CHAPTER 6

Making Investment Decisions with the Net Present Value Rule

In late 2003 Boeing announced its intention to produce and market the 787 Dreamliner. The decision committed Boeing and its partners to a $10 billion capital investment, involving 3 million square feet of additional facilities. If the technical glitches that have delayed production can be sorted out, it looks as if Boeing will earn a good return on this investment. As we write this in August 2009, Boeing has booked orders for 865 Dreamliners, making it one of the most successful aircraft launches in history.

How does a company, such as Boeing, decide to go ahead with the launch of a new airliner? We know the answer in principle. The company needs to forecast the project's cash flows and discount them at the opportunity cost of capital to arrive at the project's NPV. A project with a positive NPV increases shareholder value.

But those cash flow forecasts do not arrive on a silver platter. First, the company's managers need answers to a number of basic questions. How soon can the company get the plane into production? How many planes are likely to be sold each year and at what price? How much does the firm need to invest in new production facilities, and what is the likely production cost? How long will the model stay in production, and what happens to the plant and equipment at the end of that time?

These predictions need to be checked for completeness and accuracy, and then pulled together to produce a single set of cash-flow forecasts. That requires careful tracking of taxes, changes in working capital, inflation, and the end-of-project salvage values of plant, property, and equipment. The financial manager must also ferret out hidden cash flows and take care to reject accounting entries that look like cash flows but truly are not.

Our first task in this chapter is to look at how to develop a set of project cash flows. We will then work through a realistic and comprehensive example of a capital investment analysis.

We conclude the chapter by looking at how the financial manager should apply the present value rule when choosing between investment in plant and equipment with different economic lives. For example, suppose you must decide between machine Y with a 5-year useful life and Z with a 10-year life. The present value of Y's lifetime investment and operating costs is naturally less than Z's because Z will last twice as long. Does that necessarily make Y the better choice? Of course not. You will find that, when you are faced with this type of problem, the trick is to transform the present value of the cash flow into an *equivalent annual* flow, that is, the total cash per year from buying and operating the asset.

6-1 Applying the Net Present Value Rule

Many projects require a heavy initial outlay on new production facilities. But often the largest investments involve the acquisition of intangible assets. Consider, for example, the expenditure by major banks on information technology. These projects can soak up hundreds of millions of dollars. Yet much of the expenditure goes to intangibles such as system design, programming, testing, and training. Think also of the huge expenditure by pharmaceutical companies on research and development (R&D). Pfizer, one of the largest pharmaceutical companies, spent $7.9 billion on R&D in 2008. The R&D cost of bringing *one* new prescription drug to market has been estimated at $800 million.

Expenditures on intangible assets such as IT and R&D are investments just like expenditures on new plant and equipment. In each case the company is spending money today in the expectation that it will generate a stream of future profits. Ideally, firms should apply the same criteria to all capital investments, regardless of whether they involve a tangible or intangible asset.

We have seen that an investment in any asset creates wealth if the discounted value of the future cash flows exceeds the up-front cost. But up to this point we have glossed over the problem of *what* to discount. When you are faced with this problem, you should stick to three general rules:

1. Only cash flow is relevant.
2. Always estimate cash flows on an incremental basis.
3. Be consistent in your treatment of inflation.

We discuss each of these rules in turn.

Rule 1: Only Cash Flow Is Relevant

The first and most important point: Net present value depends on future cash flows. Cash flow is the simplest possible concept; it is just the difference between cash received and cash paid out. Many people nevertheless confuse cash flow with accounting income.

Income statements are intended to show how well the company is performing. Therefore, accountants *start* with "dollars in" and "dollars out," but to obtain accounting income they adjust these inputs in two ways. First, they try to show profit as it is *earned* rather than when the company and its customers get around to paying their bills. Second, they sort cash outflows into two categories: current expenses and capital expenses. They deduct current expenses when calculating income but do not deduct capital expenses. There is a good reason for this. If the firm lays out a large amount of money on a big capital project, you do not conclude that the firm is performing poorly, even though a lot of cash is going out the door. Therefore, the accountant does not deduct capital expenditure when calculating the year's income but, instead, depreciates it over several years.

As a result of these adjustments, income includes some cash flows and excludes others, and it is reduced by depreciation charges, which are not cash flows at all. It is not always easy to translate the customary accounting data back into actual dollars—dollars you can buy beer with. If you are in doubt about what is a cash flow, simply count the dollars coming in and take away the dollars going out. Don't assume without checking that you can find cash flow by routine manipulations of accounting data.

Always estimate cash flows on an after-tax basis. Some firms do not deduct tax payments. They try to offset this mistake by discounting the cash flows before taxes at a rate higher than the opportunity cost of capital. Unfortunately, there is no reliable formula for making such adjustments to the discount rate.

You should also make sure that cash flows are recorded *only when they occur* and not when work is undertaken or a liability is incurred. For example, taxes should be discounted from their actual payment date, not from the time when the tax liability is recorded in the firm's books.

Rule 2: Estimate Cash Flows on an Incremental Basis

The value of a project depends on *all* the additional cash flows that follow from project acceptance. Here are some things to watch for when you are deciding which cash flows to include:

Do Not Confuse Average with Incremental Payoffs Most managers naturally hesitate to throw good money after bad. For example, they are reluctant to invest more money in a losing division. But occasionally you will encounter turnaround opportunities in which the *incremental* NPV from investing in a loser is strongly positive.

Conversely, it does not always make sense to throw good money after good. A division with an outstanding past profitability record may have run out of good opportunities. You would not pay a large sum for a 20-year-old horse, sentiment aside, regardless of how many races that horse had won or how many champions it had sired.

Here is another example illustrating the difference between average and incremental returns: Suppose that a railroad bridge is in urgent need of repair. With the bridge the railroad can continue to operate; without the bridge it can't. In this case the payoff from the repair work consists of all the benefits of operating the railroad. The incremental NPV of such an investment may be enormous. Of course, these benefits should be net of all other costs and all subsequent repairs; otherwise the company may be misled into rebuilding an unprofitable railroad piece by piece.

Include All Incidental Effects It is important to consider a project's effects on the remainder of the firm's business. For example, suppose Sony proposes to launch PlayStation 4, a new version of its video game console. Demand for the new product will almost certainly cut into sales of Sony's existing consoles. This incidental effect needs to be factored into the incremental cash flows. Of course, Sony may reason that it needs to go ahead with the new product because its existing product line is likely to come under increasing threat from competitors. So, even if it decides not to produce the new PlayStation, there is no guarantee that sales of the existing consoles will continue at their present level. Sooner or later they will decline.

Sometimes a new project will *help* the firm's existing business. Suppose that you are the financial manager of an airline that is considering opening a new short-haul route from Peoria, Illinois, to Chicago's O'Hare Airport. When considered in isolation, the new route may have a negative NPV. But once you allow for the additional business that the new route brings to your other traffic out of O'Hare, it may be a very worthwhile investment.

Forecast Sales Today and Recognize After-Sales Cash Flows to Come Later Financial managers should forecast all incremental cash flows generated by an investment. Sometimes these incremental cash flows last for decades. When GE commits to the design and production of a new jet engine, the cash inflows come first from the sale of engines and then from service and spare parts. A jet engine will be in use for 30 years. Over that period revenues from service and spare parts will be roughly seven times the engine's purchase price. GE's revenue in 2008 from commercial engine services was $6.8 billion versus $5.2 billion from commercial engine sales.[1]

Many manufacturing companies depend on the revenues that come *after* their products are sold. The consulting firm Accenture estimates that services and parts typically account for about 25% of revenues and 50% of profits for industrial companies.

[1] P. Glader, "GE's Focus on Services Faces Test," *The Wall Street Journal,* March 3, 2009, p. B1. The following estimate from Accenture also comes from this article.

Do Not Forget Working Capital Requirements **Net working capital** (often referred to simply as *working capital*) is the difference between a company's short-term assets and liabilities. The principal short-term assets are accounts receivable (customers' unpaid bills) and inventories of raw materials and finished goods. The principal short-term liabilities are accounts payable (bills that *you* have not paid). Most projects entail an additional investment in working capital. This investment should, therefore, be recognized in your cash-flow forecasts. By the same token, when the project comes to an end, you can usually recover some of the investment. This is treated as a cash inflow. We supply a numerical example of working-capital investment later in this chapter.

Include Opportunity Costs The cost of a resource may be relevant to the investment decision even when no cash changes hands. For example, suppose a new manufacturing operation uses land that could otherwise be sold for $100,000. This resource is not free: It has an opportunity cost, which is the cash it could generate for the company if the project were rejected and the resource were sold or put to some other productive use.

This example prompts us to warn you against judging projects on the basis of "before versus after." The proper comparison is "with or without." A manager comparing before versus after might not assign any value to the land because the firm owns it both before and after:

Before	Take Project	After	Cash Flow, Before versus After
Firm owns land	→	Firm still owns land	0

The proper comparison, with or without, is as follows:

With	Take Project	After	Cash Flow, with Project
Firm owns land	→	Firm still owns land	0

Without	Do Not Take Project	After	Cash Flow, without Project
	→	Firm sells land for $100,000	$100,000

Comparing the two possible "afters," we see that the firm gives up $100,000 by undertaking the project. This reasoning still holds if the land will not be sold but is worth $100,000 to the firm in some other use.

Sometimes opportunity costs may be very difficult to estimate; however, where the resource can be freely traded, its opportunity cost is simply equal to the market price. Why? It cannot be otherwise. If the value of a parcel of land to the firm is less than its market price, the firm will sell it. On the other hand, the opportunity cost of using land in a particular project cannot exceed the cost of buying an equivalent parcel to replace it.

Forget Sunk Costs Sunk costs are like spilled milk: They are past and irreversible outflows. Because sunk costs are bygones, they cannot be affected by the decision to accept or reject the project, and so they should be ignored.

For example, when Lockheed sought a federal guarantee for a bank loan to continue development of the TriStar airplane, the company and its supporters argued it would be foolish to abandon a project on which nearly $1 billion had already been spent. Some of Lockheed's critics countered that it would be equally foolish to continue with a project that offered no prospect of a satisfactory return on that $1 billion. Both groups were guilty of the *sunk-cost fallacy;* the $1 billion was irrecoverable and, therefore, irrelevant.

Beware of Allocated Overhead Costs We have already mentioned that the accountant's objective is not always the same as the investment analyst's. A case in point is the allocation of overhead costs. Overheads include such items as supervisory salaries, rent, heat, and light. These overheads may not be related to any particular project, but they have to be paid for somehow. Therefore, when the accountant assigns costs to the firm's projects, a charge for overhead is usually made. Now our principle of incremental cash flows says that in investment appraisal we should include only the *extra* expenses that would result from the project. A project may generate extra overhead expenses; then again, it may not. We should be cautious about assuming that the accountant's allocation of overheads represents the true extra expenses that would be incurred.

Remember Salvage Value When the project comes to an end, you may be able to sell the plant and equipment or redeploy the assets elsewhere in the business. If the equipment is sold, you must pay tax on the difference between the sale price and the book value of the asset. The salvage value (net of any taxes) represents a positive cash flow to the firm.

Some projects have significant shut-down costs, in which case the final cash flows may be *negative*. For example, the mining company, FCX, has earmarked over $430 million to cover the future reclamation and closure costs of its New Mexico mines.

Rule 3: Treat Inflation Consistently

As we pointed out in Chapter 3, interest rates are usually quoted in *nominal* rather than *real* terms. For example, if you buy an 8% Treasury bond, the government promises to pay you $80 interest each year, but it does not promise what that $80 will buy. Investors take inflation into account when they decide what is an acceptable rate of interest.

If the discount rate is stated in nominal terms, then consistency requires that cash flows should also be estimated in nominal terms, taking account of trends in selling price, labor and materials costs, etc. This calls for more than simply applying a single assumed inflation rate to all components of cash flow. Labor costs per hour of work, for example, normally increase at a faster rate than the consumer price index because of improvements in productivity. Tax savings from depreciation do *not* increase with inflation; they are constant in nominal terms because tax law in the United States allows only the original cost of assets to be depreciated.

Of course, there is nothing wrong with discounting real cash flows at a real discount rate. In fact this is standard procedure in countries with high and volatile inflation. Here is a simple example showing that real and nominal discounting, properly applied, always give the same present value.

Suppose your firm usually forecasts cash flows in nominal terms and discounts at a 15% nominal rate. In this particular case, however, you are given project cash flows in real terms, that is, current dollars:

Real Cash Flows ($ thousands)			
C_0	C_1	C_2	C_3
−100	+35	+50	+30

It would be inconsistent to discount these real cash flows at the 15% nominal rate. You have two alternatives: Either restate the cash flows in nominal terms and discount at 15%, or restate the discount rate in real terms and use it to discount the real cash flows.

Assume that inflation is projected at 10% a year. Then the cash flow for year 1, which is $35,000 in current dollars, will be $35{,}000 \times 1.10 = \$38{,}500$ in year-1 dollars. Similarly the cash flow for year 2 will be $50{,}000 \times (1.10)^2 = \$60{,}500$ in year-2 dollars, and so on. If we discount these nominal cash flows at the 15% nominal discount rate, we have

$$\text{NPV} = -100 + \frac{38.5}{1.15} + \frac{60.5}{(1.15)^2} + \frac{39.9}{(1.15)^3} = 5.5, \text{ or } \$5{,}500$$

Instead of converting the cash-flow forecasts into nominal terms, we could convert the discount rate into real terms by using the following relationship:

$$\text{Real discount rate} = \frac{1 + \text{nominal discount rate}}{1 + \text{inflation rate}} - 1$$

In our example this gives

$$\text{Real discount rate} = \frac{1.15}{1.10} - 1 = .045, \text{ or } 4.5\%$$

If we now discount the real cash flows by the real discount rate, we have an NPV of $5,500, just as before:

$$\text{NPV} = -100 + \frac{35}{1.045} + \frac{50}{(1.045)^2} + \frac{30}{(1.045)^3} = 5.5, \text{ or } \$5{,}500$$

The message of all this is quite simple. Discount nominal cash flows at a nominal discount rate. Discount real cash flows at a real rate. *Never* mix real cash flows with nominal discount rates or nominal flows with real rates.

6-2 Example—IM&C's Fertilizer Project

As the newly appointed financial manager of International Mulch and Compost Company (IM&C), you are about to analyze a proposal for marketing guano as a garden fertilizer. (IM&C's planned advertising campaign features a rustic gentleman who steps out of a vegetable patch singing, "All my troubles have guano way.")[2]

You are given the forecasts shown in Table 6.1.[3] The project requires an investment of $10 million in plant and machinery (line 1). This machinery can be dismantled and sold for net proceeds estimated at $1.949 million in year 7 (line 1, column 7). This amount is your forecast of the plant's *salvage value.*

Whoever prepared Table 6.1 depreciated the capital investment over six years to an arbitrary salvage value of $500,000, which is less than your forecast of salvage value. *Straight-line depreciation* was assumed. Under this method annual depreciation equals a constant proportion of the initial investment less salvage value ($9.5 million). If we call the depreciable life T, then the straight-line depreciation in year t is

$$\text{Depreciation in year } t = 1/T \times \text{depreciable amount} = 1/6 \times 9.5 = \$1.583 \text{ million}$$

Lines 6 through 12 in Table 6.1 show a simplified income statement for the guano project.[4] This will be our starting point for estimating cash flow. All the entries in the table are nominal amounts. In other words, IM&C's managers have taken into account the likely effect of inflation on prices and costs.

[2] Sorry.

[3] "Live" Excel versions of Tables 6.1, 6.2, 6.4, 6.5, and 6.6 are available on the book's Web site, **www.mhhe.com/bma**.

[4] We have departed from the usual income-statement format by separating depreciation from costs of goods sold.

Table 6.2 derives cash-flow forecasts from the investment and income data given in Table 6.1. The project's net cash flow is the sum of three elements:

$$\begin{aligned}\text{Net cash flow} = {} & \text{cash flow from capital investment and disposal} \\ & + \text{cash flow from changes in working capital} \\ & + \text{operating cash flow}\end{aligned}$$

		Period							
		0	1	2	3	4	5	6	7
1	Capital investment	10,000							-1,949[a]
2	Accumulated depreciation		1,583	3,167	4,750	6,333	7,917	9,500	0
3	Year-end book value	10,000	8,417	6,833	5,250	3,667	2,083	500	0
4	Working capital		550	1,289	3,261	4,890	3,583	2,002	0
5	Total book value (3 + 4)		8,967	8,122	8,511	8,557	5,666	2,502	0
6	Sales		523	12,887	32,610	48,901	35,834	19,717	
7	Cost of goods sold[b]		837	7,729	19,552	29,345	21,492	11,830	
8	Other costs[c]	4,000	2,200	1,210	1,331	1,464	1,611	1,772	
9	Depreciation		1,583	1,583	1,583	1,583	1,583	1,583	0
10	Pretax profit (6 − 7 − 8 − 9)	−4,000	−4,097	2,365	10,144	16,509	11,148	4,532	1,449[d]
11	Tax at 35%	−1,400	−1,434	828	3,550	5,778	3,902	1,586	507
12	Profit after tax (10 − 11)	−2,600	−2,663	1,537	6,593	10,731	7,246	2,946	942

TABLE 6.1 IM&C's guano project—projections ($ thousands) reflecting inflation and assuming straight-line depreciation.

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[a] Salvage value.
[b] We have departed from the usual income-statement format by *not* including depreciation in cost of goods sold. Instead, we break out depreciation separately (see line 9).
[c] Start-up costs in years 0 and 1, and general and administrative costs in years 1 to 6.
[d] The difference between the salvage value and the ending book value of $500 is a taxable profit.

		Period							
		0	1	2	3	4	5	6	7
1	Capital investment and disposal	−10,000	0	0	0	0	0	0	1,442[a]
2	Change in working capital		−550	−739	−1,972	−1,629	1,307	1,581	2,002
3	Sales	0	523	12,887	32,610	48,901	35,834	19,717	0
4	Cost of goods sold	0	837	7,729	19,552	29,345	21,492	11,830	0
5	Other costs	4,000	2,200	1,210	1,331	1,464	1,611	1,772	0
6	Tax	−1,400	−1,434	828	3,550	5,778	3,902	1,586	
7	Operating cash flow (3 − 4 − 5 − 6)	−2,600	−1,080	3,120	8,177	12,314	8,829	4,529	
8	Net cash flow (1 + 2 + 7)	−12,600	−1,630	2,381	6,205	10,685	10,136	6,110	3,444
9	Present value at 20%	−12,600	−1,358	1,654	3,591	5,153	4,074	2,046	961
10	Net present value =	+3,520	(sum of 9)						

TABLE 6.2 IM&C's guano project—initial cash-flow analysis assuming straight-line depreciation ($ thousands).

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[a] Salvage value of $1,949 less tax of $507 on the difference between salvage value and ending book value.

Each of these items is shown in the table. Row 1 shows the initial capital investment and the estimated salvage value of the equipment when the project comes to an end. If, as you expect, the salvage value is higher than the depreciated value of the machinery, you will have to pay tax on the difference. So the salvage value in row 1 is shown after payment of this tax. Row 2 of the table shows the changes in working capital, and the remaining rows calculate the project's operating cash flows.

Notice that in calculating the operating cash flows we did not deduct depreciation. Depreciation is an accounting entry. It affects the tax that the company pays, but the firm does not send anyone a check for depreciation. The operating cash flow is simply the dollars coming in less the dollars going out:[5]

$$\text{Operating cash flow} = \text{revenues} - \text{cash expenses} - \text{taxes}$$

For example, in year 6 of the guano project:

$$\text{Operating cash flow} = 19{,}717 - (11{,}830 + 1{,}772) - 1{,}586 = 4{,}529$$

IM&C estimates the nominal opportunity cost of capital for projects of this type as 20%. When all cash flows are added up and discounted, the guano project is seen to offer a net present value of about \$3.5 million:

$$\text{NPV} = -12{,}600 - \frac{1{,}630}{1.20} + \frac{2{,}381}{(1.20)^2} + \frac{6{,}205}{(1.20)^3} + \frac{10{,}685}{(1.20)^4} + \frac{10{,}136}{(1.20)^5}$$
$$+ \frac{6{,}110}{(1.20)^6} + \frac{3{,}444}{(1.20)^7} = +3{,}520, \text{ or } \$3{,}520{,}000$$

Separating Investment and Financing Decisions

Our analysis of the guano project takes no notice of how that project is financed. It may be that IM&C will decide to finance partly by debt, but if it does we will not subtract the debt proceeds from the required investment, nor will we recognize interest and principal payments as cash outflows. We analyze the project as if it were all-equity-financed, treating all cash outflows as coming from stockholders and all cash inflows as going to them.

We approach the problem in this way so that we can separate the analysis of the investment decision from the financing decision. But this does not mean that the financing decision can be ignored. We explain in Chapter 19 how to recognize the effect of financing choices on project values.

Investments in Working Capital

Now here is an important point. You can see from line 2 of Table 6.2 that working capital increases in the early and middle years of the project. What is working capital, you may ask, and why does it increase?

Working capital summarizes the net investment in short-term assets associated with a firm, business, or project. Its most important components are *inventory, accounts receivable,*

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[5] There are several alternative ways to calculate operating cash flow. For example, you can add depreciation back to the after-tax profit:

$$\text{Operating cash flow} = \text{after-tax profit} + \text{depreciation}$$

Thus, in year 6 of the guano project:

$$\text{Operating cash flow} = 2{,}946 + 1{,}583 = 4{,}529$$

Another alternative is to calculate after-tax profit assuming *no* depreciation, and then to add back the tax saving provided by the depreciation allowance:

$$\text{Operating cash flow} = (\text{revenues} - \text{expenses}) \times (1 - \text{tax rate}) + (\text{depreciation} \times \text{tax rate})$$

Thus, in year 6 of the guano project:

$$\text{Operating cash flow} = (19{,}717 - 11{,}830 - 1{,}772) \times (1 - .35) + (1{,}583 \times .35) = 4{,}529$$

and *accounts payable*. The guano project's requirements for working capital in year 2 might be as follows:

Working capital	=	inventory	+	accounts receivable	−	accounts payable
$1,289	=	635	+	1,030	−	376

Why does working capital increase? There are several possibilities:

1. Sales recorded on the income statement overstate actual cash receipts from guano shipments because sales are increasing and customers are slow to pay their bills. Therefore, accounts receivable increase.

2. It takes several months for processed guano to age properly. Thus, as projected sales increase, larger inventories have to be held in the aging sheds.

3. An offsetting effect occurs if payments for materials and services used in guano production are delayed. In this case accounts payable will increase.

The additional investment in working capital from year 2 to 3 might be

Additional investment in working capital	=	increase in inventory	+	increase in accounts receivable	−	increase in accounts payable
$1,972	=	972	+	1,500	−	500

A more detailed cash-flow forecast for year 3 would look like Table 6.3.

Working capital is one of the most common sources of confusion in estimating project cash flows. Here are the most common mistakes:

1. *Forgetting about working capital entirely.* We hope you never fall into that trap.

2. *Forgetting that working capital may change during the life of the project.* Imagine that you sell $100,000 of goods one year and that customers pay six months late. You will therefore have $50,000 of unpaid bills. Now you increase prices by 10%, so revenues increase to $110,000. If customers continue to pay six months late, unpaid bills increase to $55,000, and therefore you need to make an *additional* investment in working capital of $5,000.

3. *Forgetting that working capital is recovered at the end of the project.* When the project comes to an end, inventories are run down, any unpaid bills are paid off (you hope) and you recover your investment in working capital. This generates a cash *inflow.*

There is an alternative to worrying about changes in working capital. You can estimate cash flow directly by counting the dollars coming in from customers and deducting the dollars

Cash Flows		Data from Forecasted Income Statement		Working-Capital Changes
Cash inflow	=	Sales	−	Increase in accounts receivable
$31,110	=	32,610	−	1,500
Cash outflow	=	Cost of goods sold, other costs, and taxes	+	Increase in inventory net of increase in accounts payable
$24,905	=	(19,552 + 1,331 + 3,550)	+	(972 − 500)
		Net cash flow = cash inflow − cash outflow $6,205 = 31,110 − 24,905		

TABLE 6.3 Details of cash-flow forecast for IM&C's guano project in year 3 ($ thousands).

going out to suppliers. You would also deduct all cash spent on production, including cash spent for goods held in inventory. In other words,

1. If you replace each year's sales with that year's cash payments received from customers, you don't have to worry about accounts receivable.
2. If you replace cost of goods sold with cash payments for labor, materials, and other costs of production, you don't have to keep track of inventory or accounts payable.

However, you would still have to construct a projected income statement to estimate taxes.

We discuss the links between cash flow and working capital in much greater detail in Chapter 30.

A Further Note on Depreciation

Depreciation is a noncash expense; it is important only because it reduces taxable income. It provides an annual *tax shield* equal to the product of depreciation and the marginal tax rate:

$$\begin{aligned}\text{Tax shield} &= \text{depreciation} \times \text{tax rate} \\ &= 1{,}583 \times .35 = 554, \text{ or } \$554{,}000\end{aligned}$$

The present value of the tax shields ($554,000 for six years) is $1,842,000 at a 20% discount rate.

Now if IM&C could just get those tax shields sooner, they would be worth more, right? Fortunately tax law allows corporations to do just that: It allows *accelerated depreciation.*

The current rules for tax depreciation in the United States were set by the Tax Reform Act of 1986, which established a Modified Accelerated Cost Recovery System (MACRS). Table 6.4 summarizes the tax depreciation schedules. Note that there are six schedules, one for each recovery period class. Most industrial equipment falls into the five- and seven-year classes. To keep things simple, we assume that all the guano project's investment goes into five-year assets. Thus, IM&C can write off 20% of its depreciable investment in year 1, as soon as the assets are placed in service, then 32% of depreciable investment in year 2, and so on. Here are the tax shields for the guano project:

	Year					
	1	2	3	4	5	6
Tax depreciation (MACRS percentage × depreciable investment)	2,000	3,200	1,920	1,152	1,152	576
Tax shield (tax depreciation × tax rate, $T_c = .35$)	700	1,120	672	403	403	202

The present value of these tax shields is $2,174,000, about $331,000 higher than under the straight-line method.

Table 6.5 recalculates the guano project's impact on IM&C's future tax bills, and Table 6.6 shows revised after-tax cash flows and present value. This time we have incorporated realistic assumptions about taxes as well as inflation. We arrive at a higher NPV than in Table 6.2, because that table ignored the additional present value of accelerated depreciation.

There is one possible additional problem lurking in the woodwork behind Table 6.5: In the United States there is an *alternative minimum tax,* which can limit or defer the tax shields of accelerated depreciation or other *tax preference* items. Because the alternative minimum tax can be a motive for leasing, we discuss it in Chapter 25, rather than here. But make a mental note not to sign off on a capital budgeting analysis without checking whether your company is subject to the alternative minimum tax.

	Tax Depreciation Schedules by Recovery-Period Class						
	Year(s)	3-year	5-year	7-year	10-year	15-year	20-year
1	1	33.33	20.00	14.29	10.00	5.00	3.75
2	2	44.45	32.00	24.49	18.00	9.50	7.22
3	3	14.81	19.20	17.49	14.40	8.55	6.68
4	4	7.41	11.52	12.49	11.52	7.70	6.18
5	5		11.52	8.93	9.22	6.93	5.71
6	6		5.76	8.92	7.37	6.23	5.28
7	7			8.93	6.55	5.90	4.89
8	8			4.46	6.55	5.90	4.52
9	9				6.56	5.91	4.46
10	10				6.55	5.90	4.46
11	11				3.28	5.91	4.46
12	12					5.90	4.46
13	13					5.91	4.46
14	14					5.90	4.46
15	15					5.91	4.46
16	16					2.95	4.46
17	17-20						4.46
18	21						2.23

TABLE 6.4 Tax depreciation allowed under the modified accelerated cost recovery system (MACRS) (figures in percent of depreciable investment).

Notes:

1. Tax depreciation is lower in the first and last years because assets are assumed to be in service for only six months.
2. Real property is depreciated straight-line over 27.5 years for residential property and 39 years for nonresidential property.

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		Period							
		0	1	2	3	4	5	6	7
1	Sales[a]		523	12,887	32,610	48,901	35,834	19,717	
2	Cost of goods sold[a]		837	7,729	19,552	29,345	21,492	11,830	
3	Other costs[a]	4,000	2,200	1,210	1,331	1,464	1,611	1,772	
4	Tax depreciation		2,000	3,200	1,920	1,152	1,152	576	
5	Pretax profit (1 − 2 − 3 − 4)	−4,000	−4,514	748	9,807	16,940	11,579	5,539	1,949[b]
6	Tax at 35%[c]	−1,400	−1,580	262	3,432	5,929	4,053	1,939	682

TABLE 6.5 Tax payments on IM&C's guano project ($ thousands).

[a] From Table 6.1.
[b] Salvage value is zero, for tax purposes, after all tax depreciation has been taken. Thus, IM&C will have to pay tax on the full salvage value of $1,949.
[c] A negative tax payment means a cash *inflow,* assuming IM&C can use the tax loss on its guano project to shield income from other projects.

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A Final Comment on Taxes

All large U.S. corporations keep two separate sets of books, one for stockholders and one for the Internal Revenue Service. It is common to use straight-line depreciation on the stockholder books and accelerated depreciation on the tax books. The IRS doesn't object to this, and it makes the firm's reported earnings higher than if accelerated depreciation were used everywhere. There are many other differences between tax books and shareholder books.[6]

[6] This separation of tax accounts from shareholder accounts is not found worldwide. In Japan, for example, taxes reported to shareholders must equal taxes paid to the government; ditto for France and many other European countries.

		Period							
		0	1	2	3	4	5	6	7
1	Capital investment and disposal	−10,000	0	0	0	0	0	0	1,949
2	Change in working capital		−550	−739	−1,972	−1,629	1,307	1,581	2,002
3	Sales[a]	0	523	12,887	32,610	48,901	35,834	19,717	0
4	Cost of goods sold[a]	0	837	7,729	19,552	29,345	21,492	11,830	0
5	Other costs[a]	4,000	2,200	1,210	1,331	1,464	1,611	1,772	0
6	Tax[b]	−1,400	−1,580	262	3,432	5,929	4,053	1,939	682
7	Operating cash flow (3 − 4 − 5 − 6)	−2,600	−934	3,686	8,295	12,163	8,678	4,176	−682
8	Net cash flow (1 + 2 + 7)	−12,600	−1,484	2,947	6,323	10,534	9,985	5,757	3,269
9	Present value at 20%	−12,600	−1,237	2,047	3,659	5,080	4,013	1,928	912
10	Net present value =	3,802	(sum of 9)						

TABLE 6.6 IM&C's guano project—revised cash-flow analysis ($ thousands).

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[a] From Table 6.1.
[b] From Table 6.5.

The financial analyst must be careful to remember which set of books he or she is looking at. In capital budgeting only the tax books are relevant, but to an outside analyst only the shareholder books are available.

Project Analysis

Let us review. Several pages ago, you embarked on an analysis of IM&C's guano project. You started with a simplified statement of assets and income for the project that you used to develop a series of cash-flow forecasts. Then you remembered accelerated depreciation and had to recalculate cash flows and NPV.

You were lucky to get away with just two NPV calculations. In real situations, it often takes several tries to purge all inconsistencies and mistakes. Then you may want to analyze some alternatives. For example, should you go for a larger or smaller project? Would it be better to market the fertilizer through wholesalers or directly to the consumer? Should you build 90,000-square-foot aging sheds for the guano in northern South Dakota rather than the planned 100,000-square-foot sheds in southern North Dakota? In each case your choice should be the one offering the highest NPV. Sometimes the alternatives are not immediately obvious. For example, perhaps the plan calls for two costly high-speed packing lines. But, if demand for guano is seasonal, it may pay to install just one high-speed line to cope with the base demand and two slower but cheaper lines simply to cope with the summer rush. You won't know the answer until you have compared NPVs.

You will also need to ask some "what if" questions. How would NPV be affected if inflation rages out of control? What if technical problems delay start-up? What if gardeners prefer chemical fertilizers to your natural product? Managers employ a variety of techniques to develop a better understanding of how such unpleasant surprises could damage NPV. For example, they might undertake a *sensitivity analysis,* in which they look at how far the project could be knocked off course by bad news about one of the variables. Or they might construct different *scenarios* and estimate the effect of each on NPV. Another technique, known as *break-even analysis*, is to explore how far sales could fall short of forecast before the project went into the red.

In Chapter 10 we practice using each of these "what if" techniques. You will find that project analysis is much more than one or two NPV calculations.[7]

Calculating NPV in Other Countries and Currencies

Our guano project was undertaken in the United States by a U.S. company. But the principles of capital investment are the same worldwide. For example, suppose that you are the financial manager of the German company, K.G.R. Ökologische Naturdüngemittel GmbH (KGR), that is faced with a similar opportunity to make a €10 million investment in Germany. What changes?

1. KGR must also produce a set of cash-flow forecasts, but in this case the project cash flows are stated in euros, the Eurozone currency.
2. In developing these forecasts, the company needs to recognize that prices and costs will be influenced by the German inflation rate.
3. Profits from KGR's project are liable to the German rate of corporate tax.
4. KGR must use the German system of depreciation allowances. In common with many other countries, Germany allows firms to choose between two methods of depreciation—the straight-line system and the declining-balance system. KGR opts for the declining-balance method and writes off 30% of the depreciated value of the equipment each year (the maximum allowed under current German tax rules). Thus, in the first year KGR writes off $.30 \times 10 =$ €3 million and the written-down value of the equipment falls to $10 - 3 =$ €7 million. In year 2, KGR writes off $.30 \times 7 =$ €2.1 million and the written-down value is further reduced to $7 - 2.1 =$ €4.9 million. In year 4 KGR observes that depreciation would be higher if it could switch to straight-line depreciation and write off the balance of €3.43 million over the remaining three years of the equipment's life. Fortunately, German tax law allows it to do this. Therefore, KGR's depreciation allowance each year is calculated as follows:

	Year					
	1	2	3	4	5	6
Written-down value, start of year (€ millions)	10	7	4.9	3.43	2.29	1.14
Depreciation (€ millions)	$.3 \times 10$ $= 3$	$.3 \times 7$ $= 2.1$	$.3 \times 4.9$ $= 1.47$	3.43/3 $= 1.14$	3.43/3 $= 1.14$	3.43/3 $= 1.14$
Written-down value, end of year (€ millions)	$10 - 3$ $= 7$	$7 - 2.1$ $= 4.9$	$4.9 - 1.47$ $= 3.43$	$3.43 - 1.14$ $= 2.29$	$2.29 - 1.14$ $= 1.14$	$1.14 - 1.14$ $= 0$

Notice that KGR's depreciation deduction declines for the first few years and then flattens out. That is also the case with the U.S. MACRS system of depreciation. In fact, MACRS is just another example of the declining-balance method with a later switch to straight-line.

[7] In the meantime you might like to get ahead of the game by viewing the live spreadsheets for the guano project and seeing how NPV would change with a shortfall in sales or an unexpected rise in costs.

6-3 Investment Timing

The fact that a project has a positive NPV does not mean that it is best undertaken now. It might be even more valuable if undertaken in the future.

The question of optimal timing is not difficult when the cash flows are certain. You must first examine alternative start dates (t) for the investment and calculate the net *future* value at each of these dates. Then, to find which of the alternatives would add most to the firm's *current* value, you must discount these net future values back to the present:

$$\text{Net present value of investment if undertaken at date } t = \frac{\text{Net future value at date } t}{(1 + r)^t}$$

For example, suppose you own a large tract of inaccessible timber. To harvest it, you have to invest a substantial amount in access roads and other facilities. The longer you wait, the higher the investment required. On the other hand, lumber prices will rise as you wait, and the trees will keep growing, although at a gradually decreasing rate.

Let us suppose that the net present value of the harvest at different *future* dates is as follows:

	Year of Harvest					
	0	**1**	**2**	**3**	**4**	**5**
Net *future* value ($ thousands)	50	64.4	77.5	89.4	100	109.4
Change in value from previous year (%)		+28.8	+20.3	+15.4	+11.9	+9.4

As you can see, the longer you defer cutting the timber, the more money you will make. However, your concern is with the date that maximizes the net *present* value of your investment, that is, its contribution to the value of your firm *today*. You therefore need to discount the net future value of the harvest back to the present. Suppose the appropriate discount rate is 10%. Then, if you harvest the timber in year 1, it has a net *present* value of \$58,500:

$$\text{NPV if harvested in year 1} = \frac{64.4}{1.10} = 58.5, \text{ or } \$58{,}500$$

The net present value for other harvest dates is as follows:

	Year of Harvest					
	0	**1**	**2**	**3**	**4**	**5**
Net present value ($ thousands)	50	58.5	64.0	67.2	68.3	67.9

The optimal point to harvest the timber is year 4 because this is the point that maximizes NPV.

Notice that before year 4 the net future value of the timber increases by more than 10% a year: The gain in value is greater than the cost of the capital tied up in the project. After year

4 the gain in value is still positive but less than the cost of capital. So delaying the harvest further just reduces shareholder wealth.[8]

The investment-timing problem is much more complicated when you are unsure about future cash flows. We return to the problem of investment timing under uncertainty in Chapters 10 and 22.

6-4 Equivalent Annual Cash Flows

When you calculate NPV, you transform future, year-by-year cash flows into a lump-sum value expressed in today's dollars (or euros, or other relevant currency). But sometimes it's helpful to reverse the calculation, transforming an investment today into an equivalent stream of future cash flows. Consider the following example.

Investing to Produce Reformulated Gasoline at California Refineries

In the early 1990s, the California Air Resources Board (CARB) started planning its "Phase 2" requirements for reformulated gasoline (RFG). RFG is gasoline blended to tight specifications designed to reduce pollution from motor vehicles. CARB consulted with refiners, environmentalists, and other interested parties to design these specifications.

As the outline for the Phase 2 requirements emerged, refiners realized that substantial capital investments would be required to upgrade California refineries. What might these investments mean for the retail price of gasoline? A refiner might ask: "Suppose my company invests $400 million to upgrade our refinery to meet Phase 2. How much extra revenue would we need every year to recover that cost?" Let's see if we can help the refiner out.

Assume $400 million of capital investment and a real (inflation-adjusted) cost of capital of 7%. The new equipment lasts for 25 years, and does not change raw-material and operating costs.

How much additional revenue does it take to cover the $400 million investment? The answer is simple: Just find the 25-year annuity payment with a present value equal to $400 million.

$$\text{PV of annuity} = \text{annuity payment} \times \text{25-year annuity factor}$$

At a 7% cost of capital, the 25-year annuity factor is 11.65.

$$\begin{aligned} \$400 \text{ million} &= \text{annuity payment} \times 11.65 \\ \text{Annuity payment} &= \$34.3 \text{ million per year}^{9} \end{aligned}$$

[8] Our timber-cutting example conveys the right idea about investment timing, but it misses an important practical point: The sooner you cut the first crop of trees, the sooner the second crop can start growing. Thus, the value of the second crop depends on when you cut the first. The more complex and realistic problem can be solved in one of two ways:

1. Find the cutting dates that maximize the present value of a series of harvests, taking into account the different growth rates of young and old trees.
2. Repeat our calculations, counting the future market value of cut-over land as part of the payoff to the first harvest. The value of cut-over land includes the present value of all subsequent harvests.

The second solution is far simpler if you can figure out what cut-over land will be worth.

[9] For simplicity we have ignored taxes. Taxes would enter this calculation in two ways. First, the $400 million investment would generate depreciation tax shields. The easiest way to handle these tax shields is to calculate their PV and subtract it from the initial outlay. For example, if the PV of depreciation tax shields is $83 million, equivalent annual cost would be calculated on an after-tax investment base of $400 − 83 = $317 million. Second, our annuity payment is after-tax. To actually achieve after-tax revenues of, say, $34.3 million, the refiner would have to achieve pretax revenue sufficient to pay tax and have $34.3 million left over. If the tax rate is 35%, the required pretax revenue is 34.3/(1 − .35) = $52.8 million. Note how the after-tax figure is "grossed up" by dividing by one minus the tax rate.

This annuity is called an **equivalent annual cash flow.** It is the annual cash flow sufficient to recover a capital investment, including the cost of capital for that investment, over the investment's economic life. In our example the refiner would need to generate an extra $34.3 million for each of the next 25 years to recover the initial investment of $400 million.

Equivalent annual cash flows are handy—and sometimes essential—tools of finance. Here is a further example.

Choosing between Long- and Short-Lived Equipment

Suppose the firm is forced to choose between two machines, A and B. The two machines are designed differently but have identical capacity and do exactly the same job. Machine A costs $15,000 and will last three years. It costs $5,000 per year to run. Machine B is an economy model costing only $10,000, but it will last only two years and costs $6,000 per year to run. These are real cash flows: the costs are forecasted in dollars of constant purchasing power.

Because the two machines produce exactly the same product, the only way to choose between them is on the basis of cost. Suppose we compute the present value of cost:

Costs ($ thousands)					
Machine	C_0	C_1	C_2	C_3	**PV at 6% ($ thousands)**
A	+15	+5	+5	+5	28.37
B	+10	+6	+6		21.00

Should we take machine B, the one with the lower present value of costs? Not necessarily, because B will have to be replaced a year earlier than A. In other words, the timing of a future investment decision depends on today's choice of A or B.

So, a machine with total PV(costs) of $21,000 spread over three years (0, 1, and 2) is not necessarily better than a competing machine with PV(costs) of $28,370 spread over four years (0 through 3). We have to convert total PV(costs) to a cost per year, that is, to an equivalent annual cost. For machine A, the annual cost turns out to be 10.61, or $10,610 per year:

Costs ($ thousands)					
Machine	C_0	C_1	C_2	C_3	**PV at 6% ($ thousands)**
Machine A	+15	+5	+5	+5	28.37
Equivalent annual cost		+10.61	+10.61	+10.61	28.37

We calculated the equivalent annual cost by finding the three-year annuity with the same present value as A's lifetime costs.

$$\begin{aligned}\text{PV of annuity} &= \text{PV of A's costs} = 28.37\\ &= \text{annuity payment} \times \text{3-year annuity factor}\end{aligned}$$

The annuity factor is 2.673 for three years and a 6% real cost of capital, so

$$\text{Annuity payment} = \frac{28.37}{2.673} = 10.61$$

A similar calculation for machine B gives:

Costs ($ thousands)				
	C_0	C_1	C_2	**PV at 6% ($ thousands)**
Machine B	+10	+6	+6	21.00
Equivalent annual cost		+11.45	+11.45	21.00

Machine A is better, because its equivalent annual cost is less ($10,610 versus $11,450 for machine B).

You can think of the equivalent annual cost of machine A or B as an annual rental charge. Suppose the financial manager is asked to *rent* machine A to the plant manager actually in charge of production. There will be three equal rental payments starting in year 1. The three payments must recover both the original cost of machine A in year 0 and the cost of running it in years 1 to 3. Therefore the financial manager has to make sure that the rental payments are worth $28,370, the total PV(costs) of machine A. You can see that the financial manager would calculate a fair rental payment equal to machine A's equivalent annual cost.

Our rule for choosing between plant and equipment with different economic lives is, therefore, to select the asset with the lowest fair rental charge, that is, the lowest equivalent annual cost.

Equivalent Annual Cash Flow and Inflation

The equivalent annual costs we just calculated are *real* annuities based on forecasted *real* costs and a 6% *real* discount rate. We could, of course, restate the annuities in nominal terms. Suppose the expected inflation rate is 5%; we multiply the first cash flow of the annuity by 1.05, the second by $(1.05)^2 = 1.1025$, and so on.

		C_0	C_1	C_2	C_3
A	Real annuity		10.61	10.61	10.61
	Nominal cash flow		11.14	11.70	12.28
B	Real annuity		11.45	11.45	
	Nominal cash flow		12.02	12.62	

Note that B is still inferior to A. Of course the present values of the nominal and real cash flows are identical. Just remember to discount the real annuity at the real rate and the equivalent nominal cash flows at the consistent nominal rate.[10]

When you use equivalent annual costs simply for comparison of costs per period, as we did for machines A and B, we strongly recommend doing the calculations in real terms.[11] But if you actually rent out the machine to the plant manager, or anyone else, be careful to specify that the rental payments be "indexed" to inflation. If inflation runs on at 5% per year and rental payments do not increase proportionally, then the real value of the rental payments must decline and will not cover the full cost of buying and operating the machine.

Equivalent Annual Cash Flow and Technological Change

So far we have the following simple rule: Two or more streams of cash outflows with different lengths or time patterns can be compared by converting their present values to equivalent annual cash flows. Just remember to do the calculations in real terms.

Now any rule this simple cannot be completely general. For example, when we evaluated machine A versus machine B, we implicitly assumed that their fair rental charges would *continue* at $10,610 versus $11,450. This will be so only if the *real* costs of buying and operating the machines stay the same.

[10] The nominal discount rate is

$$\begin{aligned} r_{\text{nominal}} &= (1 + r_{\text{real}})(1 + \text{inflation rate}) - 1 \\ &= (1.06)(1.05) - 1 = .113, \text{ or } 11.3\% \end{aligned}$$

Discounting the nominal annuities at this rate gives the same present values as discounting the real annuities at 6%.

[11] Do *not* calculate equivalent annual cash flows as level *nominal* annuities. This procedure can give incorrect rankings of true equivalent annual flows at high inflation rates. See Challenge Question 32 at the end of this chapter for an example.

Suppose that this is not the case. Suppose that thanks to technological improvements new machines each year cost 20% less in real terms to buy and operate. In this case future owners of brand-new, lower-cost machines will be able to cut their rental cost by 20%, and owners of old machines will be forced to match this reduction. Thus, we now need to ask: if the real level of rents declines by 20% a year, how much will it cost to rent each machine?

If the rent for year 1 is rent_1, rent for year 2 is $\text{rent}_2 = .8 \times \text{rent}_1$. Rent_3 is $.8 \times \text{rent}_2$, or $.64 \times \text{rent}_1$. The owner of each machine must set the rents sufficiently high to recover the present value of the costs. In the case of machine A,

$$\text{PV of renting machine A} = \frac{\text{rent}_1}{1.06} + \frac{\text{rent}_2}{(1.06)^2} + \frac{\text{rent}_3}{(1.06)^3} = 28.37$$

$$= \frac{\text{rent}_1}{1.06} + \frac{.8(\text{rent}_1)}{(1.06)^2} + \frac{.64(\text{rent}_1)}{(1.06)^3} = 28.37$$

$$\text{rent}_1 = 12.94, \text{ or } \$12{,}940$$

For machine B,

$$\text{PV of renting machine B} = \frac{\text{rent}_1}{1.06} + \frac{.8(\text{rent}_1)}{(1.06)^2} = 21.00$$

$$\text{rent}_1 = 12.69, \text{ or } \$12{,}690$$

The merits of the two machines are now reversed. Once we recognize that technology is expected to reduce the real costs of new machines, then it pays to buy the shorter-lived machine B rather than become locked into an aging technology with machine A in year 3.

You can imagine other complications. Perhaps machine C will arrive in year 1 with an even lower equivalent annual cost. You would then need to consider scrapping or selling machine B at year 1 (more on this decision below). The financial manager could not choose between machines A and B in year 0 without taking a detailed look at what each machine could be replaced with.

Comparing equivalent annual cash flow should never be a mechanical exercise; always think about the assumptions that are implicit in the comparison. Finally, remember why equivalent annual cash flows are necessary in the first place. The reason is that A and B will be replaced at different future dates. The choice between them therefore affects future investment decisions. If subsequent decisions are not affected by the initial choice (for example, because neither machine will be replaced) then we do *not need to take future decisions into account.*[12]

Equivalent Annual Cash Flow and Taxes We have not mentioned taxes. But you surely realized that machine A and B's lifetime costs should be calculated after-tax, recognizing that operating costs are tax-deductible and that capital investment generates depreciation tax shields.

Deciding When to Replace an Existing Machine

The previous example took the life of each machine as fixed. In practice the point at which equipment is replaced reflects economic considerations rather than total physical collapse. *We* must decide when to replace. The machine will rarely decide for us.

Here is a common problem. You are operating an elderly machine that is expected to produce a net cash *inflow* of $4,000 in the coming year and $4,000 next year. After that it

[12] However, if neither machine will be replaced, then we have to consider the extra revenue generated by machine A in its third year, when it will be operating but B will not.

will give up the ghost. You can replace it now with a new machine, which costs $15,000 but is much more efficient and will provide a cash inflow of $8,000 a year for three years. You want to know whether you should replace your equipment now or wait a year.

We can calculate the NPV of the new machine and also its *equivalent annual cash flow,* that is, the three-year annuity that has the same net present value:

Cash Flows ($ thousands)					
	C_0	C_1	C_2	C_3	NPV at 6% ($ thousands)
New machine	− 15	+8	+8	+8	6.38
Equivalent annual cash flow		+2.387	+2.387	+2.387	6.38

In other words, the cash flows of the new machine are equivalent to an annuity of $2,387 per year. So we can equally well ask at what point we would want to replace our old machine with a new one producing $2,387 a year. When the question is put this way, the answer is obvious. As long as your old machine can generate a cash flow of $4,000 a year, who wants to put in its place a new one that generates only $2,387 a year?

It is a simple matter to incorporate salvage values into this calculation. Suppose that the current salvage value is $8,000 and next year's value is $7,000. Let us see where you come out next year if you wait and then sell. On one hand, you gain $7,000, but you lose today's salvage value *plus* a year's return on that money. That is, $8{,}000 \times 1.06 = \$8{,}480$. Your net loss is $8{,}480 - 7{,}000 = \$1{,}480$, which only partly offsets the operating gain. You should not replace yet.

Remember that the logic of such comparisons requires that the new machine be the best of the available alternatives and that it in turn be replaced at the optimal point.

Cost of Excess Capacity Any firm with a centralized information system (computer servers, storage, software, and telecommunication links) encounters many proposals for using it. Recently installed systems tend to have excess capacity, and since the immediate marginal costs of using them seem to be negligible, management often encourages new uses. Sooner or later, however, the load on a system increases to the point at which management must either terminate the uses it originally encouraged or invest in another system several years earlier than it had planned. Such problems can be avoided if a proper charge is made for the use of spare capacity.

Suppose we have a new investment project that requires heavy use of an existing information system. The effect of adopting the project is to bring the purchase date of a new, more capable system forward from year 4 to year 3. This new system has a life of five years, and at a discount rate of 6% the present value of the cost of buying and operating it is $500,000.

We begin by converting the $500,000 present value of the cost of the new system to an equivalent annual cost of $118,700 for each of five years.[13] Of course, when the new system in turn wears out, we will replace it with another. So we face the prospect of future information-system expenses of $118,700 a year. If we undertake the new project, the series of expenses begins in year 4; if we do not undertake it, the series begins in year 5. The new project, therefore, results in an *additional* cost of $118,700 in year 4. This has a present value of $118{,}700/(1.06)^4$, or about $94,000. This cost is properly charged against the new project. When we recognize it, the NPV of the project may prove to be negative. If so, we still need to check whether it is worthwhile undertaking the project now and abandoning it later, when the excess capacity of the present system disappears.

[13] The present value of $118,700 a year for five years discounted at 6% is $500,000.

SUMMARY

By now present value calculations should be a matter of routine. However, forecasting project cash flows will never be routine. Here is a checklist that will help you to avoid mistakes:

1. Discount cash flows, not profits.

a. Remember that depreciation is not a cash flow (though it may affect tax payments).

b. Concentrate on cash flows after taxes. Stay alert for differences between tax depreciation and depreciation used in reports to shareholders.

c. Exclude debt interest or the cost of repaying a loan from the project cash flows. This enables you to separate the investment from the financing decision.

d. Remember the investment in working capital. As sales increase, the firm may need to make additional investments in working capital, and as the project comes to an end, it will recover those investments.

e. Beware of allocated overhead charges for heat, light, and so on. These may not reflect the incremental costs of the project.

2. Estimate the project's *incremental* cash flows—that is, the difference between the cash flows with the project and those without the project.

a. Include all indirect effects of the project, such as its impact on the sales of the firm's other products.

b. Forget sunk costs.

c. Include *opportunity costs,* such as the value of land that you would otherwise sell.

3. Treat inflation consistently.

a. If cash flows are forecasted in nominal terms, use a nominal discount rate.

b. Discount real cash flows at a real rate.

These principles of valuing capital investments are the same worldwide, but inputs and assumptions vary by country and currency. For example, cash flows from a project in Germany would be in euros, not dollars, and would be forecasted after German taxes.

When we assessed the guano project, we transformed the series of future cash flows into a single measure of their present value. Sometimes it is useful to reverse this calculation and to convert the present value into a stream of annual cash flows. For example, when choosing between two machines with unequal lives, you need to compare equivalent annual cash flows. Remember, though, to calculate equivalent annual cash flows in real terms and adjust for technological change if necessary.

PROBLEM SETS

BASIC

1. Which of the following should be treated as incremental cash flows when deciding whether to invest in a new manufacturing plant? The site is already owned by the company, but existing buildings would need to be demolished.

a. The market value of the site and existing buildings.

b. Demolition costs and site clearance.

c. The cost of a new access road put in last year.

d. Lost earnings on other products due to executive time spent on the new facility.

e. A proportion of the cost of leasing the president's jet airplane.

f. Future depreciation of the new plant.

g. The reduction in the corporation's tax bill resulting from tax depreciation of the new plant.

h. The initial investment in inventories of raw materials.

i. Money already spent on engineering design of the new plant.

2. Mr. Art Deco will be paid \$100,000 one year hence. This is a nominal flow, which he discounts at an 8% nominal discount rate:

$$\text{PV} = \frac{100{,}000}{1.08} = \$92{,}593$$

The inflation rate is 4%.

Calculate the PV of Mr. Deco's payment using the equivalent *real* cash flow and *real* discount rate. (You should get exactly the same answer as he did.)

3. True or false?

a. A project's depreciation tax shields depend on the actual future rate of inflation.

b. Project cash flows should take account of interest paid on any borrowing undertaken to finance the project.

c. In the U.S., income reported to the tax authorities must equal income reported to shareholders.

d. Accelerated depreciation reduces near-term project cash flows and therefore reduces project NPV.

4. How does the PV of depreciation tax shields vary across the recovery-period classes shown in Table 6.4? Give a general answer; then check it by calculating the PVs of depreciation tax shields in the five-year and seven-year classes. The tax rate is 35% and the discount rate is 10%.

5. The following table tracks the main components of working capital over the life of a four-year project.

	2010	2011	2012	2013	2014
Accounts receivable	0	150,000	225,000	190,000	0
Inventory	75,000	130,000	130,000	95,000	0
Accounts payable	25,000	50,000	50,000	35,000	0

Calculate net working capital and the cash inflows and outflows due to investment in working capital.

6. When appraising mutually exclusive investments in plant and equipment, financial managers calculate the investments' equivalent annual costs and rank the investments on this basis. Why is this necessary? Why not just compare the investments' NPVs? Explain briefly.

7. Air conditioning for a college dormitory will cost \$1.5 million to install and \$200,000 per year to operate. The system should last 25 years. The real cost of capital is 5%, and the college pays no taxes. What is the equivalent annual cost?

8. Machines A and B are mutually exclusive and are expected to produce the following real cash flows:

	Cash Flows ($ thousands)			
Machine	C_0	C_1	C_2	C_3
A	−100	+110	+121	
B	−120	+110	+121	+133

The real opportunity cost of capital is 10%.

a. Calculate the NPV of each machine.

b. Calculate the equivalent annual cash flow from each machine.

c. Which machine should you buy?

9. Machine C was purchased five years ago for $200,000 and produces an annual real cash flow of $80,000. It has no salvage value but is expected to last another five years. The company can replace machine C with machine B (see Problem 8) *either* now *or* at the end of five years. Which should it do?

INTERMEDIATE

10. Restate the net cash flows in Table 6.6 in real terms. Discount the restated cash flows at a real discount rate. Assume a 20% *nominal* rate and 10% expected inflation. NPV should be unchanged at +3,802, or $3,802,000.

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11. CSC is evaluating a new project to produce encapsulators. The initial investment in plant and equipment is $500,000. Sales of encapsulators in year 1 are forecasted at $200,000 and costs at $100,000. Both are expected to increase by 10% a year in line with inflation. Profits are taxed at 35%. Working capital in each year consists of inventories of raw materials and is forecasted at 20% of sales in the following year.

The project will last five years and the equipment at the end of this period will have no further value. For tax purposes the equipment can be depreciated straight-line over these five years. If the nominal discount rate is 15%, show that the net present value of the project is the same whether calculated using real cash flows or nominal flows.

12. In 1898 Simon North announced plans to construct a funeral home on land he owned and rented out as a storage area for railway carts. (A local newspaper commended Mr. North for not putting the cart before the hearse.) Rental income from the site barely covered real estate taxes, but the site was valued at $45,000. However, Mr. North had refused several offers for the land and planned to continue renting it out if for some reason the funeral home was not built. Therefore he did not include the value of the land as an outlay in his NPV analysis of the funeral home. Was this the correct procedure? Explain.

13. Each of the following statements is true. Explain why they are consistent.

a. When a company introduces a new product, or expands production of an existing product, investment in net working capital is usually an important cash outflow.

b. Forecasting changes in net working capital is not necessary if the timing of *all* cash inflows and outflows is carefully specified.

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14. Ms. T. Potts, the treasurer of Ideal China, has a problem. The company has just ordered a new kiln for $400,000. Of this sum, $50,000 is described by the supplier as an installation cost. Ms. Potts does not know whether the Internal Revenue Service (IRS) will permit the company to treat this cost as a tax-deductible current expense or as a capital investment. In the latter case, the company could depreciate the $50,000 using the five-year MACRS tax depreciation schedule. How will the IRS's decision affect the after-tax cost of the kiln? The tax rate is 35% and the opportunity cost of capital is 5%.

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15. After spending $3 million on research, Better Mousetraps has developed a new trap. The project requires an initial investment in plant and equipment of $6 million. This investment will be depreciated straight-line over five years to a value of zero, but, when the project comes to an end in five years, the equipment can in fact be sold for $500,000. The firm believes that working capital at each date must be maintained at 10% of next year's forecasted sales. Production costs are estimated at $1.50 per trap and the traps will be sold for $4 each. (There are no marketing expenses.) Sales forecasts are given in the following table. The firm pays tax at 35% and the required return on the project is 12%. What is the NPV?

Year:	0	1	2	3	4	5
Sales (millions of traps)	0	.5	.6	1.0	1.0	.6

16. A project requires an initial investment of $100,000 and is expected to produce a cash inflow before tax of $26,000 per year for five years. Company A has substantial accumulated tax losses and is unlikely to pay taxes in the foreseeable future. Company B pays corporate taxes at a rate of 35% and can depreciate the investment for tax purposes using the five-year MACRS tax depreciation schedule. Suppose the opportunity cost of capital is 8%. Ignore inflation.

a. Calculate project NPV for each company.

b. What is the IRR of the after-tax cash flows for each company? What does comparison of the IRRs suggest is the effective corporate tax rate?

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17. Go to the "live" Excel spreadsheet versions of Tables 6.1, 6.5, and 6.6 at **www.mhhe.com/bma** and answer the following questions.

a. How does the guano project's NPV change if IM&C is forced to use the seven-year MACRS tax depreciation schedule?

b. New engineering estimates raise the possibility that capital investment will be more than $10 million, perhaps as much as $15 million. On the other hand, you believe that the 20% cost of capital is unrealistically high and that the true cost of capital is about 11%. Is the project still attractive under these alternative assumptions?

c. Continue with the assumed $15 million capital investment and the 11% cost of capital. What if sales, cost of goods sold, and net working capital are each 10% higher in every year? Recalculate NPV. (*Note:* Enter the revised sales, cost, and working-capital forecasts in the spreadsheet for Table 6.1.)

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18. A widget manufacturer currently produces 200,000 units a year. It buys widget lids from an outside supplier at a price of $2 a lid. The plant manager believes that it would be cheaper to make these lids rather than buy them. Direct production costs are estimated to be only $1.50 a lid. The necessary machinery would cost $150,000 and would last 10 years. This investment could be written off for tax purposes using the seven-year tax depreciation schedule. The plant manager estimates that the operation would require additional working capital of $30,000 but argues that this sum can be ignored since it is recoverable at the end of the 10 years. If the company pays tax at a rate of 35% and the opportunity cost of capital is 15%, would you support the plant manager's proposal? State clearly any additional assumptions that you need to make.

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19. Reliable Electric is considering a proposal to manufacture a new type of industrial electric motor which would replace most of its existing product line. A research breakthrough has given Reliable a two-year lead on its competitors. The project proposal is summarized in Table 6.7 on the next page.

a. Read the notes to the table carefully. Which entries make sense? Which do not? Why or why not?

b. What additional information would you need to construct a version of Table 6.7 that makes sense?

c. Construct such a table and recalculate NPV. Make additional assumptions as necessary.

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20. Marsha Jones has bought a used Mercedes horse transporter for her Connecticut estate. It cost $35,000. The object is to save on horse transporter rentals.

Marsha had been renting a transporter every other week for $200 per day plus $1.00 per mile. Most of the trips are 80 or 100 miles in total. Marsha usually gives the driver a $40 tip. With the new transporter she will only have to pay for diesel fuel and maintenance, at about $.45 per mile. Insurance costs for Marsha's transporter are $1,200 per year.

The transporter will probably be worth $15,000 (in real terms) after eight years, when Marsha's horse Nike will be ready to retire. Is the transporter a positive-NPV investment? Assume a nominal discount rate of 9% and a 3% forecasted inflation rate. Marsha's transporter is a personal outlay, not a business or financial investment, so taxes can be ignored.

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	2009	2010	2011	2012–2019
1. Capital expenditure	−10,400			
2. Research and development	−2,000			
3. Working capital	−4,000			
4. Revenue		8,000	16,000	40,000
5. Operating costs		−4,000	−8,000	−20,000
6. Overhead		−800	−1,600	−4,000
7. Depreciation		−1,040	−1,040	−1,040
8. Interest		−2,160	−2,160	−2,160
9. Income	−2,000	0	3,200	12,800
10. Tax	0	0	420	4,480
11. Net cash flow	−16,400	0	2,780	8,320
12. Net present value = +13,932				

TABLE 6.7 Cash flows and present value of Reliable Electric's proposed investment ($ thousands). See Problem 19.

Notes:

1. *Capital expenditure:* $8 million for new machinery and $2.4 million for a warehouse extension. The full cost of the extension has been charged to this project, although only about half of the space is currently needed. Since the new machinery will be housed in an existing factory building, no charge has been made for land and building.
2. *Research and development:* $1.82 million spent in 2008. This figure was corrected for 10% inflation from the time of expenditure to date. Thus $1.82 \times 1.1 = \$2$ million.
3. *Working capital:* Initial investment in inventories.
4. *Revenue:* These figures assume sales of 2,000 motors in 2010, 4,000 in 2011, and 10,000 per year from 2012 through 2019. The initial unit price of $4,000 is forecasted to remain constant in real terms.
5. *Operating costs:* These include all direct and indirect costs. Indirect costs (heat, light, power, fringe benefits, etc.) are assumed to be 200% of direct labor costs. Operating costs per unit are forecasted to remain constant in real terms at $2,000.
6. *Overhead:* Marketing and administrative costs, assumed equal to 10% of revenue.
7. *Depreciation:* Straight-line for 10 years.
8. *Interest:* Charged on capital expenditure and working capital at Reliable's current borrowing rate of 15%.
9. *Income:* Revenue less the sum of research and development, operating costs, overhead, depreciation, and interest.
10. *Tax:* 35% of income. However, income is negative in 2009. This loss is carried forward and deducted from taxable income in 2011.
11. *Net cash flow:* Assumed equal to income less tax.
12. *Net present value:* NPV of net cash flow at a 15% discount rate.

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21. United Pigpen is considering a proposal to manufacture high-protein hog feed. The project would make use of an existing warehouse, which is currently rented out to a neighboring firm. The next year's rental charge on the warehouse is $100,000, and thereafter the rent is expected to grow in line with inflation at 4% a year. In addition to using the warehouse, the proposal envisages an investment in plant and equipment of $1.2 million. This could be depreciated for tax purposes straight-line over 10 years. However, Pigpen expects to terminate the project at the end of eight years and to resell the plant and equipment in year 8 for $400,000. Finally, the project requires an initial investment in working capital of $350,000. Thereafter, working capital is forecasted to be 10% of sales in each of years 1 through 7.

Year 1 sales of hog feed are expected to be $4.2 million, and thereafter sales are forecasted to grow by 5% a year, slightly faster than the inflation rate. Manufacturing costs are expected to be 90% of sales, and profits are subject to tax at 35%. The cost of capital is 12%. What is the NPV of Pigpen's project?

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22. Hindustan Motors has been producing its Ambassador car in India since 1948. As the company's Web site explains, the Ambassador's "dependability, spaciousness and comfort factor have made it the most preferred car for generations of Indians." Hindustan is now considering producing the car in China. This will involve an initial investment of RMB 4 billion.[14] The plant will start production after one year. It is expected to last for five years and have a salvage value at the end of this period of RMB 500 million in real terms. The plant will produce 100,000 cars a year. The firm anticipates that in the first year it will be able to sell each car for RMB 65,000, and thereafter the price is expected to increase by 4% a year. Raw materials for each car are forecasted to cost RMB 18,000 in the first year and these costs are predicted to increase by 3% annually. Total labor costs for the plant are expected to be RMB 1.1 billion in the first year and thereafter will increase by 7% a year. The land on which the plant is built can be rented for five years at a fixed cost of RMB 300 million a year payable at the *beginning* of each year. Hindustan's discount rate for this type of project is 12% (nominal). The expected rate of inflation is 5%. The plant can be depreciated straight-line over the five-year period and profits will be taxed at 25%. Assume all cash flows occur at the end of each year except where otherwise stated. What is the NPV of the plant?

23. In the International Mulch and Compost example (Section 6.2), we assumed that losses on the project could be used to offset taxable profits elswhere in the corporation. Suppose that the losses had to be carried forward and offset against future taxable profits from the project. How would the project NPV change? What is the value of the company's ability to use the tax deductions immediately?

24. As a result of improvements in product engineering, United Automation is able to sell one of its two milling machines. Both machines perform the same function but differ in age. The newer machine could be sold today for $50,000. Its operating costs are $20,000 a year, but in five years the machine will require a $20,000 overhaul. Thereafter operating costs will be $30,000 until the machine is finally sold in year 10 for $5,000.

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The older machine could be sold today for $25,000. If it is kept, it will need an immediate $20,000 overhaul. Thereafter operating costs will be $30,000 a year until the machine is finally sold in year 5 for $5,000.

Both machines are fully depreciated for tax purposes. The company pays tax at 35%. Cash flows have been forecasted in real terms. The real cost of capital is 12%. Which machine should United Automation sell? Explain the assumptions underlying your answer.

25. Low-energy lightbulbs cost $3.50, have a life of nine years, and use about $1.60 of electricity a year. Conventional lightbulbs cost only $.50, but last only about a year and use about $6.60 of energy. If the real discount rate is 5%, what is the equivalent annual cost of the two products?

26. Hayden Inc. has a number of copiers that were bought four years ago for $20,000. Currently maintenance costs $2,000 a year, but the maintenance agreement expires at the end of two years and thereafter the annual maintenance charge will rise to $8,000. The machines have a current resale value of $8,000, but at the end of year 2 their value will have fallen to $3,500. By the end of year 6 the machines will be valueless and would be scrapped.

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Hayden is considering replacing the copiers with new machines that would do essentially the same job. These machines cost $25,000, and the company can take out an eight-year maintenance contract for $1,000 a year. The machines will have no value by the end of the eight years and will be scrapped.

Both machines are depreciated by using seven-year MACRS, and the tax rate is 35%. Assume for simplicity that the inflation rate is zero. The real cost of capital is 7%. When should Hayden replace its copiers?

27. Return to the start of Section 6-4, where we calculated the equivalent annual cost of producing reformulated gasoline in California. Capital investment was $400 million. Suppose this amount can be depreciated for tax purposes on the 10-year MACRS schedule from Table 6.4. The marginal tax rate, including California taxes, is 39%, the cost of

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[14] The Renminbi (RMB) is the Chinese currency.

capital is 7%, and there is no inflation. The refinery improvements have an economic life of 25 years.

a. Calculate the after-tax equivalent annual cost. (*Hint:* It's easiest to use the PV of depreciation tax shields as an offset to the initial investment).

b. How much extra would retail gasoline customers have to pay to cover this equivalent annual cost? (*Note:* Extra income from higher retail prices would be taxed.)

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28. The Borstal Company has to choose between two machines that do the same job but have different lives. The two machines have the following costs:

Year	Machine A	Machine B
0	$40,000	$50,000
1	10,000	8,000
2	10,000	8,000
3	10,000 + replace	8,000
4		8,000 + replace

These costs are expressed in real terms.

a. Suppose you are Borstal's financial manager. If you had to buy one or the other machine and rent it to the production manager for that machine's economic life, what annual rental payment would you have to charge? Assume a 6% real discount rate and ignore taxes.

b. Which machine should Borstal buy?

c. Usually the rental payments you derived in part (a) are just hypothetical—a way of calculating and interpreting equivalent annual cost. Suppose you actually do buy one of the machines and rent it to the production manager. How much would you actually have to charge in each future year if there is steady 8% per year inflation? (*Note:* The rental payments calculated in part (a) are real cash flows. You would have to mark up those payments to cover inflation.)

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29. Look again at your calculations for Problem 28 above. Suppose that technological change is expected to reduce costs by 10% per year. There will be new machines in year 1 that cost 10% less to buy and operate than A and B. In year 2 there will be a second crop of new machines incorporating a further 10% reduction, and so on. How does this change the equivalent annual costs of machines A and B?

30. The president's executive jet is not fully utilized. You judge that its use by other officers would increase direct operating costs by only $20,000 a year and would save $100,000 a year in airline bills. On the other hand, you believe that with the increased use the company will need to replace the jet at the end of three years rather than four. A new jet costs $1.1 million and (at its current low rate of use) has a life of six years. Assume that the company does not pay taxes. All cash flows are forecasted in real terms. The real opportunity cost of capital is 8%. Should you try to persuade the president to allow other officers to use the plane?

CHALLENGE

31. One measure of the effective tax rate is the difference between the IRRs of pretax and after-tax cash flows, divided by the pretax IRR. Consider, for example, an investment I generating a perpetual stream of pretax cash flows C. The pretax IRR is C/I, and the after-tax IRR is $C(1 - T_C)/I$, where T_C is the statutory tax rate. The effective rate, call it T_E, is

$$T_E = \frac{C/I - C(1 - T_c)/I}{C/I} = T_c$$

In this case the effective rate equals the statutory rate.

a. Calculate T_E for the guano project in Section 6.2.

b. How does the effective rate depend on the tax depreciation schedule? On the inflation rate?

c. Consider a project where all of the up-front investment is treated as an expense for tax purposes. For example, R&D and marketing outlays are always expensed in the United States. They create no tax depreciation. What is the effective tax rate for such a project?

32. We warned that equivalent annual costs should be calculated in real terms. We did not fully explain why. This problem will show you.

Look back to the cash flows for machines A and B (in "Choosing between Long- and Short-Lived Equipment"). The present values of purchase and operating costs are 28.37 (over three years for A) and 21.00 (over two years for B). The real discount rate is 6% and the inflation rate is 5%.

a. Calculate the three- and two-year *level nominal* annuities which have present values of 28.37 and 21.00. Explain why these annuities are *not* realistic estimates of equivalent annual costs. (*Hint:* In real life machinery rentals increase with inflation.)

b. Suppose the inflation rate increases to 25%. The real interest rate stays at 6%. Recalculate the level nominal annuities. Note that the *ranking* of machines A and B appears to change. Why?

33. In December 2005 Mid-American Energy brought online one of the largest wind farms in the world. It cost an estimated \$386 million and the 257 turbines have a total capacity of 360.5 megawatts (mW). Wind speeds fluctuate and most wind farms are expected to operate at an average of only 35% of their rated capacity. In this case, at an electricity price of \$55 per megawatt-hour (mWh), the project will produce revenues in the first year of \$60.8 million (i.e., .35 × 8,760 hours × 360.5 mW × \$55 per mWh). A reasonable estimate of maintenance and other costs is about \$18.9 million in the first year of operation. Thereafter, revenues and costs should increase with inflation by around 3% a year.

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Conventional power stations can be depreciated using 20-year MACRS, and their profits are taxed at 35%. Suppose that the project will last 20 years and the cost of capital is 12%. To encourage renewable energy sources, the government offers several tax breaks for wind farms.

a. How large a tax break (if any) was needed to make Mid-American's investment a positive-NPV venture?

b. Some wind farm operators assume a capacity factor of 30% rather than 35%. How would this lower capacity factor alter project NPV?

MINI-CASE

New Economy Transport (A)

The New Economy Transport Company (NETCO) was formed in 1955 to carry cargo and passengers between ports in the Pacific Northwest and Alaska. By 2008 its fleet had grown to four vessels, including a small dry-cargo vessel, the *Vital Spark.*

The *Vital Spark* is 25 years old and badly in need of an overhaul. Peter Handy, the finance director, has just been presented with a proposal that would require the following expenditures:

Overhaul engine and generators	\$340,000
Replace radar and other electronic equipment	75,000
Repairs to hull and superstructure	310,000
Painting and other repairs	95,000
	\$820,000

Mr. Handy believes that all these outlays could be depreciated for tax purposes in the seven-year MACRS class.

NETCO's chief engineer, McPhail, estimates the postoverhaul operating costs as follows:

Fuel	$ 450,000
Labor and benefits	480,000
Maintenance	141,000
Other	110,000
	$1,181,000

These costs generally increase with inflation, which is forecasted at 2.5% a year.

The *Vital Spark* is carried on NETCO's books at a net depreciated value of only $100,000, but could probably be sold "as is," along with an extensive inventory of spare parts, for $200,000. The book value of the spare parts inventory is $40,000. Sale of the *Vital Spark* would generate an immediate tax liability on the difference between sale price and book value.

The chief engineer also suggests installation of a brand-new engine and control system, which would cost an extra $600,000.[15] This additional equipment would not substantially improve the *Vital Spark*'s performance, but would result in the following reduced annual fuel, labor, and maintenance costs:

Fuel	$ 400,000
Labor and benefits	405,000
Maintenance	105,000
Other	110,000
	$1,020,000

Overhaul of the *Vital Spark* would take it out of service for several months. The overhauled vessel would resume commercial service next year. Based on past experience, Mr. Handy believes that it would generate revenues of about $1.4 million next year, increasing with inflation thereafter.

But the *Vital Spark* cannot continue forever. Even if overhauled, its useful life is probably no more than 10 years, 12 years at the most. Its salvage value when finally taken out of service will be trivial.

NETCO is a conservatively financed firm in a mature business. It normally evaluates capital investments using an 11% cost of capital. This is a nominal, not a real, rate. NETCO's tax rate is 35%.

QUESTION

1. Calculate the NPV of the proposed overhaul of the *Vital Spark*, with and without the new engine and control system. To do the calculation, you will have to prepare a spreadsheet table showing all costs after taxes over the vessel's remaining economic life. Take special care with your assumptions about depreciation tax shields and inflation.

New Economy Transport (B)

There is no question that the *Vital Spark* needs an overhaul soon. However, Mr. Handy feels it unwise to proceed without also considering the purchase of a new vessel. Cohn and Doyle, Inc., a Wisconsin shipyard, has approached NETCO with a design incorporating a Kort nozzle, extensively automated navigation and power control systems, and much more

[15] This additional outlay would also qualify for tax depreciation in the seven-year MACRS class.

comfortable accommodations for the crew. Estimated annual operating costs of the new vessel are:

Fuel	$380,000
Labor and benefits	330,000
Maintenance	70,000
Other	105,000
	$885,000

The crew would require additional training to handle the new vessel's more complex and sophisticated equipment. Training would probably cost $50,000 next year.

The estimated operating costs for the new vessel assume that it would be operated in the same way as the *Vital Spark*. However, the new vessel should be able to handle a larger load on some routes, which could generate additional revenues, net of additional out-of-pocket costs, of as much as $100,000 per year. Moreover, a new vessel would have a useful service life of 20 years or more.

Cohn and Doyle offered the new vessel for a fixed price of $3,000,000, payable half immediately and half on delivery next year.

Mr. Handy stepped out on the foredeck of the *Vital Spark* as she chugged down the Cook Inlet. "A rusty old tub," he muttered, "but she's never let us down. I'll bet we could keep her going until next year while Cohn and Doyle are building her replacement. We could use up the spare parts to keep her going. We might even be able to sell or scrap her for book value when her replacement arrives.

"But how do I compare the NPV of a new ship with the old *Vital Spark?* Sure, I could run a 20-year NPV spreadsheet, but I don't have a clue how the replacement will be used in 2023 or 2028. Maybe I could compare the overall *cost* of overhauling and operating the *Vital Spark* to the cost of buying and operating the proposed replacement."

QUESTIONS

1. Calculate and compare the equivalent annual costs of (a) overhauling and operating the *Vital Spark* for 12 more years, and (b) buying and operating the proposed replacement vessel for 20 years. What should Mr. Handy do if the replacement's annual costs are the same or lower?
2. Suppose the replacement's equivalent annual costs are higher than the *Vital Spark*'s. What additional information should Mr. Handy seek in this case?