CHAPTER 11

Cash Flow Estimation and Risk Analysis

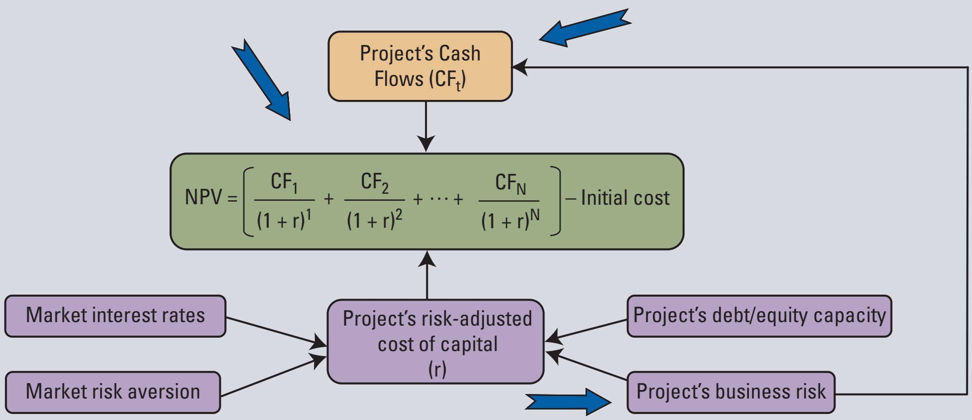
In the last chapter we discussed how the recession caused FPL Group to reduce its planned capital expenditures from $7 billion to $5.3 billion. That change rippled through the economy. It reduced FPL's job count, which had a negative effect on housing and retail sales in Florida, where most of its operations are based. It also led to job losses in supplier firms like GE that would have supplied FPL with wind turbines and other materials needed for the canceled projects. It reduced our "green" power and thus increased our reliance on coal and foreign oil. Sales taxes, property taxes, and income taxes also fell, negatively affecting cities and states as well as the federal government.

FPL's experience was matched by thousands of other businesses all over the world; in this way, it exacerbated the global recession and increased the possibilities of a 1930's type depression. Government leaders, from President Obama on down, recognized this, and they authorized spending trillions of dollars on programs designed to push back the tide and get the ship righted and back on course. No one knows either how well the stimulus program will work or how long it will take to get things back on track. Still, companies like FPL, its suppliers, retailers who depend on workers for sales, and governments who depend on all of the above for tax revenues must make decisions based on predictions about the future. This chapter obviously can't teach you how to solve the problems of the world, but it does set forth a framework for making capital expenditure decisions in a world of uncertainty. If companies use the procedures we recommend, this will help avoid serious recessions in the future.

Corporate Valuation, Cash Flows, and Risk Analysis

When we estimate a project's cash flows (CF) and then discount them at the project's risk-adjusted cost of capital, r, the result is the project's NPV, which tells us how much the project increases the firm's value. This chapter focuses on how to estimate the size and risk of a project's cash flows.

Note too that project cash flows, once a project has been accepted and placed in operation, are added to the firm's free cash flows from other sources. Therefore, projects' cash flows essentially determine the firm's free cash flows as discussed in Chapter 2 and thus form the basis for the firm's market value and stock price.



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The textbook's Web site contains an Excel file that will guide you through the chapter's calculations. The file for this chapter is **Ch11 Tool Kit.xls**, *and we encourage you to open the file and follow along as you read the chapter.*

The basic principles of capital budgeting were covered in Chapter 10. Given a project's expected cash flows, it is easy to calculate its NPV, IRR, MIRR, PI, payback, and discounted payback. Unfortunately, cash flows are rarely just given—rather, managers must estimate them based on information collected from sources both inside and outside the company. Moreover, uncertainty surrounds the cash flow estimates, and some projects are riskier than others. In the first part of this chapter, we develop procedures for estimating the cash flows associated with capital budgeting projects. Then, in the second part, we discuss techniques used to measure and take account of project risk.

11.1 Conceptual Issues

The most important but also the most difficult step in capital budgeting is estimating **project cash flows**. Many variables are involved, and many individuals and departments participate in the process. For example, the forecasts of unit sales and sales prices are normally made by the marketing group based on their knowledge of price elasticity, advertising effects, the state of the economy, competitors' reactions, and trends in consumers' tastes. Similarly, the capital outlays associated with a new product are generally obtained from the engineering and product development staffs, while operating costs are estimated by cost accountants, production experts, personnel specialists, purchasing agents, and so forth.

A proper analysis includes (1) obtaining information from various departments such as engineering and marketing, (2) ensuring that everyone involved with the forecast uses a consistent set of realistic economic assumptions, and (3) making sure that no biases are inherent in the forecasts. This last point is extremely important, because some managers become emotionally involved with pet projects and others push projects in order to build empires. Both problems cause cash flow forecast biases that make bad projects look good—on paper!

A number of conceptual issues arise in the cash flow estimation process. Some of these are covered in the balance of this section. Some of them are illustrated in the examples we explore in the subsequent sections.

Cash Flow versus Accounting Income

We saw in Chapter 2 that free cash flow differs from accounting income: Free cash flow is cash flow that is available for distribution to investors; hence free cash flow is the basis of a firm's value. It is common in the practice of finance to speak of a firm's free cash flow and a project's cash flow (or net cash flow), but these are based on the same concepts. In fact, a project's cash flow is identical to the project's free cash flow, and a firm's total net cash flow from all projects is equal to the firm's free cash flow. We will follow the typical convention and refer to a project's free cash flow simply as project cash flow, but keep in mind that the two concepts are identical.[1]

Because net income is not equal to the cash flow available for distribution to investors, in the last chapter we discounted *net cash flows*, not accounting income, to find projects' NPVs. *For capital budgeting purposes it is the project's net cash flow, not its accounting income, that is relevant.* Therefore, when analyzing a proposed capital budgeting project, disregard the project's net income and focus exclusively on its net cash flow.[2] Be especially alert to the following differences between cash flow and accounting income.

The Cash Flow Effect of Asset Purchases and Depreciation. Most projects require assets, and asset purchases represent *negative* cash flows. Even though the acquisition of assets results in a cash outflow, accountants do not show the purchase of fixed assets as a deduction from accounting income. Instead, they deduct a depreciation expense each year throughout the life of the asset. Depreciation shelters income from taxation, and this has an impact on cash flow, but depreciation itself is not a cash flow. Therefore, depreciation must be added back when estimating a project's operating cash flow.

Depreciation is the most common noncash charge, but there are many other noncash charges that might appear on a company's financial statements. Just as with depreciation, all other noncash charges should be added back when calculating a project's net cash flow.

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[1]When the financial press refers to a firm's "net cash flow," it is almost always equal to the definition we provide in Chapter 2 (which simply adds back depreciation and any other noncash charges to net income). However, as we explained in Chapter 2, the net cash flow from operations (from the statement of cash flows) and the firm's free cash flow are much more useful measures of cash flow. When financial analysts within a company use the term "a project's net cash flow," they almost always calculate it as we do in this chapter, which is in essence the project's free cash flow. Thus, free cash flow means the same thing whether you calculate it for a firm or for a project. On the other hand, when the financial press talks about a firm's net cash flow or when an internal analysts talks about a project's net cash flow, those "net cash flows" are not the same.

[2]This statement is theoretically correct but sometimes an overstatement in the real world. Stockholders in publicly owned companies do look at accounting income, it affects stock prices, and those prices affect the cost of capital. Therefore, if a project would have a negative effect on net income but a positive effect on cash flows, management should focus primarily on cash flows but try to communicate to investors that (1) the adverse effect on net income is temporary and (2) in the long run, the positive effect on cash flows will show up in future net income. Privately owned companies don't have this problem—they can and do focus almost exclusively on cash flows, and that's a significant advantage of private ownership.

Changes in Net Operating Working Capital. Normally, additional inventories are required to support a new operation, and expanded sales tie up additional funds in accounts receivable. However, payables and accruals increase as a result of the expansion, and this reduces the cash needed to finance inventories and receivables. The difference between the required increase in operating current assets and the increase in operating current liabilities is the change in net operating working capital. If this change is positive, as it generally is for expansion projects, then additional financing—beyond the cost of the fixed assets—will be needed.

Toward the end of a project's life, inventories will be used but not replaced, and receivables will be collected without corresponding replacements. As these changes occur the firm will receive cash inflows; as a result, the investment in net operating working capital will be returned by the end of the project's life.

Interest Charges Are Not Included in Project Cash Flows. Interest is a cash expense, so at first blush it would seem that interest on any debt used to finance a project should be deducted when we estimate the project's net cash flows. However, this is not correct. Recall from Chapter 10 that we discount a project's cash flows by its risk-adjusted cost of capital, which is a weighted average (WACC) of the costs of debt, preferred stock, and common equity, adjusted for the project's risk and debt capacity. This project cost of capital is the rate of return necessary to satisfy *all* of the firm's investors, including stockholders and debtholders. A common mistake made by many students and financial managers is to subtract interest payments when estimating a project's cash flows. This is a mistake because the cost of debt is already embedded in the cost of capital, so subtracting interest payments from the project's cash flows would amount to double-counting interest costs. Therefore, *you should not subtract interest expenses when finding a project's cash flows*.[3]

Timing of Cash Flows: Yearly versus Other Periods

In theory, in capital budgeting analyses we should discount cash flows based on the exact moment when they occur. Therefore, one could argue that daily cash flows would be better than annual flows. However, it would be costly to estimate daily cash flows and laborious to analyze them, and in general the analysis would be no better than one using annual flows because we simply can't make accurate forecasts of daily cash flows more than a couple of months into the future. Therefore, it is generally appropriate to assume that all cash flows occur at the end of the various years. But for projects with highly predictable cash flows, such as constructing a building and then leasing it on a long-term basis (with monthly payments) to a financially sound tenant, we would analyze the project using monthly periods.

Incremental Cash Flows

The relevant cash flows to be used in project analysis are the difference between the cash flows the firm will have if it implements the project versus the cash flows it will have if it rejects the project. These are called **incremental cash flows**:

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[3]Some years ago the interest situation was debated in the academic literature. One position was that interest should be deducted, resulting in the net cash flow to stockholders, and then that cash flow should be discounted at the cost of common equity. It was demonstrated that equity flows discounted at the equity cost and operating flows discounted at the WACC led to the same conclusions. Now most academics recommend the operating cash flow approach, and it is practiced by most companies.

$$\text{Incremental cash flows} = \begin{array}{c}\text{Company's cash flows} \\ \textit{with}\text{ the project}\end{array} - \begin{array}{c}\text{Company's cash flows} \\ \textit{without}\text{ the project}\end{array}$$

We discuss several types of incremental cash flows in the following sections.

Expansion Projects and Replacement Projects

Two types of projects can be distinguished: (1) *expansion projects*, in which the firm makes an investment in, for example, a new Home Depot store in Seattle; and (2) *replacement projects*, in which the firm replaces existing assets, generally to reduce costs. In expansion projects, the cash expenditures on buildings, equipment, and required working capital are obviously incremental, as are the sales revenues and operating costs associated with the project. The incremental costs associated with replacement projects are not so obvious. For example, Home Depot might replace some of its delivery trucks to reduce fuel and maintenance expenses. Replacement analysis is complicated by the fact that most of the relevant cash flows are the cash flow differences between the existing project and the replacement project. For example, the fuel bill for a more efficient new truck might be \$10,000 per year versus \$15,000 for the old truck, and the \$5,000 fuel savings would be an incremental cash flow associated with the replacement decision. We analyze an expansion and replacement decision later in the chapter.

Sunk Costs

A **sunk cost** is an outlay related to the project that was incurred in the past and cannot be recovered in the future regardless of whether or not the project is accepted. Therefore, sunk costs are *not incremental costs* and thus are not relevant in a capital budgeting analysis.

To illustrate, suppose Home Depot spent \$2 million to investigate sites for a potential new store in a given area. That \$2 million is a sunk cost—the money is gone, and it won't come back regardless of whether or not a new store is built. Therefore, the \$2 million should not be included in a capital budgeting decision.

Improper treatment of sunk costs can lead to bad decisions. For example, suppose Home Depot completed the analysis for a new store and found that it must spend an additional (or incremental) \$17 million to build and supply the store, on top of the \$2 million already spent on the site study. Suppose the present value of future cash flows is \$18 million. Should the project be accepted? If the sunk costs are mistakenly included, the NPV is −\$2 million + (−\$17 million) + \$18 million = −\$1 million and the project would be rejected. However, *that would be a bad decision*. The real issue is whether the *incremental* \$17 million would result in enough *incremental* cash flow to produce a positive NPV. If the \$2 million sunk cost were disregarded, as it should be, then the NPV on an incremental basis would be a *positive* \$1 million.

Opportunity Costs Associated with Assets the Firm Already Owns

Another conceptual issue relates to **opportunity costs** related to assets the firm already owns. Continuing our example, suppose Home Depot (HD) owns land with a current market value of \$2 million that can be used for the new store if it decides to build the store. If HD goes forward with the project, only another \$15 million will be required, not the full \$17 million, because it will not need to buy the required land. Does this mean that HD should use the \$15 million incremental cost as the cost of the new store? The answer is definitely "no." If the new store is *not* built, then HD could sell the land and receive a cash flow of $2 million. This $2 million is an *opportunity cost*—it is cash that HD would not receive if the land is used for the new store. Therefore, the $2 million must be charged to the new project, and failing to do so would cause the new project's calculated NPV to be too high.

Externalities

Another conceptual issue relates to **externalities**, which are the effects of a project on other parts of the firm or on the environment. As explained in what follows, there are three types of externalities: negative within-firm externalities, positive within-firm externalities, and environmental externalities.

Negative *Within-Firm Externalities.* If a retailer like Home Depot opens a new store that is close to its existing stores, then the new store might attract customers who would otherwise buy from the existing stores, reducing the old stores' cash flows. Therefore, the new store's incremental cash flow must be reduced by the amount of the cash flow lost by its other units. This type of externality is called **cannibalization**, because the new business eats into the company's existing business. Many businesses are subject to cannibalization. For example, each new iPod model cannibalizes existing models. Those lost cash flows should be considered, and that means charging them as a cost when analyzing new products.

Dealing properly with negative externalities requires careful thinking. If Apple decided not to come out with a new model of iPod because of cannibalization, another company might come out with a similar new model, causing Apple to lose sales on existing models. Apple must examine the total situation, and this is definitely more than a simple, mechanical analysis. Experience and knowledge of the industry is required to make good decisions in most cases.

One of the best examples of a company getting into trouble as a result of not dealing correctly with cannibalization was IBM's response when personal computers were first developed in the 1970s. IBM's mainframes dominated the computer industry, and they generated huge profits. IBM used its technology to enter the PC market, and initially it was the leading PC company. However, its top managers decided to deemphasize the PC division because they were afraid it would hurt the more profitable mainframe business. That decision opened the door for Apple, Dell, Hewlett Packard, Sony, and Chinese competitors to take PC business away from IBM. As a result, IBM went from being the most profitable firm in the world to one whose very survival was threatened. IBM's experience highlights that, even as it's essential to understand the theory of finance, it is equally important to understand the industry and the long-run consequences of a given decision. Good judgment is an essential element for good financial decisions.

Positive *Within-Firm Externalities.* As we noted earlier, cannibalization occurs when a new product competes with an old one. However, a new project can also be *complementary* to an old one, in which case cash flows in the old operation will be *increased* when the new one is introduced. For example, Apple's iPod was a profitable product, but when Apple considered an investment in its music store it realized that the store would boost sales of iPods. So, even if an analysis of the proposed music store indicated a negative NPV, the analysis would not be complete unless the incremental cash flows that would occur in the iPod division were credited to the music store. Consideration of positive externalities often changes a project's NPV from negative to positive.

Environmental Externalities. The most common type of negative externality is a project's impact on the environment. Government rules and regulations constrain what companies can do, but firms have some flexibility in dealing with the environment. For example, suppose a manufacturer is studying a proposed new plant. The company could meet current environmental regulations at a cost of $1 million, but the plant would still emit fumes that would cause some bad will in its neighborhood. Those ill feelings would not show up in the cash flow analysis, but they should still be considered. Perhaps a relatively small additional expenditure would reduce the emissions substantially, make the plant look good relative to other plants in the area, and provide goodwill that in the future would help the firm's sales and its negotiations with governmental agencies.

Of course, all firms' profits depend on the Earth remaining healthy, so companies have an incentive to do things that protect the environment even though those actions are not currently required. However, if one firm decides to take actions that are good for the environment but quite costly, then either it must raise its prices or suffer a decline in earnings. If its competitors decide to get by with less costly but environmentally unfriendly processes, they can price their products lower and make more money. Of course, the more environmentally friendly companies can advertise their environmental efforts, and this might—or might not—offset their higher costs. All this illustrates why government regulations are often necessary. Finance, politics, and the environment are all interconnected.

Self-Test

Why should companies use a project's net cash flows rather than its accounting income when determining a project's NPV?

Explain the following terms: incremental cash flow, sunk cost, opportunity cost, externality, cannibalization, and complementary project.

Provide an example of a "good" externality—that is, one that increases a project's true NPV over what it would be if just its own cash flows were considered.

11.2 Analysis of an Expansion Project

Chapter 10 assumed that estimated cash flows were already available and then proceeded to illustrate how project cash flows are evaluated. In this chapter, we illustrate how cash flows are estimated by analyzing a project under consideration by Guyton Products Company (GPC). The project is the application of a radically new technology to a new type of solar water heater, which will be manufactured under a 4-year license from a university. It's not clear how well the water heater will work, how strong demand for it will be, how long it will be before the product becomes obsolete, or whether the license can be renewed after the initial 4 years. Still, the water heater has the potential for being quite profitable, though it could also fail miserably. GPC is a relatively large company and this is just one of its projects, so a failure would not bankrupt the firm but would hurt profits and the stock's price.

Cash Flow Projections: Base Case

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See **Ch11 Tool Kit.xls** *on the textbook's Web site.*

We used *Excel* to do the analysis. We could have used a calculator and paper, but *Excel* is *much* easier when dealing with realistic capital budgeting problems. You don't need to know *Excel* to understand our discussion, but if you plan to work in finance—or, really, in any business field—you must know how to use *Excel*, so we recommend that you open the *Excel* ***Tool Kit*** for this chapter and scroll through it as the textbook explains the analysis.

Figure 11-1 shows the base-case inputs used in the analysis. For example, the cost of required equipment to manufacture the water heaters is $3,400 and is shown in

FIGURE 11-1 Analysis of an Expansion Project: Inputs and Key Results (Thousands of Dollars)

	A–D	E	F	G	H–I
44	Part 1. Inputs and Key Results				
45					
46	Inputs	Base-Case		Key Results	
47	Equipment cost	$3,400		NPV	$36
48	Salvage value, equipment, Year 4	$300		IRR	10.35%
49	Opportunity cost	$0		MIRR	10.23%
50	Externalities (cannibalization)	$0		PI	1.01
51	Units sold, Year 1	550		Payback	3.41
52	Annual change in units sold, after Year 1	4.00%		Discounted payback	3.98
53	Sales price per unit, Year 1	$11.60			
54	Annual change in sales price, after Year 1	2.00%			
55	Variable cost per unit (VC), Year 1	$6.00			
56	Annual change in VC, after Year 1	2.00%			
57	Nonvariable cost (Non-VC), Year 1	$2,000			
58	Annual change in Non-VC, after Year 1	2.00%			
59	Project WACC	10.00%			
60	Tax rate	40.00%			
61	Working capital as % of next year's sales	12.65%			

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Cell E47 (all dollar values in Figure 11-1 and in our discussion here are reported in thousands, so the equipment actually costs $3,400,000). If you change the inputs in Cells E47:E61, *Excel* will instantly generate revised cash flows and performance measures (shown in Figure 11-2). We report key results next to the inputs so it is easy to see in real time the effects of changes in assumptions.

The input values from Figure 11-1 are used to calculate cash flows and performance measures, as reported in Figure 11-2. Some values change each year, and we report those in Rows 77 to 80. Annual unit sales are shown on Row 77, and they are projected to grow at 4% per year. The annual sales prices per unit are shown on Row 78, variable costs per unit on Row 79, and nonvariable costs on Row 80. These values are all projected to grow at the rates assumed in Part 1, and the annual values are used in the cash flow forecast.

The initial investments at t = 0 are shown in Cells E83:E85. The initial equipment cost of $3,400 is in Cell E83. Virtually all projects require working capital, and this one is no exception. For example, raw materials must be purchased and replenished each year as they are used. In Part 1 (Figure 11-1) we assume that GPC must have an amount of net operating working capital on hand that is equal to 12.65% of the upcoming year's sales. As we explain below, projected sales in Year 1 are $6,380, so there must be an initial investment in working capital of 12.65%($6,380) = $807; this is shown in Cell E84.[4] There are no opportunity costs in the base-case scenario, so the entry in Cell E85 is zero.

Unit sales and sales prices are multiplied to find the projected sales revenues shown on Row 87. Variable costs per unit multiplied by the number of units gives us total variable costs, as shown on Row 88. Nonvariable costs are shown on Row 89, and depreciation is on Row 90 (we explain the depreciation expense later in this section). Subtracting variable costs, nonvariable costs, and depreciation from sales

[4]Net operating working capital consists of inventories and accounts receivable *less* accounts payable and accruals.

FIGURE 11-2 Analysis of an Expansion Project: Cash Flows and Performance Measures (Thousands of Dollars)

	A	E	F	G	H	I
75	Part 2. Cash Flows and Performance Measures					
76	Variables Used in the Cash Flow Forecast	0	1	2	3	4
77	Unit sales		550	572	595	619
78	Sales price per unit		$11.60	$11.83	$12.07	$12.31
79	Variable cost per unit		$6.00	$6.12	$6.24	$6.37
80	Nonvariable costs (excluding depreciation)		$2,000	$2,040	$2,081	$2,122
81			Cash Flows At End of Year			
82	Investment Outlays at Time = 0	0	1	2	3	4
83	Equipment	–$3,400				
84	Initial investment in working capital	–807				
85	Opportunity cost, after taxes	0				
86	Net Cash Flows Over the Project's Life					
87	Sales revenues = Units × Price/unit		$6,380	$6,768	$7,179	$7,616
88	Variable costs = Units × Cost/unit		3,300	3,501	3,713	3,933
89	Nonvariable costs (excluding depreciation)		2,000	2,040	2,081	2,122
90	Depreciation: Accelerated, from table below		1,122	1,530	510	238
91	Operating profit (EBIT)		–$42	–$303	$875	$1,316
92	Taxes on operating profit		–17	–121	350	526
93	Net operating profit after taxes		–$25	–$182	$525	$790
94	Add back depreciation		1,122	1,530	510	238
95	Opportunity cost, after taxes		0	0	0	0
96	Cannibalization or complementary effects, after taxes		0	0	0	0
97	Salvage value (taxed as ordinary income)					300
98	Tax on salvage value (SV is taxed at 40%)					–120
99	Change in WC: Outflow (–) or recovery (+)		–49	–52	–55	963
100						
101	Project net cash flows: Time Line	–$4,207	–$1,048	–$1,296	$980	$2,171
102						

	Project Evaluation	Accelerated Results	Accelerated Formulas	Straight Line Results
105	NPV	$36	= NPV(E59,F101:I101)+E101	–$18
106	IRR	10.35%	= IRR(E101:I101)	9.83%
107	MIRR	10.23%	=MIRR(E101:I101,E59,E59)	9.88%
108	Profitability index	1.01	=NPV(E59,F101:I101)/(–E101)	1.00
109	Payback	3.41	=PERCENTRANK(E112:I112,0,6)*I111	3.47
110	Discounted payback	3.98	=PERCENTRANK(E114:I114,0,6)*I111	#N/A

	Calculations for Payback	Year: 0	1	2	3	4
112	Cumulative cash flows for payback	–$4,207	–$3,159	–$1,863	–$883	–$1,288
113	Discounted cash flows for disc. payback	–$4,207	–$952	–$1,071	$736	–$1,483
114	Cumulative discounted cash flows	–$4,207	–$3,255	–$2,183	–$1,447	–$36
115	Accelerated Depreciation					
116	Depreciable basis: $3,400	Rate/year	33%	45%	15%	7%
117		Dollars/year	$1,122	$1,530	$510	$238

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revenues results in operating profit (EBIT), as shown on Row 91. We calculate taxes on Row 92 and subtract them to get the project's net operating profit after taxes on Row 93. We add back depreciation on Row 94 because it is a noncash expense. There are no annual opportunity costs or cannibalization effects in the base-case scenario; if there were, we would include them on an after-tax basis on Rows 95 and 96.

Because of the license, the project has a 4-year life; at Year 4, the equipment is expected to have a salvage value of $300, which is shown in Cell I97. Because the assets will be fully depreciated by Year 4, the $300 is a gain that is taxed at the firm's ordinary income tax rate of 40%; this tax is shown in Cell I98.[5]

Row 99 shows the annual changes in working capital. GPC will operate the project with net working capital equal to 12.65% of the next year's sales, so as sales grow, the firm will have to increase its net working capital. These increases are shown as negative numbers (investments) on Row 99, Years 1 through 3. Then, at the end of Year 4, all of the investments in working capital will be recovered. Inventories will be sold and not replaced, and all receivables will be collected by the end of Year 4. Total net working capital recovered at t = 4 is the sum of the initial investment at t = 0, $807, plus the additional investments during Years 1 through 3; the total is $963.

We sum Cells E83:E85 to get the total initial investment, and we sum Rows 93 to 99 to get the project's annual net cash flows, set up as a time line on Row 101. These cash flows are then used to calculate NPV, IRR, MIRR, PI, payback, and discounted payback, performance measures that are shown in Cells C105 through C110. (The results Columns H and I are based on straight-line depreciation and are discussed later.) Based on this analysis, the project looks like it is barely breaking even, with an NPV of only $36 as compared with an initial investment of over $4,200. Its IRR and MIRR are both barely greater than the 10% WACC, the PI is barely greater than 1.0, and the payback and discounted payback are almost as long as the project's life. However, before the decision is finalized, we need to look at some additional factors. In particular, we must recognize that the actual outcome could be better or worse than the base-case level, that there might be responses management can make to changing conditions, and that there might be qualitative factors to consider. We examine these concerns later in the chapter, but first we address the following issues associated with the base-case analysis.

Depreciation

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The depreciation expense is calculated as the annual rate allowed by the IRS multiplied by the project's depreciable cost basis, which in this case is $3,400.[6] Congress sets the depreciation rates used for tax purposes, which are then used in capital budgeting. The rates for this project are shown on Row 116, and more details are provided in Appendix 11A and in the chapter's ***Tool Kit.*** Congress permits firms to depreciate assets using either the straight-line method or an accelerated method. The results we have discussed thus far were based on accelerated depreciation. We also analyzed the project using straight-line depreciation with the results reported in Figure 11-2 in H105:H110; the full analysis is in the chapter's ***Tool Kit.*** The results indicate that the project is worth less when using straight-line depreciation than when using accelerated depreciation. In general, *profitable firms are better off using accelerated depreciation* because more depreciation is taken in the early years under the accelerated method, so taxes are lower in those years and higher in later years. Total depreciation, total cash flows, and total taxes are the same under both depreciation methods, but receiving the cash earlier under the accelerated method results in a higher NPV, IRR, and MIRR.

Suppose Congress wants to encourage companies to increase their capital expenditures and thereby boost economic growth and employment. What changes in de-

[5]If an asset is sold for less than its book value, the resulting "negative" tax is a credit and would increase the cash flow. If an asset is sold for exactly its book value, there will be no gain or loss and hence no tax liability or credit.

[6]Regardless of whether accelerated or straight-line depreciation is used, the basis is not adjusted by the salvage value when calculating the depreciation expense that is used to determine taxable income.

preciation regulations would have the desired effect? The answer is "Make accelerated depreciation even more accelerated." For example, if GPC could write off equipment at rates of 67%, 22%, 7%, and 4% rather than 33%, 45%, 15%, and 7%, then its early tax payments would be even lower, early cash flows would be even higher, and the project's NPV would exceed the value shown in Figure 11-2.[7]

Taxation of Salvage

In our example, GPC's project was fully depreciated by the end of the project. But suppose instead that GPC terminates operations before the equipment is fully depreciated. The after-tax salvage value depends on the price at which GPC can sell the equipment *and* on the book value of the equipment (i.e., the original basis less all previous depreciation charges). The following table shows the calculations of yearly book values.

	Year			
	1	2	3	4
Beginning book value	$3,400	$2,278	$748	$238
Annual depreciation	1,122	1,530	510	238
Ending book value	$2,278	$ 748	$238	$ 0

Suppose GPC terminates at Year 2, at which time the book value is $748. We consider two cases, gains and losses. In the first case, the salvage value is $898 and so there is a reported gain of $898 − $748 = $150. This gain is taxed as ordinary income, so the tax is 40%($150) = $60. The after-tax cash flow is equal to the sales price less the tax: $898 − $60 = $838.

Now suppose the salvage value at Year 2 is only $98. In this case, there is a reported loss: $98 − $748 = −$650. This is treated as an ordinary expense, so its tax is 40%(−$650) = −$260. This "negative" tax acts as a credit if GPC has other taxable income, so the net after-tax cash flow is $98 − (−$260) = $358.

Externalities: Cannibalization or Complementary Projects

As noted earlier, the solar water heater project does not lead to any cannibalization effects. Suppose, however, that it would reduce the net after-tax cash flows of another GPC division by $50 per year and that no other firm could take on this project if GPC turns it down. In this case, we would use the cannibalization line at Row 96, deducting $50 each year. As a result, the project would have a lower NPV. On the other hand, if the project would cause additional inflows to some other GPC division because it was complementary to that other division's products (i.e., if a positive externality exists), then those after-tax inflows should be attributed to the water heater project and thus shown as a positive inflow on Row 96.

Opportunity Costs

Now suppose the $3,400 initial cost were based on the assumption that the project would use space in a building that GPC now owns and that the space could be leased to another company for $200 per year, after taxes, if the project is rejected. The $200

[7]Indeed, this is exactly what Congress did in 2008 and 2009, in response to the global economic crisis, by establishing a temporary "bonus" depreciation to stimulate investment. The depreciation in the first year is the regular accelerated depreciation plus a bonus of 50% of the original basis. This feature of the tax code is set to expire before this book will be printed, but Congress has extended the bonus once and might extend it again.

would be an *opportunity cost*, and it should be reflected in our calculations. We would subtract the $200 per year on Row 95, causing a decrease in NPV.

Sunk Costs. Now consider a different example. Suppose GPC had spent $100,000 on a marketing study for an oil pump project, and the study was inconclusive. If it abandons the project without going forward, it would show a loss of $100,000. But suppose it could go forward with an additional investment of $500,000, and suppose the NPV on this incremental investment would be $50,000. In the final analysis, this project would be a loser regardless of whether GPC stops or goes forward. With hindsight we can see that the true "NPV" if we go forward would be the calculated NPV of $50,000 minus the $100,000 sunk cost, or $50,000 − $100,000 = −$50,000. A loss of $50,000 is bad, but not as bad as a loss of $100,000, so GPC should go ahead with the oil pump project.

Other Changes to the Inputs

All of the input variables could be changed, and these changes would alter the calculated project cash flows and thus the NPV and other capital budgeting decision criteria. We could increase or decrease the projected unit sales, the sales price, the variable and/or the fixed costs, the initial investment cost, the net working capital requirements, the salvage value, and even the tax rate if we thought Congress was likely to raise or lower taxes. Such changes can be made easily in an *Excel* model, making it possible to immediately see the resulting changes in the decision criteria. This is called *sensitivity analysis*, and we discuss it in Section 11.5.

The Importance of Incorporating Expected Inflation in Prices and Costs

Notice that the model has inputs for annual changes in prices and costs; in other words, it allows for inflation (or deflation) in prices and costs. In Figure 11-2, we let all prices and costs change by 2% annually to keep the example simple, but it is certainly possible that some items (such as energy costs) might experience higher inflation than others (such as CPU prices), so our models always include separate line items for the expected inflation in each price or cost. It is easy to overlook inflation, but it is important to include it. For example, had we forgotten to include inflation in the GPC example, then the estimated NPV would have dropped from +$36 to −$29. Forgetting to include inflation in a capital budgeting analysis typically causes the estimated NPV to be lower than the true NPV, which could cause a company to reject a project that it should have accepted.[8]

Self-Test

In what way is the setup for finding a project's cash flows similar to the projected income statements for a new, single-product firm? In what way would the two statements be different?

Would a project's NPV for a typical firm be higher or lower if the firm used accelerated rather than straight-line depreciation? Explain.

How could the analysis in Figure 11-2 be modified to consider cannibalization, opportunity costs, and sunk costs?

Why does net working capital appear with both negative and positive values in Figure 11-2?

[8]The market's estimate of expected inflation is already incorporated into the cost of debt (via the inflation premium) and the cost of equity (via the risk-free rate in the CAPM), so the project's cost of capital includes the effect of expected inflation. If you don't also include the effect of inflation in projected cash flows, then the cash flows will be too low relative to the cost of capital, leading to a downward-biased estimate of NPV.

11.3 Risk Analysis in Capital Budgeting[9]

Projects differ in risk, and risk should be reflected in capital budgeting decisions. There are three separate and distinct types of risk.

1. **Stand-alone risk** is a project's risk assuming (a) that it is the firm's only asset and (b) that each of the firm's stockholders holds only that one stock in his portfolio. Stand-alone risk is based on uncertainty about the project's expected cash flows. It is important to remember that *stand-alone risk ignores diversification by both the firm and its stockholders.*
2. **Within-firm risk** (also called **corporate risk**) is a project's risk to the corporation itself. Within-firm risk recognizes that the project is only one asset in the firm's portfolio of projects; hence some of its risk is eliminated by diversification within the firm. However, *within-firm risk ignores diversification by the firm's stockholders.* Within-firm risk is measured by the project's impact on uncertainty about the firm's future total cash flows.
3. **Market risk** (also called **beta risk**) is the risk of the project as seen by a well-diversified stockholder who recognizes (a) that the project is only one of the firm's projects and (b) that the firm's stock is but one of her stocks. The project's market risk is measured by its effect on the firm's beta coefficient.

Taking on a project with a lot of stand-alone and/or corporate risk will not necessarily affect the firm's beta. However, if the project has high stand-alone risk and if its cash flows are highly correlated with cash flows on the firm's other assets and with cash flows of most other firms in the economy, then the project will have a high degree of all three types of risk. Market risk is, *theoretically*, the most relevant because it is the one that, according to the CAPM, is reflected in stock prices. Unfortunately, market risk is also the most difficult to measure, primarily because new projects don't have "market prices" that can be related to stock market returns.

Most decision makers do a *quantitative* analysis of stand-alone risk and then consider the other two types of risk in a *qualitative* manner. Projects are classified into several categories; then, using the firm's overall WACC as a starting point, a **risk-adjusted cost of capital** is assigned to each category. For example, a firm might establish three risk classes and then assign the corporate WACC to average-risk projects, add a 5% risk premium for higher-risk projects, and subtract 2% for low-risk projects. Under this setup, if the company's overall WACC were 10%, then 10% would be used to evaluate average-risk projects, 15% for high-risk projects, and 8% for low-risk projects. Although this approach is probably better than not making any risk adjustments, these adjustments are highly subjective and difficult to justify. Unfortunately, there's no perfect way to specify how high or low the risk adjustments should be.[10]

resource

See **Web Extension 11A** *at the textbook's Web site for a more detailed discussion on alternative methods for incorporating project risk into the capital budgeting decision process.*

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[9]Some professors may choose to cover some of the risk sections and skip others. We offer a range of choices, and we tried to make the exposition clear enough that interested and self-motivated students can read these sections on their own if they are not assigned.

[10]We should note that the CAPM approach can be used for projects provided there are specialized publicly traded firms in the same business as that of the project under consideration. See the discussion in Chapter 9 regarding techniques for measuring divisional betas.

For more on risk adjustments, see Tarun K. Mukherjee, "Reducing the Uncertainty-Induced Bias in Capital Budgeting Decisions—A Hurdle Rate Approach," *Journal of Business Finance & Accounting*, September 1991, pp. 747–753.

Self-Test

What are the three types of project risk?
Which type is theoretically the most relevant? Why?
Describe a type of classification scheme that firms often use to obtain risk-adjusted costs of capital.

11.4 Measuring Stand-Alone Risk

A project's stand-alone risk reflects uncertainty about its cash flows. The required dollars of investment, unit sales, sales prices, and operating costs as shown in Figure 11-1 for GPC's project are all subject to uncertainty. First-year sales are projected at 550 units to be sold at a price of $11.60 per unit (recall that all dollar values are reported in thousands). However, unit sales will almost certainly be somewhat higher or lower than 550, and the price will probably turn out to be different from the projected $11.50 per unit. Similarly, the other variables would probably differ from their indicated values. Indeed, *all the inputs are expected values, not known values, and actual values can and do vary from expected values*. That's what risk is all about!

Three techniques are used in practice to assess stand-alone risk: (1) sensitivity analysis, (2) scenario analysis, and (3) Monte Carlo simulation. We discuss them in the sections that follow.

Self-Test

What does a project's stand-alone risk reflect?
What three techniques are used to assess stand-alone risk?

11.5 Sensitivity Analysis

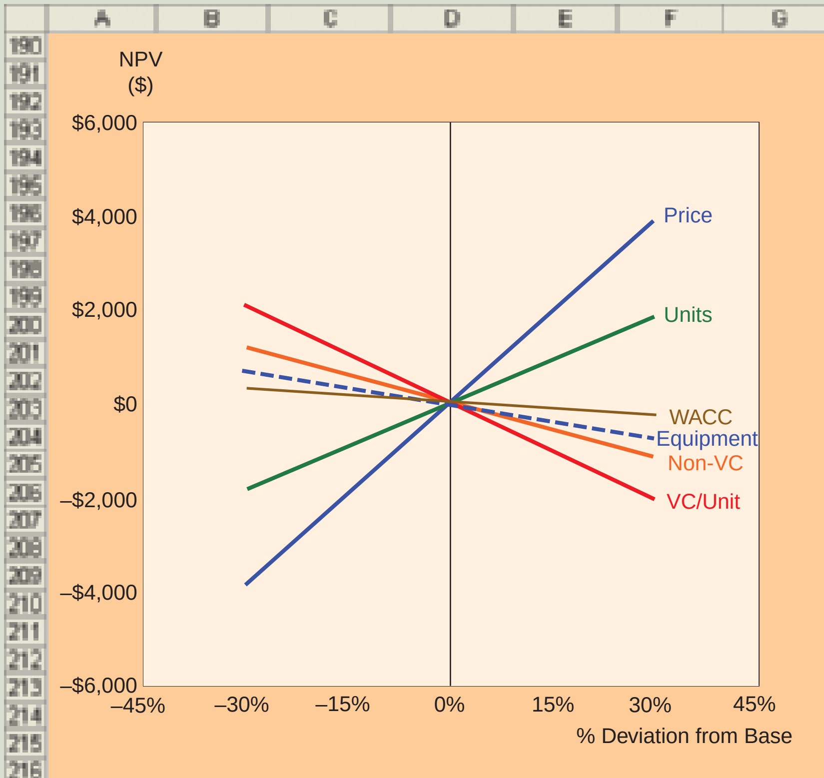
Intuitively, we know that a change in a key input variable such as units sold or the sales price will cause the NPV to change. **Sensitivity analysis** *measures the percentage change in NPV that results from a given percentage change in an input variable when other inputs are held at their expected values*. This is by far the most commonly used type of risk analysis. It begins with a base-case scenario in which the project's NPV is found using the base-case value for each input variable. GPC's base-case inputs were given in Figure 11-1, but it's easy to imagine changes in the inputs, and any changes would result in a different NPV.

When GPC's senior managers review a capital budgeting analysis, they are interested in the base-case NPV, but they always go on to ask a series of "what if" questions: "What if unit sales fall to 385?" "What if market conditions force us to price the product at $8.12, not $11.60?" "What if variable costs are higher than we have forecasted?" Sensitivity analysis is designed to provide answers to such questions. Each variable is increased or decreased by a specified percentage from its expected value, holding other variables constant at their base-case levels. Then the NPV is calculated using the changed input. Finally, the resulting set of NPVs is plotted to show how sensitive NPV is to changes in the different variables.

Figure 11-3 shows GPC's project's sensitivity graph for six key variables. The data below the graph give the NPVs based on different values of the inputs, and those NPVs were then plotted to make the graph. Figure 11-3 shows that, as unit sales and the sales price are increased, the project's NPV increases; in contrast, increases in variable costs, fixed costs, equipment costs, and WACC lower the project's NPV. The slopes of the lines in the graph and the ranges in the table below the graph indicate how sensitive NPV is to each input: *The larger the range, the steeper the variable's slope and the more sensitive the NPV is to this variable*. We see that NPV is extremely sensitive to changes in the sales price; fairly sensitive to changes in variable

FIGURE 11-3 Sensitivity Graph for Solar Water Heater Project

See **Ch11 Tool Kit.xls** *on the textbook's Web site.*



Data for Sensitivity Graph

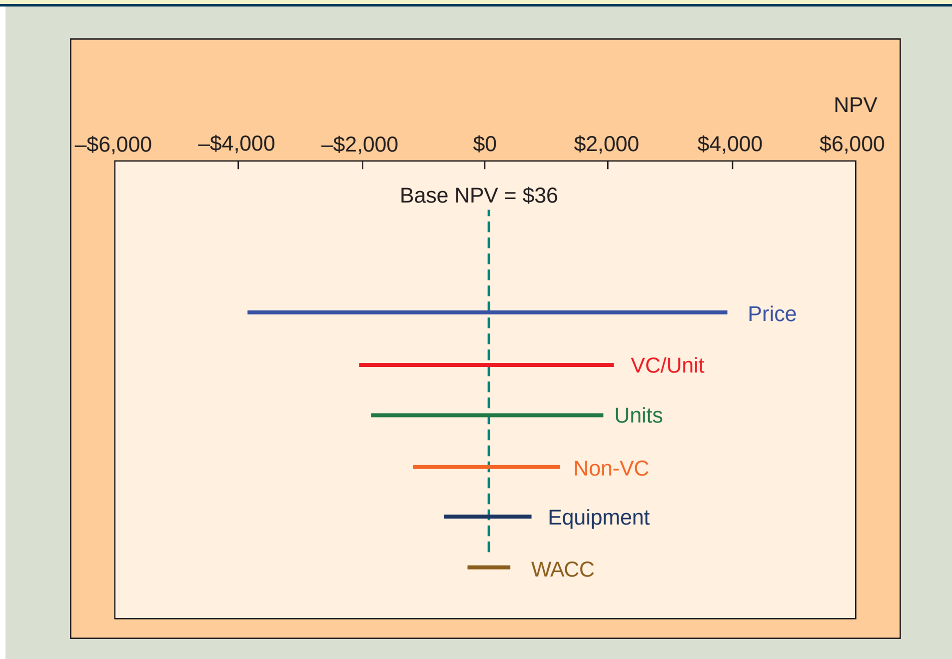
Deviation from Base	NPV With Variables At Different Deviations From Base					
	Equipment	Price	Units	VC/Unit	Non-VC	WACC
–30%	$716	–$3,839	–$1,791	–$2,083	$1,209	$361
0%	$36	$36	$36	$36	$36	$36
30%	–$645	$3,910	$1,863	–$2,011	–$1,137	–$254
Range	$1,361	$7,749	$3,655	$4,095	$2,346	$615

costs, units sold, and fixed costs; and not especially sensitive to changes in the equipment's cost and the WACC. Management should, of course, try especially hard to obtain accurate estimates of the variables that have the greatest impact on the NPV.

If we were comparing two projects, then the one with the steeper sensitivity lines would be riskier (other things held constant), because relatively small changes in the input variables would produce large changes in the NPV. Thus, sensitivity analysis provides useful insights into a project's risk.[11] Note, however, that even though NPV may be highly sensitive to certain variables, if those variables are not likely to

[11]Sensitivity analysis is tedious with a regular calculator but easy with a spreadsheet. We used the chapter's *Excel* model to calculate the NPVs and then to draw the graph in Figure 11-3. To conduct such an analysis by hand would be quite time-consuming, and if the basic data were changed even slightly—say, the cost of the equipment was increased slightly—then all of the calculations would have to be redone. With a spreadsheet, we can simply type over the old input with the new one, and presto, the analysis and the graph change instantaneously.

FIGURE 11-4 Tornado Diagram for Solar Water Heater Project: Range of Outcomes for Input Deviations from Base Case (Thousands of Dollars)



See **Ch11 Tool Kit.xls** *on the textbook's Web site.*

change much from their expected values, then the project may not be very risky in spite of its high sensitivity. Also, if several of the inputs change at the same time, the combined effect on NPV can be much greater than sensitivity analysis suggests.

Tornado Diagrams

Tornado diagrams are another way to present results from sensitivity analysis. The first step is to rank the range of possible NPVs for each of the input variables being changed. In our example, the range for sales price per unit is the largest and the range for WACC is the smallest. The ranges for each variable are then plotted, with the largest range on top and the smallest range on the bottom. It is also helpful to plot a vertical line showing the base-case NPV. We present a tornado diagram in Figure 11-4. Notice that the diagram is like a tornado in the sense that it is widest at the top and smallest at the bottom; hence its name. The tornado diagram makes it immediately obvious which inputs have the greatest impact on NPV: sales price and variable costs.

NPV Break-even Analysis

A special application of sensitivity analysis is called **NPV break-even analysis**. In a break-even analysis, we find the level of an input that produces an NPV of exactly zero. We used *Excel*'s Goal Seek feature to do this. See ***Ch11 Tool Kit.xls*** on the textbook's Web site for an explanation of how to use this *Excel* feature.

Table 11-1 shows the values of the inputs discussed previously that produce a zero NPV. For example, the number of units sold in Year 1 can drop to 547 before the project's NPV falls to zero. Break-even analysis is helpful in determining how bad things can get before the project has a negative NPV.

TABLE 11-1 NPV Break-even Analysis (Thousands of Dollars)

INPUT	INPUT VALUE THAT PRODUCES ZERO NPV HOLDING ALL ELSE CONSTANT
Sales price per unit, Year 1	$11.57
Variable cost per unit (VC), Year 1	$ 6.03
Annual change in units sold after Year 1	3.58%
Units sold, Year 1	547
Nonvariable cost (Non-VC), Year 1	$2,018
Project WACC	10.35%

resource

See ***Ch11 Tool Kit.xls*** *on the textbook's Web site.*

Extensions of Sensitivity Analysis. In our examples, we showed how one output, NPV, varied with a change in a single input. Sensitivity analysis can easily be extended to show how multiple outputs, such as NPV and IRR, vary with a change in an input. See ***Ch11 Tool Kit.xls*** on the textbook's Web site for an example showing how to use *Excel*'s Data Table feature to present multiple outputs.

It is also possible to use a Data Table to show how a single output, such as NPV, varies for changes in two inputs, such as the number of units sold and the sales price per unit. See ***Ch11 Tool Kit.xls*** on the textbook's Web site for an example. However, when we examine the impact of a change in more than one input, we usually use scenario analysis, which is described in the following section.

Self-Test

What is sensitivity analysis?

Briefly explain the usefulness of a sensitivity graph.

Discuss the following statement: "A project may not be very risky in spite of its high sensitivity to certain variables."

11.6 Scenario Analysis

In the sensitivity analysis just described, we changed one variable at a time. However, it is useful to know what would happen to the project's NPV if several of the inputs turn out to be better or worse than expected, and this is what we do in a **scenario analysis**. Also, scenario analysis allows us to assign probabilities to the base (or most likely) case, the best case, and the worst case; then we can find the *expected value* of the project's NPV, along with its *standard deviation* and *coefficient of variation*, to get a better idea of the project's risk.

In a scenario analysis, we begin with the base-case scenario, which uses the most likely value for each input variable. We then ask marketing, engineering, and other operating managers to specify a worst-case scenario (low unit sales, low sales price, high variable costs, and so on) and a best-case scenario. Often, the best and worst cases are defined as having a 25% probability of occurring, with a 50% probability for the base-case conditions. Obviously, conditions could take on many more than three values, but such a scenario setup is useful to help get some idea of the project's riskiness.

After much discussion with the marketing staff, engineers, accountants, and other experts in the company, a set of worst-case and best-case values were determined for several key inputs. Figure 11-5, taken from Tab 3 of the chapter ***Tool Kit*** model, shows the probability and inputs assumed for the base-case, worst-case, and best-case scenarios.

FIGURE 11-5 Inputs and Key Results for Each Scenario (Thousands of Dollars)

	A–D	E	F	G	H	I
33						
34		Scenarios:				
35	Inputs:	Base		Worst		Best
36	Probability of Scenario	50%		25%		25%
37	Equipment cost	$3,400		$4,250		$2,550
38	Salvage value, equipment, Year 4	$300		$300		$300
39	Opportunity cost	$0		$0		$0
40	Externalities (cannibalization)	$0		$0		$0
41	Units sold, Year 1	550		412		688
42	Annual change in units sold, after Year 1	4.00%		–6.00%		14.00%
43	Sales price per unit, Year 1	$11.60		$8.70		$14.50
44	Annual change in sales price, after Year 1	2.00%		2.00%		2.00%
45	Variable cost per unit (VC), Year 1	$6.00		$7.50		$4.50
46	Annual change in VC, after Year 1	2.00%		2.00%		2.00%
47	Nonvariable cost (Non-VC), Year 1	$2,000		$2,500		$1,500
48	Annual change in Non-VC, after Year 1	2.00%		2.00%		2.00%
49	Project WACC	10.00%		10.00%		10.00%
50	Tax rate	40.00%		50.00%		30.00%
51	Working capital as % of next year's sales	12.65%		12.65%		12.65%
52	Key Results:	Base		Worst		Best
53	NPV	$36		–$5,847		$13,379
54	IRR	10.35%		Not found		112.01%
55	MIRR	10.23%		–100.00%		60.30%
56	PI	1.01		–0.24		4.51
57	Payback	3.41		Not found		1.00
58	Discounted payback	3.98		Not found		1.09

See **Ch11 Tool Kit.xls** on the textbook's Web site.

The project's cash flows and performance measures under each scenario are calculated; see the ***Tool Kit*** for the calculations. The cash flows for each scenario are shown in Figure 11-6, along with a probability distribution of the possible outcomes for NPV. If the project is highly successful, then a low initial investment, high sales price, high unit sales, and low production costs would combine to result in a very high NPV, $13,379. However, if things turn out badly, then the NPV would be a *negative* $5,847. This wide range of possibilities, and especially the large potential negative value, suggests that this is a risky project. If bad conditions materialize, the project will not bankrupt the company—this is just one project for a large company. Still, losing $5,847 (actually $5,847,000, since the units are thousands of dollars) would certainly hurt the company's value and the reputation of the project's manager.

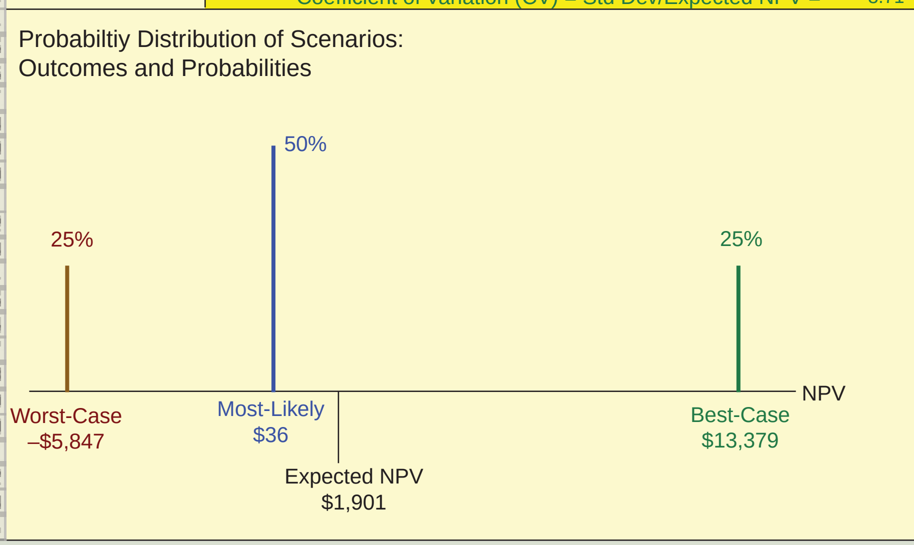
If we multiply each scenario's probability by the NPV for that scenario and then sum the products, we will have the project's expected NPV of $1,901, as shown in Figure 11-6. Note that the *expected* NPV differs from the *base-case* NPV. This is not an error—mathematically, they are not equal.[12] We also calculate the standard deviation of the expected NPV; it is $7,049. Dividing the standard deviation by the expected NPV yields the coefficient of variation, 3.71, which is a measure of stand-alone risk. The firm's average project has a coefficient of variation of about 0.50, so

[12]This result occurs because two uncertain variables, sales volume and sales price, are multiplied together to obtain dollar sales, and this process causes the NPV distribution to be skewed to the right. A large number multiplied by another large number produces a very big number, and this in turn causes the average value (or expected value) to increase.

FIGURE 11-6 Scenario Analysis: Expected NPV and Its Risk

Predicted Cash Flows for Alternative Scenarios

Scenario	Prob:	0	1	2	3	4	WACC	NPV
Best	25%	–$3,812	$3,813	$4,634	$5,256	$8,705	10.00%	$13,379
Base	50%	–$4,207	$1,048	$1,296	$980	$2,171	10.00%	$36
Worst	25%	–$4,703	–$283	–$64	–$737	–$410	10.00%	–$5,847
							Expected NPV =	$1,901
							Standard Deviation (SD) =	$7,409
							Coefficient of Variation (CV) = Std Dev/Expected NPV =	3.71



See **Ch11 Tool Kit.xls** *on the textbook's Web site.*

the 3.71 indicates that this project is much riskier than most of GPC's other typical projects.

GPC's corporate WACC is 9%, so that rate should be used to find the NPV of an average-risk project. However, the water heater project is riskier than average, so a higher discount rate should be used to find its NPV. There is no way to determine the "precisely correct" discount rate—this is a judgment call. Management decided to evaluate the project using a 10% rate.[13]

Note that the base-case results are the same in our sensitivity and scenario analyses, but in the scenario analysis the worst case is much worse than in the sensitivity analysis and the best case is much better. This is because in scenario analysis all of the variables are set at their best or worst levels, whereas in sensitivity analysis only one variable is adjusted and all the others are left at their base-case levels.

[13]One could argue that the best-case scenario should be evaluated with a relatively low WACC, the worst-case scenario with a relatively high WACC, and the base case with the average corporate WACC. However, one could also argue that, at the time of the initial decision, we don't know what case will occur and hence a single rate should be used. Observe that, in the worst-case scenario, all of the cash flows are negative. If we used a high WACC because of this branch's risk, this would lower the PV of these negative cash flows, making the worst case much better than if we used the average WACC. Determining the "right" WACC to use in the analysis is not an easy task!

The project has a positive NPV, but its coefficient of variation (CV) is 3.71, which is almost 8 times higher than the 0.50 CV of an average project. With all that risk, it is not clear if the project should be accepted or not. At this point, GPC's CEO asked the CFO to investigate the risk further by performing a simulation analysis, as described in the next section.

Self-Test

What is scenario analysis?

Differentiate between sensitivity analysis and scenario analysis. What advantage does scenario analysis have over sensitivity analysis?

11.7 Monte Carlo Simulation[14]

Monte Carlo simulation ties together sensitivities, probability distributions, and correlations among the input variables. It grew out of work in the Manhattan Project to build the first atomic bomb and was so named because it utilized the mathematics of casino gambling. Although Monte Carlo simulation is considerably more complex than scenario analysis, simulation software packages make the process manageable. Many of these packages can be used as add-ons to *Excel* and other spreadsheet programs.

In a simulation analysis, a probability distribution is assigned to each input variable—sales in units, the sales price, the variable cost per unit, and so on. The computer begins by picking a random value for each variable from its probability distribution. Those values are then entered into the model, the project's NPV is calculated, and the NPV is stored in the computer's memory. This is called a trial. After completing the first trial, a second set of input values is selected from the input variables' probability distributions, and a second NPV is calculated. This process is repeated many times. The NPVs from the trials can be charted on a histogram, which shows an estimate of the project's outcomes. The average of the trials' NPVs is interpreted as a measure of the project's expected NPV, with the standard deviation (or the coefficient of variation) of the trials' NPV as a measure of the project's risk.

Using this procedure, we conducted a simulation analysis of GPC's solar water heater project. To compare apples and apples, we focused on the same six variables that were allowed to change in the previously conducted scenario analysis. We assumed that each variable can be represented by its own continuous normal distribution with means and standard deviations that are consistent with the base-case scenario. For example, we assumed that the units sold in Year 1 come from a normal distribution with a mean equal to the base-case value of 550. We used the probabilities and outcomes of the three scenarios to estimate the standard deviation (all calculations are in the ***Tool Kit***). The standard deviation of units sold is 98, as calculated using the scenario values. We made similar assumptions for all variables. In addition, we assumed that the annual change in unit sales will be positively correlated with unit sales in the first year: If demand is higher than expected in the first year, it will continue to be higher than expected. In particular, we assume a correlation of 0.65 between units sold in the first year and growth in units sold in later years. For all other variables, we assumed zero correlation. Figure 11-7 shows the inputs used in the simulation analysis.

[14]This section is relatively technical, and some instructors may choose to skip it with no loss in continuity.

FIGURE 11-7 Inputs and Key Results for the Current Simulation Trial (Thousands of Dollars)

	A	C	D	E	F
31–33		Inputs for Simulation Probability Distributions		Random Variables Used in Current Simulation Trial	
34–36		Expected Value of input	Standard Deviation of Input	Standard Normal Random Variable	Value used in Current Trial
37	Inputs:				
38	Equipment cost	$3,400	$601	–0.30	$3,217
39	Salvage value, equipment, Year 4				$300
40	Opportunity cost				$0
41	Externalities (cannibalization)				$0
42	Units sold, Year 1	550	98	0.57	606
43	Annual change in units sold, after Year 1	4.00%	7.07%	0.93	10.60%
44	Sales price per unit, Year 1	$11.60	$2.05	–0.24	$11.11
45	Annual change in sales price, after Year 1				2.00%
46	Variable cost per unit (VC), Year 1	$6.60	$1.06	–0.70	$5.25
47	Annual change in VC, after Year 1				2.00%
48	Nonvariable cost (Non-VC), Year 1	$2,000	$354	–0.31	$1,890
49	Annual change in Non-VC, after year 1				2.00%
50	Project WACC				10.00%
51	Tax rate	40.00%	7.07%	1.23	48.67%
52	Working capital as % of next year's sales				12.65%
53–55	Assumed correlation between units sold in Year 1 and annual change in units sold in later years:	ρ =	65.00%		

Key Results Based on Current Trial	
NPV	$1,595
IRR	24.67%
MIRR	19.48%
PI	1.39
Payback	2.83
Discounted payback	3.24

See **Ch11 Tool Kit.xls** *on the textbook's Web site.*

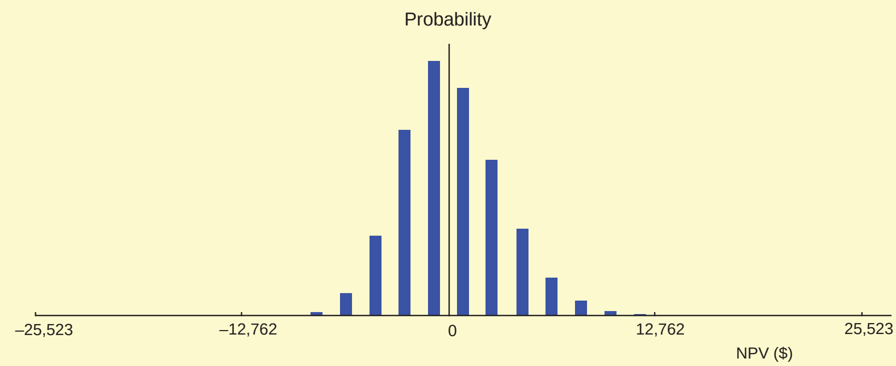
Figure 11-7 also shows the current set of random variables that were drawn from the distributions at the time we created the figure for the textbook. We used a two-step procedure to create the random variables for the inputs. First, we used *Excel*'s functions to generate standard normal random variables with a mean of 0 and a standard deviation of 1; these are shown in Cells E38:E51.[15] To create the random values for the inputs used in the analysis, we multiplied a random standard normal variable by the standard deviation and added the expected value. For

[15] See the ***Tool Kit*** for detailed explanations on using *Excel* to generate random variables.

FIGURE 11-8 Summary of Simulation Results (Thousands of Dollars)

Number of Trials = 5,000

	Simulated Input Variables							Key Results:
	Equipment cost	Units sold, Year 1	Annual change in units sold, after Year 1	Sales price per unit, Year 1	Variable cost per unit (VC), Year 1	Nonvariable cost (Non- VC), Year 1	Tax rate	NPV
Mean	$3,382	550	4.1%	$11.63	$5.99	$1,998	39.9%	$215
Standard deviation	603	99	7.2%	2.05	1.06	357	7.2%	$3,275
Maximum	5,565	925	34.6%	18.64	9.76	3,234	66.4%	$25,523
Minimum	1,130	212	–18.3%	3.18	1.78	670	11.1%	–$10,246
Correlation with unit sales			64.4%					
Median								–$51
Probability of NPV > 0								49.5%
Coefficient of variation								15.24



resource

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example, *Excel* drew the value 0.57 for first-year unit sales (Cell E42) from a standard normal distribution. We calculated the value for first-year unit sales to use in the current trial as 550 + 98(0.57) = 606, which is shown in Cell F42.[16]

We used the inputs in Cells F38:F52 to generate cash flows and to calculate performance measures for the project (the calculations are in the ***Tool Kit***). For the trial reported in Figure 11-7, the NPV is $1,595. We used a Data Table in the ***Tool Kit*** to generate additional trials. For each trial, the Data Table saved the value of the input variables and the value of the trial's NPV. Figure 11-8 presents selected results from the simulation for 5,000 trials. (The ***Tool Kit*** shows only 100 trials because simulating 5,000 trials reduces *Excel*'s speed when performing other calculations in the worksheet.)

After running a simulation, the first thing we do is verify that the results are consistent with our assumptions. The resulting sample mean and standard deviation of units sold in the first year are 550 and 99, which are virtually identical to our assumptions in Figure 11-7. The same is true for all the other inputs, so we can be reasonably confident that the simulation is doing what we are asking.

[16]We used a slightly more complicated procedure to generate a random variable for the annual change in sales to ensure that it had 0.65 correlation with the first-year units sold. See the ***Tool Kit*** for details.

THE GLOBAL ECONOMIC CRISIS

Are Bank Stress Tests Stressful Enough?

In late February of 2009, President Obama's newly appointed financial team—consisting of leaders of the Treasury, the Federal Reserve, and the FDIC—announced that the 19 largest U.S. banks (including Citi, JPMorgan Chase, and Bank of America) would have to undergo "stress tests." If its test indicated that a bank has a high probability of failure under possible conditions, then it would be forced to raise new capital. Investors would be reluctant to provide capital to a bank deemed likely to fail, so the capital would have to come from the Treasury. That would mean that the U.S. government would then own most of the equity and would control the bank, and the bank's top managers would likely be fired.

Just what is a stress test? In medicine, people are connected to a device that monitors their heart, then put on a treadmill, and then tested to see how well their heart takes the stress of a brisk uphill jog. In engineering, beams are subjected to pressure to see how much weight they can hold before breaking. In finance, scenario and simulation analyses like those described in this chapter are conducted to see what would happen under unfavorable conditions. The "worst-case" scenario we described earlier amounts to a stress test for an individual project, and similar tests can be conducted at the corporate level to answer questions like this: "Could we make the required interest and principal payments on our debt if sales fall by 50%?" Well-run companies are constantly stress-testing projects, divisions, and the entire corporation; then, as a result of these tests, managers take actions such as rejecting projects that are too risky or financing with stock rather than debt.

Banks and other financial institutions have been leaders in risk management, which includes stress-testing, but as we know all too well, those tests failed in the 2008–2009 recession. Banks grossly underestimated the combined effects of too much consumer and corporate debt, too much homebuilding, inadequate supervision of mortgage lenders, too many exotic derivatives whose risks the bankers did not fully understand, and so on. In a nutshell, banks throughout the world simply failed to test and plan for the level of economic distress that actually materialized, and the result was a meltdown of the worldwide financial system.

Regulators today are determined not to let that situation occur again; hence the administration mandated that the banks undergo stress tests under governmental supervision. Some of the parameters that the banks must test for include a 3.3% decline in GDP in 2009 followed by no growth in 2010, an additional 22% decline in housing prices, and a 10.3% unemployment rate by 2010. These conditions are worse than the consensus of economic forecasters, but the economists were much too optimistic in the months leading up to our current plight. Indeed, a number of analysts think the government's stress test is not nearly stressful enough and that, if "realistic" parameters were used, then most of the large banks would fail. If such information were released, this would set off a panic that would make the recession worse. Therefore, government officials have announced that no banks will be declared to have failed, just that they need more capital, and even that information may not be released.

A stress test makes sense, but—as with all forecasting—it may or may not do what it is supposed to do. This is true in capital budgeting, and it is even truer for the hugely important job of bank regulation. A failure to develop accurate forecasts of a project's returns could hurt a manager's chances for promotion, but the failure to develop accurate forecasts for our largest banks could do irreparable harm to our entire nation.

Figure 11-8 also reports summary statistics for the project's NPV. The mean is \$215, which suggests that the project should be accepted. However, the range of outcomes is quite large, from a loss of \$10,246 to a gain of \$25,523, so the project is clearly risky. The standard deviation of \$3,275 indicates that losses could easily occur, which is consistent with this wide range of possible outcomes.[17] Figure 11-8 also reports a median NPV of −\$51, which means that half the time the project will have an NPV of less than −\$51. In other words, most of the time the project will lose money.

A picture is worth a thousand words, and Figure 11-8 shows the probability distribution of the outcomes. Note that the distribution of outcomes is skewed to the right. As the figure shows, the potential downside losses are not as large as the potential upside gains. Our conclusion is that this is a very risky project, as indicated by the coefficient of variation, but it does have a positive expected NPV and the potential to be a "home run."

Self-Test

What is Monte Carlo simulation?

11.8 Project Risk Conclusions

We have discussed the three types of risk normally considered in capital budgeting: stand-alone risk, within-firm (or corporate) risk, and market risk. However, two important questions remain: (1) Should firms care at all about stand-alone and corporate risk, given that finance theory says that market (beta) risk is the only relevant risk? (2) What do we do when the stand-alone, within-firm, and market risk assessments lead to different conclusions?

There are no easy answers to these questions. Strict adherents of the CAPM would argue that well-diversified investors are concerned only with market risk, that managers should be concerned only with maximizing stock price, and thus that market (beta) risk ought to be given virtually all the weight in capital budgeting decisions. However, we know that not all investors are well diversified, that the CAPM does not operate exactly as the theory says it does, and that measurement problems keep managers from having complete confidence in the CAPM inputs. In addition, the CAPM ignores bankruptcy costs, even though such costs can be substantial, and the probability of bankruptcy depends on a firm's corporate risk, not on its beta risk. Therefore, even well-diversified investors should want a firm's management to give at least some consideration to a project's corporate risk, and that means giving some consideration to stand-alone project risk.

Although it would be nice to reconcile these problems and to measure risk on some absolute scale, the best we can do in practice is to estimate risk in a somewhat nebulous, relative sense. For example, we can generally say with a fair degree of confidence that a particular project has more, less, or about the same stand-alone risk as the firm's average project. Then, since stand-alone and corporate risk are generally correlated, the project's stand-alone risk is generally a reasonably good measure of its corporate risk. Finally, assuming that market risk and corporate risk are correlated, as is true for most companies, a project with a relatively high or low corporate risk will also have a relatively high or low market risk. We wish we could be more specific, but one simply must use a lot of judgment when assessing projects' risks.

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[17]Note that the standard deviation of NPV in the simulation is much smaller than the standard deviation in the scenario analysis. In the scenario analysis, we assumed that all of the poor outcomes would occur together in the worst-case scenario and that all of the positive outcomes would occur together in the best-case scenario. In other words, we implicitly assumed that all of the risky variables were perfectly positively correlated. In the simulation, we assumed that the variables were independent (except for the correlation between unit sales and growth). The independence of variables in the simulation reduces the range of outcomes. For example, in the simulation, sometimes the sales price is high but the sales growth is low. In the scenario analysis, a high sales price is always coupled with high growth. Because the scenario analysis assumption of perfect correlation is unlikely, simulation may provide a better estimate of project risk. However, if the standard deviations and correlations used as inputs in the simulation are inaccurately estimated, then the simulation output will likewise be inaccurate.

Capital Budgeting Practices in the Asian/Pacific Region

A recent survey of executives in Australia, Hong Kong, Indonesia, Malaysia, the Philippines, and Singapore asked several questions about companies' capital budgeting practices. The study yielded the results summarized below.

Techniques for Evaluating Corporate Projects

Consistent with U.S. companies, most companies in this region evaluate projects using IRR, NPV, and payback. For IRR, usage ranges from 96% (in Australia) to 86% (in Hong Kong); NPV usage ranges from 96% (in Australia) to 81% (in the Philippines); and payback usage ranges from 100% (in Hong Kong and the Philippines) to 81% (in Indonesia).

Techniques for Estimating the Cost of Equity Capital

Recall from Chapter 9 that three basic approaches can be used to estimate the cost of equity: CAPM, dividend yield plus growth (DCF), and cost of own debt plus a risk premium. The use of these methods varies considerably from country to country (see Table A). The CAPM is used most often by U.S. firms. This is also true for Australian firms, but not for the other Asian/Pacific firms, which instead more often use the DCF and risk premium approaches.

Techniques for Assessing Risk

Firms in the Asian/Pacific region rely heavily on scenario and sensitivity analyses. They also use decision trees and Monte Carlo simulation, but much less frequently (see Table B).

TABLE A

Method	Australia	Hong Kong	Indonesia	Malaysia	Philippines	Singapore
CAPM	72.7%	26.9%	0.0%	6.2%	24.1%	17.0%
Dividend yield plus growth rate	16.4	53.8	33.3	50.0	34.5	42.6
Cost of debt plus risk premium	10.9	23.1	53.4	37.5	58.6	42.6

TABLE B

Risk Assessment Technique	Australia	Hong Kong	Indonesia	Malaysia	Philippines	Singapore
Scenario analysis	96%	100%	94%	80%	97%	90%
Sensitivity analysis	100	100	88	83	94	79
Decision-tree analysis	44	58	50	37	33	46
Monte Carlo simulation	38	35	25	9	24	35

Source: Adapted from George W. Kester et al., "Capital Budgeting Practices in the Asia-Pacific Region: Australia, Hong Kong, Indonesia, Malaysia, Philippines, and Singapore," *Financial Practice and Education,* Vol. 9, No. 1, Spring/Summer 1999, pp. 25–33.

Self-Test

In theory, should a firm be equally concerned with stand-alone, corporate, and market risk? Would your answer be the same if we substituted "In practice" for "In theory"? Explain your answers.

If a project's stand-alone, corporate, and market risk are known to be highly correlated, would this make the task of evaluating the project's risk easier or harder? Explain.

11.9 Replacement Analysis

In the previous sections we assumed that the solar water heater project was an entirely new project, so all of its cash flows were incremental—they would occur if and only if the project were accepted. However, for replacement projects we must find the cash flow *differentials* between the new and old projects, and these differentials are the *incremental cash flows* that we must analyze.

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We evaluate a replacement decision in Figure 11-9, which is set up much like Figures 11-1 and 11-2 but with data on both a new, highly efficient machine (which will be depreciated on an accelerated basis) and data on the old machine (which is being depreciated on a straight-line basis). In Part I we show the key inputs in the analysis, including depreciation on the new and old machines. In Part II

FIGURE 11-9 Replacement Analysis

	A–C	D	E	F	G	H	I
16	Part I. Inputs:		Both Machines	Old Machine	New Machine		
17	Cost of new machine		$2,000				
18	After-tax salvage value old machine		$400				
19	Sales revenues (fixed)		$2,500				
20	Annual operating costs except depreciation			$1,200	$280		
21	Tax rate		40%				
22	WACC		10%				
23	Depreciation	1	2	3	4	Totals:	
24	Depr. rates (new machine)	33%	45%	15%	7%	100%	
25	Depreciation on new machine	$660	$900	$300	$140	$2,000	
26	Depreciation on old machine	–$400	–$400	–$400	–$400	–$1,600	
27	Δ: Change in depreciation	$260	$500	–$100	–$260	–$400	
28	Part II. Net Cash Flows Before Replacement: Old Machine						
29			0	1	2	3	4
30	Sales revenues			$2,500	$2,500	$2,500	$2,500
31	Operating costs except depreciation			1,200	1,200	1,200	1,200
32	Depreciation			–400	–400	–400	–400
33	Total operating costs			$800	$800	$800	$800
34	Operating income			$1,700	$1,700	$1,700	$1,700
35	Taxes 40%			680	680	680	680
36	After-tax operating income			$1,020	$1,020	$1,020	$1,020
37	Add back depreciation			–400	–400	–400	–400
38	Net cash flows **before** replacement		$0	$620	$620	$620	$620
39	Part III. Net Cash Flows After Replacement: New Machine						
40			0	1	2	3	4
41	New machine cost:		–$2,000				
42	After-tax salvage value, old machine		$400				
43	Sales revenues			–$2,500	–$2,500	–$2,500	–$2,500
44	Operating costs except depreciation			280	280	280	280
45	Depreciation			660	900	300	140
46	Total operating costs			$940	$1,180	$580	$420
47	Operating income			–$1,560	–$1,320	–$1,920	–$2,080
48	Taxes 40%			624	528	768	832
49	After-tax operating income			$936	$792	–$1,152	–$1,248
50	Add back depreciation			660	900	300	140
51	Net cash flows **after** replacement		–$1,600	$1,596	$1,692	$1,452	$1,388
52	Part IV. Incremental CF: Row 51–Row 38		–$1,600	$976	$1,072	$832	$768
53	Part V. Evaluation	NPV =	$1,322.87	IRR =	46.36%	MIRR =	27.88%

we find the cash flows the firm will have if it continues to use the old machine, and in Part III we find the cash flows if the firm replaces the old machine. Then, in Part IV, we subtract the old flows from the new to arrive at the *incremental cash flows*, and we evaluate those flows in Part V to find the NPV, IRR, and MIRR. Replacing the old machine appears to be a good decision.[18]

In some instances, replacements add capacity as well as lower operating costs. In this case, sales revenues in Part III would be increased, and if that leads to a need for more working capital, then this would be shown as a Time-0 expenditure along with a recovery at the end of the project's life. These changes would, of course, be reflected in the incremental cash flows on Row 52.

Self-Test

How are incremental cash flows found in a replacement analysis?

If you were analyzing a replacement project and suddenly learned that the old equipment could be sold for $1,000 rather than $400, would this new information make the replacement look better or worse? Explain.

In Figure 11-9 we assumed that output would remain stable if the old machine were replaced. Suppose output would actually double. How would this change be dealt with in the framework of Figure 11-9?

11.10 Real Options

According to traditional capital budgeting theory, a project's NPV is the present value of its expected future cash flows, discounted at a rate that reflects the riskiness of those cash flows. Note, however, that this says nothing about actions that can be taken *after* the project has been accepted and placed in operation that might lead to an increase in the cash flows. In other words, traditional capital budgeting theory assumes that a project is like a roulette wheel. A gambler can choose whether or not to spin the wheel, but once the wheel has been spun, nothing can be done to influence the outcome. Once the game begins, the outcome depends purely on chance, and no skill is involved.

Contrast roulette with a game such as poker. Chance plays a role in poker, and it continues to play a role after the initial deal because players receive additional cards throughout the game. However, poker players are able to respond to their opponents' actions, so skilled players usually win.

Capital budgeting decisions have more in common with poker than roulette because (1) chance plays a continuing role throughout the life of the project, but (2) managers can respond to changing market conditions and to competitors' actions. Opportunities to respond to changing circumstances are called **managerial options** because they give managers a chance to influence the outcome of a project. They are also called **strategic options** because they are often associated with large, strategic projects rather than routine maintenance projects. Finally, they are called **real options** to differentiate them from financial options because they involve real, rather than financial, assets. The following sections describe projects with several types of **embedded options**.

[18]The same sort of risk analysis discussed in previous sections can be applied to replacement decisions. One of our MBA graduates was hired as a financial analyst with a company that manufactured products for sale to other businesses. He took our *Excel* replacement model, obtained input data from several of his firm's customers, and analyzed how his firm's products would help the customers. In several cases, his analysis helped nail down a sale. He then instructed the firm's sales reps on how to use the model to stimulate sales. This effort was highly successful, so our student got a nice bonus and was promoted in the company.

Investment Timing Options

Conventional NPV analysis implicitly assumes that projects either will be accepted or rejected, which implies they will be undertaken now or never. In practice, however, companies sometimes have a third choice—delay the decision until later, when more information is available. Such **investment timing options** can dramatically affect a project's estimated profitability and risk, as we saw in our example of GPC's solar water heater project.

Keep in mind, though, that the *option to delay* is valuable only if it more than offsets any harm that might result from delaying. For example, while one company delays, some other company might establish a loyal customer base that makes it difficult for the first company to enter the market later. The option to delay is usually most valuable to firms with proprietary technology, patents, licenses, or other barriers to entry, because these factors lessen the threat of competition. The option to delay is valuable when market demand is uncertain, but it is also valuable during periods of volatile interest rates, since the ability to wait can allow firms to delay raising capital for a project until interest rates are lower.

Growth Options

A **growth option** allows a company to increase its capacity if market conditions are better than expected. There are several types of growth options. One lets a company *increase the capacity of an existing product line*. A "peaking unit" power plant illustrates this type of growth option. Such units have high variable costs and are used to produce additional power only if demand, and thus prices, are high.

The second type of growth option allows a company to *expand into new geographic markets*. Many companies are investing in China, Eastern Europe, and Russia even though standard NPV analysis produces negative NPVs. However, if these developing markets really take off, the option to open more facilities could be quite valuable.

The third type of growth option is the opportunity to *add new products*, including complementary products and successive "generations" of the original product. Auto companies are losing money on their first electric autos, but the manufacturing skills and consumer recognition those cars will provide should help turn subsequent generations of electric autos into money makers.

Abandonment Options

Section 11.11 estimates the value of an **abandonment option** for GPC's solar water heater project. The standard DCF analysis we first employed assumed that the assets would be used over a specified economic life. But even though some projects must be operated over their full economic life—in spite of deteriorating market conditions and hence lower than expected cash flows—other projects can be abandoned. Smart managers negotiate the right to abandon if a project turns out to be unsuccessful as a condition for undertaking the project.

Note, too, that some projects can be structured so that they provide the option to *reduce capacity* or *temporarily suspend operations*. Such options are common in the natural resources industry, including mining, oil, and timber, and they should be reflected in the analysis when NPVs are being estimated.

Flexibility Options

Many projects offer **flexibility options** that permit the firm to alter operations depending on how conditions change during the life of the project. Typically, either inputs or outputs (or both) can be changed. BMW's Spartanburg, South Carolina, auto assembly plant provides a good example of output flexibility. BMW needed the plant to produce sports coupes. If it built the plant configured to produce only these vehicles, the construction cost would be minimized. However, the company thought that later on it might want to switch production to some other vehicle type, and that would be difficult if the plant were designed just for coupes. Therefore, BMW decided to spend additional funds to construct a more flexible plant: one that could produce different types of vehicles should demand patterns shift. Sure enough, things did change. Demand for coupes dropped a bit and demand for sport-utility vehicles soared. But BMW was ready, and the Spartanburg plant began spewing out hot-selling SUVs. The plant's cash flows were much higher than they would have been without the flexibility option that BMW "bought" by paying more to build a more flexible plant.

Electric power plants provide an example of input flexibility. Utilities can build plants that generate electricity by burning coal, oil, or natural gas. The prices of those fuels change over time in response to events in the Middle East, changing environmental policies, and weather conditions. Some years ago, virtually all power plants were designed to burn just one type of fuel, because this resulted in the lowest construction costs. However, as fuel cost volatility increased, power companies began to build higher-cost but more flexible plants, especially ones that could switch from oil to gas and back again depending on relative fuel prices.

Valuing Real Options

A full treatment of real option valuation is beyond the scope of this chapter, but there are some things we can say. First, if a project has an embedded real option, then management should at least recognize and articulate its existence. Second, we know that a financial option is more valuable if it has a long time until maturity or if the underlying asset is very risky. If either of these characteristics applies to a project's real option, then management should know that its value is probably relatively high. Third, management might be able to model the real option along the lines of a decision tree, as we illustrate in the following section.

Self-Test

Explain the relevance of the following statement: "Capital budgeting decisions have more in common with poker than roulette."

What are managerial options? Strategic options?

Identify some different types of real options and differentiate among them.

11.11 Phased Decisions and Decision Trees

Up to this point we have focused primarily on techniques for estimating a project's risk. Although this is an integral part of capital budgeting, managers are just as interested in *reducing* risk as in *measuring* it. One way to reduce risk is to structure projects so that expenditures can be made in stages over time rather than all at once. This gives managers the opportunity to reevaluate decisions using new information and then to either invest additional funds or terminate the project. This type of analysis involves the use of *decision trees*.

The Basic Decision Tree

GPC's analysis of the solar water heater project thus far has assumed that the project cannot be abandoned once it goes into operation, even if the worst-case situation arises. However, GPC is considering the possibility of terminating (abandoning) the

FIGURE 11-10 Simple Decision Tree: Abandoning Project in Worst-Case Scenario

		Predicted Cash Flows for Alternative Scenarios						
	Prob:	0	1	2	3	4	WACC	NPV
Best	25%	–$3,812	$3,813	$4,634	$5,256	$8,705	10.00%	$13,379
1 Base	50%	–$4,207	$1,048	$1,296	$980	$2,171	10.00%	$36
Worst	25%	–$4,703	–$283	–$64	–$737	–$410		
		–$4,703	–$283	$500	2 $0	$0	10.00%	–$4,547
If abandon, can liquidate for $500 at t = 2.							Expected NPV =	$2,226
							Standard Deviation (SD) =	$6,706
							Coefficient of Variation (CV) = Std Dev/Expected NPV =	3.01

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project at Year 2 if the demand is low. The net after-tax cash flow from salvage, legal fees, liquidation of working capital, and all other termination costs and revenues is $500. Using these assumptions, the GPC ran a new scenario analysis; the results are shown in Figure 11-10, which is a simple decision tree.

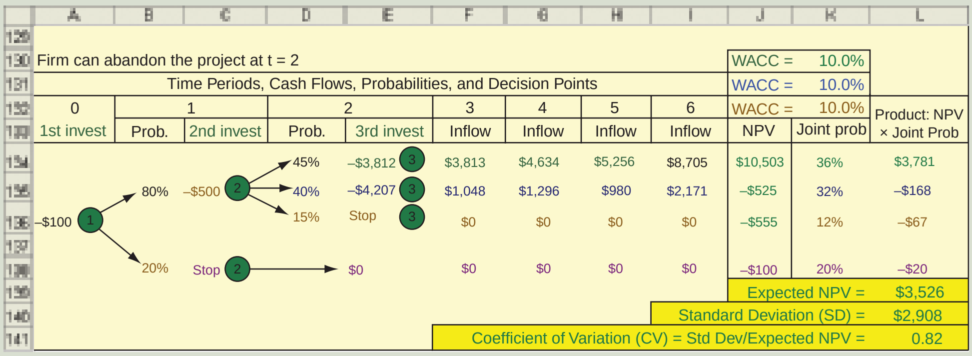
1. Here we assume that, if the worst case materializes, then this will be recognized after the negative Year-1 operating loss and GPC will abandon the project. Rather than continue realizing negative cash flows in Years 2, 3, and 4, the company will shut down the operation and liquidate the project for $500 at t = 2. Now the expected NPV rises from $1,901 to $2,226 and the CV declines from 3.71 to 3.01. So, securing the right to abandon the project if things don't work out raised the project's expected return and lowered its risk. This will give you an approximate value, but keep in mind that you may not have a good estimate of the appropriate discount rate because the real option changes the risk, and hence the required return, of the project.[19]

After the management team thought about the decision-tree approach, other ideas for improving the project emerged. The marketing manager stated that for $100,000 she could undertake a study that would give the firm a better idea of demand for the product, and the design engineer stated that he could build a prototype solar water heater that could be used to gauge consumer reactions to the actual product, which would provide even more information about the final demand and production costs. This led the CEO to discuss with the local university the possibility of delaying a final decision on the project until another type of analysis could be done, a full-blown **staged decision-tree analysis**, which is shown in Figure 11-11.

Decision trees such as the one in Figure 11-11 are often used to analyze multistage, or sequential, decisions. Each circle represents a decision point, also known as a **decision node**. The dollar value to the left of each decision node represents the net cash flow at that point, and the cash flows shown under t = 3, 4, 5, and 6 represent the cash inflows if the project is pushed on to completion. Each diagonal line leads to a **branch** of the decision tree, and each branch has an estimated probability. For example, if the firm decides to "go" with the project at Decision Point 1, then it will

[19]For more on real option valuation, see M. Amram and N. Kulatilaka, *Real Options: Managing Strategic Investment in an Uncertain World* (Boston: Harvard Business School Press, 1999); and H. Smit and L. Trigeorgis, *Strategic Investments: Real Options and Games* (Princeton, NJ: Princeton University Press, 2004).

FIGURE 11-11 Decision Tree with Multiple Decision Points



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spend $100,000 on the marketing study.[20] Management estimates that there is a 0.8 probability that the study will produce *positive* results, leading to the decision to make an additional investment and thus move on to Decision Point 2, and a 0.2 probability that the marketing study will produce *negative* results, indicating that the project should be canceled after Stage 1. If the project is canceled, the cost to the company will be the $100,000 spent on the initial marketing study.

If the marketing study yields positive results, then the firm will spend $500,000 on the prototype water heater at Decision Point 2. Management estimates (even before making the initial $100,000 investment) that there is a 45% probability of the pilot project yielding good results, a 40% probability of average results, and a 15% probability of bad results. If the prototype works well, then the firm will spend several millions more at Decision Point 3 to build a production plant, buy the necessary inventory, and commence operations. The operating cash flows over the project's 4-year life will be good, average, or bad, and these cash flows are shown under Years 3 through 6.

The column of joint probabilities in Figure 11-11 gives the probability of occurrence of each branch—and hence of each NPV. Each joint probability is obtained by multiplying together all the probabilities on that particular branch. For example, the probability that the company will, if Stage 1 is undertaken, move through Stages 2 and 3, and that a strong demand will produce the indicated cash flows, is (0.8)(0.45) = 0.36 = 36.0%. There is a 32% probability of average results, a 12% probability of building the plant and then getting bad results, and a 20% probability of getting bad initial results and stopping after the marketing study.

The NPV of the top (most favorable) branch as shown in Column J is $10,503, calculated as follows:

$$\text{NPV} = -\$100 - \frac{\$500}{(1.10)^1} - \frac{\$3{,}812}{(1.10)^2} + \frac{\$3{,}813}{(1.10)^3} + \frac{\$4{,}634}{(1.10)^4} + \frac{\$5{,}256}{(1.10)^5} + \frac{\$8{,}705}{(1.10)^6}$$
$$= \$10{,}503$$

The NPVs for the other branches are calculated similarly.[21]

[20]GPC might also have to pay the university an additional licensing fee. Such a fee could be added to the $100,000 marketing study cost.

[21]The calculations in *Excel* use nonrounded annual cash flows, so there may be small differences when calculating by hand with rounded annual cash flows.

The last column in Figure 11-11 gives the product of the NPV for each branch times the joint probability of that branch's occurring, and the sum of these products is the project's expected NPV. Based on the expectations used to create Figure 11-11 and a cost of capital of 10%, the project's expected NPV is $3,526, or $3.526 million.[22] In addition, the CV declines from 3.71 to 0.84, and the maximum anticipated loss is a manageable –$555,000. At this point, the solar water heater project looked good, and GPC's management decided to accept it.

Note also that Figure 11-11 illustrates two types of real options. The first real option in the example is a timing option: GPC can delay a decision to spend a large amount of money until it obtains additional information about the likely success of the project. The second real option is an abandonment option, where GPC has the option to abandon the project if continuing with the operation would result in negative cash flows. The analysis could also be extended to illustrate a real growth option. For example, if the project is successful, the company may be able to extend the license, expand production of this project, or develop another profitable solar project. Thus, an additional set of branches might be extended out from Cell I134, where the company would invest in one or more other projects that offer potentially high NPVs. If one or more promising growth options can be identified, then the project's expected NPV might be higher yet.

As this example shows, decision-tree analysis requires managers to explicitly articulate the types of risk a project faces and to develop responses to potential scenarios. Note also that our example could be extended to cover many other types of decisions and could even be incorporated into a simulation analysis. All in all, decision-tree analysis is a valuable tool for analyzing project risks.[23]

Self-Test

What is a decision tree? A branch? A node?

If a firm can structure a project such that expenditures can be made in stages rather than all at the beginning, how would this affect the project's risk and expected NPV? Explain.

Summary

In this chapter, we developed a framework for analyzing a project's cash flows and its risk. The key concepts covered are listed below.

- The most important (and most difficult) step in analyzing a capital budgeting project is **estimating the incremental after-tax cash flows** the project will produce.
- A project's **net cash flow** is different from its accounting income. Project net cash flow reflects (1) cash outlays for fixed assets, (2) sales revenues, (3) operating costs, (4) the tax shield provided by depreciation, and (5) cash flows due to changes in net working capital. A project's net cash flow does *not* include interest payments, since they are accounted for by the discounting process. If we deducted interest and then discounted cash flows at the WACC, this would double-count interest charges.

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[22]As we mentioned concerning the abandonment option, the presence of the real options in Figure 11-11 might cause the discount rate to change.

[23]In this example we glossed over an important issue: the appropriate cost of capital for the project. Adding decision nodes to a project clearly changes its risk, so we would expect the cost of capital for a project with few decision nodes to have a different risk than one with many nodes. If this is so then the projects should have different costs of capital. In fact, we might expect the cost of capital to change over time as the project moves to different stages, since the stages themselves differ in risk.

- In determining incremental cash flows, **opportunity costs** (the cash flows forgone by using an asset) must be included, but **sunk costs** (cash outlays that have been made and that cannot be recouped) are not included. Any **externalities** (effects of a project on other parts of the firm) should also be reflected in the analysis. Externalities can be *positive* or *negative* and may be *environmental*.
- **Cannibalization** is an important type of externality that occurs when a new project leads to a reduction in sales of an existing product.
- **Tax laws** affect cash flow analysis in two ways: (1) taxes reduce operating cash flows, and (2) tax laws determine the depreciation expense that can be taken in each year.
- The incremental cash flows from a typical project can be classified into three categories: (1) **initial investment outlay**, (2) **operating cash flows over the project's life**, and (3) **terminal year cash flows**.
- **Price level changes** (**inflation** or **deflation**) must be considered in project analysis. The best procedure is to build expected price changes into the cash flow estimates. Recognize that output prices and costs for a product can decline over time even though the economy is experiencing inflation.
- The chapter illustrates both **expansion projects**, in which the investment generates new sales, and **replacement projects**, where the primary purpose of the investment is to operate more efficiently and thus reduce costs.
- We discuss three types of risk: **Stand-alone risk, corporate** (or **within-firm**) **risk** and **market** (or **beta**) **risk**. Stand-alone risk does not consider diversification at all; corporate risk considers risk among the firm's own assets; and market risk considers risk at the stockholder level, where stockholders' own diversification is considered.
- **Risk** is important because it affects the discount rate used in capital budgeting; in other words, a project's WACC depends on its risk.
- Assuming the CAPM holds true, **market risk** is the most important risk because (according to the CAPM) it is the risk that affects stock prices. However, usually *it is difficult to measure a project's market risk*.
- **Corporate risk** is important because it influences the firm's ability to use low-cost debt, to maintain smooth operations over time, and to avoid crises that might consume management's energy and disrupt its employees, customers, suppliers, and community. Also, a project's corporate risk is generally easier to measure than its market risk; and, because corporate and market risks are generally thought to be correlated, corporate risk can often serve as a proxy for market risk.
- **Stand-alone risk** is easier to measure than either market or corporate risk. Also, most of a firm's projects' cash flows are correlated with one another, and the firm's total cash flows are correlated with those of most other firms. These correlations mean that a project's stand-alone risk can generally be used as a proxy for hard-to-measure market and corporate risk. As a result, most risk analysis in capital budgeting focuses on stand-alone risk.
- **Sensitivity analysis** is a technique that shows how much a project's NPV will change in response to a given change in an input variable, such as sales, when all other factors are held constant.
- **Scenario analysis** is a risk analysis technique in which the best- and worst-case NPVs are compared with the project's base-case NPV.

- **Monte Carlo simulation** is a risk analysis technique that uses a computer to simulate future events and thereby estimate a project's profitability and riskiness.
- The **risk-adjusted discount rate**, or **project cost of capital**, is the rate used to evaluate a particular project. It is based on the corporate WACC, a value that is increased for projects that are riskier than the firm's average project and decreased for less risky projects.
- **A decision tree** shows how different decisions during a project's life can affect its value.
- A **staged decision-tree analysis** divides the analysis into different phases. At each phase a decision is made either to proceed or to stop the project. These decisions are represented on the decision trees by circles and are called **decision nodes**.
- Opportunities to respond to changing circumstances are called **real,** or **managerial, options** because they give managers the option to influence the returns on a project. They are also called **strategic options** if they are associated with large, strategic projects rather than routine maintenance projects. Finally, they are also called "real" options because they involve "real" (or "physical") rather than "financial" assets. Many projects include a variety of these **embedded options** that can dramatically affect the true NPV.
- An **investment timing option** involves the possibility of delaying major expenditures until more information on likely outcomes is known. The opportunity to delay can dramatically change a project's estimated value.
- A **growth option** occurs if an investment creates the opportunity to make other potentially profitable investments that would not otherwise be possible. These include (1) options to expand the original project's output, (2) options to enter a new geographical market, and (3) options to introduce complementary products or successive generations of products.
- An **abandonment option** is the ability to discontinue a project if the operating cash flow turns out to be lower than expected. It reduces the risk of a project and increases its value. Instead of total abandonment, some options allow a company to reduce capacity or temporarily suspend operations.
- A **flexibility option** is the option to modify operations depending on how conditions develop during a project's life, especially the type of output produced or the inputs used.
- The **option value** can be determined by comparing the project's expected NPV with and without the option. If an initial cost is required to obtain a real option, then that cost can be compared to the calculated value of the option as a part of the overall analysis.

Questions

(11–1) Define each of the following terms:

a. Project cash flow; accounting income
b. Incremental cash flow; sunk cost; opportunity cost; externality; cannibalization; expansion project; replacement project
c. Net operating working capital changes; salvage value
d. Stand-alone risk; corporate (within-firm) risk; market (beta) risk
e. Sensitivity analysis; scenario analysis; Monte Carlo simulation analysis

f. Risk-adjusted discount rate; project cost of capital
g. Decision tree; staged decision-tree analysis; decision node; branch
h. Real options; managerial options; strategic options; embedded options
i. Investment timing option; growth option; abandonment option; flexibility option

(11–2) Operating cash flows, rather than accounting profits, are used in project analysis. What is the basis for this emphasis on cash flows as opposed to net income?

(11–3) Why is it true, in general, that a failure to adjust expected cash flows for expected inflation biases the calculated NPV downward?

(11–4) Explain why sunk costs should not be included in a capital budgeting analysis but opportunity costs and externalities should be included.

(11–5) Explain how net operating working capital is recovered at the end of a project's life and why it is included in a capital budgeting analysis.

(11–6) Define (a) simulation analysis, (b) scenario analysis, and (c) sensitivity analysis.

(11–7) Why are interest charges not deducted when a project's cash flows are calculated for use in a capital budgeting analysis?

(11–8) Most firms generate cash inflows every day, not just once at the end of the year. In capital budgeting, should we recognize this fact by estimating daily project cash flows and then using them in the analysis? If we do not, will this bias our results? If it does, would the NPV be biased up or down? Explain.

(11–9) What are some differences in the analysis for a replacement project versus that for a new expansion project?

(11–10) Distinguish among beta (or market) risk, within-firm (or corporate) risk, and stand-alone risk for a project being considered for inclusion in a firm's capital budget.

(11–11) In theory, market risk should be the only "relevant" risk. However, companies focus as much on stand-alone risk as on market risk. What are the reasons for the focus on stand-alone risk?

Self-Test Problems — Solutions Appear in Appendix A

(ST–1) New-Project Analysis

You have been asked by the president of the Farr Construction Company to evaluate the proposed acquisition of a new earth mover. The mover's basic price is $50,000, and it would cost another $10,000 to modify it for special use. Assume that the mover falls into the MACRS 3-year class (see Appendix 11A), that it would be sold after 3 years for $20,000, and that it would require an increase in net working capital (spare parts inventory) of $2,000. The earth mover would have no effect on revenues, but it is expected to save the firm $20,000 per year in before-tax operating costs, mainly labor. The firm's marginal federal-plus-state tax rate is 40%.

a. What are the Year-0 cash flows?
b. What are the operating cash flows in Years 1, 2, and 3?
c. What are the additional (nonoperating) cash flows in Year 3?
d. If the project's cost of capital is 10%, should the earth mover be purchased?

(ST–2) Corporate Risk Analysis

The staff of Porter Manufacturing has estimated the following net after-tax cash flows and probabilities for a new manufacturing process:

	Net After-Tax Cash Flows		
Year	P = 0.2	P = 0.6	P = 0.2
0	–$100,000	–$100,000	–$100,000
1	20,000	30,000	40,000
2	20,000	30,000	40,000
3	20,000	30,000	40,000
4	20,000	30,000	40,000
5	20,000	30,000	40,000
5*	0	20,000	30,000

Line 0 gives the cost of the process, Lines 1 through 5 give operating cash flows, and Line 5* contains the estimated salvage values. Porter's cost of capital for an average-risk project is 10%.

a. Assume that the project has average risk. Find the project's expected NPV. (*Hint:* Use expected values for the net cash flow in each year.)
b. Find the best-case and worst-case NPVs. What is the probability of occurrence of the worst case if the cash flows are perfectly dependent (perfectly positively correlated) over time? If they are independent over time?
c. Assume that all the cash flows are perfectly positively correlated. That is, assume there are only three possible cash flow streams over time—the worst case, the most likely (or base) case, and the best case—with respective probabilities of 0.2, 0.6, and 0.2. These cases are represented by each of the columns in the table. Find the expected NPV, its standard deviation, and its coefficient of variation.

Problems

Answers Appear in Appendix B

Easy Problems 1–4

(11–1) Investment Outlay

Talbot Industries is considering an expansion project. The necessary equipment could be purchased for $9 million, and the project would also require an initial $3 million investment in net operating working capital. The company's tax rate is 40%.

a. What is the initial investment outlay?
b. The company spent and expensed $50,000 on research related to the project last year. Would this change your answer? Explain.
c. The company plans to house the project in a building it owns but is not now using. The building could be sold for $1 million after taxes and real estate commissions. How would this affect your answer?

(11–2)
Operating Cash Flow

Cairn Communications is trying to estimate the first-year operating cash flow (at t = 1) for a proposed project. The financial staff has collected the following information:

Projected sales	$10 million
Operating costs (not including depreciation)	$ 7 million
Depreciation	$ 2 million
Interest expense	$ 2 million

The company faces a 40% tax rate. What is the project's operating cash flow for the first year (t = 1)?

(11–3)
Net Salvage Value

Allen Air Lines is now in the terminal year of a project. The equipment originally cost $20 million, of which 80% has been depreciated. Carter can sell the used equipment today to another airline for $5 million, and its tax rate is 40%. What is the equipment's after-tax net salvage value?

(11–4)
Replacement Analysis

The Chen Company is considering the purchase of a new machine to replace an obsolete one. The machine being used for the operation has both a book value and a market value of zero; it is in good working order, however, and will last physically for at least another 10 years. The proposed replacement machine will perform the operation so much more efficiently that Chen's engineers estimate it will produce after-tax cash flows (labor savings and depreciation) of $9,000 per year. The new machine will cost $40,000 delivered and installed, and its economic life is estimated to be 10 years. It has zero salvage value. The firm's WACC is 10%, and its marginal tax rate is 35%. Should Chen buy the new machine?

Intermediate Problems 5–11

(11–5)
Depreciation Methods

Wendy is evaluating a capital budgeting project that should last for 4 years. The project requires $800,000 of equipment. She is unsure what depreciation method to use in her analysis, straight-line or the 3-year MACRS accelerated method. Under straight-line depreciation, the cost of the equipment would be depreciated evenly over its 4-year life (ignore the half-year convention for the straight-line method). The applicable MACRS depreciation rates are 33%, 45%, 15%, and 7%, as discussed in Appendix 11A. The company's WACC is 10%, and its tax rate is 40%.

a. What would the depreciation expense be each year under each method?
b. Which depreciation method would produce the higher NPV, and how much higher would it be?

(11–6)
New-Project Analysis

The Campbell Company is evaluating the proposed acquisition of a new milling machine. The machine's base price is $108,000, and it would cost another $12,500 to modify it for special use. The machine falls into the MACRS 3-year class, and it would be sold after 3 years for $65,000. The machine would require an increase in net working capital (inventory) of $5,500. The milling machine would have no effect on revenues, but it is expected to save the firm $44,000 per year in before-tax operating costs, mainly labor. Campbell's marginal tax rate is 35%.

a. What is the net cost of the machine for capital budgeting purposes? (That is, what is the Year-0 net cash flow?)
b. What are the net operating cash flows in Years 1, 2, and 3?

c. What is the additional Year-3 cash flow (i.e., the after-tax salvage and the return of working capital)?
d. If the project's cost of capital is 12%, should the machine be purchased?

(11–7)
New-Project Analysis

You have been asked by the president of your company to evaluate the proposed acquisition of a new spectrometer for the firm's R&D department. The equipment's basic price is $70,000, and it would cost another $15,000 to modify it for special use by your firm. The spectrometer, which falls into the MACRS 3-year class, would be sold after 3 years for $30,000. Use of the equipment would require an increase in net working capital (spare parts inventory) of $4,000. The spectrometer would have no effect on revenues, but it is expected to save the firm $25,000 per year in before-tax operating costs, mainly labor. The firm's marginal federal-plus-state tax rate is 40%.

a. What is the net cost of the spectrometer? (That is, what is the Year-0 net cash flow?)
b. What are the net operating cash flows in Years 1, 2, and 3?
c. What is the additional (nonoperating) cash flow in Year 3?
d. If the project's cost of capital is 10%, should the spectrometer be purchased?

(11–8)
Inflation Adjustments

The Rodriguez Company is considering an average-risk investment in a mineral water spring project that has a cost of $150,000. The project will produce 1,000 cases of mineral water per year indefinitely. The current sales price is $138 per case, and the current cost per case is $105. The firm is taxed at a rate of 34%. Both prices and costs are expected to rise at a rate of 6% per year. The firm uses only equity, and it has a cost of capital of 15%. Assume that cash flows consist only of after-tax profits, since the spring has an indefinite life and will not be depreciated.

a. Should the firm accept the project? (*Hint:* The project is a perpetuity, so you must use the formula for a perpetuity to find its NPV.)
b. Suppose that total costs consisted of a fixed cost of $10,000 per year plus variable costs of $95 per unit, and suppose that only the variable costs were expected to increase with inflation. Would this make the project better or worse? Continue to assume that the sales price will rise with inflation.

(11–9)
Replacement Analysis

The Taylor Toy Corporation currently uses an injection-molding machine that was purchased 2 years ago. This machine is being depreciated on a straight-line basis, and it has 6 years of remaining life. Its current book value is $2,100, and it can be sold for $2,500 at this time. Thus, the annual depreciation expense is $2,100/6 = $350 per year. If the old machine is not replaced, it can be sold for $500 at the end of its useful life.

Taylor is offered a replacement machine that has a cost of $8,000, an estimated useful life of 6 years, and an estimated salvage value of $800. This machine falls into the MACRS 5-year class, so the applicable depreciation rates are 20%, 32%, 19%, 12%, 11%, and 6%. The replacement machine would permit an output expansion, so sales would rise by $1,000 per year; even so, the new machine's much greater efficiency would reduce operating expenses by $1,500 per year. The new machine would require that inventories be increased by $2,000, but accounts payable would simultaneously increase by $500. Taylor's marginal federal-plus-state tax rate is 40%, and its WACC is 15%. Should it replace the old machine?

(11–10)
Replacement Analysis

St. Johns River Shipyards is considering the replacement of an 8-year-old riveting machine with a new one that will increase earnings before depreciation from $27,000 to $54,000 per year. The new machine will cost $82,500, and it will have an estimated life of 8 years and no salvage value. The new machine will be depreciated over its 5-year MACRS recovery period, so the applicable depreciation rates are 20%, 32%, 19%, 12%, 11%, and 6%. The applicable corporate tax rate is 40%, and the firm's WACC is 12%. The old machine has been fully depreciated and has no salvage value. Should the old riveting machine be replaced by the new one?

CHALLENGING PROBLEMS 11–17

(11–11)
Scenario Analysis

Shao Industries is considering a proposed project for its capital budget. The company estimates the project's NPV is $12 million. This estimate assumes that the economy and market conditions will be average over the next few years. The company's CFO, however, forecasts there is only a 50% chance that the economy will be average. Recognizing this uncertainty, she has also performed the following scenario analysis:

Economic Scenario	Probability of Outcome	NPV
Recession	0.05	–$70 million
Below average	0.20	–25 million
Average	0.50	12 million
Above average	0.20	20 million
Boom	0.05	30 million

What is the project's expected NPV, its standard deviation, and its coefficient of variation?

(11–12)
New-Project Analysis

Madison Manufacturing is considering a new machine that costs $250,000 and would reduce pre-tax manufacturing costs by $90,000 annually. Madison would use the 3-year MACRS method to depreciate the machine, and management thinks the machine would have a value of $23,000 at the end of its 5-year operating life. The applicable depreciation rates are 33%, 45%, 15%, and 7%, as discussed in Appendix 11A. Working capital would increase by $25,000 initially, but it would be recovered at the end of the project's 5-year life. Madison's marginal tax rate is 40%, and a 10% WACC is appropriate for the project.

a. Calculate the project's NPV, IRR, MIRR, and payback.
b. Assume management is unsure about the $90,000 cost savings—this figure could deviate by as much as plus or minus 20%. What would the NPV be under each of these extremes?
c. Suppose the CFO wants you to do a scenario analysis with different values for the cost savings, the machine's salvage value, and the working capital (WC) requirement. She asks you to use the following probabilities and values in the scenario analysis:

Scenario	Probability	Cost Savings	Salvage Value	WC
Worst case	0.35	$ 72,000	$18,000	$30,000
Base case	0.35	90,000	23,000	25,000
Best case	0.30	108,000	28,000	20,000

Calculate the project's expected NPV, its standard deviation, and its coefficient of variation. Would you recommend that the project be accepted?

(11–13)
Replacement Analysis

The Everly Equipment Company purchased a machine 5 years ago at a cost of \$90,000. The machine had an expected life of 10 years at the time of purchase, and it is being depreciated by the straight-line method by \$9,000 per year. If the machine is not replaced, it can be sold for \$10,000 at the end of its useful life.

A new machine can be purchased for \$150,000, including installation costs. During its 5-year life, it will reduce cash operating expenses by \$50,000 per year. Sales are not expected to change. At the end of its useful life, the machine is estimated to be worthless. MACRS depreciation will be used, and the machine will be depreciated over its 3-year class life rather than its 5-year economic life, so the applicable depreciation rates are 33%, 45%, 15%, and 7%.

The old machine can be sold today for \$55,000. The firm's tax rate is 35%, and the appropriate WACC is 16%.

a. If the new machine is purchased, what is the amount of the initial cash flow at Year 0?
b. What are the incremental net cash flows that will occur at the end of Years 1 through 5?
c. What is the NPV of this project? Should Everly replace the old machine?

(11–14)
Replacement Analysis

The Balboa Bottling Company is contemplating the replacement of one of its bottling machines with a newer and more efficient one. The old machine has a book value of \$600,000 and a remaining useful life of 5 years. The firm does not expect to realize any return from scrapping the old machine in 5 years, but it can sell it now to another firm in the industry for \$265,000. The old machine is being depreciated by \$120,000 per year, using the straight-line method.

The new machine has a purchase price of \$1,175,000, an estimated useful life and MACRS class life of 5 years, and an estimated salvage value of \$145,000. The applicable depreciation rates are 20%, 32%, 19%, 12%, 11%, and 6%. It is expected to economize on electric power usage, labor, and repair costs, as well as to reduce the number of defective bottles. In total, an annual savings of \$255,000 will be realized if the new machine is installed. The company's marginal tax rate is 35%, and it has a 12% WACC.

a. What is the initial net cash flow if the new machine is purchased and the old one is replaced?
b. Calculate the annual depreciation allowances for both machines, and compute the change in the annual depreciation expense if the replacement is made.
c. What are the incremental net cash flows in Years 1 through 5?
d. Should the firm purchase the new machine? Support your answer.
e. In general, how would each of the following factors affect the investment decision, and how should each be treated?
   (1) The expected life of the existing machine decreases.
   (2) The WACC is not constant but is increasing as Balboa adds more projects into its capital budget for the year.

(11–15)
Risky Cash Flows

The Bartram-Pulley Company (BPC) must decide between two mutually exclusive investment projects. Each project costs \$6,750 and has an expected life of 3 years. Annual net cash flows from each project begin 1 year after the initial investment is made and have the following probability distributions:

Project A		Project B	
Probability	**Net Cash Flows**	**Probability**	**Net Cash Flows**
0.2	$ 6,000	0.2	$ 0
0.6	6,750	0.6	6,750
0.2	7,500	0.2	18,000

BPC has decided to evaluate the riskier project at a 12% rate and the less risky project at a 10% rate.

a. What is the expected value of the annual net cash flows from each project? What is the coefficient of variation (CV)? (*Hint:* σ_B = $5,798 and CV_B = 0.76.)
b. What is the risk-adjusted NPV of each project?
c. If it were known that Project B is negatively correlated with other cash flows of the firm whereas Project A is positively correlated, how would this affect the decision? If Project B's cash flows were negatively correlated with gross domestic product (GDP), would that influence your assessment of its risk?

(11–16) Simulation

Singleton Supplies Corporation (SSC) manufactures medical products for hospitals, clinics, and nursing homes. SSC may introduce a new type of X-ray scanner designed to identify certain types of cancers in their early stages. There are a number of uncertainties about the proposed project, but the following data are believed to be reasonably accurate.

Probability	Developmental Costs	Random Numbers
0.3	$2,000,000	00–29
0.4	4,000,000	30–69
0.3	6,000,000	70–99
Probability	**Project Life**	**Random Numbers**
0.2	3 years	00–19
0.6	8 years	20–79
0.2	13 years	80–99
Probability	**Sales in Units**	**Random Numbers**
0.2	100	00–19
0.6	200	20–79
0.2	300	80–99
Probability	**Sales Price**	**Random Numbers**
0.1	$13,000	00–09
0.8	13,500	10–89
0.1	14,000	90–99
Probability	**Cost per Unit (Excluding Developmental Costs)**	**Random Numbers**
0.3	$5,000	00–29
0.4	6,000	30–69
0.3	7,000	70–99

SSC uses a cost of capital of 15% to analyze average-risk projects, 12% for low-risk projects, and 18% for high-risk projects. These risk adjustments primarily reflect the uncertainty about each project's NPV and IRR as measured by their coefficients of variation. The firm is in the 40% federal-plus-state income tax bracket.

a. What is the expected IRR for the X-ray scanner project? Base your answer on the expected values of the variables. Also, assume the after-tax "profits" figure that you develop is equal to annual cash flows. All facilities are leased, so depreciation may be disregarded. Can you determine the value of σ_{IRR} short of actual simulation or a fairly complex statistical analysis?
b. Assume that SSC uses a 15% cost of capital for this project. What is the project's NPV? Could you estimate σ_{NPV} without either simulation or a complex statistical analysis?
c. Show the process by which a computer would perform a simulation analysis for this project. Use the random numbers 44, 17, 16, 58, 1; 79, 83, 86; and 19, 62, 6 to illustrate the process with the first computer run. Actually calculate the first-run NPV and IRR. Assume the cash flows for each year are independent of cash flows for other years. Also, assume the computer operates as follows: (1) A developmental cost and a project life are estimated for the first run using the first two random numbers. (2) Next, sales volume, sales price, and cost per unit are estimated using the next three random numbers and used to derive a cash flow for the first year. (3) Then, the next three random numbers are used to estimate sales volume, sales price, and cost per unit for the second year, hence the cash flow for the second year. (4) Cash flows for other years are developed similarly, on out to the first run's estimated life. (5) With the developmental cost and the cash flow stream established, NPV and IRR for the first run are derived and stored in the computer's memory. (6) The process is repeated to generate perhaps 500 other NPVs and IRRs. (7) Frequency distributions for NPV and IRR are plotted by the computer, and the distributions' means and standard deviations are calculated.

(11–17) Decision Tree

The Yoran Yacht Company (YYC), a prominent sailboat builder in Newport, may design a new 30-foot sailboat based on the "winged" keels first introduced on the 12-meter yachts that raced for the America's Cup.

First, YYC would have to invest $10,000 at t = 0 for the design and model tank testing of the new boat. YYC's managers believe there is a 60% probability that this phase will be successful and the project will continue. If Stage 1 is not successful, the project will be abandoned with zero salvage value.

The next stage, if undertaken, would consist of making the molds and producing two prototype boats. This would cost $500,000 at t = 1. If the boats test well, YYC would go into production. If they do not, the molds and prototypes could be sold for $100,000. The managers estimate the probability is 80% that the boats will pass testing and that Stage 3 will be undertaken.

Stage 3 consists of converting an unused production line to produce the new design. This would cost $1 million at t = 2. If the economy is strong at this point, the net value of sales would be $3 million; if the economy is weak, the net value would be $1.5 million. Both net values occur at t = 3, and each state of the economy has a probability of 0.5. YYC's corporate cost of capital is 12%.

a. Assume this project has average risk. Construct a decision tree and determine the project's expected NPV.
b. Find the project's standard deviation of NPV and coefficient of variation of NPV. If YYC's average project had a CV of between 1.0 and 2.0, would this project be of high, low, or average stand-alone risk?

SPREADSHEET PROBLEM

(11-18)
Build a Model: Issues in Capital Budgeting

Start with the partial model in the file ***Ch11 P18 Build a Model.xls*** on the textbook's Web site. Webmasters.com has developed a powerful new server that would be used for corporations' Internet activities. It would cost $10 million at Year 0 to buy the equipment necessary to manufacture the server. The project would require net working capital at the beginning of a year in an amount equal to 10% of the year's projected sales: $NOWC_0$ = 10%($Sales_1$). The servers would sell for $24,000 per unit, and Webmasters believes that variable costs would amount to $17,500 per unit. After Year 1, the sales price and variable costs will increase at the inflation rate of 3%. The company's nonvariable costs would be $1 million at Year 1 and would increase with inflation.

The server project would have a life of 4 years. If the project is undertaken, it must be continued for the entire 4 years. Also, the project's returns are expected to be highly correlated with returns on the firm's other assets. The firm believes it could sell 1,000 units per year.

The equipment would be depreciated over a 5-year period, using MACRS rates. The estimated market value of the equipment at the end of the project's 4-year life is $500,000. Webmasters' federal-plus-state tax rate is 40%. Its cost of capital is 10% for average-risk projects, defined as projects with an NPV coefficient of variation between 0.8 and 1.2. Low-risk projects are evaluated with a WACC of 8% and high-risk projects at 13%.

a. Develop a spreadsheet model, and use it to find the project's NPV, IRR, and payback.
b. Now conduct a sensitivity analysis to determine the sensitivity of NPV to changes in the sales price, variable costs per unit, and number of units sold. Set these variables' values at 10% and 20% above and below their base-case values. Include a graph in your analysis.
c. Now conduct a scenario analysis. Assume that there is a 25% probability that best-case conditions, with each of the variables discussed in part b being 20% better than its base-case value, will occur. There is a 25% probability of worst-case conditions, with the variables 20% worse than base, and a 50% probability of base-case conditions.
d. If the project appears to be more or less risky than an average project, find its risk-adjusted NPV, IRR, and payback.
e. On the basis of information in the problem, would you recommend that the project be accepted?

Mini Case

Shrieves Casting Company is considering adding a new line to its product mix, and the capital budgeting analysis is being conducted by Sidney Johnson, a recently graduated MBA. The production line would be set up in unused space in Shrieves's main plant. The machinery's invoice price would be approximately $200,000, another $10,000 in shipping charges would be required, and it would cost an additional $30,000 to install the equipment. The machinery has an economic life of 4 years, and Shrieves has obtained a special tax ruling that places the equipment in the MACRS 3-year class. The machinery is expected to have a salvage value of $25,000 after 4 years of use.

The new line would generate incremental sales of 1,250 units per year for 4 years at an incremental cost of $100 per unit in the first year, excluding depreciation. Each unit can be sold for $200 in the first year. The sales price and cost are both expected to increase by 3% per year due to inflation. Further, to handle the new line, the firm's net working capital would have to increase by an amount equal to 12% of sales revenues. The firm's tax rate is 40%, and its overall weighted average cost of capital is 10%.

a. Define "incremental cash flow."

(1) Should you subtract interest expense or dividends when calculating project cash flow?
(2) Suppose the firm had spent $100,000 last year to rehabilitate the production line site. Should this be included in the analysis? Explain.
(3) Now assume the plant space could be leased out to another firm at $25,000 per year. Should this be included in the analysis? If so, how?
(4) Finally, assume that the new product line is expected to decrease sales of the firm's other lines by $50,000 per year. Should this be considered in the analysis? If so, how?

b. Disregard the assumptions in part a. What is Shrieves's depreciable basis? What are the annual depreciation expenses?
c. Calculate the annual sales revenues and costs (other than depreciation). Why is it important to include inflation when estimating cash flows?
d. Construct annual incremental operating cash flow statements.
e. Estimate the required net working capital for each year and the cash flow due to investments in net working capital.
f. Calculate the after-tax salvage cash flow.
g. Calculate the net cash flows for each year. Based on these cash flows, what are the project's NPV, IRR, MIRR, PI, payback, and discounted payback? Do these indicators suggest that the project should be undertaken?
h. What does the term "risk" mean in the context of capital budgeting; to what extent can risk be quantified; and, when risk is quantified, is the quantification based primarily on statistical analysis of historical data or on subjective, judgmental estimates?

i. (1) What are the three types of risk that are relevant in capital budgeting?
(2) How is each of these risk types measured, and how do they relate to one another?
(3) How is each type of risk used in the capital budgeting process?

j. (1) What is sensitivity analysis?
(2) Perform a sensitivity analysis on the unit sales, salvage value, and cost of capital for the project. Assume each of these variables can vary from its base-case, or expected, value by ±10%, ±20%, and ±30%. Include a sensitivity diagram, and discuss the results.
(3) What is the primary weakness of sensitivity analysis? What is its primary usefulness?

k. Assume that Sidney Johnson is confident in her estimates of all the variables that affect the project's cash flows except unit sales and sales price. If product acceptance is poor, unit sales would be only 900 units a year and the unit price would only be $160; a strong consumer response would produce sales of 1,600 units and a unit price of $240. Johnson believes there is a 25% chance of poor acceptance, a 25% chance of excellent acceptance, and a 50% chance of average acceptance (the base case).

(1) What is scenario analysis?
(2) What is the worst-case NPV? The best-case NPV?
(3) Use the worst-, base-, and best-case NPVs and probabilities of occurrence to find the project's expected NPV, as well as the NPV's standard deviation and coefficient of variation.

l. Are there problems with scenario analysis? Define simulation analysis, and discuss its principal advantages and disadvantages.

m. (1) Assume Shrieves's average project has a coefficient of variation in the range of 0.2 to 0.4. Would the new line be classified as high risk, average risk, or low risk? What type of risk is being measured here?
(2) Shrieves typically adds or subtracts 3 percentage points to the overall cost of capital to adjust for risk. Should the new line be accepted?
(3) Are there any subjective risk factors that should be considered before the final decision is made?

n. What is a real option? What are some types of real options?

Selected Additional Cases

The following cases from Textchoice, *Cengage Learning's online library, cover many of the concepts discussed in this chapter and are available at* ***http://www.textchoice2.com.***

Klein-Brigham Series:
Case 12, "Indian River Citrus Company (A)," Case 44, "Cranfield, Inc. (A)," and Case 14, "Robert Montoya, Inc.," focus on cash flow estimation. Case 13, "Indian River Citrus (B)," Case 45, "Cranfield, Inc. (B)," Case 58, "Tasty Foods (B)," Case 60, "Heavenly Foods," and Case 15, "Robert Montoya, Inc. (B)," illustrate project risk analysis. Cases 75, 76, and 77, "The Western Company (A and B)," are comprehensive cases.

Brigham-Buzzard Series:
Case 7, "Powerline Network Corporation (Risk and Real Options in Capital Budgeting)."