CHAPTER 20

# Capital Investment

## AFTER STUDYING THIS CHAPTER, YOU SHOULD BE ABLE TO:

1. Describe the difference between independent and mutually exclusive capital investment decisions.
2. Explain the roles of the payback period and accounting rate of return in capital investment decisions.
3. Calculate the net present value (NPV) for independent projects.
4. Compute the internal rate of return (IRR) for independent projects.
5. Tell why NPV is better than IRR for choosing among mutually exclusive projects.
6. Convert gross cash flows to after-tax cash flows.
7. Describe capital investment for advanced technology and environmental impact settings.

Organizations are often faced with the opportunity (or need) to invest in assets or projects that represent long-term commitments. New production systems, new plants, new equipment, and new product development are examples of assets and projects that fit this category. Usually, many alternatives are available. For example, **Federal Express** has chosen to make a capital investment in airplanes, sorting equipment, and distribution facilities. The FedEx hub in Memphis represents a significant outlay of funds (capital outlay). Sound capital investment decision making of this type requires the estimation of a project's cash flows. How cash flows can be used to evaluate the merits of a proposed project is the focus of this chapter. We will study four financial models that are useful in capital investment analysis: the payback period, the accounting rate of return, net present value, and the internal rate of return.

OBJECTIVE 1

Describe the difference between independent and mutually exclusive capital investment decisions.

# Capital Investment Decisions

**Capital investment decisions** are concerned with the process of planning, setting goals and priorities, arranging financing, and using certain criteria to select long-term assets. Because capital investment decisions place large amounts of resources at risk for long periods of time and simultaneously affect the future development of the firm, they are among the most important decisions managers make. Every organization has limited resources, which should be used to maintain or enhance its long-run profitability. Poor capital investment decisions can be costly. For example, a study of capital expenditure decisions made by deregulated utility plants revealed that 25 to 30 percent of the capital projects were unnecessary.[1] One example offered by the study is a $17 million investment to rebuild a low-pressure turbine; yet, the turbine that was rebuilt posed no danger nor was it having any negative impact on operations. Perhaps these unnecessary capital investment decisions explain why production costs increased by 20 percent in spite of the fact that each plant averaged between $2 and $3 million in new capital investments. Normally, the expectation is that capital investments will enhance profitability—not reduce it.

The process of making capital investment decisions is often referred to as **capital budgeting**. Two types of capital budgeting projects will be considered. **Independent projects** are projects that, if accepted or rejected, do not affect the cash flows of other projects. Suppose that the managers of the marketing and research and development departments jointly propose the addition of a new product line where each would entail significant outlays of working capital and equipment. Acceptance or rejection of one product line does not require the acceptance or rejection of the other product line. Thus, the investment decisions for the product lines are independent of each other.

The second type of capital budgeting project requires a firm to choose among competing alternatives that provide the same basic service. Acceptance of one option precludes the acceptance of another. Thus, **mutually exclusive projects** are those projects that, if accepted, preclude the acceptance of all other competing projects. For example, when **Monsanto**'s Fiber Division decided to automate its Pensacola, Florida, plant, it was faced with the choice of continuing with its existing manual production operation or replacing it with an automated system. In all likelihood, part of the company's deliberation concerned different types of automated systems. If three different automated systems were being considered, this would produce four alternatives—the current system plus the three potential new systems. Once one system is chosen, the other three are excluded; they are mutually exclusive.

Notice that one of the competing alternatives in the example is that of maintaining the status quo (the manual system). This emphasizes the fact that new investments replacing existing investments must prove to be economically superior. Of course, at times, replacement of the old system is mandatory and not discretionary if the firm wishes to remain in business (e.g., equipment in the old system may be worn out; thus, the old system is not a viable alternative). In such a situation, going out of business could be a viable alternative, especially if none of the new investment alternatives is profitable.

Capital investment decisions often are concerned with investments in long-term capital assets. With the exception of land, these assets depreciate over their lives, and the original investment is used up as the assets are employed. In general terms, a sound capital investment will earn back its original capital outlay over its life and, at the same time, provide a reasonable return on the original investment. Therefore, one task of a manager is to decide whether or not a capital investment will earn back its original outlay and provide a reasonable return. By making this assessment, a manager can decide

1. Holt Bradswahw, "Merchant Costs: Reckless Abandonment," *Public Utilities Fortnightly* (April 2004): 30–34.

on the acceptability of independent projects and compare competing projects on the basis of their economic merits. But what is meant by reasonable return? It is generally agreed that any new project must cover the *opportunity cost* of the funds invested. For example, if a company takes money from a money market fund that is earning 6 percent and invests it in a new project, then the project must provide at least a 6 percent return (the return that could have been earned had the money been left in the money market fund). Of course, in reality, funds for investment often come from different sources—each representing a different opportunity cost. The return that must be earned is a blend of the opportunity costs of the different sources. Thus, if a company uses two sources of funds, one with an opportunity cost of 4 percent and the other with an opportunity cost of 6 percent, then the return that must be earned is somewhere between 4 and 6 percent, depending on the relative amounts used from each source. Furthermore, it is usually assumed that managers should select projects that promise to maximize the wealth of the owners of the firm.

## COST MANAGEMENT — Technology in Action

In health care, IT systems represent 2 to 3 percent of the annual operating budget and consume between 15 and 30 percent of the capital budget. Thus, purchasing a new information system or upgrading existing technology can have a significant effect on the operating margin of a hospital. IT capital budget requests tend to come with a variety of objectives. Some projects are designed to improve services and others to improve care quality or revenue or even to satisfy some level of regulatory compliance. Numerous examples of these different project types are available. For example, at **Brigham and Women's Hospital**, an investment in an in-patient order entry system led to a 55 percent reduction in medication errors. At **Massachusetts General Hospital**, investment in a picture archival and communication system reduced the time spent for interpreting radiology images from 72 hours to one hour. Other investments target increasing quality by reducing patient wait time, increasing physician access to patient information, improving treatment outcomes, and reducing errors in treatment. IT capital investments can also provide new products (and thus new sources of revenues), such as Web access to clinical guidelines and consumer-oriented medical textbooks.

*Source:* John Glaser, "Analyzing Information Technology Value," *Healthcare Financial Management* (March 2003): 98–102.

To make a capital investment decision, a manager must estimate the quantity and timing of cash flows, assess the risk of the investment, and consider the impact of the project on the firm's profits. One of the most difficult tasks is to estimate the cash flows. Projections must be made years into the future, and forecasting is far from a perfect science. Obviously, as the accuracy of cash flow forecasts increases, the reliability of the decision improves. In making projections, managers must identify and quantify the benefits associated with the proposed project(s). For example, an automated cash deposit system can produce the following benefits (relative to a manual system): bank charge reductions, productivity gains, forms cost reduction, greater data integrity, lower training costs, and savings in time required to audit and do bank/cash reconciliations. The dollar value of these benefits must be assessed. Although forecasting future cash flows is a critical part of the capital investment process, forecasting methods will not be considered here. Consequently, cash flows are assumed to be known; the focus will be on making capital investment decisions *given* these cash flows.

Managers must set goals and priorities for capital investments. They also must identify some basic criteria for the acceptance or rejection of proposed investments. In this chapter, we will study four basic methods to guide managers in accepting or rejecting potential investments. The methods include both nondiscounting and discounting decision approaches. (Two methods are discussed for each approach.) The discounting methods are applied to investment decisions involving both independent and mutually exclusive projects.

OBJECTIVE 2

Explain the roles of the payback period and accounting rate of return in capital investment decisions.

# Payback and Accounting Rate of Return: Nondiscounting Methods

Models used for making capital investment decisions fall into two major categories: *nondiscounting models* and *discounting models*. **Nondiscounting models** ignore the time value of money, whereas **discounting models** explicitly consider it. Although many accounting theorists disparage the nondiscounting models because they ignore the time value of money, many firms continue to use them in making capital investment decisions. However, the use of discounting models has increased over the years, and few firms use only one model—indeed, firms seem to use both types of models. This suggests that both categories supply useful information to managers as they struggle to make capital investment decisions.

## Payback Period

One type of nondiscounting model is the *payback period*. The **payback period** is the time required for a firm to recover its original investment. For example, assume that a dentist invests in a new grinder costing $160,000. The cash flow (cash inflows less cash outflows) generated by the equipment is $80,000 per year. Thus, the payback period is two years ($160,000/$80,000). When the cash flows of a project are assumed to be even, the following formula can be used to compute the project's payback period:

Payback period = Original investment/Annual cash flow

If, however, the cash flows are uneven, the payback period is computed by adding the annual cash flows until such time as the original investment is recovered. If a fraction of a year is needed, it is assumed that cash flows occur evenly within each year. For example, suppose that a laundromat requires an investment of $200,000 and has a life of five years with the following expected annual cash flows: $60,000, $80,000, $100,000, $120,000, and $140,000. The payback period for the project is 2.6 years, computed as follows: $60,000 (1 year) + $80,000 (1 year) + $60,000 (0.6 year). In the third year, when only $60,000 is needed and $100,000 is available, the amount of time required to earn the $60,000 is found by dividing the amount needed by the annual cash flow ($60,000/$100,000). Exhibit 20-1 summarizes this analysis.

One way to use the payback period is to set a maximum payback period for all projects and to reject any project that exceeds this level. Why would a firm use the payback period in this way? Some analysts suggest that the payback period can be used as a

**EXHIBIT 20-1 Payback Analysis**

| Year | Unrecovered Investment (Beginning of Year) | Annual Cash Flow |
|---|---|---|
| 1 | $200,000 | $ 60,000 |
| 2 | 140,000 | 80,000 |
| 3 | 60,000* | 100,000 |
| 4 | — | 120,000 |
| 5 | — | 140,000 |

*At the beginning of Year 3, $60,000 is needed to recover the investment. Since a net cash inflow of $100,000 is expected, only 0.6 year ($60,000/$100,000) is needed to recover the $60,000. Thus, the payback period is 2.6 years (2 + 0.6).

rough measure of risk, with the notion that the longer it takes for a project to pay for itself, the riskier it is. Also, firms with riskier cash flows could require a shorter payback period than normal. Additionally, firms with liquidity problems would be more interested in projects with quick paybacks. Another critical concern is obsolescence. In some industries, the risk of obsolescence is high; firms within these industries would be interested in recovering funds rapidly.

Another reason, less beneficial to the firm, may also be at work. Many managers in a position to make capital investment decisions may choose investments with quick payback periods out of self-interest. If a manager's performance is measured using such short-run criteria as annual operating income, he or she may choose projects with quick paybacks to show improved operating income as quickly as possible. Consider that division managers often are responsible for making capital investment decisions and are evaluated on divisional profit. The tenure of divisional managers, however, is typically short—three to five years would be average. Consequently, the incentive is for such managers to shy away from investments that promise healthy long-run returns but relatively meager returns in the short run. These problems can be eliminated by corporate budgeting policies and a budget review committee.

The payback period can be used to choose among competing alternatives. Under this approach, the investment with the shortest payback period is preferred over investments with longer payback periods. However, this use of the payback period is less defensible because this measure suffers from two major deficiencies: (1) it ignores the performance of the investments beyond the payback period and (2) it ignores the time value of money.

These two significant deficiencies are easily illustrated. Assume that a tire manufacturing firm is considering two different types of automated conveyor systems—Autocon and Maticmuv. Each system requires an initial outlay of $600,000, has a 5-year life, and displays the following annual cash flows:

| *Investment* | *Year 1* | *Year 2* | *Year 3* | *Year 4* | *Year 5* |
|---|---|---|---|---|---|
| Autocon | $360,000 | $240,000 | $200,000 | $200,000 | $200,000 |
| Maticmuv | 160,000 | 440,000 | 100,000 | 100,000 | 100,000 |

Both investments have payback periods of two years. If a manager uses the payback period to choose among competing investments, then the two investments would be equally desirable. In reality, however, the Autocon system should be preferred over the Maticmuv system for two reasons. First, the Autocon system provides a much larger dollar return for the years beyond the payback period ($600,000 versus $300,000). Second, the Autocon system returns $360,000 in the first year, while Maticmuv returns only $160,000. The extra $200,000 that the Autocon system provides in the first year could be put to productive use, such as investing it in another project. It is better to have a dollar now than a dollar one year from now because the dollar on hand can be invested to provide a return one year from now.

In summary, the payback period provides managers with information that can be used as follows:

1. To help control the risks associated with the uncertainty of future cash flows.
2. To help minimize the impact of an investment on a firm's liquidity problems.
3. To help control the risk of obsolescence.
4. To help control the effect of the investment on performance measures.

However, the method suffers significant deficiencies: it ignores a project's total profitability and the time value of money. While the computation of the payback period may be useful to a manager, to rely on it solely for a capital investment decision would be foolish.

## Accounting Rate of Return

The **accounting rate of return (ARR)** is the second commonly used nondiscounting model. The accounting rate of return measures the return on a project in terms of income, as opposed to using a project's cash flow. It is computed by the following formula:

$$\text{Accounting rate of return} = \text{Average income}/\text{Original investment}$$

or

$$\text{Accounting rate of return} = \text{Average income}/\text{Average investment}$$

Income is not equivalent to cash flows because of accruals and deferrals used in its computation. The average income of a project is obtained by adding the income for each year of the project and then dividing this total by the number of years. Average income for a project can be approximated by subtracting average depreciation from average cash flow. Assuming that all revenues earned in a period are collected and that depreciation is the only noncash expense, the approximation is exact.

Investment can be defined as the original investment or as the average investment. Letting $I$ equal original investment, $S$ equal salvage value, and assuming that the investment is uniformly consumed, average investment is defined as follows:

$$\text{Average investment} = (I + S)/2$$

To illustrate the computation of the accounting rate of return, assume that an investment requires an initial outlay of \$300,000. The life of the investment is five years with the following cash flows: \$90,000, \$90,000, \$120,000, \$90,000, and \$150,000. Assume that the asset has no salvage value after the five years and that all revenues earned within a year are collected in that year. The total cash flow for the five years is \$540,000, making the average cash flow \$108,000 (\$540,000/5). Average depreciation is \$60,000 (\$300,000/5). The average income is the difference between these two figures: \$48,000 (\$108,000 − \$60,000). Using the average income and original investment, the accounting rate of return is 16 percent (\$48,000/\$300,000). If average investment were used instead of original investment, then the accounting rate of return would be 32 percent (\$48,000/\$150,000).

Unlike the payback period, the accounting rate of return does consider a project's profitability; like the payback period, it ignores the time value of money. Ignoring the time value of money is a critical deficiency and can lead a manager to choose investments that do not maximize profits. Unfortunately, incentive plans may actually encourage the use of the accounting rate of return. Bonuses to managers are often based on accounting income or return on assets. Thus, managers may have a personal interest in seeing that any new investment contributes significantly to income. A manager seeking to maximize personal income will select investments that return the highest income per dollar invested.

It is because the payback period and the accounting rate of return ignore the time value of money that they are referred to as *nondiscounting models.* Discounting models use **discounted cash flows**, which are future cash flows expressed in terms of their present value. The use of discounting models requires an understanding of the present value concepts. Present value concepts are reviewed in Appendix A at the end of this chapter. You should review these concepts and make sure that you understand them before studying capital investment discount models. Present value tables (Exhibits 20B-1 and 20B-2) are presented in Appendix B at the end of this chapter. These tables are referred to and used throughout the rest of the chapter.

OBJECTIVE 3

Calculate the net present value (NPV) for independent projects.

# The Net Present Value Method

*Net present value (NPV)* is one of two discounting models that explicitly consider the time value of money and, therefore, incorporate the concept of discounting cash inflows and outflows. The other discounting model is the *internal rate of return* (IRR). The net present value method will be discussed first; the internal rate of return method is discussed in the following section.

## The Meaning of NPV

**Net present value** is the difference in the present value of the cash inflows and outflows associated with a project:

$$\begin{aligned} NPV &= [\Sigma\ CF_t/(1 + i)^t] - I \\ &= [\Sigma\ (CF_t)(df_t)] - I \\ &= P - I \end{aligned} \tag{20.1}$$

where

$I$ = The present value of the project's cost (usually the initial outlay)
$CF_t$ = The cash inflow to be received in period $t$, with $t = 1, \ldots, n$
$i$ = The required rate of return
$n$ = The useful life of the project
$t$ = The time period
$P$ = The present value of the project's future cash inflows
$df_t$ = $1/(1 + i)^t$, the discount factor

Net present value measures the profitability of an investment. If the NPV is positive, it measures the increase in wealth. For a firm, this means that the size of a positive NPV measures the increase in the value of the firm resulting from an investment. To use the NPV method, a required rate of return must be defined. The **required rate of return** is the minimum acceptable rate of return. It is also referred to as the *discount rate* or the *hurdle rate* and should correspond to the *cost of capital* (but often does not as firms frequently choose discount rates greater than the cost of capital).

If the net present value is positive, it signals that (1) the initial investment has been recovered, (2) the required rate of return has been recovered, and (3) a return in excess of (1) and (2) has been received. Thus, if NPV is greater than zero, then the investment is profitable and therefore acceptable. It also conveys the message that the value of the firm should increase because more than the cost of capital is being earned. If NPV equals zero, then the decision maker will find acceptance or rejection of the investment equal. Finally, if NPV is less than zero, then the investment should be rejected. In this case, it is earning less than the required rate of return.

## Weighted Average Cost of Capital

The cost of capital is a blend of the costs of capital from *all* sources. It is a weighted average of the costs from the various sources, where the weight is defined by the *relative* amount from each source. Assume, for example, that a new firm has two sources of capital: (1) $500,000 from a loan with an after-tax cost of 8 percent and (2) $500,000 raised from issuing stock to shareholders that expect a return of 12 percent. In other words, each source contributes 50 percent ($500,000/$1,000,000) to the total capital raised. The relative weights, then, are 0.5 for the loan and 0.5 for the capital stock. The *weighted cost of capital* is computed as follows:

| *Source* | *Amount of Capital* | *Percentage Cost* | *Dollar Cost* |
|---|---|---|---|
| Loan | $ 500,000 | 8% | $ 40,000 |
| Stock | 500,000 | 12 | 60,000 |
| | $1,000,000 | 10* | $100,000 |

*The weighted average can be computed in two ways: as $100,000/$1,000,000 or as (0.5 × 0.08) + (0.5 × 0.12).

## An Example Illustrating Weighted Average Cost of Capital

Polson Company has developed new cell phones that are less costly to produce than those of competitors. The marketing manager is excited about the new product's prospects after completing a detailed market study that revealed expected annual revenues of $750,000. The cell phone has a projected product life cycle of five years. Equipment to produce the cell phone would cost $800,000. After five years, that equipment can be sold for $100,000. In addition to the equipment expenditure, working capital is expected to increase by $100,000 because of increases in inventories and receivables. The firm expects to recover the investment in working capital at the end of the project's life. Annual cash operating expenses are estimated at $450,000. Assuming that the required rate of return is 12 percent, should the company manufacture the new cell phone?

To answer the question, two steps must be taken: (1) the cash flow for each year must be identified, and (2) the NPV must be computed using the cash flow from step 1. The solution to the problem is given in Exhibit 20-2 on the following page. Notice that step 2 offers two approaches for computing NPV. Step 2A computes NPV by using discount factors from Exhibit 20B-1. Step 2B simplifies the computation by using a single discount factor from Exhibit 20B-2 for the even cash flow occurring in Years 1–4. Polson should manufacture the cell phone because the NPV is greater than zero.

OBJECTIVE 4

Compute the internal rate of return (IRR) for independent projects.

# Internal Rate of Return

The **internal rate of return (IRR)** is defined as the interest rate that sets the present value of a project's cash inflows equal to the present value of the project's cost. In other words, it is the interest rate that sets the project's NPV at zero. The following equation can be used to determine a project's IRR:

$$I = \Sigma\ CF_t/(1 + i)^t \qquad (20.2)$$

where

$$t = 1, \ldots, n$$

The right-hand side of Equation 20.2 is the present value of future cash flows, and the left-hand side is the investment. $I$, $CF_t$, and $t$ are known. Thus, the IRR (the interest rate, $i$, in the equation) can be found using trial and error. Once the IRR for a project is computed, it is compared with the firm's required rate of return. If the IRR is greater than the required rate, the project is deemed acceptable; if the IRR is equal to the required rate of return, acceptance or rejection of the investment is equal; and if the IRR is less than the required rate of return, the project is rejected.

The internal rate of return is the most widely used of the capital investment techniques. One reason for its popularity may be that it is a rate of return, a concept that managers are comfortable in using. Another possibility is that managers may believe (in most cases, incorrectly) that the IRR is the true or actual compounded rate of return being earned by the initial investment. Whatever the reasons for its popularity, a basic understanding of the IRR is necessary.

## Example with Uniform Cash Flows

To illustrate the computation of the IRR with even cash flows, assume that an engineering firm has the opportunity to invest $240,000 in a new computer-aided design system that will produce net cash inflows of $99,900 at the end of each year for the next three years. The IRR is the interest rate that equates the present value of the three equal receipts of $99,900 to the investment of $240,000. Since the series of cash flows is uniform, a single discount factor from Exhibit 20B-2 can be used to compute the

**EXHIBIT 20-2 Cash Flow and NPV Analysis**

**Step 1. Cash Flow Identification**

| Year | Item | Cash Flow |
|---|---|---|
| 0 | Equipment | $(800,000) |
| | Working capital | (100,000) |
| | Total | $(900,000) |
| 1–4 | Revenues | $ 750,000 |
| | Operating expenses | (450,000) |
| | Total | $ 300,000 |
| 5 | Revenues | $ 750,000 |
| | Operating expenses | (450,000) |
| | Salvage | 100,000 |
| | Recovery of working capital | 100,000 |
| | Total | $ 500,000 |

**Step 2A. NPV Analysis**

| Year | Cash Flow[a] | Discount Factor[b] | Present Value |
|---|---|---|---|
| 0 | $(900,000) | 1.000 | $(900,000) |
| 1 | 300,000 | 0.893 | 267,900 |
| 2 | 300,000 | 0.797 | 239,100 |
| 3 | 300,000 | 0.712 | 213,600 |
| 4 | 300,000 | 0.636 | 190,800 |
| 5 | 500,000 | 0.567 | 283,500 |
| Net present value | | | $ 294,900 |

**Step 2B. NPV Analysis**

| Year | Cash Flow | Discount Factor | Present Value |
|---|---|---|---|
| 0 | $(900,000) | 1.000 | $(900,000) |
| 1–4 | 300,000 | 3.037 | 911,100 |
| 5 | 500,000 | 0.567 | 283,500 |
| Net present value | | | $ 294,600[c] |

[a]From step 1.
[b]From Exhibit 20B-1.
[c]Differs from computation in step 2A because of rounding.

present value of the annuity. Letting *df* be this discount factor and *CF* be the annual cash flow, Equation 20.2 assumes the following form:

$$I = CF(df)$$

Solving for *df*, we obtain:

$$\begin{aligned} df &= I/CF \\ &= \text{Investment/Annual cash flow} \end{aligned}$$

Once the discount factor is computed, go to Exhibit 20B-2, find the row corresponding to the life of the project, and move across that row until the computed discount factor is found. The interest rate corresponding to this discount factor is the IRR.

For example, the discount factor for the firm's investment is 2.402 ($240,000/$99,900). Since the life of the investment is three years, we must find the third row in Exhibit 20B-2 and move across this row until we encounter 2.402. The interest rate corresponding to 2.402 is 12 percent, which is the IRR.

Exhibit 20B-2 does not provide discount factors for every possible interest rate. To illustrate, assume that the annual cash inflows expected by the engineering firm are $102,000 instead of $99,900. The new discount factor is 2.353 ($240,000/$102,000). Going once again to the third row in Exhibit 20B-2, we find that the discount factor—and thus the IRR—lies between 12 and 14 percent. It is possible to approximate the IRR by interpolation; however, for our purposes, we will simply identify the range for the IRR as indicated by the table values.

## IRR and Uneven Cash Flows

If the cash flows are not uniform, then Equation 20.2 must be used. For a multiple-period setting, Equation 20.2 can be solved by trial and error or by using a business calculator or a software package like Excel®. To illustrate solution by trial and error, assume that a $50,000 investment in an inventory management system produces labor savings of $30,000 and $36,000 for each of two years. The IRR is the interest rate that sets the present value of these two cash inflows equal to $50,000:

$$P = [\$30{,}000/(1 + i)] + [\$36{,}000/(1 + i)^2] \\ = \$50{,}000$$

To solve the above equation by trial and error, start by selecting a possible value for $i$. Given this first guess, the present value of the future cash flows is computed and then compared to the initial investment. If the present value is greater than the initial investment, the interest rate is too low; if the present value is less than the initial investment, the interest rate is too high. The next guess is adjusted accordingly.

Assume the first guess is 18 percent. Using $i$ equal to 0.18, Exhibit 20B-1 yields the following discount factors: 0.847 and 0.718. These discount factors produce the following present value for the two cash inflows:

$$P = (0.847 \times \$30{,}000) + (0.718 \times \$36{,}000) \\ = \$51{,}258$$

Since $P$ is greater than $50,000, the interest rate selected is too low. A higher guess is needed. If the next guess is 20 percent, we obtain the following:

$$P = (0.833 \times \$30{,}000) + (0.694 \times \$36{,}000) \\ = \$49{,}974$$

Since this value is reasonably close to $50,000, we can say that the IRR is 20 percent. (The IRR is, in fact, exactly 20 percent; the present value is slightly less than the investment due to rounding of the discount factors found in Exhibit 20B-1.)

OBJECTIVE 5

Tell why NPV is better than IRR for choosing among mutually exclusive projects.

# NPV versus IRR: Mutually Exclusive Projects

Up to this point, we have focused on independent projects. Many capital investment decisions deal with mutually exclusive projects. How NPV analysis and IRR are used to choose among competing projects is an intriguing question. An even more interesting question to consider is whether NPV and IRR differ in their ability to help managers make wealth-maximizing decisions in the presence of competing alternatives. For example, we already know that the nondiscounting models can produce erroneous choices because they ignore the time value of money. Because of this deficiency, the discounting models are judged to be superior. Similarly, it can be shown that the NPV model is generally preferred to the IRR model when choosing among mutually exclusive alternatives.

## NPV Compared with IRR

NPV and IRR both yield the same decision for independent projects. For example, if the NPV is greater than zero, then the IRR is also greater than the required rate of return; both models signal the correct decision. However, for competing projects, the two methods can produce different results. Intuitively, we believe that, for mutually exclusive projects, the project with the highest NPV or the highest IRR should be chosen. Since it is possible for the two methods to produce different rankings of mutually exclusive projects, the method that consistently reveals the wealth-maximizing project should be preferred. As will be shown, the NPV method is that model.

NPV differs from IRR in two major ways. First, NPV assumes that each cash inflow received is reinvested at the required rate of return, whereas the IRR method assumes that each cash inflow is reinvested at the computed IRR. Second, the NPV method measures profitability in absolute terms, whereas the IRR method measures it in relative terms. Because NPV is measured in absolute terms, it is affected by the size of the investment, whereas IRR is size independent. For example, an investment of $100,000 that produces a cash flow one year from now of $121,000 has the same IRR (21 percent) as an investment of $10,000 that produces a cash flow one year from now of $12,100. Note, however, that the NPV is $10,000 for the first investment and $1,000 for the second. Since absolute measures often produce different rankings than relative measures, it shouldn't be too surprising that NPV and IRR can, on occasion, produce different signals regarding the attractiveness of projects. When a conflict does occur between the two methods, NPV produces the correct signal, as can be shown by a simple example.

Assume that a manager is faced with the prospect of choosing between two mutually exclusive investments whose cash flows, timing, NPV, and IRR are given in Exhibit 20-3. (A required rate of return of 8 percent is assumed for NPV computation.) Both projects have the same life, require the same initial outlay, have positive NPVs, and have IRRs greater than the required rate of return. However, Project A has a higher NPV, whereas Project B has a higher IRR. The NPV and IRR give conflicting signals regarding which project should be chosen.

**EXHIBIT 20-3 NPV and IRR: Conflicting Signals**

| Year | Project A | Project B |
|---|---|---|
| 0 | $(1,000,000) | $(1,000,000) |
| 1 | — | 686,342 |
| 2 | 1,440,000 | 686,342 |
| IRR | 20% | 24% |
| NPV | $234,080 | $223,748 |

The preferred project can be identified by modifying the cash flows of one project so that the cash flows of both can be compared year by year. The modification, which appears in Exhibit 20-4, was achieved by carrying the Year 1 cash flow of Project B forward to Year 2. This can be done by assuming that the Year 1 cash flow of $686,342 is invested to earn the required rate of return. Under this assumption, the future value

**EXHIBIT 20-4 Modified Comparison of Projects A and B**

| | Projects | |
|---|---|---|
| **Year** | **A** | **Modified B** |
| 0 | $(1,000,000) | $(1,000,000) |
| 1 | — | — |
| 2 | 1,440,000 | 1,427,591* |

*1.08($686,342) + $686,342.

of $686,342 is equal to $741,249 (1.08 × $686,342). When $741,249 is added to the $686,342 received at the end of Year 2, the cash flow expected for Project B is $1,427,591.

As can be seen from Exhibit 20-4, Project A is preferable to Project B. It has the same outlay initially and a greater cash inflow in Year 2. (The difference is $12,409.) Since the NPV approach originally chose Project A over Project B, it provided the correct signal for wealth maximization.

Some may object to this analysis, arguing that Project B should be preferred, since it does provide a cash inflow of $686,342 at the end of Year 1, which can be reinvested at a much more attractive rate than the firm's required rate of return. The response is that if such an investment does exist, the firm should still invest in Project A, borrow $686,342 at the cost of capital, and invest that money in the attractive opportunity. Then, at the end of Year 2, the firm should repay the money borrowed plus the interest by using the combined proceeds of Project A and the other investment. For example, assume that the other investment promises a return of 20 percent. The modified cash inflows for Projects A and B are shown in Exhibit 20-5 (assuming that the additional investment at the end of Year 1 is made under either alternative). Notice that Project A is still preferable to Project B—and by the same $12,409.

**EXHIBIT 20-5 Modified Cash Flows with Additional Opportunity**

| | Projects | |
|---|---|---|
| **Year** | **A** | **Modified B** |
| 0 | $(1,000,000) | $(1,000,000) |
| 1 | — | — |
| 2 | 1,522,361[a] | 1,509,952[b] |

[a]$1,440,000 + [(1.20 × $686,342) − (1.08 × $686,342)]. This last term is what is needed to repay the capital and its cost at the end of Year 2.
[b]$686,342 + (1.20 × $686,342).

NPV provides the correct signal for choosing among mutually exclusive investments. At the same time, it measures the impact competing projects have on the value of the firm. Choosing the project with the largest NPV is consistent with maximizing the wealth of shareholders. On the other hand, IRR does not consistently result in choices that maximize wealth. IRR, as a *relative* measure of profitability, has the virtue of measuring accurately the rate of return of funds that remain internally invested. However, maximizing IRR will not necessarily maximize the wealth of firm owners because it cannot, by nature, consider the absolute dollar contributions of projects. In the final analysis, what counts are the total dollars earned—the absolute profits—not the relative profits. Accordingly, NPV, not IRR, should be used for choosing among competing, mutually exclusive projects, or competing projects when capital funds are limited.

An independent project is acceptable if its NPV is positive. For mutually exclusive projects, the project with the largest NPV is chosen. Selecting the best project from several competing projects involves three steps: (1) assessing the cash flow pattern for each project, (2) computing the NPV for each project, and (3) identifying the project with the greatest NPV. To illustrate NPV analysis for competing projects, an example is provided.

## Example: Mutually Exclusive Projects

Milagro Travel Agency is setting up an office in Milwaukee and is trying to select a computer system. Two different systems are being considered: the Standard T2 System and the Custom Travel System. (The systems are offered by competitors and include equipment and software.) The Custom Travel System is more elaborate than the Standard T2 System and requires a larger investment and greater annual operating costs; however, it will also generate greater annual revenues. The projected annual revenues, annual costs, capital outlays, and project life for each system (in after-tax cash flows) are as follows:

| | *Standard T2* | *Custom Travel* |
|---|---|---|
| Annual revenues | $240,000 | $300,000 |
| Annual operating costs | 120,000 | 160,000 |
| System investment | 360,000 | 420,000 |
| Project life | 5 years | 5 years |

Assume that the cost of capital for the company is 12 percent.

The Standard T2 System requires an initial outlay of $360,000 and has a net annual cash inflow of $120,000 (revenues of $240,000 minus costs of $120,000). The Custom Travel System, with an initial outlay of $420,000, has a net annual cash inflow of $140,000 ($300,000 − $160,000). With this information, the cash flow pattern for each project can be described and the NPV and IRR computed. These are shown in Exhibit 20-6. Based on NPV analysis, the Custom Travel System is more profitable; it has the larger NPV. Accordingly, the company should select the Custom Travel System.

Interestingly, both systems have identical internal rates of return. As Exhibit 20-6 illustrates, both systems have a discount factor of 3.0. From Exhibit 20B-2, it is easily seen that a discount factor of 3.0 and a life of five years yields an IRR of approximately 20 percent. Although both projects have an IRR of 20 percent, the firm should not consider the two systems equally desirable. The analysis above has just shown that the Custom Travel System produces a larger NPV and therefore will increase the value of the firm more than the Standard T2 System. The Custom Travel System should be chosen.

# Computing After-Tax Cash Flows

OBJECTIVE 6

Convert gross cash flows to after-tax cash flows.

Determining the cash flow pattern for each project being considered is a critical step in capital investment analysis. In fact, the computation of cash flows may be the most critical step in the capital investment process. Erroneous estimates may result in erroneous decisions, regardless of the sophistication of the decision models being used. Two steps are needed to compute cash flows: (1) forecasting revenues, expenses, and capital outlays and (2) adjusting these gross cash flows for inflation and tax effects. Of the two steps, the more challenging is the first. Forecasting cash flows is technically demand-

**EXHIBIT 20-6 Cash Flow Pattern, NPV and IRR Analysis: Standard T2 versus Custom Travel**

**Cash Flow Pattern**

| Year | Standard T2 | Custom Travel |
|---|---|---|
| 0 | $(360,000) | $(420,000) |
| 1 | 120,000 | 140,000 |
| 2 | 120,000 | 140,000 |
| 3 | 120,000 | 140,000 |
| 4 | 120,000 | 140,000 |
| 5 | 120,000 | 140,000 |

**Standard T2: NPV Analysis**

| Year | Cash Flow | Discount Factor[a] | Present Value |
|---|---|---|---|
| 0 | $(360,000) | 1.000 | $(360,000) |
| 1–5 | 120,000 | 3.605 | 432,600 |
| Net present value | | | $ 72,600 |
| IRR | | | ≈20% |

IRR Analysis[b]

Discount factor = Initial investment/Annual cash flow
= $360,000/$120,000
= 3.0

**Custom Travel System: NPV Analysis**

| Year | Cash Flow | Discount Factor[a] | Present Value |
|---|---|---|---|
| 0 | $(420,000) | 1.000 | $(420,000) |
| 1–5 | 140,000 | 3.605 | 504,700 |
| Net present value | | | $ 84,700 |
| IRR | | | ≈20% |

IRR Analysis[b]

Discount factor = Initial investment/Annual cash flow
= $420,000/$140,000
= 3.0

[a]From Exhibit 20B-2.
[b]From Exhibit 20B-2, *df* = 3.0 implies that IRR ≈20%.

ing, and its methodology is typically studied in management science and statistics courses. It is important to understand that estimating future cash flows involves considerable judgment on the part of managers. Once gross cash flows are estimated, they should be adjusted for significant inflationary effects. Finally, straightforward applications of tax law can then be used to compute the after-tax cash flows. At this level of study, we assume that gross cash forecasts are available and focus on adjusting forecasted cash flows to improve their accuracy and utility in capital expenditure analysis.

## Inflationary Adjustments

In the United States, inflation has been relatively modest, and the need to adjust cash flows may not be as critical. For firms that operate in the international environment, however, the effect on capital investment decisions can be dramatic because inflation can be very high in certain countries. Many Latin American countries like Peru and Venezuela, for example, have experienced double-digit inflation rates for years. Thus, it is important to know how to adjust the capital budgeting models for inflationary effects—particularly given the fact that many U.S. firms make capital investment decisions within many different national environments.

In an inflationary environment, financial markets react by increasing the cost of capital to reflect inflation. Thus, the cost of capital is composed of two elements:

1. The real rate
2. The inflationary element (Investors demand a premium to compensate for the loss in general purchasing power of the dollar or local currency.)

Since the required rate of return (which should be the cost of capital) used in capital investment analysis reflects an inflationary component at the time NPV analysis is performed, inflation must also be considered in predicting the operating cash flows. If the operating cash flows are not adjusted to account for inflation, an erroneous decision may result. In adjusting predicted cash flows, specific price change indexes should be used if possible. If that is not possible, a general price index can be used.

Note, however, that the cash inflows due to the tax effects of depreciation need *not* be adjusted for inflation as long as the national tax law requires that depreciation be based on the *original* dollar investment. In this case, depreciation deductions should not be increased for inflation.

To illustrate, assume that a subsidiary of a U.S. firm operating in Venezuela is considering a project that requires an investment of 10,000,000 bolivares and is expected to produce annual cash inflows of 5,800,000 bolivares for the coming two years. The required rate of return is 20 percent, which includes an inflationary component. The general inflation rate in Venezuela is expected to average 15 percent for the next two years. Net present value analysis with and without the adjustment of predicted cash flows for inflation is given in Exhibit 20-7. (*Note:* All cash flows in Exhibit 20-7 are given in bolivares, expressed as "Bs".) As the analysis shows, *not* adjusting predicted cash flows for inflation leads to a decision to reject the project, whereas adjusting for inflation leads to a decision to accept it. Thus, failure to adjust the predicted cash flows for inflationary effects can lead to an incorrect conclusion.

## Conversion of Gross Cash Flows to After-Tax Cash Flows

Assuming that inflation-adjusted gross cash flows are predicted with the desired degree of accuracy, the analyst must adjust these cash flows for taxes. To analyze tax effects, cash flows are usually broken into three categories: (1) the initial cash outflows needed to acquire the assets of the project, (2) the cash flows produced over the life of the project (operating cash flows), and (3) the cash flows from the final disposal of the project. Cash outflows and cash inflows adjusted for tax effects are called *net* cash outflows and inflows. Net cash flows include provisions for revenues, operating expenses, depreciation, and relevant tax implications. They are the proper inputs for capital investment decisions.

### After-Tax Cash Flows: Year 0

The net cash outflow in Year 0 (the initial out-of-pocket outlay) is simply the difference between the initial cost of the project and any cash inflows directly associated with

**EXHIBIT 20-7 The Effects of Inflation on Capital Investment**

**Without Inflationary Adjustment**

| Year | Cash Flow | Discount Factor[a] | Present Value |
|---|---|---|---|
| 0 | Bs(10,000,000) | 1.000 | Bs(10,000,000) |
| 1–2 | 5,800,000 | 1.528 | 8,862,400 |
| NPV | | | Bs (1,137,600) |

**With Inflationary Adjustment**

| Year | Cash Flow[b] | Discount Factor[c] | Present Value |
|---|---|---|---|
| 0 | Bs(10,000,000) | 1.000 | Bs(10,000,000) |
| 1 | 6,670,000 | 0.833 | 5,556,110 |
| 2 | 7,670,500 | 0.694 | 5,323,327 |
| NPV | | | Bs 879,437 |

[a]From Exhibit 20B-2.
[b]6,670,000 bolivares = 1.15 × 5,800,000 bolivares (adjustment for one year of inflation)
7,670,500 bolivares = 1.15 × 1.15 × 5,800,000 bolivares (adjustment for two years of inflation).
[c]From Exhibit 20B-1.

it. The gross cost of the project includes such things as the cost of land, the cost of equipment (including transportation and installation), taxes on gains from the sale of assets, and increases in working capital. Cash inflows occurring at the time of acquisition include tax savings from the sale of assets, cash from the sale of assets, and other tax benefits such as tax credits.

Under current tax law, all costs relating to the acquisition of assets other than land must be capitalized and written off over the useful life of the assets. (The write-off is achieved through depreciation.) Depreciation is deducted from revenues in computing taxable income during each year of the asset's life; however, at the point of acquisition, no depreciation expense is computed. Thus, depreciation is not relevant at Year 0. The principal tax implications at the point of acquisition are related to recognition of gains and losses on the sale of existing assets and to the recognition of any investment tax credits.

Gains on the sale of assets produce additional taxes and, accordingly, reduce the cash proceeds received from the sale of old assets. Losses, on the other hand, are non-cash expenses that reduce taxable income, producing tax savings. Consequently, the cash proceeds from the sale of an old asset are increased by the amount of the tax savings.

Adjusting cash inflows and outflows for tax effects requires knowledge of current corporate tax rates. Currently, most corporations face a federal tax rate of 35 percent. State corporate tax rates vary by state. For purposes of analysis, we will assume that 40 percent is the combined rate for state and federal taxes.

Let us look at an example. Currently, Lewis Company uses two types of manufacturing equipment (M1 and M2) to produce one of its products. It is now possible to replace these two machines with a flexible manufacturing system. Management wants to know the net investment needed to acquire the flexible system. If the system is acquired, the old equipment will be sold.

*Disposition of Old Machines*

| | *Book Value* | *Sale Price* |
|---|---|---|
| M1 | $ 600,000 | $ 780,000 |
| M2 | 1,500,000 | 1,200,000 |

*Acquisition of Flexible System*

| | |
|---|---|
| Purchase cost | $7,500,000 |
| Freight | 60,000 |
| Installation | 600,000 |
| Additional working capital | 540,000 |
| Total | $8,700,000 |

The net investment can be determined by computing the net proceeds from the sale of the old machines and subtracting those proceeds from the cost of the new system. The net proceeds are determined by computing the tax consequences of the sale and adjusting the gross receipts accordingly.

The tax consequences can be assessed by subtracting the book value from the selling price. If the difference is positive, the firm has experienced a gain and will owe taxes. Money received from the sale will be reduced by the amount of taxes owed. On the other hand, if the difference is negative, a loss is experienced—a noncash loss. However, this noncash loss does have cash implications. It can be deducted from revenues and, as a consequence, can shield revenues from being taxed; accordingly, taxes will be saved. Thus, a loss produces a cash inflow equal to the taxes saved.

To illustrate, consider the tax effects of selling M1 and M2 as illustrated in Exhibit 20-8.

**EXHIBIT 20-8 Tax Effects of the Sale of M1 and M2**

| Asset | Gain(Loss) |
|---|---|
| M1[a] | $ 180,000 |
| M2[b] | (300,000) |
| Net gain (loss) | $(120,000) |
| Tax rate | × 0.40 |
| Tax savings | $ 48,000 |

[a]Sale price minus book value is $780,000 − $600,000.
[b]Sale price minus book value is $1,200,000 − $1,500,000.

By selling the two machines, the company receives the following net proceeds:

| | |
|---|---|
| Sale price, M1 | $ 780,000 |
| Sale price, M2 | 1,200,000 |
| Tax savings | 48,000 |
| Net proceeds | $2,028,000 |

Given these net proceeds, the net investment can be computed as follows:

| | |
|---|---|
| Total cost of flexible system | $8,700,000 |
| Less: Net proceeds of old machines | 2,028,000 |
| Net investment (cash outflow) | $6,672,000 |

## After-Tax Operating Cash Flows: Life of the Project

In addition to determining the initial out-of-pocket outlay, managers must also estimate the annual after-tax operating cash flows expected over the life of the project. If the project generates revenue, the principal source of cash flows is from operations. Operating cash inflows can be assessed from the project's income statement. The annual after-tax cash flows are the sum of the project's after-tax profits and its noncash expenses. In terms of a simple formula, this computation can be represented as follows:

$$\text{After-tax cash flow} = \text{After-tax net income} + \text{Noncash expenses}$$
$$CF = NI + NC$$

The most prominent examples of noncash expenses are depreciation and losses. At first glance, it may seem odd that after-tax cash flows are computed using noncash expenses. Noncash expenses are not cash flows, but they do generate cash flows by reducing taxes. By shielding revenues from taxation, actual cash savings are created. The use of the income statement to determine after-tax cash flows is illustrated in the following example. The example is also used to show how noncash expenses can increase cash inflows by saving taxes.

Assume that a company plans to make a new product that requires new equipment costing $1,600,000. The new product is expected to increase the firm's annual revenues by $1,200,000. Materials, labor, and other cash operating expenses will be $500,000 per year. The equipment has a life of four years and will be depreciated on a straight-line basis. The machine is not expected to have any salvage value at the end of four years. The income statement for the project is as follows:

| | |
|---|---|
| Revenues | $1,200,000 |
| Less: Cash operating expenses | (500,000) |
| Depreciation | (400,000) |
| Income before income taxes | $ 300,000 |
| Less: Income taxes (@ 40%) | 120,000 |
| Net income | $ 180,000 |

Cash flow from the income statement is computed as follows:

$$\begin{aligned} CF &= NI + NC \\ &= \$180{,}000 + \$400{,}000 \\ &= \$580{,}000 \end{aligned}$$

The income approach to determine operating cash flows can be decomposed to assess the after-tax, cash flow effects of each individual category on the income statement. The decomposition approach calculates the operating cash flows by computing the after-tax cash flows for each item of the income statement as follows:

$$CF = [(1 - \text{Tax rate}) \times \text{Revenues}] - [(1 - \text{Tax rate}) \times \text{Cash expenses}] + (\text{Tax rate} \times \text{Noncash expenses})$$

The first term, $[(1 - \text{Tax rate}) \times \text{Revenues}]$, gives the after-tax cash inflows from cash revenues. For our example, the cash revenue is projected to be $1,200,000. The firm, therefore, can expect to keep $720,000 of the revenues received: $(1 - \text{Tax rate}) \times \text{Revenues} = 0.60 \times \$1{,}200{,}000 = \$720{,}000$. The after-tax revenue is the actual amount of after-tax cash available from the sales activity of the firm.

The second term, [(1 − Tax rate) × Cash expenses], is the after-tax cash outflows from cash operating expenses. Because cash expenses can be deducted from revenues to arrive at taxable income, the effect is to shield revenues from taxation. The consequence of this shielding is to save taxes and to reduce the actual cash outflow associated with a given expenditure. In our example, the firm has cash operating expenses of $500,000. The actual cash outflow is not $500,000 but $300,000 (0.60 × $500,000). The cash outlay for operating expenses is reduced by $200,000 because of tax savings. To see this, assume that operating expense is the only expense and that the firm has revenues of $1,200,000. If operating expense is *not* tax deductible, then the tax owed is $480,000 (0.40 × $1,200,000). If the operating expense is deductible for tax purposes, then the taxable income is $700,000 ($1,200,000 − $500,000), and the tax owed is $280,000 (0.40 × $700,000). Because the deductibility of operating expense saves $200,000 in taxes, the actual outlay for that expenditure is reduced by $200,000.

The third term, (Tax rate × Noncash expenses), is the cash inflow from the tax savings produced by the noncash expenses. Noncash expenses, such as depreciation, also shield revenues from taxation. The depreciation *shields* $400,000 of revenues from being taxed and, thus, saves $160,000 (0.40 × $400,000) in taxes.

The sum of the three items is as follows:

| | |
|---|---|
| After-tax revenues | $ 720,000 |
| After-tax cash expenses | (300,000) |
| Depreciation tax shield | 160,000 |
| Operating cash flow | $ 580,000 |

The decomposition approach yields the same outcome as the income approach. For convenience, the three decomposition terms are summarized in Exhibit 20-9.

**EXHIBIT 20-9 Computation of Operating Cash Flows: Decomposition Terms**

After-tax cash revenues (cash inflow) = (1 − Tax rate) × Revenues
After-tax cash expenses (cash outflow) = (1 − Tax rate) × Cash expenses
Tax savings, noncash expenses (cash inflow) = Tax rate × Noncash expenses

One feature of decomposition is the ability to compute after-tax cash flows in a spreadsheet format. This format highlights the cash flow effects of individual items and facilitates the use of spreadsheet software packages. The spreadsheet format is achieved by creating four columns, one for each of the three cash flow categories and one for the total after-tax cash flow, which is the sum of the first three. This format is illustrated in Exhibit 20-10 for our example. Recall that cash revenues were $1,200,000 per year for four years, annual cash expenses were $500,000, and annual depreciation was $400,000.

A second feature of decomposition is the ability to compute the after-tax cash effects on an item-by-item basis. For example, suppose that a firm is considering a project and is uncertain as to which method of depreciation should be used. By computing the tax savings produced under each depreciation method, a firm can quickly assess which method is most desirable.

For tax purposes, all depreciable business assets other than real estate are referred to as *personal property*, which is classified into one of six classes. Each class specifies the life of the assets that must be used for figuring depreciation. This life must be used even if the actual expected life is different from the class life; the class lives are set for

**EXHIBIT 20-10 Illustration of the Spreadsheet Format**

| Year | $(1 - t)R$[a] | $-(1 - t)C$[b] | $tNC$[c] | $CF$ |
|---|---|---|---|---|
| 1 | $720,000 | $(300,000) | $160,000 | $580,000 |
| 2 | 720,000 | (300,000) | 160,000 | 580,000 |
| 3 | 720,000 | (300,000) | 160,000 | 580,000 |
| 4 | 720,000 | (300,000) | 160,000 | 580,000 |

[a]$R$ = Revenues; $t$ = tax rate; $(1 - t)R = (1 - 0.40)\$1,200,000 = \$720,000$.
[b]$C$ = Cash expenses; $-(1 - t)C = -(1 - 0.40)\$500,000 = (\$300,000)$.
[c]$NC$ = Noncash expenses; $tNC = 0.40(\$400,000) = \$160,000$.

purposes of recognizing depreciation and usually will be shorter than the actual life. Most equipment, machinery, and office furniture are classified as **7-year assets**. Light trucks, automobiles, and computer equipment are classified as **5-year assets**. Most small tools are classified as **3-year assets**. Because the majority of personal property can be put into one of these categories, we will restrict our attention to them.

The taxpayer can use either the straight-line method or the **modified accelerated cost recovery system (MACRS)** to compute annual depreciation. Current law defines MACRS as the double-declining-balance method.[2] In computing depreciation, no consideration of salvage value is required. However, under either method, a **half-year convention** applies.[3] This convention assumes that a newly acquired asset is in service for one-half of its first taxable year of service, regardless of the date that use of the asset actually began. When the asset reaches the end of its life, the other half year of depreciation can be claimed in the following year. If an asset is disposed of before the end of its class life, the half-year convention allows half the depreciation for that year.

For example, assume that an automobile is purchased on March 1, 2006. The automobile costs $30,000, and the firm elects the straight-line method. Automobiles are 5-year assets (for tax purposes). The annual depreciation is $6,000 for a 5-year period ($30,000/5). However, using the half-year convention, the firm can deduct only $3,000 for 2006, half of the straight-line amount (0.5 × $6,000). The remaining half is deducted in the sixth year (or the year of disposal, if earlier). Deductions are as follows:

| *Year* | *Depreciation Deduction* |
|---|---|
| 2006 | $3,000 (half-year amount) |
| 2007 | 6,000 |
| 2008 | 6,000 |
| 2009 | 6,000 |
| 2010 | 6,000 |
| 2011 | 3,000 (half-year amount) |

Assume that the asset is disposed of in April 2008. In this case, only $3,000 of depreciation can be claimed for 2008 (early disposal rule).

If the double-declining-balance method is selected, the amount of depreciation claimed in the first year is twice that of the straight-line method. Under this method,

2. The tax law also allows the 150-percent-declining-balance method; however, we will focus only on the straight-line method and the double-declining version of MACRS.
3. The tax law requires a mid-quarter convention if more than 40 percent of personal property is placed in service during the last three months of the year. We will not illustrate this scenario.

the amount of depreciation claimed becomes progressively smaller until eventually it is exceeded by that claimed under the straight-line method. When this happens, the straight-line method is used to finish depreciating the asset. Exhibit 20-11 provides a table of depreciation rates for the double-declining-balance method for assets belonging to the 3-year, 5-year, and 7-year classes. The rates shown in this table incorporate the half-year convention and therefore are the MACRS depreciation rates.

**EXHIBIT 20-11 MACRS Depreciation Rates**

| Year | Three-Year Assets | Five-Year Assets | Seven-Year Assets |
|---|---|---|---|
| 1 | 33.33% | 20.00% | 14.29% |
| 2 | 44.45 | 32.00 | 24.49 |
| 3 | 14.81 | 19.20 | 17.49 |
| 4 | 7.41 | 11.52 | 12.49 |
| 5 | | 11.52 | 8.93 |
| 6 | | 5.76 | 8.92 |
| 7 | | — | 8.93 |
| 8 | | — | 4.46 |

Both the straight-line and double-declining-balance methods yield the same total amount of depreciation over the life of the asset. Both methods also produce the same total tax savings (assuming the same tax rate over the life of the asset). However, since the depreciation claimed in the early years of a project is greater using the double-declining-balance method, the tax savings are also greater during those years. Considering the time value of money, it is preferable to have the tax savings earlier than later. Thus, firms should prefer the MACRS method of depreciation to the straight-line method. This conclusion is illustrated by the following example.

A firm is considering the purchase of computer equipment for $60,000. The tax guidelines require that the cost of the equipment be depreciated over five years. However, tax guidelines also permit the depreciation to be computed using either the straight-line or double-declining-balance method. Of course, the firm should choose the double-declining-balance method because it brings the greater benefit.

From decomposition, we know that the cash inflows caused by shielding can be computed by multiplying the tax rate by the amount depreciated ($t \times NC$). The cash flows produced by each depreciation method and its present value, assuming a discount rate of 10 percent, are given in Exhibit 20-12. As you will see, the present value of the tax savings from using MACRS is greater than the present value realized using straight-line depreciation.

## After-Tax Cash Flows: Final Disposal

At the end of the life of the project, there are two major sources of cash: (1) release of working capital and (2) preparation, removal, and sale of the equipment (salvage value effects). Any working capital committed to a project is released at this point. The release of working capital is a cash inflow with no tax consequences. Thus, if $180,000 of additional working capital is needed at the beginning of a project, this $180,000 will be a cash inflow at the end of the project's life. Disposing of an asset associated with a project also has cash consequences. At times, an asset may have a market value at the end of its life. The selling price less the cost of removal and cleanup produces a gross cash inflow. For example, if an asset has a selling price of $120,000 and if its removal and cleanup costs are $30,000, then the gross cash inflow is $90,000. The tax

**EXHIBIT 20-12 Value of Accelerated Methods Illustrated**

**Straight-Line Method**

| Year | Depreciation | Tax Rate | Tax Savings | Discount Factor | Present Value |
|---|---|---|---|---|---|
| 1 | $ 6,000 | 0.40 | $2,400.00 | 0.909 | $ 2,181.60 |
| 2 | 12,000 | 0.40 | 4,800.00 | 0.826 | 3,964.80 |
| 3 | 12,000 | 0.40 | 4,800.00 | 0.751 | 3,604.80 |
| 4 | 12,000 | 0.40 | 4,800.00 | 0.683 | 3,278.40 |
| 5 | 12,000 | 0.40 | 4,800.00 | 0.621 | 2,980.80 |
| 6 | 6,000 | 0.40 | 2,400.00 | 0.564 | 1,353.60 |
| Net present value | | | | | $17,364.00 |

**MACRS Method**

| Year | Depreciation* | Tax Rate | Tax Savings | Discount Factor | Present Value |
|---|---|---|---|---|---|
| 1 | $12,000 | 0.40 | $4,800.00 | 0.909 | $ 4,363.20 |
| 2 | 19,200 | 0.40 | 7,680.00 | 0.826 | 6,343.68 |
| 3 | 11,520 | 0.40 | 4,608.00 | 0.751 | 3,460.61 |
| 4 | 6,912 | 0.40 | 2,764.80 | 0.683 | 1,888.36 |
| 5 | 6,912 | 0.40 | 2,764.80 | 0.621 | 1,716.94 |
| 6 | 3,456 | 0.40 | 1,382.40 | 0.564 | 779.67 |
| Net present value | | | | | $18,552.46 |

*Computed by multiplying the 5-year rates in Exhibit 20-11 by $60,000. For example, depreciation for Year 1 is 0.20 × $60,000.

effects of the transaction must also be assessed. If, for example, the book value of the asset is $15,000, then the firm must recognize a $75,000 *gain* on the sale of the asset ($90,000 − $15,000). If the tax rate is 40 percent, then the cash inflow from disposition is reduced by $30,000 ($75,000 × 0.40). Therefore, the expected cash inflow at the end of the project's life is $60,000 ($90,000 − $30,000).

OBJECTIVE 7

Describe capital investment for advanced technology and environmental impact settings.

## Capital Investment: Advanced Technology and Environmental Considerations

In today's manufacturing environment, long-term investments in advanced technology and in pollution prevention (P2) technology can be the sources of a significant competitive advantage. Investing in advanced manufacturing technology such as robotics and computer-integrated manufacturing can improve quality, increase flexibility and reliability, and decrease lead times. As a consequence, customer satisfaction will likely increase, which will then produce an increase in market share. Likewise, pollution prevention (P2) opportunities are now beginning to attract the attention of management. P2 takes a proactive approach that targets the causes of pollution rather than the consequences. It often calls for the redesign of complex products and processes and investment in new technologies. The potential for a competitive advantage stems from the possibility that a firm can eliminate the pollutants at their source and, thus, avoid the need for treating or disposing of these pollutants later on. This will then reduce environmental costs. The argument is that the reduction in environmental costs will produce positive net present values. **Irving Pulp and Paper**, a pulp mill, invested in technologies that resulted in the reuse and reduction of water and also reduced the amount of energy and materials used in the pulp making process. Its on-site surface water discharges were reduced by over 80 percent, preventing a number of chemicals from entering the aquatic ecosystem. The savings from investing in mill modernization and pollution prevention technologies are estimated to be $8 to $10 million per year.[4]

Although discounted cash flow analysis (using net present value and internal rate of return) remains preeminent in capital investment decisions involving advanced technology or P2 opportunities, more attention must be paid to the inputs used in discounted cash flow models. How investment is defined, how operating cash flows are estimated, how salvage value is treated, and how the discount rate is chosen are all different in nature from the traditional approach.[5]

## How Investment Differs

Investment in automated manufacturing processes is much more complex than investment in the standard manufacturing equipment of the past. For standard equipment, the direct costs of acquisition represent virtually the entire investment. For automated manufacturing, the direct costs can represent as little as 50 or 60 percent of the total investment; software, engineering, training, and implementation are a significant percentage of the total costs. Thus, great care must be exercised to assess the actual cost of an automated system. It is easy to overlook the peripheral costs, which can be substantial. For example, U.S. bankers and insurance companies have found that their substantial investment in computer technology is only now starting to pay off. The reason is that there were very large investments to be made in training. Until the companies had experience with the technology, they were unable to adequately use its power and improve productivity. Similar comments can be made about P2 investments. P2 investments may involve radical new technology, and indirect costs can be substantial as well.

## How Estimates of Operating Cash Flows Differ

Estimates of operating cash flows from investments in standard equipment have typically relied on directly identifiable tangible benefits, such as direct savings from labor, power, and scrap. Similarly, environmental investments in end-of-pipe emissions control have relied on the direct environmental cost savings, e.g., reductions in the costs of waste management and regulatory compliance. In reality, many environmental costs are hidden within other costs. Some are buried in overhead, e.g., the portion of maintenance cost attributable to maintaining equipment associated with end-of-pipe emissions control. **Quebecor Printing Mount Morris, Inc.**, found that a project to improve a wastewater treatment system was more cost effective when indirect environmental costs were fully considered.[6] On the other hand, **Monsanto**'s Fibers Division used direct labor savings as the main justification for automating its Pensacola, Florida, plant.[7]

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4. *Pollution Prevention Canadian Success Stories*, http://www.ec.gc.ca/pp/en/storyoutput.cfm?storyid=112, as of October 26, 2004.
5. See the following sources: Robert A. Howell and Stephen R. Soucy, "Capital Investment in the New Manufacturing Environment," *Management Accounting* (November 1987): 26–32; Callie Berliner and James A. Brimson, eds., *Cost Management for Today's Advanced Manufacturing* (Boston: Harvard Business School Press, 1988); Thomas Klammer, "Improving Investment Decisions," *Management Accounting* (July 1993): 35–43; David Sinason, "A Dynamic Model for Present Value Analysis," *Journal of Cost Management* (Spring 1991): 40–45; and James Boyd, "Searching for Profit in Pollution Prevention: Case Studies in the Corporate Evaluation of Environmental Opportunities," April 1998, EPA 742-R-98-005.
6. Tellus Institute, "Strengthening Corporate Commitment to Pollution Prevention in Illinois: Concepts & Case Studies of Total Cost Assessment," http://www.emawebsite.org/library_detail.asp?record=214, as of October 25, 2004.
7. Raymond C. Cole and H. Lee Hales, "How Monsanto Justified Automation," *Management Accounting* (January 1992): 39–43.

Intangible benefits and indirect savings were ignored as they often are in traditional capital investment analyses; however, the intangible and indirect benefits can be material and critical to the viability of the project. Greater quality, more reliability, reduced lead time, improved customer satisfaction, and an enhanced ability to maintain market share are all important intangible benefits of an advanced manufacturing system. Reduction of labor in support areas such as production scheduling and stores are indirect benefits. More effort is needed to measure these intangible and indirect benefits in order to assess more accurately the potential value of investments. Monsanto discovered, for example, that the new automated system in its Pensacola plant produced large savings in terms of reduced waste, lower inventories, increased quality, and reduced indirect labor. Productivity increased by 50 percent. What if the direct labor savings had not been sufficient to justify the investment? Consider the lost returns that Monsanto would have experienced by what could have been a faulty decision. Monsanto's experience also illustrates the importance of a *postaudit*. A **postaudit** is a follow-up analysis of a capital project once it is implemented. It compares the actual benefits and costs with the estimated benefits and costs. For Monsanto, the postaudit revealed the importance of intangible and indirect benefits. In future investment decisions, these factors are more likely to be considered.

## An Example: Investing in Advanced Technology

An example can be used to illustrate the importance of considering intangible and indirect benefits. Consider a company that is evaluating a potential investment in a flexible manufacturing system (FMS). The choice facing the company is to continue producing with its traditional equipment, expected to last 10 years, or to switch to the new system, which is also expected to have a useful life of 10 years. The company's discount rate is 12 percent. The data pertaining to the investment are presented in Exhibit 20-13 on the following page. Using these data, the net present value of the proposed system can be computed as follows:

| | |
|---|---|
| Present value ($4,000,000 × 5.65*) | $22,600,000 |
| Less: Investment | 18,000,000 |
| Net present value | $ 4,600,000 |

*Discount factor for an interest rate of 12 percent and a life of 10 years (see Exhibit 20B-2).

The net present value is positive and large in magnitude, and it clearly signals the acceptability of the FMS. This outcome is strongly dependent, however, on explicit recognition of both intangible and indirect benefits. If those benefits are eliminated, then the direct savings total $2.2 million, and the NPV is negative.

| | |
|---|---|
| Present value ($2,200,000 × 5.65) | $12,430,000 |
| Less: Investment | 18,000,000 |
| Net present value | $(5,570,000) |

The rise of activity-based costing has made identifying indirect benefits easier with the use of activity drivers. Once they are identified, they can be included in the analysis if they are material.

Examination of Exhibit 20-13 reveals the importance of intangible benefits. One of the most important intangible benefits is maintaining or improving a firm's competitive position. A key question that needs to be asked is what will happen to the cash flows of the firm if the investment is *not* made. That is, if the company chooses to forgo an investment in technologically advanced equipment, will it be able to continue to compete with other firms on the basis of quality, delivery, and cost? (The question becomes especially relevant if competitors choose to invest in advanced equipment.) If the competitive position deteriorates, the company's current cash flows will decrease.

**EXHIBIT 20-13 Investment Data: Direct, Intangible, and Indirect Benefits**

| | FMS | Status Quo |
|---|---|---|
| Investment (current outlay): | | |
| Direct costs | $10,000,000 | $ 0 |
| Software, engineering | 8,000,000 | — |
| Total current outlay | $18,000,000 | $ 0 |
| Net after-tax cash flow | $ 5,000,000 | $1,000,000 |
| Less: After-tax cash flow for status quo | 1,000,000 | n/a |
| Incremental benefit | $ 4,000,000 | n/a |

**Incremental Benefit Explained**

| | | |
|---|---|---|
| Direct benefits: | | |
| Direct labor | $1,500,000 | |
| Scrap reduction | 500,000 | |
| Setups | 200,000 | $2,200,000 |
| Intangible benefits: Quality savings | | |
| Rework | $ 200,000 | |
| Warranties | 400,000 | |
| Maintenance of competitive position | 1,000,000 | 1,600,000 |
| Indirect benefits: | | |
| Production scheduling | $ 110,000 | |
| Payroll | 90,000 | 200,000 |
| Total | | $4,000,000 |

If cash flows decrease if the investment is not made, this decrease should show up as an incremental benefit for the advanced technology. In Exhibit 20-13, the company estimates this competitive benefit as $1,000,000. Estimating this benefit requires some serious strategic planning and analysis, but its effect can be critical. If this benefit had been ignored or overlooked, then the net present value would have been negative, and the investment alternative rejected. This calculation is as follows:

| | |
|---|---|
| Present value ($3,000,000 × 5.65) | $16,950,000 |
| Less: Investment | 18,000,000 |
| Net present value | $ (1,050,000) |

## Salvage Value

Terminal or salvage value has often been ignored in investment decisions. The usual reason offered is the difficulty in estimating it. Because of this uncertainty, the effect of salvage value has often been ignored or heavily discounted. This approach may be unwise, however, because salvage value could make the difference between investing or not investing. Given the highly competitive environment, companies cannot afford to make incorrect decisions. A much better approach to deal with uncertainty is to use sensitivity analysis. **Sensitivity analysis** changes the assumptions on which the capital investment analysis relies and assesses the effect on the cash flow pattern. Sensitivity analysis is often referred to as **what-if analysis**. For example, this approach is used to address such questions as *what* is the effect on the decision to invest in a project *if* the cash receipts are 5 percent less than projected? 5 percent more? Although sensitivity analysis is computationally demanding if done manually, it can be done rapidly and easily using computers and software packages such as Lotus® and Excel®. In fact, these packages can also be used to carry out the NPV and IRR computations that have been illustrated manually throughout the chapter. They have built-in NPV and IRR functions that greatly facilitate the computational requirements.

To illustrate the potential effect of terminal value, assume that the after-tax annual operating cash flow of the project shown in Exhibit 20-13 is $3.1 million instead of $4 million. The net present value without salvage value is as follows:

| | |
|---|---|
| Present value ($3,100,000 × 5.65) | $17,515,000 |
| Less: Investment | 18,000,000 |
| Net present value | $ (485,000) |

Without the terminal value, the project would be rejected. The net present value with salvage value of $2 million, however, is a positive result, meaning that the investment should be made.

| | |
|---|---|
| Present value ($3,100,000 × 5.65) | $ 17,515,000 |
| Present value ($2,000,000 × 0.322*) | 644,000 |
| Less: Investment | (18,000,000) |
| Net present value | $ 159,000 |

*Discount factor, 12 percent and 10 years (Exhibit 20B-1).

But what if the salvage value is less than expected? Suppose that the worst possible outcome is a salvage value of $1,600,000? What is the effect on the decision? The NPV can be recomputed under this new scenario.

| | |
|---|---|
| Present value ($3,100,000 × 5.65) | $ 17,515,000 |
| Present value ($1,600,000 × 0.322) | 515,200 |
| Less: Investment | (18,000,000) |
| Net present value | $ 30,200 |

Thus, under a pessimistic scenario, the NPV is still positive. This illustrates how sensitivity analysis can be used to deal with the uncertainty surrounding salvage value. It can also be used for other cash flow variables.

## Discount Rates

Being overly conservative with discount rates can prove even more damaging. In theory, if future cash flows are known with certainty, the correct discount rate is a firm's cost of capital. In practice, future cash flows are uncertain, and managers often choose a discount rate higher than the cost of capital to deal with that uncertainty. If the rate chosen is excessively high, it will bias the selection process toward short-term investments.

To illustrate the effect of an excessive discount rate, consider the project in Exhibit 20-13 once again. Assume that the correct discount rate is 12 percent but that the firm uses 18 percent. The net present value using an 18 percent discount rate is calculated as follows:

| | |
|---|---|
| Present value ($4,000,000 × 4.494*) | $17,976,000 |
| Less: Investment | 18,000,000 |
| Net present value | $ (24,000) |

*Discount rate for 18 percent and 10 years (Exhibit 20B-2).

The project would be rejected. With a higher discount rate, the discount factor decreases in magnitude much more rapidly than the discount factor for a lower rate. (Compare the discount factor for 12 percent, 5.65, with the factor for 18 percent, 4.494.) The effect of a higher discount factor is to place more weight on earlier cash flows and less weight on later cash flows, which favors short-term over long-term investments. This outcome makes it more difficult for automated manufacturing systems to appear as viable projects, since the cash returns required to justify the investment are received over a longer period of time. The same problem exists with P2 projects.[8]

8. Michael Porter, for example, contends that firms use excessively high hurdle rates to evaluate environmental projects. See Michael E. Porter, "Green and Competitive: Ending the Stalemate," *Harvard Business Review* (September–October 1995): 120–134.

## SUMMARY

Capital investment decisions are concerned with the acquisition of long-term assets and usually involve a significant outlay of funds. The two types of capital investment projects are independent and mutually exclusive. Independent projects are projects that, if accepted or rejected, do not affect the cash flows of other projects. Mutually exclusive projects are those projects that, if accepted, preclude the acceptance of all other competing projects.

Managers make capital investment decisions by using formal models to decide whether to accept or reject proposed projects. These decision models are classified as nondiscounting or discounting, depending on whether they address the question of the time value of money. The two nondiscounting models are the payback period and the accounting rate of return.

The payback period is the time required for a firm to recover its initial investment. For even cash flows, it is calculated by dividing the investment by the annual cash flow. For uneven cash flows, the cash flows are summed until the investment is recovered. If only a fraction of a year is needed, the cash flow is estimated by assuming that the cash flows occur evenly within each year. The payback period ignores the time value of money and the profitability of projects because it does not consider the cash inflows available beyond the payback period. However, it does supply some useful information. The payback period is useful in assessing and controlling risk, minimizing the impact of an investment on a firm's liquidity, and controlling the risk of obsolescence.

The accounting rate of return is computed by dividing the average income expected from an investment by either the original or average investment. Unlike the payback period, it does consider the profitability of a project; however, it ignores the time value of money. The accounting rate of return may be useful to managers to screen new investments to ensure that certain accounting ratios are not adversely affected (specifically, accounting ratios that may be monitored to ensure compliance with debt covenants).

NPV is the difference between the present value of future cash flows and the initial investment outlay. To use the model, a required rate of return must be identified (usually, the cost of capital). The NPV method uses the required rate of return to compute the present value of a project's cash inflows and outflows. If the present value of the inflows is greater than the present value of the outflows, the net present value is greater than zero, and the project is profitable. If the NPV is less than zero, the project is not profitable and should be rejected.

The IRR is computed by finding the interest rate that equates the present value of a project's cash inflows with the present value of its cash outflows. If the IRR is greater than the required rate of return (cost of capital), the project is acceptable. If the IRR is less than the required rate of return, the project should be rejected.

In evaluating mutually exclusive or competing projects, managers have a choice of using NPV or IRR. When choosing among competing projects, the NPV model correctly identifies the best investment alternative. IRR, at times, may choose an inferior project. Thus, since NPV always provides the correct signal, it should be used.

Accurate and reliable cash flow forecasts are absolutely critical for capital budgeting analyses. Managers should assume responsibility for the accuracy of cash flow projections. All cash flows in a capital investment analysis should be after-tax cash flows. There are two different, but equivalent, ways to compute after-tax cash flows: the income method and the decomposition method. Although depreciation is not a cash flow, it does have cash flow implications because tax laws allow depreciation to be deducted in computing taxable income. Straight-line and double-declining-balance depreciation both produce the same total depreciation deductions over the life of the depreciated asset. Because the latter method accelerates depreciation, however, it would be preferred.

Capital investment in advanced technology and P2 projects is affected by the way in which inputs are determined. Much greater attention must be paid to the investment outlays because peripheral items can require substantial resources. Furthermore, in assessing benefits, intangible items such as product quality, environmental quality, and maintaining competitive position can be deciding factors. Choice of the required rate of return is also critical. The tendency of firms to use hurdle rates that are much greater than the cost of capital should be discontinued. Also, since the salvage value of an automated system can be considerable, it should be estimated and included in the analysis.

# Appendix A: Present Value Concepts

An important feature of money is that it can be invested and can earn interest. A dollar today is not the same as a dollar tomorrow. This fundamental principle is the backbone of discounting methods. Discounting methods rely on the relationships between current and future dollars. Thus, to use discounting methods, we must understand these relationships.

## Future Value

Suppose a bank advertises a 4 percent annual interest rate. If a customer invests \$100, he or she would receive, after one year, the original \$100 plus \$4 interest [\$100 + (0.04 ? \$100) = (1 + 0.04) × \$100 = 1.04 × \$100 = \$104]. This result can be expressed by the following equation, where $F$ is the future amount, $P$ is the initial or current outlay, and $i$ is the interest rate:

$$F = P(1 + i) \qquad (20A.1)$$

For the example, $F = \$100 \times (1 + 0.04) = \$100 \times 1.04 = \$104$.

Now suppose that the same bank offers a 5 percent rate if the customer leaves the original deposit, plus any interest, on deposit for a total of two years. How much will the customer receive at the end of two years? Again, assume that a customer invests \$100. Using Equation 20A.1, the customer will earn \$105 at the end of Year 1 [$F = \$100 \times (1 + 0.05) = \$100 \times 1.05 = \$105$]. If this amount is left in the account for a second year, Equation 20A.1 is used again with $P$ now assumed to be \$105. At the end of the second year, then, the total is \$110.25 [$F = \$105 \times (1 + 0.05) = \$105 \times 1.05 = \$110.25$]. In the second year, interest is earned on both the original deposit and the interest earned in the first year. The earning of interest on interest is referred to as **compounding of interest**. The value that will accumulate by the end of an investment's life, assuming a specified compound return, is the **future value**. The future value of the \$100 deposit in the second example is \$110.25.

A more direct way to compute the future value is possible. Since the first application of Equation 20A.1 can be expressed as $F = \$105 = \$100 \times 1.05$, the second application can be expressed as $F = \$105 \times 1.05 = \$100 \times 1.05 \times 1.05 = \$100(1.05)^2 = P(1 + i)^2$. This suggests the following formula for computing amounts for $n$ periods into the future:

$$F = P(1 + i)^n \qquad (20A.2)$$

# Present Value

Often, a manager needs to compute not the future value but the amount that must be invested *now* in order to earn some given future value. The amount that must be invested now to produce the future value is known as the **present value** of the future amount. For example, how much must be invested now in order to earn \$363 two years from now, assuming that the interest rate is 10 percent? Or, put another way, what is the present value of \$363 to be received two years from now?

In this example, the future value, the years, and the interest rate are all known; we want to know the current outlay that will produce that future amount. In Equation 20A.2, the variable representing the current outlay (the present value of $F$) is $P$. Thus, to compute the present value of a future outlay, all we need to do is solve Equation 20A.2 for $P$:

$$P = F/(1 + i)^n \qquad (20A.3)$$

Using Equation 20A.3, we can compute the present value of \$363:

$$\begin{aligned} P &= \$363/(1 + 0.1)^2 \\ &= \$363/1.21 \\ &= \$300 \end{aligned}$$

The present value, \$300, is what the future amount of \$363 is worth *today*. All other things being equal, having \$300 today is the same as having \$363 two years from now. Put another way, if a firm requires a 10 percent rate of return, the most the firm would be willing to pay today is \$300 for any investment that yields \$363 two years from now.

The process of computing the present value of future cash flows is often referred to as **discounting**; thus, we say that we have discounted the future value of \$363 to its present value of \$300. The interest rate used to discount the future cash flow is the **discount rate**.

The expression $1/(1 + i)^n$ in Equation 20A.3 is the **discount factor**. By letting the discount factor, called $df$, equal $1/(1 + i)^n$, Equation 20A.3 can be expressed as $P = F(df)$. To simplify the computation of present value, a table of discount factors is given for various combinations of $i$ and $n$ (see Exhibit 20B-1 in Appendix B). For example, the discount factor for $i$ = 10 percent and $n = 2$ is 0.826 (simply go to the 10 percent column of the table and move down to the second row). With the discount factor, the present value of \$363 is computed as follows:

$$\begin{aligned} P &= F(df) \\ &= \$363 \times 0.826 \\ &= \$300 \text{ (rounded)} \end{aligned}$$

# Present Value of an Uneven Series of Cash Flows

Exhibit 20B-1 can be used to compute the present value of any future cash flow or series of future cash flows. A series of future cash flows is called an **annuity**. The present value of an annuity is found by computing the present value of each future cash flow and then summing these values. For example, suppose that an investment is expected to produce the following annual cash flows: \$110, \$121, and \$133.10. Assuming a discount rate of 10 percent, the present value of this series of cash flows is computed in Exhibit 20A-1 on the following page.

## Present Value of a Uniform Series of Cash Flows

If the series of cash flows is even, the computation of the annuity's present value is simplified. Assume, for example, that an investment is expected to return $100 per year for three years. Using Exhibit 20B-1 and assuming a discount rate of 10 percent, the present value of the annuity is computed in Exhibit 20A-2 on the following page.

As with the uneven series of cash flows, the present value in Exhibit 20A-2 was computed by calculating the present value of each cash flow separately and then summing them. However, in the case of an annuity displaying uniform cash flows, the computations can be reduced from three to one as described in the note to the exhibit. The sum of the individual discount factors can be thought of as a discount factor for an annuity of uniform cash flows. A table of discount factors that can be used for an annuity of uniform cash flows is available in Exhibit 20B-2 in Appendix B.

### EXHIBIT 20A-1 Present Value of an Uneven Series of Cash Flows

| Year | Cash Receipt | Discount Factor | Present Value* |
|---|---|---|---|
| 1 | $110.00 | 0.909 | $100.00 |
| 2 | 121.00 | 0.826 | 100.00 |
| 3 | 133.10 | 0.751 | 100.00 |
| | | | $300.00 |

*Rounded.

### EXHIBIT 20A-2 Present Value of a Uniform Series of Cash Flows

| Year | Cash Receipt | Discount Factor | Present Value |
|---|---|---|---|
| 1 | $100 | 0.909 | $ 90.90 |
| 2 | 100 | 0.826 | 82.60 |
| 3 | 100 | 0.751 | 75.10 |
| | | 2.486 | $248.60 |

*Note:* The annual cash flow of $100 can be multiplied by the sum of the discount factors (2.486) to obtain the present value of the uniform series ($248.60).

# Appendix B: Present Value Tables

EXHIBIT 20B-1 Present Value of $1*

| Periods | 2% | 4% | 6% | 8% | 10% | 12% | 14% | 16% | 18% | 20% | 22% | 24% | 26% | 28% | 30% | 32% | 40% |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.980 | 0.962 | 0.943 | 0.926 | 0.909 | 0.893 | 0.877 | 0.862 | 0.847 | 0.833 | 0.820 | 0.806 | 0.794 | 0.781 | 0.769 | 0.758 | 0.714 |
| 2 | 0.961 | 0.925 | 0.890 | 0.857 | 0.826 | 0.797 | 0.769 | 0.743 | 0.718 | 0.694 | 0.672 | 0.650 | 0.630 | 0.610 | 0.592 | 0.574 | 0.510 |
| 3 | 0.942 | 0.889 | 0.840 | 0.794 | 0.751 | 0.712 | 0.675 | 0.641 | 0.609 | 0.579 | 0.551 | 0.524 | 0.500 | 0.477 | 0.455 | 0.435 | 0.364 |
| 4 | 0.924 | 0.855 | 0.792 | 0.735 | 0.683 | 0.636 | 0.592 | 0.552 | 0.516 | 0.482 | 0.451 | 0.423 | 0.397 | 0.373 | 0.350 | 0.329 | 0.260 |
| 5 | 0.906 | 0.822 | 0.747 | 0.681 | 0.621 | 0.567 | 0.519 | 0.476 | 0.437 | 0.402 | 0.370 | 0.341 | 0.315 | 0.291 | 0.269 | 0.250 | 0.186 |
| 6 | 0.888 | 0.790 | 0.705 | 0.636 | 0.564 | 0.507 | 0.456 | 0.410 | 0.370 | 0.335 | 0.303 | 0.275 | 0.250 | 0.227 | 0.207 | 0.189 | 0.133 |
| 7 | 0.871 | 0.760 | 0.665 | 0.583 | 0.513 | 0.452 | 0.400 | 0.354 | 0.314 | 0.279 | 0.249 | 0.222 | 0.198 | 0.178 | 0.159 | 0.143 | 0.095 |
| 8 | 0.853 | 0.731 | 0.627 | 0.540 | 0.467 | 0.404 | 0.351 | 0.305 | 0.266 | 0.233 | 0.204 | 0.179 | 0.157 | 0.139 | 0.123 | 0.108 | 0.068 |
| 9 | 0.837 | 0.703 | 0.592 | 0.500 | 0.424 | 0.361 | 0.308 | 0.263 | 0.225 | 0.194 | 0.167 | 0.144 | 0.125 | 0.108 | 0.094 | 0.082 | 0.048 |
| 10 | 0.820 | 0.676 | 0.558 | 0.463 | 0.386 | 0.322 | 0.270 | 0.227 | 0.191 | 0.162 | 0.137 | 0.116 | 0.099 | 0.085 | 0.073 | 0.062 | 0.035 |
| 11 | 0.804 | 0.650 | 0.527 | 0.429 | 0.350 | 0.287 | 0.237 | 0.195 | 0.162 | 0.135 | 0.112 | 0.094 | 0.079 | 0.066 | 0.056 | 0.046 | 0.025 |
| 12 | 0.788 | 0.625 | 0.497 | 0.397 | 0.319 | 0.257 | 0.208 | 0.168 | 0.137 | 0.112 | 0.092 | 0.076 | 0.062 | 0.052 | 0.043 | 0.036 | 0.018 |
| 13 | 0.773 | 0.601 | 0.469 | 0.368 | 0.290 | 0.229 | 0.182 | 0.145 | 0.116 | 0.093 | 0.075 | 0.061 | 0.050 | 0.040 | 0.033 | 0.027 | 0.013 |
| 14 | 0.758 | 0.577 | 0.442 | 0.340 | 0.263 | 0.205 | 0.160 | 0.125 | 0.099 | 0.078 | 0.062 | 0.049 | 0.039 | 0.032 | 0.025 | 0.021 | 0.009 |
| 15 | 0.743 | 0.555 | 0.417 | 0.315 | 0.239 | 0.183 | 0.140 | 0.108 | 0.084 | 0.065 | 0.051 | 0.040 | 0.031 | 0.025 | 0.020 | 0.016 | 0.006 |
| 16 | 0.728 | 0.534 | 0.394 | 0.292 | 0.218 | 0.163 | 0.123 | 0.093 | 0.071 | 0.054 | 0.042 | 0.032 | 0.025 | 0.019 | 0.015 | 0.012 | 0.005 |
| 17 | 0.714 | 0.513 | 0.371 | 0.270 | 0.198 | 0.146 | 0.108 | 0.080 | 0.060 | 0.045 | 0.034 | 0.026 | 0.020 | 0.015 | 0.012 | 0.009 | 0.003 |
| 18 | 0.700 | 0.494 | 0.350 | 0.250 | 0.180 | 0.130 | 0.095 | 0.069 | 0.051 | 0.038 | 0.028 | 0.021 | 0.016 | 0.012 | 0.009 | 0.007 | 0.002 |
| 19 | 0.686 | 0.475 | 0.331 | 0.232 | 0.164 | 0.116 | 0.083 | 0.060 | 0.043 | 0.031 | 0.023 | 0.017 | 0.012 | 0.009 | 0.007 | 0.005 | 0.002 |
| 20 | 0.673 | 0.456 | 0.312 | 0.215 | 0.149 | 0.104 | 0.073 | 0.051 | 0.037 | 0.026 | 0.019 | 0.014 | 0.010 | 0.007 | 0.005 | 0.004 | 0.001 |
| 21 | 0.660 | 0.439 | 0.294 | 0.199 | 0.135 | 0.093 | 0.064 | 0.044 | 0.031 | 0.022 | 0.015 | 0.011 | 0.008 | 0.006 | 0.004 | 0.003 | 0.001 |
| 22 | 0.647 | 0.422 | 0.278 | 0.184 | 0.123 | 0.083 | 0.056 | 0.038 | 0.026 | 0.018 | 0.013 | 0.009 | 0.006 | 0.004 | 0.003 | 0.002 | 0.001 |
| 23 | 0.634 | 0.406 | 0.262 | 0.170 | 0.112 | 0.074 | 0.049 | 0.033 | 0.022 | 0.015 | 0.010 | 0.007 | 0.005 | 0.003 | 0.002 | 0.002 | 0.000 |
| 24 | 0.622 | 0.390 | 0.247 | 0.158 | 0.102 | 0.066 | 0.043 | 0.028 | 0.019 | 0.013 | 0.008 | 0.006 | 0.004 | 0.003 | 0.002 | 0.001 | 0.000 |
| 25 | 0.610 | 0.375 | 0.233 | 0.146 | 0.092 | 0.059 | 0.038 | 0.024 | 0.016 | 0.010 | 0.007 | 0.005 | 0.003 | 0.002 | 0.001 | 0.001 | 0.000 |
| 26 | 0.598 | 0.361 | 0.220 | 0.135 | 0.084 | 0.053 | 0.033 | 0.021 | 0.014 | 0.009 | 0.006 | 0.004 | 0.002 | 0.002 | 0.001 | 0.001 | 0.000 |
| 27 | 0.586 | 0.347 | 0.207 | 0.125 | 0.076 | 0.047 | 0.029 | 0.018 | 0.011 | 0.007 | 0.005 | 0.003 | 0.002 | 0.001 | 0.001 | 0.001 | 0.000 |
| 28 | 0.574 | 0.333 | 0.196 | 0.116 | 0.069 | 0.042 | 0.026 | 0.016 | 0.010 | 0.006 | 0.004 | 0.002 | 0.002 | 0.001 | 0.001 | 0.000 | 0.000 |
| 29 | 0.563 | 0.321 | 0.185 | 0.107 | 0.063 | 0.037 | 0.022 | 0.014 | 0.008 | 0.005 | 0.003 | 0.002 | 0.001 | 0.001 | 0.000 | 0.000 | 0.000 |
| 30 | 0.552 | 0.308 | 0.174 | 0.099 | 0.057 | 0.033 | 0.020 | 0.012 | 0.007 | 0.004 | 0.003 | 0.002 | 0.001 | 0.001 | 0.000 | 0.000 | 0.000 |

$*P_n = A/(1 + i)^n$.

EXHIBIT 20B-2 **Present Value of an Annuity of $1 in Arrears***

| Periods | 2% | 4% | 6% | 8% | 10% | 12% | 14% | 16% | 18% | 20% | 22% | 24% | 26% | 28% | 30% | 32% | 40% |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.980 | 0.962 | 0.943 | 0.926 | 0.909 | 0.893 | 0.877 | 0.862 | 0.847 | 0.833 | 0.820 | 0.806 | 0.794 | 0.781 | 0.769 | 0.758 | 0.714 |
| 2 | 1.942 | 1.866 | 1.833 | 1.783 | 1.736 | 1.690 | 1.647 | 1.605 | 1.566 | 1.528 | 1.492 | 1.457 | 1.424 | 1.392 | 1.361 | 1.331 | 1.224 |
| 3 | 2.884 | 2.775 | 2.673 | 2.577 | 2.487 | 2.402 | 2.322 | 2.246 | 2.174 | 2.106 | 2.042 | 1.981 | 1.923 | 1.868 | 1.816 | 1.766 | 1.589 |
| 4 | 3.808 | 3.630 | 3.465 | 3.312 | 3.170 | 3.037 | 2.914 | 2.798 | 2.690 | 2.589 | 2.494 | 2.404 | 2.320 | 2.241 | 2.166 | 2.096 | 1.849 |
| 5 | 4.713 | 4.452 | 4.212 | 3.993 | 3.791 | 3.605 | 3.433 | 3.274 | 3.127 | 2.991 | 2.864 | 2.745 | 2.635 | 2.532 | 2.436 | 2.345 | 2.035 |
| 6 | 5.601 | 5.242 | 4.917 | 4.623 | 4.355 | 4.111 | 3.889 | 3.685 | 3.498 | 3.326 | 3.167 | 3.020 | 2.885 | 2.759 | 2.643 | 2.534 | 2.168 |
| 7 | 6.472 | 6.002 | 5.582 | 5.206 | 4.868 | 4.564 | 4.288 | 4.039 | 3.812 | 3.605 | 3.416 | 3.242 | 3.083 | 2.937 | 2.802 | 2.677 | 2.263 |
| 8 | 7.325 | 6.733 | 6.210 | 5.747 | 5.335 | 4.968 | 4.639 | 4.344 | 3.078 | 3.837 | 3.619 | 3.421 | 3.241 | 3.076 | 2.925 | 2.786 | 2.331 |
| 9 | 8.162 | 7.435 | 6.802 | 6.247 | 5.759 | 5.328 | 4.946 | 4.607 | 4.303 | 4.031 | 3.786 | 3.566 | 3.366 | 3.184 | 3.019 | 2.868 | 2.379 |
| 10 | 8.983 | 8.111 | 7.360 | 6.710 | 6.145 | 5.650 | 5.216 | 4.833 | 4.494 | 4.192 | 3.923 | 3.682 | 3.465 | 3.269 | 3.092 | 2.930 | 2.414 |
| 11 | 9.787 | 8.760 | 7.887 | 7.139 | 6.495 | 5.938 | 5.453 | 5.029 | 4.656 | 4.327 | 4.035 | 3.776 | 3.543 | 3.335 | 3.147 | 2.978 | 2.438 |
| 12 | 10.575 | 9.385 | 8.384 | 7.536 | 6.814 | 6.194 | 5.660 | 5.197 | 4.793 | 4.439 | 4.127 | 3.851 | 3.606 | 3.387 | 3.190 | 3.013 | 2.456 |
| 13 | 11.348 | 9.986 | 8.853 | 7.904 | 7.103 | 6.424 | 5.842 | 5.342 | 4.910 | 4.533 | 4.203 | 3.912 | 3.656 | 3.427 | 3.223 | 3.040 | 2.469 |
| 14 | 12.106 | 10.563 | 9.295 | 8.244 | 7.367 | 6.628 | 6.002 | 5.468 | 5.008 | 4.611 | 4.265 | 3.962 | 3.695 | 3.459 | 3.249 | 3.061 | 2.478 |
| 15 | 12.849 | 11.118 | 9.712 | 8.559 | 7.606 | 6.811 | 6.142 | 5.575 | 5.092 | 4.675 | 4.315 | 4.001 | 3.726 | 3.483 | 3.268 | 3.076 | 2.484 |
| 16 | 13.578 | 11.652 | 10.106 | 8.851 | 7.824 | 6.974 | 6.265 | 5.668 | 5.162 | 4.730 | 4.357 | 4.033 | 3.751 | 3.503 | 3.283 | 3.088 | 2.489 |
| 17 | 14.292 | 12.166 | 10.477 | 9.122 | 8.022 | 7.120 | 6.373 | 5.749 | 5.222 | 4.775 | 4.391 | 4.059 | 3.771 | 3.518 | 3.295 | 3.097 | 2.492 |
| 18 | 14.992 | 12.659 | 10.828 | 9.372 | 8.201 | 7.250 | 6.467 | 5.818 | 5.273 | 4.812 | 4.419 | 4.080 | 3.786 | 3.529 | 3.304 | 3.104 | 2.494 |
| 19 | 15.678 | 13.134 | 11.158 | 9.604 | 8.365 | 7.366 | 6.550 | 5.877 | 5.316 | 4.843 | 4.442 | 4.097 | 3.799 | 3.539 | 3.311 | 3.109 | 2.496 |
| 20 | 16.351 | 13.590 | 11.470 | 9.818 | 8.514 | 7.469 | 6.623 | 5.929 | 5.353 | 4.870 | 4.460 | 4.110 | 3.808 | 3.546 | 3.316 | 3.113 | 2.497 |
| 21 | 17.011 | 14.029 | 11.764 | 10.017 | 8.649 | 7.562 | 6.687 | 5.973 | 5.384 | 4.891 | 4.476 | 4.121 | 3.816 | 3.551 | 3.320 | 3.116 | 2.498 |
| 22 | 17.658 | 14.451 | 12.042 | 10.201 | 8.772 | 7.645 | 6.743 | 6.011 | 5.410 | 4.909 | 4.488 | 4.130 | 3.822 | 3.556 | 3.323 | 3.118 | 2.498 |
| 23 | 18.292 | 14.857 | 12.303 | 10.371 | 8.883 | 7.718 | 6.792 | 6.044 | 5.432 | 4.925 | 4.499 | 4.137 | 3.827 | 3.559 | 3.325 | 3.120 | 2.499 |
| 24 | 18.914 | 15.247 | 12.550 | 10.529 | 8.985 | 7.784 | 6.835 | 6.073 | 5.451 | 4.937 | 4.507 | 4.143 | 3.831 | 3.562 | 3.327 | 3.121 | 2.499 |
| 25 | 19.523 | 15.622 | 12.783 | 10.675 | 9.077 | 7.843 | 6.873 | 6.097 | 5.467 | 4.948 | 4.514 | 4.147 | 3.834 | 3.564 | 3.329 | 3.122 | 2.499 |
| 26 | 20.121 | 15.983 | 13.003 | 10.810 | 9.161 | 7.896 | 6.906 | 6.118 | 5.480 | 4.956 | 4.520 | 4.151 | 3.837 | 3.566 | 3.330 | 3.123 | 2.500 |
| 27 | 20.707 | 16.330 | 13.211 | 10.935 | 9.237 | 7.943 | 6.935 | 6.136 | 5.492 | 4.964 | 4.524 | 4.154 | 3.839 | 3.567 | 3.331 | 3.123 | 2.500 |
| 28 | 21.281 | 16.663 | 13.406 | 11.051 | 9.307 | 7.984 | 6.961 | 6.152 | 5.502 | 4.970 | 4.528 | 4.157 | 3.840 | 3.568 | 3.331 | 3.124 | 2.500 |
| 29 | 21.844 | 16.984 | 13.591 | 11.158 | 9.370 | 8.022 | 6.983 | 6.166 | 5.510 | 4.975 | 4.531 | 4.159 | 3.841 | 3.569 | 3.332 | 3.124 | 2.500 |
| 30 | 22.396 | 17.292 | 13.765 | 11.258 | 9.427 | 8.055 | 7.003 | 6.177 | 5.517 | 4.979 | 4.534 | 4.160 | 3.842 | 3.569 | 3.332 | 3.124 | 2.500 |

*$P_n = (1/i)[1 - 1/(1 + i)^n]$.

# REVIEW PROBLEMS AND SOLUTIONS

## 1 Basics of Capital Investment (Ignore income taxes for this exercise.)

Kenn Day, manager of Day Laboratory, is investigating the possibility of acquiring some new test equipment. To acquire the equipment requires an initial outlay of $300,000. To raise the capital, Kenn will sell stock valued at $200,000 (the stock pays dividends of $24,000 per year) and borrow $100,000. The loan for $100,000 would carry an interest rate of 6 percent. Kenn figures that his weighted cost of capital is 10 percent [(2/3 × 0.12) + (1/3 × 0.06)]. This weighted cost of capital is the rate he will use for capital investment decisions.

Kenn estimates that the new test equipment will produce a cash inflow of $50,000 per year. Kenn expects the equipment to last for 20 years.

**Required:**

1. Compute the payback period.
2. Assuming that depreciation is $14,000 per year, compute the accounting rate of return (on total investment).
3. Compute the NPV of the investment.
4. Compute the IRR of the investment.
5. Should Kenn buy the equipment? Explain.

SOLUTION

1. The payback period is $300,000/$50,000, or six years.
2. The accounting rate of return is ($50,000 − $14,000)/$300,000, or 12 percent.
3. From Exhibit 20B-2, the discount factor for an annuity with $i$ at 10 percent and $n$ at 20 years is 8.514. Thus, the NPV is [(8.514 × $50,000) − $300,000], or $125,700.
4. The discount factor associated with the IRR is 6.00 ($300,000/$50,000). From Exhibit 20B-2, the IRR is between 14 and 16 percent (using the row corresponding to period 20).
5. Since the NPV is positive and the IRR is greater than Kenn's cost of capital, the test equipment is a sound investment. This assumes, of course, that the cash flow projections are accurate.

## 2 Capital Investment with Competing Projects (with tax effects)

Weins Postal Service (WPS) has decided to acquire a new delivery truck. The choice has been narrowed to two models. The following information has been gathered for each model:

| | *Custom* | *Deluxe* |
|---|---|---|
| Acquisition cost | $20,000 | $25,000 |
| Annual operating costs | $3,500 | $2,000 |
| Depreciation method | MACRS | MACRS |
| Expected salvage value | $5,000 | $8,000 |

WPS's cost of capital is 14 percent. The company plans to use the truck for five years and then sell it for its salvage value. Assume the combined state and federal tax rate is 40 percent.

**Required:**

1. Compute the after-tax operating cash flows for each model.
2. Compute the NPV for each model, and make a recommendation.

SOLUTION

1. For light trucks, MACRS guidelines allow a 5-year life. Using the rates from Exhibit 20-11 on page 898, depreciation is calculated for each model.

| *Year* | *Custom* | *Deluxe* |
|---|---|---|
| 1 | $ 4,000 | $ 5,000 |
| 2 | 6,400 | 8,000 |
| 3 | 3,840 | 4,800 |
| 4 | 2,304 | 2,880 |
| 5 | 1,152* | 1,440* |
| Total | $17,696 | $22,120 |

*Only half the depreciation is allowed in the year of disposal.

The after-tax operating cash flows are computed using the spreadsheet format.

*Custom*

| *Year* | *(1 − t)R* | *−(1 − t)C* | *tNC* | *Other* | *CF* |
|---|---|---|---|---|---|
| 1 | n/a | $(2,100) | $1,600 | | $ (500) |
| 2 | n/a | (2,100) | 2,560 | | 460 |
| 3 | n/a | (2,100) | 1,536 | | (564) |
| 4 | n/a | (2,100) | 922 | | (1,178) |
| 5 | $1,618[a] | (2,100) | 461 | $2,304[b] | 2,283 |

[a]Salvage value ($5,000) − Book value ($20,000 − $17,696 = $2,304) = $2,696; 0.60 × $2,696 = $1,618
[b]Recovery of capital = Book value = $2,304. Capital recovered is not taxed—only the gain on sale. Footnote (a) illustrates how the gain is treated.

*Deluxe*

| *Year* | *(1 − t)R* | *−(1 − t)C* | *tNC* | *Other* | *CF* |
|---|---|---|---|---|---|
| 1 | n/a | $(1,200) | $2,000 | | $ 800 |
| 2 | n/a | (1,200) | 3,200 | | 2,000 |
| 3 | n/a | (1,200) | 1,920 | | 720 |
| 4 | n/a | (1,200) | 1,152 | | (48) |
| 5 | $3,072[a] | (1,200) | 576 | $2,880[b] | 5,328 |

[a]Salvage value ($8,000) − Book value ($25,000 − $22,120 = $2,880) = $5,120; 0.60 × $5,120 = $3,072.
[b]Recovery of capital = Book value = $2,880. Capital recovered is not taxed—only the gain on sale of the asset. Footnote (a) illustrates how the gain is treated. The nontaxable item requires an additional column for the spreadsheet analysis.

2. NPV computation—Custom:

| *Year* | *Cash Flow* | *Discount Factor* | *Present Value* |
|---|---|---|---|
| 0 | $(20,000) | 1.000 | $(20,000) |
| 1 | (500) | 0.877 | (439) |
| 2 | 460 | 0.769 | 354 |
| 3 | (564) | 0.675 | (381) |
| 4 | (1,178) | 0.592 | (697) |
| 5 | 2,283 | 0.519 | 1,185 |
| Net present value | | | $(19,978) |

NPV computation—Deluxe:

| *Year* | *Cash Flow* | *Discount Factor* | *Present Value* |
|---|---|---|---|
| 0 | $(25,000) | 1.000 | $(25,000) |
| 1 | 800 | 0.877 | 702 |
| 2 | 2,000 | 0.769 | 1,538 |
| 3 | 720 | 0.675 | 486 |
| 4 | (48) | 0.592 | (28) |
| 5 | 5,328 | 0.519 | 2,765 |
| Net present value | | | $(19,537) |

The Deluxe model should be chosen, since it has the larger NPV, indicating that it is the least costly of the two cars. Note also that the net present values are negative and that we are choosing the least costly investment.

## KEY TERMS

Accounting rate of return (ARR) 883
Annuity 905
Capital budgeting 879
Capital investment decisions 879
Compounding of interest 904
Discount factor 905
Discount rate 905
Discounted cash flows 883
Discounting 905
Discounting models 881
Five-year assets 897
Future value 904
Half-year convention 897
Independent projects 879
Internal rate of return (IRR) 885
Modified accelerated cost recovery system (MACRS) 897
Mutually exclusive projects 879
Net present value (NPV) 884
Nondiscounting models 881
Payback period 881
Postaudit 901
Present value 904
Required rate of return 884
Sensitivity analysis 902
Seven-year assets 897
Three-year assets 897
What-if analysis 902

## QUESTIONS FOR WRITING AND DISCUSSION

1. Explain the difference between independent projects and mutually exclusive projects.
2. Explain why the timing and quantity of cash flows are important in capital investment decisions.
3. The time value of money is ignored by the payback period and the accounting rate of return. Explain why this is a major deficiency in these two models.
4. What is the payback period? Name and discuss three possible reasons that the payback period is used to help make capital investment decisions.
5. What is the accounting rate of return?
6. What is the cost of capital? What role does it play in capital investment decisions?
7. The IRR is the true or actual rate of return being earned by the project. Do you agree or disagree? Discuss.
8. Explain how the NPV is used to determine whether a project should be accepted or rejected.
9. Explain why NPV is generally preferred over IRR when choosing among competing or mutually exclusive projects. Why would managers continue to use IRR to choose among mutually exclusive projects?
10. Why is it important to have accurate projections of cash flows for potential capital investments?
11. What are the principal tax implications that should be considered in Year 0?
12. Explain why the MACRS method of recognizing depreciation is better than the straight-line method.
13. Explain the important factors to consider for capital investment decisions relating to advanced technology and P2 opportunities.
14. Explain what a postaudit is and how it can provide useful input for future capital investment decisions—especially those involving advanced technology.
15. Explain what sensitivity analysis is. How can it help in capital budgeting decisions?

## EXERCISES

### 20-1 PAYBACK AND ARR

LO2 Each of the following scenarios is independent. All cash flows are after-tax cash flows.

**Required:**

1. Don Blackburn has purchased a tractor for $62,500. He expects to receive a net cash flow of $15,625 per year from the investment. What is the payback period for Don?
2. Bill Johnson invested $600,000 in a laundromat. The facility has a 10-year life expectancy with no expected salvage value. The laundromat will produce a net cash flow of $180,000 per year. What is the accounting rate of return? Use original investment for the computation.
3. Kathleen Shorts has purchased a business building for $700,000. She expects to receive the following cash flows over a 10-year period:

   Year 1: $87,500
   Year 2: $122,500
   Years 3–10: $175,000

   What is the payback period for Kathleen? What is the accounting rate of return (using average investment and assuming straight-line depreciation over the 10 years)?

## 20-2 Future Value, Present Value

**Appendix**

The following cases are each independent of the others.

**Required:**

1. Sam Lilliam places $5,000 in a savings account that pays 3 percent. Suppose Sam leaves the original deposit plus any interest in the account for two years. How much will Sam have in savings after two years?
2. Suppose that the parents of a 12-year-old son want to have $80,000 in a fund six years from now to provide support for his college education. How much must they invest now to have the desired amount if the investment can earn 4 percent? 6 percent? 8 percent?
3. Killian Manufacturing is asking $500,000 for automated equipment, which is expected to last six years and will generate equal annual net cash inflows (because of reductions in labor costs, material waste, and so on). What is the minimum cash inflow that must be realized each year to justify the acquisition? The cost of capital is 8 percent.

## 20-3 NPV and IRR

**LO1, LO3, LO4**

Each of the following scenarios is independent. All cash flows are after-tax cash flows.

**Required:**

1. Jackman Corporation is considering the purchase of a computer-aided manufacturing system. The cash benefits will be $1,000,000 per year. The system costs $6,000,000 and will last eight years. Compute the NPV assuming a discount rate of 10 percent. Should the company buy the new system?
2. Lehi Henderson has just invested $1,350,000 in a restaurant specializing in Italian food. He expects to receive $217,350 per year for the next eight years. His cost of capital is 5.5 percent. Compute the internal rate of return. Did Lehi make a good decision?

## 20-4 Basic Concepts

**LO1, LO2, LO3, LO4**

Roberts Company is considering an investment in equipment that is capable of producing electronic parts twice as fast as existing technology. The outlay required is $2,340,000. The equipment is expected to last five years and will have no salvage value. The expected cash flows associated with the project are as follows:

| *Year* | *Cash Revenues* | *Cash Expenses* |
|---|---|---|
| 1 | $3,042,000 | $2,340,000 |
| 2 | 3,042,000 | 2,340,000 |
| 3 | 3,042,000 | 2,340,000 |
| 4 | 3,042,000 | 2,340,000 |
| 5 | 3,042,000 | 2,340,000 |

**Required:**

1. Compute the project's payback period.
2. Compute the project's accounting rate of return on:
   a. Initial investment
   b. Average investment
3. Compute the project's net present value, assuming a required rate of return of 10 percent.
4. Compute the project's internal rate of return.

## 20-5 NPV

LO1, LO3

A hospital is considering the possibility of two new purchases: new X-ray equipment and new biopsy equipment. Each project would require an investment of $750,000. The expected life for each is five years with no expected salvage value. The net cash inflows associated with the two independent projects are as follows:

| *Year* | *X-Ray Equipment* | *Sonogram Equipment* |
|---|---|---|
| 1 | $375,000 | $ 75,000 |
| 2 | 150,000 | 75,000 |
| 3 | 300,000 | 525,000 |
| 4 | 150,000 | 600,000 |
| 5 | 75,000 | 675,000 |

**Required:**

Compute the net present value of each project, assuming a required rate of 12 percent.

## 20-6 Payback, Accounting Rate of Return

LO1, LO2

Refer to **Exercise 20-5**.

1. Compute the payback period for each project. Assume that the manager of the hospital accepts only projects with a payback period of three years or less. Offer some reasons why this may be a rational strategy even though the NPV computed in **Exercise 20-5** may indicate otherwise.
2. Compute the accounting rate of return for each project using average investment.

## 20-7 NPV: Basic Concepts

LO3

Escucha Hearing Clinic is considering an investment that requires an outlay of $370,000 and promises a net cash inflow one year from now of $450,000. Assume the cost of capital is 12 percent.

**Required:**

1. Break the $450,000 future cash inflow into three components:
   a. The return of the original investment
   b. The cost of capital
   c. The profit earned on the investment
   
   Now, compute the present value of the profit earned on the investment.
2. Compute the NPV of the investment. Compare this with the present value of the profit computed in Requirement 1. What does this tell you about the meaning of NPV?

## 20-8 Solving for Unknowns

LO3, LO4

Consider each of the following independent cases.

**Required:**

1. Hal's Stunt Company is investing $120,000 in a project that will yield a uniform series of cash inflows over the next four years. If the internal rate of return is 14 percent, how much cash inflow per year can be expected?
2. Warner Medical Clinic has decided to invest in some new blood diagnostic equipment. The equipment will have a 3-year life and will produce a uniform series of cash savings. The net present value of the equipment is $1,750, using a

discount rate of 8 percent. The internal rate of return is 12 percent. Determine the investment and the amount of cash savings realized each year.

3. A new lathe costing $60,096 will produce savings of $12,000 per year. How many years must the lathe last if an IRR of 18 percent is realized?
4. The NPV of a new product (a new brand of candy) is $6,075. The product has a life of four years and produces the following cash flows:

| | |
|---|---|
| Year 1 | $15,000 |
| Year 2 | 20,000 |
| Year 3 | 30,000 |
| Year 4 | ? |

The cost of the project is three times the cash flow produced in Year 4. The discount rate is 10 percent. Find the cost of the project and the cash flow for Year 4.

## 20-9 Advanced Technology, Payback, NPV, IRR, Sensitivity Analysis

LO2, LO3, LO4, LO5, LO7

Gina Ripley, president of Dearing Company, is considering the purchase of a computer-aided manufacturing system. The annual net cash benefits/savings associated with the system are described as follows:

Spreadsheet

| | |
|---|---|
| Decreased waste | $300,000 |
| Increased quality | 400,000 |
| Decrease in operating costs | 600,000 |
| Increase in on-time deliveries | 200,000 |

The system will cost $9,000,000 and last 10 years. The company's cost of capital is 12 percent.

**Required:**

1. Calculate the payback period for the system. Assume that the company has a policy of only accepting projects with a payback of five years or less. Would the system be acquired?
2. Calculate the NPV and IRR for the project. Should the system be purchased—even if it does not meet the payback criterion?
3. The project manager reviewed the projected cash flows and pointed out that two items had been missed. First, the system would have a salvage value, net of any tax effects, of $1,000,000 at the end of 10 years. Second, the increased quality and delivery performance would allow the company to increase its market share by 20 percent. This would produce an additional annual net benefit of $300,000. Recalculate the payback period, NPV, and IRR given this new information. (For the IRR computation, initially ignore salvage value.) Does the decision change? Suppose that the salvage value is only half what is projected. Does this make a difference in the outcome? Does salvage value have any real bearing on the company's decision?

## 20-10 NPV versus IRR

LO5

Covington Pharmacies has decided to automate its insurance claims process. Two networked computer systems are being considered. The systems have an expected life of two years. The net cash flows associated with the systems are as follows. The cash benefits represent the savings created by switching from a manual to an automated system.

| *Year* | *System I* | *System II* |
|---|---|---|
| 0 | $(120,000) | $(120,000) |
| 1 | — | 76,628 |
| 2 | 162,708 | 76,628 |

The company's cost of capital is 10 percent.

**Required:**

1. Compute the NPV and the IRR for each investment.
2. Show that the project with the larger NPV is the correct choice for the company.

## 20-11 Computation of After-Tax Cash Flows

**LO6**

Masamora Company is considering two independent projects. One project involves a new product line, and the other involves the acquisition of forklifts for the materials handling department. The projected annual operating revenues and expenses are as follows:

*Project I (investment in a new product)*

| | |
|---|---|
| Revenues | $ 90,000 |
| Cash expenses | (45,000) |
| Depreciation | (15,000) |
| Income before income taxes | $ 30,000 |
| Income taxes | (12,000) |
| Net income | $ 18,000 |

*Project II (acquisition of two forklifts)*

| | |
|---|---|
| Cash expenses | $30,000 |
| Depreciation | 30,000 |

**Required:**

Compute the after-tax cash flows of each project. The tax rate is 40 percent and includes federal and state assessments.

## 20-12 MACRS, NPV

**LO3, LO6**

Spreadsheet

Lilly Company is planning to buy a set of special tools for its grinding operation. The cost of the tools is $18,000. The tools have a 3-year life and qualify for the use of the 3-year MACRS. The tax rate is 40 percent; the cost of capital is 12 percent.

**Required:**

1. Calculate the present value of the tax depreciation shield, assuming that straight-line depreciation with a half-year life is used.
2. Calculate the present value of the tax depreciation shield, assuming that MACRS is used.
3. What is the benefit to the company of using MACRS?

## 20-13 Inflation

**LO3, LO6**

Excalibur Company is planning on introducing a new product that will have a 2-year life. Producing the product requires an initial outlay of $20,000; it will generate after-tax cash inflows of $11,000 and $12,000 in the two years. The company's cost of capital is 12 percent. During the coming two years, inflation is expected to average 5 percent. The cash flows have not been adjusted for inflation. The cost of capital, however, reflects an inflationary component.

**Required:**

1. Compute the NPV using the unadjusted cash flows.
2. Compute the NPV using cash flows adjusted for inflationary effects.

## 20-14 Various Cash Flow Computations

LO6 Solve each of the following independent cases:

1. A printing company has decided to purchase a new printing press. Its old press will be sold for $10,000. (It has a book value of $25,000.) The new press will cost $50,000. Assuming that the tax rate is 40 percent, compute the net after-tax cash outflow.
2. The maintenance department is purchasing new diagnostic equipment costing $30,000. Additional cash expenses of $2,000 per year are required to operate the equipment. MACRS depreciation will be used (5-year property qualification). Assuming a tax rate of 40 percent, prepare a schedule of after-tax cash flows for the first four years.
3. The projected income for a project during its first year of operation is as follows:

| | |
|---|---|
| Cash revenues | $120,000 |
| Less: Cash expenses | (50,000) |
| Depreciation | (20,000) |
| Income before income taxes | $ 50,000 |
| Less: Income taxes | 20,000 |
| Net income | $ 30,000 |

Compute the following:

a. After-tax cash flow
b. After-tax cash flow from revenues
c. After-tax cash expenses
d. Cash inflow from the shielding effect of depreciation

# PROBLEMS

## 20-15 Pollution Prevention, P2 Investment

LO2, LO3, LO4, LO5, LO6, LO7

Lewis Company produces jewelry that requires electroplating with gold, silver, and other valuable metals. Electroplating uses large amounts of water and chemicals, producing wastewater with a number of toxic residuals. Currently, Lewis uses settlement tanks to remove waste; unfortunately, the approach is inefficient, and much of the toxic residue is left in the water that is discharged into a local river. The amount of toxic discharge exceeds the legal, allowable amounts, and the company is faced with substantial, ongoing environmental fines. The environmental violations are also drawing unfavorable public reaction, and sales are being affected. A lawsuit is also impending, which could prove to be quite costly.

Management is now considering the installation of a zero-discharge, closed-loop system to treat the wastewater. The proposed closed-loop system would not only purify the wastewater, but it would also produce cleaner water than that currently being used, increasing plating quality. The closed-loop system would produce only four pounds of sludge, and the sludge would be virtually pure metal, with significant market value. The system requires an investment of $420,000 and will cost $30,000 in increased annual operation plus an annual purchase of $5,000 of filtration medium. However, management projects the following savings:

| | |
|---|---|
| Water usage | $ 45,000 |
| Chemical usage | 28,000 |
| Sludge disposal | 60,000 |
| Recovered metal sales | 30,000 |
| Sampling of discharge | 80,000 |
| Total | $243,000 |

The equipment qualifies as a 7-year MACRS asset. Management has decided to use straight-line depreciation for tax purposes, using the required half-year convention. The tax rate is 40 percent. The projected life of the system is 10 years. The hurdle rate is 16 percent for all capital budgeting projects, although the company's cost of capital is 12 percent.

**Required:**

1. Based on the financial data provided, prepare a schedule of expected cash flows.
2. What is the payback period?
3. Calculate the NPV of the closed-loop system. Should the company invest in the system?
4. The calculation in Requirement 3 ignored several factors that could affect the project's viability: savings from avoiding the annual fines, positive effect on sales due to favorable environmental publicity, increased plating quality from the new system, and the avoidance of the lawsuit. Can these factors be quantified? If so, should they have been included in the analysis? Suppose, for example, that the annual fines being incurred are $50,000, the sales effect is $40,000 per year, the quality effect is not estimable, and that cancellation of the lawsuit because of the new system would avoid an expected settlement at the end of Year 3 (including legal fees) of $200,000. Assuming these are all after-tax amounts, what effect would their inclusion have on the payback period? On the NPV?

## 20-16 Discount Rates, Quality, Market Share, Contemporary Manufacturing Environment

LO3, LO5, LO7

Sweeney Manufacturing has a plant where the equipment is essentially worn out. The equipment must be replaced, and Sweeney is considering two competing investment alternatives. The first alternative would replace the worn-out equipment with traditional production equipment; the second alternative uses contemporary technology and has computer-aided design and manufacturing capabilities. The investment and after-tax operating cash flows for each alternative are as follows:

| *Year* | *Traditional Equipment* | *Contemporary Technology* |
|---|---|---|
| 0 | $(1,000,000) | $(4,000,000) |
| 1 | 600,000 | 200,000 |
| 2 | 400,000 | 400,000 |
| 3 | 200,000 | 600,000 |
| 4 | 200,000 | 800,000 |
| 5 | 200,000 | 800,000 |
| 6 | 200,000 | 800,000 |

*(continued)*

| *Year* | *Traditional Equipment* | *Contemporary Technology* |
|---|---|---|
| 7 | 200,000 | 1,000,000 |
| 8 | 200,000 | 2,000,000 |
| 9 | 200,000 | 2,000,000 |
| 10 | 200,000 | 2,000,000 |

The company uses a discount rate of 18 percent for all of its investments. The company's cost of capital is 14 percent.

**Required:**

1. Calculate the net present value for each investment using a discount rate of 18 percent.
2. Calculate the net present value for each investment using a discount rate of 14 percent.
3. Which rate should the company use to compute the net present value? Explain.
4. Now, assume that if the traditional equipment is purchased, the competitive position of the firm will deteriorate because of lower quality (relative to competitors who did automate). Marketing estimates that the loss in market share will decrease the projected net cash inflows by 50 percent for Years 3–10. Recalculate the NPV of the traditional equipment given this outcome. What is the decision now? Discuss the importance of assessing the effect of intangible and indirect benefits.

## 20-17 Competing P2 Investments

**LO3, LO5, LO6, LO7**

Spreadsheet

Ron Booth, the CEO for Sunders Manufacturing, was wondering which of two pollution control systems he should choose. The firm's current production process produces a gaseous and a liquid residue. A recent state law mandated that emissions of these residues be reduced to levels considerably below current performance. Failure to reduce the emissions would invoke stiff fines and possible closure of the operating plant. Fortunately, the new law provided a transition period, and Ron had used the time wisely. His engineers had developed two separate proposals. The first proposal involved the acquisition of scrubbers for gaseous emissions and a treatment facility to remove the liquid residues. The second proposal was more radical. It entailed the redesign of the manufacturing process and the acquisition of new production equipment to support this new design. The new process would solve the environmental problem by avoiding the production of residues.

Although the equipment for each proposal normally would qualify as 7-year property, the state managed to obtain an agreement with the federal government to allow any pollution abatement equipment to qualify as 5-year property. State tax law follows federal guidelines. Both proposals qualify for the 5-year property benefit.

Ron's vice president of marketing has projected an increase in revenues because of favorable environmental performance publicity. This increase is the result of selling more of Sunders's products to environmentally conscious customers. However, because the second approach is "greener," the vice president believes that the revenue increase will be greater. Cost and other data relating to the two proposals are as follows:

| | *Scrubbers and Treatment* | *Process Redesign* |
|---|---|---|
| Initial outlay | $50,000,000 | $100,000,000 |
| Incremental revenues | 10,000,000 | 30,000,000 |
| Incremental cash expenses | 24,000,000 | 10,000,000 |

The expected life for each investment's equipment is six years. The expected salvage value is $2,000,000 for scrubbers and treatment equipment and $3,000,000 for process redesign equipment. The combined federal and state tax rate is 40 percent. The cost of capital is 10 percent.

**Required:**

1. Compute the NPV of each proposal and make a recommendation to Ron Booth.
2. The environmental manager observes that the scrubbers and treatment facility enable the company to just meet state emission standards. She feels that the standards will likely increase within three years. If so, this would entail a modification at the end of three years costing an additional $8,000,000. Also, she is concerned that continued liquid residue releases—even those meeting state standards—could push a local lake into a hazardous state by the end of three years. If so, this could prompt political action requiring the company to clean up the lake. Cleanup costs would range between $40,000,000 and $60,000,000. Analyze and discuss the effect this new information has on the two alternatives. If you have read the chapter on environmental cost management, describe how the concept of ecoefficiency applies to this setting.

## 20-18 Payback, NPV, Managerial Incentives, Ethical Behavior

LO1, LO2, LO3

Spreadsheet

Kent Tessman, manager of a Dairy Products Division , was pleased with his division's performance over the past three years. Each year, divisional profits had increased, and he had earned a sizable bonus. (Bonuses are a linear function of the division's reported income.) He had also received considerable attention from higher management. A vice president had told him in confidence that if his performance over the next three years matched his first three, he would be promoted to higher management.

Determined to fulfill these expectations, Kent made sure that he personally reviewed every capital budget request. He wanted to be certain that any funds invested would provide good, solid returns. (The division's cost of capital is 10 percent.) At the moment, he is reviewing two independent requests. Proposal A involves automating a manufacturing operation that is currently labor intensive. Proposal B centers on developing and marketing a new ice cream product. Proposal A requires an initial outlay of $250,000, and Proposal B requires $312,500. Both projects could be funded, given the status of the division's capital budget. Both have an expected life of six years and have the following projected after-tax cash flows:

| *Year* | *Proposal A* | *Proposal B* |
|---|---|---|
| 1 | $150,000 | $ (37,500) |
| 2 | 125,000 | (25,000) |
| 3 | 75,000 | (12,500) |
| 4 | 37,500 | 212,500 |
| 5 | 25,000 | 275,000 |
| 6 | 12,500 | 337,500 |

After careful consideration of each investment, Kent approved funding of Proposal A and rejected Proposal B.

**Required:**

1. Compute the NPV for each proposal.
2. Compute the payback period for each proposal.
3. According to your analysis, which proposal(s) should be accepted? Explain.

4. Explain why Kent accepted only Proposal A. Considering the possible reasons for rejection, would you judge his behavior to be ethical? Explain.

## 20-19 Basic IRR Analysis

LO1, LO4

Ireland Company is considering installing a new IT system. The cost of the new system is estimated to be $750,000, but it would produce after-tax savings of $150,000 per year in labor costs. The estimated life of the new system is 10 years, with no salvage value expected. Intrigued by the possibility of saving $150,000 per year and having a more reliable information system, the president of Ireland has asked for an analysis of the project's economic viability. All capital projects are required to earn at least the firm's cost of capital, which is 12 percent.

**Required:**

1. Calculate the project's internal rate of return. Should the company acquire the new IT system?
2. Suppose that savings are less than claimed. Calculate the minimum annual cash savings that must be realized for the project to earn a rate equal to the firm's cost of capital. Comment on the safety margin that exists, if any.
3. Suppose that the life of the IT system is overestimated by two years. Repeat Requirements 1 and 2 under this assumption. Comment on the usefulness of this information.

## 20-20 Replacement Decision, Computing After-Tax Cash Flows, Basic NPV Analysis

LO1, LO3, LO5, LO6

Okmulgee Hospital (a large metropolitan for-profit hospital) is considering replacing its MRI equipment with a new model manufactured by a different company. The old MRI equipment was acquired three years ago, has a remaining life of five years, and will have a salvage value of $100,000. The book value is $2,000,000. Straight-line depreciation with a half-year convention is being used for tax purposes. The cash operating costs of the existing MRI equipment total $1,000,000 per year.

The new MRI equipment has an initial cost of $5,000,000 and will have cash operating costs of $500,000 per year. The new MRI will have a life of five years and a salvage value of $1,000,000 at the end of the fifth year. MACRS depreciation will be used for tax purposes. If the new MRI equipment is purchased, the old one will be sold for $500,000. The company needs to decide whether to keep the old MRI equipment or buy the new one. The cost of capital is 12 percent. The combined federal and state tax rate is 40 percent.

**Required:**

Compute the NPV of each alternative. Should the company keep the old MRI equipment or buy the new one?

## 20-21 Inflation and Capital Budgeting

LO3, LO5, LO6

Leo Thayn, manager of the Electronics Manufacturing Division, has been pushing headquarters to grant approval for the installation of a new computer-aided design system. Finally, in the last executive meeting, Leo was told that if he could show the new system would increase the firm's value, then it would be approved. Leo has collected the following information:

| | Old System | CAD System |
|---|---|---|
| Initial investment | — | $1,250,000 |
| Annual operating costs | $300,000 | $95,000 |
| Annual depreciation | $100,000 | MACRS |
| Effective tax rate* | 34% | 34% |
| Cost of capital | 12% | 12% |
| Expected life | 10 years | 10 years |
| Salvage value | none | none |

*The division is located in a state that provided a tax incentive package that lowers the tax rate from the usual average of 40 percent to 34 percent. This incentive package was granted for a 15-year period. Ten years of benefits remain.

With the exception of the cost of capital, the preceding information ignores the rate of inflation, which has been 4 percent per year and is expected to continue at this level for the next decade.

**Required:**

1. Compute the NPV for each system.
2. Compute the NPV for each system, adjusting the future cash flows for the rate of inflation.
3. Comment on the importance of adjusting cash flows for inflationary effects.

## 20-22 Capital Investment, Discount Rates, Intangible and Indirect Benefits, Time Horizon, Contemporary Manufacturing Environment

**LO3, LO6, LO7**

Mallette Manufacturing, Inc., produces washing machines, dryers, and dishwashers. Because of increasing competition, Mallette is considering investing in an automated manufacturing system. Since competition is most keen for dishwashers, the production process for this line has been selected for initial evaluation. The automated system for the dishwasher line would replace an existing system (purchased one year ago for $6 million). Although the existing system will be fully depreciated in nine years, it is expected to last another 10 years. The automated system would also have a useful life of 10 years.

The existing system is capable of producing 100,000 dishwashers per year. Sales and production data using the existing system are provided by the accounting department:

| | |
|---|---|
| Sales per year (units) | 100,000 |
| Selling price | $300 |
| Costs per unit: | |
| Direct materials | 80 |
| Direct labor | 90 |
| Volume-related overhead | 20 |
| Direct fixed overhead | 40* |

*All cash expenses with the exception of depreciation, which is $6 per unit. The existing equipment is being depreciated using straight-line with no salvage value considered.

The automated system will cost $34 million to purchase, plus an estimated $20 million in software and implementation. (Assume that all investment outlays occur at the beginning of the first year.) If the automated equipment is purchased, the old equipment can be sold for $3 million.

The automated system will require fewer parts for production and will produce with less waste. Because of this, the direct material cost per unit will be reduced by 25 percent. Automation will also require fewer support activities, and as a consequence, volume-related overhead will be reduced by $4 per unit and direct fixed overhead (other than depreciation) by $17 per unit. Direct labor is reduced by 60 percent. Assume, for simplicity, that the new investment will be depreciated on a pure straight-line basis for tax purposes with no salvage value. Ignore the half-life convention.

The firm's cost of capital is 12 percent, but management chooses to use 20 percent as the required rate of return for evaluation of investments. The combined federal and state tax rate is 40 percent.

**Required:**

1. Compute the net present value for the old system and the automated system. Which system would the company choose?
2. Repeat the net present value analysis of Requirement 1, using 12 percent as the discount rate.
3. Upon seeing the projected sales for the old system, the marketing manager commented: "Sales of 100,000 units per year cannot be maintained in the current competitive environment for more than one year unless we buy the automated system. The automated system will allow us to compete on the basis of quality and lead time. If we keep the old system, our sales will drop by 10,000 units per year." Repeat the net present value analysis, using this new information and a 12 percent discount rate.
4. An industrial engineer for Mallette noticed that salvage value for the automated equipment had not been included in the analysis. He estimated that the equipment could be sold for $4 million at the end of 10 years. He also estimated that the equipment of the old system would have no salvage value at the end of 10 years. Repeat the net present value analysis using this information, the information in Requirement 3, and a 12 percent discount rate.
5. Given the outcomes of the previous four requirements, comment on the importance of providing accurate inputs for assessing investments in automated manufacturing systems.

## 20-23 NPV, Make or Buy, MACRS, Basic Analysis

LO3, LO6

CMA

Jonfran Company manufactures three different models of paper shredders including the waste container, which serves as the base. While the shredder heads are different for all three models, the waste container is the same. The number of waste containers that Jonfran will need during the next five years is estimated as follows:

| | |
|---|---|
| 2007 | 50,000 |
| 2008 | 50,000 |
| 2009 | 52,000 |
| 2010 | 55,000 |
| 2011 | 55,000 |

The equipment used to manufacture the waste container must be replaced because it is broken and cannot be repaired. The new equipment would have a purchase price of $945,000 with terms of 2/10, n/30; the company's policy is to take all purchase discounts. The freight on the equipment would be $11,000, and installation costs would total $22,900. The equipment would be purchased in December 2006 and placed into service on January 1, 2007. It would have a 5-year economic life and would be treated as 3-year property under MACRS. This equipment is expected to have a salvage value of $12,000 at the end of its economic life in 2007. The new equipment would be more efficient than the old equipment, resulting in a 25 percent reduction in both direct material and variable overhead. The savings in direct material would result in an additional 1-time decrease in working capital requirements of $2,500, resulting from a reduction in direct material inventories. This working capital reduction would be recognized at the time of equipment acquisition.

The old equipment is fully depreciated and is not included in the fixed overhead. The old equipment from the plant can be sold for a salvage amount of $1,500. Rather than replace the equipment, one of Jonfran's production managers has suggested that the waste containers be purchased. One supplier has quoted a price of $27 per container. This price is $8 less than Jonfran's current manufacturing cost, which is as follows:

| | | |
|---|---|---|
| Direct materials | | $10 |
| Direct labor | | 8 |
| Variable overhead | | 6 |
| Fixed overhead: | | |
| Supervision | $2 | |
| Facilities | 5 | |
| General | 4 | 11 |
| Total unit cost | | $35 |

Jonfran uses a plantwide fixed overhead rate in its operations. If the waste containers are purchased outside, the salary and benefits of one supervisor, included in fixed overhead at $45,000, would be eliminated. There would be no other changes in the other cash and noncash items included in fixed overhead except depreciation on the new equipment.

Jonfran is subject to a 40 percent tax rate. Management assumes that all cash flows occur at the end of the year and uses a 12 percent after-tax discount rate.

**Required:**

1. Prepare a schedule of cash flows for the make alternative. Calculate the NPV of the make alternative.
2. Prepare a schedule of cash flows for the buy alternative. Calculate the NPV of the buy alternative.
3. Which should Jonfran do—make or buy the containers? What qualitative factors should be considered? *(CMA adapted)*

## 20-24 Structured Problem Solving, Cash Flows, NPV, Choice of Discount Rate, Advanced Manufacturing Environment

LO3, LO6, LO7

Brindon Thayn, president and owner of Orangeville Metal Works, has just returned from a trip to Europe. While there, he toured several plants that use robotic manufacturing. Seeing the efficiency and success of these companies, Brindon became convinced that robotic manufacturing is essential for Orangeville to maintain its competitive position.

Based on this conviction, Brindon requested an analysis detailing the costs and benefits of robotic manufacturing for the materials handling and merchandising equipment group. This group of products consists of such items as cooler shelving, stocking carts, and bakery racks. The products are sold directly to supermarkets.

A committee, consisting of the controller, the marketing manager, and the production manager, was given the responsibility to prepare the analysis. As a starting point, the controller provided the following information on expected revenues and expenses for the existing manual system:

| | | *Percentage of Sales* |
|---|---|---|
| Sales | $400,000 | 100% |
| Less: Variable expenses[a] | 228,000 | 57 |
| Contribution margin | $172,000 | 43 |
| Less: Fixed expenses[b] | 92,000 | 23 |
| Income before income taxes | $ 80,000 | 20 |

[a]Variable cost detail (as a percentage of sales):

| | |
|---|---|
| Direct materials | 16% |
| Direct labor | 20 |
| Variable overhead | 9 |
| Variable selling | 12 |

[b]$20,000 is depreciation; the rest is cash expenses.

Given the current competitive environment, the marketing manager thought that the preceding level of profitability would not likely change for the next decade.

After some investigation into various robotic equipment, the committee settled on an Aide 900 system, a robot that has the capability to weld stainless steel or aluminum. It is capable of being programmed to adjust the path, angle, and speed of the torch. The production manager was excited about the robotic system because it would eliminate the need to hire welders. This was an attractive possibility because the market for welders seemed perpetually tight. By reducing the dependence on welders, better production scheduling and fewer late deliveries would result. Moreover, the robot's production rate is four times that of a person.

It was also discovered that robotic welding is superior in quality to manual welding. As a consequence, some of the costs of poor quality could be reduced. By providing better-quality products and avoiding late deliveries, the marketing manager was convinced that the company would have such a competitive edge that it would increase sales by 50 percent for the affected product group by the end of the fourth year. The marketing manager provided the following projections for the next 10 years, the useful life of the robotic equipment:

| | *Year 1* | *Year 2* | *Year 3* | *Years 4–10* |
|---|---|---|---|---|
| Sales | $400,000 | $450,000 | $500,000 | $600,000 |

Currently, the company employs four welders, who work 40 hours per week and 50 weeks per year at an average wage of $10 per hour. If the robot is acquired, it will need one operator, who will be paid $10 per hour. Because of improved quality, the robotic system will also reduce the cost of direct materials by 25 percent, the cost of variable overhead by 33.33 percent, and variable selling expenses by 10 percent. All of these reductions will take place immediately after the robotic system is in place and operating. Fixed costs will be increased by the depreciation associated with the robot. The robot will be depreciated using MACRS. (The manual system uses straight-line depreciation without a half-year convention and has a current book value of $200,000.) If the robotic system is acquired, the old system will be sold for $40,000.

The robotic system requires the following initial investment:

| | |
|---|---|
| Purchase price | $380,000 |
| Installation | 70,000 |
| Training | 30,000 |
| Engineering | 40,000 |

At the end of 10 years, the robot will have a salvage value of $20,000. Assume that the company's cost of capital is 12 percent. The tax rate is 40 percent.

**Required:**

1. Prepare a schedule of after-tax cash flows for the manual and robotic systems.
2. Using the schedule of cash flows computed in Requirement 1, compute the NPV for each system. Should the company invest in the robotic system?
3. In practice, many financial officers tend to use a higher discount rate than is justified by the firm's cost of capital. For example, a firm may use a discount rate of 20 percent when its cost of capital is or could be 12 percent. Offer some reasons for this practice. Assume that the annual after-tax cash benefit of adopting the robotic system is $80,000 per year more than the manual system. The initial outlay for the robotic system is $340,000. Compute the NPV using 12 percent and 20 percent. Would the robotic system be acquired if 20 percent is used? Could this conservative approach have a negative impact on a firm's ability to stay competitive?

## 20-25 Collaborative Learning Exercise

LO2, LO3, LO4

Peter Hennings, manager of the Cosmetics Division, had asked Laura Gibson, divisional controller and CMA, to meet with him regarding a recent analysis of a capital budgeting proposal. Peter was disappointed that the proposal had not met the company's minimum guidelines. Specifically, the company requires that all proposals show a positive net present value, have an IRR that exceeds the cost of capital (which is 11 percent), and have a payback period of less than five years. Funding for any new proposal had to be approved by company headquarters. Typically, proposals are approved if they meet the minimum guidelines and if the division's allocated share of the capital budget is not exhausted. The following conversation took place at their meeting:

**PETER:** Laura, I asked you to meet with me to discuss Proposal 678. Reviewing your analysis, I see that the NPV is negative and that the IRR is 9 percent. The payback is 5.5 years. In my opinion, the automated materials handling system in this proposal is an absolute must for this division. I feel that the consulting firm has underestimated the cash savings.

**LAURA:** I did some checking on my own because of your feelings about the matter. I called a friend who is an expert in the area and asked him to review the report on the system. After a careful review, he agreed with the report—in fact, he indicated that the savings were probably on the optimistic side.

**PETER:** Well, I don't agree. I know this business better than any of these so-called consulting experts. I think that the cash savings are significantly better than indicated.

**LAURA:** Why don't you explain this to headquarters? Perhaps they will allow an exception this time and fund the project.

**PETER:** No, that's unlikely. They're pretty strict when it comes to those guidelines, especially with the report from an outside consulting firm. I have a better idea, but I need your help. So far, you're the only one besides me who has seen the outside report. I think it is flawed. I would like to modify it so that it reflects my knowledge of the potential of the new system. Then, you can take the revised figures and prepare a new analysis for submission to headquarters. You need to tell me how much I need to revise the cash savings so that the project is viable. Although I am confident that the savings are significantly underestimated, I would prefer to revise them so that the minimum guidelines are slightly exceeded. Believe me, I will ensure that the project exceeds expectations once it's online.

**Required:**

Individually, read the ethical problem, and formulate answers to the following questions. Form groups of three or four. Each group member should write on a slip of paper the word TALK. This piece of paper is the Talking Chip. The Talking Chip is the ticket that allows a group member to speak. Group discussion begins with a volunteer. Discussion begins with Requirement 1 and moves to the next requirement only after all members have contributed to the discussion. After making his/her contribution, this person places the Talking Chip down in full view of the other members. Another person then contributes and subsequently places the Talking Chip down in full view. This continues until all members have contributed. Once all members have contributed, the chips can be retrieved and a second round of discussion can begin.

1. Evaluate the conduct of Peter Hennings. Are his suggestions unethical?
2. Suppose you were in Laura's position. What should you do?
3. Refer to the IMA code in Chapter 1. If Laura complies with Peter's request to modify the capital budgeting analysis, are any of the Standards of Ethical Conduct for Management Accountants violated? Which ones, if any?
4. Suppose that Laura tells Peter she will consider his request. She then meets with Jay Dixon, Peter's superior, and describes Peter's request. Upon hearing of the incident, Jay chuckles and says that he pulled a couple of stunts like that when he was a divisional manager. He tells Laura not to worry about it—to go ahead and support Peter—and assures her that he will keep her visit confidential. Given this development, what should Laura do?

## 20-26 Cyber Research Case

### Environmental Issues, Capital Budgeting

LO1, LO2, LO3, LO4, LO7

Capital budgeting for environmental projects offers an interesting area for additional study. The Environmental Protection Agency has partnered with Tellus Institute to further its ongoing interest in environmental cost management. All of the information relating to the U.S. EPA environmental accounting project is now incorporated in the Environmental Management Accounting International Web site (http://www.emawebsite.org). This new Web site deals with such topics as environmental cost definitions, decisions using environmental costs, and capital budgeting. The focus of the Web site is the use of environmental accounting as a management accounting tool of internal business decisions. Using this Web site and other sources that you can locate, answer the following questions:

1. What evidence exists that firms use the payback period for screening and evaluating environmental projects? If payback is used, can you find the most common hurdle rate that firms use to justify environmental projects?
2. Are NPV and IRR used for environmental project approval? Can you find out what the hurdle rate is for IRR? Do you think this hurdle rate is the cost of capital? If not, then discuss why a different required rate is used.
3. Do you think the approval thresholds for environmental projects tend to be higher, lower, or the same when compared to nonenvironmental projects? See if you can find any evidence to support your viewpoint. Why might the approval thresholds differ from nonenvironmental projects?
4. See if you can find a discussion on how capital budgeting for environmental projects may differ from that of conventional projects. List these differences.