CHAPTER

16

Business Investment Decisions

LEARNING OBJECTIVES

After completing this chapter, you will be able to:

- Calculate the net present value (*NPV*) of a capital investment and use the *NPV* to decide whether the investment should be made
- Under conditions of capital rationing, choose the best combination of investments from a group of acceptable capital investment opportunities
- Select the best investment from two or more mutually exclusive investments
- Calculate the internal rate of return (*IRR*) of a capital investment and use the *IRR* to decide whether the investment should be made
- Calculate the payback period of a capital investment

CHAPTER OUTLINE

WHAT ANALYSIS SHOULD A BUSINESS undertake for investment decisions such as expanding production, adding another product line, or replacing the existing plant or equipment?

In this chapter we will study techniques used by managers to make sound financial decisions on capital investments. We will study three criteria widely employed to guide business investment decisions. Two of them rest on a solid economic foundation. The third is flawed in some respects but, nevertheless, is frequently used in business—it is important that you understand its limitations.

Given the long-term nature of capital investments, any rigorous analysis must recognize the time value of money. Most of the concepts and mathematics you need to evaluate business investments have already been presented in previous chapters. What remains to learn is the terminology and procedures for applying this knowledge in the analysis potential business investments.

16.1 COMPARING BUSINESS TO PERSONAL INVESTMENT DECISIONS

The fundamental principles that guide both personal and business investment decisions are the same. The Valuation Principle is as relevant to business investments as it is to personal investments. Use of the Valuation Principle to determine the fair market value of an investment requires three steps:

1. Identify or estimate the cash flows expected from the investment. If there are cash outflows as well as cash inflows in any particular period, estimate the period's

$$\text{Net cash flow} = \text{Cash inflows} - \text{Cash outflows}$$

2. Determine the rate of return appropriate for the type of investment.
3. Calculate the sum of the present values of the net cash flows estimated in Step 1, discounted at the rate of return determined in Step 2.

If cash flows are actually received as forecast in Step 1, an investor paying the amount calculated in Step 3 will realize the Step 2 rate of return. But a *higher* purchase price or *lower* (than forecast) cash flows will result in a rate of return that is *smaller* than the discount rate used in Step 2. On the other hand, a *lower* price or *higher* cash flows will result in a rate of return *greater* than the discount rate.

The *nature* of investments made by an *operating* business differs markedly from the nature of most personal investments. Personal investments fall primarily in a limited number of categories such as Treasury bills, GICs, bonds, and stocks. With the exception of common stocks, there is a considerable degree of similarity among investments within each category. In addition, an individual investor can usually depend on competitive bidding in the financial markets to set fair prices for widely traded securities. In these cases, the investor may not explicitly use the Valuation Principle in selecting investments.

For investments in plant and equipment by a business, the way in which the asset will be used and the resulting pattern of cash flows tend to make each investment situation unique. Also, there are likely to be ongoing cash outflows as well as cash inflows associated with a business investment. These factors argue for a more comprehensive and rigorous approach in business to handle the great variety of investment possibilities.

Individual investors and business managers take different perspectives in determining the discount rate used with the Valuation Principle. An individual investor looks to the financial markets for benchmark rates of return on each category of investment. A business manager takes the view that a capital investment must be financed by some combination of debt and equity financing. Therefore, a business investment project must provide a rate of return *at least equal to* the return required by the providers of the capital. The weighted average rate of return required by a firm's sources of debt and equity financing is called the firm's **cost of capital.** *This cost of capital is the discount rate that should be used when applying the Valuation Principle* to a proposed capital investment project. The sum of the present values of the project's future (net) cash flows discounted at the firm's cost of capital represents the value of the project to the business. The business should not pay more than this value. The same project may be worth more or less to another business primarily because

the project's future cash flows are likely to differ when operated by another business. It could also be the case that different firms would use differing discount rates because of differing costs of capital.

There are three possible outcomes of a comparison between the present value of future net cash flows and the initial capital investment required.

1. **Present value of the future cash flows = Initial investment** The cash flows will provide a rate of return (on the initial investment) exactly *equal* to the discount rate—the firm's cost of capital. The investment's net cash flows will be just enough to repay the invested capital along with the minimum required rate of return. This is, therefore, the *minimum condition* for acceptance of a capital investment project.
2. **Present value of the future cash flows < Initial investment** The project's net cash flows will not be enough to provide the sources of financing with their *full* minimum required rate of return (on top of the return of their capital investment). Note that we are not necessarily saying that the project or the suppliers of capital lose money—we are saying only that the project will not provide the *full* rate of return embodied in the discount rate. In this case, the investment opportunity should be *rejected.*
3. **Present value of the future cash flows > Initial investment** The investment will earn a rate of return greater than the discount rate—more than the minimum needed to give the suppliers of capital their minimum required return (as well as their capital investment back). The project should be accepted.

The preceding discussion can be summarized in the following decision criterion:

Investment Decision Criterion

Undertake a business investment opportunity if the present value of the future net cash flows (discounted at the firm's cost of capital) is greater than or equal to the initial investment.

The Economic Value That an Investment Adds to a Firm We have seen that the sources of investment capital receive their required rate of return (the cost of capital) when

$$\text{Present value of (net) cash flows} = \text{Initial investment}$$

In this circumstance, the economic value (present value) of the future cash flows is the same as the amount initially spent to buy the investment. Therefore, undertaking this investment does not change the firm's value. It follows that, in Case 3 of the preceding list, the difference

$$(\text{Present value of cash flows}) - (\text{Initial investment})$$

represents the *value immediately added* to the firm when it makes the initial investment. That is,

$$\begin{pmatrix}\text{Value added}\\ \text{to the firm}\end{pmatrix} = \begin{pmatrix}\text{Present value of the}\\ \text{future net cash flows}\end{pmatrix} - \begin{pmatrix}\text{Initial}\\ \text{investment}\end{pmatrix}$$

The providers of debt financing have no claim on this added value. It belongs entirely to the firm's owners (the providers of equity capital).

The following example considers an investment opportunity with features typical of business investment opportunities. Periodic cash flows are unequal and include a cash outflow subsequent to the initial investment. The investment, if undertaken, must be financed with borrowed funds.

Note: Since forecasts of future cash flows are imprecise, all calculations in this chapter will be rounded to the nearest dollar. Even this suggests a degree of precision that does not really exist in this sort of analysis. It does, however, permit you to verify the mathematical accuracy of your calculations.

Example 16.1A EVALUATING A BUSINESS INVESTMENT OPPORTUNITY

A low-risk, four-year investment promises to pay \$3000, \$6000, and \$5000 at the end of the first, second, and fourth years, respectively. A cash injection of \$1000 is required at the end of the third year. The investment may be purchased for \$10,000, which would have to be borrowed at an interest rate of 10%. Use the Valuation Principle to determine whether the investment should be undertaken.

Solution

The purchase price at which a 10% rate of return would be realized on the amount invested is the present value of the cash flows discounted at 10%.

$$\begin{aligned}\text{Price for a 10\% rate of return} &= \frac{\$3000}{1.10} + \frac{\$6000}{1.10^2} + \frac{(-\$1000)}{1.10^3} + \frac{\$5000}{1.10^4} \\ &= \$2727 + \$4959 - \$751 + \$3415 \\ &= \$10{,}350\end{aligned}$$

The \$10,000 offering price should be accepted. By paying a price that is *below* \$10,350, the purchaser will realize a rate of return on investment *greater* than the 10% cost of capital to finance the investment.

Interpretation: The \$10,350 figure for the present value of the investment's cash flows represents the amount today that is *equivalent* to the cash-flow stream from the investment. By paying \$10,000 today for a payment stream that is worth \$10,350 today, the firm's value is immediately increased by \$350 (in current dollars).

Example 16.1B EVALUATING A BUSINESS INVESTMENT OPPORTUNITY

Repeat the problem in Example 16.1A, with the change that the interest rate on the loan to finance the investment is 12% instead of 10%.

Solution

The purchase price at which a 12% rate of return would be realized on the amount invested is the present value of the cash flows discounted at 12%.

$$\begin{aligned}\text{Price for a 12\% rate of return} &= \frac{\$3000}{1.12} + \frac{\$6000}{1.12^2} + \frac{(-\$1000)}{1.12^3} + \frac{\$5000}{1.12^4} \\ &= \$2679 + \$4783 - \$712 + \$3178 \\ &= \$9928\end{aligned}$$

The \$10,000 offering price should be rejected. Paying a price that is *above* \$9928 would result in a rate of return on investment that is *less* than the 12% cost of capital to finance the investment.

Cost Minimization Suppose the replacement of a piece of machinery is essential to the operation of an entire production line. Either Machine A or Machine B will do the job equally well. In other words, the future benefits will be the same whether we obtain Machine A or Machine B. In such a case, the scope of the financial analysis can be narrowed to finding the lowest-cost alternative. This involves a comparison of the *current* economic values of the future cash *outflows* for each alternative. The best choice is the one having the *lower* present value of cash outflows.[1]

Example 16.1C EVALUATING LEASE VERSUS PURCHASE ALTERNATIVES

Laven and Co., Certified General Accountants, are considering whether to buy or lease a photocopy machine. A five-year lease requires payments of $550 at the beginning of every three months. The same machine can be purchased for $9000 and would have a trade-in value of $1500 after five years. If the accounting firm can borrow funds at 11% compounded quarterly, should it buy or lease a photocopy machine?

Solution

The preferred alternative is the one having the lower present value of expenditures (net of any amounts recovered from resale, salvage, or trade-in).

As discussed in Section 13.2, leasing is usually regarded as an alternative to borrowing the funds to purchase the asset. Therefore, the appropriate discount rate to use in the present-value calculation is the firm's cost of borrowing. The lease payments form a simple annuity due with

$$PMT = \$550 \qquad n = 4(5) = 20 \qquad \text{and} \qquad i = \frac{11\%}{4} = 2.75\%$$

The present value of the lease payments is

$$\begin{aligned} PV(\text{lease}) &= PMT\left[\frac{1-(1+i)^{-n}}{i}\right] \times (1+i) \\ &= \$550\left(\frac{1-1.0275^{-20}}{0.0275}\right)(1.0275) \\ &= \$8605 \end{aligned}$$

BGN mode
20 N
11 I/Y
550 +/− PMT
0 FV
P/Y 4 ENTER
Same *C/Y*
CPT PV
Ans: 8605

If the photocopy machine is purchased, there will be an initial expenditure of $9000 and a $1500 recovery from trading it in five years later. The present value of these payments is

$$\begin{aligned} PV(\text{purchase}) &= \$9000 - FV(1+i)^{-n} \\ &= \$9000 - \$1500(1.0275^{-20}) \\ &= \$9000 - \$872 \\ &= \$8128 \end{aligned}$$

Same *N, I/Y, P/Y, C/Y,*
0 PMT
1500 FV
CPT PV
Ans: −872
+ 9000 =
Ans: 8128

Hence, purchasing of the photocopy machine is the lower cost alternative. The current economic value of the difference in net costs over the five-year lifetime is $8605 – 8128 = $477.

[1] If the alternatives do not have equal lifetimes, the analysis must go beyond a simple comparison of the present values of cash outflows for the respective lifetimes. The additional analysis needed will be presented in Section 16.3.

EXERCISE 16.1

Answers to the odd-numbered problems are at the end of the book.

Unless otherwise indicated in the following exercises, assume that the initial capital investment occurs at the beginning of the first year and subsequent cash flows occur at the end of each year.

•1. Vencap Enterprises is evaluating an investment opportunity that can be purchased for $30,000. Further product development will require contributions of $30,000 in Year 1 and $10,000 in Year 2. Then returns of $20,000, $60,000, and $40,000 are expected in the three following years.

a. Use the Valuation Principle to determine whether Vencap should make the investment if its cost of capital is 15%.

b. By what amount will the current economic value of Vencap be increased or decreased if it proceeds with purchasing the investment for $30,000?

•2. Repeat Problem 1 with the change that Vencap's cost of capital is 18%.

•3. What price should Vencap offer for the investment opportunity described in Problem 1 if it requires a 20% return on investment?

•4. The timber rights to a tract of forest can be purchased for $90,000. The harvesting agreement would allow 25% of the timber to be cut in each of the first, second, fourth, and fifth years. The purchaser of the timber rights would be required to replant, at its expense, the logged areas in Years 3 and 6. Arrowsmith Lumber calculates that its profit in each of the four cutting years would be $50,000 and that the cost of replanting the harvested areas in each of Years 3 and 6 would be $20,000.

a. Should Arrowsmith Lumber buy the timber rights if its cost of capital is 14%?

b. By what amount would the economic value of Arrowsmith Lumber be increased or decreased if it proceeded with purchasing the timber rights for $90,000?

•5. Repeat Problem 4 with the change that Arrowsmith Lumber's cost of capital is 18%.

•6. At what price would Arrowsmith Lumber be willing to purchase the timber rights described in Problem 4 if it requires a return on investment of 20%?

•7. A machine can be leased for four years at $1000 per month payable at the beginning of each month. Alternatively, it can be purchased for $43,000 and sold for $5000 after four years. Should the machine be purchased or leased if the firm's cost of borrowing is:

a. 12% compounded monthly? **b.** 9% compounded monthly?

•8. A real estate salesperson can lease an automobile for five years at $500 per month payable at the beginning of each month, or purchase it for $28,000. She can obtain a loan at 9.75% compounded monthly to purchase the car. Should she lease or buy the car if:

a. The trade-in value after five years is $5000?

b. The trade-in value after five years is $8000?

•9. A college can purchase a telephone system for $30,000 or lease a system for five years for a front-end charge of $3000 and regular payments of $1500 at the beginning of every quarter (including the first quarter). The system can be purchased at the end of the lease period for $3000.

a. Should the college lease or buy the system if it can borrow funds at 10% compounded quarterly?

b. What is the current economic value of the savings with the lower-cost option?

•10. Rocky Mountain Bus Tours needs an additional bus for three years. It can lease a bus for $2100 payable at the beginning of each month, or it can buy a similar bus for $110,000, using financing at the rate of 12% compounded monthly. The bus's resale value after three years is expected to be $60,000.

a. On strictly financial considerations, should the company lease or buy the bus?

b. What is the financial advantage in current dollars of the preferred choice?

••11. Ralph Harder has been transferred to Regina for five years. He has found an attractive house that he can buy for $180,000 or rent for $1000 per month, payable at the beginning of each month. He estimates that the resale value of the house in five years will be $200,000 net of the selling commission. If he buys the house, the average (month-end) costs for repairs, maintenance, and property taxes will be $300. Should Mr. Harder rent or buy the house if mortgage rates are:

a. 7% compounded monthly? **b.** 6% compounded monthly?

16.2 THE NET PRESENT VALUE OF AN INVESTMENT

In this section, we will express the investment criterion and the concepts from Section 16.1 in language customarily used for business investment analysis. Recall that

$$\begin{pmatrix}\text{Value added}\\ \text{to the firm}\end{pmatrix} = \left(\begin{matrix}\text{Present value of the}\\ \text{future net cash flows}\end{matrix}\right) - \left(\begin{matrix}\text{Initial}\\ \text{investment}\end{matrix}\right)$$

Since an operating period's "net cash flow" means

$$\text{Cash inflows}^{2} - \text{Cash outflows}$$

we can expand the first quantity (in brackets on the right side) giving

$$\begin{pmatrix}\text{Value added}\\ \text{to the firm}\end{pmatrix} = \left(\begin{matrix}\text{Present value of}\\ \text{future cash inflows}\end{matrix}\right) - \left(\begin{matrix}\text{Present value of}\\ \text{future cash outflows}\end{matrix}\right) - \left(\begin{matrix}\text{Initial}\\ \text{investment}\end{matrix}\right)$$

If we include the "initial investment" among the cash *outflows,* the second and third terms may be combined to give

$$\begin{pmatrix}\text{Value added}\\ \text{to the firm}\end{pmatrix} = \left(\begin{matrix}\text{Present value of}\\ \text{cash inflows}\end{matrix}\right) - \left(\begin{matrix}\text{Present value of}\\ \text{cash outflows}\end{matrix}\right)$$

The right side can be viewed as the *net* amount by which the *present value* of cash inflows exceeds the *present value* of cash outflows. For this reason, the "value added to the firm" is customarily called the **net present value** (*NPV*) of an investment. That is,

$$NPV = \left(\begin{matrix}\text{Present value of}\\ \text{cash inflows}\end{matrix}\right) - \left(\begin{matrix}\text{Present value of}\\ \text{cash outflows}\end{matrix}\right)$$

[2] A rigorous analysis of capital investments requires the calculation of cash flows *before* interest charges but *after* income tax (including the tax savings from any capital cost allowance on a depreciable asset). You will learn these refinements if you take a course in managerial finance. In this chapter, we will use *profit* or *operating profit* to mean the net before-interest after-tax cash flow from the investment during an accounting period.

The Investment Decision Criterion developed in Section 16.1 may be expressed in terms of the *NPV*.

NPV Investment Decision Criterion:

Accept the investment if $NPV \geq 0$.
Reject the investment if $NPV < 0$.

The firm's cost of capital (for financing the investment) is used for the discount rate in the *NPV* calculation. To simplify the calculation of present values, the assumption is usually made that the cash inflows and outflows within each year occur at the *end* of the year.[3] The initial capital investment outlay is assumed to take place at the *beginning* of the first year.

Significance of an Investment's NPV

The *NPV* of an investment is the amount (in current dollars) by which the economic value of the cash inflows exceeds the economic value of the cash outflows. Therefore, the *NPV* represents the value added to the firm on the date the investment is made.

This added value belongs to the owners of the business and increases the market value of the owners' equity. A negative *NPV* does not necessarily mean that the investment will cause the firm to suffer an accounting loss. It does mean, however, that the project's cash flows are not sufficient to provide the sources of financing with their full minimum required rate of return. As a result, a negative *NPV* project would, if undertaken, reduce the market value of the firm's equity (by the amount of the *NPV*).

Example 16.2A USING THE NPV CRITERION TO EVALUATE A CAPITAL INVESTMENT

A firm is contemplating the purchase of a $10,000 machine that would reduce labour costs by $4000 in each of Years 1 and 2, and by $3000 in each of Years 3 and 4. The machine's salvage value at the end of Year 4 is $1000. Should the machine be purchased if the firm's cost of capital is 15% compounded annually?

Solution

Profits would rise by $4000 in Years 1 and 2 and by $3000 in Years 3 and 4 as a result of purchasing the machine. These profit increases plus the salvage value in Year 4 are the net cash flows that the investment will generate.

[3] The errors introduced by ignoring the time value of money *within* each year are usually smaller than the uncertainties in forecasts of the amounts and the timing of the cash flows.

$$NPV = \$4000(1.15^{-1}) + \$4000(1.15^{-2}) + \$3000(1.15^{-3}) + \$4000(1.15^{-4}) - \$10{,}000$$
$$= \$3478 + \$3025 + \$1973 + \$2287 - \$10{,}000$$
$$= \$763$$

Since the $NPV > 0$, the machine should be purchased. The savings will add \$783 to the value of the firm.

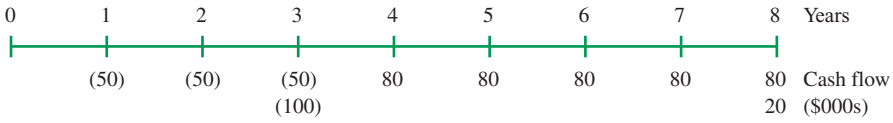
Example 16.2B USING THE NPV CRITERION WHEN CASH FLOWS FORM ANNUITIES

Digitel Electronics' engineering and marketing departments have prepared forecasts for the development costs and operating profits of the next generation of their digital electrical meters. Development costs for each of the next three years will be \$50,000. Manufacturing equipment costing \$100,000 will be purchased near the end of Year 3. Annual profits for the normal five-year product life (Years 4 to 8 inclusive) are projected to be \$80,000. The salvage value of the manufacturing equipment at the end of Year 8 is \$20,000. Should Digitel proceed with the product development if its annually compounded cost of capital is:

a. 14%? **b.** 15.5%? **c.** 17%?

Solution

The cash flows are presented on a time line below. Our convention is to assume cash flows occur at the year's end unless otherwise indicated. Cash outflows (negative) are placed in parentheses. Digitel should proceed with the product development if the net present value of the cash flows, discounted at the cost of capital, is greater than or equal to zero.



NPV = Present value of cash inflows − Present value of cash outflows

To reduce the number of calculations, do not break up annuities. In this problem, there is an ordinary simple annuity with three \$50,000 payments and a deferred (three years) ordinary simple annuity with five \$80,000 payments.

$$NPV = -\$50{,}000\left[\frac{1-(1+i)^{-3}}{i}\right] - \frac{\$100{,}000}{(1+i)^3}$$
$$+ \$80{,}000\left[\frac{1-(1+i)^{-3}}{i}\right] \times \frac{1}{(1+i)^3} + \frac{\$20{,}000}{(1+i)^8}$$

a. For $i = 14\%$,

$$NPV = -\$116{,}082 - \$67{,}497 + \$185{,}379 + \$7011 = \$8811$$

Since $NPV > 0$, Digitel should proceed with the project. The interpretation of the NPV is that the current economic value of the funds remaining after repaying the sources of financing is \$8811. This is also the increase in the firm's current market value as a result of investing in the product development project.

b. For $i = 15.5\%$,

$$NPV = -\$113{,}221 - \$64{,}901 + \$172{,}007 + \$6315 = \$200$$

Given the sizes of the cash flows in the forecast, this is basically a zero-*NPV* investment. This does not imply that there is no profit. Rather, it means that the estimated profits will be just sufficient to repay the project's financing along with a 15.5% rate of return on the funds while they are invested in the project. This is acceptable, but represents the threshold for acceptability.

c. For $i = 17\%$, we obtain $NPV = -\$7414$. In this case, the project will fall short (by \$7414 in terms of current dollars) of repaying the financing along with the required 17% rate of return on investment. Digitel should not proceed in this case.

EXERCISE 16.2

Answers to the odd-numbered problems are at the end of the book.

Use the NPV investment criterion to answer the following problems. Unless otherwise indicated, assume that the initial capital investment occurs at the beginning of the first year and that subsequent cash flows occur at the end of the year. Show calculations that justify your decision.

•1. St. Lawrence Bus Lines is offered a contract for busing schoolchildren that will produce an annual profit of \$36,000 for seven years. To fulfill the contract, St. Lawrence would have to buy three buses at a total cost of \$165,000. At the end of the contract, the resale value of the buses is estimated to be \$40,000. Should St. Lawrence Bus Lines sign the contract if its cost of capital is:

a. 12%? **b.** 15%? **c.** 18%?

•2. An automotive parts plant is scheduled to be closed in 10 years. Nevertheless, its engineering department thinks that some investments in computer-controlled equipment can be justified by savings in labour and energy costs within that time frame. The engineering department is proposing a four-phase program that would require the expenditure of \$100,000 at the beginning of each of the next four years. Each successive phase would produce additional annual savings of \$30,000, \$27,000, \$22,000, and \$22,000. The savings from any phase are in addition to annual savings already realized from previous phases. There will be no significant residual value. The firm's cost of capital is 14%. As the plant's financial analyst, what phases, if any, of the proposal would you accept?

•3. The pro forma projections for growing a 20-hectare ginseng crop require the expenditure of \$150,000 in the summer that the crop is planted, and an additional \$50,000 in each of the next two summers to cultivate and fertilize the growing crop. After payment of the costs of harvesting the crop, the profit should be \$200,000 in the third summer after planting, and \$300,000 in the fourth summer. Allowing for a cost of capital of 15% compounded annually, what is the economic value of the project at the time of planting? (*Hint:* The project's economic value is its *NPV*.)

•4. A proposed strip mine would require the investment of \$1 million at the beginning of the first year and a further investment of \$1.5 million at the end of the first year. Mining operations are expected to yield annual profits of \$500,000 beginning in Year 2. The ore body will sustain 10 years of mining

operations. At the beginning of the twelfth year, the mining company would have to spend $500,000 on environmental restoration. Would the project provide the mining company with a rate of return exceeding its 18% cost of capital? (*Hint:* The project will provide a rate of return exceeding the cost of capital if it has a positive *NPV*.)

•5. The development of a new product will require the expenditure of $150,000 at the beginning of each of the next three years. When the product reaches the market in Year 4, it is expected to increase the firm's annual profit by $90,000 for seven years. Then the product will be replaced by a new model, and $100,000 of the original expenditures should be recoverable. If the firm's cost of capital is 14%, should it proceed with the project?

•6. The introduction of a new product will require an initial investment of $45,000. The annual profit expected from the new product is forecast to be $9000 for Years 1 to 3, $6000 for Years 4 to 6, and $4000 for Years 7 to 12. Should the firm proceed with the investment if its required compound annual return is 15%?

••7. Jasper Ski Corp. is studying the feasibility of installing a new chair lift to expand the capacity of its downhill-skiing operation. Site preparation would require the expenditure of $400,000 at the beginning of the first year. Construction would take place early in the second year at a cost of $1.8 million. The lift would have a useful life of 12 years and a residual value of $400,000. The increased capacity should generate increased annual profits of $300,000 at the end of Years 2 to 5 inclusive and $500,000 in Years 6 to 13 inclusive. Should Jasper proceed with the project if it requires a return on investment of 16%?

••8. A capital project would require an immediate investment of $150,000 and a further investment of $40,000 on a date four years from now. On the operating side, the project is expected to lose $30,000 in the first year and $10,000 in the second, to break even in the third year, and to turn annual profits of $60,000 in Years 4 to 7 and $30,000 in Years 8 to 10. The estimated residual value at the end of the tenth year is $50,000. Is the project acceptable if a return on investment of 17% is required?

••9. To manufacture a new product, a company must immediately invest $275,000 in new equipment. At the end of Years 3 and 5, there will have to be a major overhaul of the equipment at a cost of $40,000 on each occasion. The new product is expected to increase annual operating profits by $75,000 in each of the first four years, and by $55,000 in each of the next three years. The equipment will then be salvaged to recover about $30,000. Should the product be manufactured if the company's cost of capital is 14% compounded annually?

••10. A new machine that will lead to savings in labour costs of $16,000 per year can be purchased for $52,000. However, it will cost $1500 per year for the first four years and $2500 per year for the next four years to service and maintain it. In addition, its annual electrical power consumption will cost $1000. After a service life of eight years, the salvage value of the machine is expected to be $5000. Should the machine be acquired if the company requires a minimum return on investment of 15%?

16.3 COMPARING INVESTMENT PROJECTS

Normally, a firm should accept every investment project that has a positive net present value. Any positive-*NPV* project produces a net economic benefit to the firm after the sources of financing have received their required returns. The *NPV* gives the magnitude of the economic benefit on the date of the initial capital expenditure.

There are two circumstances in which a business will not necessarily proceed with all of the positive-*NPV* investments available to it. In these situations, choosing one of the projects may exclude the selection of other positive-*NPV* projects. Some refinements to our selection criterion are needed to rank or select from projects that, in some sense, are competing alternatives.

Capital Rationing

Capital rationing is the circumstance in which there is a limit on the total amount of capital funds that a firm may invest during a period. In this situation, the firm should *choose the group of projects that have the highest combined NPV* subject to the limitation on the total capital budget. By this choice, the increase in the firm's value is maximized.

Example 16.3A SELECTING CAPITAL PROJECTS SUBJECT TO A CAPITAL RATIONING CONSTRAINT

The strategic planning group at Hardy Toy Co. has identified the following positive-*NPV* projects, ranked in order of their *NPV*. All projects are independent—selection of any project neither requires nor precludes the selection of any other project.

Capital investment project	Initial capital investment	Project NPV
Expand production facilities	$270,000	$195,000
Open western distribution centre	250,000	155,000
Introduce Toy A	90,000	130,000
Buy out regional wood-toy maker	155,000	120,000
Introduce Game B	60,000	80,000
Purchase plastic moulding machine	54,000	70,000
Introduce Toy C	110,000	65,000
Introduce plastic recycling process	56,000	63,000
Replace old packaging machine	62,000	40,000
Introduce new doll	60,000	31,000

The board of directors has imposed a $600,000 capital expenditure limit for the next year. What projects should the company undertake within the capital budget restriction?

Solution

The company will want to choose the group of projects with the largest combined *NPV*, subject to the requirement that the total initial capital investment must not exceed $600,000. To obtain the "biggest bang per invested buck," it is helpful to calculate each project's *NPV* per dollar of initial investment. In the following table, the projects are ranked on the basis of this ratio (presented in the third column).

Project number	Capital investment project	NPV per invested dollar	Initial capital investment	Cumulative capital investment
1	Introduce Toy A	$1.44	$ 90,000	$ 90,000
2	Introduce Game B	1.33	60,000	150,000
3	Purchase plastic moulding machine	1.30	54,000	204,000
4	Introduce plastic recycling process	1.13	56,000	260,000
5	Buy out regional wood-toy maker	0.77	155,000	
6	Expand production facilities	0.72	270,000	
7	Replace old packaging machine	0.65	62,000	
8	Open western distribution centre	0.62	250,000	
9	Introduce Toy C	0.59	110,000	
10	Introduce new doll	0.52	60,000	

Until the capital budget constraint becomes a consideration, the projects with the highest *NPV* per invested dollar are automatically selected. The first four projects require a total investment of $260,000, leaving $340,000 available for others. If Project 5 is chosen next, Project 6 cannot be undertaken, because it would take the total investment beyond the $600,000 limit. But Projects 7 and 9 can still be included, along with 5, while remaining within the $600,000 limit. Therefore, one group of projects that must be considered is Projects 1, 2, 3, 4, 5, 7, and 9, for which

$$\text{Required total capital investment} = \$587{,}000$$
$$\text{Total net present value} = \$225{,}000$$

If we do not include Project 5, we can proceed with Project 6 and still have enough funds remaining in the $600,000 global budget to undertake Project 7 as well. This second combination (Projects 1, 2, 3, 4, 6, and 7) has

$$\text{Required total capital investment} = \$592{,}000$$
$$\text{Total net present value} = \$235{,}000$$

The second group should be selected since it adds $10,000 more economic value to Hardy Toy Co.

Mutually Exclusive Projects

Alternative capital investments, any one of which will substantially satisfy the same need or purpose, are called **mutually exclusive projects**. For example, three different machines that fabricate the same product are mutually exclusive projects if any one of them will satisfy the firm's requirements. Only one will be selected, even if each one has a positive *NPV*.

If the mutually exclusive projects all have the *same* lifetime, a direct comparison may be made among the *NPV*s of the projects. The one with the largest positive *NPV* should be chosen because it provides the greatest economic benefit to the firm.

It projects have *unequal* lifetimes, it is *not* a simple matter of selecting the project with the largest lifetime *NPV*. A fair comparison requires a common time frame that might involve replacement cycles for one or more of the projects. However, we cannot arbitrarily pick the duration of the common time period because cash flows are unevenly distributed over each project's lifetime. Either of two methods—the *replacement chain method* or the *equivalent annual cash-flow method*—may be used to deal with unequal investment lifetimes and uneven cash flows.

Replacement Chain Method The replacement chain approach repeats the replacement cycle of one or more of the mutually exclusive alternatives until *all* terminate on the *same* date. Then the *NPV*s of all cash flows within this common time horizon are calculated for each project. The one with the highest positive *NPV* should be selected.

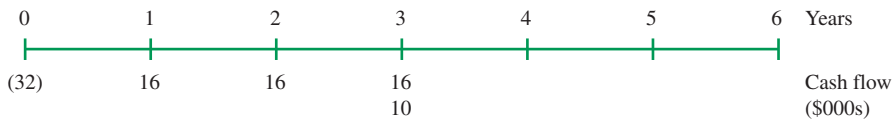
Example 16.3B REPLACEMENT CHAIN METHOD WITH MUTUALLY EXCLUSIVE PROJECTS

A machine shop is trying to decide which of two types of metal lathe to purchase. The more versatile Japanese lathe costs $32,000, and will generate an annual profit of $16,000 for three years. Its trade-in value after three years will be about $10,000. The more durable German lathe costs $42,000, and will increase profits by $12,000 per year for six years. Its trade-in value at that point is estimated at $15,000. Based on an *NPV* calculation at a 10% cost of capital, which lathe should be purchased?

Solution

We will first determine the lifetime *NPV* of a capital investment in each lathe.

Time diagram for the Japanese lathe



Time diagram for the German lathe

The *NPV* for the acquisition of the Japanese lathe is

$$NPV_J = PMT\left[\frac{1-(1+i)^{-n}}{i}\right] + FV(1+i)^{-n} - \$32{,}000$$

$$= \$16{,}000\left[\frac{1-(1.10)^{-3}}{0.10}\right] + \$10{,}000(1.10)^{-3} - \$32{,}000$$

$$= \$39{,}790 + \$7513 - \$32{,}000$$

$$= \$15{,}303$$

3 N
10 I/Y
16000 PMT
10000 FV
P/Y 1 ENTER
Same *C/Y*
CPT PV
Ans: −47,303
+ 32000 =
Ans: −15,303

The *NPV* for the purchase of the German lathe is

$$NPV_G = \$12{,}000\left[\frac{1-(1.10)^{-6}}{0.10}\right] + \$15{,}000(1.10)^{-6} - \$42{,}000$$

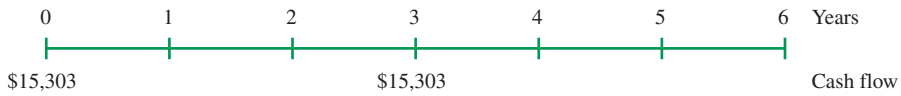
$$= \$18{,}730$$

Same *I/Y, P/Y, C/Y,*
6 N
1200 PMT
1500 FV
CPT PV
Ans: −60,730
+ 42000 =
Ans: −18,730

A comparison of the *NPV*s at this point would not necessarily lead to a valid conclusion (to purchase the higher-*NPV* German lathe). For a fair comparison, an adjustment must be made for the unequal service lives of the two lathes.

Since the machine shop is prepared to commit to the German lathe for six years, it is logical to infer that it is also prepared to have a Japanese lathe for six years. By including one replacement cycle of the Japanese lathe in the analysis, we obtain a common time frame of six years for both alternatives.

To reconsider the Japanese option, it is not necessary to begin again with each year's cash flows. Remember the significance of the present value of a number of cash flows—it is the single amount that is equivalent, at the focal date, to all of the cash flows. Therefore, an investment's *NPV* is equivalent to all of the cash flows included in its calculation. The actual cash flows for six years with the Japanese lathe may be replaced by inflows of \$15,303 at the beginning of each three-year service life. The following equivalent time diagram may be used for six years of operation with the Japanese lathe.



The *NPV* for six years with the Japanese lathe is

$$NPV_J = \$15{,}303 + \$15{,}303(1.10)^{-3} = \$26{,}800$$

With the alternative investments transformed to a common time horizon, the Japanese lathe gives the higher *NPV*. Therefore, it should be selected.

The replacement chain method works well when the service life of one alternative is an integer multiple of the service life of a second alternative (as in Example 16.3B). But what if the service lives of two competing alternatives were five years and seven years? We would have to consider five cycles of the seven-year lifetime and seven cycles of the five-year lifetime to have a common time frame containing a whole number of replacement cycles of both alternatives. If there are more than two alternatives, the replacement chain approach becomes even more unwieldy. In these cases the equivalent annual cash-flow method is simpler.

Equivalent Annual Cash-Flow Method In this approach, we calculate the *constant annual* cash flow during each project's lifetime that has the same *NPV* as the *actual* cash flows. Since the equivalent annual flows also apply to any number of replacement cycles, we can directly compare the equivalent annual cash flows of competing projects. *The project with the largest positive equivalent annual cash flow should be selected.*

Example 16.3C EQUIVALENT ANNUAL CASH-FLOW METHOD WITH MUTUALLY EXCLUSIVE PROJECTS

Repeat the problem in Example 16.3B using the equivalent annual cash-flow method.

Solution

Recall that the *NPV* for one three-year investment cycle for the Japanese lathe was

$$NPV_J = \$15{,}303$$

and that the *NPV* for one six-year investment cycle for the German lathe was

$$NPV_G = \$18{,}730$$

For the Japanese lathe, the equivalent annual cash flow is the value of PMT_J satisfying formula (10-2).

$$\$15{,}303 = PMT_J\left[\frac{1-(1.10)^{-3}}{0.10}\right]$$

The solution is $PMT_J = \$6154$.

For the German lathe, the equivalent annual cash flow is the solution to

$$\$18{,}730 = PMT_G\left[\frac{1-(1.10)^{-6}}{0.10}\right]$$

The solution is $PMT_G = \$4301$.

Since the Japanese lathe has the larger equivalent annual cash flow, it should be selected.

Note: The ratio of the two equivalent annual cash flows in this solution is

$$\frac{PMT_J}{PMT_G} = \frac{\$6154}{\$4301} = 1.431$$

The ratio of the *NPV*s of investments in the two lathes calculated in Example 16.3B for a common six-year time horizon is:

$$\frac{NPV_J \text{ for 6 years}}{NPV_G \text{ for 6 years}} = \frac{\$26{,}800}{\$18{,}730} = 1.431$$

The equality of the two ratios demonstrates the equivalence of the two methods.

TIP

Unequal Lives Matter Only for Mutually Exclusive Projects

Remember that unequal lives do not have to be taken into account when *independent* projects are being selected under conditions of capital rationing. Unequal lives are a consideration only for *mutually exclusive* projects.

Cost Minimization When mutually exclusive alternatives generate the same benefits or cash inflows, it is sufficient to focus on the cash outflows. We should select the lowest-cost alternative, recognizing the time value of money. When the time horizons of the competing alternatives are the same, the present values of the lifetime cash outflows may be directly compared. However, when the time horizons differ, calculate the *equivalent annual cash outflow* for each alternative. Select the one with the *smallest* equivalent annual cash outflow.

EXERCISE 16.3

Answers to the odd-numbered problems are at the end of the book.

Problems 1, 2, and 3 require the selection of independent capital investments subject to a capital budget limitation.

•**1.** A firm has identified the following four investment opportunities and calculated their net present values. If the firm's capital budget for this period is limited to $300,000, which projects should be selected?

Project	Initial investment	NPV
A	$100,000	$ 25,000
B	60,000	40,000
C	130,000	60,000
D	200,000	110,000

•**2.** The investment committee of a company has identified the following seven projects with positive *NPV*s. If the board of directors has approved a $3 million capital budget for the current period, which projects should be selected?

Project	Initial investment	NPV
1	$1,000,000	$600,000
2	1,800,000	324,000
3	750,000	285,000
4	600,000	270,000
5	450,000	113,000
6	150,000	21,000
7	250,000	20,000

•**3.** Mohawk Enterprises is considering the following investment opportunities.

Project	Initial investment	Profit for year			
		Year 1	Year 2	Year 3	Year 4
A	$30,000	$12,000	$9000	$ 8000	$20,000
B	36,000	6000	23,000	10,000	14,000
C	18,000	10,000	0	0	20,000
D	22,000	0	18,000	2500	11,000
E	28,000	26,000	0	0	17,000
F	20,000	6000	7000	10,000	11,000

If Mohawk's cost of capital is 15% per annum and its capital budget is limited to $90,000, which projects should it choose?

Problems 4 through 11 require the selection of the best investment from two or more mutually exclusive alternatives.

•**4.** A small regional airline has narrowed down the possible choices for its next passenger plane purchase to two alternatives. The Eagle model costs $250,000, and would have an estimated resale value of $50,000 after seven years. The Albatross model has a $325,000 price, and would have an estimated resale value of $150,000 after seven years. The annual operating profit from the Eagle would be $75,000. Because of its greater fuel efficiency and slightly larger seating capacity, the Albatross's annual profit would be $95,000. Which plane should the airline purchase if its cost of capital is 15%?

In current dollars, what is the economic advantage of selecting the preferred alternative over the other?

•5. Carl Williams does custom wheat combining in southern Alberta. He will purchase either a new Massey or a new Deere combine to replace his old machine. The Massey combine costs $95,000, and the Deere combine costs $78,000. Their trade-in values after six years would be about $25,000 and $20,000, respectively. Because the Massey cuts an 18-foot swath versus the Deere's 15-foot swath, Carl estimates that his annual profit with the Massey will be 10% higher than the $35,000 he could make with the Deere. The Massey equipment dealer will provide 100% financing at 11% per annum, and the Deere dealer will approve 100% financing at 10% per annum. Which combine should Carl purchase? How much more, in current dollars, is the better alternative worth?

••6. A business is evaluating two mutually exclusive projects. Project A requires an immediate investment of $6000, plus another $8000 in three years. It would produce a profit of $6000 in the second year, $18,000 in the fourth year, and $12,000 in the seventh year. Project B requires an immediate investment of $5000, another $8000 in two years, and a further $5000 in four years. It would produce an annual profit of $5200 for seven years. Neither project would have any residual value after seven years. Which project should be selected if the required rate of return is 16%? What is the economic advantage, in current dollars, of the preferred project over the other?

••7. A company must choose between two investments. Investment C requires an immediate outlay of $50,000 and then, in two years, another investment of $30,000. Investment D requires annual investments of $25,000 at the beginning of each of the first four years. C would return annual profits of $16,000 for 10 years beginning with the first year. D's profits would not start until Year 4 but would be $35,000 in Years 4 to 10 inclusive. The residual values after 10 years are estimated to be $30,000 for C and $20,000 for D. Which investment should the company choose if its cost of capital is 15%? How much more is the preferred project worth today?

•8. Machine A costs $40,000 and is forecast to generate an annual profit of $15,000 for four years. Machine B, priced at $60,000, will produce the same annual profits for eight years. The trade-in value of A after four years is expected to be $10,000, and the resale value of B after eight years is also estimated to be $10,000. If either machine satisfies the firm's requirements, which one should be selected? Use a required return of 14%.

•9. A sawmill requires a new saw for cutting small-dimension logs. Model H, with a three-year service life, costs $100,000 and will generate an annual profit of $55,000. Model J, with a four-year service life, costs $140,000 and will return an annual profit of $58,000. Neither saw will have significant salvage value. If the mill's cost of capital is 16%, which model should be purchased?

••10. A landscaping business will buy one of three rototillers. The initial cost, expected service life, and trade-in value (at the end of the service life) of each model are presented in the following table. The annual profit from rototilling services is $700.

Model	Cost	Service life (years)	Trade-in value
A	$1000	2	$200
AA	1400	3	450
AAA	2100	6	700

Which model should be purchased if the required return on investment is 20%?

••11. An independent trucker is trying to decide whether to buy a 15-ton or a 25-ton truck. A 15-ton vehicle would cost $75,000; it would have a service life of seven years, and a trade-in value of about $15,000 at seven years of age. A 25-ton truck would cost $100,000, and would have a service life of six years and a trade-in value of about $20,000 at six years of age. The estimated annual profit (after provision for a normal salary for the driver–owner) would be $24,000 for the smaller truck and $32,000 for the larger truck. Which truck should be purchased if the cost of financing a truck is 12.5% compounded annually? What is the average annual economic benefit of making the right decision?

Problems 12 through 15 require the selection of the lowest-cost alternative.

•12. *Consumer Digest* recently reported that car batteries X, Y, and Z have average service lives of three, four, and six years, respectively. Grace found that the best retail prices for these batteries in her town are $60, $75, and $105. If money is worth 10% compounded annually, which battery has the lowest equivalent annual cost?

•13. The provincial government's Ministry of Forest Resources requires a spotter plane for its fire service. The price of a Hawk is $120,000, and its annual operating costs will be $30,000. Given the heavy use it will receive, it will be sold for about $30,000 after five years and replaced. A more durable but less efficient Falcon, priced at $100,000, will cost $40,000 per year to operate, will last seven years, and will have a resale value of $40,000. If the provincial government pays an interest rate of 9% compounded annually on its mid-term debt, which plane has the lower equivalent annual cost?

••14. Neil always trades his car in when it reaches five years of age because of the large amount of driving he does in his job. He is investigating whether there would be a financial advantage in buying a two-year-old car every three years instead of buying a new car every five years. His research indicates that, for the make of car he prefers, he could buy a two-year-old car for $12,000, whereas a new car of the same model sells for $20,000. In either case, the resale value of the five-year-old car would be $4000. Repairs and maintenance average $300 per year for the first two years of the car's life and $1000 per year for the next three. Which alternative has the lower equivalent annual cost if money is worth 11% compounded annually?

••15. A construction company has identified two machines that will accomplish the same job. The Caterpillar model costs $80,000, and has a service life of eight years if it receives a $15,000 overhaul every two years. The International model costs $105,000, and should last 12 years with a $10,000 overhaul every three years. In either case, the overhaul scheduled for the year of disposition would not be performed, and the machine would be sold for about $10,000. If the company's cost of capital is 15%, which machine should be purchased?

16.4 INTERNAL RATE OF RETURN

Business managers often prefer to discuss and compare investment opportunities in terms of an annual rate of return on investment. The net present value calculation does not provide the rate of return on the invested funds.

Recall that the net cash flows from an investment project having an *NPV* of zero will be just sufficient to repay the project's financing, including a rate of return *equal* to the discount rate. Therefore, the rate of return on investment for a zero-*NPV* project equals the discount rate (cost of capital) used in the *NPV* calculation. This special case suggests a technique for determining the rate of return on investment from any project. If we can find a discount rate that makes the *NPV* of the project's net cash flows equal to zero, then that discount rate is the project's rate of return on investment. In the context of business capital investments, this rate of return is often called the **internal rate of return** (*IRR*).

Internal Rate of Return (IRR):
An investment's *IRR* is the discount rate that makes the net present value of the investment equal to zero.

When the periodic cash flows from a capital investment form an annuity, you may use a financial calculator to compute the *IRR*. Otherwise, you must employ the trial-and-error approach (Appendix 11B) to solve for the *IRR*.[4] The basic procedure is:

1. Make a reasonable estimate of the investment's *IRR*. (Start with an estimate larger than the cost of capital if the project has a positive *NPV*.)
2. Calculate the investment's *NPV* using the estimated *IRR* as the discount rate.
3. Make a better estimate of the *IRR*. (If the *NPV* in Step 2 was positive, choose a larger value for the estimated *IRR*. If the *NPV* was negative, choose a smaller value for the *IRR*.) Repeat Steps 2 and 3 until positive and negative *NPV*s are obtained for two *IRR* estimates differing by less than 1%.
4. Interpolate between these two *IRR* estimates to calculate the *IRR* at which the investment's *NPV* is zero. This interpolation step should give you the *IRR* accurate to within $\pm 0.1\%$.

A positive-*NPV* investment has an *IRR* greater than the cost of capital, whereas a negative-*NPV* investment has an *IRR* less than the cost of capital. The *NPV* Investment Decision Criterion developed in Section 16.2 may be restated in terms of the investment's *IRR*.

IRR Investment Decision Criterion:
Accept the investment if $IRR \geq$ Cost of capital.
Reject the investment if $IRR <$ Cost of capital.

[4] Advanced models of financial calculators have pre-programmed functions that permit the calculation of the *NPV* and *IRR* for a non-uniform series of cash flows.

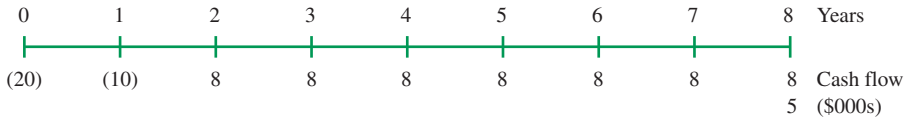
As net cash flows are received from a project, the invested funds are gradually recovered. The *IRR* continues to be earned only on the *unrecovered* portion of the original investment. The recovered funds subsequently earn the rate of return for the next project in which they are reinvested.[5]

Example 16.4A CALCULATION OF AN INVESTMENT'S IRR BY TRIAL AND ERROR

A project requires an immediate investment of $20,000, and an additional investment of $10,000 in one year. It will generate an annual profit of $8000 in Years 2 to 8, and have a residual value of $5000 at the end of the eighth year. Calculate the project's internal rate of return. Should the project be undertaken if the firm's cost of capital is 14%?

Solution

The cash flows are presented in the time diagram below.



The project's net present value at the discount rate i is

$$NPV = -\$20{,}000 - \underbrace{\frac{\$10{,}000}{1+i}}_{\text{Term ①}} + \underbrace{\$8000\left[\frac{1-(1+i)^{-7}}{i}\right] \times \left(\frac{1}{1+i}\right)}_{\text{Term ②}} + \underbrace{\frac{\$5000}{(1+i)^8}}_{\text{Term ③}}$$

The project's internal rate of return is the value for i that makes the *NPV* zero. Now begin a trial-and-error process to find two values for i that will make the sum of the terms in the *NPV* expression a few hundred dollars above zero and a few hundred dollars below zero. Then interpolation can be used to improve upon these two estimates of the *IRR*. A natural choice for the first trial is $i = 14\%$ (the cost of capital).

Trial number	Estimated *i*	Term ①	Term ②	Term ③	*NPV*
1	0.14	−$8772	$30,093	$1753	$3074
2	0.15	−8695	28,941	1635	1881
3	0.16	−8621	27,852	1575	756
4	[0.165 *IRR*	−8584	27,329	1474	[219 0
5	0.168]	−8562	27,022	1444	−96]

[5] An alternative definition of the *IRR* is "the discount rate that makes the present value of the future cash flows equal to the initial capital outlay." From this version of the definition, it is clearer that the *IRR* is a new name for a familiar concept. The returns on investment that we calculated for various investment instruments in previous chapters are the internal rates of return for those investments. For example, the yield to maturity on a bond (Section 15.3) could also be called the bond's *IRR*. It is merely prevailing business practice that dictates which term is used for the same quantity in different contexts.

Interpolating,

$$\frac{IRR - 0.165}{0.168 - 0.165} \doteq \frac{0 - \$219}{-\$96 - \$219} = \frac{\$219}{\$315} = 0.695$$

$$IRR - 0.165 \doteq 0.003(0.695)$$
$$IRR \doteq 0.165 + 0.0021$$
$$\doteq 0.167$$
$$\doteq 16.7\%$$

The project's *IRR* is 16.7%. Since the *IRR* is greater than the cost of capital, the project should be accepted. (This conclusion is consistent with the outcome of the first trial, where the project had a positive *NPV* when the cost of capital was used as the discount rate.)

EXERCISE 16.4

Answers to the odd-numbered problems are at the end of the book.

Determine the IRR in the following problems to the nearest 0.1%.

1. A 10-year licence to distribute a product should increase the distributor's profit by $10,000 per year. If the licence can be acquired for $50,000, what is the investment's *IRR*?

2. Burger Master bought the food concession for a baseball stadium for five years at a price of $1.2 million. If the operating profit is $400,000 per year, what *IRR* will Burger Master realize on its investment?

•3. Calculate the *IRR* of each of the four stages of the cost reduction proposal in Problem 2 of Exercise 16.2. Based on the *IRR* investment criterion, which stages should be approved at a 14% cost of capital?

•4. A project requires an initial investment of $60,000. It will generate an annual profit of $12,000 for eight years and have a terminal value of $10,000. Calculate the project's *IRR*. Should it be accepted if the cost of capital is 15%?

•5. An investment of $100,000 will yield annual profits of $20,000 for 10 years. The proceeds on disposition at the end of the 10 years are estimated at $25,000. On the basis of its *IRR* and a 16% cost of capital, should the investment be made?

•6. Determine the *IRR* on the school bus contract in Problem 1 of Exercise 16.2. At which of the three costs of capital would the contract be financially acceptable?

••7. A $100,000 capital investment will produce annual profits of $25,000 for the first five years and $15,000 for the next five years. It will have no residual value. What is its *IRR*? Should it be undertaken if the cost of capital is 15%?

••8. A natural resource development and extraction project would require an investment of $1 million now and $1 million at the end of each of the next four years. Then it would generate annual profits of $2 million in each of the following five years. There would be no residual value. What would be the *IRR* of the project? Would it be acceptable to a company requiring a 16% return on investment?

••9. The introduction of a new product would require an initial investment of $120,000. The forecast profits in successive years of the anticipated four-year product life are

$25,000, $60,000, $50,000, and $35,000. Determine the *IRR* of the investment. Should the product be introduced if the firm's cost of capital is 15%?

••10. A venture requiring an immediate investment of $500,000 and an additional investment of $200,000 in three years' time will generate annual profits of $150,000 for seven years starting next year. There will be no significant terminal value. Calculate the *IRR* of the investment. Should the investment be undertaken at a 13% cost of capital?

••11. Determine the *IRR* on the strip-mine proposal in Problem 4 of Exercise 16.2. Should the mine be developed, given the mining company's 18% cost of capital?

16.5 COMPARING *NPV* AND *IRR* APPROACHES

For independent projects, the *NPV* and *IRR* investment decision criteria lead to the same "accept" or "reject" conclusion.[6] If the *NPV* criterion is satisfied, the *IRR* criterion will also be met.

The *NPV* approach has the advantage that it also quantifies the magnitude of the economic benefit to the firm of undertaking a capital investment. The primary objective of the managers of a firm is to maximize the value of the firm. The *NPV* analysis relates directly to this objective since it gives the amount that each potential investment will add to the firm's value. Nevertheless, studies of actual business practice reveal that more managers prefer to base business investment decisions on the *IRR* than on the *NPV*. This seems to reflect a traditional bias toward measures of profitability stated as percentage rates of return. Managers are also inclined to think in terms of the spread between the cost of capital and the (internal) rate of return on an investment.

A flawed investment decision can result if the *IRR* is used to rank projects that are mutually exclusive, or to rank projects that are competing for a limited capital budget. In these cases, it can happen that the project with the larger *IRR* has the smaller *NPV*. The ranking should be based strictly on the projects' *NPV*s. Then you can be sure you are selecting the project that adds the most value to the firm.

In summary, the *NPV* approach to evaluating and ranking capital investment opportunities *always* works. It also gives the amount by which the investment will increase the value of the firm. There are some situations, particularly the ranking of mutually exclusive investments, in which the *IRR* method can lead to a suboptimal decision.[7]

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[6] An exception sometimes occurs if there is more than one sign reversal among the periodic net cash flows. In such cases there can be more than one discount rate that makes the project's *NPV* equal to zero, and the *IRR* investment criterion will not necessarily apply. These cases will not be encountered in this text; they are considered in texts on managerial finance.

[7] The fundamental reason for this limitation can be traced to a subtle point. Any valuation of cash flows based on a present-value calculation implicitly assumes that cash flows from the investment may be reinvested at the discount rate used in the present-value calculation. An *NPV* ranking of projects therefore assumes the same reinvestment rate (the cost of capital) for all projects. An *IRR* ranking of projects assumes a different reinvestment rate for each project—namely, each project's own internal rate of return. It is not a fair comparison to rank projects on the basis of a criterion that does not use the same reinvestment rate for all projects being compared. Therefore, an *IRR* ranking of projects may differ from an *NPV* ranking, and the latter should take precedence.

Example 16.5A RANKING PROJECTS WITH UNEVEN CASH FLOWS

The initial investment and subsequent profits for two mutually exclusive, three-year projects are forecast as follows:

	Project S	Project T
Initial investment	$100,000	$100,000
Year 1 profit	100,000	25,000
Year 2 profit	20,000	25,000
Year 3 profit	20,000	110,000

a. Rank the projects on the basis of their *IRR*s.

b. Rank the projects on the basis of their *NPV*s if the firm's cost of capital is 15%.

c. Rank the projects on the basis of their *NPV*s if the firm's cost of capital is 12%?

d. Which project should be selected if the cost of capital is 12%?

Solution

a. The *IRR* of Project S is the value of i in

$$0 = -\$100{,}000 + \underbrace{\frac{\$100{,}000}{1+i}}_{\text{Term ①}} + \underbrace{\frac{\$20{,}000}{(1+i)^2}}_{\text{Term ②}} + \underbrace{\frac{\$20{,}000}{(1+i)^3}}_{\text{Term ③}}$$

Estimate i by the trial-and-error method.

Trial number	Estimated i	Term ①	Term ②	Term ③	RHS
1	0.15	$86,957	$15,123	$13,150	$15,230
2	0.20	83,333	13,889	11,574	8796
3	0.25	80,000	12,800	10,240	3040
4	0.28	78,125	12,207	9537	−131
	IRR				0
5	0.278	78,247	12,245	9582	74

Interpolating,

$$\frac{IRR - 0.278}{0.28 - 0.278} \doteq \frac{0 - \$74}{-\$131 - \$74} = \frac{\$74}{\$205} = 0.361$$

$$IRR - 0.278 \doteq 0.002(0.361)$$

$$IRR \doteq 0.278 + 0.0007$$

$$\doteq 0.2787$$

$$\doteq 27.87\% \text{ compounded annually for Project S}$$

The *IRR* for Project T may be similarly shown to be 20.91% compounded annually. Therefore, Project S has the greater *IRR* and, on that basis, would rank ahead of Project T.

b. At a cost of capital of 15%, the *NPV* of Project S is

$$\begin{aligned} NPV_S &= -\$100{,}000 + \frac{\$100{,}000}{1.15} + \frac{\$20{,}000}{1.15^2} + \frac{\$20{,}000}{1.15^3} \\ &= -\$100{,}000 + \$86{,}957 + \$15{,}123 + \$13{,}150 \\ &= \$15{,}230 \end{aligned}$$

The *NPV* of Project T may be calculated in a similar manner to give

$$NPV_T = \$12{,}970$$

Therefore, Project S has the greater *NPV* and ranks ahead of Project T. This is the same as the *IRR* ranking in part (a).

c. At a cost of capital of 12%, the *NPV*s of the two projects can be calculated again using the same method as in part (b). The values are

$$NPV_S = \$19{,}465 \qquad NPV_T = \$20{,}547$$

In this case, T has the larger *NPV* and ranks ahead of S. We note from parts (b) and (c) that the *NPV* ranking can depend on the cost of capital.

d. A project's *IRR* is not affected by the cost of capital. On the basis of the *IRR*, Project S would always be selected over Project T.

At a 12% cost of capital, the *IRR* and *NPV* rankings do not agree. We should let the *NPV* ranking take precedence and select the project that adds the greater value to the firm. Therefore, Project T should be chosen.

Example 16.5b. RANKING PROJECTS WITH UNIFORM CASH FLOWS

A company is considering two mutually exclusive projects. The initial investment required and the expected profits are presented in the following table. Neither project will have any residual value.

	Project A	Project B
Initial investment	$50,000	$100,000
Year 1 profit	28,000	50,000
Year 2 profit	28,000	50,000
Year 3 profit	28,000	50,000

a. Rank the projects on the basis of their *IRR*s.

b. Which project should be chosen if the company's cost of capital is 17%?

c. Which project should be chosen if the cost of capital is 14%?

Solution

a. Each project's annual profits form a simple annuity. The *IRR* of Project A is the value of i satisfying

$$0 = \$28{,}000\left[\frac{1-(1+i)^{-3}}{i}\right] - \$50{,}000$$

Similarly, the *IRR* of Project B is the solution to

$$0 = \$50{,}000\left[\frac{1-(1+i)^{-3}}{i}\right] - \$100{,}000$$

An algebraic solution to these equations requires a trial-and-error approach. When the periodic cash flows form an annuity, we can use the calculator's basic financial functions to solve for i.

Project A:

3 **N**
50000 **+/−** **PV**
28000 **PMT**
0 **FV**
P/Y 1 **ENTER**
Same *C/Y*
CPT **I/Y**
Ans: 31.21

Project B:

Same *N, FV,P/Y,C/Y*
100000 **+/−** **PV**
50000 **PMT**
CPT **I/Y**
Ans: 23.38

The *IRR* of Project A is 31.21% compounded annually and of Project B is 23.38% compounded annually. On the basis of an *IRR* ranking, Project A should be selected over Project B.

b. At a cost of capital of 17%,

$$NPV_A = \$28{,}000\left[\frac{1-(1.17)^{-3}}{0.17}\right] - \$50{,}000 = \$11{,}868$$

$$NPV_B = \$50{,}000\left[\frac{1-(1.17)^{-3}}{0.17}\right] - \$100{,}000 = \$10{,}479$$

Since $NPV_A > NPV_B$, Project A should be selected.

c. At a cost of capital of 14%,

$$NPV_A = \$28{,}000\left[\frac{1-(1.14)^{-3}}{0.14}\right] - \$50{,}000 = \$15{,}006$$

$$NPV_B = \$50{,}000\left[\frac{1-(1.14)^{-3}}{0.14}\right] - \$100{,}000 = \$16{,}082$$

Since $NPV_B > NPV_A$, Project B should be selected (even though $IRR_A > IRR_B$).

EXERCISE 16.5

Answers to the odd-numbered problems are at the end of the book.

Calculate internal rates of return to the nearest 0.1%.

•1. Two mutually exclusive investments are available to a firm. Project C, requiring a capital investment of $150,000, will generate an annual profit of $43,000 for six years. Project D is expected to yield an annual profit of $30,000 for six years on an initial investment of $100,000.

a. Calculate the internal rate of return on each project. Based upon their *IRR*s, which project should be selected?

b. Which project should be selected if the firm's cost of capital is 15%?

c. Which project should be selected if the firm's cost of capital is 12%?

•2. Academic Publishing is trying to decide which of two books to publish. The larger book will cost $100,000 to publish and print. Sales are expected to produce an annual profit of $32,000 for five years. The smaller book will cost $60,000 to publish and print, and should generate an annual profit of $20,000 for five years.

a. Calculate the internal rate of return on each book. On the basis of their *IRR*s, which book should be published?

b. Which book should be published if the firm's cost of capital is 17%?

c. Which book should be published if the firm's cost of capital is 14%?

••3. Due to a restricted capital budget, a company can undertake only one of the following three-year projects. Both require an initial investment of $650,000 and will have no significant terminal value. Project XXX is anticipated to have annual profits of $400,000, $300,000, and $200,000 in successive years, whereas Project YYY's only profit, $1.05 million, comes at the end of Year 3.

a. Calculate the *IRR* of each project. On the basis of their *IRR*s, which project should be selected?

b. Which project should be selected if the firm's cost of capital is 14%?

c. Which project should be selected if the firm's cost of capital is 11%?

••4. Two mutually exclusive projects each require an initial investment of $50,000 and should have a residual value of $10,000 after three years. The following table presents their forecast annual profits.

Year	Project 1	Project 2
1	$10,000	$50,000
2	15,000	10,000
3	50,000	5000

a. Calculate the *IRR* of each project. On the basis of their *IRR*s, which project should be selected?

b. Which project should be selected if the firm's cost of capital is 14%?

c. Which project should be selected if the firm's cost of capital is 12%?

••5. A company is examining two mutually exclusive projects. Project X requires an immediate investment of $100,000 and produces no profit until Year 3. Then the annual profit is $60,000 for Years 3 to 5 inclusive. Project Y requires an investment of $50,000 now and another $50,000 in one year. It is expected to generate an annual profit of $40,000 in Years 2 to 5.

a. Calculate the *IRR* of each project. On the basis of their *IRR*s, which project is preferred?

b. Which project should be selected if the firm's cost of capital is 15%?

c. Which project should be selected if the firm's cost of capital is 12%?

••6. A company is evaluating two mutually exclusive projects. Both require an initial investment of $240,000 and have no appreciable disposal value. Their expected profits over their five-year lifetimes are as follows:

Year	Project Alpha	Project Beta
1	$140,000	$ 20,000
2	80,000	40,000
3	60,000	60,000
4	20,000	100,000
5	20,000	180,000

The company's cost of capital is 12%. Calculate the *NPV* and *IRR* for each project. Which project should be chosen? Why?

16.6 THE PAYBACK PERIOD

Many smaller firms still use the payback period as a measure of the attractiveness of a capital investment. The **payback period** is the number of years it takes to recover an initial investment from the investment's future operating profits. For example, if an initial capital investment of $450,000 generates an annual profit of $100,000 for 10 years, it has a $4\frac{1}{2}$-year payback. A firm that uses this approach establishes a maximum payback period for an acceptable investment. Investment opportunities that have a payback period shorter than or equal to the maximum should be accepted.

The payback approach to investment selection has three serious shortcomings. The first is that the payback calculation ignores the time value of money—there is no discounting of the future cash flows. In the example above, $1 in Year 5 is treated as having the same value as $1 of the initial investment. A second flaw is that the payback calculation ignores the profits and residual value that would be received beyond the maximum payback period. The third weakness is that the maximum acceptable payback period is set by the firm in a rather arbitrary manner without rigorous economic justification. The payback method is included in our coverage of investment decision criteria not because it has any great merit, but only because it is still widely used.

Example 16.6 CALCULATION OF THE PAYBACK PERIOD; COMPARISON OF DECISIONS BASED ON PAYBACK VERSUS NPV

A firm is considering three independent projects. They all require the same initial investment of $90,000 and have no residual value after eight years. All three generate the same aggregate total of profits ($160,000), but the profits are distributed differently over the eight-year period, as presented in the following table.

Year	Annual profit		
	Project A	Project B	Project C
1	$25,000	$20,000	$ 0
2	25,000	20,000	0
3	25,000	20,000	45,000
4	25,000	20,000	45,000
5	15,000	20,000	15,000
6	15,000	20,000	15,000
7	15,000	20,000	20,000
8	15,000	20,000	20,000

a. Which projects should be accepted if the firm has a four-year payback requirement?

b. Which projects would be accepted on the *NPV* criterion if the firm's cost of capital is 14%?

Solution

a. To be accepted on the payback criterion, a project must have cumulative profits after four years that equal or exceed the original capital investment ($90,000). The following table presents the cumulative profits from the three projects at the end of each year.

Year	Cumulative profits		
	Project A	Project B	Project C
1	$ 25,000	$ 20,000	$ 0
2	50,000	40,000	0
3	75,000	60,000	45,000
4	100,000	80,000	90,000
5	115,000	100,000	105,000
6	130,000	120,000	120,000
7	145,000	140,000	140,000
8	160,000	160,000	160,000

Assuming that the profits accumulate uniformly within each year, the payback periods are:

$$\text{Project A:} \quad 3 + \frac{\$15{,}000}{\$25{,}000} = 3.6 \text{ years}$$

$$\text{Project B:} \quad 4 + \frac{\$10{,}000}{\$20{,}000} = 4.5 \text{ years}$$

Project C: 4.0 years

Projects A and C will be accepted because they recover the original investment within the four-year payback period. Project B will be rejected on the same criterion.

b. The net present value of Project A is

$$\begin{aligned} NPV_A &= \$25{,}000\left[\frac{1-(1.14)^{-4}}{0.14}\right] + \$15{,}000\left[\frac{1-(1.14)^{-4}}{0.14}\right](1.14)^{-4} - \$90{,}000 \\ &= \$72{,}843 + \$25{,}877 - \$90{,}000 \\ &= \$8720 \end{aligned}$$

The net present value of Project B is

$$NPV_B = \$20{,}000\left[\frac{1-(1.14)^{-8}}{0.14}\right] - \$90{,}000 = \$2777$$

The net present value of Project C is

$$\begin{aligned} NPV_C &= \frac{\$45{,}000}{1.14^3} + \frac{\$45{,}000}{1.14^4} + \frac{\$15{,}000}{1.14^5} + \frac{\$15{,}000}{1.14^6} + \frac{\$20{,}000}{1.14^7} + \frac{\$20{,}000}{1.14^8} - \$90{,}000 \\ &= \$30{,}374 + \$26{,}644 + \$7790 + \$6834 + \$7993 + \$7011 - \$90{,}000 \\ &= -\$3354 \end{aligned}$$

Since Projects A and B both have a positive *NPV*, they should be accepted. Project C, with a negative *NPV*, should be rejected.

Note: Since there is no fundamental economic rationale behind the payback period, we should not expect a high degree of consistency between investment decisions based on a payback period and decisions based on the *NPV* criterion. In this example Project B was accepted based on its *NPV* but was rejected because its payback period exceeded four years. Conversely, Project C failed to satisfy the *NPV* criterion but met the payback requirement. A general statement that can be made is that the shorter a project's payback period, the more likely it is to have a positive *NPV*.

POINT of Interest

What Investment Criteria Do Businesses Really Use?

Discounted-cash-flow techniques—primarily the net present value (*NPV*) and internal rate of return (*IRR*) methods—started to be used by large corporations in the early 1950s. An early study[8] concluded that, in 1955, only 9% of large American firms used some form of discounted-cash-flow analysis in making capital investment decisions. A trend toward increased usage of *NPV* and *IRR* techniques developed as more and more accounting and business school graduates were educated in discounted-cash-flow techniques.

A recent survey[9] of chief financial officers of Canada's largest industrial corporations produced the data presented in the following table. The number in any cell in the table gives the percentage of corporations using the technique named in the column heading for the type of investment project named in the row heading. The total of the numbers in each row exceeds 100% because most firms use more than one technique for each investment project.

Type of investment project	NPV	IRR	Payback period	Other methods
Replacement project	34.6	46.6	48.9	26.4
Expansion—existing operations	41.4	61.6	50.0	24.0
Expansion—new operations	45.1	61.6	47.4	25.6
Abandonment	29.3	19.6	15.0	33.1
Leases	42.9	36.1	14.3	21.0

In spite of the 40-year trend toward increasing use of discounted-cash-flow methods, the payback period was still the second most popular technique in the mid-1990s, although not by a large margin.

Of the two discounted-cash-flow methods, the *NPV* method tells managers what they most need to know. We might wonder why, then, the *IRR* approach is used significantly more than the *NPV* approach. Samuel Weaver, Director of Corporate Financial Planning and Analysis for the Hershey Foods Corporation provided the following reasons.[10] "Decision makers at all levels sometimes find it difficult to comprehend an *NPV* result. It is not enough to know that the *NPV* is positive, or even more positive than for an alternative investment. Decision makers seek a level of comfort in how profitable an investment is by relating it to other standards. Although the *IRR* may provide a misleading indication of which project to select, the result is provided in a way that can be interpreted by all parties. An *IRR* can be compared to expected inflation, current borrowing rates, the cost of capital, and so on. Perhaps this ease of understanding is why surveys indicate that most Fortune 500 companies use the *IRR* method as a primary evaluation technique."

We have doubts about Dr. Weaver's premise that the *IRR* concept is more easily understood than the *NPV* concept. Footnotes 6 and 7 in Section 16.5 allude to subtle but profound aspects of *IRR* that have no counterpart in *NPV*. What we are prepared to believe is that many decision makers, blissfully unaware of the subtleties of the *IRR*, *think* they can readily interpret the *IRR*.

[8] Alexander A. Robichek and James G. MacDonald, *Financial Management in Transition, Long-Range Planning Service,* Report no. 268 (Menlo Park, Calif.: Stanford Research Institute, 1966).

[9] V. M. Jog and A.K. Srivastava, "Corporate Financial Decision-Making in Canada," *Canadian Journal of Administrative Sciences* (June 1994), pp. 156-76.

[10] Ross, S. A., R. W. Westerfield, B. D. Jordan, and G. S. Roberts, Fundamentals of Corporate Finance, 3rd Canadian ed. Toronto, ON: McGraw-Hill Ryerson, 1999, p. 275.

EXERCISE 16.6

Answers to the odd-numbered problems are at the end of the book.

1. The expected profits from a $52,000 investment are $8000 in Year 1, $12,000 in each of Years 2 to 5, and $6000 in each of Years 6 and 7.

a. What is the investment's payback period?

b. If the firm's required payback period is four years, will it make the investment?

2. A firm is considering the purchase of a $30,000 machine that would save labour costs of $5000 per year in the first three years and $6000 per year for the next four years. Will the firm purchase the machine if the payback requirement is:

a. Five years? **b.** Six years?

•3. Projects X and Y both require an initial investment of $100,000. Project X will generate an annual operating profit of $25,000 per year for six years. Project Y produces no profit in the first year, but will yield an annual profit of $25,000 for the seven subsequent years. Rank the projects based on their payback periods and on their *NPV*s (at a 10% cost of capital).

•4. A capital investment requiring a single initial cash outflow is forecast to have an operating profit of $50,000 per year for five years. There is no salvage value at the end of the five years. If the investment has an *IRR* of 17%, calculate its payback period.

••5. Investment proposals A and B require initial investments of $45,000 and $35,000, respectively. Both have an economic life of four years with no residual value. Their expected profits are as follows:

Year	Proposal A	Proposal B
1	$16,250	$12,500
2	17,500	12,500
3	17,500	15,000
4	17,500	15,000

If the firm's cost of capital is 14%, rank the proposals based on their:

a. *NPV*s. **b.** *IRR*s. **c.** Payback periods.

REVIEW PROBLEMS

Answers to the odd-numbered review problems are at the end of the book.

● **1.** A manufacturer's sales rep can lease an automobile for five years at $385 per month payable at the beginning of each month, or purchase it for $22,500. He can obtain a loan at 9% compounded monthly to purchase the car. Should he lease or buy the car if:

a. The trade-in value after five years is $5000?

b. The trade-in value after five years is $7000?

●● **2.** Jurgen Wiebe has been transferred to Winnipeg for five years. He has found an attractive house that he can buy for $150,000 or rent for $1150 per month, payable at the beginning of each month. He estimates that the resale value of the house in five years will be $175,000 net of the selling commission. If he buys the house, the average (end-of-month) costs for repairs, maintenance, and property taxes will be $300. Should Mr. Wiebe rent or buy the house if the interest rate on five-year mortgage loans is 8.25% compounded monthly?

● **3.** A proposed open-pit mine would require the investment of $2 million at the beginning of the first year and a further investment of $1 million at the end of the first year. Mining operations are expected to yield annual profits of $750,000, beginning in Year 2. The ore body will sustain eight years of ore extraction. At the beginning of the tenth year, the mining company must spend $1 million on cleanup and environmental restoration. Will the project provide the mining company with a rate of return exceeding its 16% cost of capital?

● **4.** The development of a new product will require the expenditure of $125,000 at the beginning of each of the next two years. When the product reaches the market in Year 3, it is expected to increase the firm's annual profit by $50,000 for eight years. (Assume that the profit is received at the end of each year.) Then $75,000 of the original expenditures should be recoverable. If the firm's cost of capital is 14%, should it proceed with the project?

●● **5.** A new machine that will lead to savings in labour costs of $20,000 per year can be purchased for $60,000. However, it will cost $2000 per year for the first four years, and $3000 per year for the next four years to service and maintain the machine. In addition, its annual fuel consumption will cost $1500. After a service life of eight years, the salvage value of the machine is expected to be $10,000. Should the machine be acquired if the company requires a minimum annual rate of return on investment of 15%?

● **6.** The investment committee of a company has identified the following seven projects with positive *NPV*s. If the board of directors has approved a $4.5 million capital budget for the current period, which projects should be selected?

Project	Initial investment	NPV
1	$1,125,000	$428,000
2	2,700,000	486,000
3	675,000	170,000
4	375,000	30,000
5	1,500,000	900,000
6	225,000	32,000
7	900,000	405,000

● **7.** Machine X costs $50,000 and is forecast to generate an annual profit of $16,000 for five years. Machine Y, priced at $72,000, will produce the same annual profits for 10 years. The trade-in value of X after five years is expected to be $10,000, and the resale value of Y after 10 years is also thought to be $10,000. If either machine satisfies the firm's requirements, which one should be selected? Use a required return of 14%.

● **8.** A U-Print store requires a new photocopier. A Sonapanic copier with a four-year service life costs $35,000 and will generate an annual profit of $14,000. A higher-speed Xorex copier with a five-year service life costs $43,500 and will return an annual profit of $17,000. Neither copier will have significant salvage value. If U-Print's cost of capital is 16%, which model should be purchased?

● **9.** The provincial government's Ministry of Fisheries requires a new patrol boat. The price of a Songster is $45,000, and its annual operating costs will be $5000. It will be sold for about $10,000 after five years, and replaced. A more durable and more efficient Boston Wailer, priced at $55,000, would cost $4000 per year to operate, last seven years, and have a resale value of $20,000. If the provincial government pays an interest rate of 8% compounded annually on its midterm debt, which boat has the lower equivalent annual cost?

10. A seven-year licence to distribute a product should increase the distributor's profit by $18,000 per year. If the licence can be acquired for $70,000, what is the investment's *IRR*?

● **11.** An investment of $300,000 will yield annual profits of $55,000 for eight years. The proceeds on disposition of the investment at the end of the eight years are estimated at $125,000. On the basis of its *IRR* and a 15% cost of capital, should the investment be made?

●● **12.** A $500,000 capital investment will produce annual profits of $100,000 for the first four years and $150,000 for the next four years. It will have no residual value. What is its *IRR*? Should the investment be undertaken if the cost of capital is 15%?

●● **13.** A company is examining two mutually exclusive projects. Project P requires an immediate investment of $225,000 and produces no profit until the fourth year. Then the expected annual profit is $120,000 for Years 4 to 7 inclusive. Project Q requires an investment of $225,000 now and is expected to generate an annual profit of $55,000 in Years 1 to 7. Neither project has any residual value after seven years.

a. Calculate the *IRR* of each project. On the basis of their *IRR*s, which project is preferred?

b. Which project should be selected if the firm's cost of capital is 16%?

c. Which project should be selected if the firm's cost of capital is 13%?

14. The expected profits from an $80,000 investment are $15,000 in Year 1 and $20,000 in each of Years 2 to 7.

a. What is the investment's payback period?

b. If the firm's required payback period is four years, will it make the investment?

c. If the firm's cost of capital is 14%, will it make the investment based on the *NPV* criterion?

SELF-TEST EXERCISE

Answers to the self-test problems are at the end of the book.

● **1.** Rainbow Aviation needs an additional plane for five years. It could buy the plane for $180,000, using funds borrowed at 11.25% compounded monthly and then sell the plane for an estimated $70,000 after five years. Alternatively, it could lease the plane for $2800, payable at the beginning of each month. Which alternative should Rainbow Aviation choose? What is the economic value of the financial advantage of the preferred alternative?

● **2.** Huron Charters can purchase a sailboat for $50,000 down and a $30,000 payment due in one year. The boat would generate additional annual operating profits of $12,000 for the first five years and $15,000 for the next five years. New sails costing $8000 would be required after five years. After 10 years the boat would be replaced; its resale value would be about $30,000. Should Huron purchase the sailboat if its cost of capital is 15% compounded annually?

● **3.** A company's board of directors has imposed an $800,000 limit on capital spending for the current year. Management has identified the following five projects with positive *NPV*s. Which projects should be chosen?

Project	Initial investment	NPV
A	$200,000	$ 63,000
B	400,000	100,000
C	350,000	90,000
D	250,000	75,000
E	100,000	20,000

● **4.** A company is considering two mutually exclusive investment projects. Each requires an initial investment of $25,000. Project A will generate an annual profit of $6000 for eight years and have a residual value of $5000. Project B's profits are more irregular: $15,000 in the first year, $19,000 in the fifth year, and $24,000 (including the residual value) in the eighth year. Which project should be chosen if the required return on investment is 18% compounded annually?

●● **5.** A firm can manufacture the same product with either of two machines. Machine C requires an initial investment of $55,000 and would earn a profit of $30,000 per year for three years. It would then be replaced, because repairs would be required too frequently after three years. Its trade-in value would be $10,000. Machine D costs $100,000 and would have a service life of five years. The annual profit would be $5000 higher than Machine C's profit because of its lower repair and maintenance costs. Its recoverable value after five years would be about $20,000. Which machine should be purchased if the firm's cost of capital is 16%? What is the average annual economic advantage of the preferred choice?

● **6.** A potato farmer needs to buy a new harvester. Two types have performed satisfactorily in field trials. The SpudFinder costs $70,000 and should last for five years. The simpler TaterTaker costs only $40,000 but requires an extra operator at $10,000 per season. This machine has a service life of seven years. The salvage value of either machine is insignificant. If the farmer requires a 13% return on investment, which harvester should she buy?

● **7.** A capital investment requiring one initial cash outflow is forecast to have the operating profits listed below. The investment has an *NPV* of $20,850, based on a required rate of return of 12%. Calculate the payback period of the investment.

Year	Operating profit
1	$74,000
2	84,000
3	96,000
4	70,000

●● **8.** The introduction of a new product will require a $400,000 investment in demonstration models, promotion, and staff training. The new product will increase annual profits by $100,000 for the first four years and $50,000 for the next four years. There will be no significant recoverable amounts at the end of the eight years. The firm's cost of capital is 13%. Calculate the expected *IRR* on the proposed investment in the new product. Should the new product be introduced? Why?

●● **9.** The initial investment and expected profits from two mutually exclusive capital investments being considered by a firm are as follows:

	Investment A	Investment B
Initial investment	$70,000	$65,000
Year 1 profit	30,000	50,000
Year 2 profit	80,000	50,000

a. Calculate the internal rate of return for each investment. Which one would be selected based on an *IRR* ranking?

b. Which investment should be chosen if the firm's cost of capital is 14%?

c. Which investment should be chosen if the firm's cost of capital is 17%?

SUMMARY OF NOTATION AND KEY FORMULAS

NPV = Net present value (of an investment)
IRR = Internal rate of return (on an investment)

$$NPV = \begin{pmatrix}\text{Present value}\\ \text{of cash inflows}\end{pmatrix} - \begin{pmatrix}\text{Present value}\\ \text{of cash outflows}\end{pmatrix}$$

NPV Investment Decision Criterion:

Accept the investment if $NPV \geq 0$.
Reject the investment if $NPV < 0$.

IRR Investment Decision Criterion:

Accept the investment if $IRR \geq$ Cost of capital.
Reject the investment if $IRR <$ Cost of capital.

GLOSSARY

Capital rationing The circumstance where there is a limit on the total amount of capital funds that a firm may invest during a period. p. 671

Cost of capital The average of the rates of return required by a firm's various sources of financing. p. 660

Internal rate of return The discount rate that makes the net present value of an investment's cash flows equal to zero. p. 679

Mutually exclusive projects Alternative capital investments, any one of which will substantially satisfy the same need or purpose. p. 672

Net present value The present value of cash inflows minus the present value of cash outflows p. 666

Payback period The number of years it will take to recover an initial investment outlay from the investment's future operating profits. p. 687