



# chapter 12

## Cash Flow Estimation and Risk Analysis

Home Depot Inc. grew phenomenally during the 1990s, and it is still growing rapidly. At the beginning of 1990, it had 118 stores and annual sales of \$2.8 billion. It now (mid-2006) has more than 2,065 stores and sales of more than \$84 billion. The stock has also performed quite well—a \$10,000 investment in 1990 would now be worth about \$129,200, for an annual return of more than 17%!

For a typical new store, Home Depot spends around \$20 million to purchase land, construct a new store, and stock it with inventory. Each new store thus represents a major capital expenditure, so the company must use capital budgeting techniques to determine if a potential store's expected cash flows are sufficient to cover its costs. Home Depot uses information from its existing stores to forecast new stores' expected cash flows. Thus far, its forecasts have been outstanding, but there are always risks that must be considered.

First, sales might be less than projected if the economy weakens. Second, some of Home Depot's customers might in the future bypass it altogether and buy directly from manufacturers through the Internet or from competitors such as Lowe's. Third, new stores could take sales away from existing stores, or "cannibalize" them.

To broaden its customer base from do-it-yourself customers and professional contractors, Home Depot also operates its Expo Design Center chain, which provides decorating advice, materials, and installation for middle- and upper-income customers.

The decision to expand requires a detailed assessment of the forecasted cash flows, including the risk that the forecasted level of sales might not be realized. In this chapter, we describe techniques for estimating a project's cash flows and their associated risk. As you read this chapter, think about how Home Depot might use these techniques to evaluate its capital budgeting decisions.

The basic principles of capital budgeting were covered in Chapter 11. 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.

## 12.1 Estimating Cash Flows



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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 **FM12 Ch 12 Tool Kit.xls**, and we encourage you to open the file and follow along as you read the chapter.

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 seek to build empires. Both problems cause cash flow forecast biases which make bad projects look good—on paper!

It is vital to identify the **relevant cash flows**, defined as the specific set of cash flows that should be considered in the decision at hand. Analysts often make errors in estimating cash flows, but two cardinal rules can help you minimize mistakes: (1) Capital budgeting decisions must be based on *cash flows*, not accounting income. (2) Only *incremental cash flows* are relevant.

Recall from Chapter 3 that **free cash flow (FCF)** is the cash flow available for distribution to investors. In a nutshell, the relevant cash flow for a project is the

### Corporate Valuation, Cash Flows, and Risk Analysis

You can calculate the free cash flows (FCF) for a project in much the same way as for a firm. When the project's expected free cash flows are discounted at the

project's appropriate risk-adjusted rate,  $r$ , the result is the project's value. This chapter focuses on how to estimate the size and risk of a project's cash flows.

$$\text{NPV} = \left[ \frac{\text{FCF}_1}{(1+r)^1} + \frac{\text{FCF}_2}{(1+r)^2} + \frac{\text{FCF}_3}{(1+r)^3} + \cdots + \frac{\text{FCF}_N}{(1+r)^N} \right] - \text{Initial cost.}$$

*additional* free cash flow that the company can expect if it implements the project. This is also called the **incremental cash flow**, and it is the cash flow above and beyond what the company could expect if it doesn't implement the project. Chapter 3 defined FCF as:

$$\text{FCF} = \frac{\text{Net operating profit after taxes (NOPAT)}}{\text{Net investment in operating capital}} \quad (12-1)$$

When working with a company's financial statements, as we did in Chapter 3, the definition above is the most straightforward one to apply. But when estimating a project's cash flows, there are two reasons that make it more convenient to use a modified version of this equation. First, we are going to estimate the individual components that make up NOPAT and the net investment in operating capital. We can use these individual cash flow components directly in our analysis rather than taking the extra step to combine them so they appear exactly like a financial statement. Second, some of the cash flow components occur at the project's inception, some throughout its life, and some at the project's termination. Therefore, we typically show them in our analysis in roughly this order.

As shown in Chapter 3, NOPAT is equal to the earnings before interest and taxes (EBIT) that remain after paying operating taxes. By adding depreciation both to NOPAT and to the net investment in operating capital, an equivalent definition of FCF is

$$\text{FCF} = \text{EBIT}(1 - T) + \text{Depreciation} - \left( \frac{\text{Net investment in operating capital}}{\text{Depreciation}} \right) \quad (12-2)$$

Chapter 3 defined operating cash flow as the sum of depreciation and  $\text{EBIT}(1 - T)$ . That chapter also showed that the net investment in operating capital is the sum of the net investment in long-term fixed assets and the investment in net operating working capital (NOWC), where NOWC is defined as operating current assets less operating current liabilities. The net investment in long-term fixed assets is equal to the gross fixed asset expenditure minus depreciation. Using these relationships, we can rewrite Equation 12-2 as

$$\text{FCF} = \frac{\text{Operating cash flows}}{\text{Gross fixed asset expenditures}} - \left( \frac{\Delta \text{Operating current assets} - \Delta \text{Operating current liabilities}}{\Delta \text{Operating current liabilities}} \right) \quad (12-3)$$

Some projects require expenditures on fixed assets at different times during their lives, but most require only an initial investment outlay in gross fixed assets. Also, the fixed assets of many projects have some salvage value at the end of the project. Therefore, it is common in capital budgeting analysis to break the gross fixed asset expenditures into the cash flows due to the initial investment outlay and the cash flows due to salvage. Substituting these definitions into Equation 12-3 gives us the usual approach to defining a project's free cash flows:

$$\text{FCF} = \frac{\text{Investment outlay cash flow}}{\text{Operating cash flow}} + \frac{\text{NOWC cash flow}}{\text{Salvage cash flow}} \quad (12-4)$$

where all cash flows are after taxes and the sign of the cash flow indicates whether it is an inflow or outflow. The project's free cash flows are also sometimes called **net cash flow**, and we will use the terms interchangeably.

It is worth mentioning that project analysis focuses on expected cash flows, not accounting net income. Accounting net income is based on the depreciation rate the firm's accountants choose, not necessarily the depreciation rates allowed by the IRS. Also, net income is measured after the deduction of interest expenses, whereas net cash flow focuses on operating cash flow. Moreover, the investment in working capital is not deducted from accounting income. For these and other reasons, net income is generally different from cash flow. Each has a role in financial management, *but for capital budgeting purposes it is the project's net cash flow, not its accounting net income, that is relevant.*

### SELF-TEST

What is the most important step in a capital budgeting analysis?

What are the major components of a project's free cash flows?

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## 12.2 Project Analysis: An Example

We illustrate the principles of capital budgeting analysis by examining a new project being considered by Regency Integrated Chips (RIC), a large Nashville-based technology company. This is a **new expansion project**, defined as one where the firm invests in new assets to increase sales. Following is some background information on the project.

### Background on the Project

RIC's research and development department has been applying its expertise in microprocessor technology to develop a small computer designed to control home appliances. Once programmed, the computer will automatically control the heating and air-conditioning systems, security system, hot water heater, and even small appliances such as a coffee maker. By increasing a home's energy efficiency, the computer can cut costs enough to pay for itself within a few years. Development has now reached the stage where a decision must be made about whether or not to go forward with full-scale production.

RIC's marketing vice president believes that annual sales would be 20,000 units if the units were priced at \$3,000 each, so annual sales are estimated at \$60 million. RIC expects no growth in unit sales, and it believes that the unit price will rise by 2% each year. The engineering department has reported that the project will require additional manufacturing space, and RIC currently has an option to purchase an existing building, at a cost of \$12 million, which would meet this need. The building would be bought and paid for on December 31, 2008. RIC bases depreciation on the Modified Accelerated Cost Recovery System (MACRS), which we explain in a later section. For depreciation purposes, the building falls into the MACRS 39-year class.

The necessary equipment would be purchased and installed in late 2008, and it would also be paid for on December 31, 2008. The equipment falls into the MACRS 5-year class. The equipment would cost \$7.8 million and would require \$0.2 million for shipping and installation. The depreciable basis under MACRS is equal to the purchase price of an asset plus any shipping and installation costs.

The basis is *not* adjusted for *salvage value* (which is the estimated market value of the asset at the end of its useful life), so the depreciation basis for the building is  $\$7.8 + \$0.2 = \$8$  million.<sup>1</sup>

The project's estimated economic life is 4 years. At the end of that time, the building is expected to have a market value of \$7.5 million and a book value of \$10.908 million, whereas the equipment would have a market value of \$2 million and a book value of \$1.36 million.

The production department has estimated that variable manufacturing costs would be \$2,100 per unit and that fixed overhead costs, excluding depreciation, would be \$8 million a year. They expect variable costs to rise by 2% per year, and fixed costs to rise by 1% per year. Depreciation expenses would be determined in accordance with MACRS rates.

RIC's marginal federal-plus-state tax rate is 40%; its cost of capital is 12%; and, for capital budgeting purposes, the company's policy is to assume that operating cash flows occur at the end of each year. Because the plant would begin operations on January 1, 2009, the first full year of operating cash flows would end on December 31, 2009.

Several other points should be noted: (1) RIC is a relatively large corporation, with sales of more than \$4 billion, and it takes on many investments each year. Thus, if the computer control project does not work out, it will not bankrupt the company—management can afford to take a chance on the computer control project. (2) If the project is accepted, the company will be contractually obligated to operate it for its full 4-year life. Management must make this commitment to its component suppliers. (3) Returns on this project would be positively correlated with returns on RIC's other projects and also with the stock market—the project should do well if other parts of the firm and the general economy are strong.

Assume that you have been assigned to conduct the capital budgeting analysis. For now, assume that the project has the same risk as an average project and use the corporate weighted average cost of capital, 12%.

## Estimation of the Cash Flows

Most projects are analyzed using a spreadsheet program such as *Excel*, and this one is no exception. The analysis is shown in Table 12-1 and is divided into five parts: (1) Input Data, (2) Depreciation Schedule, (3) Net Salvage Values, (4) Projected Net Cash Flows, and (5) Key Output. Note that numbers in the printed table are rounded from the actual numbers in the spreadsheet, although the spreadsheet uses the unrounded number for all calculations.

**Input Data (Part 1)** Part 1 of Table 12-1, the Input Data section, provides the basic data used in the analysis. The inputs are really “assumptions”—thus, in the analysis we *assume* that 20,000 units can be sold at a price of \$3 per unit (the sales price is actually \$3,000, but for convenience we show all dollars in thousands). Some of the inputs are known with near certainty—for example, the 40% tax rate is not likely to change. Others are more speculative—units sold and the variable cost percentage are in this category. Obviously, if sales or costs are different from the assumed



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See **FM12 Ch 12 Tool Kit.xls** at the textbook's Web site for all calculations.

<sup>1</sup>Regardless of whether accelerated or straight-line depreciation is used, the basis is not adjusted by the salvage value when calculating the depreciation that is used to determine taxable income.



levels, then profits and cash flows, hence NPV and IRR, will differ from their projected levels. Later in the chapter, we discuss how changes in the inputs affect the results. We usually show a key output, such as NPV, in the same section as the inputs, so that we can quickly see how a change in an input affects the output.

**Table 12-1**

Analysis of a New (Expansion) Project: Parts 1 and 2 (Dollars in Thousands)

	A	B	C	D	E	F	G	H	I
24	<b>Part 1. Input Data</b>								
25							<b>Key Output: NPV =</b>		<b>\$5,809</b>
26	Building cost (= Depreciable basis)			\$12,000					
27	Equipment cost (= Depreciable basis)			\$8,000		Market value of building at salvage			\$7,500
28	Net Operating WC / Sales			10%		Market value of equip. at salvage			\$2,000
29	First year sales (in units)			20,000		Tax rate			40%
30	Growth rate in units sold			0.0%		WACC			12.0%
31	Sales price per unit			\$3.00		Inflation: growth in sales price			2.0%
32	Variable cost per unit			\$2.10		Inflation: growth in VC per unit			2.0%
33	Fixed costs			\$8,000		Inflation: growth in fixed costs			1.0%
34									
35	<b>Part 2. Depreciation Schedule<sup>a</sup></b>								
36					<b>Years</b>				
37					1	2	3	4	Cumulative
					2009	2010	2011	2012	Depr'n
38	Building depr'n rate				1.3%	2.6%	2.6%	2.6%	
39	Building depr'n				\$156	\$312	\$312	\$312	\$1,092
40	Ending book val: Cost - cum. depr'n				11,844	11,532	11,220	\$10,908	
41									
42	Equipment depr'n rate				20.0%	32.0%	19.0%	12.0%	
43	Equipment depr'n				\$1,600	\$2,560	\$1,520	\$960	\$6,640
44	Ending book val: Cost - cum. depr'n				6,400	3,840	2,320	\$1,360	
45									
46	<sup>a</sup> The depreciation rates are multiplied by the depreciable basis (\$12,000 for the building and \$8,000 for the equipment) to determine the yearly depreciation expense. The correct depreciation percentages for the building depend upon the month that the building is put in service. Because this analysis assumes that								
47	all cash flows occur at the end of the year, and to prevent unnecessary complexity, we have rounded the depreciation percentages for the building. See the Tab								
48	named DeprTables for more details.								
49									

**Table 12-1**

Analysis of a New (Expansion) Project: Part 3 (Dollars in Thousands)

	A	B	C	D	E	F	G	H	I
51	<b>Part 3. Net Salvage Values at End of Project</b>								
52					<b>Building</b>	<b>Equipment</b>	<b>Total</b>		
53	Market value when salvaged				\$7,500	\$2,000			
54	Book value when salvaged <sup>b</sup>				10,908	1,360			
55	Expected gain or loss <sup>c</sup>				-3,408	640			
56	Taxes paid or tax credit				-1,363	256			
57	Net cash flow from salvage <sup>d</sup>				\$8,863	\$1,744	\$10,607		
58									
59	<sup>b</sup> Book value equals depreciable basis (initial cost in this case) minus accumulated MACRS depreciation. For the building, accumulated depreciation equals								
60	\$1,092, so book value equals \$12,000 - \$1,092 = \$10,908. For the equipment, accumulated depreciation equals \$6,640, so book value equals \$8,000 - \$6,640 =								
61	\$1,360.								
62	<sup>c</sup> Building: \$7,500 market value - \$10,908 book value = -\$3,408 a loss. This represents a shortfall in depreciation taken versus "true" depreciation, and it is								
63	treated as an operating expense for Year 4. Equipment: \$2,000 market value - \$1,360 book value = \$640 profit. Here the depreciation charge exceeds the "true"								
64	depreciation, and the difference is called "depreciation recapture." It is taxed as ordinary income in Year 4. The actual book value at the time of disposition								
65	depends on the month of disposition. We have simplified the analysis and assumed that there will be a full year of depreciation in Year 4.								
66									
67	<sup>d</sup> Net cash flow from salvage equals salvage (market) value minus taxes. For the building, the loss results in a tax credit, so net salvage value = \$7,500 - (-\$1,363)								
68	= \$8,863.								

**Depreciation Schedule (Part 2)** Rows 38 and 42 give the yearly MACRS depreciation rates for the building and equipment; a later section explains why these are the appropriate rates, but for now we will just use them. Rows 39 and 43 give the annual depreciation expense, calculated as the depreciation rate multiplied by the asset's depreciable basis. Rows 40 and 44 show the book values at the end of each year, found by subtracting the accumulated annual depreciation from the depreciable basis.

**Net Salvage Values (Part 3)** See Part 3 of Table 12-1 for the calculation of after-tax salvage cash flows. Row 53 shows the salvage values for the building and equipment, which are the prices the company expects to receive when it sells the assets at the end of the project's life. Row 54 shows the book values at the end of Year 4; these values are calculated in Part 2. Row 55 shows the expected gain or loss, defined as the difference between the sale price and the book value. For tax purposes, gains and losses on depreciable assets are treated as ordinary income, not capital gains or losses.

RIC expects to sell the equipment for \$2,000 even though it has a book value of only \$1,360. To the IRS, this signifies that the depreciation rates were too high during the project's life, which allowed the company to shield too much of its earlier income from taxes. Therefore, the gain is called "depreciation recapture" by the IRS and is taxed as ordinary income. RIC's \$640 gain on the sale of the equipment will be taxed at RIC's 40 percent corporate tax rate, resulting in a tax liability of  $\$640(0.40) = \$256$ , as shown in Row 56. Thus, RIC's net after-tax cash flow from the sale of the equipment is the salvage price minus the tax:  $\$2,000 - \$256 = \$1,744$ .

As shown in Row 54, RIC's building will have a book value of \$10,908 at the time of salvage, but the company expects to realize only \$7,500 when it is sold. This would result in a loss of \$3,408. This indicates that the building should have been depreciated at a faster rate—only if depreciation had been \$3,408 larger would the book and market values have been equal. To compensate for the fact that not enough depreciation was charged during the building's life, the Tax Code stipulates that losses on the sale of operating assets can be used to reduce taxable ordinary income, just as depreciation reduces income. RIC expects to sell the building for \$7,500 and receive a tax credit of  $\$3,408(0.4) = \$1,363$ . The resulting net after-tax cash flow is  $\$7,500 + \$1,363 = \$8,863$ , as shown in Row 57.<sup>2</sup> Thus, RIC expects to net \$8,863 from the sale of the building and \$1,744 from the equipment, for a total of \$10,607.<sup>3</sup>

**Projected Net Cash Flows (Part 4)** This section of Table 12-1 uses the information developed in Parts 1, 2, and 3 to find the projected cash flows over the project's life. Five periods are shown, from Year 0 to Year 4, in Columns E through I.

The initial investment outlays for long-term assets are shown as negative cash flows in Cells E75 and E76 for Year 0. Had there been additional fixed assets purchased during the project's life, their cash flows also would have been shown.

Rows 79 through 90 show the calculations for the operating cash flows. We begin with sales revenues, found as the product of units sold and the sales price. Next, we subtract variable costs, which were assumed to be \$2.10 per unit. We then deduct fixed operating costs and depreciation to obtain taxable operating

<sup>2</sup>The formula in the spreadsheet subtracts the expected tax, but since the expected tax is negative, this is equivalent to adding a tax credit to the sales price.

<sup>3</sup>Note that if an asset is sold for exactly its book value, there will be no gain or loss, hence no tax liability or credit.

**Table 12-1**

Analysis of a New (Expansion) Project: Part 4 (Dollars in Thousands)

	A	B	C	D	E	F	G	H	I
71	<b>Part 4. Projected Net Cash Flows</b>				<b>Years</b>				
72					0	1	2	3	4
73					2008	2009	2010	2011	2012
74	<i>Investment Outlays: Long-Term Assets</i>								
75	Building				(\$12,000)				
76	Equipment				(8,000)				
77									
78	<i>Operating Cash Flows over the Project's Life</i>								
79	Units sold					20,000	20,000	20,000	20,000
80	Sales price					\$3.00	\$3.06	\$3.12	\$3.18
81	Sales revenue					\$60,000	\$61,200	\$62,424	\$63,672
82	Variable costs					42,000	42,840	43,697	44,571
83	Fixed operating costs					8,000	8,080	8,161	8,242
84	Depreciation (building)					156	312	312	312
85	Depreciation (equipment)					1,600	2,560	1,520	960
86	Oper. income before taxes (EBIT)					8,244	7,408	8,734	9,587
87	Taxes on operating income (40%)					3,298	2,963	3,494	3,835
88	Net operating profit after taxes (NOPAT)					4,946	4,445	5,241	5,752
89	Add back depreciation					1,756	2,872	1,832	1,272
90	Operating cash flow					\$6,702	\$7,317	\$7,073	\$7,024
91									
92	<i>Cash Flows Due to Net Operating Working Capital</i>								
93	Net operating working capital (based on sales)					\$6,000	\$6,120	\$6,242	\$6,367
94	Cash flow due to investment in NOWC					(\$6,000)	(\$120)	(\$122)	(\$125)
95									\$6,367
96	<i>Salvage Cash Flows: Long-Term Assets</i>								
97	Net salvage cash flow: Building								\$8,863
98	Net salvage cash flow: Equipment								1,744
99	Total salvage cash flows								\$10,607
100									
101	Net cash flow (Time line of cash flows)					(\$26,000)	\$6,582	\$7,194	\$6,948
102									\$23,999

income, or EBIT, in Row 86. When taxes (at a 40% rate) are subtracted, we are left with net operating profit after taxes, or NOPAT, in Row 88. We add back depreciation to obtain annual values for operating cash flow, as shown in Row 90.

RIC must purchase raw materials and replenish them each year as they are used. In Part 1 we assume that RIC must have an amount of NOWC on hand equal to 10% of the upcoming year's sales. For example, sales in Year 1 are \$60,000, so RIC must have \$6,000 in NOWC at Year 0, as shown in Cell E93. Because RIC had no NOWC prior to Year 0, it must make a \$6,000 investment in NOWC at Year 0, as shown in Cell E94. Sales increase to \$61,200 in Year 2, so RIC must have \$6,120 of NOWC at Year 1. Because it already had \$6,000 in NOWC on hand, its net investment at Year 1 is just \$120, shown in Cell F94. Note that RIC will have no sales after Year 4, so it will require no NOWC at Year 4. Thus, it has a positive cash flow of \$6,367 at Year 4 as working capital is sold but not replaced.

When the project's life ends, the company will receive the "Salvage Cash Flows" as shown in the column for Year 4 in Rows 97 and 98.<sup>4</sup> Thus, the total salvage cash flow amounts to \$10,607 as shown in Row 99.

<sup>4</sup>These after-tax cash flows were estimated previously in Part 3.



Table 12-1

Analysis of a New (Expansion) Project: Part 5 (Dollars in Thousands)

	A	B	C	D	E	F	G	H	I
104	<b>Part 5. Key Output and Appraisal of the Proposed Project (WACC = 12%)</b>								
105									
106	<b>Net Present Value</b>			<b>\$5,809</b>					
107	<b>IRR</b>			<b>20.12%</b>					
108	<b>MIRR</b>			<b>17.79%</b>					
109	<b>PI</b>			<b>1.22</b>					
110									
111	<b>Years</b>								
112				<b>0</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	
113	<b>Cumulative cash flow for payback</b>				<b>(19,418)</b>	<b>(12,223)</b>	<b>(5,275)</b>	<b>18,723</b>	
114	<b>Part of year required for payback:</b>				<b>1.00</b>	<b>1.00</b>	<b>1.00</b>	<b>0.22</b>	
115	<b>Payback =</b>			<b>3.22</b>					
116									
117	<b>Years</b>								
118				<b>0</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	
119	<b>Discounted cash flow for payback:</b>				<b>5,877</b>	<b>5,735</b>	<b>4,945</b>	<b>15,252</b>	
120	<b>Cumulative cash flow for payback</b>				<b>(20,123)</b>	<b>(14,388)</b>	<b>(9,442)</b>	<b>5,809</b>	
121	<b>Part of year required for payback:</b>				<b>1.00</b>	<b>1.00</b>	<b>1.00</b>	<b>0.39</b>	
122	<b>Payback =</b>			<b>3.39</b>					

We sum the subtotals in Part 4 to obtain the net cash flows shown in Row 101. Those cash flows constitute a *cash flow time line*, and they are evaluated in Part 5 of Table 12-1.

## Making the Decision

Part 5 of Table 12-1 shows the standard evaluation criteria—NPV, IRR, MIRR, PI, payback, and discounted payback—based on the cash flows shown in Row 101. The NPV is positive, the IRR and MIRR both exceed the 12% cost of capital, and the PI is greater than 1.0. Therefore, on the basis of the analysis thus far, it appears that the project should be accepted. Note, though, that we have been assuming that the project is about as risky as the company's average project. If the project were judged to be riskier than average, it would be necessary to increase the cost of capital, which might cause the NPV to become negative and leave the IRR and MIRR below the new WACC. Therefore, we cannot make a final decision until we evaluate the project's risk, the topic of a later section.

### SELF-TEST

Refer to Table 12-1 and answer these questions:

- If the WACC is 15%, what is the new NPV? (**\$3,454**)
- If the equipment were depreciated over a 10-year life rather than a 5-year life, but other aspects of the project were unchanged, would the NPV increase or decrease? Why?

## 12.3 Issues in Project Analysis

Now that you have seen an application of project analysis, here are some additional issues to keep in mind.

## Purchase of Fixed Assets and Noncash Charges

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 to NOPAT 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.

## 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, over and above 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, and as a result, the investment in net operating working capital will be returned by the end of the project's life.

## Interest Expenses Are Not Included in Project Cash Flows

Recall from Chapter 11 that we discount a project's cash flows by its cost of capital and that the cost of capital is a weighted average (WACC) of the costs of debt, preferred stock, and common equity, adjusted for the project's risk. This WACC is the rate of return necessary to satisfy all of the firm's investors, both 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 WACC, so subtracting interest payments from the project's cash flows would amount to double-counting interest costs.

If someone subtracted interest (or interest plus principal payments) from the project's cash flows, then they would be calculating the cash flows available to the equity holders, and these cash flows should be discounted at the cost of equity. This technique can give the correct answer, but in order for it to work you must be very careful to adjust the amount of debt outstanding each year in order to keep the risk of the equity cash flows constant. This process is very complicated, and we do not recommend it. Here is one final caution: If someone subtracts interest, then it is definitely wrong to discount the resulting cash flows by the WACC, and no amount of care can correct that error.

*Therefore, you should not subtract interest expenses when finding a project's cash flows.*

## Sunk Costs

A **sunk cost** is an outlay that has already occurred, hence is not affected by the decision under consideration. Since sunk costs are not incremental costs, they should not be included in the analysis. For example, RIC spent \$100,000 in 2007 for R&D to develop the technology for the integrated chips project. Is this 2007 expenditure a relevant cost with respect to the 2008 capital budgeting decision? The answer is no—the \$100,000 is a *sunk cost*, and it will not affect future cash flows regardless of whether or not the new project is implemented. It often turns out that a particular project has a negative NPV if all the associated costs, including sunk costs, are considered. However, on an incremental basis, the project may be a good one because the *future incremental cash flows* are large enough to produce a positive NPV on the *incremental investment*.

## Opportunity Costs

**Opportunity costs** are cash flows that could be generated from an asset the firm already owns, provided the asset is not used for the project in question. Instead of buying a new building, suppose that RIC already owns a building that could be used for the project. If RIC's managers decided to use this building rather than buy a new one, RIC would not incur the \$12 million cash outlay to buy a new building. Would this mean that we should delete the \$12 million expenditure from the analysis, which would obviously raise the estimated NPV well above the \$5.8 million we found in Table 12-1?

The answer is that we should remove the cash flows related to the new building, but we should include the *opportunity cost* associated with the existing building as a cash cost. For example, if the building had a market value, after taxes and brokerage expenses, of \$14 million, then RIC would be giving up \$14 million if it used the building for the computer project. Therefore, we should charge the project the \$14 million that would be forgone as an opportunity cost.

## Effects on Other Parts of the Firm: Externalities

Economists define **externalities** as the effects a project has on other parts of the firm or on the environment. For example, Apple's introduction of the iPod nano caused some people who were planning to purchase a regular iPod to switch to a nano. The nano project generates positive cash flows, but it also reduces some of the company's current cash flows. This type of externality is called a **cannibalization effect**, because the new business eats into the company's existing business. The lost cash flows should be charged to the new project. However, it often turns out that if the one company does not produce a new product, some other company will, so the old cash flows would be lost anyway. In this case, no charge should be assessed against the new project. All this makes determining the cannibalization effect difficult, because it requires estimates of changes in sales and costs, and also the timing of when those changes will occur. Still, cannibalization can be important, so its potential effects should be considered.

Note that externalities can be positive as well as negative. For example, Apple's introduction of the nano has helped spur music sales at Apple's Music Store. When Apple was evaluating the nano project, it should have increased the project's cash flows by the expected cash flows due to additional music sales. It often turns out that a project's direct cash flows are insufficient to produce a

positive NPV, but when indirect effects are considered, the project is deemed to be a good one.

Firms must also be concerned with *environmental externalities*. For example, it might be that RIC's new facility would give off noxious fumes that, while not bad enough to trigger governmental actions, would still cause ill feelings in the plant's neighborhood. Those ill feelings might not show up in the cash flow analysis, but they should still be considered. Perhaps a relatively small expenditure could correct the problem and keep the firm from suffering future ill will which might be costly in some hard-to-measure way.

Rather than focusing narrowly on the project at hand, analysts must anticipate the project's impact on the rest of the firm, which requires imagination and creative thinking. It is critical to identify and account for all externalities when evaluating a proposed project.



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For more discussion on replacement analysis decisions, refer to **Web Extension 12A** at the text book's Web site.

## Replacement Projects

A **replacement project** occurs when the firm replaces an existing asset with a new one. In this case, the incremental cash flows are the firm's *additional* inflows and outflows that result from investing in the new project. In a replacement analysis, the company is comparing its value if it takes on the new project to its value if it continues to use the existing asset. Thus, it is important to take into account all of the existing project's cash flow components, including depreciation and maintenance.

## Timing of Cash Flows

We must account properly for the timing of cash flows. Accounting income statements are for periods such as years or months, so they do not reflect exactly when during the period cash revenues or expenses occur. Because of the time value of money, capital budgeting cash flows should in theory be analyzed exactly as they occur. Of course, there must be a compromise between accuracy and feasibility. A time line with daily cash flows would in theory be most accurate, but daily cash flow estimates would be costly to construct, unwieldy to use, and probably no more accurate than annual cash flow estimates because we simply cannot forecast well enough to warrant this degree of detail. Therefore, in most cases, we simply assume that all cash flows occur at the end of every year. However, for some projects, it may be useful to assume that cash flows occur at mid-year, or even quarterly or monthly.

### SELF-TEST

What is the most common noncash charge that must be added back when finding project cash flows? What is net operating working capital, and how does it affect a project's cash flows in capital budgeting? Explain the following terms: sunk cost, opportunity cost, externality, and cannibalization.

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## 12.4 Depreciation

We already discussed several issues associated with depreciation during the analysis of RIC's project, but there are additional topics that we discuss here.

Companies often calculate depreciation one way when figuring taxes and another way when reporting income to investors: Many use the **straight-line method** for stockholder reporting (or "book" purposes), but they use the fastest rate permitted by law for tax purposes. Under the straight-line method used for

stockholder reporting, one normally takes the cost of the asset, subtracts its estimated salvage value, and divides the net amount by the asset's useful economic life. For example, consider an asset with a 5-year life that costs \$100,000 and has a \$12,500 salvage value; its annual straight-line depreciation charge is  $(\$100,000 - \$12,500)/5 = \$17,500$ . Note, however, as we stated earlier, salvage value is a factor in financial reporting but it is *not* considered for tax depreciation purposes.

For tax purposes, Congress changes the permissible tax depreciation methods from time to time. Prior to 1954, the straight-line method was required for tax purposes, but in 1954 **accelerated methods** (double-declining balance and sum-of-years'-digits) were permitted. Then, in 1981, the old accelerated methods were replaced by a simpler procedure known as the Accelerated Cost Recovery System (ACRS). The ACRS system was changed again in 1986 as a part of the Tax Reform Act, and it is now known as the **Modified Accelerated Cost Recovery System (MACRS)**; a 1993 tax law made further changes in this area.

Note that U.S. tax laws are very complicated, and in this text we can only provide an overview of MACRS designed to give you a basic understanding of the impact of depreciation on capital budgeting decisions. Further, the tax laws change so often that the numbers we present may be outdated before the book is even published. Thus, when dealing with tax depreciation in real-world situations, current Internal Revenue Service (IRS) publications or individuals with expertise in tax matters should be consulted.

For tax purposes, the entire cost of an asset is expensed over its depreciable life. Historically, an asset's depreciable life was set equal to its estimated useful economic life; it was intended that an asset would be fully depreciated at approximately the same time that it reached the end of its useful economic life. However, MACRS totally abandoned that practice and set simple guidelines that created several classes of assets, each with a more-or-less arbitrarily prescribed life called a *recovery period* or *class life*. The MACRS class lives bear only a rough relationship to assets' expected useful economic lives.

A major effect of the MACRS system has been to shorten the depreciable lives of assets, thus giving businesses larger tax deductions early in the assets' lives, and thereby increasing the present value of the cash flows. Table 12-2 describes the types of property that fit into the different class life groups, and Table 12-3 sets forth the MACRS recovery allowance percentages (depreciation rates) for selected classes of investment property.

Consider Table 12-2, which gives the MACRS class lives and the types of assets that fall into each category. Property in the 27.5- and 39-year categories (real estate) must be depreciated by the straight-line method, but 3-, 5-, 7-, and 10-year

**Table 12-2**

Major Classes and Asset Lives for MACRS

Class	Type of Property
3-year	Certain special manufacturing tools
5-year	Automobiles, light-duty trucks, computers, and certain special manufacturing equipment
7-year	Most industrial equipment, office furniture, and fixtures
10-year	Certain longer-lived types of equipment
27.5-year	Residential rental real property such as apartment buildings
39-year	All nonresidential real property, including commercial and industrial buildings



property (personal property) can be depreciated either by the accelerated method set forth in Table 12-3 or by the straight-line method.<sup>5</sup>

As we saw earlier in the chapter, higher depreciation expenses result in lower taxes in the early years, hence a higher present value of cash flows. Therefore, since a firm has the choice of using straight-line rates or the accelerated rates shown in Table 12-3, most elect to use the accelerated rates.

Table 12-3

Recovery Allowance Percentage for Personal Property

Ownership Year	Class of Investment			
	3-Year	5-Year	7-Year	10-Year
1	33%	20%	14%	10%
2	45	32	25	18
3	15	19	17	14
4	7	12	13	12
5		11	9	9
6		6	9	7
7			9	7
8			4	7
9				7
10				6
11				3
	100%	100%	100%	100%

## Notes:

<sup>a</sup> We developed these recovery allowance percentages based on the 200% declining balance method prescribed by MACRS, with a switch to straight-line depreciation at some point in the asset's life. For example, consider the 5-year recovery allowance percentages. The straight-line percentage would be 20% per year, so the 200% declining balance multiplier is  $2.0(20\%) = 40\% = 0.4$ . However, because the half-year convention applies, the MACRS percentage for Year 1 is 20%. For Year 2, there is 80% of the depreciable basis remaining to be depreciated, so the recovery allowance percentage is  $0.40(80\%) = 32\%$ . In Year 3,  $20\% + 32\% = 52\%$  of the depreciation has been taken, leaving 48%, so the percentage is  $0.4(48\%) \approx 19\%$ . In Year 4, the percentage is  $0.4(29\%) \approx 12\%$ . After 4 years, straight-line depreciation exceeds the declining balance depreciation, so a switch is made to straight-line (this is permitted under the law). However, the half-year convention must also be applied at the end of the class life, and the remaining 17% of depreciation must be taken (amortized) over 1.5 years. Thus, the percentage in Year 5 is  $17\%/1.5 \approx 11\%$ , and in Year 6,  $17\% - 11\% = 6\%$ . Although the tax tables carry the allowance percentages out to two decimal places, we have rounded to the nearest whole number for ease of illustration.

<sup>b</sup> Residential rental property (apartments) is depreciated over a 27.5-year life, whereas commercial and industrial structures are depreciated over 39 years. In both cases, straight-line depreciation must be used. The depreciation allowance for the first year is based, pro rata, on the month the asset was placed in service, with the remainder of the first year's depreciation being taken in the 28th or 40th year. A half-month convention is assumed; that is, an asset placed in service in February would receive 10.5 months of depreciation in the first year.

<sup>5</sup>The Tax Code currently (for 2006) permits companies to expense, which is equivalent to depreciating over 1 year, up to \$108,000 of equipment; see IRS Publication 946 for details. This is a benefit primarily for small companies. Thus, if a small company bought one asset worth up to \$108,000, it could write the asset off in the year it was acquired. This is called "Section 179 expensing." We shall disregard this provision throughout the book. Also, Congress enacted the Job Creation and Worker Assistance Act of 2002 following the terrorist attacks on the World Trade Center and Pentagon. This act, among other things, temporarily changed how depreciation is charged for property acquired after September 10, 2001, and before September 11, 2004, and put in service before January 1, 2005. We shall disregard this provision throughout the book as well.

The yearly recovery allowance, or depreciation expense, is determined by multiplying each asset's *depreciable basis* by the applicable recovery percentage shown in Table 12-3. You might be wondering why 4 years of depreciation rates are shown for property in the 3-year class. Under MACRS, the assumption is generally made that property is placed in service in the middle of the first year. Thus, for 3-year-class property, the recovery period begins in the middle of the year the asset is placed in service and ends 3 years later. The effect of the *half-year convention* is to extend the recovery period out one more year, so 3-year-class property is depreciated over 4 calendar years, 5-year property is depreciated over 6 calendar years, and so on. This convention is incorporated into Table 12-3's recovery allowance percentages.<sup>6</sup>

### SELF-TEST

What do the acronyms ACRS and MACRS stand for?

Briefly describe the tax depreciation system under MACRS.

## 12.5 Adjusting for Inflation

Inflation is a fact of life in the United States and most other nations, so it must be considered in any sound capital budgeting analysis.

### Inflation-Induced Bias

Note that *in the absence of inflation*, the real rate,  $r_r$ , would be equal to the nominal rate,  $r_{\text{NOM}}$ . Moreover, the real and nominal expected net cash flows— $\text{RCF}_t$  and  $\text{NCF}_t$ —would also be equal. Remember that *real* interest rates and cash flows do not include inflation effects, while *nominal* rates and flows do reflect the effects of inflation. In particular, an inflation premium,  $\text{IP}$ , is built into all nominal market interest rates.

Suppose the expected rate of inflation is positive, and we expect *all* of the project's cash flows—including those related to depreciation—to rise at the rate  $i$ . Further, assume that this same inflation rate,  $i$ , is built into the market cost of capital as an inflation premium,  $\text{IP} = i$ . In this situation, the nominal net cash flow,  $\text{NCF}_t$ , will increase annually at the rate of  $i$  percent, producing this result:

$$\text{NCF}_t = \text{RCF}_t(1 + i)^t.$$

For example, if we expected a net cash flow of \$100 in Year 5 in the absence of inflation, then with a 5% annual rate of inflation,  $\text{NCF}_5 = \$100(1.05)^5 = \$127.63$ .

In general, the cost of capital used as the discount rate in capital budgeting analysis is based on the market-determined costs of debt and equity, so it is a nominal rate. To convert a real interest rate,  $r_r$ , to a nominal rate,  $r_{\text{NOM}}$ , when the inflation rate is  $i$ , we use this formula:

$$(1 + r_{\text{NOM}}) = (1 + r_r)(1 + i).$$

<sup>6</sup>The half-year convention also applies if the straight-line alternative is used, with half of one year's depreciation taken in the first year, a full year's depreciation taken in each of the remaining years of the asset's class life, and the remaining half-year's depreciation taken in the year following the end of the class life. You should recognize that virtually all companies have computerized depreciation systems. Each asset's depreciation pattern is programmed into the system at the time of its acquisition, and the computer aggregates the depreciation allowances for all assets when the accountants close the books and prepare financial statements and tax returns.

For example, if the real cost of capital is 7% and the inflation rate is 5%, then  $1 + r_{\text{NOM}} = (1.07)(1.05) = 1.1235$ , so  $r_{\text{NOM}} = 12.35\%$ .<sup>7</sup>

Now if net cash flows increase at the rate of  $i$  percent per year, and if this same inflation premium is built into the firm's cost of capital, then the NPV would be calculated as follows:

$$\text{NPV (with inflation)} = \sum_{t=0}^N \frac{\text{NCF}_t}{(1 + r_{\text{NOM}})^t} = \sum_{t=0}^N \frac{\text{RCF}_t(1 + i)^t}{(1 + r_r)^t (1 + i)^t} \quad (12-5)$$

Since the  $(1 + i)^t$  terms in the numerator and denominator cancel, we are left with

$$\text{NPV} = \sum_{t=0}^N \frac{\text{RCF}_t}{(1 + r_r)^t} \quad (12-6)$$

Thus, if all costs and also the sales price, hence annual cash flows, are expected to rise at the same inflation rate that investors have built into the cost of capital, then the inflation-adjusted NPV as determined using Equation 12-5 is the same whether you discount nominal cash flows at a nominal rate or real cash flows at a real rate. For example, the PV of a real \$100 at Year 5 at a real rate of 7% is  $\$71.30 = \$100/(1.07)^5$ . The PV of a nominal \$127.63 at Year 5 at a nominal rate of 12.35% is also  $\$71.30 = \$127.63/(1.1235)^5$ .

However, some analysts mistakenly use base year, or constant (unadjusted), dollars throughout the analysis—say, 2008 dollars if the analysis is done in 2008—along with a cost of capital as determined in the marketplace as we described in Chapter 10. This is wrong: *If the cost of capital includes an inflation premium, as it typically does, but the cash flows are all stated in constant (unadjusted) dollars, then the calculated NPV will be lower than the true NPV.* The denominator will reflect inflation, but the numerator will not, and this will produce a downward-biased NPV.

## Making the Inflation Adjustment

There are two ways to adjust for inflation. First, all project cash flows can be expressed as real (unadjusted) flows, with no consideration of inflation, and then the cost of capital can be adjusted to a real rate by removing the inflation premiums from the component costs. This approach is simple in theory, but to produce an unbiased NPV it requires (1) that all project cash flows, including depreciation, be affected identically by inflation, and (2) that this rate of increase equals the inflation rate built into investors' required returns. Because these assumptions do not necessarily hold in practice, this method is not commonly used.

The second method involves leaving the cost of capital in its nominal form, and then adjusting the individual cash flows to reflect expected inflation. This is what we did earlier in our RIC example as summarized in Table 12-1. There we assumed that sales prices and variable costs would increase at a rate of 2% per year,

<sup>7</sup>To focus on inflation effects, we have simplified the situation somewhat. The actual project cost of capital is made up of debt and equity components, both of which are affected by inflation, but only the debt component is adjusted for tax effects. Thus, the relationship between nominal and real costs of capital is more complex than indicated in our discussion here.

fixed costs would increase by 1% per year, and that depreciation charges would not be affected by inflation. One should always build inflation into the cash flow analysis, with the specific adjustment reflecting as accurately as possible the most likely set of circumstances. With a spreadsheet, it is easy to make the adjustments.

Our conclusions about inflation may be summarized as follows. First, inflation is critically important, for it can and does have major effects on businesses. Therefore, it must be recognized and dealt with. Second, the most effective way of dealing with inflation in capital budgeting analyses is to build inflation estimates into each cash flow element, using the best available information on how each element will be affected. Third, since we cannot estimate future inflation rates with precision, errors are bound to be made. Thus, inflation adds to the uncertainty, or risk, of capital budgeting as well as to its complexity.

### SELF-TEST

What is the best way of handling inflation, and how does this procedure eliminate the potential bias?

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## 12.6 Project Risk Analysis: Techniques for Measuring Stand-Alone Risk

Recall from Chapter 10 that there are three distinct types of risk: stand-alone risk, corporate risk, and market risk. Why should a project's stand-alone risk be important to anyone? In theory, this type of risk should be of little or no concern. However, it is actually of great importance for two reasons:

1. It is easier to estimate a project's stand-alone risk than its corporate risk, and it is far easier to measure stand-alone risk than market risk.
2. In the vast majority of cases, all three types of risk are highly correlated—if the general economy does well, so will the firm, and if the firm does well, so will most of its projects. Because of this high correlation, stand-alone risk is generally a good proxy for hard-to-measure corporate and market risk.

The starting point for analyzing a project's stand-alone risk involves determining the uncertainty inherent in its cash flows. To illustrate what is involved, consider again Regency Integrated Chips' appliance control computer project that we discussed above. Many of the key inputs shown in Part 1 of Table 12-1 are subject to uncertainty. For example, sales were projected at 20,000 units to be sold at a net price of \$3,000 per unit. However, actual unit sales will almost certainly be somewhat higher or lower than 20,000, and the sales price will probably turn out to be different from the projected \$3,000 per unit. *In effect, the sales quantity and price estimates are really expected values based on probability distributions, as are many of the other values that were shown in Part 1 of Table 12-1.* The distributions could be relatively "tight," reflecting small standard deviations and low risk, or they could be "wide," denoting a great deal of uncertainty about the actual value of the variable in question and thus a high degree of stand-alone risk.

The nature of the individual cash flow distributions, and their correlations with one another, determine the nature of the NPV probability distribution and, thus, the project's stand-alone risk. In the following sections, we discuss three techniques for assessing a project's stand-alone risk: (1) sensitivity analysis, (2) scenario analysis, and (3) Monte Carlo simulation.

## Sensitivity Analysis

Intuitively, we know that many of the variables that determine a project's cash flows could turn out to be different from the values used in the analysis. We also know that a change in a key input variable, such as units sold, will cause the NPV to change. **Sensitivity analysis** is a technique that indicates how much NPV will change in response to a given change in an input variable, other things held constant.

**Sensitivity Tables and Graphs** Sensitivity analysis begins with a *base-case* situation, which is developed using the *expected* values for each input. To illustrate, consider the data given back in Table 12-1, where projected cash flows for RIC's computer project were shown. The values used to develop the table, including unit sales, sales price, fixed costs, and variable costs, are all most likely, or base-case, values, and the resulting \$5.809 million NPV shown in Table 12-1 is called the **base-case NPV**. Now we ask a series of "what if" questions: What if unit sales fall 15% below the most likely level? What if the sales price per unit falls? What if variable costs are \$2.50 per unit rather than the expected \$2.10? Sensitivity analysis is designed to provide decision makers with answers to questions such as these.

In a sensitivity analysis, each variable is changed by several percentage points above and below the expected value, holding all other variables constant. Then a new NPV is calculated using each of these values. Finally, the set of NPVs is plotted to show how sensitive NPV is to changes in each variable. Figure 12-1 shows the computer project's sensitivity graphs for six of the input variables. The table below the graph gives the NPVs that were used to construct the graph. The slopes of the lines in the graph show how sensitive NPV is to changes in each of the inputs: *The steeper the slope, the more sensitive the NPV is to a change in the variable.* From the figure and the table, we see that the project's NPV is very sensitive to changes in the sales price and variable costs, fairly sensitive to changes in the growth rate and units sold, and not very sensitive to changes in either fixed costs or the cost of capital.

If we were comparing two projects, the one with the steeper sensitivity lines would be riskier, because for that project a relatively small error in estimating a variable such as unit sales would produce a large error in the project's expected NPV. Thus, sensitivity analysis can provide useful insights into the risk of a project.

Spreadsheet computer programs such as *Excel* are ideally suited for sensitivity analysis. We used the Data Table feature in the file *FM12 Ch 12 Tool Kit.xls* to generate the data for the graph in Figure 12-1. To conduct such an analysis by hand would be extremely time-consuming.

**NPV Breakeven Analysis** A special application of sensitivity analysis is called **NPV breakeven analysis**. In a breakeven 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.

Table 12-4 shows the values of the inputs discussed above that produce a zero NPV. For example, the unit sales price can drop to \$2.84 before the project's NPV falls to zero. Breakeven analysis is helpful in determining how bad things can get before the project has a negative NPV.

## Scenario Analysis

Although sensitivity analysis is probably the most widely used risk analysis technique, it does have limitations. For example, we saw earlier that the computer



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See **FM12 Ch 12 Tool Kit.xls** for all calculations.



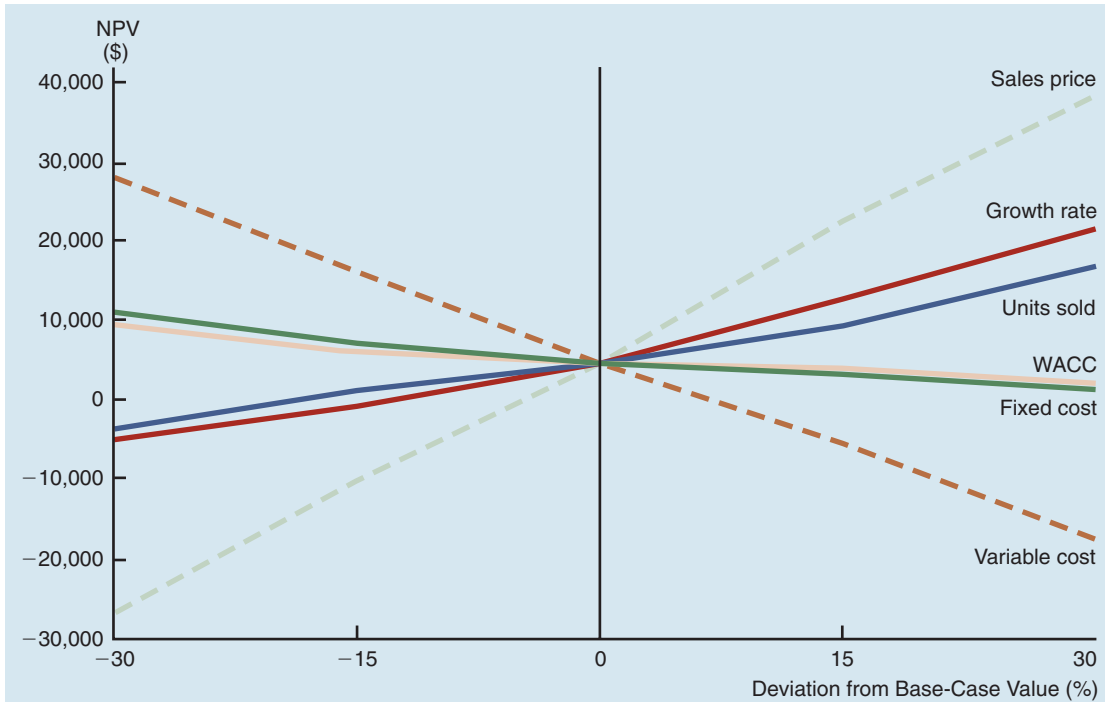
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See **FM12 Ch 12 Tool Kit.xls** at the textbook's Web site.



**Figure 12-1**

Evaluating Risk: Sensitivity Analysis (Dollars in Thousands)



**NPV At Different Deviations From Base**

Deviation from Base Case	Sales Price	Variable Cost/Unit	Growth Rate	Year 1 Units Sold	Fixed Cost	WACC
-30%	(\$27,223)	\$29,404	(\$ 4,923)	(\$ 3,628)	\$10,243	\$9,030
-15	(10,707)	17,607	(115)	1,091	8,026	7,362
0	5,809	5,809	5,809	5,809	5,809	5,809
15	22,326	(5,988)	12,987	10,528	3,593	4,363
30	38,842	(17,785)	21,556	15,247	1,376	3,014
Range	\$66,064	\$47,189	\$26,479	\$18,875	\$ 8,867	\$6,016

**Table 12-4**

NPV Breakeven Analysis (Dollars in Thousands)

Input	Input Value that Produces Zero NPV
Sales price	\$2.84
Variable cost/unit	\$2.26
Growth rate	-14.7%
Year 1 units sold	16,307
Fixed cost	\$11,145
WACC	20.1%

project's NPV is highly sensitive to changes in the sales price and the variable cost per unit. Those sensitivities suggest that the project is risky. Suppose, however, that Home Depot or Circuit City was anxious to get the new computer product and would sign a contract to purchase 20,000 units per year for 4 years at \$3,000 per unit. Moreover, suppose Intel would agree to provide the principal component at a price that would ensure that the variable cost per unit would not exceed \$2,100. Under these conditions, there would be a low probability of high or low sales prices and input costs, so the project would not be at all risky in spite of its sensitivity to those variables.

We see, then, that we need to extend sensitivity analysis to deal with the *probability distributions* of the inputs. In addition, it would be useful to vary more than one variable at a time so we could see the combined effects of changes in the variables. Scenario analysis provides these extensions—it brings in the probabilities of changes in the key variables, and it allows us to change more than one variable at a time. In a scenario analysis, the financial analyst begins with the **base case**, or most likely set of values for the input variables. Then, he or she asks 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 case and worst case are set so as to have a 25% probability of conditions being that good or bad, and a 50% probability is assigned to the base-case conditions. Obviously, conditions could actually take on other values, but parameters such as these are useful to get people focused on the central issues in risk analysis.

The best-case, base-case, and worst-case values for RIC's computer project are shown in Table 12-5, along with a plot of the NPVs. If the product is highly successful, then the combination of a high sales price, low production costs, high first year sales, and a strong growth rate in future sales will result in a very high NPV, \$146 million. However, if things turn out badly, then the NPV will be -\$37 million. The graph shows a very wide range of possibilities, indicating that this is indeed a very risky project. If the bad conditions materialize, this will not bankrupt the company—this is just one project for a large company. Still, losing \$37 million would certainly not help the stock price or the career of the project's manager.

The scenario probabilities and NPVs constitute a probability distribution of returns like those we dealt with in Chapter 6, except that the returns are measured in dollars instead of percentages (rates of return). The expected NPV (in thousands of dollars) is \$30,135:<sup>8</sup>

$$\begin{aligned}\text{Expected NPV} &= \sum_{i=1}^n P_i(\text{NPV}_i) \\ &= 0.25(\$146,180) + 0.50(\$5,809) + 0.25(-\$37,257) \\ &= \$30,135.\end{aligned}$$

<sup>8</sup>Note that the expected NPV, \$30,135, is *not* the same as the base-case NPV, \$5,809 (in thousands). This is because the 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 big number times another big number produces a very big number, which, in turn, causes the average, or expected value, to increase.



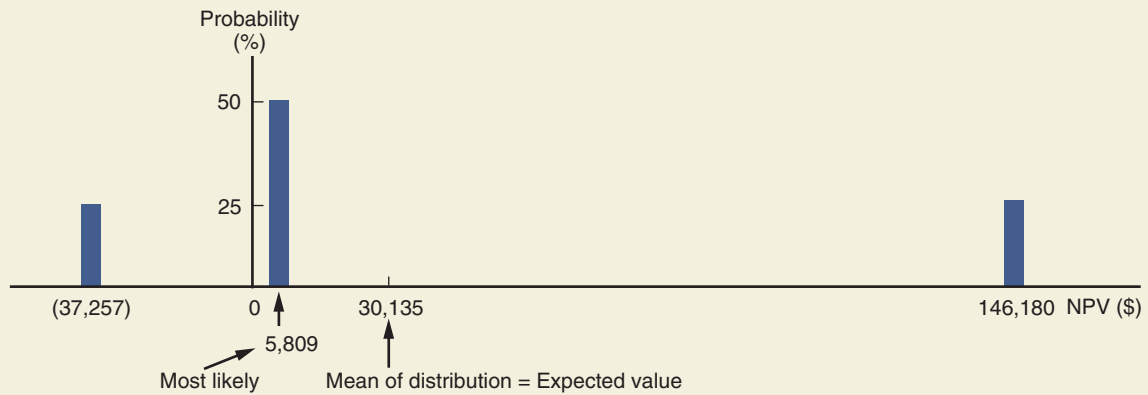
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See **FM12 Ch 12 Tool Kit.xls** for a scenario analysis using Excel's Scenario Manager.

Table 12-5

## Scenario Analysis (Dollars in Thousands)

Scenario	Probability	Sales Price	Unit Sales	Variable Costs	Growth Rate	NPV	
Best case	25%	\$3.90	26,000	\$1.47	30%	\$146,180	
Base case	50	3.00	20,000	2.10	0	5,809	
Worst case	25	2.10	14,000	2.73	-30	(37,257)	
						Expected NPV =	\$30,135
						Standard deviation =	\$69,267
						Coefficient of variation = Standard deviation/Expected NPV =	2.30



Note: The scenario analysis calculations were performed in the Excel model, **FM12 Ch 12 Tool Kit.xls**.

The standard deviation of the NPV is \$69,267 (in thousands of dollars):

$$\begin{aligned}\sigma_{\text{NPV}} &= \sqrt{\sum_{i=1}^n P_i(\text{NPV}_i) - (\text{Expected NPV})^2} \\ &= \sqrt{0.25(\$146,180 - \$30,135)^2 + 0.50(\$5,809 - \$30,135)^2} \\ &\quad + 0.25(-\$37,257 - \$30,135)^2 \\ &= \$69,267.\end{aligned}$$

Finally, the project's coefficient of variation is

$$CV_{\text{NPV}} = \frac{\sigma_{\text{NPV}}}{E(\text{NPV})} = \frac{\$69,267}{\$30,135} = 2.30.$$

The project's coefficient of variation can be compared with the coefficient of variation of RIC's "average" project to get an idea of the relative risk of the proposed project. RIC's existing projects, on average, have a coefficient of variation of about 1.0, so, on the basis of this stand-alone risk measure, we conclude that this project is much riskier than an "average" project.

Scenario analysis provides useful information about a project's stand-alone risk. However, it is limited in that it considers only a few discrete outcomes



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See **FM12 Ch 12 Tool Kit.xls** at the textbook's Web site.

## Capital Budgeting Practices in the Asia/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. IRR usage ranged from 96% (in Australia) to 86% (in Hong Kong). NPV usage ranged from 96% (in Australia) to 81% (in the Philippines). Payback usage ranged from 100% (in Hong Kong and the Philippines) to 81% (in Indonesia).

### Techniques for Estimating the Cost of Equity Capital

Recall from Chapter 10 that three basic approaches can be used to estimate the cost of equity: CAPM,

dividend yield plus growth rate (DCF), and cost of debt plus a risk premium. The use of these methods varied 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, who 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 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

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*, Spring/Summer 1999, pp. 25–33.

(NPVs), even though there are an infinite number of possibilities. We describe a more complete method of assessing a project's stand-alone risk in the next section.

## Monte Carlo Simulation

**Monte Carlo simulation** ties together sensitivities and probability distributions. 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. While Monte

Carlo simulation is considerably more complex than scenario analysis, simulation software packages make this process manageable. Many of these packages are included as add-ons to spreadsheet programs such as *Excel*.

In a simulation analysis, the computer begins by picking at random a value for each variable—sales in units, the sales price, the variable cost per unit, and so on. Then those values are combined, and the project's NPV is calculated and stored in the computer's memory. Next, a second set of input values is selected at random, and a second NPV is calculated. This process is repeated perhaps 1,000 times, generating 1,000 NPVs. The mean and standard deviation of the set of NPVs is determined. The mean, or average value, is used as a measure of the project's expected NPV, and the standard deviation (or coefficient of variation) is used as a measure of risk.

Using this procedure, we conducted a simulation analysis of RIC's proposed project. As in our scenario analysis, we simplified the illustration by specifying the distributions for only four key variables: (1) sales price, (2) variable cost, (3) Year 1 units sold, and (4) growth rate.

We assumed that sales price can be represented by a continuous normal distribution with an expected value of \$3.00 and a standard deviation of \$0.35. Recall from Chapter 6 that there is about a 68% chance that the actual price will be within one standard deviation of the expected price, which results in a range of \$2.65 to \$3.35. Put another way, there is only a 32% chance that the price will fall outside the indicated range. Note too that there is less than a 1% chance that the actual price will be more than three standard deviations away from the expected price, which gives us a range of \$1.95 to \$4.05. Therefore, the sales price is very unlikely to be less than \$1.95 or more than \$4.05.

RIC has existing labor contracts and strong relationships with some of its suppliers, which makes the variable cost less uncertain. In the simulation we assumed that the variable cost can be described by a triangular distribution, with a lower bound of \$1.40, a most likely value of \$2.10, and an upper bound of \$2.50. Note that this is not a symmetric distribution. The lower bound is \$0.70 less than the most likely value, but the upper bound is only \$0.40 higher than the most likely value. This is because RIC has an active risk management program under which it hedges against increases in the prices of the commodities used in its production processes. The net effect is that RIC's hedging activities reduce its exposure to price increases but still allow it to take advantage of falling prices.

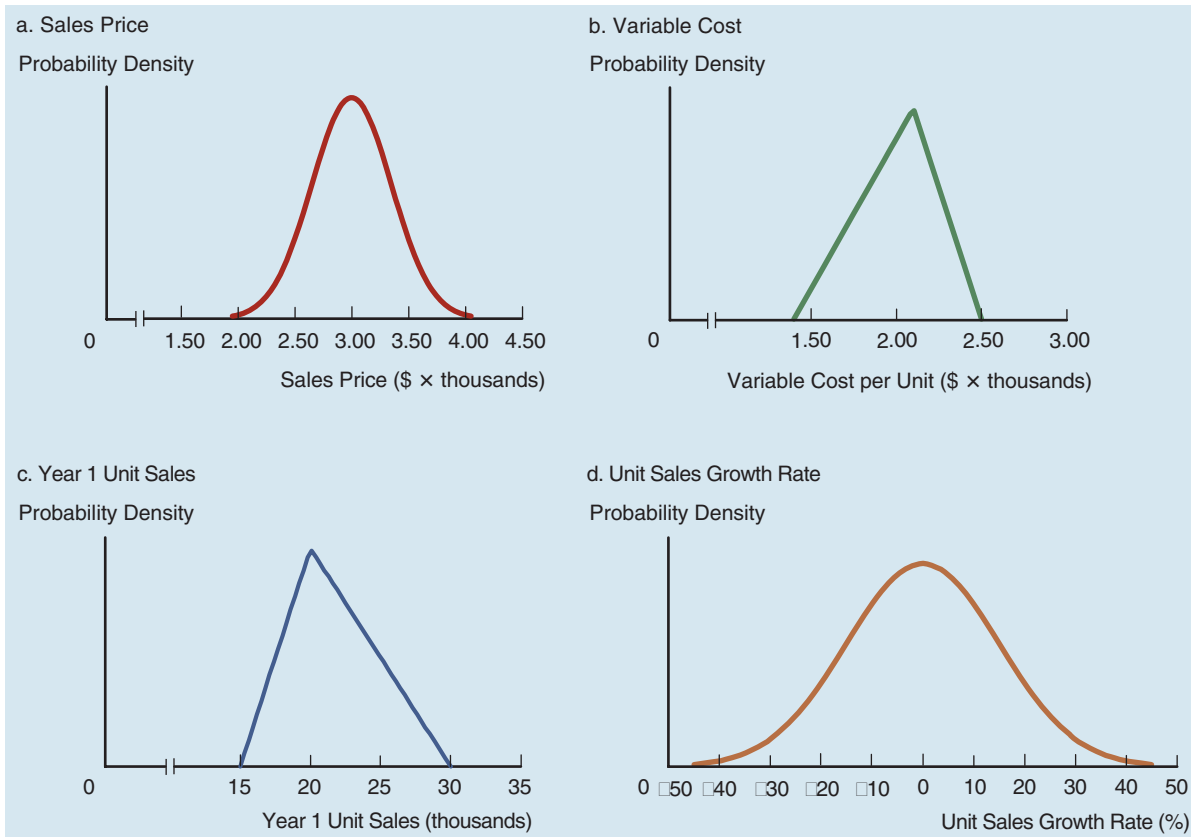
Based on preliminary purchase agreements with major customers, RIC is certain that sales in the first year will be at least 15,000 units. The marketing department believes the most likely demand will be 20,000 units, but it is possible that demand will be much higher. The plant can produce a maximum of 30,000 units in the first year, although production can be expanded in subsequent years if there is higher than expected demand. Therefore, we represented Year 1 unit sales with a triangular distribution with a lower bound of 15,000 units, a most likely value of 20,000 units, and an upper bound of 30,000 units.

The marketing department anticipates no growth in unit sales after the first year, but it recognizes that actual sales growth could be either positive or negative. Moreover, actual growth is likely to be positively correlated with units sold in the first year, which means that if demand is higher than expected in the first year, then growth will probably be higher than expected in subsequent years. We represented growth with a normal distribution having an expected value of 0 percent and a standard deviation of 15%. We also specified the correlation between Year 1 unit sales and growth in sales to be 0.65. Graphs of these probability distributions are shown in Figure 12-2.



**Figure 12-2**

Probability Distributions Used in the Monte Carlo Simulation



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See *Explanation of Simulation.doc*, *Simtools.xla*, and *FM12 Ch 12 Tool Kit Simulation.xls* at the textbook's Web site.

We used these inputs and the model from *FM12 Ch 12 Tool Kit.xls* to conduct the simulation analysis. If you want to do the simulation yourself, you should first read the instructions in the file *Explanation of Simulation.doc*. This explains how to install an *Excel* add-in, *Simtools.xla*, which is necessary to run the simulation. After you have installed *Simtools.xla*, you can run the simulation analysis, which is in a separate spreadsheet, *FM12 Ch 12 Tool Kit Simulation.xls*.<sup>9</sup> Using this model, we simulated 1,000 outcomes for the capital budgeting project. Table 12-6 presents selected results from the simulation.

After running the simulation, the first thing to do is to verify that the results are consistent with our assumptions. The resulting mean and standard deviation of sales price are \$3.01 and \$0.35, respectively, which are virtually identical to our assumptions. Similarly, the resulting mean of  $-0.4\%$  and standard deviation of  $14.8\%$  for growth are very close to our assumed distribution. The maximum for variable cost is \$2.47, which is just under our specified maximum of \$2.50, and the minimum is \$1.40, which is equal to our specified minimum. Unit sales have a maximum of 29,741 and a minimum of 15,149, both of which are consistent with

<sup>9</sup>We are grateful to Professor Roger Myerson of Northwestern University for making *Simtools.xla* available to us. Note too that there are a number of commercially available simulation programs that can be used with *Excel*, including *@Risk* and *Crystal Ball*. Many universities and companies have such programs installed on their networks, and they can also be installed on PCs.

Table 12-6

## Summary of Simulation Results (Thousands of Dollars)

	Risky Inputs				Output
	Sales Price	Variable Costs	Unit Sales	Growth	NPV
Mean	\$3.01	\$2.00	21,662	-0.4%	\$13,867
Standard deviation	0.35	0.23	3,201	14.8	22,643
Maximum	4.00	2.47	29,741	42.7	124,091
Minimum	1.92	1.40	15,149	-51.5	-49,550
Median					10,607
Probability of NPV > 0					72.8%
Coefficient of variation					1.63

our assumptions. Finally, the resulting correlation between unit sales and growth is 0.664, which is very close to our assumed correlation of 0.65. Therefore, the results of the simulation are consistent with our assumptions.

Table 12-6 also reports summary statistics for the project's NPV. The mean is \$13,867, which suggests that the project should be accepted. However, the range of outcomes is quite large, from a loss of \$49,550 to a gain of \$124,091, so the project is clearly risky. The standard deviation of \$22,643 indicates that losses could easily occur, and this is consistent with this wide range of possible outcomes.<sup>10</sup> The coefficient of variation is 1.63, which is large compared with most of RIC's other projects. Table 12-6 also reports a median NPV of \$10,607, which means that half the time the project will have an NPV greater than \$10,607. The table also reports that 72.8% of the time we would expect the project to have a positive NPV.

A picture is worth a thousand words, and Figure 12-3 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

List two reasons why, in practice, a project's stand-alone risk is important.

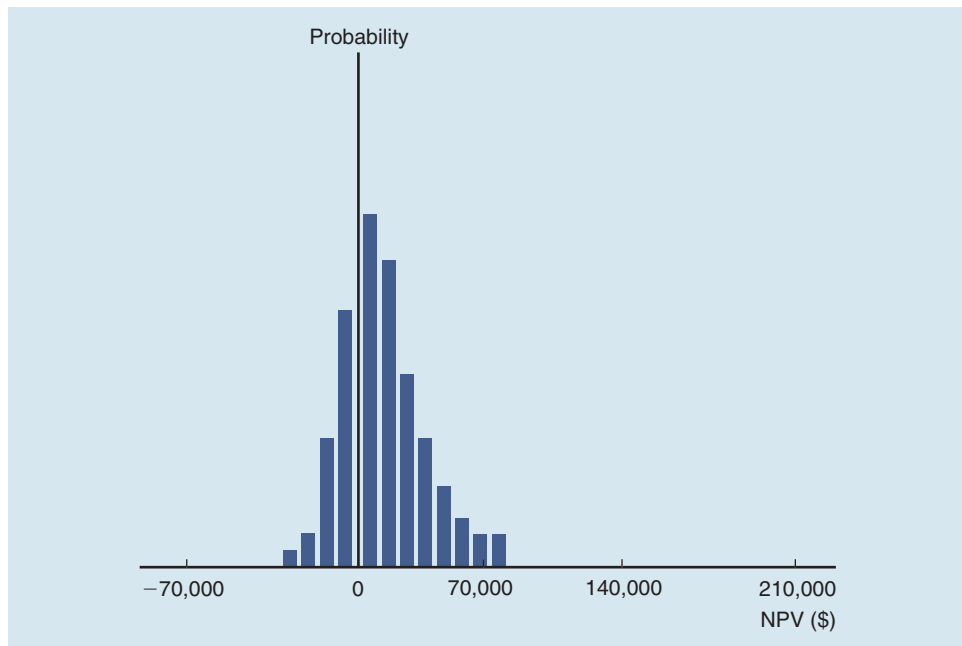
Differentiate between sensitivity and scenario analyses. What advantage does scenario analysis have over sensitivity analysis?

What is Monte Carlo simulation?

<sup>10</sup>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 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, with the exception of 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's 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 not estimated accurately, then the simulation output will likewise be inaccurate.

Figure 12-3

NPV Probability Distribution



## 12.7 Project Risk Conclusions

We have discussed the three types of risk normally considered in capital budgeting analysis—stand-alone risk, within-firm (or corporate) risk, and market risk—and we have discussed ways of assessing each. However, two important questions remain: (1) Should firms be concerned with stand-alone or corporate risk in their capital budgeting decisions, and (2) what do we do when the stand-alone, within-firm, and market risk assessments lead to different conclusions?

These questions do not have easy answers. From a theoretical standpoint, well-diversified investors should be concerned only with market risk, managers should be concerned only with stock price maximization, and this should lead to the conclusion that market (beta) risk ought to be given virtually all the weight in capital budgeting decisions. However, if investors are not well diversified, if the CAPM does not operate exactly as theory says it should, or if measurement problems keep managers from having confidence in the CAPM approach in capital budgeting, it may be appropriate to give stand-alone and corporate risk more weight than financial theory suggests. Note also that 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 instead of concentrating entirely on market risk.

Although it would be nice to reconcile these problems and to measure project risk on some absolute scale, the best we can do in practice is to estimate project 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 or less stand-alone risk than the firm's average project. Then, assuming that stand-alone and corporate risk are highly correlated (which is typical), the project's stand-alone

risk will be a good measure of its corporate risk. Finally, assuming that market risk and corporate risk are highly correlated (as is true for most companies), a project with more corporate risk than average will also have more market risk, and vice versa for projects with low corporate risk.

### SELF-TEST

In theory, should a firm be concerned with stand-alone and corporate risk? Should the firm be concerned with these risks in practice?

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

## 12.8 Incorporating Project Risk into Capital Budgeting

As we described in Chapter 10, many firms calculate a cost of capital for each division, based on the division's market risk and capital structure. This is the first step toward incorporating risk analysis into capital budgeting decisions, but it is limited because it encompasses only market risk. Rather than directly estimating the corporate risk of a project, the risk management departments at many firms regularly assess the entire firm's likelihood of financial distress, based on current and proposed projects.<sup>11</sup> In other words, they assess a firm's corporate risk, given its portfolio of projects. This screening process will identify those projects that significantly increase corporate risk.

Suppose a proposed project doesn't significantly affect a firm's likelihood of financial distress, but it does have greater stand-alone risk than the typical project in a division. Two methods are used to incorporate this project risk into capital budgeting. One is called the *certainty equivalent* approach. Here every cash inflow that is not known with certainty is scaled down, and the riskier the flow, the lower its certainty equivalent value. The other method, and the one we focus on here, is the **risk-adjusted discount rate** approach, under which differential project risk is dealt with by changing the discount rate. Average-risk projects are discounted at the firm's average cost of capital, higher-risk projects are discounted at a higher cost of capital, and lower-risk projects are discounted at a rate below the firm's average cost of capital. Unfortunately, there is no good way of specifying exactly *how much* higher or lower these discount rates should be. Given the present state of the art, risk adjustments are necessarily judgmental and somewhat arbitrary.<sup>12</sup>

### SELF-TEST

How are risk-adjusted discount rates used to incorporate project risk into the capital budget decision process?



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See **Web Extension 12B** at the textbook's Web site, for a more detailed discussion of certainty equivalents and risk-adjusted discount rates.

## 12.9 Managing Risk through Phased Decisions: Decision Trees

Up to this point we have focused primarily on techniques for estimating a project's stand-alone risk. Although this is an integral part of capital budgeting,

<sup>11</sup>These processes also measure the magnitude of the losses, which is often called *value at risk*.

<sup>12</sup>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; J. S. Butler and Barry Schachter, "The Investment Decision: Estimation Risk and Risk Adjusted Discount Rates," *Financial Management*, Winter 1989, pp. 13–22; and Samuel C. Weaver, Peter J. Clemmens III, Jack A. Gunn, and Bruce D. Danneburg, "Divisional Hurdle Rates and the Cost of Capital," *Financial Management*, Spring 1989, pp. 18–25.

managers are generally more interested in *reducing* risk than in *measuring* it. For example, sometimes projects can be structured so that expenditures do not have to be made all at one time, but, rather, can be made in stages over a period of years. This reduces risk by giving managers the opportunity to reevaluate decisions using new information and then either investing additional funds or terminating the project. Such projects can be evaluated using *decision trees*.

### The Basic Decision Tree

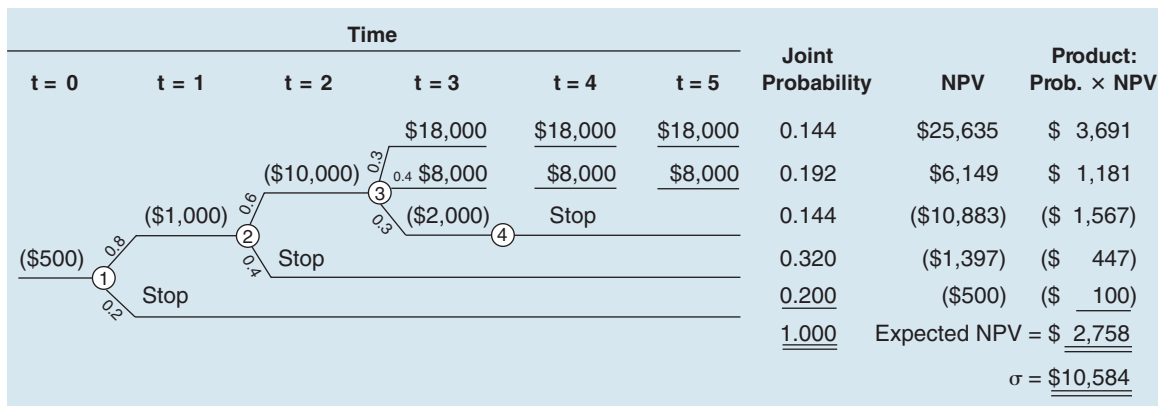
Suppose United Robotics is considering the production of an industrial robot for the television manufacturing industry. The net investment for this project can be broken down into stages, as set forth in Figure 12-4:

- STAGE 1.** At  $t = 0$ , which in this case is sometime in the near future, conduct a \$500,000 study of the market potential for robots in television assembly lines.
- STAGE 2.** If it appears that a sizable market does exist, then at  $t = 1$  spend \$1,000,000 to design and build a prototype robot. This robot would then be evaluated by television engineers, and their reactions would determine whether the firm should proceed with the project.
- STAGE 3.** If reaction to the prototype robot is good, then at  $t = 2$  build a production plant at a net cost of \$10,000,000. If this stage were reached, the project would generate either high, medium, or low net cash flows over the following 4 years.
- STAGE 4.** At  $t = 3$  market acceptance will be known. If demand is low, the firm will terminate the project and avoid the negative cash flows in Years 4 and 5.

A **decision tree** such as the one in Figure 12-4 can be used to analyze such multistage, or sequential, decisions. Here we assume that 1 year goes by between decisions. Each circle represents a decision point, and it is called a **decision node**. The dollar value to the left of each decision node represents the net investment required at that decision point, and the cash flows shown under  $t = 3$  to  $t = 5$  represent the cash inflows if the project is pushed on to completion. Each diagonal line represents 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, it will spend \$500,000 on a marketing study. Management estimates that

**Figure 12-4**

United Robotics: Decision Tree Analysis (Thousands of Dollars)



there is a 0.8 probability that the study will produce favorable results, leading to the decision to move on to Stage 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 \$500,000 for the initial marketing study, and it will be a loss.

If the marketing study yields positive results, then United Robotics will spend \$1,000,000 on the prototype robot at Decision Point 2. Management estimates (before even making the initial \$500,000 investment) that there is a 60% probability that the television engineers will find the robot useful and a 40% probability that they will not like it.

If the engineers like the robot, the firm will spend the final \$10,000,000 to build the plant and go into production. If the engineers do not like the prototype, the project will be dropped. If the firm does go into production, the operating cash flows over the project's 4-year life will depend on how well the market accepts the final product. There is a 30% chance that acceptance will be quite good and net cash flows will be \$18 million per year, a 40% probability of \$8 million each year, and a 30% chance of losing \$2 million. These cash flows are shown under Years 3 through 5.

In summary, the decision tree in Figure 12-4 defines the decision nodes and the branches that leave the nodes. There are two types of nodes, decision nodes and outcome nodes. Decision nodes are the points at which management can respond to new information. The first decision node is at  $t = 1$ , after the company has completed the marketing study (Decision Point 1 in Figure 12-4). The second decision node is at  $t = 2$ , after the company has completed the prototype study (Decision Point 2 in Figure 12-4). The outcome nodes show the possible results if a particular decision is taken. There is one relevant outcome node (Decision Point 3 in Figure 12-4), the one occurring at  $t = 3$ , and its branches show the possible cash flows if the company goes ahead with the industrial robot project. There is one more decision node, Decision Point 4, at which United Robotics terminates the project if acceptance is low. Note that the decision tree also shows the probabilities of moving into each branch that leaves a node.

The column of joint probabilities in Figure 12-4 gives the probability of occurrence of each branch, hence of each NPV. Each joint probability is obtained by multiplying together all probabilities on a 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 \$18,000,000 per year of inflows, is  $(0.8)(0.6)(0.3) = 0.144 = 14.4\%$ .

The company has a cost of capital of 11.5%, and management assumes initially that the project is of average risk. The NPV of the top (most favorable) branch as shown in the next-to-last column is \$25,635 (in thousands of dollars):

$$\begin{aligned} \text{NPV} &= -\$500 - \frac{\$1,000}{(1.115)^1} - \frac{\$10,000}{(1.115)^2} + \frac{\$18,000}{(1.115)^3} + \frac{\$18,000}{(1.115)^4} + \frac{\$18,000}{(1.115)^5} \\ &= \$25,635. \end{aligned}$$

The NPVs for other branches were calculated similarly.

The last column in Figure 12-4 gives the product of the NPV for each branch times the joint probability of that branch, and the sum of these products is the project's expected NPV. Based on the expectations set forth in Figure 12-4 and a cost of capital of 11.5%, the project's expected NPV is \$2.758 million.

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 risk.<sup>13</sup>

## SELF-TEST

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

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## 12.10 Introduction to 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 the expected future 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 cause the cash flows to increase. 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, there is nothing he or she can do to influence the outcome. Once the game begins, the outcome depends purely on chance, with no skill involved.

Contrast roulette with other games, such as draw 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 skillful 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**, which are differentiated from financial options because they involve real, rather than financial, assets. The following sections describe several types of projects with **embedded options**.

### Investment Timing Options

Conventional NPV analysis implicitly assumes that projects will either be accepted or rejected, which implies that 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.

For example, suppose Sony plans to introduce an interactive DVD-TV system, and your software company has two alternatives: (1) immediately begin full-scale production of game software on DVDs for the new system or (2) delay investment in the project until you get a better idea of the size of the market for interactive DVDs. You might prefer delaying implementation. Keep in mind, though, that the *option to delay* is valuable only if it more than offsets any harm that might come from delaying. For example, if you delay, some other company might establish a loyal customer base that makes it difficult for your company to enter the market later. The

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<sup>13</sup>In the United Robotics example we glossed over an important issue, namely, 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 were so, we would expect the projects to 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.

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 projects 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 therefore prices are high.

The second type of growth option allows a company to *expand into new geographic markets*. Many companies are investing in Eastern Europe, Russia, and China 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. Toshiba probably lost money on its first laptop computers, but the manufacturing skills and consumer recognition it gained helped turn subsequent generations of laptops into money makers. In addition, Toshiba used its experience and name recognition in laptops as a springboard into the desktop computer market.

## Abandonment Options

Many projects contain an **abandonment option**. When evaluating a potential project, standard DCF analysis assumes that the assets will be used over a specified economic life. While some projects must be operated over their full economic life, even though market conditions might deteriorate and cause lower than expected cash flows, others can be abandoned. For example, some contracts between automobile manufacturers and their suppliers specify the quantity and price of the parts that must be delivered. If a supplier’s labor costs increase, then the supplier might well lose money on each part it ships. Including the option to abandon in such a contract might be quite valuable.

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 that

for sports utility vehicles soared. But BMW was ready, and the Spartanburg plant began spewing out hot-selling SUVs. The plant's cash flows are 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, depending on 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 cost. 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 your project has an embedded real option, you 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 your real option, then you know that its value is relatively high, qualitatively speaking. Third, you might be able to model the real option along the lines of a decision tree. 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.<sup>14</sup> We will discuss real options in more detail in Chapter 13.

### SELF-TEST

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Name some different types of real options.

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## Summary

Throughout the book, we have indicated that the value of any asset depends on the amount, timing, and risk of the cash flows it produces. In this chapter, we developed a framework for analyzing a project's cash flows and 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.
- **Project cash flow** is different from accounting income. Project cash flow reflects (1) **cash outlays for fixed assets**, (2) the **tax shield provided by depreciation**, and (3) cash flows due to **changes in net operating working capital**. Project cash flow does not include interest payments.
- In determining incremental cash flows, **opportunity costs** (the cash flows forgone by using an asset) must be included, but **sunk costs** (cash outlays that

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<sup>14</sup>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 M. Brennan and L. Trigeorgis, *Project Flexibility, Agency, and Competition: New Developments in the Theory and Application of Real Options* (New York: Oxford University Press, 2000).

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.

- **Cannibalization** 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) They reduce operating cash flows, and (2) they determine the depreciation expense that can be taken in each year.
- Capital projects often require additional investments in **net operating working capital (NOWC)**.
- 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**.
- **Inflation effects** must be considered in project analysis. The best procedure is to build expected inflation into the cash flow estimates.
- Since stockholders are generally diversified, **market risk** is theoretically the most relevant measure of risk. Market, or beta, risk is important because beta affects the cost of capital, which, in turn, affects stock prices.
- **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.
- **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, other things held constant.
- **Scenario analysis** is a risk analysis technique in which the best- and worst-case NPVs are compared with the project's expected NPV.
- **Monte Carlo simulation** is a risk analysis technique that uses a computer to simulate future events and thus to estimate the profitability and riskiness of a project.
- 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, which is increased for projects that are riskier than the firm's average project but decreased for less risky projects.
- **Decision tree analysis** shows how different decisions in a project's life affect its value.
- Opportunities to respond to changing circumstances are called **managerial options** because they give managers the option 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 also called **real options** because they involve "real," rather than "financial," assets. Many projects include a variety of **embedded options** that can dramatically affect the true NPV.
- An **investment timing option** involves not only the decision of *whether* to proceed with a project but also the decision of *when* to proceed with it. This opportunity to affect a project's timing can dramatically change its 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 output, (2) options to enter a new geographical market, and (3) options to introduce complementary products or successive generations of products.

- The **abandonment option** is the ability to abandon a project if the operating cash flows and/or abandonment value turn 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.

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## Questions

- (12-1) Define each of the following terms:
- Cash flow; accounting income
  - Incremental cash flow; sunk cost; opportunity cost
  - Net operating working capital changes; salvage value
  - Real rate of return,  $r_r$ , versus nominal rate of return,  $r_{\text{NOM}}$
  - Sensitivity analysis; scenario analysis; Monte Carlo simulation analysis
  - Risk-adjusted discount rate; project cost of capital
  - Real options; managerial options; strategic options; embedded options
  - Investment timing option; growth option; abandonment option; flexibility option
- (12-2) Operating cash flows, rather than accounting profits, are listed in Table 12-1. What is the basis for this emphasis on cash flows as opposed to net income?
- (12-3) Why is it true, in general, that a failure to adjust expected cash flows for expected inflation biases the calculated NPV downward?
- (12-4) Explain why sunk costs should not be included in a capital budgeting analysis, but opportunity costs and externalities should be included.
- (12-5) 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.
- (12-6) Define (a) simulation analysis, (b) scenario analysis, and (c) sensitivity analysis.

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## 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, it would be sold after 3 years for \$20,000, and 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%.
- What is the net cost of the earth mover? (That is, what are the Year 0 cash flows?)
  - 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:

Year	Net After-Tax Cash Flows		
	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, there are only three possible cash flow streams over time: (1) the worst case, (2) the most likely, or base, case, and (3) the best case, with probabilities of 0.2, 0.6, and 0.2, respectively. 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 1–3

**(12-1)**  
 Investment Outlay

Johnson 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%. What is the project's initial investment outlay?

**(12-2)**  
 Operating Cash Flow

Nixon 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 ( $t = 1$ )?

- (12-3)** Net Salvage Value Carter 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?

**Intermediate  
Problems 4–6**

- (12-4)** 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%.
- What is the net cost of the machine for capital budgeting purposes? (That is, what is the Year 0 net cash flow?)
  - What are the net operating cash flows in Years 1, 2, and 3?
  - What is the additional Year 3 cash flow (that is, the after-tax salvage and the return of working capital)?
  - If the project's cost of capital is 12%, should the machine be purchased?

- (12-5)** 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%.
- What is the net cost of the spectrometer? (That is, what is the Year 0 net cash flow?)
  - What are the net operating cash flows in Years 1, 2, and 3?
  - What is the additional (nonoperating) cash flow in Year 3?
  - If the project's cost of capital is 10%, should the spectrometer be purchased?

- (12-6)** 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 (all variable) 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.
- 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.)
  - If total costs consisted of a fixed cost of \$10,000 per year and variable costs of \$95 per unit, and if only the variable costs were expected to increase with

inflation, would this make the project better or worse? Continue with the assumption that the sales price will rise with inflation.

### Challenging Problems 7–10

#### (12-7) Scenario Analysis

Shao Industries is considering a proposed project for its capital budget. The company estimates that 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 that 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?

#### (12-8) 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.

- What is the expected value of the annual net cash flows from each project? What is the coefficient of variation (CV)? (Hint:  $\sigma_B = \$5,798$  and  $CV_B = 0.76$ .)
- What is the risk-adjusted NPV of each project?
- If it were known that Project B was negatively correlated with other cash flows of the firm, whereas Project A was positively correlated, how would this knowledge 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?

#### (12-9) 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	Value	Random Numbers
Developmental costs	0.3	\$2,000,000	00–29
	0.4	4,000,000	30–69
	0.3	6,000,000	70–99
Project life	0.2	3 years	00–19
	0.6	8 years	20–79
	0.2	13 years	80–99
Sales in units	0.2	100	00–19
	0.6	200	20–79
	0.2	300	80–99
Sales price	0.1	\$13,000	00–09
	0.8	13,500	10–89
	0.1	14,000	90–99
Cost per unit (excluding developmental costs)	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 reflect primarily the uncertainty about each project's NPV and IRR as measured by the coefficients of variation of NPV and IRR. SSC is in the 40% federal-plus-state income tax bracket.

- 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 you develop is equal to annual cash flows. All facilities are leased, so depreciation may be disregarded. Can you determine the value of  $\sigma_{IRR}$  short of actual simulation or a fairly complex statistical analysis?
- Assume that SSC uses a 15% cost of capital for this project. What is the project's NPV? Could you estimate  $\sigma_{NPV}$  without either simulation or a complex statistical analysis?
- 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 that the cash flows for each year are independent of cash flows for other years. Also, assume that 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.

(12-10)  
Sequential Decisions

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 that 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 that 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 \$1,000,000 at  $t = 2$ . If the economy is strong at this point, the net value of sales would be \$3,000,000, while if the economy is weak, the net value would be \$1,500,000. 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%.

- Assume that this project has average risk. Construct a decision tree and determine the project’s expected NPV.
- Find the project’s standard deviation of NPV and coefficient of variation (CV) 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?

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## Spreadsheet Problem

(12-11)  
Build a Model: Issues in  
Capital Budgeting



Start with the partial model in the file *FM12 Ch 12 P11 Build a Model.xls* from 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 to buy the equipment necessary to manufacture the server, and it would require net operating working capital equal to 10% of sales. The servers would sell for \$24,000 per unit, and Webmasters believes that variable costs would amount to \$17,500 per unit. After the first year the sales price and variable costs will increase at the inflation rate of 3%. The company’s non-variable costs would be \$1 million at Year 1 and would increase with inflation. It would take 1 year to buy the required equipment and set up operations, and 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 a coefficient of variation of NPV between 0.8 and 1.2. Low-risk projects are evaluated with a WACC of 8%, and high-risk projects at 13%.

- Develop a spreadsheet model and use it to find the project’s NPV, IRR, and payback.
- 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.
- 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.
  - If the project appears to be more or less risky than an average project, find its risk-adjusted NPV, IRR, and payback.
  - On the basis of information in the problem, would you recommend that the project be accepted?



## Cyberproblem

Please go to the textbook's Web site to access any Cyberproblems.

### 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 operating 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%.

- Define "incremental cash flow."
  - Should you subtract interest expense or dividends when calculating project cash flow?
  - Suppose the firm had spent \$100,000 last year to rehabilitate the production line site. Should this be included in the analysis? Explain.
  - Now assume that 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?
  - 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 operating working capital for each year and the cash flow due to investments in net operating 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, and 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 that each of these variables can vary from its base-case, or expected, value by  $\pm 10\%$ ,  $20\%$ , 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 of 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 that 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, 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 that 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?
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## Selected Additional Cases

*The following cases from Textchoice, Thomson 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)."