

Capital-Budgeting Techniques and Practice

Learning Objectives

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| b¹ Discuss the difficulty encountered in finding profitable projects in competitive markets and the importance of the search. | Finding Profitable Projects |
| b² Determine whether a new project should be accepted or rejected using the payback period, the net present value, the profitability index, and the internal rate of return. | Capital-Budgeting Decision Criteria |
| b³ Explain how the capital-budgeting decision process changes when a dollar limit is placed on the capital budget. | Capital Rationing |
| b⁴ Discuss the problems encountered when deciding among mutually exclusive projects. | Ranking Mutually Exclusive Projects |

Back in 1955, the Walt Disney Company changed the face of entertainment when it opened Disneyland, its first theme park, in Anaheim, California, at a cost of \$17.5 million. Since then Disney has opened theme parks in Orlando, Florida; Tokyo, Japan; Paris, France; and in September 2005, 香港迪士尼樂園, or Hong Kong Disneyland, was opened. This \$3.5 billion project, with much of that money provided by the Hong Kong government, was opened in hopes of reaching what has largely been an untapped Chinese market. For Disney, a market this size was simply too large to pass up.

Unfortunately, while Hong Kong Disneyland's opening was spectacular, it has yet to earn a profit. One of the unexpected problems it has faced has been knockoff rides by rival Asian theme parks, which used the Hong Kong Disneyland's advance publicity to design their rides and put them in use before Hong Kong Disneyland's opening.

For Disney, keeping its theme parks and resorts division healthy is extremely important because this division accounts for over one-quarter of the company's revenues. Certainly, there are opportunities for Disney in China; with a population of 1.26 billion people, it accounts for 20 percent of the entire world's total population and Hong Kong Disneyland was supposed to provide Disney with a foothold in the potentially lucrative China market. While Hong Kong Disneyland has not lived up to Disney's expectations, Disney has not given up

on the Chinese market and with 330 million people living within a 3-hour drive or train ride from Shanghai, it picked its next location. Work has already begun on the Shanghai Disney Resort, which will be the home to Shanghai Disneyland, targeted to open at the end of 2015. Learning from its mistakes in Hong Kong, Disney's new proposed park will be much larger and easier for Chinese families to visit, but Disney has been a bit vague on the specifics of the park in an attempt to avoid a repeat of competition from knockoff rides that it experienced in Hong Kong.

To say the least, with a total investment of over \$8 billion shared by Disney and its Chinese partner, the outcome of this decision will have a major effect on Disney's future. Whether this was a good or a bad decision, only time will tell. The question we will ask in this chapter is: How did Disney go about making this decision to enter the Chinese market and build Hong Kong Disneyland, and, after losing money on its Hong Kong venture, how did it go about making the decision to build Shanghai Disney Resort? The answer is that the company did it using the decision criteria we will examine in this chapter.



This chapter is actually the first of two chapters dealing with the process of decision making with respect to making investments in fixed assets—that is, should a proposed project be accepted or rejected? We will refer to this process as capital budgeting. In this chapter, we will look at the methods used to evaluate new projects. In deciding whether to accept a new project, we will focus on free cash flows. Free cash flows represent the benefits generated from accepting a capital-budgeting proposal. We will assume we know what level of free cash flows is generated by a project and will work on determining whether that project should be accepted. In the following chapter, we will examine what a free cash flow is and how we measure it. We will also look at how risk enters into this process.

Finding Profitable Projects

Without question it is easier to *evaluate profitable projects or investments in fixed assets, a process referred to as capital budgeting*, than it is to find them. In competitive markets, generating ideas for profitable projects is extremely difficult. The competition is brisk for new profitable projects, and once they have been uncovered, competitors generally rush in, pushing down prices and profits. For this reason a firm must have a systematic strategy for generating capital-budgeting projects based on these ideas. Without this flow of new projects and ideas, the firm cannot grow or even survive for long. Instead, it will be forced to live off the profits from existing projects with limited lives. So where do these ideas come from for new products, or for ways to improve existing products or make them more profitable? The answer is from inside the firm—from everywhere inside the firm, in fact.

Typically, a firm has a research and development (R&D) department that searches for ways of improving existing products or finding new products. These ideas may come

b¹ Discuss the difficulty encountered in finding profitable projects in competitive markets and the importance of the search.

capital budgeting the process of decision making with respect to investments made in fixed assets—that is, should a proposed project be accepted or rejected.

from within the R&D department or may be based on referral ideas from executives, sales personnel, anyone in the firm, or even customers. For example, at Ford Motor Company before the 1990s, ideas for product improvements had typically been generated in Ford's R&D department. Unfortunately, this strategy was not enough to keep Ford from losing much of its market share to Japanese competitors. In an attempt to cut costs and improve product quality, Ford moved from strict reliance on an R&D department to seeking the input of employees at all levels for new ideas. Bonuses are now provided to workers for their cost-cutting suggestions, and assembly-line personnel who can see the production process from a hands-on point of view are now brought into the hunt for new projects. The effect on Ford has been positive and it helped Ford avoid the bankruptcy problems that befell GM and Chrysler. Although not all suggested projects prove to be profitable, many new ideas generated from within the firm turn out to be good ones.

Another way an existing product can be applied to a new market is illustrated by Kimberly-Clark, the manufacturer of Huggies disposable diapers. The company took its existing diaper product line, made the diapers more waterproof, and began marketing them as disposable swim pants called Little Swimmers. Sara Lee Hosiery boosted its market by expanding its offerings to appeal to more customers and more customer needs. For example, Sara Lee Hosiery introduced Sheer Energy pantyhose for support, Just My Size pantyhose aimed at larger-women sizes, and Silken Mist pantyhose in shades better suited for African American women.

Big investments such as these go a long way toward determining the future of the company, but they don't always work as planned. Just look at Burger King's development of its new french fries. It looked like a slam-dunk great idea. Burger King took an uncooked french fry and coated it with a layer of starch that made it crunchier and kept it hot longer. The company spent over \$70 million on the new fries and even gave away 15 million orders on a "Free Fryday." Unfortunately, the product didn't go down with consumers, and Burger King was left to eat the loss. Given the size of the investment we're talking about, you can see why such a decision is so important.

Concept Check

1. Why is it so difficult to find an exceptionally profitable project?
2. Why is the search for new profitable projects so important?

CAUTIONARY TALE

FORGETTING PRINCIPLE 3: RISK REQUIRES A REWARD AND PRINCIPLE 4: MARKET PRICES ARE GENERALLY RIGHT

In the world of investing, you win some, you lose some. A common misconception is that high-risk investments always provide high returns. In fact, there are no guarantees. That's why consistently high returns paid year in and year out from a fund known for its exclusivity and its double-digit rates of return should have given investors pause.

In December of 2008 an investor in the fund, quoted in *Time* magazine, wrote, "All we knew was that my wife's entire family had been in the fund for decades and lived well on the returns, which ranged from 15 percent to 22 percent. It was all very secretive and tough to get into, which, looking back, was a brilliant strategy to lure suckers."

The fund in question is the one we now know as the Ponzi scheme orchestrated by Bernard "Bernie" Madoff. A Ponzi scheme is an investment that pays returns to investors from the money they originally invested along with money provided by new investors,

rather than any profits earned. A Ponzi scheme is destined to collapse because the payments made exceed any earnings from the investment. Madoff's scam is considered to be the biggest Wall Street fraud ever attempted. Prosecutors estimate the size of the scam as somewhere between \$50 billion to \$54.8 billion.

In efficient markets, high returns are extremely difficult to achieve in good and bad years. Harry Markopolos, who once worked for one of Madoff's competitors, long suspected that Madoff's returns were simply too good to be true and wrote letters for at least a decade to the Securities and Exchange Commission trying to persuade them to investigate Madoff. As Markopolos observed, one thing that we know from efficient markets is that if an investment promises a return that looks too good to be true, it probably is.

Source: Robert Chew, "How I Got Screwed by Bernie Madoff," *Time*, December 15, 2008, <http://www.time.com/time/business/article/0,8599,1866398,00.html>.

Capital-Budgeting Decision Criteria

As we explained, when deciding whether to accept a new project, we focus on cash flows because cash flows represent the benefits generated from accepting a capital-budgeting proposal. In this chapter we assume a given cash flow is generated by a project and work on determining whether that project should be accepted.

We consider four commonly used criteria for determining the acceptability of investment proposals. The first one is the least sophisticated in that it does not incorporate the time value of money into its calculations; the other three do take it into account. For the time being, the problem of incorporating risk into the capital-budgeting decision is ignored. This issue is examined in Chapter 11. In addition, we assume that the appropriate discount rate, required rate of return, or cost of capital is given.



Determine whether a new project should be accepted or rejected using the payback period, the net present value, the profitability index, and the internal rate of return.

The Payback Period

The **payback period** is the *number of years needed to recover the initial cash outlay related to an investment*. Thus, the payback period becomes the number of years prior to the year of complete recovery of the initial outlay plus the unrecovered dollar amount at the beginning of the year recovery is completed divided by the cash flow in the year in which recovery is completed:

$$\text{Payback period} = \begin{array}{c} \text{number of years just} \\ \text{prior to complete} \\ \text{payback} \end{array} + \frac{\begin{array}{c} \text{unpaid-back amount} \\ \text{at beginning of year} \\ \text{free cash flow in year} \\ \text{payback is completed} \end{array}}{\text{free cash flow in year}} \quad (10-1)$$

payback period the number of years it takes to recapture a project's initial outlay.

The accept/reject criteria for the payback period is if the payback period is less than the required payback period, then the project is accepted. Shorter payback periods are preferred over longer payback periods because the shorter the payback period, the quicker you get your money back. Because this criterion measures how quickly the project will return its original investment, it deals with free cash flows, which measure the true timing of the benefits, rather than accounting profits. Unfortunately, it also ignores the time value of money and does not discount these free cash flows back to the present. Rather, the accept/reject criterion centers on whether the project's payback period is less than or equal to the firm's maximum desired payback period. For example, if a firm's maximum desired payback period is 3 years, and an investment proposal requires an initial cash outlay of \$10,000 and yields the following set of annual cash flows, what is its payback period? Should the project be accepted?

YEAR	FREE CASH FLOW
1	\$2,000
2	4,000
3	3,000
4	3,000
5	9,000

In this case, after 3 years the firm will have recaptured \$9,000 on an initial investment of \$10,000, leaving \$1,000 of the initial investment to be recouped. During the fourth year \$3,000 will be returned from this investment, and, assuming it will flow into the firm at a constant rate over the year, it will take one-third of the year (\$1,000/\$3,000) to recapture the remaining \$1,000. Thus, the payback period on this project is 3½ years, which is more than the desired payback period. Using the payback period criterion, the firm would reject this project without even considering the \$9,000 cash flow in year 5.

Although the payback period is used frequently, it does have some rather obvious drawbacks that are best demonstrated through the use of an example. Consider two investment projects, A and B, which involve an initial cash outlay of \$10,000 each and produce the annual cash flows shown in Table 10-1. Both projects have a payback period of 2 years; therefore, in terms of the payback criterion both are equally acceptable. However, if we had our choice, it is clear we would select A over B, for at least two reasons. First, regardless of what happens after the payback period, project A returns more of our initial investment to us faster within the payback period (\$6,000 in year 1 versus \$5,000). Thus, because there is a time value of money, the cash flows occurring within the payback period should not be

TABLE 10-1 Payback Period Example

	PROJECTS	
	A	B
Initial cash outlay	−\$10,000	−\$10,000
Annual free cash inflows		
Year 1	\$ 6,000	\$ 5,000
2	4,000	5,000
3	3,000	0
4	2,000	0
5	1,000	0

weighted equally, as they are. In addition, all cash flows that occur after the payback period are ignored. This violates the principle that investors desire more in the way of benefits rather than less—a principle that is difficult to deny, especially when we are talking about money. Finally, the choice of the maximum desired payback period is arbitrary. That is, there is no good reason why the firm should accept projects that have payback periods less than or equal to 3 years rather than 4 years.

Although these deficiencies limit the value of the payback period as a tool for investment evaluation, the payback period has several positive features. First, it deals with cash flows, as opposed to accounting profits, and therefore focuses on the true timing of the project's benefits and costs, even though it does not adjust the cash flows for the time value of money. Second, it is easy to visualize, quickly understood, and easy to calculate. Third, the payback period may make sense for the capital-constrained firm, that is, the firm that needs funds and is having problems raising additional money. These firms need cash flows early on to allow them to continue in business and to take advantage of future investments. Finally, although the payback period has serious deficiencies, it is often used as a rough screening device to eliminate projects whose returns do not materialize until later years. This method emphasizes the earliest returns, which in all likelihood are less uncertain, and provides for the liquidity needs of the firm. Although its advantages are certainly significant, its disadvantages severely limit its value as a discriminating capital-budgeting criterion.

discounted payback period the number of years it takes to recapture a project's initial outlay from the discounted free cash flows.

Discounted Payback Period To deal with the criticism that the payback period ignores the time value of money, some firms use the discounted payback period approach. The **discounted payback period** method is similar to the traditional payback period except that it uses discounted free cash flows rather than actual undiscounted free cash flows in calculating the payback period. The discounted payback period is defined as *the number of years it takes to recapture a project's initial outlay from the discounted free cash flows*. This equation can be written as

$$\text{Discounted payback period} = \text{number of years just prior to complete payback from discounted free cash flows} + \frac{\text{unpaid-back amount at the beginning of year}}{\text{discounted free cash flow in year payback is completed}} \quad (10-2)$$

The accept/reject criterion then becomes whether the project's discounted payback period is less than or equal to the firm's maximum desired discounted payback period. Using the assumption that the required rate of return on projects A and B illustrated in Table 10-1 is 17 percent, the discounted cash flows from these projects are given in Table 10-2. On project A, after 3 years, only \$74 of the initial outlay remains to be recaptured, whereas year 4 brings in a discounted free cash flow of \$1,068. Thus, if the \$1,068 comes in at a constant rate over the year, it will take about 7/100 of the year (\$74/\$1,068) to recapture the remaining \$74. The discounted payback period for project A is 3.07 years, calculated as follows:

$$\text{Discounted payback period}_A = 3.0 + \$74/\$1,068 = 3.07 \text{ years}$$

TABLE 10-2 Discounted Payback, Period Example Using a 17 Percent Required Rate of Return

PROJECT A			
Year	Undiscounted Free Cash Flows	Discounted Free Cash Flows at 17%	Cumulative Discounted Free Cash Flows
0	−\$10,000	−\$10,000	−\$10,000
1	6,000	5,130	−4,870
2	4,000	2,924	−1,946
3	3,000	1,872	−74
4	2,000	1,068	994
5	1,000	456	1,450

PROJECT B			
Year	Undiscounted Free Cash Flows	Discounted Free Cash Flows at 17%	Cumulative Discounted Free Cash Flows
0	−\$10,000	−\$10,000	−\$10,000
1	5,000	4,275	−5,725
2	5,000	3,655	−2,070
3	0	0	−2,070
4	0	0	−2,070
5	0	0	−2,070

If project A's discounted payback period was less than the firm's maximum desired discounted payback period, then project A would be accepted. Project B, however, does not have a discounted payback period because it never fully recovers the project's initial cash outlay and thus should be rejected. The major problem with the discounted payback period comes in setting the firm's maximum desired discounted payback period. This is an arbitrary decision that affects which projects are accepted and which ones are rejected. In addition, cash flows that occur after the discounted payback period are not included in the analysis. Thus, although the discounted payback period is superior to the traditional payback period, in that it accounts for the time value of money in its calculations, its use is limited by the arbitrariness of the process used to select the maximum desired payback period. Moreover, as we will soon see, the net present value criterion is theoretically superior and no more difficult to calculate. These two payback period rules can be summarized as follows:

FINANCIAL DECISION TOOLS

Name of Tool	Formula	What It Tells You
Payback period	Number of years required to recapture the initial investment from the free cash flows:	- How long it will take to recapture the initial investment - The shorter the payback period, the better - If it is less than the maximum acceptable payback period, it is accepted
	$\text{Payback period} = \text{number of years just prior to complete payback} + \frac{\text{unpaid-back amount at beginning of year}}{\text{free cash flow in year payback is completed}}$	
Discounted payback period	Number of years required to recapture the initial investment from the discounted free cash flows:	- How long it will take to recapture the initial investment from the discounted cash flows - The shorter the discounted payback period, the better - If it is less than the maximum acceptable discounted payback period, it is accepted.
	$\text{Discounted payback period} = \text{number of years just prior to complete payback from discounted free cash flows} + \frac{\text{unpaid-back amount at beginning of year}}{\text{discounted free cash flow in year payback is completed}}$	

net present value (NPV) the present value of an investment's annual free cash flows less the investment's initial outlay.

The Net Present Value

The **net present value (NPV)** of an investment proposal is equal to the *present value of its annual free cash flows less the investment's initial outlay*. The net present value can be expressed as follows:

$$\begin{aligned} NPV &= (\text{present value of all the future annual free cash flows}) - (\text{the initial cash outlay}) \\ &= \frac{FCF_1}{(1+k)^1} + \frac{FCF_2}{(1+k)^2} + \cdots + \frac{FCF_n}{(1+k)^n} - IO \end{aligned} \quad (10-1)$$

where FCF_t = the annual free cash flow in time period t (this can take on either positive or negative values)

k = the firm's required rate of return or cost of capital¹

IO = the initial cash outlay

n = the project's expected life

If any of the future free cash flows (FCF_s) are cash outflows rather than inflows, say for example that there is another large investment in year 2 that results in the FCF_2 being negative, then the FCF_2 would take on a negative sign when calculating the project's net present value. In effect, the NPV can be thought of as the present value of the benefits minus the present value of the costs,

$$NPV = PV_{\text{benefits}} - PV_{\text{costs}}$$



REMEMBER YOUR PRINCIPLES

The final three capital-budgeting criteria all incorporate Principle 2: Money Has a Time Value in their calculations. If we are to make rational business decisions, we must recognize that money has a time value. In examining the following three capital-budgeting techniques, you will notice that this principle is the driving force behind each of them.

A project's NPV measures the net value of the investment proposal in terms of today's dollars. Because all cash flows are discounted back to the present, comparing the difference between the present value of the annual cash flows and the investment outlay recognizes the time value of money. The difference between the present value of the annual cash flows and the initial outlay determines the net value of the investment proposal. Whenever the project's NPV is greater than or equal to zero, we will accept the project; whenever the NPV is negative, we will reject the project. If the project's NPV is

zero, then it returns the required rate of return and should be accepted. This accept/reject criterion is represented as follows:

$$NPV \geq 0.0: \text{accept}$$

$$NPV < 0.0: \text{reject}$$

Realize, however, that the worth of the NPV calculation is a function of the accuracy of the cash-flow predictions.

The following example illustrates the use of NPV as a capital-budgeting criterion.

EXAMPLE 10.1

Calculating net present value

Ski-Doo is considering new machinery that would reduce manufacturing costs associated with its Mach Z snowmobile for which the free cash flows are shown in Table 10-3. If the firm has a 12 percent required rate of return, what is the NPV of the project? Should the company accept the project?

STEP 1: FORMULATE A SOLUTION STRATEGY

The net present value (NPV) of an investment proposal is equal to the present value of its annual free cash flows less the investment's initial outlay. Given the company's free cash flows information, the NPV can be calculated as:

¹The required rate of return or cost of capital is the rate of return necessary to justify raising funds to finance the project or, alternatively, the rate of return necessary to maintain the firm's current market price per share. These terms were defined in detail in Chapter 9.

TABLE 10-3 Ski-Doo's Investment in New Machinery and Its Associated Free Cash Flows

	Free Cash Flow
Initial outlay	−\$40,000
Inflow year 1	15,000
Inflow year 2	14,000
Inflow year 3	13,000
Inflow year 4	12,000
Inflow year 5	11,000

$NPV = (\text{present value of all the future annual free cash flows}) - (\text{the initial cash outlay})$

$$= \frac{FCF_1}{(1+k)^1} + \frac{FCF_2}{(1+k)^2} + \cdots + \frac{FCF_n}{(1+k)^n} - IO \quad (10-1)$$

where FCF_t = the annual free cash flow in time period t (this can take on either positive or negative values)

k = the firm's required rate of return or cost of capital

IO = the initial cash outlay

n = the project's expected life

STEP 2: CRUNCH THE NUMBERS

If the firm has a 12 percent required rate of return, the present value of the free cash flow is \$47,675, as calculated in Table 10-4. Subtracting the \$40,000 initial outlay leaves an NPV of \$7,675.

TABLE 10-4 Calculating the NPV of Ski-Doo's Investment in New Machinery

PRESENT VALUE				
	Free Cash Flow	×	Factor at 12 Percent	= Present Value
Inflow year 1	\$15,000	×	$\frac{1}{(1 + 0.12)^1}$	= \$13,393
Inflow year 2	14,000	×	$\frac{1}{(1 + 0.12)^2}$	= 11,161
Inflow year 3	13,000	×	$\frac{1}{(1 + 0.12)^3}$	= 9,253
Inflow year 4	12,000	×	$\frac{1}{(1 + 0.12)^4}$	= 7,626
Inflow year 5	11,000	×	$\frac{1}{(1 + 0.12)^5}$	= 6,242
Present value of free cash flows				\$47,675
Initial outlay				−40,000
Net present value				\$ 7,675

CALCULATOR SOLUTION (USING A TEXAS INSTRUMENTS BA II PLUS):

Data and Key Input	Display
$\boxed{CF}$; −40,000; $\boxed{ENTER}$	CFo = −40,000.
$\boxed{\downarrow}$; 15,000; $\boxed{ENTER}$	C01 = 15,000.
$\boxed{\downarrow}$; 1; $\boxed{ENTER}$	F01 = 1.00
$\boxed{\downarrow}$; 14,000; $\boxed{ENTER}$	C02 = 14,000.
$\boxed{\downarrow}$; 1; $\boxed{ENTER}$	F02 = 1.00
$\boxed{\downarrow}$; 13,000; $\boxed{ENTER}$	C03 = 13,000.
$\boxed{\downarrow}$; 1; $\boxed{ENTER}$	F03 = 1.00
$\boxed{\downarrow}$; 12,000; $\boxed{ENTER}$	C04 = 12,000.
$\boxed{\downarrow}$; 1; $\boxed{ENTER}$	F04 = 1.00
$\boxed{\downarrow}$; 11,000; $\boxed{ENTER}$	C05 = 11,000
$\boxed{\downarrow}$; 1; $\boxed{ENTER}$	F05 = 1.00
$\boxed{NPV}$	I = 0.00
12; $\boxed{ENTER}$	I = 1200
$\boxed{\downarrow}$; $\boxed{CPT}$	NPV = 7,675.

STEP 3: ANALYZE YOUR RESULTS

The NPV tells us how much value is created if the project is accepted, and if the NPV is positive, value is created; if the NPV is negative, the project destroys value. In this case because this value is greater than zero, this project creates value and should be accepted.

The *NPV* criterion is the capital-budgeting decision tool we find most favorable for several reasons. First of all, it deals with free cash flows rather than accounting profits. In this regard it is sensitive to the true timing of the benefits resulting from the project. Moreover, recognizing the time value of money allows the benefits and costs to be compared in a logical manner. Finally, because projects are accepted only if a positive *NPV* is associated with them, the acceptance of a project using this criterion will increase the value of the firm, which is consistent with the goal of maximizing the shareholders' wealth.

The disadvantage of the *NPV* method stems from the need for detailed, long-term forecasts of the free cash flows accruing from the project's acceptance. Despite this drawback, the *NPV* is the most theoretically correct criterion that we will examine. The following example provides an additional illustration of its application.

EXAMPLE 10.2

Calculating net present value

A firm is considering the purchase of a new computer system, which will cost \$30,000 initially, to aid in credit billing and inventory management. The free cash flows resulting from this project are provided below:

	FREE CASH FLOW
Initial outlay	−\$30,000
Inflow year 1	15,000
Inflow year 2	15,000
Inflow year 3	15,000

The required rate of return demanded by the firm is 10 percent. Determine the system's *NPV*. Should the firm accept the project?

CALCULATOR SOLUTION

STEP 1

Calculate payment value of inflows

Data Input	Function Key
3	N
10	I/Y
−15,000	PMT
0	FV

Function Key	Answer
CPT	
PV	37,303

STEP 2

Subtract initial outlay from present value of inflows

\$ 37,303
−30,000
\$ 7,303

STEP 1: FORMULATE A SOLUTION STRATEGY

To determine the system's *NPV*, the 3-year \$15,000 cash flow annuity is first discounted back to the present at 10 percent. The present value of the \$15,000 annuity can be found using a calculator (as is done in the margin), or by using the relationship from equation (5-4),

$$PV = PMT \left[\frac{1 - \frac{1}{(1 + k)^n}}{k} \right]$$

STEP 2: CRUNCH THE NUMBERS

Using the mathematical relationship we get:

$$PV = \$15,000 \left[\frac{1 - \frac{1}{(1 + 0.10)^3}}{0.10} \right] = \$15,000 (2.4869) = \$37,303$$

STEP 3: ANALYZE YOUR RESULTS

Seeing that the cash inflows have been discounted back to the present, they can now be compared with the initial outlay because both of the flows are now stated in terms of today's dollars. Subtracting the initial outlay (\$30,000) from the present value of the cash inflows (\$37,303), we find that the system's *NPV* is \$7,303. Because the *NPV* on this project is positive, the project should be accepted.

Using Spreadsheets to Calculate the Net Present Value

Although we can calculate the *NPV* by hand or with a financial calculator, it is more commonly done with the help of a spreadsheet. Just as with the keystroke calculations on a

CAN YOU DO IT?

DETERMINING THE NPV OF A PROJECT

Determine the *NPV* for a new project that costs \$7,000, is expected to produce 10 years' worth of annual free cash flows of \$1,000 per year, and has a required rate of return of 5 percent.
(The solution can be found on page 314.)

financial calculator, a spreadsheet can make easy work of *NPV* calculations. The only real glitch here is that in Excel, along with most other spreadsheets, the *=NPV* function calculates the present value of only the future cash flows and ignores the initial outlay in its *NPV* calculations. Sounds strange? Well, it is. It is essentially just a carryforward of an error in one of the first spreadsheets. That means that the actual *NPV* is the Excel-calculated *NPV* minus the initial outlay:

$$\text{Actual NPV} = \text{Excel-calculated NPV} - \text{initial outlay}$$

This can be input into a spreadsheet cell as:

$$=NPV(\text{rate}, \text{inflow 1}, \text{inflow 2}, \dots, \text{inflow 29}) - \text{initial outlay}$$

Looking back at the Ski-Doo example in Table 10-3, we can use a spreadsheet to calculate the net present value of the investment in machinery as long as we remember to subtract the initial outlay in order to get the correct number.

	A	B	C	D	E
2	Spreadsheets and NPV – the Ski-Doo Example				
3					
4	Looking at the example in Table 10-3, given a 12 percent				
5	discount rate and the following after-tax cash flows, the				
6	Net Present Value could be calculated as follows:				
7					
8			rate (k) =	12%	
9					
10			Year	Cash Flow	
11			Initial Outlay	(\$40,000)	
12			1	\$15,000	
13			2	\$14,000	
14			3	\$13,000	
15			4	\$12,000	
16			5	\$11,000	
17					
18			NPV =	\$7,674.63	
19					
20	Excel formula: =NPV(rate,inflow1,inflow2, ...,inflow29)				
21					
22	Again, from the Excel NPV calculation we must then				
23	subtract out the initial outlay in order to calculate the				
24	actual NPV.				
25					
26					
27					

Entered value in cell c18:
=NPV(D8,D12:D16)-40000

The Profitability Index (Benefit–Cost Ratio)

The **profitability index (PI)**, or **benefit–cost ratio**, is the *ratio of the present value of the future free cash flows to the initial outlay*. Although the *NPV* investment criterion gives a measure of the absolute dollar desirability of a project, the profitability index provides a relative

profitability index (PI) or benefit–cost ratio the ratio of the present value of an investment's future free cash flows to the investment's initial outlay.

measure of an investment proposal's desirability—that is, the ratio of the present value of its future net benefits to its initial cost. The profitability index can be expressed as follows:

$$PI = \frac{\text{present value of all the future annual free cash flows}}{\text{initial cash outlay}}$$

$$= \frac{\frac{FCF_1}{(1+k)^1} + \frac{FCF_2}{(1+k)^2} + \cdots + \frac{FCF_n}{(1+k)^n}}{IO} \quad (10-2)$$

where FCF_t = the annual free cash flow in time period t (this can take on either positive or negative values)

k = the firm's required rate of return or cost of capital

IO = the initial cash outlay

n = the project's expected life

The decision criterion is to accept the project if the PI is greater than or equal to 1.00 and to reject the project if the PI is less than 1.00.

$PI \geq 1.0$: accept

$PI < 1.0$: reject

Looking closely at this criterion, we see that it yields the same accept/reject decision as the NPV criterion. Whenever the present value of the project's free cash flows is greater than the initial cash outlay, the project's NPV will be positive, signaling a decision to accept. When this is true, then the project's PI will also be greater than 1 because the present value of the free cash flows (the PI 's numerator) is greater than the initial outlay (the PI 's denominator). Thus, these two decision criteria will always yield the same decision, although they

DID YOU GET IT?

DETERMINING THE NPV OF A PROJECT

You were asked to determine the NPV for a project with an initial outlay of \$7,000 and free cash flows in years 1 through 10 of \$1,000, given a 5 percent required rate of return.

$NPV = (\text{present value of all future free cash flows}) - (\text{initial outlay})$

1. Using the Mathematical Formulas.

STEP 1 Determine the present value of the future cash flows. Substituting these example values in equation (5-4), we find

$$PV = \$1,000 \left[\frac{1 - \frac{1}{(1 + 0.05)^{10}}}{0.05} \right]$$

$$= \$1,000 [(1 - 1/1.62889463)/0.05]$$

$$= \$1,000 [(1 - 0.61391325)/0.05]$$

$$= \$1,000 (7.72173493) = \$7,721.73$$

STEP 2 Subtract the initial outlay from the present value of the free cash flows.

$$\begin{array}{r} \$7,721.73 \\ -\$7,000.00 \\ \hline \$ 721.73 \end{array}$$

2. Using a Financial Calculator.

STEP 1 Determine the present value of the future cash flows.

Data Input	Function Key
10	N
5	I/Y
-1,000	PMT
0	FV
Function Key	Answer
CPT	
PV	7,721.73

STEP 2 Subtract the initial outlay from present value of the free cash flows.

$$\begin{array}{r} \$7,721.73 \\ -\$7,000.00 \\ \hline \$ 721.73 \end{array}$$

Alternatively, you could use the **CF** button on your calculator (using a TI BA II Plus).

Data and Key Input	Display
CF ; 2nd ; CE/C	CFo = 0. (this clears out any past cash flows)
-7,000; ENTER	CFo = -7,000.
↓ ; 1,000; ENTER	C01 = 1,000.
↓ ; 10; ENTER	F01 = 10.00
NPV	I = 0.
5; ENTER	I = 5.00
↓	NPV = 0.
CPT	NPV = 721.73

will not necessarily rank acceptable projects in the same order. This problem of conflicting ranking is dealt with at a later point.

Because the *NPV* and *PI* criteria are essentially the same, they have the same advantages over the other criteria examined. Both employ free cash flows, recognize the timing of the cash flows, and are consistent with the goal of maximizing shareholders' wealth. The major disadvantage of the *PI* criterion, similar to the *NPV* criterion, is that it requires long, detailed free cash flow forecasts.

EXAMPLE 10.3 Calculating the profitability index

A firm with a 10 percent required rate of return is considering investing in a new machine with an expected life of 6 years. The free cash flows resulting from this investment are given in Table 10-5. Determine the firm's profitability index. According to the profitability index, should the firm accept the investment?

TABLE 10-5 The Free Cash Flows Associated with an Investment in New Machinery

	Free Cash Flow
Initial outlay	−\$50,000
Inflow year 1	15,000
Inflow year 2	8,000
Inflow year 3	10,000
Inflow year 4	12,000
Inflow year 5	14,000
Inflow year 6	16,000

STEP 1: FORMULATE A SOLUTION STRATEGY

The profitability index can be calculated using equation (10-2) as follows:

$$PI = \frac{\text{present value of all the future annual free cash flows}}{\text{initial cash outlay}}$$

$$= \frac{\frac{FCF_1}{(1+k)^1} + \frac{FCF_2}{(1+k)^2} + \dots + \frac{FCF_n}{(1+k)^n}}{IO}$$

where FCF_t = the annual free cash flow in time period t (this can take on either positive or negative values)

k = the firm's required rate of return or cost of capital

IO = the initial cash outlay

n = the project's expected life

STEP 2: CRUNCH THE NUMBERS

Discounting the project's future net free cash flows back to the present yields a present value of \$53,682; dividing this value by the initial outlay of \$50,000 yields a profitability index of 1.0736, as shown in Table 10-6.

STEP 3: ANALYZE YOUR RESULTS

This tells us that the present value of the future benefits accruing from this project is 1.0736 times the level of the initial outlay. Because the profitability index is greater than 1.0, the project should be accepted. In addition, because the profitability index is greater than 1.0 we also know that the *NPV* is positive—that's because the present value of the future benefits is greater than the initial outlay. These two measures always give consistent accept/reject decisions on investment projects.

TABLE 10-6 Calculating the *PI* of an Investment in New Machinery

	Free Cash Flow	×	Present Value Factor at 10 Percent	=	Present Value
Inflow year 1	15,000	×	$\frac{1}{(1 + 0.10)^1}$	=	13,636
Inflow year 2	8,000	×	$\frac{1}{(1 + 0.10)^2}$	=	6,612
Inflow year 3	10,000	×	$\frac{1}{(1 + 0.10)^3}$	=	7,513
Inflow year 4	12,000	×	$\frac{1}{(1 + 0.10)^4}$	=	8,196
Inflow year 5	14,000	×	$\frac{1}{(1 + 0.10)^5}$	=	8,693
Inflow year 6	16,000	×	$\frac{1}{(1 + 0.10)^6}$	=	9,032
$PI = \frac{\frac{FCF_1}{(1+k)^1} + \frac{FCF_2}{(1+k)^2} + \dots + \frac{FCF_n}{(1+k)^n}}{IO}$ $= \frac{\$13,636 + \$6,612 + \$7,513 + \$8,196 + \$8,693 + \$9,032}{\$50,000}$ $= \frac{\$53,682}{\$50,000} = 1.0736$					

internal rate of return (IRR) the rate of return that the project earns. For computational purposes, the internal rate of return is defined as the discount rate that equates the present value of the project's free cash flows with the project's initial cash outlay.

The Internal Rate of Return

The **internal rate of return (IRR)** attempts to answer the question, what rate of return does this project earn? For computational purposes, the internal rate of return is defined as *the discount rate that equates the present value of the project's free cash flows with the project's initial cash outlay*. Mathematically, the internal rate of return is defined as the value *IRR* in the following equation:

IRR = the rate of return that equates the present value of the project's free cash flows with the initial outlay

$$IO = \frac{FCF_1}{(1 + IRR)^1} + \frac{FCF_2}{(1 + IRR)^2} + \dots + \frac{FCF_n}{(1 + IRR)^n} \quad (10-3)$$

where FCF_t = the annual free cash flow in time period t (this can take on either positive or negative values)

IO = the initial cash outlay

n = the project's expected life

IRR = the project's internal rate of return

In effect, the *IRR* is analogous to the concept of the yield to maturity for bonds, which was examined in Chapter 7. In other words, a project's *IRR* is simply the rate of return that the project earns.

The decision criterion is to accept the project if the *IRR* is greater than or equal to the firm's required rate of return. We reject the project if its *IRR* is less than the required rate of return. This accept/reject criterion can be stated as

$IRR \geq$ firm's required rate of return or cost of capital: accept

$IRR <$ firm's required rate of return or cost of capital: reject

If the *IRR* on a project is equal to the firm's required rate of return, then the project should be accepted because the firm is earning the rate that its shareholders are demanding. By contrast, accepting a project with an *IRR* below the investors' required rate of return will decrease the firm's stock price.

If the *NPV* is positive, then the *IRR* must be greater than the required rate of return, *k*. Thus, all the discounted cash-flow criteria are consistent and will result in similar accept/reject decisions. One disadvantage of the *IRR* relative to the *NPV* deals with the implied reinvestment rate assumptions made by these two methods. The *NPV* assumes that cash flows over the life of the project are reinvested back in projects that earn the required rate of return. That is, if we have a mining project with a 10-year expected life that produces a \$100,000 cash flow at the end of the second year, the *NPV* technique assumes that this \$100,000 is reinvested over years 3 through 10 at the required rate of return. The use of the *IRR*, however, implies that cash flows over the life of the project can be reinvested at the *IRR*. Thus, if the mining project we just looked at has a 40 percent *IRR*, the use of the *IRR* implies that the \$100,000 cash flow that is received at the end of year 2 could be reinvested at 40 percent over the remaining life of the project. In effect, *the NPV method implicitly assumes that cash flows over the life of the project can be reinvested at the project's required rate of return, whereas the use of the IRR method implies that these cash flows could be reinvested at the IRR*. The better assumption is the one made by the *NPV*—that the cash flows can be reinvested at the required rate of return because they can either be (1) returned in the form of dividends to shareholders, who demand the required rate of return on their investments, or (2) reinvested in a new investment project. If these cash flows are invested in a new project, then they are simply substituting for external funding on which the required rate of return is again demanded. Thus, the opportunity cost of these funds is the required rate of return.

The bottom line of all this is that the *NPV* method makes the best reinvestment rate assumption, and, as such, is superior to the *IRR* method. Why should we care which method is used if both methods result in similar accept/reject decisions? The answer, as we will see, is that although they may result in the same accept/reject decision, they may rank projects differently in terms of desirability.

Computing the *IRR* with a Financial Calculator With today's calculators, determining an *IRR* is merely a matter of a few keystrokes. In Chapter 5, whenever we were solving time value of money problems for *i*, we were really solving for the *IRR*. For instance, in Chapter 5 when we solve for the rate at which \$100 must be compounded annually for it to grow to \$179.10 in 10 years, we are actually solving for that problem's *IRR*. Thus, with financial calculators we need only input the initial outlay, the cash flows, and their timing and then input the function key “I/Y” or the “IRR” button to calculate the *IRR*. On some calculators it is necessary to press the compute key, CPT, before pressing the function key to be calculated.

Computing the *IRR* with a Spreadsheet Calculating the *IRR* using a spreadsheet is extremely simple. Once the cash flows have been entered on the spreadsheet, all you need to do is input the Excel *IRR* function into a spreadsheet cell and let the spreadsheet do the calculations for you. Of course, at least one of the cash flows must be positive and at least one must be negative. The *IRR* function to be input into a spreadsheet cell is: =**IRR(values)**, where “values” is simply the range of cells in which the cash flows including the initial outlay are stored.

	A	B	C	D	E
1					
2		Spreadsheets and the IRR			
3					
4	Three investment proposals being examined have the following				
5	cash flows:				
6					
7	Year	Project A	Project B	Project C	
8	Initial Outlay	(\$10,000)	(\$10,000)	(\$10,000)	
9	1	3.362	0	1.000	
10	2	3.362	0	3.000	
11	3	3.362	0	6.000	
12	4	3.362	13.605	7.000	
13					
14		IRR =	13.001%	8.000%	19.040%
15					
16	Excel Formula: =IRR(values)				
17					
18	where:				
19	values = the range of cells where the cash flows are stored.				
20	Note: There must be at least one positive and one				
21	negative cash flow.				

Entered value in cell B14:=IRR(B8:B12)
Entered value in cell C14:=IRR(C8:C12)
Entered value in cell D14:=IRR(D8:D12)

Computing the *IRR* for Uneven Cash Flows with a Financial Calculator Solving for the *IRR* when the cash flows are uneven is quite simple with a calculator: One need only key in the initial cash outlay, the cash flows, and their timing and press the “IRR” button. Let’s take a look at how you might solve a problem with uneven cash flows using a financial calculator. Every calculator works a bit differently, so you’ll want to be familiar with how to input data into yours, but that being said, they all work essentially the same way. As you’d expect, you will enter all the cash flows, then solve for the project’s *IRR*. With a Texas Instruments BA II Plus calculator, you begin by hitting the CF button. Then, C_{FO} indicates the initial outlay, which you’ll want to give a negative value; C₀₁ is the first free cash flow; and F₀₁ is the number of years in which the first free cash flow appears. Thus, if the free cash flows in years 1, 2, and 3 are all \$1,000, then F₀₁ = 3. C₀₂ then becomes the second free cash flow, and F₀₂ is the number of years in which the second free cash flow appears. You’ll notice that you move between the different cash flows using the down arrow (↓) located on the top row of your calculator. Once you have inputted the initial outlay and all the free cash flows, you then calculate the project’s *IRR* by hitting the “IRR” button followed by “CPT,” the compute button. Let’s look at a quick example. Consider the following investment proposal:

Initial outlay	−\$5,000
FCF in year 1	2,000
FCF in year 2	2,000
FCF in year 3	3,000

CALCULATOR SOLUTION
(USING A TI BA II PLUS):

Data and Key Input	Display
CF; −5,000; ENTER	C _{FO} = −5,000.00
↓ 2,000; ENTER	C ₀₁ = 2,000.00
↓ 2; ENTER	F ₀₁ = 2.00
↓ 3,000; ENTER	C ₀₂ = 3,000.00
↓ 1; ENTER	F ₀₂ = 1.00
IRR; CPT	IRR = 17.50%

EXAMPLE 10.4 Calculating internal rate of return

Consider the following investment proposal:

Initial outlay	−\$10,010
FCF in year 1	1,000
FCF in year 2	3,000
FCF in year 3	6,000
FCF in year 4	7,000

If the required rate of return is 15 percent, should this project be accepted?

STEP 1: FORMULATE A SOLUTION STRATEGY

Because the cash flows are uneven, you’ll want to either use Excel or use a financial calculator. Let’s use a financial calculator; specifically, let’s use a Texas Instruments BA II Plus calculator.

CAN YOU DO IT?

DETERMINING THE *IRR* OF A PROJECT

Determine the *IRR* for a new project that costs \$5,019 and is expected to produce 10 years’ worth of annual free cash flows of \$1,000 per year.
(The solution can be found on page 319.)

STEP 2: CRUNCH THE NUMBERS

Calculate the internal rate of return using the calculator.

CALCULATOR SOLUTION
(USING A TI BA II PLUS)

Data and Key Input	Display
CF ; -10,010; ENTER	CFo = -10,010.00
↓ 1,000; ENTER	C01 = 1,000.00
↓ 1; ENTER	F01 = 1.00
↓ 3,000; ENTER	C02 = 3,000.00
↓ 1; ENTER	F02 = 1.00
↓ 6,000; ENTER	C03 = 6,000.00
↓ 1; ENTER	F03 = 1.00
↓ 7,000; ENTER	C04 = 7,000.00
↓ 1; ENTER	F04 = 1.00
IRR ; CPT	IRR = 19.00%

STEP 3: ANALYZE YOUR RESULTS

In this case, the project's *IRR* is 19 percent, which is above the required rate of return of 15 percent. That means that this project would add value to the firm and should be accepted. In addition, we also know that since the *IRR* is greater than the required rate of return, the *NPV* must also be positive.

Viewing the NPV–IRR Relationship: The Net Present Value Profile

Perhaps the easiest way to understand the relationship between the *IRR* and the *NPV* value is to view it graphically through the use of a **net present value profile**. A net present value profile is simply *a graph showing how a project's NPV changes as the discount rate changes*. To graph a project's net present value profile, you simply need to determine the project's *NPV*, first using a 0 percent discount rate, then slowly increasing the discount rate until a representative curve has been plotted. How does the *IRR* enter into the net present value profile? The *IRR* is the discount rate at which the *NPV* is zero.

net present value profile a graph showing how a project's *NPV* changes as the discount rate changes.

Let's look at an example of a project that involves an after-tax initial outlay of \$105,517 with free cash flows expected to be \$30,000 per year over the project's 5-year life. Calculating the *NPV* of this project at several different discount rates results in the following:

Discount Rate	Project's NPV
0%	\$44,483
5%	\$24,367
10%	\$ 8,207
13%	\$ 0
15%	-\$ 4,952
20%	-\$15,798
25%	-\$24,839

DID YOU GET IT?**DETERMINING THE IRR OF A PROJECT**

You were asked to determine the *IRR* for a project with an initial outlay of \$5,019 and free cash flows in years 1 through 10 of \$1,000.

1. **Using a Financial Calculator.** Substituting in a financial calculator, we are solving for *i*.

Data Input	Function Key
10	N
-5,019	PV
1,000	PMT
0	FV

Function Key	Answer
--------------	--------

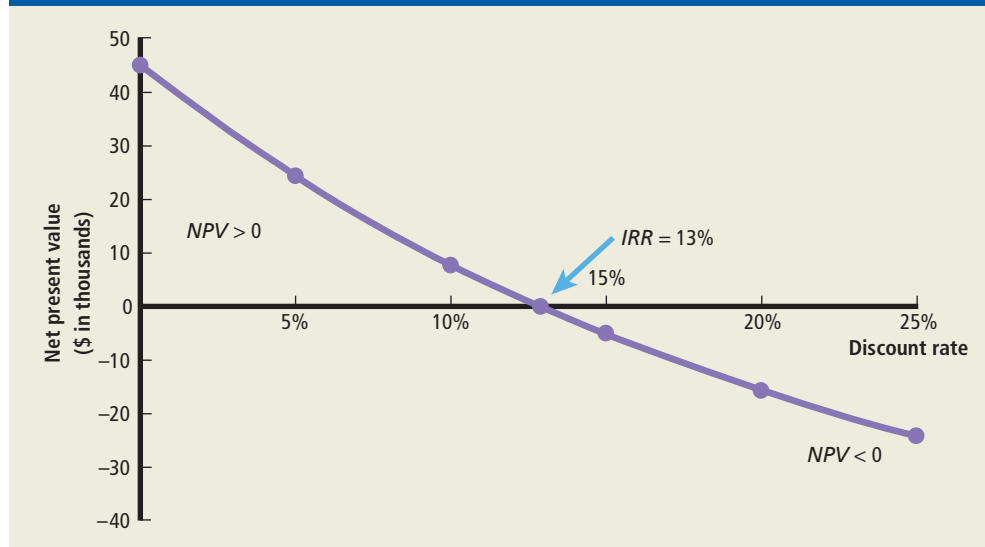
CPT**I/Y**

15

Alternatively, you could use the **CF** button on your calculator (using a TI BA II Plus):

Data and Key Input	Display
CF ; -5,019; ENTER	CFo = -5,019.
↓ ; 1,000; ENTER	C01 = 1,000.
↓ ; 10; ENTER	F01 = 10.00
IRR ; CPT	IRR = 15

2. **Using Excel.** Using Excel, the *IRR* could be calculated using the **= IRR** function.

FIGURE 10-1 An Example of the Net Present Value Profile of a Project

Plotting these values yields the net present value profile in Figure 10-1.

Where is the *IRR* in this figure? Recall that the *IRR* is the discount rate that equates the present value of the inflows with the present value of the outflows; thus, the *IRR* is the point at which the *NPV* is equal to zero—in this case, 13 percent. This is exactly the process that we use in computing the *IRR* for a series of uneven cash flows—we simply calculate the project's *NPV* using different discount rates and the discount rate that makes the *NPV* equal to zero is the project's *IRR*.

From the net present value profile you can easily see how a project's *NPV* varies inversely with the discount rate—as the discount rate is raised, the *NPV* drops. By analyzing a project's net present value profile, you can also see how sensitive the project is to your selection of the discount rate. The more sensitive the *NPV* is to the discount rate, the more important it is that you use the correct one in your calculations.

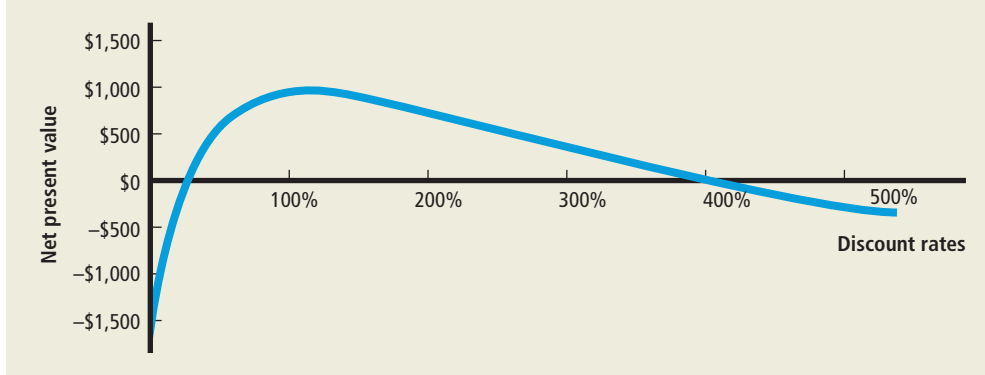
Complications with the *IRR*: Multiple Rates of Return

Although any project can have only one *NPV* and one *PI*, a single project under certain circumstances can have more than one *IRR*. The reason for this can be traced to the calculations involved in determining the *IRR*. Equation (10-3) states that the *IRR* is the discount rate that equates the present value of the project's future net cash flows with the project's initial outlay:

$$IO = \frac{FCF_1}{(1 + IRR)^1} + \frac{FCF_2}{(1 + IRR)^2} + \cdots + \frac{FCF_n}{(1 + IRR)^n} \quad (10-3)$$

However, because equation (10-3) is a polynomial of a degree n , it has n solutions. Now if the initial outlay (*IO*) is the only negative cash flow and all the annual free cash flows (*FCF*) are positive, then all but one of these n solutions is either a negative or an imaginary number and there is no problem. But problems occur when there are sign reversals in the cash-flow stream; in fact, there can be as many solutions as there are sign reversals. A normal, or “conventional,” pattern with a negative initial outlay and positive annual free cash flows after that ($-, +, +, +, \dots, +$) has only one sign reversal, hence, only one positive *IRR*. However, an “unconventional” pattern with more than one sign reversal can have more than one *IRR*.

	FREE CASH FLOW
Initial outlay	−\$ 1,600
Year 1 free cash flow	+\$10,000
Year 2 free cash flow	−\$10,000

FIGURE 10-2 Multiple IRRs

In this pattern of cash flows, there are two sign reversals: one from $-\$1,600$ to $+\$10,000$ and one from $+\$10,000$ to $-\$10,000$, so there can be as many as two positive *IRRs* that will make the present value of the free cash flows equal to the initial outlay. In fact, two internal rates of return solve this problem: 25 percent and 400 percent. Graphically, what we are solving for is the discount rate that makes the project's *NPV* equal to zero. As Figure 10-2 illustrates, this occurs twice.

Which solution is correct? The answer is that neither solution is valid. Although each fits the definition of *IRR*, neither provides any insight into 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 the normal interpretation of the *IRR* loses its meaning. In this case, try the *NPV* criterion instead.

The Modified Internal Rate of Return (*MIRR*)²

Problems with multiple rates of return and the reinvestment rate assumption make the *NPV* superior to the *IRR* as a capital-budgeting technique. However, because of the ease of interpretation, the *IRR* is preferred by many practitioners. Recently, a new technique, the **modified internal rate of return (*MIRR*)**, has gained popularity as an alternative to the *IRR* method because it avoids multiple *IRRs* and allows the decision maker to directly specify the appropriate reinvestment rate. As a result, the *MIRR* provides the decision maker with the intuitive appeal of the *IRR* coupled with an improved reinvestment rate assumption.

Is this really a problem? The answer is yes. One of the problems of the *IRR* is that it creates unrealistic expectations both for the corporation and for its shareholders. For example, the consulting firm McKinsey & Company examined one firm that approved 23 major projects over 5 years based on average *IRRs* of 77 percent.³ However, when McKinsey adjusted the reinvestment rate on these projects to the firm's required rate of return, this return rate fell to 16 percent. The ranking of the projects also changed with the top-ranked project falling to the 10th most attractive project. Moreover, the returns on the highest-ranked projects with *IRRs* of 800, 150, and 130 percent dropped to 15, 23, and 22 percent, respectively, once the reinvestment rate was adjusted downward.

The driving force behind the *MIRR* is the assumption that all free cash flows over the life of the project are reinvested at the required rate of return until the termination of the project. Thus, to calculate the *MIRR*, we:

STEP 1 Determine the present value of the project's free cash *outflows*. We do this by discounting all the free cash *outflows* back to the present at the required rate of return. If the initial outlay is the only free cash *outflow*, then the initial outlay is the present value of the free cash *outflows*.

modified internal rate of return (*MIRR*)

the discount rate that equates the present value of the project's future free cash flows with the terminal value of the cash inflows.

²This section is relatively complex and can be omitted without loss of continuity.

³John C. Kelleher and Justin J. MacCormack, "Internal Rate of Return: A Cautionary Tale," *McKinsey Quarterly*, September 24, 2004, pp. 1–4.

STEP 2 Determine the future value of the project's free cash *inflows*. Take all the annual free cash *inflows* and find their future value at the end of the project's life, compounded forward at the required rate of return. We will call this the project's *terminal value*, or *TV*.

STEP 3 Calculate the *MIRR*. The *MIRR* is the discount rate that equates the present value of the free cash outflows with the project's terminal value.⁴

Mathematically, the modified internal rate of return is defined as the value of *MIRR* in the following equation:

$$PV_{\text{outflows}} = \frac{TV_{\text{inflows}}}{(1 + MIRR)^n} \quad (10-4)$$

where PV_{outflows} = the present value of the project's free cash *outflows*

TV_{inflows} = the project's terminal value, calculated by taking all the annual free cash *inflows* and finding their future value at the end of the project's life, compounded forward at the required rate of return

n = the project's expected life

MIRR = the project's modified internal rate of return

In terms of decision rules, if the project's *MIRR* is greater than or equal to the project's required rate of return, it should be accepted. While we have now introduced a number of different capital-budgeting decision rules, interestingly the *NPV*, *PI*, *IRR*, and *MIRR* will always give the same accept/reject decision for independent projects. These financial decision rules can be summarized as follows:

FINANCIAL DECISION TOOLS		
Name of Tool	Formula	What It Tells You
Net present value (<i>NPV</i>)	The present value of all the future annual free cash flows minus the initial cash outlay: $= \frac{FCF_1}{(1+k)^1} + \frac{FCF_2}{(1+k)^2} + \cdots + \frac{FCF_n}{(1+k)^n} - IO$	- The amount of wealth that is created if the project is accepted - If the <i>NPV</i> is positive, then wealth is created and the project should be accepted.
Profitability index (<i>PI</i>) (Also referred to as the benefit–cost ratio)	The ratio of the present value of the future free cash flows to the initial outlay: $= \frac{\frac{FCF_1}{(1+k)^1} + \frac{FCF_2}{(1+k)^2} + \cdots + \frac{FCF_n}{(1+k)^n}}{IO}$	- The ratio of the present value of future benefits to the initial cost - If it is greater than 1.0, the <i>NPV</i> must be positive; the project creates value and should be accepted.
Internal rate of return (<i>IRR</i>)	The discount rate that equates the present value of the project's future free cash flows with the project's initial outlay: $IO = \frac{FCF_1}{(1+IRR)^1} + \frac{FCF_2}{(1+IRR)^2} + \cdots + \frac{FCF_n}{(1+IRR)^n}$ Where <i>IRR</i> = the project's internal rate of return	- The rate of return that the project earns - If the project earns more than the required rate of return, then the <i>NPV</i> must be positive; the project creates value and should be accepted.
Modified internal rate of return (<i>MIRR</i>)	The discount rate that equates the present value of the project's future free cash flows with the terminal value of the cash inflows $PV_{\text{outflows}} = \frac{TV_{\text{inflows}}}{(1 + MIRR)^n}$	What the <i>IRR</i> would be if it was based upon the assumption that cash flows are reinvested at the required rate of return

⁴You will notice that we differentiate between annual cash inflows and annual cash outflows, compounding all the inflows to the end of the project and bringing all the outflows back to the present as part of the present value of the cost. Although there are alternative definitions of the *MIRR*, this is the most widely accepted definition.

EXAMPLE 10.5 Calculating the *MIRR*

Let's look at an example of a project with a 3-year life and a required rate of return of 10 percent assuming the following cash flows are associated with it:

FREE CASH FLOWS	
Initial outlay	−\$6,000
Year 1	2,000
Year 2	\$3,000
Year 3	4,000

Determine the *MIRR* of the project.

STEP 1: FORMULATE A SOLUTION STRATEGY

The calculation of the *MIRR* can be viewed as a three-step process:

STEP 1 Determine the present value of the project's free cash outflows.

STEP 2 Determine the terminal value of the project's free cash inflows.

STEP 3 Determine the discount rate that equates the present value of the terminal value and the present value of the project's cash outflows.

Mathematically, the modified internal rate of return is defined as the value of *MIRR* in the following equation:

$$PV_{\text{outflows}} = \frac{TV_{\text{inflows}}}{(1 + MIRR)^n} \quad (10-4)$$

where PV_{outflows} = the present value of project's free cash *outflows*

TV_{inflows} = the project's terminal value, calculated by taking all the annual free cash *inflows* and finding their future value at the end of the project's life, compounded forward at the required rate of return

n = the project's expected life

MIRR = the project's modified internal rate of return

STEP 2: CRUNCH THE NUMBERS

Using the three-step process:

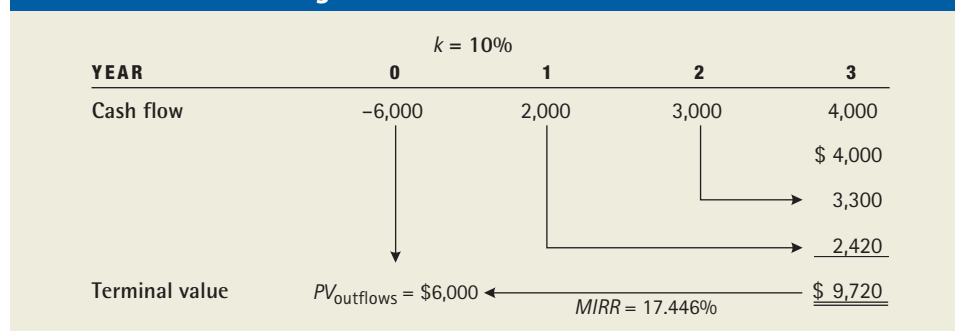
STEP 1 Determine the present value of the project's free cash outflows. In this case, the only outflow is the initial outlay of \$6,000, which is already at the present; thus, it becomes the present value of the cash outflows.

STEP 2 Determine the terminal value of the project's free cash inflows. To do this, we merely use the project's required rate of return to calculate the future value of the project's three cash inflows at the termination of the project. In this case, the terminal value becomes \$9,720.

STEP 3 Determine the discount rate that equates the present value of the terminal value and the present value of the project's cash outflows. Thus, the *MIRR* is calculated to be 17.446 percent.

The calculations are as follows:

FIGURE 10-3 Calculating the *MIRR*



$$\begin{aligned}
 \$6,000 &= \frac{TV_{\text{inflows}}}{(1 + MIRR)^n} \\
 \$6,000 &= \frac{\$2,000(1 + 0.10)^2 + \$3,000(1 + 0.10)^1 + \$4,000(1 + 0.10)^0}{(1 + MIRR)^3} \\
 \$6,000 &= \frac{\$2,420 + \$3,300 + \$4,000}{(1 + MIRR)^3} \\
 \$6,000 &= \frac{\$9,720}{(1 + MIRR)^3} \\
 MIRR &= 17.45\%
 \end{aligned}$$

STEP 3: ANALYZE YOUR RESULTS

Thus, the *MIRR* for this project (17.45 percent) is less than its *IRR*, which comes out to 20.614 percent. In this case, it only makes sense that the *IRR* should be greater than the *MIRR*, because the *IRR* implicitly assumes intermediate cash inflows to grow at the *IRR* rather than the required rate of return.

In terms of decision rules, if the project's *MIRR* is greater than or equal to the project's required rate of return, then the project should be accepted; if not, it should be rejected:

$MIRR \geq$ required rate of return: accept

$MIRR <$ required rate of return: reject

Because of the frequent use of the *IRR* in the real world as a decision-making tool and its limiting reinvestment rate assumption, the *MIRR* has become increasingly popular as an alternative decision-making tool.

Using Spreadsheets to Calculate the *MIRR*

As with other financial calculations using a spreadsheet, calculating the *MIRR* is extremely simple. The only difference between this calculation and that of the traditional *IRR* is that with a spreadsheet you also have the option of specifying both a *financing rate* and a *reinvestment rate*. The *financing rate* refers to the rate at which you borrow the money needed for the investment, whereas the *reinvestment rate* is the rate at which you reinvest the cash flows. Generally, it is assumed that these two values are one and the same. Thus, we enter the value of k , the appropriate discount rate, for both of these values. Once the cash flows have been entered on the spreadsheet, all you need to do is input the Excel *MIRR* function into a spreadsheet cell and let the spreadsheet do the calculations for you. Of course, as with the *IRR* calculation, at least one of the cash flows must be positive and at least one must be negative. The *MIRR* function to be input into a spreadsheet cell is **=MIRR(values,finance rate,reinvestment rate)**, where *values* is simply the range of cells where the cash flows are stored, and k is entered for both the finance rate and the reinvestment rate.

	A	B	C	D	E
1					
2	Using a Spreadsheet to Calculate the MIRR				
3					
4	Looking back on the previous example, we can also calculate the				
5	MIRR using a spreadsheet. However, with a spreadsheet you also				
6	have the option of specifying both a financing rate and a reinvestment				
7	rate. The <i>financing rate</i> would be the rate at which you borrow the money				
8	you need for the investment, while the <i>reinvestment rate</i> is the rate				
9	at which you reinvest the cash flows. In our calculations we assume				
10	these values to be identical. Thus we will put k , the appropriate				
11	discount rate, in for both of these values. Going back to the				
12	previous example:				
13					
14		Year	Cash Flow		
15		Initial Outlay	(\$6,000)		
16		1	2000		
17		2	3000		
18		3	4000		
19					
20		MIRR =	17.446%		
21					
22	Excel formula: =MIRR(values,finance rate,reinvestment rate)				
23					
24	where:				
25	values = the range of cells where the cash flows are stored.				
26	Note: There must be at least one positive and one				
27	negative cash flow.				
28	finance rate = the rate at which you borrow the money needed				
29	for the investment. Generally assumed to be k .				
30	reinvestment rate = the reinvestment rate. Generally assumed to be k .				
31					

Entered value in cell C20:
=MIRR(C15:C18,10%,10%)

Concept Check

1. Provide an intuitive definition of an internal rate of return for a project.
2. What does a net present value profile tell you, and how is it constructed?
3. What is the difference between the *IRR* and the *MIRR*?
4. Why do the net present value and profitability index always yield the same accept/reject decision for any project?

Capital Rationing

The use of our capital-budgeting decision rules developed in this chapter implies that the size of the capital budget is determined by the availability of acceptable investment proposals. However, a firm may *place a limit on the dollar size of the capital budget*. This situation is called **capital rationing**. As we will see, examining capital rationing not only better enables us to deal with complexities of the real world but also serves to demonstrate the superiority of the *NPV* method over the *IRR* method for capital budgeting. It is always somewhat uncomfortable to deal with problems associated with capital rationing because, under rationing, projects with positive net present values are rejected. This is a situation that violates the firm's goal of shareholder wealth maximization. However, in the real world, capital rationing does exist, and managers must deal with it. Often when firms impose capital constraints, they are recognizing that they do not have the ability to profitably handle more than a certain number of new and/or large projects.

Using the *IRR* as the firm's decision rule, a firm accepts all projects with an *IRR* greater than the firm's required rate of return. This rule is illustrated in Figure 10-4, where projects A through E would be chosen. However, when capital rationing is imposed, the dollar size of the total investment is limited by the budget constraint. In Figure 10-4, the budget constraint of \$X precludes the acceptance of an attractive investment, project E. This situation obviously contradicts prior decision rules. Moreover, choosing the projects with the highest *IRR* is complicated by the fact that some projects are indivisible. For example, it may be illogical to recommend that half of project D be undertaken.



Explain how the capital-budgeting decision process changes when a dollar limit is placed on the capital budget.

capital rationing placing a limit on the dollar size of the capital budget.

The Rationale for Capital Rationing

In general, three principal reasons are given for imposing a capital-rationing constraint. First, managers may think market conditions are temporarily adverse. In the period surrounding the downturn in the economy in the late 2000s, this reason was frequently given. At that time stock prices were depressed, which made the cost of funding projects high. Second, there may be a shortage of qualified managers to direct new projects; this can happen when projects are of a highly technical nature. Third, there may be intangible considerations. For example, managers may simply fear debt, wishing to avoid interest payments at any cost. Or perhaps the firm wants to limit the issuance of common stock to maintain a stable dividend policy.

FIGURE 10-4 Projects Ranked by the *IRR*

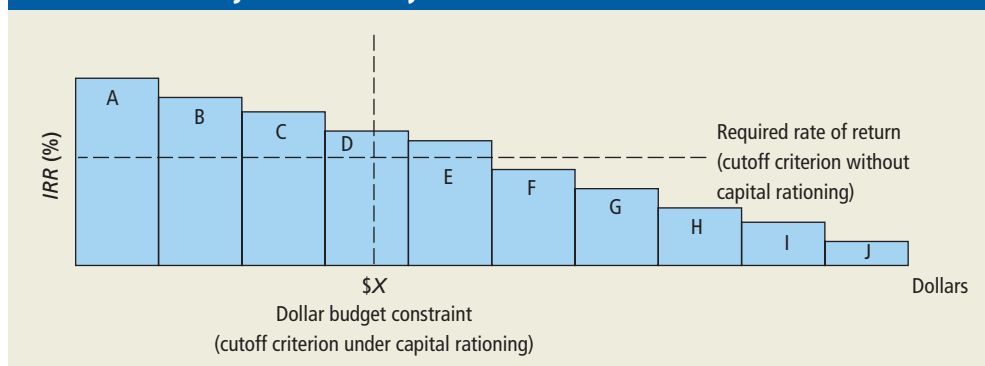


TABLE 10-7 Capital Rationing: Choosing Among Five Indivisible Projects

Project	Initial Outlay	Profitability Index	Net Present Value
A	\$200,000	2.4	\$280,000
B	200,000	2.3	260,000
C	800,000	1.7	560,000
D	300,000	1.3	90,000
E	300,000	1.2	60,000

So what is capital rationing's effect on the firm? In brief, the effect is negative. To what degree it is negative depends on the severity of the rationing. If the rationing is minor and short-lived, the firm's share price will not suffer to any great extent. In this case, capital rationing can probably be excused, although it should be noted that any capital-rationing action that rejects projects with positive *NPVs* is contrary to the firm's goal of maximization of shareholders' wealth. If the capital rationing is a result of the firm's decision to limit dramatically the number of new projects or to use only internally generated funds for projects, then this policy will eventually have a significantly negative effect on the firm's share price. For example, a lower share price will eventually result from lost competitive advantage if, because of a decision to arbitrarily limit its capital budget, a firm fails to upgrade its products and manufacturing processes.

Capital Rationing and Project Selection

If a firm decides to impose a capital constraint on its investment projects, the appropriate decision criterion is to select the set of projects with the highest *NPV* subject to the capital constraint. In effect, it should select the projects that increase shareholders' wealth the most. This guideline may preclude merely taking the highest-ranked projects in terms of the *PI* or the *IRR*. If the projects shown in Figure 10-4 are divisible, the last project accepted will be only partially accepted. Although partial acceptance may be possible, as we have said, in some cases, the indivisibility of most capital investments prevents it. For example, purchasing half a sales outlet or half a truck is impossible.

Consider a firm with a budget constraint of \$1 million and five indivisible projects available to it, as given in Table 10-7. If the highest-ranked projects were taken, projects A and B would be taken first. At that point there would not be enough funds available to take on project C; hence, projects D and E would be taken on. However, a higher total *NPV* is provided by the combination of projects A and C. Thus, projects A and C should be selected from the set of projects available. This illustrates our guideline: to select the set of projects that maximizes the firm's *NPV*.

Concept Check

1. What is capital rationing?
2. How might capital rationing conflict with the goal of maximizing shareholders' wealth?
3. What are mutually exclusive projects? How might they complicate the capital-budgeting process?

b4 Discuss the problems encountered when deciding among mutually exclusive projects.

mutually exclusive projects projects that, if undertaken, would serve the same purpose. Thus, accepting one will necessarily mean rejecting the others.

Ranking Mutually Exclusive Projects

In the past, we have proposed that all projects with a positive *NPV*, a *PI* greater than 1.0, or an *IRR* greater than the required rate of return be accepted, assuming there is no capital rationing. However, this acceptance is not always possible. In some cases, when two projects are judged acceptable by the discounted cash-flow criteria, it may be necessary to select only one of them because they are mutually exclusive. **Mutually exclusive projects** are projects that, if undertaken, would serve the same purpose. For example, a company considering the installation of a computer system might evaluate three or four systems, all of which have positive *NPVs*. However, the acceptance of one system automatically means rejection of the others. In general, to deal with mutually exclusive projects, we simply rank them by means

of the discounted cash-flow criteria and select the project with the highest ranking. On occasion, however, problems of conflicting ranking may arise. As we will see, in general, the *NPV* method is the preferred decision-making tool because it leads to the selection of the project that increases shareholder wealth the most.

When dealing with mutually exclusive projects, there are three general types of ranking problems: the size-disparity problem, the time-disparity problem, and the unequal-lives problem. Each involves the possibility of conflict in the ranks yielded by the various discounted cash-flow, capital-budgeting criteria. As noted previously, when one discounted cash-flow criterion gives an accept signal, they will all give an accept signal, but they will not necessarily rank all projects in the same order. In most cases this disparity is not critical; however, for mutually exclusive projects the ranking order is important.

The Size-Disparity Problem

The size-disparity problem occurs when mutually exclusive projects of unequal size are examined. This problem is most easily clarified with an example.

EXAMPLE 10.6 The size-disparity problem

Suppose a firm is considering two mutually exclusive projects, A and B; both have required rates of return of 10 percent. Project A involves a \$200 initial outlay and a cash inflow of \$300 at the end of year 1, whereas project B involves an initial outlay of \$1,500 and a cash inflow of \$1,900 at the end of year 1. The net present values, profitability indexes, and internal rates of return for these projects are given in Table 10-8.

TABLE 10-8 The Size-Disparity Ranking Problem

PROJECT A		
YEARS	0	1
Cash Flow	-200	300
<i>NPV</i> = \$72.73		
<i>PI</i> = 1.36		
<i>IRR</i> = 50%		
PROJECT B		
YEARS	0	1
Cash Flow	-1,500	1,900
<i>NPV</i> = \$227.28		
<i>PI</i> = 1.15		
<i>IRR</i> = 27%		

In this case, if the *NPV* criterion is used, project B should be accepted; whereas if the *PI* or *IRR* criterion is used, project A should be chosen. The question now becomes, which project is better?

STEP 1: FORMULATE A SOLUTION STRATEGY

The answer depends on whether capital rationing exists.

STEP 2: CRUNCH THE NUMBERS

Without capital rationing, project B is better because it provides the largest increase in shareholders' wealth; that is, it has a larger *NPV*. If there is a capital constraint, the problem then focuses on what can be done with the additional \$1,300 that is freed up if project A is chosen (costing \$200, as opposed to \$1,500). If the firm can earn more on project A plus the project financed with the additional \$1,300 than it can on project B, then project A and the marginal project should be accepted. In effect, we are attempting to select the set of projects that maximize the firm's *NPV*. Thus, if the marginal project has an *NPV* greater than \$154.55 (\$227.28 - \$72.73), selecting it plus project A with an *NPV* of \$72.73 will provide an *NPV* greater than \$227.28, the *NPV* for project B.

STEP 3: ANALYZE YOUR RESULTS

In summary, whenever the size-disparity problem results in conflicting rankings between mutually exclusive projects, the project with the largest *NPV* will be selected, provided there is no capital rationing. When capital rationing exists, the firm should select the set of projects with the largest *NPV*.

The Time-Disparity Problem

The time-disparity problem and the conflicting rankings that accompany it result from the differing reinvestment assumptions made by the net present value and internal rate of return decision criteria. The *NPV* criterion assumes that cash flows over the life of the project can be reinvested at the required rate of return or cost of capital, whereas the *IRR* criterion implicitly assumes that the cash flows over the life of the project can be reinvested at the *IRR*. One possible solution to this problem is to use the *MIRR* method introduced earlier. As you recall, this method allows you to explicitly state the rate at which cash flows over the life of the project will be reinvested. Again, this problem may be illustrated through the use of an example.

EXAMPLE 10.7 The time-disparity problem

Suppose a firm with a required rate of return or cost of capital of 10 percent and with no capital constraint is considering the two mutually exclusive projects illustrated in Table 10-9. How to solve this time-disparity problem?

TABLE 10-9 The Time-Disparity Ranking Problem

PROJECT A				
	<i>k</i> = 10%			
YEARS	0	1	2	3
Cash Flow	−1,000	100	200	2,000
<i>NPV</i> = \$758.83				
<i>PI</i> = 1.759				
<i>IRR</i> = 35%				
PROJECT B				
	<i>k</i> = 10%			
YEARS	0	1	2	3
Cash Flow	−1,000	650	650	650
<i>NPV</i> = \$616.45				
<i>PI</i> = 1.616				
<i>IRR</i> = 43%				

STEP 1: FORMULATE A SOLUTION STRATEGY

Which criterion would be followed depends on which reinvestment assumption is used. The *NPV* and *PI* indicate that project A is the better of the two, whereas the *IRR* indicates that project B is the better. Project B receives its cash flows earlier than project A, and the different assumptions made about how these flows can be reinvested result in the difference in rankings.

STEP 2: CRUNCH THE NUMBERS

The *NPV* criterion assumes that cash flows over the life of the project can be reinvested at the required rate of return or cost of capital, whereas the *IRR* criterion implicitly assumes that the cash flows over the life of the project can be reinvested at the *IRR*.

STEP 3: ANALYZE YOUR RESULTS

The *NPV* criterion is preferred in this case because it makes the most acceptable assumption for the wealth-maximizing firm. It is certainly the most conservative assumption that can be made, because the required rate of return is the lowest possible reinvestment rate. Moreover, as we have already noted, the *NPV* method maximizes the value of the firm and the shareholders' wealth.

The Unequal-Lives Problem

The final ranking problem to be examined asks whether it is appropriate to compare mutually exclusive projects with different life spans. The incomparability of projects with different lives arises because future, profitable investment proposals will be precluded without ever having been considered. For example, let's say you own an older hotel on some prime beachfront property on Hilton Head Island, and you're considering either remodeling the hotel, which will extend its life by 5 years, or tearing it down and building a new hotel that has an expected life of 10 years. Either way you're going to make money because beachfront property is exactly where everyone would like to stay. But clearly, you can't do both.

Is it fair to compare the *NPVs* on these two projects? No. Why not? Because if you accept the 10-year project, you will not only be rejecting the 5-year project but also the chance to do something else profitable with the property in years 5 through 10. In effect, if the project with the shorter life were taken, at its termination you could either remodel again or rebuild and receive additional benefits, whereas accepting the project with the longer life would exclude this possibility, which is not included in the analysis. The key question thus becomes: Does today's investment decision include all future profitable investment proposals in its analysis? If not, the projects are not comparable.

EXAMPLE 10.8 The unequal-lives problem

Suppose a firm with a 10 percent required rate of return must replace an aging machine and is considering two replacement machines, one with a 3-year life and one with a 6-year life. The relevant cash-flow information for these projects is given in Figure 10-5.

FIGURE 10-5 Unequal Lives Ranking Problem

PROJECT A:

	<i>k</i> = 10%			
YEARS	0	1	2	3
Cash Flows	-1,000	500	500	500
<i>NPV</i> = \$243.43				
<i>PI</i> = 1.243				
<i>IRR</i> = 23.4%				

PROJECT B:

	<i>k</i> = 10%						
YEARS	0	1	2	3	4	5	6
Cash Flows	-1,000	300	300	300	300	300	300
<i>NPV</i> = \$306.58							
<i>PI</i> = 1.307							
<i>IRR</i> = 19.9%							

Examining the discounted cash-flow criteria, we find that the net present value and profitability index criteria indicate that project B is the better project, whereas the internal rate of return favors project A. This ranking inconsistency is caused by the different life spans of the projects being compared. In this case, the decision is a difficult one because the projects are not comparable. How to solve this unequal-lives problem?

STEP 1: FORMULATE A SOLUTION STRATEGY

There are several methods to deal with this situation. The first option is to assume that the cash inflows from the shorter-lived investment will be reinvested at the required rate of return until the termination of the longer-lived asset. Although this approach is the simplest because it merely involves calculating the net present value, it actually ignores the problem at hand—the possibility of undertaking another replacement opportunity with a positive net present value. Thus, the proper solution involves projecting reinvestment opportunities into the future—that is, making assumptions about possible future investment opportunities. Unfortunately, whereas the first method is too simplistic to be of any value, the second is extremely difficult, requiring extensive cash-flow forecasts. The final technique for confronting the problem is to assume that the firm's reinvestment opportunities in the future will be similar to its current ones. The two most common ways of doing this are by creating a replacement chain to equalize the life spans of projects or by calculating the equivalent annual annuity (*EAA*) of the projects.

Using a replacement chain, the present example would call for the creation of a two-chain cycle for project A; that is, we assume that project A can be replaced with a similar investment at the end of 3 years. Thus, project A would be viewed as two A projects occurring back to back, as illustrated in Figure 10-6. The first project begins with a \$1,000 outflow in year 0, or the beginning of year 1. The second project would have an initial outlay of \$1,000 at the beginning of year 4, or end of year 3, followed by \$500 cash flows in years 4 through 6. As a result, in year 3 there would be a \$500 inflow associated with the first project along with a \$1,000 outflow associated with repeating the project, resulting in a net cash flow in year 3 of $-\$500$. The net present value on this replacement chain is \$426.32, which can be compared with project B's net present value.

FIGURE 10-6 Replacement Chain Illustration: Two Project A's Back to Back

	$k = 10\%$						
YEARS	0	1	2	3	4	5	6
Cash Flows	-1,000	500	500	-500	500	500	500
$NPV = \$426.32$							

Therefore, project A should be accepted because the net present value of its replacement chain is greater than the net present value of project B. One problem with replacement chains is that, depending on the life of each project, it can be quite difficult to come up with equivalent lives. For example, if the two projects had 7- and 13-year lives, because the lowest common denominator is $7 \times 13 = 91$, a 91-year replacement chain would be needed to establish equivalent lives. In this case, it is easier to determine the project's **equivalent annual annuity (*EAA*)**. A project's *EAA* is simply an annuity cash flow that yields the same present value as the project's *NPV*.

To calculate an *EAA*, we need only calculate a project's *NPV* and then determine what annual annuity (PMT on your financial calculator) it is equal to. This can be done in two steps as follows:

STEP 1 Calculate the project's *NPV*.

STEP 2 Calculate the *EAA*.

STEP 2: CRUNCH THE NUMBERS

STEP 1 Calculate the project's *NPV*. In Figure 10-5 we determined that project A had an *NPV* of \$243.43, whereas project B had an *NPV* of \$306.58.

STEP 2 Calculate the *EAA*. The *EAA* is determined by using the *NPV* as the project's present value (PV), the number of years in the project as *N*, the required rate

equivalent annual annuity (*EAA*) an annuity cash flow that yields the same present value as the project's *NPV*.

of return as I/Y , entering a 0 for the future value (FV), and solving for the annual annuity (PMT). This determines the level of an annuity cash flow that would produce the same NPV as the project. For project A the calculations are:

CALCULATOR SOLUTION

Data Input	Function Key
3	N
10	I/Y
-243.43	PV
0	FV
Function Key	Answer
CPT	
PMT	97.89

For project B, the calculations are:

CALCULATOR SOLUTION

Data Input	Function Key
6	N
10	I/Y
-306.58	PV
0	FV
Function Key	Answer
CPT	
PMT	70.39

STEP 3: ANALYZE YOUR RESULTS

How do we interpret the EAA ? For a project with an n -year life, it tells us what the dollar value is of an n -year annual annuity that would provide the same NPV as the project. Thus, for project A, it means that a 3-year annuity of \$97.89 with a discount rate of 10 percent would produce a net present value the same as project A's net present value, which is \$243.43. We can now compare the equivalent annual annuities directly to determine which project is better. We can do this because we now have found the level of annual annuity that produces an NPV equivalent to the project's NPV . Thus, because they are both annual annuities, they are comparable.

FINANCIAL DECISION TOOLS

Name of Tool	Formula	What It Tells You
Equivalent annual annuity (EAA)	The annuity cash flow that yields the same present value as the project's NPV	- It makes mutually exclusive projects with unequal lives comparable by determining the level of an annual annuity that produces an NPV equivalent to the project's NPV. - The EAAs for projects with unequal lives can be compared because they represent annual annuities.

Concept Check

1. What are the three general types of ranking problems?

ETHICS IN FINANCIAL MANAGEMENT

THE FINANCIAL DOWNSIDE OF POOR ETHICAL BEHAVIOR

As we discussed in Chapter 1, ethics and trust are essential elements of the business world. Knowing the inevitable outcome—for truth does percolate—why do bright and experienced people ignore it? For even if the truth is known only within the confines of the company, it will get out. Circumstances beyond even the best manager's control take over once the chance has passed to act on the moment of truth. Consider the following cases:

Dow Corning didn't deserve its bankruptcy or the multibillion-dollar settlements for its silicone implants because the science didn't support the alleged damages. However, there was a moment of truth when those implants, placed on a blotter, left a stain. The company could have disclosed the possible leakage, researched the risk, and warned doctors and patients. Given the congressional testimony on the implants, many women would have chosen them despite the risk. Instead, they sued because they were not warned.

Beech-Nut's crisis was a chemical concoction instead of apple juice in its baby food products. Executives there ignored an in-house chemist who tried to tell them they were selling adulterated products.

Kidder-Peabody fell despite warnings from employees about a glitch in its accounting system that was reporting bond swaps as sales and income.

In 2004, Merck removed one of the world's best-selling painkillers from the market after a study showed Vioxx caused an increased risk of serious cardiovascular events, such as stroke and heart attack. Producing Vioxx wasn't Merck's problem; its problem was that, according to an editorial in the *New England Journal of Medicine*, Merck was alleged to have withheld data and information that would affect conclusions drawn in an earlier study that appeared in the *New England Journal of Medicine* in

2000. Now, Merck faces thousands of lawsuits, and studies continue to deliver bad news about the drug. In fact, in one case, a jury awarded \$51 million to a retired FBI agent who suffered a heart attack after taking the drug.

As a now-infamous memo reveals, Ford and Firestone did not feel obligated to reveal to the U.S. Transportation Department that certain tires were being recalled in overseas markets. The companies should have realized that it was not a question of whether the recall would be reported but by whom.

These cases all have several things in common. First, their moments of truth came and went while the companies took no action. Second, employees who raised the issue were ignored or, in some cases, fired. Third, there were lawyers along for the ride, as they were with Ford and Firestone.

Never rely on a lawyer in these moments of truth. Lawyers are legal experts but are not particularly good at controlling damage. They shouldn't make business decisions; managers should. More importantly, moments of truth require managers with strong ethics who will do more than the law requires.

Do businesses ever face a moment of truth wisely? One example is Foxy brand lettuce, which in 2006, shortly after E. coli-contaminated spinach was linked to three deaths, recalled all its lettuce after it discovered irrigation water on its farms tested positive for the bacterium. Although the lettuce was not found to be carrying any bacterium, it did everything possible to protect the public and, as a result, has very loyal customers.

Source: Kevin Kingsbury, "Corporate News: Merck Settles Claims Over Vioxx Ads," *Wall Street Journal*, May 21, 2008, p. B3; "Manager's Journal: Ford-Firestone Lesson: Heed the Moment of Truth," *Wall Street Journal*, September 11, 2000, p. A44; "Foxy's lettuce recalled after E. coli scare," *USA Today*, October 9, 2006, p. A10; and Joe Queenan, "Juice Men—Ethics and the Beech-Nut Sentences," *Barron's*, June 20, 1988, p. 14.

Chapter Summaries



Discuss the difficulty encountered in finding profitable projects in competitive markets and the importance of the search. (pgs. 305–306)

SUMMARY: The process of capital budgeting involves decision making with respect to investments in fixed assets. Before a profitable project can be adopted, it must be identified or found. Unfortunately, coming up with ideas for new products, for ways to improve existing products, or for ways to make existing products more profitable is extremely difficult. In general, the best source of ideas for new, potentially profitable products is within the firm.

KEY TERM

Capital budgeting, page 305 The process of decision making with respect to investments made in fixed assets—that is, should a proposed project be accepted or rejected.

Determine whether a new project should be accepted or rejected using the payback period, the net present value, the profitability index, and the internal rate of return. (pgs. 307–325)



SUMMARY: We examine four commonly used criteria for determining the acceptance or rejection of capital-budgeting proposals. The first method, the payback period, does not incorporate the time value of money into its calculations. However, the net present value, profitability index, and internal rate of return methods do account for the time value of money. These methods are summarized in Table 10-10.

TABLE 10-10 Capital-Budgeting Methods: A Summary

1A. Payback period = number of years required to recapture the initial investment from the free cash flows

Accept if payback period $\leq$ maximum acceptable payback period

Reject if payback period $>$ maximum acceptable payback period

Advantages:

- Uses free cash flows.
- Is easy to calculate and understand.
- Benefits the capital-constrained firm.
- May be used as rough screening device.

Disadvantages:

- Ignores the time value of money.
- Ignores cash flows occurring after the payback period.
- Selection of the maximum acceptable payback period is arbitrary.

1B. Discounted payback period = the number of years needed to recover the initial cash outlay from the discounted free cash flows

Accept if discounted payback $\leq$ maximum acceptable discounted payback period

Reject if discounted payback $>$ maximum acceptable discounted payback period

Advantages:

- Uses cash flows.
- Is easy to calculate and understand.
- Considers time value of money.

Disadvantages:

- Ignores cash flows occurring after the payback period.
- Selection of the maximum acceptable discounted payback period is arbitrary.

2. Net present value = present value of the future free cash flows less the investment's initial outlay

NPV = present value of all the future annual free cash flows – the initial cash outlay

Accept if $NPV \geq 0.0$

Reject if $NPV < 0.0$

Advantages:

- Uses free cash flows.
- Recognizes the time value of money.
- Is consistent with the firm's goal of shareholder wealth maximization.

Disadvantage:

- Requires detailed long-term forecasts of a project's cash flows.

3. Profitability index = the ratio of the present value of the future free cash flows to the initial outlay.

Accept if $PI \geq 1.0$

Reject if $PI < 1.0$

Advantages:

- Uses free cash flows.
- Recognizes the time value of money.
- Is consistent with the firm's goal of shareholder wealth maximization.

Disadvantage:

- Requires detailed long-term forecasts of a project's cash flows.

4A. Internal rate of return = the discount rate that equates the present value of the project's future free cash flows with the project's initial outlay

IRR = the rate of return that equates the present value of the project's free cash flows with the initial outlay

Accept if $IRR \geq$ required rate of return

Reject if $IRR <$ required rate of return

Advantages:

- Uses free cash flows.
- Recognizes the time value of money.
- Is, in general, consistent with the firm's goal of shareholder wealth maximization.

Disadvantages:

- Requires detailed long-term forecasts of a project's cash flows.
- Possibility of multiple IRR s.
- Assumes cash flows over the life of the project can be reinvested at the IRR .

(Continued)

TABLE 10-10 (Continued)

4B. Modified internal rate of return = the discount rate that equates the present value of the cash outflows with the terminal value of the cash inflows

Accept if $MIRR \geq$ required rate of return

Reject if $MIRR <$ required rate of return

Advantages:

- Uses free cash flows.
- Recognizes the time value of money.
- Is consistent with the firm's goal of shareholder wealth maximization.
- Allows reinvestment rate to be directly specified.

Disadvantage:

- Requires detailed long-term cash-flow forecasts.

KEY TERMS

Payback period, page 307 The number of years it takes to recapture a project's initial outlay.

Discounted payback period, page 308 The number of years it takes to recapture a project's initial outlay from the discounted free cash flows.

Net present value (NPV), page 310 The present value of an investment's annual free cash flows less the investment's initial outlay.

Profitability Index (PI) or benefit–cost ratio, page 313 The ratio of the present value of an investment's future free cash flows to the investment's initial outlay.

Internal rate of return (IRR), page 316 The rate of return that the project earns. For computational purposes, the internal rate of return is defined as the discount rate that equates the present value of the project's free cash flows with the project's initial cash outlay.

Net present value profile, page 319 A graph showing how a project's NPV changes as the discount rate changes.

Modified internal rate of return (MIRR), page 321 The discount rate that equates the present value of the project's future free cash flows with the terminal value of the cash inflows.

KEY EQUATIONS

$$\text{Payback period} = \frac{\text{number of years just prior to complete payback}}{\text{unpaid-back amount at beginning of year}} + \frac{\text{free cash flow in year payback is completed}}{\text{free cash flow in year payback is completed}}$$

$$\text{Discounted payback period} = \frac{\text{number of years just prior to complete payback from discounted free cash flows}}{\text{unpaid-back amount at the beginning of year}} + \frac{\text{discounted free cash flow in year payback is completed}}{\text{discounted free cash flow in year payback is completed}}$$

$$\text{Net present value} = \frac{FCF_1}{(1+k)^1} + \frac{FCF_2}{(1+k)^2} + \cdots + \frac{FCF_n}{(1+k)^n} - IO$$

$$\text{Profitability index (PI) or benefit–cost ratio} = \frac{\frac{FCF_1}{(1+k)^1} + \frac{FCF_2}{(1+k)^2} + \cdots + \frac{FCF_n}{(1+k)^n}}{IO}$$

$$\text{Internal rate of return (IRR): } IO = \frac{FCF_1}{(1+IRR)^1} + \frac{FCF_2}{(1+IRR)^2} + \cdots + \frac{FCF_n}{(1+IRR)^n}$$

$$\text{Modified internal rate of return (MIRR): } PV_{\text{outflows}} = \frac{TV_{\text{inflows}}}{(1+MIRR)^n}$$

Explain how the capital-budgeting decision process changes when a dollar limit is placed on the capital budget. (pgs. 325–326)



SUMMARY: There are several complications related to the capital-budgeting process. First, we examined capital rationing and the problems it can create by imposing a limit on the dollar size of the capital budget. Although capital rationing does not, in general, maximize shareholders' wealth, it does exist. The goal of maximizing shareholders' wealth remains, but it is now subject to a budget constraint.

KEY TERM

Capital rationing, page 325 Placing a limit on the dollar size of the capital budget.

Discuss the problems encountered when deciding among mutually exclusive projects. (pgs. 326–331)



SUMMARY: There are a number of problems associated with evaluating mutually exclusive projects. Mutually exclusive projects occur when different investments, if undertaken, would serve the same purpose. In general, to deal with mutually exclusive projects, we rank them by means of the discounted cash-flow criteria and select the project with the highest ranking. Conflicting rankings can arise because of the projects' size disparities, time disparities, and unequal lives. The incomparability of projects with different life spans is not simply a result of the different life spans; rather, it arises because future profitable investment proposals will be rejected without being included in the initial analysis. Replacement chains and equivalent annual annuities can solve this problem.

A perpetuity is an annuity that continues forever; that is, every year following its establishment the investment pays the same dollar amount. An example of a perpetuity is preferred stock, which pays a constant dollar dividend infinitely. Determining the present value of a perpetuity is delightfully simple. We merely need to divide the constant flow by the discount rate.

KEY TERMS

Mutually exclusive projects, page 326

Projects that, if undertaken, would serve the same purpose. Thus, accepting one will necessarily mean rejecting the others.

Equivalent annual annuity (EAA), page 330

An annuity cash flow that yields the same present value as the project's *NPV*.

Review Questions

All Review Questions are available in [MyFinanceLab](#).

10-1. Why is capital budgeting such an important process? Why are capital-budgeting errors so costly?

10-2. What are the disadvantages of using the payback period as a capital-budgeting technique? What are its advantages? Why is it so frequently used?

10-3. In some countries, the expropriation (seizure) of foreign investments is a common practice. If you were considering an investment in one of those countries, would the use of the payback period criterion seem more reasonable than it otherwise might? Why or why not?

10-4. Briefly compare and contrast the *NPV*, *PI*, and *IRR* criteria. What are the advantages and disadvantages of using each of these methods?

10-5. What are mutually exclusive projects? Why might the existence of mutually exclusive projects cause problems in the implementation of the discounted cash-flow capital-budgeting criteria?

10-6. What are common reasons for capital rationing? Is capital rationing rational?

10-7. How should managers compare two mutually exclusive projects of unequal size? Should the approach change if capital rationing is a factor?

10-8. What causes the time-disparity ranking problem? What reinvestment rate assumptions are associated with the *NPV* and *IRR* capital-budgeting criteria?

10-9. When might two mutually exclusive projects having unequal lives be incomparable? How should managers deal with this problem?

Study Problems

All Study Problems are available in [MyFinanceLab](#).



10-1. (IRR calculation) Determine the *IRR* on the following projects:

- An initial outlay of \$10,000 resulting in a single free cash flow of \$17,182 after 8 years
- An initial outlay of \$10,000 resulting in a single free cash flow of \$48,077 after 10 years
- An initial outlay of \$10,000 resulting in a single free cash flow of \$114,943 after 20 years
- An initial outlay of \$10,000 resulting in a single free cash flow of \$13,680 after 3 years

10-2. (IRR calculation) Determine the *IRR* on the following projects:

- An initial outlay of \$10,000 resulting in a free cash flow of \$1,993 at the end of each year for the next 10 years
- An initial outlay of \$10,000 resulting in a free cash flow of \$2,054 at the end of each year for the next 20 years
- An initial outlay of \$10,000 resulting in a free cash flow of \$1,193 at the end of each year for the next 12 years
- An initial outlay of \$10,000 resulting in a free cash flow of \$2,843 at the end of each year for the next 5 years

10-3. (IRR calculation) Determine to the nearest percent the *IRR* on the following projects:

- An initial outlay of \$10,000 resulting in a free cash flow 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
- An initial outlay of \$10,000 resulting in a free cash flow 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
- An initial outlay of \$10,000 resulting in a free cash flow of \$2,000 at the end of years 1 through 5 and \$5,000 at the end of year 6

10-4. (NPV, *PI*, and *IRR* calculations) Fijisawa Inc. is considering a major expansion of its product line and has estimated the following cash flows associated with such an expansion. The initial outlay would be \$1,950,000, and the project would generate incremental free cash flows of \$450,000 per year for 6 years. The appropriate required rate of return is 9 percent.

- Calculate the *NPV*.
- Calculate the *PI*.
- Calculate the *IRR*.
- Should this project be accepted?

10-5. (Payback period, *NPV*, *PI*, and *IRR* calculations) You are considering a project with an initial cash outlay of \$80,000 and expected free cash flows of \$20,000 at the end of each year for 6 years. The required rate of return for this project is 10 percent.

- What is the project's payback period?
- What is the project's *NPV*?
- What is the project's *PI*?
- What is the project's *IRR*?

10-6. (NPV, *PI*, and *IRR* calculations) 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 required rate of return on both projects is 12 percent. The expected annual free cash inflows from each project are as follows:

	PROJECT A	PROJECT B
Initial outlay	−\$50,000	−\$70,000
Inflow year 1	12,000	13,000
Inflow year 2	12,000	13,000
Inflow year 3	12,000	13,000
Inflow year 4	12,000	13,000
Inflow year 5	12,000	13,000
Inflow year 6	12,000	13,000

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

10-7. (Payback period calculations) You are considering three independent projects, project A, project B, and project C. Given the following cash-flow information, calculate the payback period for each.

	PROJECT A	PROJECT B	PROJECT C
Initial outlay	−\$1,000	−\$10,000	−\$5,000
Inflow year 1	600	5,000	1,000
Inflow year 2	300	3,000	1,000
Inflow year 3	200	3,000	2,000
Inflow year 4	100	3,000	2,000
Inflow year 5	500	3,000	2,000

If you require a 3-year payback before an investment can be accepted, which project(s) would be accepted?

10-8. (NPV with varying required rates of return) Gubanich Sportswear is considering building a new factory to produce aluminum baseball bats. This project would require an initial cash outlay of \$5,000,000 and will generate annual free cash inflows of \$1,000,000 per year for 8 years. Calculate the project's NPV given:

- A required rate of return of 9 percent
- A required rate of return of 11 percent
- A required rate of return of 13 percent
- A required rate of return of 15 percent

10-9. (IRR calculations) Given the following free cash flows, determine the IRR for the three independent projects A, B, and C.

	PROJECT A	PROJECT B	PROJECT C
Initial outlay	−\$50,000	−\$100,000	−\$450,000
Cash inflows:			
Year 1	\$10,000	\$125,000	\$200,000
Year 2	15,000	25,000	200,000
Year 3	20,000	25,000	200,000
Year 4	25,000	25,000	—
Year 5	30,000	25,000	—

10-10. (NPV with varying required rates of return) Big Steve's, a maker of swizzle sticks, is considering the purchase of a new plastic stamping machine. This investment requires an initial outlay of \$100,000 and will generate free cash inflows of \$18,000 per year for 10 years.

- If the required rate of return is 10 percent, what is the project's NPV?
- If the required rate of return is 15 percent, what is the project's NPV?
- Would the project be accepted under part (a) or (b)?
- What is the project's IRR?

10-11. (NPV with different required rates of return) Mooby's is considering building a new theme park. After estimating the future cash flows, but before the project could be evaluated, the economy picked up and with that surge in the economy interest rates rose. That rise in interest rates was reflected in the required rate of return Mooby's used to evaluate new products. As a result, the required rate of return for the new theme park jumped from 9.5 percent to 11.00 percent. If the initial outlay for the park is expected to be \$250 million and the project is expected to return free cash flows of \$50 million in years 1 through 5 and \$75 million in years 6 and 7, what is the project's NPV using the new required rate of return? How much did the project's NPV change as a result of the rise in interest rates?

10-12. (IRR with uneven cash flows) The Tiffin Barker Corporation is considering introducing a new currency verifier that has the ability to identify counterfeit dollar bills. The required rate of

return on this project is 12 percent. What is the *IRR* on this project if it is expected to produce the following cash flows?

Initial outlay	−\$927,917
<i>FCF</i> in year 1	200,000
<i>FCF</i> in year 2	300,000
<i>FCF</i> in year 3	300,000
<i>FCF</i> in year 4	200,000
<i>FCF</i> in year 5	200,000
<i>FCF</i> in year 6	160,000

10-13. (*NPV calculation*) Calculate the *NPV* given the following cash flows if the appropriate required rate of return is 10%.

YEAR	CASH FLOWS
0	−\$60,000
1	20,000
2	20,000
3	10,000
4	10,000
5	30,000
6	30,000

Should the project be accepted?

10-14. (*NPV calculation*) Calculate the *NPV* given the following cash flows if the appropriate required rate of return is 10%.

YEAR	CASH FLOWS
0	−\$70,000
1	30,000
2	30,000
3	30,000
4	−30,000
5	30,000
6	30,000

Should the project be accepted?

10-15. (*MIRR calculation*) Calculate the *MIRR* given the following cash flows if the appropriate required rate of return is 10% (use this as the reinvestment rate).

YEAR	CASH FLOWS
0	−\$50,000
1	25,000
2	25,000
3	25,000
4	−25,000
5	25,000
6	25,000

Should the project be accepted?

10-16. (*PI calculation*) Calculate the *PI* given the following cash flows if the appropriate required rate of return is 10%.

YEAR	CASH FLOWS
0	−\$55,000
1	10,000
2	10,000
3	10,000
4	10,000
5	10,000
6	10,000

Should the project be accepted? Without calculating the *NPV*, do you think it would be positive or negative? Why?

10-17. (*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?

10-18. (*Discounted payback period*) You are considering a project with the following cash flows:

YEAR	PROJECT CASH FLOW
0	−\$50,000
1	20,000
2	20,000
3	20,000
4	20,000

If the appropriate discount rate is 10 percent, what is the project's discounted payback period?

10-19. (*Discounted payback period*) Assuming an appropriate discount rate of 11 percent, what is the discounted payback period on a project with an initial outlay of \$100,000 and the following cash flows?

Year 1 = \$30,000

Year 2 = \$35,000

Year 3 = \$25,000

Year 4 = \$25,000

Year 5 = \$30,000

Year 5 = \$20,000

10-20. (*IRR*) Jella Cosmetics is considering a project that costs \$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*?

10-21. (*IRR*) Your investment advisor has offered you an investment that will provide you with one cash flow of \$10,000 at the end of 20 years if you pay premiums of \$200 per year at the end of each year for 20 years. Find the internal rate of return on this investment.

10-22. (*IRR, payback, and calculating a missing cash flow*) Mode Publishing is considering a new printing facility that will involve a large initial outlay and then result in a series of positive cash flows for 4 years. The estimated cash flows associated with this project are:

YEAR	PROJECT CASH FLOW
0 (initial outlay)	?
1	\$800 million
2	400 million
3	300 million
4	500 million

If you know that the project has a regular payback of 2.5 years, what is the project's internal rate of return?

10-23. (*Discounted payback period*) Sheinhardt Wig Company is considering a project that has the following cash flows:

YEAR	PROJECT CASH FLOW
0	−\$100,000
1	20,000
2	60,000
3	70,000
4	50,000
5	40,000

If the appropriate discount rate is 10 percent, what is the project's discounted payback?

10-24. (*IRR of 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, 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 internal rate of return on this new plant?

10-25. (*MIRR*) Dunder Mifflin Paper Company is considering purchasing a new stamping machine that costs \$400,000. This new machine will produce cash inflows of \$150,000 each year at the end of years 1 through 5, then at the end of year 7 there will be a cash *outflow* of \$200,000. The company has a weighted average cost of capital of 12 percent (use this as the reinvestment rate). What is the *MIRR* of the investment?

10-26. (*MIRR calculation*) Artie's Wrestling Stuff is considering building a new plant. This plant would require an initial cash outlay of \$8 million and will generate annual free cash inflows of \$2 million per year for 8 years. Calculate the project's *MIRR* given:

- A required rate of return of 10 percent
- A required rate of return of 12 percent
- A required rate of return of 14 percent



10-27. (*Capital rationing*) The Cowboy Hat Company of Stillwater, Oklahoma, is considering seven capital investment proposals for which the total funds available are limited to a maximum of \$12 million. The projects are independent and have the following costs and profitability indexes associated with them:

PROJECT	COST	PROFITABILITY INDEX
A	\$4,000,000	1.18
B	3,000,000	1.08
C	5,000,000	1.33
D	6,000,000	1.31
E	4,000,000	1.19
F	6,000,000	1.20
G	4,000,000	1.18

- Under strict capital rationing, which projects should be selected?
- What problems are there with capital rationing?

10-28. (*Mutually exclusive projects*) Nanotech, Inc. currently has a production electronics facility and it is cost-prohibitive to expand this production facility. Nanotech is deciding between the following four contracts:

	CONTRACT'S NPV	USE OF PRODUCTION FACILITY
A	\$100 million	100%
B	\$ 90 million	80%
C	\$ 60 million	60%
D	\$ 50 million	40%

Which project or projects should they accept?

10-29. (*Mutually exclusive projects and NPV*) 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?

10-30. (*Size-disparity problem*) The D. Dörner Farms Corporation is considering purchasing one of two fertilizer-herbicides for the upcoming year. The more expensive of the two is better and will produce a higher yield. Assume these projects are mutually exclusive and that the required rate of return is 10 percent. Given the following free cash flows:

	PROJECT A	PROJECT B
Initial outlay	−\$500	−\$5,000
Inflow year 1	700	6,000

- Calculate the *NPV* of each project.
- Calculate the *PI* of each project.
- Calculate the *IRR* of each project.
- If there is no capital-rationing constraint, which project should be selected? If there is a capital-rationing constraint, how should the decision be made?

10-31. (*Time-disparity problem*) The State Spartan Corporation is considering two mutually exclusive projects. The free cash flows associated with those projects are as follows:

	PROJECT A	PROJECT B
Initial outlay	−\$50,000	−\$ 50,000
Inflow year 1	15,625	0
Inflow year 2	15,625	0
Inflow year 3	15,625	0
Inflow year 4	15,625	0
Inflow year 5	15,625	100,000

The required rate of return on these projects is 10 percent.

- What is each project's payback period?
- What is each project's *NPV*?
- What is each project's *IRR*?
- What has caused the ranking conflict?
- Which project should be accepted? Why?

10-32. (Replacement chains) Destination Hotels currently owns an older hotel on the best beach-front property on Hilton Head Island, and it is considering either remodeling the hotel or tearing it down and building a new convention hotel, but because they both would occupy the same physical location, the company can only do one—that is, these are mutually exclusive projects. Both these projects have the same initial outlay of \$1,000,000. The first project, since it is a remodel of an existing hotel, has an expected life of 8 years and will provide free cash flows of \$250,000 at the end of each year for all 8 years. In addition, this project can be repeated at the end of 8 years at the same cost and with the same set of future cash flows. The proposed new convention hotel has an expected life of 16 years and will produce cash flows of \$175,000 per year. The required rate of return on both of these projects is 10 percent. Calculate the *NPV* using replacement chains to compare these two projects.

10-33. (Equivalent annual annuity) Rib & Wings-R-Us is considering the purchase of a new smoker oven for cooking barbecue, ribs, and wings. It is looking at two different ovens. The first is a relatively standard smoker and would cost \$50,000, last for 8 years, and produce annual cash flows of \$16,000 per year. The alternative is the deluxe, award-winning Smoke-alator, which costs \$78,000 and, because of its patented humidity control, produces the “moistest, tastiest barbecue in the world.” The Smoke-alator would last for 11 years and produce cash flows of \$23,000 per year. Assuming a 10 percent required rate of return on both projects, compute their equivalent annual annuity (*EAA*).

Mini Case

This Mini Case is available in [MyFinanceLab](#).

Your first assignment in your new position as assistant financial analyst at Caledonia Products is to evaluate two new capital-budgeting proposals. Because this is your first assignment, you have been asked not only to provide a recommendation but also to respond to a number of questions aimed at assessing your understanding of the capital-budgeting process. This is a standard procedure for all new financial analysts at Caledonia, and it will serve to determine whether you are moved directly into the capital-budgeting analysis department or are provided with remedial training. The memorandum you received outlining your assignment follows:

To: The New Financial Analysts
 From: Mr. V. Morrison, CEO, Caledonia Products
 Re: Capital-Budgeting Analysis

Provide an evaluation of two proposed projects, both with 5-year expected lives and identical initial outlays of \$110,000. Both of these projects involve additions to Caledonia's highly successful Avalon product line, and as a result, the required rate of return on both projects has been established at 12 percent. The expected free cash flows from each project are as follows:

	PROJECT A	PROJECT B
Initial outlay	−\$110,000	−\$110,000
Inflow year 1	20,000	40,000
Inflow year 2	30,000	40,000
Inflow year 3	40,000	40,000
Inflow year 4	50,000	40,000
Inflow year 5	70,000	40,000

In evaluating these projects, please respond to the following questions:

- Why is the capital-budgeting process so important?
- Why is it difficult to find exceptionally profitable projects?
- What is the payback period on each project? If Caledonia imposes a 3-year maximum acceptable payback period, which of these projects should be accepted?
- What are the criticisms of the payback period?
- Determine the *NPV* for each of these projects. Should they be accepted?
- Describe the logic behind the *NPV*.
- Determine the *PI* for each of these projects. Should they be accepted?
- Would you expect the *NPV* and *PI* methods to give consistent accept/reject decisions? Why or why not?
- What would happen to the *NPV* and *PI* for each project if the required rate of return increased? If the required rate of return decreased?
- Determine the *IRR* for each project. Should they be accepted?
- How does a change in the required rate of return affect the project's internal rate of return?
- What reinvestment rate assumptions are implicitly made by the *NPV* and *IRR* methods? Which one is better?

You have also been asked for your views on three unrelated sets of projects. Each set of projects involves two mutually exclusive projects. These projects follow.

- Caledonia is considering two investments with 1-year lives. The more expensive of the two is the better and will produce more savings. Assume these projects are mutually exclusive and that the required rate of return is 10 percent. Given the following free cash flows:

	PROJECT A	PROJECT B
Initial outlay	−\$195,000	−\$1,200,000
Inflow year 1	240,000	1,650,000

- Calculate the *NPV* for each project.
 - Calculate the *PI* for each project.
 - Calculate the *IRR* for each project.
 - If there is no capital-rationing constraint, which project should be selected? If there is a capital-rationing constraint, how should the decision be made?
- Caledonia is considering two additional mutually exclusive projects. The free cash flows associated with these projects are as follows:

	PROJECT A	PROJECT B
Initial outlay	−\$100,000	−\$100,000
Inflow year 1	32,000	0
Inflow year 2	32,000	0
Inflow year 3	32,000	0
Inflow year 4	32,000	0
Inflow year 5	32,000	200,000

The required rate of return on these projects is 11 percent.

- What is each project's payback period?
- What is each project's *NPV*?
- What is each project's *IRR*?
- What has caused the ranking conflict?
- Which project should be accepted? Why?