}$$

and

$$\text{Net Present Value } (NPV) = \text{Present Value of Future Cash Flows} - \text{Initial Cash Outlay}$$

> ***NPV Decision Criterion:*** *When the PI is greater than 1, the NPV will be positive, so the project should be accepted. When the PI is less than 1, the NPV will be negative, which indicates a bad investment, so the project should be rejected.*

The PI of an investment is always greater than 1 for all positive-NPV projects and is always less than 1 for all negative-NPV projects. Thus, for independent projects, the NPV criterion and the PI criterion are exactly the same. However, for mutually exclusive projects that have different costs, the criteria may provide different rankings. For example, suppose that Project 1 costs \$200,000 and has future cash flows with a present value of \$250,000 and that Project 2 costs \$500,000 and has future cash flows with a present value of \$600,000. Project 2 has the higher NPV: \$100,000 versus \$50,000 for Project 1. But Project 1 has the higher PI: 1.25 versus 1.20 for Project 2.

Firms with easy access to capital prefer the NPV criterion because it measures the amount of wealth created by the investment. However, if the firm's management have a limited amount of capital and cannot undertake all of its positive-NPV investments, the PI offers a useful way to rank investment opportunities to determine which ones to accept. The PI is useful in this setting because, unlike the NPV, it measures the amount of wealth created per dollar invested.

Tools of Financial Analysis— Profitability Index

Name of Tool	Formula	What It Tells You
Profitability index (PI)	$PI = \dfrac{\text{Present Value of Future Cash Flows}}{\text{Initial Cash Outlay } (CF_0)} = \dfrac{\dfrac{\text{Cash Flow for Year 1 } (CF_1)}{\left(1 + \text{Discount Rate } (k)\right)^1} + \dfrac{\text{Cash Flow for Year 2 } (CF_2)}{\left(1 + \text{Discount Rate } (k)\right)^2} + \cdots + \dfrac{\text{Cash Flow for Year } n \ (CF_n)}{\left(1 + \text{Discount Rate } (k)\right)^n}}{\text{Initial Cash Outlay } (CF_0)}$	• Sometimes referred to as the cost-benefit ratio, the PI is a relative valuation measure. • A PI ratio greater than 1 indicates that the project's cash flows are more valuable than the cost of making the investment. • If the PI is greater than 1, then the NPV is greater than 0, so the NPV and the PI provide the same signal as to whether a project creates shareholder value.

Internal Rate of Return

The **internal rate of return (IRR)** of an investment is analogous to the yield to maturity (YTM) on a bond, which we defined in Chapter 9. Specifically, the IRR is the discount rate that results in a zero NPV for the project. For example, if you invest \$100 today in a project expected to return \$120 in one year, the IRR for the investment is 20 percent. We can show that this is correct by discounting the \$120 cash flow one year at 20 percent, which results in a present value equal to the initial cash outlay of \$100 ($CF_0 = -100$). The result, then, is an NPV of zero.

$$\text{Net Present Value} = \text{Cash Flow for Year 0 } (CF_0) + \frac{\text{Cash Flow for Year 1 } (CF_1)}{\left(1 + \text{Internal Rate of Return } (IRR)\right)^1} = 0$$

$$0 = -\$100 + \frac{\$120}{(1 + IRR)}$$

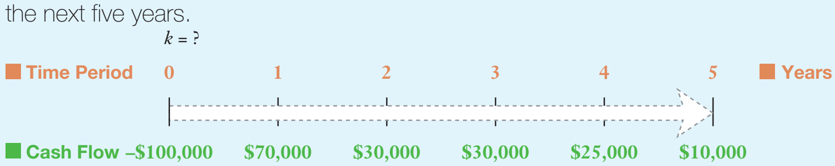
Checkpoint 11.3

Calculating the Profitability Index for Project Long

Project Long is expected to provide five years of cash inflows and to require an initial investment of \$100,000. The discount rate that is appropriate for calculating the PI of Project Long is 17 percent. Is Project Long a good investment opportunity? (See Checkpoint 11.1 for cash flow details.)

STEP 1: Picture the problem

Project Long requires an initial investment of \$100,000 and is expected to produce the following cash flows over the next five years.

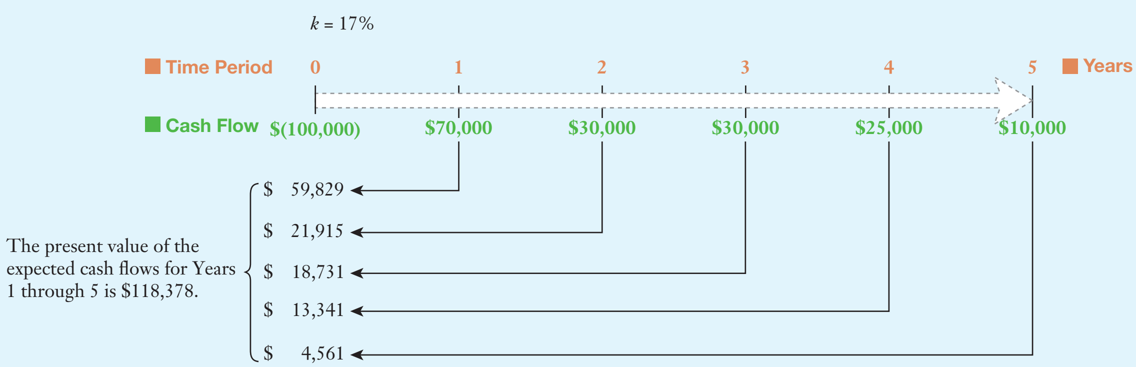


STEP 2: Decide on a solution strategy

The PI for Project Long is equal to the present value of the project's expected cash flows for Years 1 through 5 divided by the negative value of the initial cash outlay ($-CF_0$). Thus, the first step in the solution is to calculate the present value of the future cash flows, discounting those cash flows using $k = 17\%$. We then divide this quantity by \$100,000. Note that although the initial cash outlay is a negative number, we make it positive when we divide so that the PI comes out positive.

STEP 3: Solve

In Checkpoint 11.1, we demonstrated how to calculate the present value of Project Long's future cash flows using the time-value-of-money formulas, a financial calculator, and a spreadsheet. Thus, we only summarize the results of these calculations below:



Present value of cash flows for Years 1 – 5 =	\$ 118,378
Less: Initial cash outlay =	\$(100,000)
Equals: Net present value =	\$ 18,378
Profitability index = \$118,378/100,000 =	1.18378

STEP 4: Analyze

Project Long requires an initial investment of $100,000 and provides future cash flows that have a present value of $118,378. Consequently, the project's future cash flows are worth 1.18378 times the initial investment. Because the project's future cash flows are worth more than the initial cash outlay required to create the investment, this is an acceptable project.

STEP 5: Check yourself

PNG Pharmaceuticals, Inc., is considering an investment in a new automated materials handling system that is expected to reduce its drug manufacturing costs by eliminating much of the waste currently involved in its specialty drug division. The new system will require an initial investment of $50,000 and is expected to provide cash savings over the next six-year period as follows:

Year	Expected Cash Flow
Initial outlay (Year 0)	$(50,000)
Year 1	15,000
Year 2	8,000
Year 3	10,000
Year 4	12,000
Year 5	14,000
Year 6	16,000

PNG uses a 10 percent discount rate to evaluate investments of this type. Should PNG go forward with the investment? Use the PI to evaluate the project.

ANSWER: PI = 1.0733.

Your Turn: For more practice, do related **Study Problem** 11–26 at the end of this chapter. >> **END Checkpoint 11.3**

For investments that offer more than one year of expected cash flows, the calculation is a bit more tedious. Mathematically, we solve for the internal rate of return for a multiple-period investment by solving for IRR, which is the unknown discount rate in the following equation that makes the present value of the investment cash flows (the initial outlay and future cash flows) equal to zero. In other words, using the IRR as the discount rate makes the NPV equal to zero:

$$\text{Net Present Value} = \text{Cash Flow for Year 0 } (CF_0) + \frac{\text{Cash Flow for Year 1 } (CF_1)}{\left(1 + \text{Internal Rate of Return } (IRR)\right)^1} + \frac{\text{Cash Flow for Year 2 } (CF_2)}{\left(1 + \text{Internal Rate of Return } (IRR)\right)^2} + \cdots + \frac{\text{Cash Flow for Year } n \ (CF_n)}{\left(1 + \text{Internal Rate of Return } (IRR)\right)^n} = 0 \quad \textbf{(11–4)}$$

Solving for IRR when there are multiple future periods can be done in several ways, which we demonstrate in Checkpoint 11.4.

IRR Decision Criterion: *Accept the project if the IRR is greater than the required rate of return or discount rate used to calculate the net present value of the project, and reject it otherwise.*

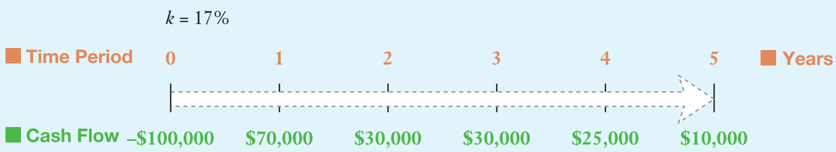
Checkpoint 11.4

Calculating the Internal Rate of Return for Project Long

Project Long is expected to provide five years of cash inflows and to require an initial investment of $100,000. The required rate of return or discount rate that is appropriate for valuing the cash flows of Project Long is 17 percent. What is Project Long's IRR, and is it a good investment opportunity?

STEP 1: Picture the problem

Project Long requires an initial investment of $100,000 and is expected to produce the following cash flows over the next five years.

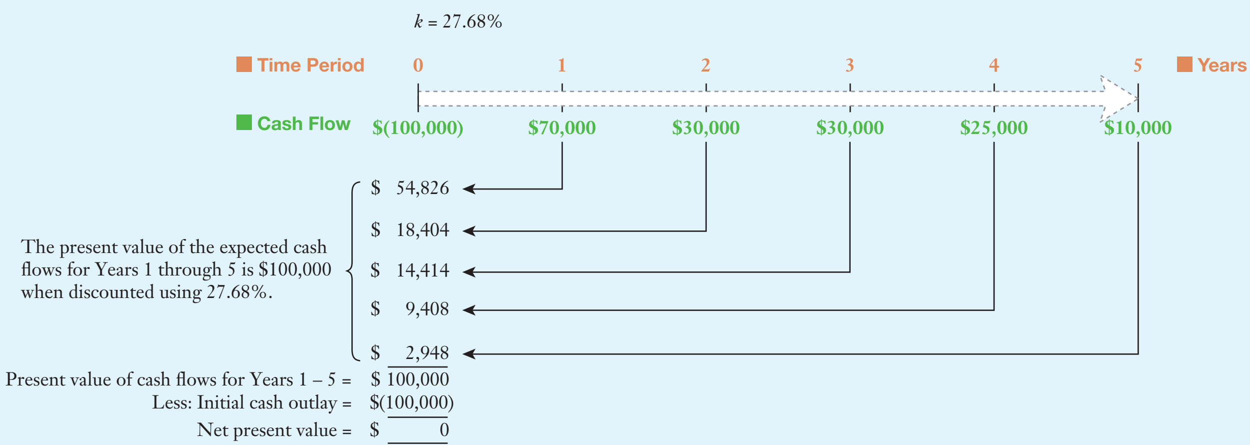


STEP 2: Decide on a solution strategy

With projects that provide multiple cash flows received over many years, calculating a single rate of return requires that we estimate the project's IRR. Specifically, the IRR for Project Long is the discount rate that makes the present value of Project Long's future cash flows equal, in absolute terms, to the initial cash outflow of $100,000. We could solve for this discount rate by trial and error—that is, by experimenting with different discount rates to find the one that satisfies our definition of NPV. However, as we demonstrate here, this can be very time-consuming. Luckily, we can use either a financial calculator or a spreadsheet program such as Microsoft Excel to solve for the IRR. We illustrate both of these methods here.

STEP 3: Solve

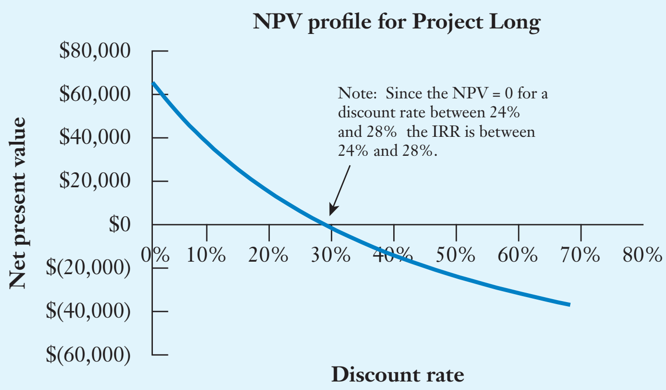
Before we demonstrate the solution methods, let's first take a look at the solution, which we will find to be 27.68 percent. Discounting the project cash flows for Years 1 through 5 back to the present using the IRR, which is 27.68 percent, we see that the resulting NPV is 0.



Using the Mathematical Formulas. To solve for the IRR by hand, we follow a trial-and-error approach. Using this method, we must calculate the NPV using many different discount rates until we find the discount rate that produces a zero NPV. For example, if we were to calculate the NPV for discount rates starting with 0 percent and increasing in increments of 4 percent up to 68 percent, we would get the following set of results (note that we have cheated here and used an Excel spreadsheet to reduce the tedium of making all these NPV calculations).

Discount Rate	Computed NPV
0%	$ 65,000
4%	$ 51,304
8%	$ 39,532
12%	$ 29,331
16%	$ 20,428
20%	$ 12,603
24%	**$ 5,683**
28%	**$ (473)**
32%	$ (5,978)
36%	$ (10,926)
40%	$ (15,394)
44%	$ (19,445)
48%	$ (23,133)
52%	$ (26,504)
56%	$ (29,595)
60%	$ (32,439)
64%	$ (35,063)
68%	$ (37,492)

NPV = 0



Notice that the computed NPV approaches a value of zero where we use a discount rate between 24 and 28 percent. This graph of NPVs and different discount rates is called the NPV profile of the project (we will have more to say about this profile later). We can calculate the IRR directly using either a financial calculator or spreadsheet, as we now demonstrate.

Using a Financial Calculator.

Data and Key Input	Display
CF; –100,000; ENTER	CF0 = −100,000.00
↓; 70,000; ENTER	C01 = 70,000.00
↓ ; 1; ENTER	F01 = 1.00
↓ ; 30,000; ENTER	C02 = 30,000.00
↓; 2; ENTER	F02 = 2.00
↓; 25,000; ENTER	C03 = 25,000.00
↓; 1; ENTER	F03 = 1.00
↓; 10,000; ENTER	C04 = 10,000.00
↓; 1; ENTER	F04 = 1.00
IRR; CPT	IRR = 27.68%

Using an Excel Spreadsheet. Cell B10 contains the Excel formula for the IRR calculation, which appears as = IRR (B3:B8). The only inputs to the IRR function in Excel are the project cash flows.[4]

	A	B
1		Annual
2	Year	Cash Flows
3	0	$(100,000)
4	1	70,000
5	2	30,000
6	3	30,000
7	4	25,000
8	5	10,000
9		
10	IRR =	27.68%

Entered equation in Cell B10: = IRR(B3:B8)

What appears in the spreadsheet, then, is the IRR of 27.68 percent.

(11.4 CONTINUED >> ON NEXT PAGE)

[4]Actually, the IRR function will appear with a final input option for [guess], which allows you to enter a guess as to what the IRR may be. However, this is typically not needed for Excel to calculate the IRR.

STEP 4: Analyze

Project Long requires an initial investment of $100,000 and provides future cash flows that offer a return on this investment of 27.68 percent. Because we have decided that the minimum rate of return we need to earn on this investment is 17 percent, it appears that Project Long is an acceptable investment opportunity.

STEP 5: Check yourself

Knowledge Associates, a small consulting firm in Portland, Oregon, is considering the purchase of a new copying center for the office that can copy, fax, and scan documents. The new machine costs $10,010 to purchase and is expected to provide cash flow savings over the next four years of $1,000, $3,000, $6,000, and $7,000. The employee in charge of performing a financial analysis of the proposed investment has decided to use the IRR as her primary criterion for making a recommendation to the managing partner of the firm. If the required rate of return or discount rate the firm uses to value the cash flows from office equipment purchases is 15 percent, is this a good investment for the firm?

ANSWER: IRR = 19 percent.

Your Turn: For more practice, do related **Study Problems** 11–9, 11–12, 11–19, and 11–26 at the end of this chapter.

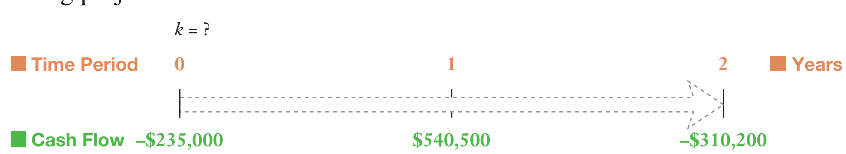
>> **END Checkpoint 11.4**

Complications with the IRR: Multiple Rates of Return

An investment project will always have only one NPV. However, in some situations an investment project can have more than one IRR. We can trace the reasons for this to the calculations involved in determining the IRR. In Equation (11–4), we defined the IRR as the discount rate that results in an NPV calculation of zero:

$$NPV = CF_0 + \frac{CF_1}{(1+IRR)^1} + \frac{CF_2}{(1+IRR)^2} + \frac{CF_3}{(1+IRR)^3} + \cdots + \frac{CF_n}{(1+IRR)^n} = 0 \quad \textbf{(11–4)}$$

When the first cash flow is negative (the initial investment) and the subsequent cash flows are positive, there is one unique IRR. However, there can be multiple values for the IRR that solve Equation (11–4) when at least one of the later cash flows is negative.[5] Consider, for example, the following project:



In Checkpoint 11.5, we calculate the IRR for this project and find that both 10 and 20 percent solve this problem.

Which solution (IRR) is correct? The answer is that neither solution is valid. Although each fits the definition of the IRR, neither provides the true project returns. In summary, when there is more than one sign reversal in the cash flow stream, the possibility of multiple IRRs exists, and when there are multiple IRRs, we can no longer use this investment criterion to evaluate the project. Fortunately, NPV is not subject to this problem.

Using the IRR with Mutually Exclusive Investments

IRRs are often used by managers to select among mutually exclusive investments. A complication can arise in this setting, since there often are ranking conflicts between the NPV and the IRR of the evaluated projects. That is, although both mutually exclusive projects may have positive NPVs and IRRs greater than their required rates of return, one project may have a

[5] To be specific, there can be as many IRRs as there are changes in the sign of the cash flows over the *n*-year project life. Technically, the multiple IRR problem arises out of the fact that the IRR we calculate is actually the solution to an *n*th degree polynomial equation, where *n* is the number of years over which cash flows are produced by the project (and, consequently, the highest exponent in the equation). The seventeenth-century philosopher René Descartes gave us Descartes' Rule of Signs, which can be used to tell us the maximum number of IRRs that a given project can produce. Here's how it works: There can be a different IRR for each sign change in a project's cash flows over its *n*-year life. For example, Project Long only has one sign change: In Year 0, the project has a negative $100,000 cash outlay, followed in Year 1 by a positive $70,000. The project can therefore have a maximum of one IRR. Note that the Rule of Signs says a project can have a *maximum* number of IRRs equal to the number of sign changes, but the actual number of IRRs may be fewer.

higher NPV, whereas the other has a higher IRR. When this is the case, which criterion should we go with, the higher NPV or the higher IRR?

For example, Apex Engineering is considering the purchase of an automated accounting system. Two software systems are being considered that will perform the same functions, Automated Accounting Plus (AA+) and Business Basics Reporting (BBR). The cash flows from the AA+ system grow over time because this system offers the user the opportunity to expand functionality. The cash flows for the BBR system, on the other hand, decline over time as the initial cost savings are captured in the early years of implementation. The expected cash flows of the two systems are found in Panel A of Figure 11.1.

Note that both accounting systems provide positive NPVs using the firm's 15 percent discount rate or required rate of return. This suggests that one of the two systems should indeed be purchased. However, the AA+ system, which offers an NPV of $412,730 compared to $370,241 for the BBR alternative, has the lower IRR (38 percent compared to 52 percent). Why do the two criteria provide different answers? It is because the larger cash flows come earlier for the BBR system. The BBR system earns a very high return—but over a shorter period of time. The fact that the BBR system uses the firm's capital over a shorter time period may be relevant if there are constraints on the firm's ability to raise capital (that is, if capital is being rationed). However, if the firm has unlimited access to external capital markets, the project with the higher NPV should be chosen.

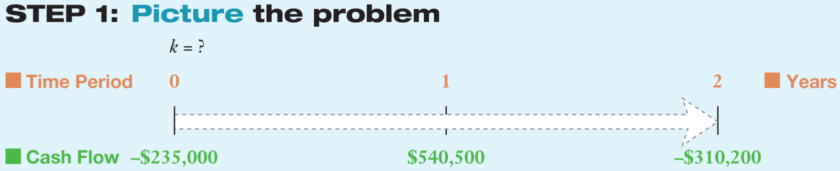
To examine this more closely, we will look at each project's **NPV profile**, a graph of its NPV using required rates of return ranging from 0 percent to 65 percent. As shown in Panel B of Figure 11.1, for discount rates below 19.5 percent, the AA+ system offers higher NPVs, and for higher discount rates, the BBR system has higher NPVs. This implies that if the appropriate required rate of return for the projects is less than 19.5 percent and the firm is not capital-constrained, the AA+ system should be taken. However, if the firm is capital-constrained and is likely to have opportunities with IRRs greater than 19.5 percent in the near future, it may want to take the BBR system, which allows it to recover its capital sooner.

Checkpoint 11.5

The Problem of Multiple Internal Rates of Return for Projects

Descartes' Rule of Signs tells us that there can be as many IRRs for an investment project as there are changes in the sign of the cash flows over its *n*-year life. To illustrate the problem, consider a project that has three cash flows: a –$235,000 outlay in Year 0, a $540,500 inflow in Year 1, and a –$310,200 outflow at the end of Year 2. Calculate the IRR for the investment.

STEP 1: Picture the problem



STEP 2: Decide on a solution strategy

To solve the problem, we determine the discount rate that makes the NPV = 0 by constructing an NPV profile for the project. In this instance, we use discount rates in increments of 2 percent ranging from 0 percent to 30 percent.

STEP 3: Solve

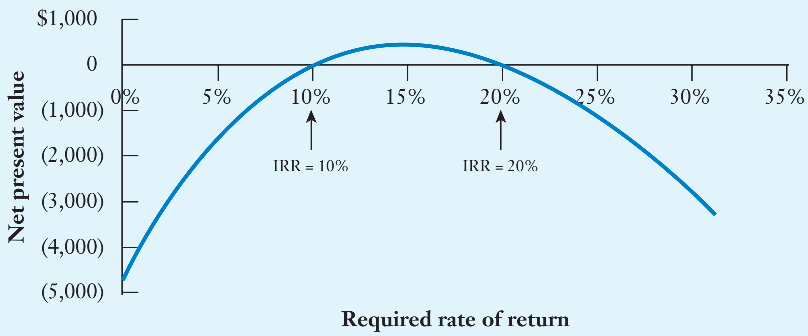
We calculate the discount rate that makes the investment's NPV = 0 using discount rates ranging from 0 percent to 30 percent. For example, the NPV for a 10 percent discount rate is calculated using Equation (11–1) as follows:

$$NPV = CF_0 + \frac{CF_1}{(1+k)^1} + \frac{CF_2}{(1+k)^2} \quad \textbf{(11–1)}$$

$$= -\$235{,}000 + \frac{\$540{,}500}{(1+.10)^1} + \frac{-\$310{,}200}{(1+.10)^2} = 0$$

(11.5 CONTINUED >> ON NEXT PAGE)

Discount Rate	Net Present Value
0%	$(4,700)
2%	$(3,253)
4%	$(2,086)
6%	$(1,171)
8%	$ (484)
10%	$ 0
12%	$ 300
14%	$ 434
16%	$ 419
18%	$ 270
20%	$ 0
22%	$ (379)
24%	$ (856)
26%	$(1,421)
28%	$(2,065)
30%	$(2,781)



STEP 4: Analyze

There are two IRRs for this project: 10 percent and 20 percent. This results from the fact that there are two sign changes in the project cash flows. At this point we can turn to NPV to evaluate the investment opportunity or use a modified version of IRR which is discussed in the next section.

STEP 5: Check yourself

Suppose that the firm considering the above investment is able to pay an additional $65,000 in Year 0, which pays for cleanup expenses at the end of the project's life in Year 3. In its previous analysis, the firm estimated these costs to be $100,000, so the Year 3 cash outflow is reduced to $210,200. What is your estimate of the firm's NPV and IRR for the project based on the renegotiated cash flows?

ANSWER: The revised cash flows result in an NPV of $14,572 and an IRR of 23.07%. Moreover, a review of the NPV profile for the project reveals that there is but one IRR.

>> **END Checkpoint 11.5**

Tools of Financial Analysis—Internal Rate of Return

Name of Tool	Formula	What It Tells You
Internal rate of return (IRR)	$\left(\begin{array}{c}\text{Present Value}\\ \text{of Future Cash Flows}\\ \text{Discounted Using } IRR\end{array}\right) = 0$ Note that the IRR is the discount rate that makes the NPV equal to zero.	• The compound annual rate of return earned on an investment. • An IRR greater than the required rate of return for the investment signals a good investment. • The IRR is analogous to the yield to maturity (YTM) on a bond defined in Chapter 9.

Modified Internal Rate of Return

As we discovered earlier, in cases where there is more than one IRR for a particular project, the IRR criterion is less useful. In order to eliminate the problem of multiple IRRs, the **modified internal rate of return (MIRR)** was developed. *The idea behind the MIRR is to rearrange the project cash flows so that there is only one IRR. We do this by modifying the project cash flows so there is just one change in the sign of the cash flows over the life of the project.* This can be accomplished by discounting all the negative cash flows after the initial cash outflow back to Year 0 and adding them to the initial cash outflow. This process is described as follows:

STEP 1. Modify the project cash flow stream by discounting the negative future cash flows back to the present using the required rate of return (that is, the discount rate that is used to calculate the project's NPV). The present value of

Figure 11.1

Ranking Mutually Exclusive Investments: NPV Versus IRR

Apex Engineering is considering the purchase of an automated accounting system and is trying to decide between the AA+ and BBR systems. Both systems have the same cost, but because of functionality differences, the patterns of cash flows are quite different. Apex uses a 15 percent required rate of return or discount rate to evaluate its investments.

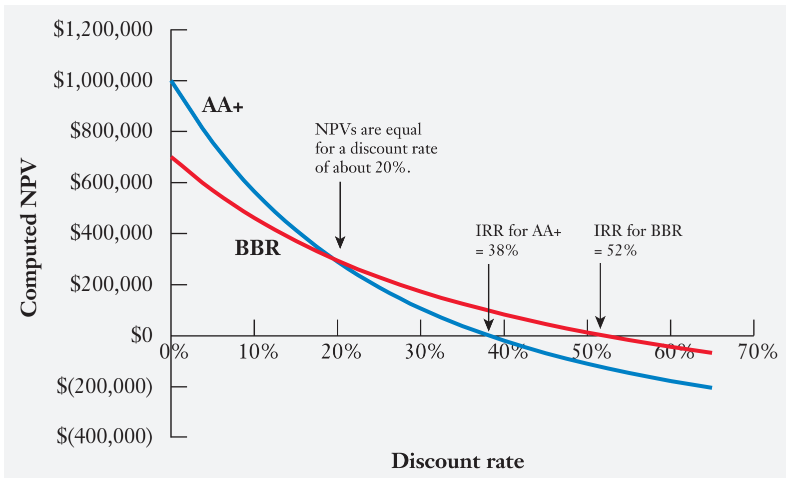
(Panel A) Expected Cash Flows

Year	AA+	BBR
0	$(500,000)	$(500,000)
1	100,000	400,000
2	200,000	300,000
3	300,000	200,000
4	400,000	200,000
5	500,000	100,000
NPV	$412,730	$370,241
IRR	38%	52%

- Both alternatives have positive NPVs and IRRs that exceed Apex's 15% required rate of return.
- However, the projects are ranked differently using NPV or IRR: AA+ has the higher NPV, while BBR has a higher IRR.
- The ranking difference is due to the effect of discounting and the difference in the patterns of the cash flows for the two projects.
- AA+'s cash flows increase over time, while BBR's decrease.
- Higher discount rates have a disproportionate effect on present values, as we see in Panel B.

(Panel B) NPV Profiles

Discount Rate	AA+	BBR
0%	$1,000,000	$700,000
5%	$ 756,639	$568,722
10%	$ 565,259	$460,528
15%	$ 412,730	$370,241
20%	$ 289,673	$294,046
25%	$ 189,280	$229,088
30%	$ 106,532	$173,199
35%	$ 37,680	$124,709
40%	$ (20,111)	$ 82,317
45%	$ (69,011)	$ 44,998
50%	$ (110,700)	$ 11,934
55%	$ (146,489)	$ (17,531)
60%	$ (177,414)	$ (43,930)
65%	$ (204,298)	$ (67,701)



(Panel C) Estimating the Break-Even Discount Rate

Year	Cash Flows		Differential Cash Flows
	AA+	BBR	BBR − AA+
0	$(500,000)	$(500,000)	$ 0
1	100,000	400,000	$ 300,000
2	200,000	300,000	$ 100,000
3	300,000	200,000	$(100,000)
4	400,000	200,000	$(200,000)
5	500,000	100,000	$(400,000)

IRR of the Differential Cash Flows = 19.5%

- Using a 19.5% discount rate, the two projects have exactly the same NPV.
- For discount rates lower than this break-even 19.5% rate, AA+ has the higher NPV, whereas for higher discount rates BBR has the higher NPV.
- Trust NPV. Given the discount rate appropriate for valuing project cash flows, NPV gives the correct ranking of projects!

>> END FIGURE 11.1

these future negative cash flows is then added to the initial outlay to form a modified project cash flow stream in which all the cash outflows have been moved back to Year 0.

STEP 2. Calculate the MIRR as the IRR of the modified cash flow stream. We add the "modified" to IRR because the MIRR is based on a *modified* set of cash flows.

Let's reconsider Checkpoint 11.5, where there were two sign changes. Checkpoint 11.6 illustrates how we can eliminate the sign changes by discounting the negative cash flow in Year 2 back to the present and combining it with the Year 0 initial cash outlay. The IRR of the modified cash flows, or MIRR, of 12.07 percent exceeds the 12 percent required rate of return or discount rate used to value the project cash flows, which indicates the project is a good one.

To close our discussion of the MIRR, here are some summary points and caveats concerning its use:

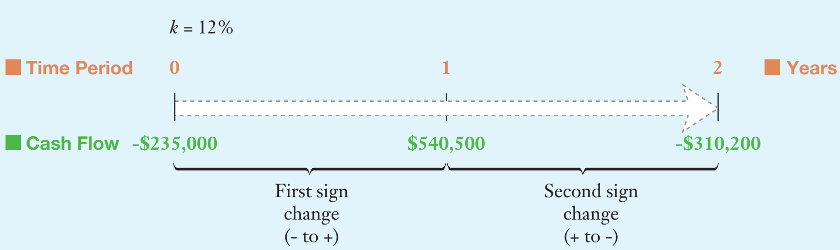
- **There is more than one way to compute the MIRR, and each method can potentially result in a different value for the MIRR.** In our example, we discounted the project's negative cash flows back to the present using the project's required rate of return and then computed the MIRR from the modified cash flows. An alternative is to discount the negative future cash flows to the present using the risk-free rate, which has the effect of increasing the present value of the negative cash flows and thus lowering the IRR of the entire cash flow stream. Some analysts prefer this approach because it reduces the level of the MIRR and thereby provides a more conservative criterion when the cost of capital is high and the cash flows are very uncertain.
- **The NPV is our capital-budgeting method of choice. Unlike the IRR criterion, the NPV approach is always straightforward and provides an estimate of the dollar value created by investing in the project.** This is true whether or not a unique estimate of the IRR can be calculated.

Checkpoint 11.6

Calculating the Modified Internal Rate of Return

Reconsider the investment project in Checkpoint 11.5. The project we analyzed has three cash flows: a –$235,000 outlay in Year 0, a $540,500 cash inflow in Year 1, and a –$310,200 outflow at the end of Year 2. Our analysis in Checkpoint 11.5 indicated that this investment has two IRRs, 10 percent and 20 percent. One way to reduce the number of IRRs to only one is to use the MIRR method. We can do this in this example by moving the final negative cash flow to the present by discounting it at 12 percent, which is the required rate of return for the project.

STEP 1: Picture the problem

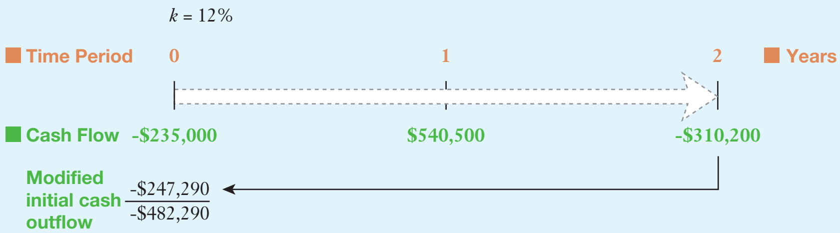


STEP 2: Decide on a solution strategy

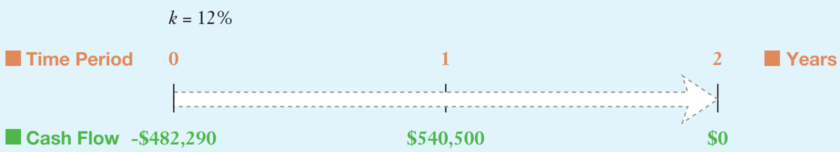
There are two sign changes in this cash flow stream. To implement the MIRR method, we can discount the Year 2 negative cash flow back to Year 0 using the 12 percent discount rate used to calculate the NPV and then calculate the MIRR of the resulting cash flows for Years 0 and 1.

STEP 3: Solve

Discount the Year 2 negative cash flow back to Year 0 and add it to the Year 0 initial cash outlay, which produces a modified initial cash outflow for Year 0 of –$482,290 (–$235,000 – $247,290):



The modified cash flows of the investment are as follows:



Calculating the IRR for these modified cash flows produces the MIRR of 12.07 percent.

STEP 4: Analyze

By eliminating the second sign change that occurs between Year 1's positive cash flow and Year 2's negative cash flow, the computation of an IRR using the modified cash flow stream yields a single IRR that we refer to as the MIRR. The MIRR is not the same as the IRR because it is based on modified cash flows that have been moved around in time using the discount rate used to both value project cash flows and calculate the NPV (which is not used in the IRR). Consequently, although the MIRR does produce a single rate-of-return estimate for the project, it depends on the discount rate used to move the cash flows from period to period and is no longer intrinsic to the project. For example, if the required rate of return had been 14 percent in this example, the MIRR would have been 14.10 percent (not 12.07 percent). The NPV, on the other hand, does not suffer from the multiple IRR problem and yields consistent results even in the face of multiple sign changes.

STEP 5: Check yourself

Assume the required rate of return used to discount the cash flows in this example is changed to 8 percent. What is the MIRR?

ANSWER: Using the 8 percent discount rate results in a MIRR of 7.90 percent. Note that the project has a negative NPV of –$483.54 for this lower required rate of return. Can you explain why the NPV goes negative when the discount rate is lowered? (Hint: Reducing the discount rate from 12 percent to 8 percent makes the present value of the negative cash flow in Year 2 much larger.)

Your Turn: For more practice, do related **Study Problems** 11–14, 11–17, and at the end of this chapter. **>> END Checkpoint 11.6**

Tools of Financial Analysis—Modified Internal Rate of Return

Name of Tool	Formula	What It Tells You
Modified internal rate of return (MIRR)	$\left(\begin{array}{c}\text{Present Value}\\ \text{of Negative Cash Flows}\\ \text{Discounted Using Cost of Capital}\end{array}\right) + \left(\begin{array}{c}\text{Present Value}\\ \text{of Positive Cash Flows}\\ \text{Discounted Using } MIRR\end{array}\right) = 0$ This formula is solved using the following two steps: **STEP 1.** Modify the project cash flow stream by discounting the negative future cash flows back to the present using the required rate of return (that is, the discount rate that is used to calculate the project's NPV). **STEP 2.** Calculate the MIRR as the IRR of the modified cash flow stream.	• The compound annual rate of return earned on the "modified" cash flows for a project where cash flows have been modified to eliminate the possibility of getting more than one IRR. • Project cash flows are modified by discounting all the negative cash flows back to Year 0 using the project's discount rate and then adding them to the initial cash outflow before computing the IRR of the modified cash flows or MIRR.

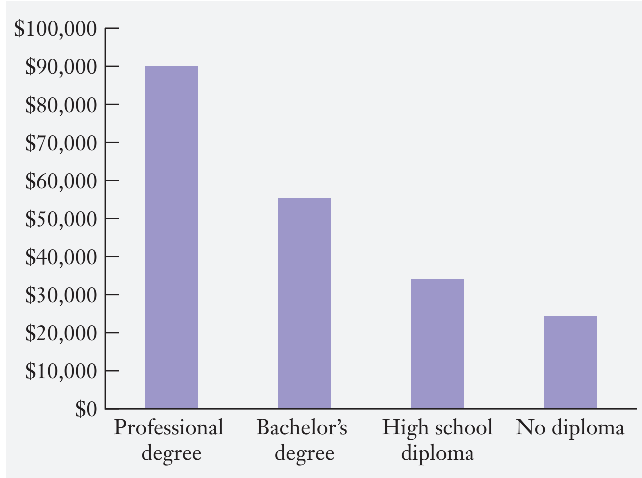
Finance for Life

Higher Education as an Investment in Yourself

Your decision to pursue a college education, and specifically a business degree, can be viewed as an investment decision. After all, to go to college you must delay entering the workforce for four to six years (or sometimes longer), and you are likely to spend between $10,000 and $40,000 per year, depending on whether you attend a public or private college or university.* Financially speaking, is it worth it? We should hasten to point out that having a college education can (and should) enrich your life in ways that are not reflected in the amount of money you earn. However, for our purposes, let's concentrate on the financial implications of getting a college degree.

According to the U.S. Department of Labor's Bureau of Labor Statistics, in 2012 the average annual earnings for workers ranged from only $24,492 per year for workers with no high school diploma to $90,120 for those with professional degrees. Simply having a high school diploma increased earnings by over $9,000 a year, and a bachelor's degree almost doubled earnings for high school grads.

The salaries reported in the diagram above are for all degrees and across the complete spectrum of years of experience (new hires to those close to retirement). What about business degrees and starting salaries in particular? For undergraduate business majors in the class of 2012, the average starting salary was $53,900. This would suggest that down the road, after some experience, having a business degree would produce much higher average earnings than the $53,900 reported starting salary for all majors.



Average Earnings by Education Level, 2012

Source: U.S. Department of Labor, Bureau of Labor Statistics, Employment Projection (2012).

We do not have to do a lot of calculations to figure out that education pays. For example, the average earnings differential of $21,530 between the holder of a bachelor's degree and that of a high school diploma ($55,432 – $33,902), spread over a 45-year working life and discounted using a 5 percent discount rate, produces a present value at the end of college of $382,676 and has a present value of $314,828 today (assuming you are in college for four years). If the present value of the benefits of a college education is $314,828, what does it cost? Assuming that the cost of attending college is $15,000 for a public college and $35,000 for a private college, the present values of the costs of attending college are ($53,189) and ($124,108), respectively. There's one more important cost of attending college that we must consider, and that's lost earnings while in college. If we assume that the student would be earning $20,000 per year for all four years he or she was not in college (this is approximately the minimum wage), the present value of four years of lost income is ($70,919). Adding up the costs of college (tuition and lost income), the present value cost of a public college degree is $124,108 while that of a private college degree is $195,027. Comparing these costs with the present value of future benefits yields an NPV of $190,720 for obtaining a bachelor's degree from a public college. Similarly, the NPV is $119,801 for obtaining a bachelor's degree from a private college.

Your Turn: **See Study Question 11-11.**

*This is the average cost of attending a public four-year college. The average cost of attending a private college was $35,074 in 2012–2013.
Source: http://nces.ed.gov/fastfacts/display.asp?id = 76, accessed February 11, 2016.

Payback Period

The **payback period** for an investment opportunity is the number of years needed to recover the initial cash outlay required to make the investment. For example, suppose Exec Corporation was deciding whether to spend $8 million for a new software system that would allow it to monitor the daily production from its thousands of operating oil and gas wells. If the new automated system was to reduce the costs of monitoring production by $4 million a year, the payback period for the investment would be only two years. Similarly, if the savings were only $2 million per year, the payback period would be four years. If the savings were not the same each year, the company would simply cumulate them over time until they reached the total investment outlay of $8 million. In this case, the payback period is often not an even number of years. For example, if the savings for the first three years of the investment were $4 million, $3 million, and $2 million, the payback period would equal 2.5 years. The company would recover $7 million of the investment during the first two years and the remaining $1 million from half of the third year's savings—thus, a 2.5-year payback.

Payback Period Decision Criterion: *Accept the project if the payback period is less than a prespecified maximum number of years.*

The payback criterion measures how quickly the project will return its original investment, which is a very useful piece of information to have when evaluating a risky investment. Specifically, the longer the firm has to wait to recover its investment, the more things that can happen that might reduce or eliminate the benefits of making the investment. However, using the payback period as the sole criterion for evaluating whether to undertake an investment has three fundamental limitations:

Limitation 1. The payback period calculation ignores the time value of money, treating, for example, cash flows three years from now the same as cash flows in one year.

Limitation 2. The payback period method ignores cash flows that are generated by the project beyond the end of the payback period.

Limitation 3. There is no clear-cut way to define the cutoff criterion for the payback period that is tied to the value-creation potential of the investment.

To illustrate these limitations of the payback period method, consider the cash flows for Project Long and Project Short found in Table 11.1. Both projects require an initial cash outlay of $100,000, and we assume that the payback criterion being used to evaluate the projects is three years. Note that although both projects have the same payback period of two years, which is shorter than the cutoff criteria of three years, we would clearly prefer Project Long to Project Short for the following reasons:

1. Regardless of what happens after the payback period, Project Long returns the initial investment earlier within the payback period (i.e., $70,000 in Year 1 as compared to only $50,000 for Project Short).
2. Project Long generates $65,000 in cash flows during Years 3 through 5, whereas Project Short provides no cash flows after the payback period.

Discounted Payback Period

To deal with the criticism that the payback period method ignores the time value of money, some firms use the **discounted payback period** approach. The discounted payback period approach is similar to that of the traditional payback period except that it uses discounted cash flows (using the same discount rate used in calculating the NPV) to calculate the payback period. Thus, the discounted payback period is defined as the number of years needed to recover the initial cash outlay from the discounted cash flows.

Discounted Payback Period Decision Criterion: *Accept the project if its discounted payback period is less than the prespecified number of years.*

If we assume that the discount rate for Projects Long and Short is 17 percent, the discounted cash flows calculated for these projects are as shown in Table 11.2. After two years, Project Long still needs $18,256 in present value dollars to achieve payback. Therefore, payback occurs when approximately 97 percent of Year 3's discounted cash flow is received (i.e., $18,256/$18,731). Thus, Project Long has a discounted payback period of 2.97 years. Project Short, on the other hand, never achieves discounted payback, as the cumulative present value of its cash flows falls $20,739 short of the initial investment at the end of its life in Year 2. Clearly, the discounted payback period method is an improvement over the straight payback period method.

Table 11.1 Limitations of the Payback Period Criterion

Limitations of the payback period as an investment criteria include the following:

a. Does not account for the time value of money

b. Does not consider cash flows beyond the payback period

c. Utilizes an arbitrary cutoff criterion

The payback period equals two years for both projects because it takes two years to recover the cost of the initial outlay from the cash inflows. However, Project Long looks a lot better because it continues to provide cash inflows after the payback year.

	Project Long		Project Short	
	Annual Cash Flow	Cumulative Cash Flow	Annual Cash Flow	Cumulative Cash Flow
Initial cash outlay	$(100,000)	$(100,000)	$(100,000)	$(100,000)
Year 1	70,000	(30,000)	50,000	(50,000)
Year 2	**30,000**	**0**	**50,000**	**0**
Year 3	30,000	30,000	0	0
Year 4	25,000	55,000	0	0
Year 5	10,000	65,000	0	0

Table 11.2 Discounted Payback Period Example (discount rate = 17%)

The standard payback period method does not account for the time value of money; the discounted payback period method discounts investment cash flows back to the present before cumulating them to calculate payback.

The discounted payback period equals 2.97 years for Project Long. Three years of discounted cash flows sum to a positive $476. However, since we need to sum to 0, we do not need a full three years of discounted cash flows (we need $18,256/$18,731 = .97 of Year 3's cash inflow).

Project Long

	Annual Cash Flow	Cumulative Cash Flow	Discounted Cash Flow	Cumulative Discounted Cash Flow
Initial cash outlay	$(100,000)	$(100,000)	$(100,000)	$(100,000)
Year 1	70,000	(30,000)	59,829	(40,171)
Year 2	**30,000**	**0**	**21,915**	**(18,256)**
Year 3	30,000	30,000	18,731	476
Year 4	25,000	55,000	13,341	13,817
Year 5	10,000	65,000	4,561	18,378

Discounted payback is *never* achieved for Project Short. The discounted cash flows never cumulate to equal zero.

Project Short

	Annual Cash Flow	Cumulative Cash Flow	Discounted Cash Flow	Cumulative Discounted Cash Flow
Initial cash outlay	$(100,000)	$(100,000)	$(100,000)	$(100,000)
Year 1	50,000	(50,000)	42,735	(57,265)
Year 2	**50,000**	**0**	**36,526**	**(20,739)**
Year 3	–	–	–	(20,739)
Year 4	–	–	–	(20,739)
Year 5	–	–	–	(20,739)

Although the deficiencies of the payback criterion do limit the usefulness of the payback period and discounted payback period methods as tools for investment evaluation, these methods have several positive features as supplemental tools for evaluating investment opportunities in conjunction with net present value:

1. For many individuals, both the payback and the discounted payback period methods are more intuitive and easier to understand than other decision criteria such as NPV.

2. The payback period is often used as a crude indicator of project risk because payback favors projects that produce significant cash flows in the early years of a project's life, which, in general, are less risky than more distant cash flows.
3. The discounted payback period method is used as a supplemental analytical tool in instances where obsolescence is a risk; the method provides insights about whether a company will get its money back in today's dollars before the market disappears or the product is obsolete.
4. Managers often find the payback period method useful when capital is being rationed; the method provides insights about how long the company's capital will be tied up in the project.

Tools of Financial Analysis—Payback Measures

Name of Tool	Formula	What It Tells You
Payback period	The number of years of project cash flows that are required to recover the initial cash investment in the project.	• The number of years needed to recover the initial cash outlay for the investment. • Project cash flows are summed but not discounted to determine the payback period. • There is no hard-and-fast rule for determining the minimum payback period, however.
Discounted payback period	The number of years of discounted project cash flows that are required to recover the initial cash investment in the project. Future cash flows are discounted using the cost of capital for the investment.	• The discounted payback period method sums the present value of future cash flows to determine payback. • There is no hard-and-fast rule for determining the minimum discounted payback period, however.

Summing Up the Alternative Decision Rules

We have reviewed six different decision rules that are used by businesses to evaluate new investment alternatives. The NPV decision rule, which considers the expected impact of an investment alternative on shareholder value, is generally the preferred rule for making investment decisions. However, as we have discussed, there are a number of other techniques that enjoy widespread use. Table 11.3 summarizes each of these methods, providing a definition of each method, a description of its investment decision rule, and some brief comments concerning the pros and cons of the methodology.

Before you move on to 11.4

Concept Check | 11.3

1. Describe what the IRR metric tells the analyst about a new investment opportunity.
2. Describe the situations in which the NPV and IRR metrics can provide conflicting signals.
3. What is the modified internal rate of return metric, and why is it sometimes used?
4. What is the payback period method, and what is the source of its appeal?
5. What is the discounted payback period method, and how does it improve on the payback period measure?

11.4 A Glance at Actual Capital-Budgeting Practices

During the past 50 years, the popularity of each of the capital-budgeting methods we have discussed here has shifted rather dramatically. In the 1950s and 1960s, the payback period method dominated all other capital-budgeting metrics; however, in recent years the internal rate of return and the net present value techniques have gained in popularity and today are used by virtually all major corporations.

Table 11.3 Basic Capital-Budgeting Techniques

These are the primary capital-budgeting techniques or criteria that are used in industry practice. Of these techniques, net present value, or NPV, offers the best single indicator of the investment alternative's potential contribution to the value of the firm.

Investment Criterion	Definition	Decision Rule	Advantages	Disadvantages
Net present value (NPV)	The present value of expected cash inflows minus the present value of expected cash outflows.	Accept investments that have a positive NPV.	Is theoretically correct in that it measures directly the increase in value that the project is expected to produce. Measures the increase in shareholder wealth expected from undertaking the project being analyzed.	Is somewhat complicated to compute (requires an understanding of the time value of money). Is not familiar to managers without formal business education.
Equivalent annual cost (EAC) or equivalent annual annuity (EAA)	The annual cost that is equivalent in present value to the initial cost and annual cash flows of an investment.	Select the investment alternative that has the lowest annual cost.	Provides a tool that can be used to account for different initial costs of purchase, different annual costs of operation, and different productive lives.	Should be used only where the investments being compared are expected to be used indefinitely. For single-use investments, the NPV is appropriate.
Profitability index (PI)	The present value of expected future cash flows divided by the initial cash investment.	When the PI is greater than 1, the NPV will be positive, so the project should be accepted. When PI is less than 1, the NPV will be negative, which indicates a bad investment, and the project should be rejected.	Is theoretically correct in that it measures directly the increase in value that the project is expected to produce. Is useful when rank ordering positive-NPV projects where capital is being rationed.	Is not as familiar to managers as the NPV. Does not add any additional information to the NPV.
Internal rate of return (IRR)	The discount rate that makes the NPV equal to zero.	Accept the project if the IRR is greater than the required rate of return or discount rate used to calculate the net present value of the project, and reject it otherwise.	Provides a rate-of-return metric, which many managers prefer.	Cannot always be estimated. Sometimes provides multiple rates of return for projects with multiple changes in the sign of their cash flows over time. Can provide results that conflict with the NPV for mutually exclusive projects.
Modified internal rate of return (MIRR)	The discount rate that makes the NPV of the modified cash flow stream equal to zero.	Accept the project if the MIRR is greater than the required rate of return or discount rate used to calculate the net present value of the project, and reject it otherwise.	Always produces a single rate-of-return estimate.	The rate of return produced by the MIRR is not unique to the project because it is influenced by the discount rate used to discount the negative cash flows.
Payback period	The number of years required to recover the initial cash outlay out of project future cash flows.	If the project payback period is less than the maximum the firm will accept, the project is acceptable.	Is easy to understand and calculate. Indicates risk by showing how long it takes to recover the investment.	Ignores the time value of money. Ignores cash flows beyond the payback period. There is no rational way to determine the cutoff value for payback.
Discounted payback period	The number of years required to recover the initial cash outlay out of project *discounted* future cash flows.	If the discounted project payback period is less than the maximum the firm will accept, the project is acceptable.	Same as payback period. Also, by discounting the cash flows, this measure takes into account the time value of money.	Same as the last two items above. Also, because cash inflows must be discounted, discounted payback is more complicated to compute than payback.

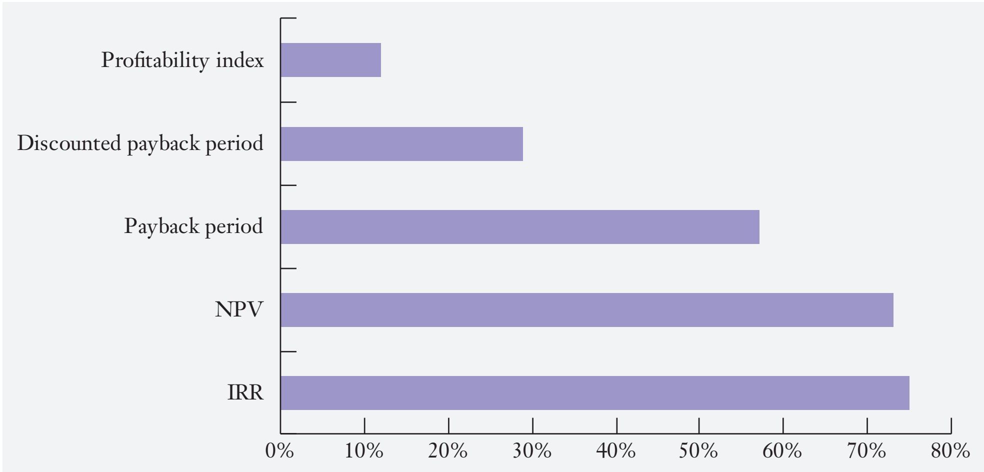
Figure 11.2 provides the results of a survey of the chief financial officers (CFOs) of large U.S. firms, showing the popularity of the payback period, discounted payback period, NPV, PI, and IRR methods for evaluating capital investment opportunities. The results show that the IRR and NPV methods are by far the most widely used methods, although more than half the firms surveyed did use the payback period method. The survey reported that larger firms tended to use the NPV and IRR more frequently than their smaller counterparts and that the smaller firms tended to rely more on the payback period.

The popularity of the payback period may derive from its simplicity; however, an alternate explanation is that it is used in combination with the NPV or IRR as a secondary method to control for project risk. The logic behind this is that the payback period method emphasizes early-period cash inflows, which are generally more certain—have less risk—than cash inflows occurring later in a project's life. Managers believe its use will lead to projects with more certain cash flows.

Figure 11.2

Survey of the Popularity of Capital-Budgeting Methods

These survey results are based on the survey responses of 392 chief financial officers of large U.S. firms. These CFOs were asked if they used any of the following standard techniques. Specifically, they were asked how frequently they used different capital-budgeting techniques on a scale of 0 to 4 (with 0 meaning "never," 1 "almost never," 2 "sometimes," 3 "almost always," and 4 "always"). The results below are the percentages of the CFOs who said they always or almost always used a particular method.



Source: John Graham and Campbell Harvey, "How Do CFOs Make Capital Budgeting and Capital Structure Decisions?" *Journal of Applied Corporate Finance* 15, no. 1 (Spring 2002): 8–23.

>> END FIGURE 11.2

Before you begin end-of-chapter material

Concept Check | 11.4

1. What is the most widely used measure of capital budgeting in business practice?
2. How does the payback period method provide an indication of the risk of an investment proposal?

Applying the Principles of Finance to Chapter 11

P Principle 1: **Money Has a Time Value** The value of an asset or an investment proposal is equal to the present value of the future cash flows, discounted at the required rate of return. As a result, Principle 1 plays a pivotal role in making investment decisions.

P Principle 2: **There Is a Risk-Return Tradeoff** Different projects have different levels of risk associated with them, and we deal with this by increasing the discount rate when calculating the present value of the project's future cash flows.

P Principle 3: **Cash Flows Are the Source of Value** The calculation of the value of an asset or an investment proposal begins with an estimation of the amount and timing of expected future cash flows. These free cash flows are then discounted back to present at the required rate of return.

P Principle 5: **Individuals Respond to Incentives** Managers respond to the incentives, and when their incentives are not properly aligned with those of the firm's stockholders, they may not make investment decisions that are consistent with increasing shareholder value.

Chapter Summaries

11.1 Understand how to identify the sources and types of profitable investment opportunities. (pgs. 362–364)

SUMMARY: Before a profitable project can be adopted, it must be identified. In general, the best source of ideas for potentially profitable investments is the firm itself. Specifically, the firm's marketing and operations employees are rich sources of investment ideas.

Concept Check | 11.1

1. What does the term *capital budgeting* mean?
2. Describe the two-phase process typically involved in carrying out a capital-budgeting analysis.
3. What makes a capital-budgeting project a good one?
4. What are the three basic types of capital investment projects?

11.2 Evaluate investment opportunities using the net present value and describe why it is the best measure to use. (pgs. 364–372)

SUMMARY: The net present value (NPV) of an investment proposal is equal to the present value of its cash flows (including the initial cash outlay in Year 0, CF_0):

$$NPV = CF_0 + \frac{CF_1}{(1+k)^1} + \frac{CF_2}{(1+k)^2} + \cdots + \frac{CF_n}{(1+k)^n} \quad \textbf{(11–1)}$$

where CF_t is the *expected* cash flow for periods t equal to 0, 1, 2, and so forth; k is the required rate of return or discount rate used in calculating the present value of the project's expected future cash flows; and n is the last cash flow used to value the investment opportunity. If the computed NPV is greater than zero, this indicates that the project creates value for the firm and its shareholders and therefore is an acceptable investment opportunity.

KEY TERMS

Capital rationing, page 368 A situation in which a firm's access to capital is limited, so it is unable to undertake all projects that have positive NPVs.

Equivalent annual cost (EAC), page 369 The annuity cash flow amount that is equivalent to the present value of the project's costs.

Independent investment project, page 366 An investment project whose acceptance will not affect the acceptance or rejection of any other project.

Mutually exclusive projects, page 366 Related or dependent investment proposals where the acceptance of one proposal means the rejection of the other.

Net present value (NPV), page 364 The difference in the present value of an investment proposal's future cash flows and the initial cash outlay. This difference is the expected increase in the value of the firm due to the acceptance of the project.

Concept Check | 11.2

1. Describe what the NPV tells the analyst about a new investment opportunity.
2. What is the equivalent annual cost (EAC) measure, and when should it be used?
3. What is capital rationing?

KEY EQUATIONS

$$\text{Net Present Value or } (NPV) = \text{Cash Flow for Year 0 } (CF_0) + \frac{\text{Cash Flow for Year 1 } (CF_1)}{\left(1 + \text{Discount Rate } (k)\right)^1} + \frac{\text{Cash Flow for Year 2 } (CF_2)}{\left(1 + \text{Discount Rate } (k)\right)^2} + \cdots + \frac{\text{Cash Flow for Year } n \ (CF_n)}{\left(1 + \text{Discount Rate } (k)\right)^n} \quad \textbf{(11–1)}$$

Cost of making the investment = Initial cash flow (this is typically a cash outflow, taking on a negative value)

Present value of the investment's cash inflows = Present value of the project's future cash inflows

$$\text{Equivalent Annual Cost } (EAC) = \frac{NPV}{(1+k)^1 + (1+k)^2 + \cdots + (1+k)^n} = \frac{NPV}{\text{Present Value of an Annuity Discount Factor}}$$

$$= \frac{NPV}{\left(\frac{1}{k} - \frac{1}{k(1+k)^n}\right)} \quad \textbf{(11–2)}$$

11.3 Use the profitability index, internal rate of return, and payback criteria to evaluate investment opportunities. (pgs. 372–387)

SUMMARY: The profitability index (PI) is closely related to the NPV. Specifically, instead of subtracting the initial cash outlay from the present value of future cash flows, the PI *divides* the present value of the future cash flows by the negative of the initial outlay, CF_0. The profitability index can be expressed as follows:

$$\text{Profibility Index (PI)} = \frac{\text{Present Value of Future Cash Flows}}{\text{Initial Cash Outlay}}$$

Using the symbols we used earlier to define NPV, we define the PI as follows:

$$PI = \frac{\frac{CF_1}{(1+k)^1} + \frac{CF_2}{(1+k)^2} + \frac{CF_3}{(1+k)^3} + \cdots + \frac{CF_n}{(1+k)^n}}{-\,CF_0} \quad \textbf{(11–3)}$$

The decision criterion is this: Accept the project if the PI is greater than 1.00, and reject the project if the PI is less than 1.00.

The internal rate of return (IRR) attempts to answer this question: "What rate of return is an investment expected to earn?" For computational purposes, the IRR is defined as the discount rate that results in an NPV of zero:

$$NPV = CF_0 + \frac{CF_1}{(1+IRR)^1} + \frac{CF_2}{(1+IRR)^2} + \frac{CF_3}{(1+IRR)^3} + \cdots + \frac{CF_n}{(1+IRR)^n} = 0 \quad \textbf{(11–4)}$$

The decision rule for using the IRR is the following: Accept the project if the IRR is greater than the required rate of return, which is equal to the discount rate used to value (discount) the project's future cash flows, and reject the project if the IRR is less than this discount rate.

There are circumstances, however, where the IRR cannot be calculated or where there are multiple discount rates that satisfy the definition of the IRR in Equation (11–4). The problem of multiple estimates of the IRR arises when project cash flows change signs multiple times over the life of the project. Some firms that want to use a rate-of-return criterion have adopted the use of the modified internal rate of return (MIRR) as a means to avoid the problem of multiple IRRs. The MIRR addresses this problem by combining cash flows until there is only one sign change. Specifically, negative cash flows are discounted back to Year 0 using the discount rate used in calculating the NPV before calculating the MIRR of the altered cash flow pattern.

The payback period criterion measures how quickly the project will return its original investment, and this is a very useful piece of information because it indicates something about the risk of the investment. The longer the firm has to wait to recover its investment, the more things that can happen that might reduce or eliminate the benefits of making the investment. However, using the payback period as the sole criterion for evaluating whether to undertake an investment has three fundamental limitations. First, the payback period calculation ignores the time value of money, as it does not require that the future cash flows be discounted back to the present. Second, it does not take into account how much cash flow is expected to be generated by the project beyond the end of the payback period. Finally, there is no clear-cut way to define the cutoff criterion for the payback period that is tied to the value-creation potential of the investment.

To deal with the criticism that the payback period method ignores the time value of money, some firms use the discounted payback period approach. The discounted payback period method is similar to that of the traditional payback period except that it uses discounted cash flows to calculate the payback period. Thus, the discounted payback period is defined as the number of years needed to recover the initial cash outlay from the discounted cash flows. However, the discounted payback period approach still ignores cash flows beyond the payback period, and there is still no clear-cut way to define the cutoff criterion for discounted payback.

KEY TERMS

Discounted payback period, page 385 The number of years required for a project's discounted cash flows to recover the initial cash outlay for an investment.

Internal rate of return (IRR), page 374 The compound annual rate of return earned by an investment.

Modified internal rate of return (MIRR), page 380 The compound annual rate of return earned by an investment whose cash flows have been moved through time so as to eliminate the problem of multiple IRRs. For example, all negative cash flows after Year 0 are discounted back to Year 0 using the firm's required rate of return, and then the IRR is determined for this modified cash flow stream.

NPV profile, page 379 A plot of multiple NPV estimates calculated using a succession of different discount rates. This profile illustrates when there are multiple IRRs—that is, where the NPV is equal to zero for more than one discount rate.

Payback period, page 384 The number of years of future cash flows needed to recover the initial investment in a proposed project.

Profitability index (PI), page 372 The ratio of the present value of the expected future cash flows for an investment proposal (discounted using the required rate of return for the project) divided by the initial investment in the project.

KEY EQUATIONS

$$\text{Profitability Index } (PI) = \frac{\dfrac{\text{Cash Flow for Year 1 } (CF_1)}{\left(1+\text{Discount Rate } (k)\right)^1} + \dfrac{\text{Cash Flow for Year 2 } (CF_2)}{\left(1+\text{Discount Rate } (k)\right)^2} + \cdots + \dfrac{\text{Cash Flow for Year } n\ (CF_n)}{\left(1+\text{Discount Rate } (k)\right)^n}}{\text{Initial Cash Outlay } (-CF_0)} \quad \textbf{(11–3)}$$

$$\text{Net Present Value} = \text{Cash Flow for Year 0 } (CF_0) + \frac{\text{Cash Flow for Year 1 } (CF_1)}{\left(1+\text{Internal Rate of Return } (IRR)\right)^1} + \frac{\text{Cash Flow for Year 2 } (CF_2)}{\left(1+\text{Internal Rate of Return } (IRR)\right)^2}$$

$$+ \cdots + \frac{\text{Cash Flow for Year } n\ (CF_n)}{\left(1+\text{Internal Rate of Return } (IRR)\right)^n} = 0 \quad \textbf{(11–4)}$$

Concept Check | 11.3

1. Describe what the IRR metric tells the analyst about a new investment opportunity.
2. Describe the situations in which the NPV and IRR metrics can provide conflicting signals.
3. What is the modified internal rate of return metric, and why is it sometimes used?
4. What is the payback period method, and what is the source of its appeal?
5. What is the discounted payback period method, and how does it improve on the payback period measure?

11.4 Understand current business practice with respect to the use of capital-budgeting criteria. (pgs. 387–389)

SUMMARY: Recent survey evidence from large U.S. firms on the popularity of the standard methods for evaluating capital investment opportunities showed that the IRR and NPV are by far the most widely used. However, more than half the firms surveyed use the payback period method. Larger firms use the NPV and IRR more frequently than their smaller counterparts, and smaller firms tend to rely more on the payback period. Finally, most firms use multiple investment criteria and often use the payback period as a secondary measure to reflect project risk considerations.

Concept Check | 11.4

1. What is the most widely used measure of capital budgeting in business practice?
2. How does the payback period method provide an indication of the risk of an investment proposal?

Study Questions

11–1. In *Regardless of Your Major: Making Personal Investment Decisions* on page 362, what were the types of personal decisions discussed that can be addressed using capital-budgeting analyses?

11–2. Why might it be difficult for firms to find good investment ideas?

11–3. Distinguish between revenue enhancement investments, cost-reduction investments, and mandated investments.

11–4. How is the presence or absence of product market competition that a firm faces related to the NPV of the firm's investment opportunities? What are the types of barriers to competition (market entry) that tend to preserve positive NPVs?

11–5. Why is the NPV generally considered to be the preferred method for evaluating new capital investment proposals? Describe the meaning of the NPV to a close relative who has no business background in terms they would understand.

11–6. What does it mean to say that two or more investment projects are mutually exclusive?

11–7. What are the limitations of the payback period as an investment decision criterion? What are its advantages? Why do you think it is used so frequently?

11–8. Briefly compare and contrast the NPV, PI, and IRR criteria. What are the advantages and disadvantages of using each of these methods?

11–9. If a project's payback period is less than the maximum payback period that the firm will accept, does this mean that the project's NPV will also be positive?

11–10. What is the rationale for using the MIRR as opposed to the IRR decision criterion? Describe the fundamental shortcoming of the MIRR method.

11–11. In *Finance for Life: Higher Education as an Investment in Yourself* on page 384, the decision to get a college education was discussed in the context of an investment decision. Discuss the analogy in more detail by identifying the initial cash outlay(s) and the future benefits of your investment in higher education.

11–12. Discuss the merits and shortcomings of using the payback period for capital budgeting decisions.

11–13. What are the most widely used methods for evaluating capital expenditure projects in practice?

11–14. Some analysts argue that the payback period criterion is actually a measure of project risk. What is the logic behind this belief?

Study Problems

Net Present Value

11–1. **(Calculating NPV)** **(Related to Checkpoint 11.1 on page 367)** Dowling Sportswear is considering building a new factory to produce aluminum baseball bats. This project will require an initial cash outlay of $8,000,000 and will generate annual net cash inflows of $2,000,000 per year for six years. Calculate the project's NPV for each of the following discount rates:

a. 9 percent
b. 11 percent
c. 13 percent
d. 15 percent

11–2. **(Calculating NPV)** Carson Trucking is considering whether to expand its regional service center in Moab, Utah. The expansion will require the expenditure of $10,000,000 on new service equipment and will generate annual net cash inflows by reducing operating costs $2,500,000 per year for each of the next eight years. In Year 8, the firm will also get back a cash flow equal to the salvage value of the equipment, which is valued at $1 million. Thus, in Year 8 the investment cash inflow will total $3,500,000. Calculate the project's NPV using each of the following discount rates:

a. 9 percent
b. 11 percent
c. 13 percent
d. 15 percent

11–3. **(Calculating NPV)** Big Steve's Swizzle Sticks is considering the purchase of a new plastic-stamping machine. This investment will require an initial outlay of $100,000 and will generate net cash inflows of $18,000 per year for 10 years.

a. What is the project's NPV using a discount rate of 12 percent? Should the project be accepted? Why or why not?
b. What is the project's NPV using a discount rate of 13 percent? Should the project be accepted? Why or why not?
c. What is this project's IRR? Should the project be accepted? Why or why not?

11–4. **(Calculating EAC)** **(Related to Checkpoint 11.2 on page 370)** Barry Boswell is a financial analyst for Dossman Metal Works, Inc., and he is analyzing two alternative configurations for the firm's new plasma cutter shop. The two alternatives, denoted A and B below, will perform the same task, but alternative A will cost $80,000 to purchase, while alternative B will cost only $55,000. Moreover, the two alternatives will have very different cash flows and useful lives. The after-tax costs for the two projects are as follows:

Year	Alternative A	Alternative B
0	$(80,000)	$(55,000)
1	(20,000)	(6,000)
2	(20,000)	(6,000)
3	(20,000)	(6,000)
4	(20,000)	
5	(20,000)	
6	(20,000)	
7	(20,000)	

a. Calculate each project's EAC, given a 10 percent discount rate.
b. Which of the alternatives do you think Barry should select? Why?

11–5. **(Calculating EAC)** The Templeton Manufacturing and Distribution Company of Tacoma, Washington, is contemplating the purchase of a new conveyor belt system for one of its regional distribution facilities. Both the alternatives it is considering will accomplish the same task, but the Eclipse model will cost substantially more than the Sabre model and will not have to be replaced for 10 years, whereas the Sabre model will need to be replaced in just 5 years. The costs of purchasing the two systems and the costs of operating them annually over their expected lives are as follows:

Year	Eclipse	Sabre
0	(1,400,000)	(800,000)
1	(25,000)	(50,000)
2	(30,000)	(50,000)
3	(30,000)	(60,000)
4	(30,000)	(60,000)
5	(40,000)	(80,000)
6	(40,000)	
7	(40,000)	
8	(40,000)	
9	(40,000)	
10	(40,000)	

a. Templeton typically evaluates investments in plant improvements using a 12 percent required rate of return. What are the NPVs for the two systems?
b. Calculate the EACs for the two systems.
c. Based on your analysis of the two systems using both their NPVs and their EACs, which system do you recommend that the company pick? Why?

Other Investment Criteria

11–6. **(Calculating IRR)** **(Related to Checkpoint 11.1 on page 367)** What are the IRRs for the following projects?

a. An initial outlay of $10,000 resulting in a single cash inflow of $17,182 in 8 years
b. An initial outlay of $10,000 resulting in a single cash inflow of $48,077 in 10 years
c. An initial outlay of $10,000 resulting in a single cash inflow of $115,231 in 20 years
d. An initial outlay of $10,000 resulting in a single cash inflow of $13,680 in 3 years

11–7. **(Calculating IRR)** Determine the IRRs for the following projects:

a. An initial outlay of $10,000 resulting in a cash inflow of $1,993 at the end of each year for the next 10 years
b. An initial outlay of $10,000 resulting in a cash inflow of $2,054 at the end of each year for the next 20 years
c. An initial outlay of $10,000 resulting in a cash inflow of $1,193 at the end of each year for the next 12 years
d. An initial outlay of $10,000 resulting in a cash inflow of $2,843 at the end of each year for the next 5 years

11–8. **(Calculating NPV and IRR)** **(Related to Checkpoint 11.1 on page 367)** East Coast Television is considering a project with an initial outlay of $X (you will have to determine this amount). It is expected that the project will produce a positive cash flow of $50,000 at the end of each year for the next 15 years. The appropriate discount rate for this project is 10 percent. If the project has a 14 percent IRR, what is the project's NPV?

11–9. **(Calculating IRR)** **(Related to Checkpoint 11.4 on page 376)** Determine the IRR to the nearest percent for the following projects:

a. An initial outlay of $10,000 resulting in cash inflows of $2,000 at the end of Year 1, $5,000 at the end of Year 2, and $8,000 at the end of Year 3

b. An initial outlay of $10,000 resulting in cash inflows of $8,000 at the end of Year 1, $5,000 at the end of Year 2, and $2,000 at the end of Year 3

c. An initial outlay of $10,000 resulting in cash inflows of $2,000 at the end of Years 1 through 5 and $5,000 at the end of Year 6

11–10. **(Calculating IRR)** Jella Cosmetics is considering a project that will cost $800,000 and is expected to last for 10 years and produce future cash flows of $175,000 per year. If the appropriate discount rate for this project is 12 percent, what is the project's IRR?

11–11. **(Calculating IRR)** Your investment advisor has offered you an investment that will provide you with a single cash flow of $10,000 at the end of 20 years if you pay premiums of $200 per year in the interim period. Specifically, the annual premiums will begin immediately and extend through the end of Year 19. You will then receive the $10,000 at the end of Year 20. Find the IRR for this investment.

11–12. **(Calculating IRR and NPV)** **(Related to Checkpoint 11.1 on page 367 and Checkpoint 11.4 on page 376)** The cash flows for three independent projects are as follows:

Year	Project A	Project B	Project C
0 (initial investment)	$(50,000)	$(100,000)	$(450,000)
1	$ 10,000	$ 25,000	$ 200,000
2	15,000	25,000	200,000
3	20,000	25,000	200,000
4	25,000	25,000	—
5	30,000	25,000	—

a. Calculate the IRR for each of the projects.

b. If the discount rate for all three projects is 10 percent, which project or projects would you want to undertake?

c. What is the NPV of each of the projects where the appropriate discount rate is 10 percent? 20 percent?

11–13. **(Calculating IRR, payback, and a missing cash flow)** The Merriweather Printing Company is trying to decide on the merits of constructing a new publishing facility. The project is expected to provide a series of positive cash flows for each of the next four years. The estimated cash flows associated with this project are as follows:

Year	Project Cash Flow
0	?
1	$800,000
2	400,000
3	300,000
4	500,000

If you know that the project has a regular payback period of 2.5 years, what is the project's IRR?

11–14. **(Calculating MIRR)** (**Related to Checkpoint 11.6 on page 382**) Emily's Soccer Mania is considering building a new indoor soccer facility for local soccer clubs to rent. This project will require an initial cash outlay of $10 million and will generate annual cash inflows of $3 million per year for Years 1 through 5. In addition, in Year 5 the project will require an additional investment outlay of $5,000,000. During Years 6 through 10, the project will provide cash inflows of $5 million per year. Calculate the project's MIRR, given the following:

a. A discount rate of 10 percent
b. A discount rate of 12 percent
c. A discount rate of 14 percent

11–15. **(Calculating MIRR)** OTR Trucking runs a fleet of long-haul trucks and has recently expanded into the Midwest, where it has decided to build a maintenance facility. This project will require an initial cash outlay of $20 million and will generate annual cash inflows of $4.5 million per year for Years 1 through 3. In Year 4, the project will provide a net negative cash flow of $5,000,000 due to anticipated expansion of and repairs to the facility. During Years 5 through 10, the project will provide cash inflows of $2 million per year.

a. Calculate the project's NPV and IRR where the discount rate is 12 percent. Is the project a worthwhile investment based on these two measures? Why or why not?
b. Calculate the project's MIRR. Is the project a worthwhile investment based on this measure? Why or why not?

11–16. **(Calculating IRR for an uneven cash flow stream)** Microwave Oven Programming, Inc., is considering the construction of a new plant. The plant will have an initial cash outlay of $7 million ($CF_0 = -\$7$ million) and will produce cash flows of $3 million at the end of Year 1, $4 million at the end of Year 2, and $2 million at the end of Years 3 through 5. What is the IRR for this new plant?

11–17. **(Calculating MIRR)** **(Related to Checkpoint 11.6 on page 382)** The Dunder Muffin Company is considering purchasing a new commercial oven that costs $350,000. This new oven will produce cash inflows of $125,000 at the end of Years 1 through 10. In addition to the cash inflows, at the end of Year 5 there will be a net cash outflow of $200,000. The company has a required rate of return of 12 percent. What is the MIRR of the investment? Would you make the investment? Why or why not?

11–18. **(Calculating MIRR)** Star Industries owns and operates landfills for several municipalities throughout the U.S. Midwest. Star typically contracts with the municipality to provide landfill services for a period of 20 years. The firm then constructs a lined landfill (required by federal law) that has capacity for 5 years. The $10 million expenditure required to construct the new landfill results in negative cash flows at the end of Years 0, 5, 10, and 15. This change in sign on the stream of cash flows over the 20-year contract period introduces the potential for multiple IRRs, so Star's management has decided to use the MIRR to evaluate new landfill investment contracts. The annual cash inflows to Star begin in Year 1 and extend through Year 20 and are estimated to equal $3 million (this does not reflect the cost of constructing the landfills every 5 years). Star uses a 10 percent discount rate to evaluate its new projects, so it plans to discount all the construction costs every 5 years back to Year 0 using this rate before calculating the MIRR.

a. What are the project's NPV, IRR, and MIRR?
b. Is this a good investment opportunity for Star Industries? Why or why not?

11–19. **(Calculating NPV, PI, and IRR)** **(Related to Checkpoint 11.1 on page 367 and Checkpoint 11.4 on page 376)** Fijisawa, Inc., is considering a major expansion of its top-selling product line and has estimated the following cash flows associated with the expansion. The initial outlay will be $10,800,000, and the project will generate cash flows of $1,250,000 per year for 20 years. The appropriate discount rate is 9 percent.

a. Calculate the NPV.
b. Calculate the PI.
c. Calculate the IRR.
d. Should this project be accepted? Why or why not?

11–20. **(Calculating the discounted payback period)** Gio's Restaurants is considering a project with the following expected cash flows:

Year	Project Cash Flow
0	$(150 million)
1	90 million
2	70 million
3	90 million
4	100 million

If the project's appropriate discount is 12 percent, what is the project's discounted payback period?

11–21. **(Calculating the discounted payback period)** The Callaway Cattle Company is considering the construction of a new feed-handling system for its feedlot in Abilene, Kansas. The new system will provide annual labor savings and reduced waste totaling $200,000, and the initial investment will be only $500,000. Callaway's management has used a simple payback period method for evaluating new investments in the past but plans to calculate the discounted payback period to analyze the investment. Where the appropriate discount rate for this type of project is 10 percent, what is the project's discounted payback period?

11–22. **(Calculating the payback and discounted payback periods)** The Bar-None Manufacturing Company manufactures fence panels used in cattle feedlots throughout the Midwest. Bar-None's management is considering three investment projects for next year but doesn't want to make any investment that requires more than three years to recover the firm's initial investment. The cash flows for the three projects (A, B, and C) are as follows:

Year	Project A	Project B	Project C
0	$(1,000)	$(10,000)	$(5,000)
1	600	5,000	1,000
2	300	3,000	1,000
3	200	3,000	2,000
4	100	3,000	2,000
5	500	3,000	2,000

a. Given Bar-None's three-year payback period, which of the projects will qualify for acceptance?
b. Rank the three projects using their payback periods. Which project looks the best using this criterion? Do you agree with this ranking? Why or why not?
c. If Bar-None uses a 10 percent discount rate to analyze projects, what is the discounted payback period for each of the three projects? If the firm still maintains its three-year payback policy for the discounted payback, which projects should the firm undertake?

11–23. **(Calculating the payback period and NPV)** Plato Energy is an oil-and-gas exploration and development company located in Farmington, New Mexico. The company drills shallow wells in hopes of finding significant oil and gas deposits. The firm is considering two different drilling opportunities that have very different production potentials. One is in the Barnett Shale region of central Texas, and the other is on the Gulf Coast. The Barnett Shale project requires a much larger initial investment but provides cash flows (if successful) over a much longer period of time than the Gulf Coast opportunity. In addition, the longer life of the Barnett Shale project results in additional expenditures in Year 3 of the project to enhance production throughout the project's 10-year expected life. This expenditure involves pumping either water or CO_2 down into the wells in order to increase the flow of oil and gas. The expected cash flows for the two projects are as follows:

Year	Barnett Shale	Gulf Coast
0	$(5,000,000)	$ (1,500,000)
1	2,000,000	800,000
2	2,000,000	800,000
3	(1,000,000)	400,000
4	2,000,000	100,000
5	1,500,000	
6	1,500,000	
7	1,500,000	
8	800,000	
9	500,000	
10	100,000	

a. What is the payback period for each of the two projects?
b. Based on the calculated payback periods, which of the two projects appears to be the better alternative? What are the limitations of the payback period ranking? That is, what does the payback period not consider that is important in determining the value-creation potential of these two projects?
c. If Plato's management uses a 20 percent discount rate to evaluate the present values of its energy investment projects, what are the NPVs of the two proposed investments?
d. What is your estimate of the value that will be created for Plato by the acceptance of each of these two investments?

11–24. **(Calculating the payback period, NPV, PI, and IRR)** You are considering a project with an initial cash outlay of $80,000 and expected cash flows of $20,000 at the end of each year for six years. The discount rate for this project is 10 percent.

a. What are the project's payback and discounted payback periods?
b. What is the project's NPV?
c. What is the project's PI?
d. What is the project's IRR?

11–25. **(Using NPV for mutually exclusive projects)** You have been assigned the task of evaluating two mutually exclusive projects with the following projected cash flows:

Year	Project A Cash Flow	Project B Cash Flow
0	$(100,000)	$(100,000)
1	33,000	0
2	33,000	0
3	33,000	0
4	33,000	0
5	33,000	220,000

If the appropriate discount rate on these projects is 10 percent, which would be chosen and why?

11–26. **(Calculating NPV, PI, and IRR)** **(Related to Checkpoint 11.1 on page 367, Checkpoint 11.3 on page 374, and Checkpoint 11.4 on page 376)** You are considering two independent projects, Project A and Project B. The initial cash outlay associated with Project A is $50,000, and the initial cash outlay associated with Project B is $70,000. The discount rate on both projects is 12 percent. The expected annual cash flows from each project are as follows:

Year	Project A	Project B
0	$(50,000)	$(70,000)
1	12,000	13,000
2	12,000	13,000
3	12,000	13,000
4	12,000	13,000
5	12,000	13,000
6	12,000	13,000

Calculate the NPV, PI, and IRR for each project, and indicate if either project should be accepted.

11–27. **(Solving a comprehensive problem)** Garmen Technologies Inc. operates a small chain of specialty retail stores throughout the U.S. Southwest. The company markets technology-based consumer products both in its stores and over the internet, with sales split roughly equally between the two channels of distribution. The company's products range from radar detection devices and GPS mapping systems used in automobiles to home-based weather monitoring stations. The company recently began investigating the possible acquisition of a regional warehousing facility that could be used both to stock its retail shops and to make direct shipments to the firm's online customers. The warehouse facility would require an expenditure of $250,000 for a rented space in Oklahoma City, Oklahoma, and would provide cash flows over the next 10 years. The estimated cash flows are as follows:

Year	Cash Flow	Year	Cash Flow
0	$(250,000)	6	$65,000
1	60,000	7	65,000
2	60,000	8	65,000
3	60,000	9	65,000
4	60,000	10	90,000
5	(45,000)		

The negative cash flow in Year 5 reflects the cost of a planned renovation and expansion of the facility. Finally, in Year 10 Garmen estimates some recovery of its investment at the close of the lease and, consequently, a higher-than-usual cash flow. Garmen uses a 12 percent discount rate in evaluating its investments.

a. As a preliminary step in analyzing the new investment, Garmen's management decided to evaluate the project's anticipated payback period. What is the project's expected payback period? Jim Garmen, CEO, questioned the analyst performing the analysis about the meaning of the payback period because it seems to ignore the fact that the project will provide cash flows over many years beyond the end of the payback period. Specifically, he wanted to know what useful information the payback period provides. If you were the analyst, how would you respond to Mr. Garmen?

b. In the past, Garmen's management has relied almost exclusively on the IRR to make its investment choices. However, in this instance the lead financial analyst on the project suggested that there may be a problem with the IRR because the sign on the cash flows changes three times over its life. Calculate the IRR for the project. Evaluate the NPV profile of the project for discount rates of 0 percent, 20 percent, 50 percent, and 100 percent. Does there appear to be a problem of multiple IRRs in this range of discount rates?

c. Calculate the project's NPV. What does the NPV indicate about the potential value created by the project? Describe to Mr. Garmen what the NPV means, recognizing that he was trained as an engineer and has no formal business education.

Mini-Cases

RWE Enterprises: Expansion Project Analysis

RWE Enterprises, Inc. (RWE), is a small manufacturing firm located in the hills just outside of Nashville, Tennessee. The firm is engaged in the manufacture and sale of feed supplements used by cattle raisers. The product has a molasses base but is supplemented with minerals and vitamins that are generally thought to be essential to the health and growth of beef cattle. The final product is put in 125-pound or 200-pound tubs, which are then made available for the cattle to lick as desired. The material in the tub becomes very hard, which limits the animals' consumption.

The firm has been running a single production line for the past 5 years and is considering the addition of a new line. The addition would expand the firm's capacity by almost 120 percent because the newer equipment requires a shorter downtime between batches. After each production run, the boiler used to prepare the molasses for the addition of minerals and vitamins must be heated to 180 degrees Fahrenheit and then cooled down before beginning the next batch. The total production run entails about four hours, and the cool-down period is two hours (during which time the whole process comes to a halt). Using two production lines increases the overall efficiency of the operation because workers from the line that is cooling down can be moved to the other line to support the "canning" process involved in filling the feed tubs.

The equipment for the second production line will cost $3 million to purchase and install and will have an estimated life of 10 years, at which time it can be sold for an estimated after-tax scrap value of $200,000. Furthermore, at the end of 5 years the production line will have to be refurbished at an estimated cost of $2 million. RWE's management estimates that the new production line will add $700,000 per year in after-tax cash flow to the firm, so the full 10-year cash flows for the line are as follows:

Year	After-Tax Cash Flow
0	$(3,000,000)
1	700,000
2	700,000
3	700,000
4	700,000
5	(1,300,000)
6	700,000
7	700,000
8	700,000
9	700,000
10	900,000

a. If RWE uses a 10 percent discount rate to evaluate investments of this type, what is the NPV of the project? What does this NPV indicate about the potential value RWE might create by adding the new production line?

b. Calculate the IRR and PI for the proposed investment. What do these two measures tell you about the project's viability?

c. Calculate the payback and discounted payback periods for the proposed investment. Interpret your findings.

Jamie Dermott: Mutually Exclusive Project Analysis

Jamie Dermott graduated from Midland State University in June and has been working for about a month as a junior financial analyst at Caledonia Products. When Jamie arrived at work on Friday morning, he found the following memo in his e-mail:

TO: Jamie Dermott
FROM: V. Morrison, CFO, Caledonia Products
RE: Capital-Budgeting Analysis

Provide an evaluation of two proposed projects with the following cash flow forecasts:

Year	Project A	Project B
0 (initial outlay)	$(110,000)	$(110,000)
1	20,000	40,000
2	30,000	40,000
3	40,000	40,000
4	50,000	40,000
5	70,000	40,000

Because these projects involve additions to Caledonia's highly successful Avalon product line, the company requires a rate of return on both projects equal to 12 percent. As you are no doubt aware, Caledonia relies on a number of criteria when evaluating new investment opportunities. In particular, we require that projects that are accepted have a payback period of no more than three years, provide a positive NPV, and have an IRR that exceeds the firm's discount rate.

Give me your thoughts on these two projects by 9 A.M. Monday morning.

Jamie was not surprised by the memo, for he had been expecting something like this for some time. Caledonia followed a practice of testing each new financial analyst with some type of project evaluation exercise after the new hire had been on the job for a few months.

After rereading the memo, Jamie decided on his plan of attack. Specifically, he would first do the obligatory calculations of payback period, NPV, and IRR for both projects. Jamie knew that the CFO would grill him thoroughly on Monday morning about his analysis, so he wanted to prepare well for the experience. One of the things that occurred to Jamie was that the memo did not indicate whether the two projects were independent or mutually exclusive. So, just to be safe, he thought he had better rank the two projects in case he was asked to do so on Monday morning. Jamie sat down and made up the following "to do" list:

1. Compute payback period, NPV, and IRR for both projects.
2. Evaluate the two projects' acceptability using all three decision criteria (listed above) and basing the conclusion on the assumption that the projects are independent—that is, that both could be accepted if both are acceptable.
3. Rank the two projects and make a recommendation as to which (if either) should be accepted under the assumption that the projects are mutually exclusive.

Assignment: Prepare Jamie's evaluation for his Monday meeting with the CFO by completing his "to do" list.

Ethics Case: Ford's Pinto and the Value of Life

In 1968, Ford Motor Company (F) executives decided to produce a subcompact car called the Pinto in response to the onslaught of Japanese economy cars. Known inside the company as "Lee's car," after Ford President Lee Iacocca, the Pinto was to weigh no more than 2,000 pounds and cost no more than $2,000.

Eager to have its subcompact ready for the 1971 model year, Ford decided to compress the normal drafting-board-to-showroom time from three-and-a-half years down to only two. The compressed schedule meant that design changes typically made before production-line tooling would have to be made during it.

Before producing the Pinto, Ford crash tested 11 cars, in part to learn if they met the National Highway Traffic Safety Administration's (NHTSA) proposed safety standard that all autos be able to withstand a fixed-barrier impact of 20 miles per hour without fuel loss. Eight standard-design Pintos failed these tests. The three cars that passed the test all had some kind of gas-tank modification. The first had a plastic baffle between the front of the tank and the differential housing, the second had a piece of steel between the tank and the rear bumper, and the third had a rubber-lined gas tank.

Ford officials faced a tough decision. Should they go ahead with the standard design, thereby meeting the production timetable but possibly jeopardizing consumer safety? Or should they delay production of the Pinto and redesign the gas tank to make it safer? If they chose the latter course of action, they would effectively concede another year of subcompact dominance to foreign companies.

To determine whether to proceed with the original design of the Pinto fuel tank, Ford compared the expected costs and benefits of making the change. Would the benefits of a new tank design outweigh its costs or not? To find the answer, Ford estimated the costs of the design improvement to be $11 per vehicle. The benefit to Ford of having a safer gas tank relates to the avoidance of the potential costs Ford might incur in the event of a fatality resulting from a fuel tank rupture if the auto was involved in an accident. To determine this benefit, Ford analyzed the dollar value of the average loss resulting from a traffic fatality. The NHTSA had estimated a cost of $200,725 every time a person was killed in an auto accident. The costs were broken down as follows:

Future Productivity Losses	
Direct	$132,000
Indirect	41,300
Medical Costs	
Hospital	700
Other	425
Property damage	1,500
Insurance administration	4,700
Legal and court expenses	3,000
Employer losses	1,000
Victim's pain and suffering	10,000
Funeral	900
Assets (lost consumption)	5,000
Miscellaneous accident costs	200
Total per fatality	$200,725[a]

[a]Ralph Drayton, "One Manufacturer's Approach to Automobile Safety Standards," *CTLA News 8*, no. 2 (February 1968): 11.

Ford analysts used NHTSA's estimates and other statistical studies in their cost-benefit analysis, which yielded the following estimates:

Benefits	Losses avoided by redesigning the fuel tank in the Pinto
Savings:	180 burn deaths; 180 serious burn injuries; and 2,100 burned vehicles
Unit cost:	\$200,000 per death; \$67,000 per injury; and \$700 per vehicle
Total benefit:	(180 × \$200,000) + (180 × \$67,000) + (2,100 × \$700) = \$49.5 million
Costs	Losses incurred by the redesign of the fuel tank in the Pinto
Sales:	11 million cars; 1.5 million light trucks
Unit cost:	\$11 per car and \$11 per truck
Total cost:	12.5 million × \$11 = \$137.5 million[a]

[a]Mark Dowie, "Pinto Madness," *Mother Jones,* September–October 1977, 20. See also Russell Mokhiber, *Corporate Crime and Violence* (San Francisco: Sierra Club Books, 1988), 373–382, and Francis T. Cullen, William J. Maakestad, and Gary Cavender, *Corporate Crime Under Attack: The Ford Pinto Case and Beyond* (Cincinnati: Anderson Publishing, 1987).

Because the \$137.5 million cost of the safety improvement outweighed the \$49.5 million benefit of the redesign, Ford decided to push ahead with the original design.

Questions

1. Do you think Ford analyzed the problem of redesigning the Pinto fuel tank in a reasonable way?
2. Should questions involving the risk of loss of human life be answered using a cost-benefit analysis? After all, don't life insurance companies do this all the time in pricing life insurance policies to older versus younger customers?

Source: This case is based on William Shaw and Vincent Barry, "Ford's Pinto," *Moral Issues in Business*, 9th ed. (New York: Wadsworth, 2004), 84–86. © by Wadsworth, Inc.