CHAPTER 13

Risk Analysis and Project Evaluation

Chapter Outline

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13.2 Tools for Analyzing the Risk of Project Cash Flows (pgs. 443–453)

Objective 2. Use sensitivity, scenario, and simulation analyses to investigate the determinants of project cash flows.

13.3 Break-Even Analysis (pgs. 454–464)

Objective 3. Use break-even analysis to evaluate project risk.

13.4 Real Options in Capital Budgeting (pgs. 464–466)

Objective 4. Describe the types of real options.

How does a firm estimate the potential worst-case scenarios from taking on an investment project? What other what-if scenarios should the analyst consider? These are the types of questions that we address in this chapter. The focus of the chapter is on evaluating risk, which is central to **P** Principle 2: **There Is a Risk-Return Tradeoff**. From a practical viewpoint, we cannot hope to know how much reward to look for if we do not understand the nature of the risks we assume. In this chapter, we explore techniques that we can implement to understand the risk inherent in project cash flows, which, according to **P** Principle 3: **Cash Flows Are the Source of Value**, are the source of value. Finally, the timing of future cash flows is another source of project risk, and because money has a time value—**P** Principle 1: **Money Has a Time Value**—we need to incorporate this factor into our analysis of project risk.

Risk Analysis of a Condo Investment

We introduced Chapter 11 by describing the opportunity to invest in a condo. Let's return to that investment opportunity for a moment to consider the role that risk can have in carrying out a project analysis. Recall that your landlord offered to sell you a condo for $90,000. You estimate that after spending $2,000 to paint and fix up the condo, you can sell it for $100,000.

In this example, the only certain cash flow is the purchase price of $90,000. The $2,000 worth of painting and fix-up expenses as well as the eventual selling price are what we expect, but these numbers are just estimates that may turn out to be either too high or too low. For example, in the process of having the place painted, you may discover structural damage to the ceiling from a water leak that was not discovered at the time of the sale inspection. More important, the $100,000 estimated selling price is far from a sure thing. It may take several months to get an offer, and then it may be for substantially less than the $100,000 asking price. The key learning point here is that the future is uncertain, and analyst evaluations of project cash flows must consider this to make sound investment decisions.

Regardless of Your

"Project Risk for Entrepreneurs"

Some day you may want to start your own business. But starting a new business is a very risky investment. About 40 percent of new businesses shut their doors during their first year, and only about one in five makes it longer than five years. In part, this is because, as a group, entrepreneurs tend to be very optimistic and to put too little emphasis on evaluating the risks of their new ventures.

However, a budding entrepreneur can avoid this mistake by drawing on the principles of finance. As we see in this chapter, there are several ways to predict and analyze possible outcomes for a new project under consideration. Assessing risk is so important to the entrepreneur that there is even a whole field dedicated to it: specialists called decision analysts study decision making under conditions of uncertainty by modeling the possible outcomes. Management departments in business schools and operations research departments in engineering schools often include classes on decision analysis.

Clearly, both marketing and economics also play a crucial role in the evaluation of a new business venture because the entrepreneur will need to forecast sales under a variety of scenarios that describe possible future states of the economy. In addition, knowledge of cost accounting and operations is important for risk analysis because the entrepreneur will need to evaluate the cost of production under various circumstances.

Your Turn: See Study Question 13–1.

13.1 The Importance of Risk Analysis

In the previous chapter, we calculated the expected cash flows for a potential investment project, and we then used the investment criteria we studied in Chapter 11 to perform a net present value (NPV) analysis of those cash flows to determine whether the investment would add value to the firm. We also assumed that the cash flows for different projects all had the same level of risk for the firm. However, different projects have different levels of risk, and, as a result, financial managers need to evaluate the risk of a proposed investment project.

There are two fundamental reasons to perform a project risk analysis before making the final accept/reject decision:

1. **Project cash flows are risky.** We base our estimation of project NPV on estimates of future cash flows, but the future cash flows that actually occur will almost certainly not be equal to our estimates. Therefore, it is very helpful to explore the nature of the risks the project entails so that we can be better prepared to manage the project if it is accepted.

2. **Forecasts are made by humans who can be either too optimistic or too pessimistic when making their cash flow forecasts.** The fact that the analyst may not be totally objective about the analysis injects a source of bias into the investment decision-making process. An overly optimistic bias can result in the acceptance of investments that fail to produce the optimistic forecasts, whereas a pessimistic bias can lead to the firm passing up worthwhile projects. Both types of bias are costly to the firm's shareholders, and a careful risk analysis of projects can minimize these biases.

Before you move on to 13.2

Concept Check | 13.1

1. What are the reasons for performing a project risk analysis?
2. How does the optimism or pessimism of the manager doing a cash flow forecast influence the cash flow estimates?

13.2 Tools for Analyzing the Risk of Project Cash Flows

The actual cash flows an investment produces will almost never exactly equal the expected cash flows used to estimate the investment's NPV. There are many possible cash flow outcomes for any risky project, and simply specifying a single expected cash flow can provide a misleading characterization of the investment. Although it is generally impossible to specify all possible outcomes, an analyst can use some basic tools to examine the uncertain nature of future cash flows and, consequently, the reliability of the NPV estimate.

The first tool we will consider is *sensitivity analysis*, which helps the analyst identify the most important forces that ultimately determine the success or failure of an investment. The second tool we will consider is *scenario analysis*, which allows the analyst to consider alternative scenarios in which a number of possible value drivers differ. Finally, we consider the use of *simulation*, which allows the analyst to consider very large numbers of possible scenarios.

Key Concepts: Expected Values and Value Drivers

Before we launch into an investigation of the tools of risk analysis, we need to define two key concepts: expected values and value drivers. We will use both concepts throughout our discussion.

Expected Values

The cash flows used in the calculation of a project's NPV are actually the **expected values** of the investment's risky cash flows. The expected value of a future cash flow is simply a probability-weighted average of all the possible cash flows that might occur. For example, if there are only two possible cash flows, $0 and $100, and the probability of each is 50 percent, then the expected cash flow is (.5 × $0) + (.5 × $100) = $50. Because it is generally not possible to specify all the possible cash flows that might occur and their associated probabilities, it is customary to forecast cash flows for specific states of the economy—recession, normal, and expansion.

To illustrate how a firm might approach the problem of estimating the expected cash flows from an investment, consider the following hypothetical problem faced by one of the country's largest homebuilders. The firm is attempting to forecast the cash flows for a new subdivision in Kern County, California. Its management might make the following estimates: If the home-building slump continues, cash flow will be –$2 million; if a recovery begins during the year, cash flow will climb to $1 million; and if the turnaround in the economy is so dramatic that growth rates equal the high rates experienced before the recession began, cash flow will reach $6 million.

To complete this analysis of the expected cash flows, management must also estimate the probability attached to each potential state of Kern County's home-building economy. Estimates of these probabilities, like the estimates of cash flows for the three states of the economy, are based on managerial judgment and are highly subjective. Suppose the home-builder's management estimates that there is a .50 probability of a continued housing slump that will result in the recession cash flow, a .40 probability of the beginning of a turnaround, and only a .10 probability of a return to the dramatic growth rate experienced before the onset of the recession. Given these estimates, the expected cash flow for 2017 is

$$\text{Expected Cash Flow for 2017} = (-\$2 \text{ million} \times .50) + (\$1 \text{ million} \times .40) + (\$6 \text{ million} \times .10)$$
$$= \$0$$

In this example, the homebuilder estimates that in 2017 it will get a zero cash flow out of the Kern County development. In actuality, there are many possible cash flow outcomes, but we estimate the expected outcome in this example to be zero. In the pages that follow, we will learn how to use three types of tools for digging deeper into the determinants of each expected cash flow outcome, and in the process, we will learn more about the value of the investment.

Checkpoint 13.1

Forecasting Revenues Using Expected Values

Marshall Custom Homes is a Texas homebuilder that specializes in the construction of high-end homes costing $1.5 million to $10 million. To estimate its revenues for 2017, it divided its home sales into three categories based on selling price (high, medium, and low) and estimated the number of units it expects to sell under these three different economic scenarios for 2017. These scenarios include a decline into a recession (Scenario I), a continuation of the modest growth that characterizes current conditions in the economy (Scenario II), and, finally, a period of rapid expansion (Scenario III). What are Marshall's expected revenues for 2017?

STEP 1: Picture the problem

The following table lays out the number of units the firm's managers estimate they will sell in each of the three home categories for each of the three possible states of the economy:

	Scenario I: Recession	Scenario II: Current Conditions	Scenario III: Rapid Expansion
Probability	20%	60%	20%
High-Priced Home Category			
Unit sales	0	5	10
Average price per unit	$ 8,000,000	$ 8,000,000	$ 8,000,000
Total revenues	$ 0	$ 40,000,000	$ 80,000,000
Medium-Priced Home Category			
Unit sales	5	15	30
Average price per unit	$ 4,000,000	$ 4,000,000	$ 4,000,000
Total revenues	$20,000,000	$ 60,000,000	$120,000,000
Low-Priced Home Category			
Unit sales	10	20	60
Average price per unit	$ 2,000,000	$ 2,000,000	$ 2,000,000
Total revenues	$20,000,000	$ 40,000,000	$120,000,000
Total revenues for each scenario	$40,000,000	$140,000,000	$320,000,000

STEP 2: Decide on a solution strategy

The expected or forecast revenues for Marshall Custom Homes are a probability-weighted average of the revenues the firm projects it will generate from building and selling homes in each of the three price categories. Solving for the expected total revenues for the company in 2017 therefore entails following a three-step procedure:

STEP 2A: Estimate the probability of each state of the economy.

STEP 2B: Calculate the total revenues from each category of homes for each of the three states of the economy.

STEP 2C: Calculate a probability-weighted average of total revenues that is equal to the expected revenues for the firm in 2017.

STEP 3: Solve

The expected total revenues for Marshall Custom Homes in 2017 are thus estimated to be $156 million by multiplying the total revenues estimated for each scenario by the probability estimated for each scenario and then adding the results:

	Scenario I: Recession	Scenario II: Current Conditions	Scenario III: Rapid Expansion	
Probability	20%	60%	20%	**Step 1**
Total revenues for each scenario	$40,000,000	$140,000,000	$320,000,000	**Step 2**
Probability × Total revenues	$ 8,000,000	$ 84,000,000	$ 64,000,000	
		Expected Revenues = $156,000,000		**Step 3**

Value Drivers

Financial managers sometimes refer to the basic determinants of an investment's cash flows—and, consequently, its performance—as **value drivers**. For example, a key value driver for a manufacturing firm would be its inventory turnover because high inventory turnover ratios indicate the efficient use of the firm's investment in inventories.

Identification of an investment's value drivers is crucial to the success of an investment project because it allows the financial manager to

- Allocate more time and money toward refining forecasts of these key variables.
- Monitor the key value drivers throughout the life of the project, so corrective action can be taken in the event that the project does not function as planned.

Value drivers for investment cash flows consist of the fundamental determinants of project revenues (e.g., market size, market share, and unit price) and costs (e.g., variable costs and cash fixed costs, which exclude depreciation expense).

Sensitivity Analysis

When conducting a **sensitivity analysis**, a financial manager evaluates the effect of each value driver on the investment's NPV. To illustrate the use of sensitivity analysis as a tool of risk analysis, consider the investment opportunity faced by Longhorn Enterprises, Inc., which has the opportunity to manufacture and sell a novelty third brake light for automobiles. The light, which is mounted in the rear window of an automobile to replace the factory-installed third brake light can be shaped into the logos of university mascots or other preferred symbols. Producing the light requires an initial investment of $500,000 in manufacturing equipment, which depreciates over a five-year time period toward a $50,000 salvage value, plus an investment of $20,000 in net operating working capital (the increase in receivables and inventory less the increase in accounts payable). The discount rate used to analyze the project cash flows is 10 percent. This rate, as we will discuss in Chapter 14 when we discuss the cost of capital, is the opportunity cost of investing in the proposed investment and should reflect the risk of the investment. We can summarize other pertinent information for the investment opportunity as follows:

Initial cost of equipment	$(500,000)
Project and equipment life	5 years
Salvage value of equipment	$ 50,000
Working-capital requirement	$ 20,000
Depreciation method	Straight line
Depreciation expense	$ (90,000)
Discount	10%
Tax rate	30%

Longhorn's management estimates that it can sell 15,000 units per year for the next five years and expects to sell them for $200 each. Longhorn's management team has identified four key value drivers for the project: unit sales, price per unit, variable cost per unit, and cash fixed cost (that is, fixed cost other than depreciation) per year. The expected values for the value drivers, along with corresponding estimates for the best- and worst-case scenarios, are summarized as follows:

	Expected or Base Case	Worst Case	Best Case
Unit sales	15,000	12,500	18,000
Price per unit	$ 200	$ 190	$ 220
Variable cost per unit	$ (150)	$ (160)	$ (130)
Cash fixed cost per year	$(285,000)	$(285,000)	$(285,000)
Depreciation expense	$ (90,000)	$ (90,000)	$ (90,000)

Using the expected or base-case value for each of the value drivers, we calculate the investment cash flows for the expected or base case as follows:

> Calculating net operating profit after taxes (NOPAT).
> Note: This calculation looks a lot like an income statement. But there is a subtle difference. We do not deduct interest expense when calculating the income tax liability.

> Recapture of working capital in Year 5.
> Note: Because this is a recovery of the original investment in working capital, there is no profit; thus, no taxes are owed on the $20,000.

> Recovery of salvage value in Year 5.
> Note: Because the book value of the machinery and equipment is equal to the salvage value, there is no taxable gain or loss from the $50,000 salvage value received in Year 5.

	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5
Revenues (15,000 units × $200)		$ 3,000,000	$ 3,000,000	$ 3,000,000	$ 3,000,000	$ 3,000,000
Less: Variable cost ($150 per unit)		(2,250,000)	(2,250,000)	(2,250,000)	(2,250,000)	(2,250,000)
Less: Depreciation expense		$ (90,000)	$ (90,000)	$ (90,000)	$ (90,000)	$ (90,000)
Less: Cash fixed cost		(285,000)	(285,000)	(285,000)	(285,000)	(285,000)
Net operating income (NOI)		375,000	375,000	375,000	375,000	375,000
Less: Taxes (tax rate = 30%)		(112,500)	(112,500)	(112,500)	(112,500)	(112,500)
Net operating profit after tax (NOPAT)		$ 262,500	$ 262,500	$ 262,500	$ 262,500	$ 262,500
Plus: Depreciation expense		90,000	90,000	90,000	90,000	90,000
Less: Increase in capital expenditures (CAPEX)	$ (500,000)	—	—	—	—	50,000
Less: Increase in working capital	(20,000)	—	—	—	—	20,000
Free cash flow	$ (520,000)	$ 352,500	$ 352,500	$ 352,500	$ 352,500	$ 422,500

Note that the total initial cash outlay for Year 0 is –$520,000, which includes both the cost of acquiring machinery and equipment and the initial investment in net operating working capital required to get the business up and running.

Unit sales and price per unit are forecast to be the same for Years 1 through 5, so revenues are equal to 15,000 units × $200 per unit = $3,000,000 per year. Multiplying the variable cost per unit of $150 by 15,000 units produces a total annual variable cost of $2,250,000. The firm has depreciation expense of $90,000 plus cash fixed costs (such as salaries and utilities, which are cash expenses) of $285,000 per year. Net operating income is estimated to be $375,000 per year, and taxes are 30 percent of this total ($112,500), so the net operating profit after tax (NOPAT) is $375,000(1 − .30) = $262,500 per year. Adding back depreciation (which is not a cash expense) of $90,000 produces a free cash flow estimate for Years 1 through 4 equal to $352,500. In Year 5, the company receives the salvage value of $50,000 for the equipment (note that because this amount equals the book value of the equipment in that year, there are no taxable gains from the sale) plus the return of the $20,000 investment in working capital to produce a free cash flow of $422,500.

We calculate the expected NPV using the expected or base-case cash flows, which are the expected future cash flows, as $859,717 as follows:

$$NPV = -\$520,000 + \frac{\$352,500}{(1 + .10)^1} + \frac{352,500}{(1 + .10)^2} + \frac{352,500}{(1 + .10)^3} + \frac{352,500}{(1 + .10)^4} + \frac{\$422,500}{(1 + .10)^5}$$

$$= -\$520,000 + \$1,379,717 = \$859,717$$

Therefore, the investment looks like a good one. Note that when we calculate the NPV for a project, we do so using expected future cash flows; hence, the NPV we estimate is the *expected* NPV. In this case, the project has an *expected* NPV greater than zero, indicating that, based on the expected (base-case) forecasts of the project's value drivers, the company expects to create value by undertaking the project.

Although this analysis is based on the expected values of the key value drivers, the actual realizations of these value drivers are likely to turn out to be very different than the original estimates. For some value drivers, these inevitable deviations from expectations may not be crucial to the project's success, but for others, the deviations can be quite important. Managers would like to know which value drivers are the most critical to project success since this knowledge allows them to focus their attention on the most important ones, both when they are preparing forecasts and when they are monitoring the success of the project.

To evaluate the importance of the different value drivers the analyst can perform a sensitivity analysis by changing one variable at a time to determine its impact on the overall project NPV. For example, consider the effect of a 10 percent decrease in unit sales on the project's NPV. In this case, unit sales would drop to 13,500, and the resulting NPV (holding everything else constant) would drop to $660,700. This is a drop of 23 percent in NPV caused by a 10 percent drop in unit sales. Next, consider a 10 percent increase in variable cost per unit ($165), which results in an NPV of $262,668, or a drop of 69 percent. Finally, consider a 10 percent increase in annual cash fixed cost from ($285,000) to ($313,500). The resulting NPV is $784,091, which is only 9 percent less than the base-case NPV.

Value Driver	Expected NPV	Revised NPV	% Change in NPV
Unit sales (−10%)	$859,717	$660,700	−23%
Variable cost per unit (+10%)	$859,717	$262,668	−69%
Cash fixed cost per year (+10%)	$859,717	$784,091	−9%

Clearly, the most critical value driver we have considered here is variable cost per unit, which implies that having a very good grasp on per unit costs is critical to the project's success. This knowledge might lead the analyst to open discussions with the engineering staff that provided the variable cost estimates to learn more about the accuracy of their estimates. Longhorn's management might ask its engineers how confident they are in their worst-case scenario estimate of $160 per unit for the variable cost and what, if anything, the company could do if the variable cost is higher than anticipated. Answers to such questions might lead to a more in-depth analysis of the determinants of the variable cost per unit and a better understanding of the possible success or failure of the investment.

Checkpoint 13.2

Project Risk Analysis: Sensitivity Analysis

Crainium, Inc., is considering an investment in a new plasma cutter that it will use to cut out steel silhouettes. The firm plans to cut the silhouettes into two-dimensional shapes such as the outline of a state, a university mascot, or a logo and sell them through the firm's catalog sales operations. Crainium's management estimates that these products can be sold for an average price of $25 per unit, and the company analysts expect that the firm can sell 200,000 units per year at this price for a period of five years. Launching this service will require an initial outlay of $1.5 million to purchase the plasma cutter and a materials-handling system that has a residual or salvage value in five years of $250,000. In addition, the firm expects to have to invest an additional $500,000 in working capital to support the new business. Other pertinent information concerning the business venture is as follows:

Initial cost of equipment	$ (1,500,000)
Project and equipment life	5 years
Salvage value of equipment	$250,000
Working-capital requirement	$500,000
Depreciation method	Straight line
Depreciation expense	$(250,000) per year
Variable cost per unit	$(20)
Cash fixed cost per year	$(400,000)
Discount rate	12%
Tax rate	30%

Crainium's analysts have estimated the project's expected or base-case cash flows, NPV, and internal rate of return (IRR) to be the following:

	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5
Revenues		$ 5,000,000	$ 5,000,000	$ 5,000,000	$ 5,000,000	$ 5,000,000
Less: Variable cost		(4,000,000)	(4,000,000)	(4,000,000)	(4,000,000)	(4,000,000)
Less: Depreciation expense		$ (250,000)	$ (250,000)	$ (250,000)	$ (250,000)	$ (250,000)
Less: Cash fixed cost		(400,000)	(400,000)	(400,000)	(400,000)	(400,000)
Net operating income (NOI)		350,000	350,000	350,000	350,000	350,000
Less: Taxes (tax rate = 30%)		(105,000)	(105,000)	(105,000)	(105,000)	(105,000)
Net operating profit after tax (NOPAT)		$ 45,000	$ 245,000	$ 245,000	$ 245,000	$ 245,000
Plus: Depreciation expense		250,000	250,000	250,000	250,000	250,000
Less: Increase in capital expenditures (CAPEX)	$(1,500,000)	—	—	—	—	250,000
Less: Increase in working capital	(500,000)	—	—	—	—	500,000
Free cash flow	$(2,000,000)	$ 495,000	$ 495,000	$ 495,000	$ 495,000	$ 1,245,000
NPV	$ 209,934					
IRR	15.59%					

Although the project is expected to have a $209,934 NPV and a 15.59 percent IRR (which exceeds the project's 12 percent discount rate), it is risky, so the firm's analysts want to explore the importance of uncertainty in the project cash flows. Perform a sensitivity analysis on this proposed investment.

STEP 1: Picture the problem

To evaluate the sensitivity of the project's NPV and IRR to uncertainty surrounding the project's value drivers, we analyze the effects of changes in the value drivers (unit sales, price per unit, variable cost per unit, and cash fixed cost per year [which, as noted, does not include depreciation]). Specifically, we consider each of the following changes:

Value Driver	Change in Driver
Unit sales	−10%
Price per unit	−10%
Variable cost per unit	+10%
Cash fixed cost per year	+10%

STEP 2: Decide on a solution strategy

The objective of this analysis is to explore the effects of the prescribed changes in the value drivers on the project's NPV. In this instance, we calculate the project's NPV using estimates of each of the value drivers that

deviate 10 percent from their expected or base-case values. The deviations we consider are each in an adverse direction (i.e., they lead to a reduction in the NPV). The resulting NPVs are then compared to the base-case NPV (calculated using the expected values for all the value drivers) in order to determine which value driver has the greatest influence on NPV.

STEP 3: Solve

Recalculating the project NPV by changing each value driver by 10 percent, we get the following results:

Value Driver	% Change in Driver	Expected NPV	Revised NPV	% Change in NPV
Unit sales	−10%	$ 209,934	$ (42,400)	−120%
Price per unit	−10%	$ 209,934	$(1,051,737)	−601%
Variable cost per unit	+10%	$ 209,934	$ (799,402)	−481%
Cash fixed cost per year	+10%	$ 209,934	$ 109,001	−48%

STEP 4: Analyze

The first thing we observe is that a 10 percent adverse change in the estimated values of the first three value drivers results in a negative NPV for the project and that a 10 percent increase in cash fixed cost per year reduces the NPV by almost half. Moreover, the most critical value driver is price per unit, followed closely by variable cost per unit.

   The results of this analysis suggest two courses of action. First, Crainium's managers should make sure that they are as comfortable as possible with their price-per-unit forecast as well as their estimate of the variable cost per unit. This might entail using additional market research to explore the pricing issue and a careful cost-accounting study of unit production costs. Second, should the project be implemented, it is imperative that the managers monitor these two critical value drivers (price per unit and variable cost per unit) very closely so that they can react quickly, should an adverse change in either variable occur.

STEP 5: Check yourself

Crainium's management has determined that it will be possible to reduce the variable cost per unit to $18 per unit by purchasing an additional option for the equipment that will raise its initial cost to $1.8 million (the residual or salvage value for this configuration is estimated to be $300,000). All other information remains the same as before. For this new machinery configuration, analyze the sensitivity of the project NPV.

   ANSWER: NPV = $1,001,714 and IRR = 26.65 percent.

Your Turn: For more practice, do related **Study Problem** 13–7 at the end of this chapter.   **>> END** Checkpoint 13.2

Scenario Analysis

Our sensitivity analysis of Longhorn Enterprises, Inc., involved changing only one value driver at a time and analyzing its effect on the investment NPV. This is very useful when attempting to determine the most critical value drivers, but it ignores the fact that some of the value drivers are correlated, that is, they tend to move together. For example, when unit sales are less than expected, unit selling prices are likely to be less than expected. Therefore, analyzing the effect of lower than expected sales units may be misleading if sales price and unit sales move together.

   To consider the effects of changes in multiple value drivers, analysts conduct **scenario analysis**, which allows the financial manager to consider the effects of simultaneous changes in the estimates of many value drivers on the investment opportunity's NPV. Each scenario consists of a different set of estimates for the project value drivers. In one possible scenario, all the value drivers are equal to Longhorn management's worst-case estimates presented earlier. To evaluate this possibility, we analyze the project cash flows and NPV as follows:

	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5
Revenues (12,500 units × $190 each)		$2,375,000	$2,375,000	$2,375,000	$2,375,000	$2,375,000
Less: Variable cost ($160 per unit)		(2,000,000)	(2,000,000)	(2,000,000)	(2,000,000)	(2,000,000)
Less: Depreciation expense		(90,000)	(90,000)	(90,000)	(90,000)	(90,000)
Less: Cash fixed cost		(285,000)	(285,000)	(285,000)	(285,000)	(285,000)
Net operating income (NOI)		$ —	$ —	$ —	$ —	$ —
Less: Taxes (tax rate = 30%)		—	—	—	—	—
Net operating profit after tax (NOPAT)		$ —	$ —	$ —	$ —	$ —
Plus: Depreciation expense		90,000	90,000	90,000	90,000	90,000
Less: Increase in capital expenditures (CAPEX)	$(500,000)	—	—	—	—	50,000
Less: Increase in working capital	(20,000)	—	—	—	—	20,000
Free cash flow	$(520,000)	$ 90,000	$ 90,000	$ 90,000	$ 90,000	$ 160,000
NPV	$(135,365)					
IRR	0.00%					

Because the worst-case scenario has a much lower estimate of revenues due to the lower selling price and number of units sold, the resulting cash flow estimates are much lower. Indeed, when we analyze the investment's NPV, we get a worst-case estimate of –$135,365, which means that in this case the project reduces shareholder wealth. But what is the likelihood that this worst-case scenario will occur? We will leave this question unanswered for the moment but will return to it shortly when we discuss the use of simulation analysis.

What about the best-case scenario? If this rosy outcome were to occur, then the following cash flows would result:

	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5
Revenues (18,000 units × $220)		$ 3,960,000	$ 3,960,000	$ 3,960,000	$ 3,960,000	$ 3,960,000
Less: Variable cost ($130 per unit)		(2,340,000)	(2,340,000)	(2,340,000)	(2,340,000)	(2,340,000)
Less: Depreciation expense		$ (90,000)	(90,000)	(90,000)	(90,000)	(90,000)
Less: Cash fixed cost		(285,000)	(285,000)	(285,000)	(285,000)	(285,000)
Net operating income (NOI)		$ 1,245,000	$ 1,245,000	$ 1,245,000	$ 1,245,000	$ 1,245,000
Less: Taxes (tax rate = 30%)		(373,500)	(373,500)	(373,500)	(373,500)	(373,500)
Net operating profit after tax (NOPAT)		$ 871,500	$ 871,500	$ 871,500	$ 871,500	$ 871,500
Plus: Depreciation expense		90,000	90,000	90,000	90,000	90,000
Less: Increase in capital expenditures (CAPEX)	$ (500,000)	—	—	—	—	50,000.00
Less: Increase in working capital	(20,000)	—	—	—	—	20,000.00
Free cash flow	$ (520,000)	$ 961,500	$ 961,500	$ 961,500	$ 961,500	$ 1,031,500
NPV	$ 3,168,306					
IRR	184.04%					

In this case, the NPV of the project is a whopping $3,168,306, and the IRR is 184.04 percent!

Combining our analyses of the expected or base-case, worst-case, and best-case scenarios results in a wide range of possible NPVs for the project:

Scenario	NOPAT	Free Cash Flow (Years 1–4)	NPV
Expected or Base Case	$262,500	$352,500	$ 859,717
Worst Case	$ 0	$ 90,000	$(135,365)
Best Case	$871,500	$961,500	$3,168,306

In fact, we expect the investment is going to create value for Longhorn with an expected NPV equal to $859,717. However, this estimate reflects Longhorn's base-case estimates of the key value drivers (unit sales, unit price, variable cost per unit, and cash fixed cost per year). When we evaluate what Longhorn's management feels are the worst- and best-case estimates of these value drivers, we discover a wide range of possible NPVs, depending on what actually happens. What we do not know is the likelihood or probability that the worst-case or best-case scenario will occur. Moreover, we do not know the probability that the project will lose money (i.e., have a negative NPV). Simulation offers a useful tool for risk analysis that provides us not only with estimates of the NPV for many scenarios but also with probabilities for those scenarios.[1]

Checkpoint 13.3

Project Risk Analysis: Scenario Analysis

The analysts performing the risk analysis on the plasma cutter described in Checkpoint 13.2 now want to evaluate the project risk using scenario analysis. Specifically, they want to examine the project's risk using scenario analysis aimed at evaluating the project's NPV under the worst- and best-case scenarios for the project's value drivers.

STEP 1: Picture the problem

The values for the expected or base-case, worst-case, and best-case scenarios are as follows:

	Expected or Base Case	Worst Case	Best Case
Unit sales	200,000	150,000	250,000
Price per unit	$ 25	$ 23	$ 28
Variable cost per unit	$ (20)	$ (21)	$ (18)
Cash fixed cost per year	$(400,000)	$(450,000)	$(350,000)
Depreciation expense	$(250,000)	$(250,000)	$(250,000)

STEP 2: Decide on a solution strategy

The objective of scenario analysis is to explore the sensitivity of the project's NPV to different scenarios. The scenarios differ in terms of the estimated values for each of the project's value drivers. In this instance, we have two scenarios corresponding to the worst- and best-case outcomes for the project.

STEP 3: Solve

Recalculating the project NPV for both sets of value drivers results in the following estimates:

Scenario	NOPAT	Free Cash Flow (Years 1–4)	NPV
Expected or Base Case	$ 245,000	$ 495,000	$209,934
Worst Case	$ (280,000)	$ (30,000)	$(1,682,573)
Best Case	$1,330,000	$1,580,000	$ 4,121,117

STEP 4: Analyze

Examination of the worst- and best-case scenarios for the project indicates that although the project is expected to produce an NPV of $209,934, the NPV might be as high as $4,121,117 or as low as –$1,682,573. Clearly, this is a risky investment opportunity. Had the worst-case scenario produced an NPV close to zero, then

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[1] The number of scenarios in a simulation is equal to the number of iterations of the simulation. This can be tens, if not hundreds or thousands, as each of the iterations represents a different scenario with a probability equal to 1 divided by the total number of iterations.

Crainium's management could have been much more confident that the project would be a good one. If the very low NPV of the worst-case scenario is particularly troublesome to the firm's managers, they might consider an alternative course of action that reduces the likelihood of this worst-case result.

STEP 5: Check yourself

A recent economic downturn caused Crainium's management to reconsider the base-case scenario for the project by lowering the unit sales estimate to 175,000 at a revised price per unit of $24.50. Based on these revised projections, is the project still viable? What if Cranium followed a higher price strategy of $35 per unit but only sold 100,000 units? What would you recommend that Cranium do?

ANSWER: NPV = ($326,276) and NPV = $1,471,606.

Your Turn: For more practice, do related **Study Problems** 13–4, 13–6, and 13–7 at the end of this chapter.   **>> END** Checkpoint 13.3

Simulation Analysis

Scenario analysis provides the analyst with a discrete number of project NPV estimates for a limited number of cases or scenarios. **Simulation analysis**, on the other hand, provides the analyst with a very powerful tool for generating thousands of NPV estimates that are built on thousands of values for each of the investment's value drivers. These different values arise out of each value driver's individual probability distribution. This may sound confusing if you have not heard the term *probability distribution* in a while, so here is a simple example. Let's say that the unit selling price for Longhorn's third-brake-light can be either $180 or $220, with equal probabilities of 50 percent. The expected price then is (.50 × $180) + (.50 × $220) = $200. The probability distribution for unit price in this instance is fully described by the two possible values for price and their corresponding probabilities.[2]
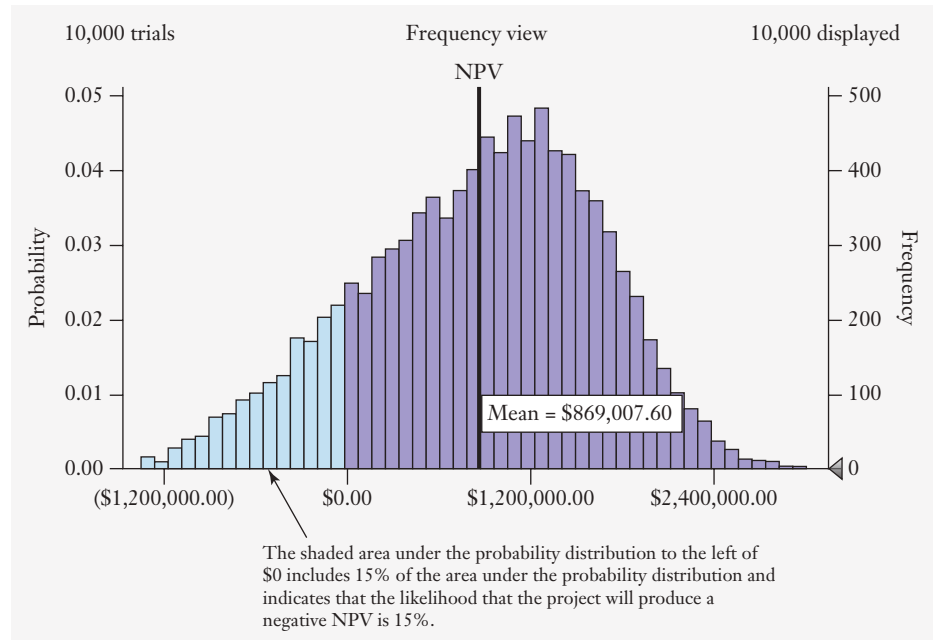
Let's consider how Longhorn might use simulation analysis to evaluate the NPV of its proposed brake-light project. We can summarize the simulation process using a five-step process:

Step 1. Select appropriate probability distributions for each of the investment's key value drivers (i.e., the variables or factors that determine the project's cash flows). In the Longhorn example, the value drivers are the factors that determine project revenues, which include the number of units that are sold and the price per unit they command as well as the factors underlying the cost of manufacturing and selling the brake lights (variable and fixed costs).

Step 2. Randomly select one value for each of the value drivers from its respective probability distribution.

Step 3. Combine the values selected for each of the value drivers to estimate project cash flows for each year of the project's life, and calculate the project's NPV.

Step 4. Store or save the calculated value of the NPV, and repeat steps 2 and 3. Simulations are easily carried out using readily available computer software that allows one to repeat steps 2 and 3 thousands of times.

Step 5. Use the stored values of the project NPV to construct a histogram or probability distribution of the NPV.

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[2] The distribution of unit price in this example is discrete because price can take on only one of two discrete values. If the price could be anything between $180 and $220, then the distribution would be continuous. The bell-shaped normal distribution, for example, is an example of a continuous probability distribution.

Figure 13.1

Probability Distribution of NPVs for Longhorn's Brake-Light Project

The final output of the simulation is a probability distribution of the project's NPVs. Having set up and run the simulation experiment, the analyst not only knows the expected NPV but also can make probability statements about the likelihood of achieving particular NPV values. For example, in the results that follow, the probability of achieving a positive NPV is 85 percent.

The shaded area under the probability distribution to the left of $0 includes 15% of the area under the probability distribution and indicates that the likelihood that the project will produce a negative NPV is 15%.

>> END FIGURE 13.1

Once we have finished running the simulation, it is time to sit down and interpret the results. Note that in step 5 we summarize the final set of simulation results in a probability distribution of possible NPVs like the one found in Figure 13.1. So we can now analyze the distribution of *possible* NPVs to determine the probability of a negative NPV. In Figure 13.1, we see that the probability of achieving an NPV greater than zero is 85 percent, indicating a 15 percent probability that the project will produce an NPV that is less than zero. What a simulation does is allow us to analyze all sources of uncertainty simultaneously and get some idea as to what might happen before we actually commit to the investment.

Before you move on to 13.3

Concept Check | **13.2**

1. What are value drivers, and how are they important in the analysis of project risk?

2. What is sensitivity analysis, and how does an analyst use this tool to evaluate the risk of project cash flows?

3. Describe scenario analysis, and contrast it with sensitivity analysis.

4. Describe the five-step process used to carry out simulation analysis. How is simulation analysis similar to scenario analysis?

Finance in a **Flat World**

Currency Risk

When multinational firms do their risk analyses, a very important variable that they consider is uncertainty about currency exchange rates. For example, in 2010 Boeing began deliveries of its 787 Dreamliner aircraft, which competes directly with models made by

European manufacturer Airbus. Boeing produces these planes in the United States, paying workers and suppliers in U.S. dollars. Airbus, on the other hand, has costs that are more closely tied to the euro. What this means is that when the dollar is very strong relative to the euro, Airbus has a competitive advantage over Boeing. However, when the euro is strong relative to the dollar, Boeing has a competitive advantage over Airbus. The exchange rate between the euro and the U.S. dollar can fluctuate dramatically, and as a result, it plays a particularly important role in the sensitivity and scenario analyses of Boeing investment projects. For example, at the beginning of December 2009, it took $1.51 to buy one euro, and by the end of February 2010, it took only $1.35, about an 11 percent drop in only three months. The dollar, relative to the euro, continued to strengthen over the following 5 years, making Boeing's Dreamliner more expensive for those buying it with euros and making Airbus models less expensive for those buying them with U.S. dollars.

Your Turn: See Study Question 13–4.

13.3 **Break-Even Analysis**

Although the tools of risk analysis discussed in the previous section provide us with an understanding of the different possible outcomes, it is also useful for a firm to know the least-favorable scenarios in which the project still breaks even. Because the increase in sales that can be generated by an investment is one of the most critical value drivers, managers typically do a **break-even analysis** to determine the minimum level of output or sales that the firm must achieve in order to avoid losing money—that is, to break even. In most cases, we define the break-even sales estimate as the level of sales at which net operating income (NOI) equals zero.

To illustrate break-even analysis, we refer back to the Longhorn Enterprises example introduced in the previous section. The worst-case scenario results are repeated below for the novelty-brake-light investment proposal:

	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5
Revenues (12,500 units × $190 each)		$ 2,375,000	$ 2,375,000	$ 2,375,000	$ 2,375,000	$ 2,375,000
Less: Variable cost ($160 per unit)		(2,000,000)	(2,000,000)	(2,000,000)	(2,000,000)	(2,000,000)
Less: Depreciation expense		(90,000)	(90,000)	(90,000)	(90,000)	(90,000)
Less: Cash fixed cost		(285,000)	(285,000)	(285,000)	(285,000)	(285,000)
Net operating income (NOI)		$ —	$ —	$ —	$ —	$ —
Less: Taxes (tax rate = 30%)		—	—	—	—	—
Net operating profit after tax (NOPAT)		$ —	$ —	$ —	$ —	$ —
Plus: Depreciation expense		90,000	90,000	90,000	90,000	90,000
Less: Increase in capital expenditures (CAPEX)	$ (500,000)	—	—	—	—	50,000
Less: Increase in working capital	(20,000)	—	—	—	—	20,000
Free cash flow	$ (520,000)	$ 90,000	$ 90,000	$ 90,000	$ 90,000	$ 160,000

Notice that NOI is equal to zero for a sales level of $2,375,000, which corresponds to the sale of 12,500 units at a price of $190 per unit, with variable cost per unit equal to $160. Let's now consider how we could calculate the break-even level of sales.

Accounting Break-Even Analysis

Accounting break-even analysis involves determining the level of sales necessary to cover total fixed costs—that is, both cash fixed costs (or fixed operating costs before depreciation) and depreciation. We use the term *accounting break-even* to refer to the fact that we are using accounting costs, which include non–cash flow items—specifically, depreciation.

Performing an accounting break-even analysis requires that we decompose production costs into two components: fixed costs and variable costs. This decomposition depends on whether the costs being analyzed vary with firm sales (variable costs) or not (fixed costs).

Fixed Costs

Fixed costs do not vary directly with sales revenues but instead remain constant despite any change to the business; they can be divided into fixed operating costs before depreciation and depreciation itself. Examples of fixed operating costs before depreciation include administrative salaries, insurance premiums, intermittent advertising program costs, property taxes, and rent. Because fixed costs do not vary directly with sales revenues, accountants often refer to them as **indirect costs**. As the number of units sold increases, the fixed cost *per unit* of product decreases because the fixed costs are spread over larger and larger quantities of output.

Variable Costs

Variable costs are those costs that vary with firm sales. In fact, variable costs are sometimes referred to as **direct costs** because they vary *directly* with sales. Although it is a simplification, it is customary to assume that the per unit variable cost of sales is constant. For example, in Longhorn Enterprises' worst-case scenario, the variable cost per unit is $160. Consequently, when 10,000 units are sold, the total variable costs for the project are $1,600,000, and when units sold double to 20,000 units, the total variable costs also double to $3,200,000. For a manufacturing operation, some examples of variable costs include sales commissions paid to the sales personnel, hourly wages paid to the manufacturing personnel, the cost of materials used, energy costs (fuel, electricity, natural gas), freight costs, and packaging costs. Thus, it is important to remember that total variable costs depend on the quantity of product sold. Notice that if Longhorn makes zero units of the product, it incurs zero variable costs.

Figure 13.2 depicts Longhorn Enterprises' fixed, variable, and total costs of producing novelty brake lights for output levels ranging from 0 to 20,000 units. Panel A illustrates the behavior of fixed and variable costs as the number of units produced and sold increases. For example, at 20,000 units produced and sold, Longhorn will incur fixed costs of $375,000 plus $3,200,000 ($160 per unit × 20,000 units) of variable costs, for a total cost of $3,575,000.

Total Revenues or Volume of Output

The last element used in accounting break-even analysis is total revenues. Total revenues are equal to the unit selling price multiplied by the number of units sold or volume of output. Panel B of Figure 13.2 contains a graphical depiction of the total revenues for Longhorn Enterprises' investment opportunity. Total revenues are equal to the product of the selling price of $190 per unit and the number of units produced and sold.

Calculating the Accounting Break-Even Point

The accounting break-even point is the level of sales or output that is necessary to cover both variable and total fixed costs, where total fixed costs equal cash fixed costs plus depreciation, so NOI is equal to zero:

$$\text{Net Operating Income } (NOI) = \text{Total Revenues} - \text{Total Costs} = 0$$

or

$$\text{Net Operating Income } (NOI) = \text{Total Revenues} - \left(\text{Total Variable Costs} + \text{Total Fixed Costs} \right) = 0 \quad \textbf{(13–1)}$$

Figure 13.2

Accounting Break-Even Analysis

Longhorn Enterprises, Inc., is evaluating the accounting break-even level of sales units for its novelty-brake-light investment opportunity. The firm is using its worst-case scenario estimates of selling price ($190 per unit) and variable cost ($160 per unit) and also its fixed cost estimate of $375,000 in its analysis. Variable costs include all the costs incurred in the manufacturing process that vary with the number of units produced. Fixed costs do not vary with the number of units produced.

(Panel A)   Fixed and Variable Costs
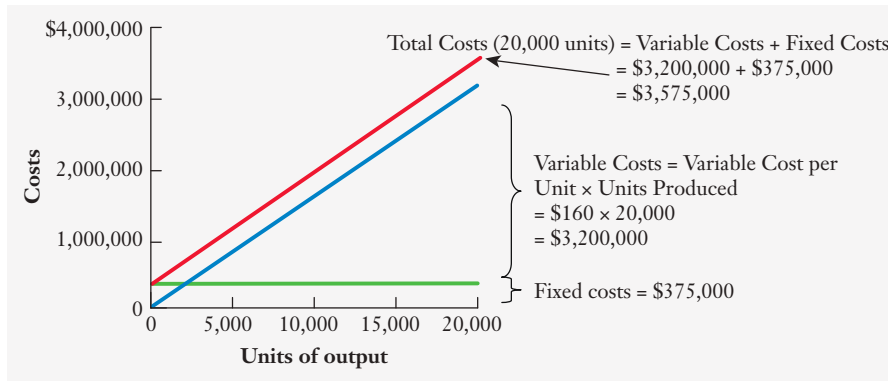
(Panel B)   Accounting Break-Even Point
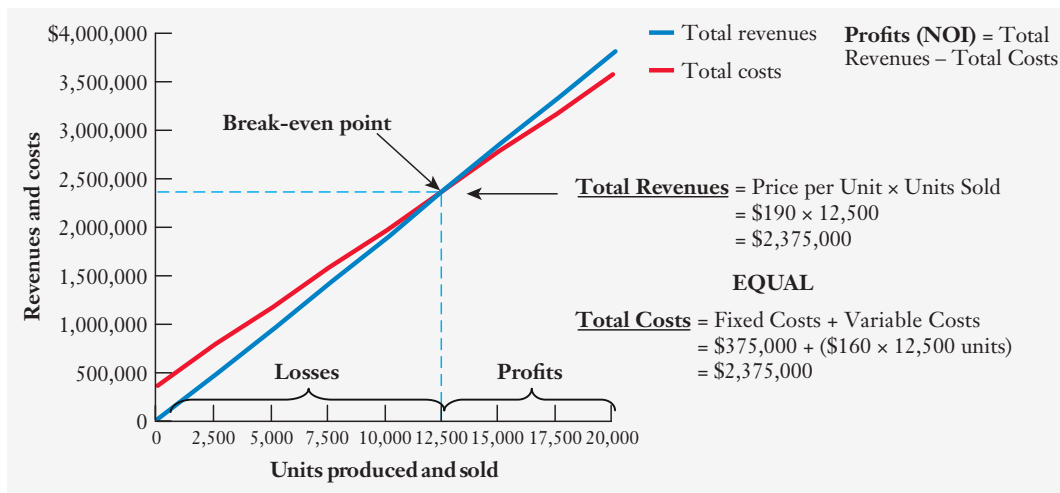
In Panel B of Figure 13.2, NOI is equal to zero—and, consequently, Longhorn Enterprises experiences accounting break-even—when the firm produces and sells 12,500 units.

We do not have to graph total costs and revenues to determine the break-even point. In fact, we can solve for the break-even number of units mathematically. To do this, we need to define the determinants of each of the terms in Equation (13–1). The firm's total dollar revenues or sales are equal to the price per unit (P) multiplied by the number of units sold (Q), and its total costs are equal to the total fixed costs (F) added to the product of the number of units sold (Q) and the variable cost per unit (V):

$$\underset{\text{Total Revenues}}{\underbrace{\text{Net Operating}\atop\text{Income }(NOI)}} = \underset{\text{Total Revenues}}{\underbrace{\left(\begin{array}{c}\text{Price per}\\\text{Unit }(P)\end{array} \times \begin{array}{c}\text{Units}\\\text{Sold }(Q)\end{array}\right)}} - \underset{\text{Total Costs}}{\underbrace{\left[\left(\begin{array}{c}\text{Variable Cost}\\\text{per Unit }(V)\end{array} \times \begin{array}{c}\text{Units}\\\text{Sold }(Q)\end{array}\right) + \begin{array}{c}\text{Total Fixed}\\\text{Cost }(F)\end{array}\right]}} = 0 \quad \textbf{(13-1a)}$$

We can find the accounting break-even level of units produced and sold ($Q_{\text{Accounting break-even}}$) by solving Equation (13–1a) for the value of Q that satisfies the requirement that NOI equals zero:

$$Q_{\text{Accounting break-even}} = \frac{\text{Total Fixed Costs } (F)}{\substack{\text{Price per} \\ \text{Unit } (P)} - \substack{\text{Variable Cost} \\ \text{per Unit } (V)}} = \frac{\text{Total Fixed Costs } (F)}{\substack{\text{Contribution Margin} \\ \text{per Unit}}} \quad \textbf{(13–2)}$$

We call the denominator in Equation (13–2) the **contribution margin**, which is the difference between the selling price per unit (P) and the variable cost per unit (V). That is, $P - V$ represents the dollar amount from each unit sold that goes toward covering total fixed costs and then, once fixed costs are covered, goes toward profits. Returning to our Longhorn break-even example, we substitute total fixed costs of $375,000 and a contribution margin of $30 ($190 – $160) into Equation (13–2) to calculate the firm's break-even point of 12,500 units:

$$Q_{\text{Accounting break-even}} = \frac{\text{Total Fixed Costs } (F)}{\substack{\text{Price per} \\ \text{Unit } (P)} - \substack{\text{Variable Cost} \\ \text{per Unit } (V)}} = \frac{375{,}000}{\$190 - \$160} = 12{,}500 \text{ units}$$

Checkpoint 13.4

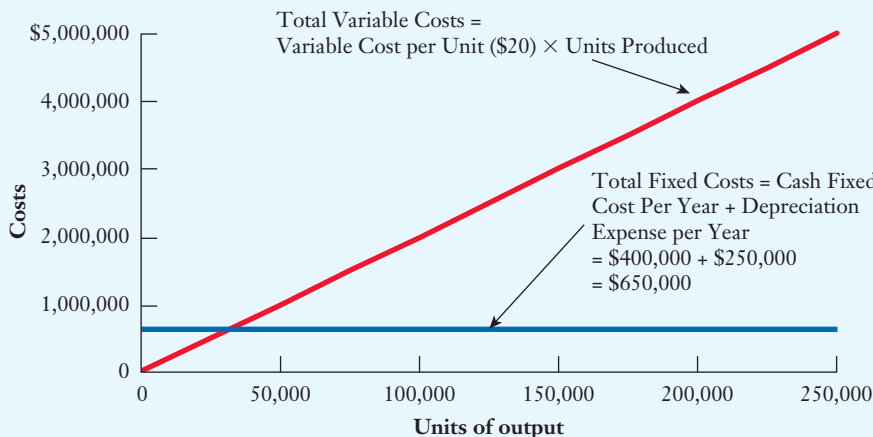## Project Risk Analysis: Accounting Break-Even Analysis

The new plasma cutter that Crainium, Inc., is considering investing in, as described in Checkpoint 13.2, has the following value driver estimates of fixed and variable costs:

	Expected or Base Case
Unit sales	200,000
Price per unit	$ 25
Variable cost per unit	$ (20)
Cash fixed cost per year	$(400,000)
Depreciation expense	$(250,000)

Company analysts are evaluating the project's risks and want to estimate the accounting break-even for the project's annual revenues and expenses. What is the break-even level of units?

STEP 1: Picture the problem

The annual cost structure for the proposed investment is comprised of total fixed costs and variable costs, which are different for each possible level of output:

Total Variable Costs = Variable Cost per Unit ($20) × Units Produced

Total Fixed Costs = Cash Fixed Cost Per Year + Depreciation Expense per Year = $400,000 + $250,000 = $650,000

STEP 2: Decide on a solution strategy

To find the accounting break-even quantity of units produced and sold, we solve for NOI of zero:

$$(P \times Q) - [(V \times Q) + F] = NOI = 0 \qquad \text{(13–1a)}$$

or we solve for the accounting break-even quantity, $Q_{\text{Accounting break-even}}$:
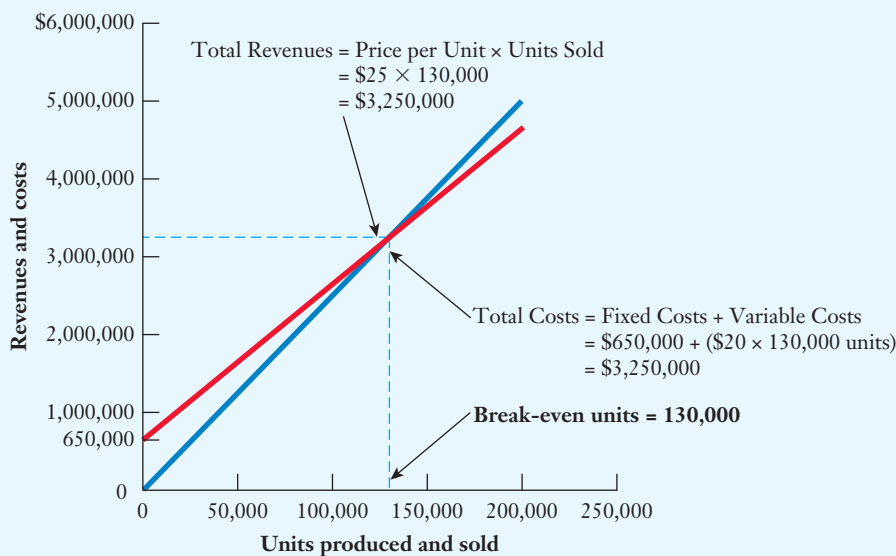
$$Q_{\text{Accounting break-even}} = \frac{F}{P - V} \qquad \text{(13–2)}$$

STEP 3: Solve

Using Equation (13–2), we can solve for the accounting break-even quantity as follows:

$$Q_{\text{Accounting break-even}} = \frac{F}{P - V} = \frac{\$650,000}{\$25 - \$20} = 130,000 \text{ units}$$

Graphically, we can locate the accounting break-even output level as follows:

STEP 4: Analyze

Break-even analysis provides us with an understanding of what level of sales we need to break even in an accounting sense—that is, what level of sales we need in order to cover our total fixed and variable costs, resulting in NOI equaling zero. Often managers are concerned with whether a project contributes to a firm's accounting earnings; accounting break-even analysis tells us if it does. A project that does not break even reduces the firm's earnings, whereas a project that breaks even will add to a firm's earnings. Still, we must keep in mind that just breaking even does not mean that shareholders will benefit. In fact, projects that merely break even in an accounting sense have negative NPVs and result in a loss of shareholder value. That is because we do include opportunity costs. In effect, the money spent on a project that merely breaks even simply covers the project's costs, but it does not provide investors with their required rate of return. In effect, it ignores the opportunity cost of money. Still, break-even analysis provides managers with excellent insights into what might happen if the projected level of sales is not reached.

STEP 5: Check yourself

Crainium, Inc.'s analysts have estimated the accounting break-even for the project to be 130,000 units and now want to consider how the values for the worst-case scenario affect the accounting break-even. Specifically, consider a unit price of $23, a variable cost per unit of $21, and total fixed costs of $700,000.

ANSWER: $Q_{\text{Accounting break-even}}$ = 350,000 units.

Your Turn: For more practice, do related **Study Problems** 13–8, 13–9, and 13–10 at the end of this chapter.   >> END Checkpoint 13.4

Cash Break-Even Analysis

In addition to calculating the accounting break-even point, it is common to calculate the cash break-even point. This certainly makes sense when we think back to ▶ Principle 3: **Cash Flows Are the Source of Value**. The accounting break-even point tells us the level of sales necessary to cover our variable and total fixed costs, where total fixed costs include both cash fixed costs and depreciation expense (which is not a cash expense for the period). The **cash break-even point** tells us the level of sales where we have covered our cash fixed costs (ignoring depreciation) and, as a result, our cash flow is zero. To calculate the cash break-even point, we consider only those fixed costs that entail a cash payment by the firm (specifically, we exclude depreciation expense):

$$Q_{\text{Cash break-even}} = \frac{\text{Fixed Operating Costs Other Than Depreciation per Year}}{\begin{array}{cc}\text{Price per} & \text{Variable Cost} \\ \text{Unit } (P) & \text{per Unit } (V)\end{array}}$$

$$= \frac{\text{Total Fixed Costs } (F) - \text{Depreciation}}{\begin{array}{c}\text{Contribution Margin} \\ \text{per Unit}\end{array}} \tag{13–2a}$$

Going back to the Longhorn example, recall that the company had cash fixed costs of $285,000 and depreciation expense of $90,000, for total fixed costs of $375,000. In calculating the cash break-even point, we are interested only in the cash fixed expenses (or fixed costs other than depreciation) of $285,000. Longhorn's price per unit is $190, and its variable cost per unit is $160, so the cash break-even point can be calculated as

$$Q_{\text{Cash break-even}} = \frac{\text{Fixed Operating Expenses Other Than Depreciation per Year}}{\begin{array}{cc}\text{Price per} & \text{Variable Cost} \\ \text{Unit } (P) & \text{per Unit } (V)\end{array}}$$

$$= \frac{\$375,000 - \$90,000}{\$190 - \$160} = 9,500 \text{ units}$$

NPV Break-Even Analysis

NPV break-even analysis identifies the level of sales necessary to produce an NPV of zero. It differs from accounting break-even analysis in that NPV break-even focuses on cash flows, not accounting profits, and also accounts for ▶ Principle 1: **Money Has a Time Value**. Let's return to the worst-case scenario for Longhorn Enterprises' novelty-brake-light investment to see just how NPV break-even differs from accounting break-even. The worst-case cash flows are presented below, along with the estimated NPV and IRR for this scenario:

	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5
Revenues (12,500 units × $190 each)		$ 2,375,000	$ 2,375,000	$ 2,375,000	$ 2,375,000	$ 2,375,000
Less: Variable cost ($160 per unit)		(2,000,000)	(2,000,000)	(2,000,000)	(2,000,000)	(2,000,000)
Less: Depreciation expense		(90,000)	(90,000)	(90,000)	(90,000)	(90,000)
Less: Cash fixed costs per year		(285,000)	(285,000)	(285,000)	(285,000)	(285,000)
Net operating income (NOI)		$ —	$ —	$ —	$ —	$ —
Less: Taxes (tax rate = 30%)		—				
Net operating profit after tax (NOPAT)		$ —	$ —	$ —	$ —	$ —
Plus: Depreciation expense		90,000	90,000	90,000	90,000	90,000
Less: Increase in capital expenditures (CAPEX)	$(500,000)					50,000
Less: Increase in working capital	(20,000)					20,000
Free cash flow	$(520,000)	$ 90,000	$ 90,000	$ 90,000	$ 90,000	$ 160,000
NPV	$(135,365)					
IRR	0.00%					

Note that NOI is zero, so this is the accounting break-even sales level. However, the annual free cash flows are equal to the depreciation expense except for Year 5, when they also include the salvage value of the equipment plus the return of working capital. When we calculate the NPV for these cash flows, we find that it is negative and the IRR is equal to zero. The zero IRR indicates that if we discounted the future cash flows of the project using a 0 percent rate (that is, simply adding up the cash flows of $90,000 for Years 1 through 4 plus $160,000 in Year 5), we would get our money back. However, if we require a rate of return greater than zero, the project does not produce enough cash flow to break even. This difference in results between break-even analysis and the NPV should not come as much of a surprise; after all, break-even analysis does not look at cash flows and ignores the time value of money. Moreover, accounting break-even analysis looks only at one period, trying to determine the level of sales that will produce zero NOI.

Solving for the NPV break-even is a bit more complicated than solving for the accounting break-even, and it is very helpful to have a spreadsheet model to do the calculations. However, you can also do it using trial and error by simply inserting different output levels until the calculated NPV equals zero. In this example, the sale of 14,200 units leads to a zero NPV, as the following set of cash flows shows:

	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5
Revenues (14,200 units × $190 each)		$ 2,698,000	$ 2,698,000	$ 2,698,000	$ 2,698,000	$ 2,698,000
Less: Variable cost ($160 per unit)		(2,272,000)	(2,272,000)	(2,272,000)	(2,272,000)	(2,272,000)
Less: Depreciation expense		(90,000)	(90,000)	(90,000)	(90,000)	(90,000)
Less: Cash fixed costs per year		(285,000)	(285,000)	(285,000)	(285,000)	(285,000)
Net operating income (NOI)		$ 51,000	$ 51,000	$ 51,000	$ 51,000	$ 51,000
Less: Taxes (tax rate = 30%)		(15,300)	(15,300)	(15,300)	(15,300)	(15,300)
Net operating profit after tax (NOPAT)		$ 35,700	$ 35,700	$ 35,700	$ 35,700	$ 35,700
Plus: Depreciation expense		90,000	90,000	90,000	90,000	90,000
Less: Increase in capital expenditures (CAPEX)	$(500,000)	—	—	—	—	50,000
Less: Increase in working capital	(20,000)	—	—	—	—	20,000
Free cash flow	$(520,000)	$ 125,700	$ 125,700	$ 125,700	$ 125,700	$ 195,700
NPV	$ 0					
IRR	10.00%					

Figure 13.3 contains NPV calculations for 7,500 to 17,500 units. These calculations lie along a straight line that crosses the horizontal axis where NPV = 0—that is, at the break-even NPV of 14,200 units. This is much easier, of course, if you let the spreadsheet do the recalculations of NPV. However, we leave this analysis to subsequent finance classes because it is beyond the scope of this book.[3]

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[3] For those who would like to do this analysis, you will find the Goal Seek function in Excel very helpful. Also, note that because units produced must be a whole number, we have a break-even of 14,200. The solution we find using Goal Seek is 14,200.42 units.

Figure 13.3

NPV Break-Even

Longhorn Enterprises is considering an investment that involves producing novelty brake lights for automobiles. The analysis of NPV break-even presented here corresponds to the assumptions underlying the worst-case scenario for the investment:

	Worst-Case Scenario
Price per unit	$190
Variable cost per unit	$(160)
Cash fixed costs per year	$ (285,000)
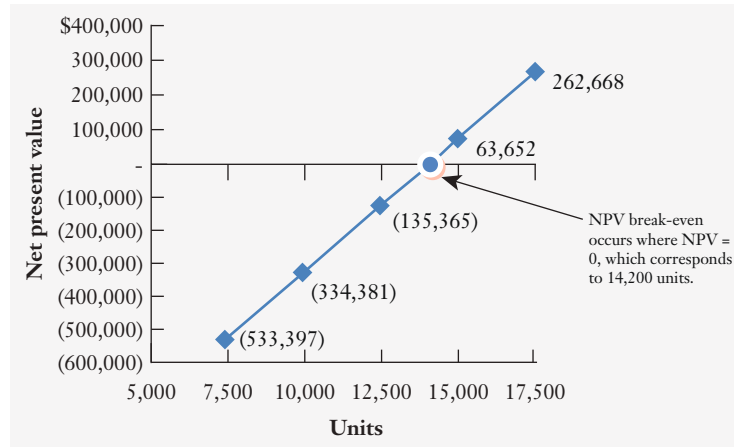
>> END FIGURE 13.3

Tools of Financial Analysis—Break-Even Concepts

Name of Tool	Formula	What It Tells You
Accounting break-even ($Q_{\text{Accounting break-even}}$)	$Q_{\text{Accounting break-even}} = \dfrac{\text{Total Fixed Costs }(F)}{\text{Price per Unit }(P) - \text{Variable Cost per Unit }(V)} = \dfrac{\text{Total Fixed Costs }(F)}{\text{Contribution Margin per Unit}}$	• Measures the number of units a firm must sell in order to cover all its fixed and variable costs. • Note that total fixed costs include both out-of-pocket expenses for the period and depreciation expense.
Cash break-even ($Q_{\text{Cash break-even}}$)	$Q_{\text{Cash break-even}} = \dfrac{\text{Fixed Operating Expenses Other than Depreciation per Year}}{\text{Price per Unit}(P) - \text{Variable Cost per Unit}(V)}$	• Measures the number of units a firm must sell in order to cover all its cash fixed costs and variable costs. • The difference in the accounting and cash break-even points is driven by the inclusion of depreciation expense (which is a noncash expense) in the former but not the latter.
Net Present Value Break-Even	The number of units produced and sold that produces an NPV of 0	• Measures the number of units the firm must sell annually in order to cover the present value of all its expenses (fixed and variable) over the life of an investment.

Operating Leverage and the Volatility of Project Cash Flows

In Equation (13–2), we learned that a project's accounting break-even point is determined by its total fixed costs and the difference between the price per unit and the variable costs per unit. In general, this mixture of fixed and variable operating costs is determined by the nature of the business. For example, companies that manufacture semiconductors will have very high fixed costs associated with the expense of building and maintaining large factories that can cost billions of dollars to build. On the other hand, law firms have relatively modest fixed costs (office rent, administrative salaries, and utilities) but high variable costs (in particular, the bonuses it pays its attorneys), which are driven by the firm's attorneys' billable hours, which, in turn, drive the firm's revenues.

Most businesses have some flexibility in their cost structure and can substitute fixed costs for variable costs to some degree. For example, Longhorn Enterprises may pay its sales personnel for the brake-light project with salaries, which are a fixed cost (i.e., salaries are not dependent on the level of sales), or alternatively, Longhorn's management might pay its sales personnel on a pure commission basis, in which would be a variable cost that is tied directly to sales.

The mix of fixed and variable operating costs not only affects the break-even output but also determines something called operating leverage. **Operating leverage**, which tends to be higher for firms with more fixed costs, measures the sensitivity of changes in operating income to changes in sales. For example, if Longhorn's sales were to increase by 20 percent, the project's operating costs would not increase proportionately because some of them are fixed. As a result, NOI rises by more than 20 percent. If the firm's fixed costs are higher, its operating leverage is higher, which means that the sensitivity of the firm's operating income to changes in sales is higher. We can measure the firm's operating leverage for a particular level of sales using the **degree of operating leverage (DOL)**; when there is a percentage change in sales, the DOL tells us how that is reflected in a percentage change in NOI, as follows:

$$DOL = \frac{\% \text{ Change in Net Operating Income } (NOI)}{\% \text{ Change in Sales}} \qquad \textbf{(13–3)}$$

Thus, if the DOL is 4.0 and there is a 10 percent change in sales, NOI will increase by 40 percent (4.0 × 10%).

To illustrate how this works, consider the Longhorn example found in Table 13.1. The firm's base-case sales are $3,000,000, and its fixed costs are $375,000. To keep things simple, let's also assume that Longhorn's variable costs remain constant at $150 per unit. If Longhorn's sales increase 20 percent, up to $3,600,000, we calculate that the firm's NOI (or earnings before interest and taxes [EBIT]) will rise by 40 percent, from $375,000 to $525,000. Note that in the last column of Table 13.1 we calculate the percentage change in both sales and NOI. Therefore, the DOL for Longhorn can be calculated using Equation (13–3) to equal 2.0 (40% ÷ 20%). The reason that NOI rose by 40 percent while sales rose by only 20 percent is that some of Longhorn's costs are fixed and, consequently, do not increase with sales. If Longhorn had no operating leverage (that is, if all of its operating costs were variable), then the 20 percent increase in sales would have led to a 20 percent increase in NOI and a DOL equal to 1. Note also that if Longhorn experiences a 20 percent decline in revenues, it will experience a 40 percent decline in NOI, as the numbers in Table 13.2 illustrate. Clearly, a higher operating leverage means greater volatility in operating profit or NOI.

Table 13.1   **How Operating Leverage Affects NOI for a 20% Increase in Longhorn's Sales**

	Base Sales Level for Year t	Forecast Sales Level for Year $t+1$	Percentage Change in Sales and NOI
Unit sales	15,000	18,000	
Sales	$3,000,000	$3,600,000	**+20%** = $3.6 million/$3.0 million − 1
Less: Total variable costs	2,250,000	2,700,000	
Revenue before fixed costs	$ 750,000	$ 900,000	
Less: Total fixed costs	375,000	375,000	
NOI (or EBIT)	$ 375,000	$ 525,000	**+40%** = $525,000/$375,000 − 1

Table 13.2 How Operating Leverage Affects NOI for a 20% Decrease in Longhorn's Sales

	Base Sales Level for Year t	Forecast Sales Level for Year t+1	Percentage Change in Sales and NOI
Unit sales	15,000	12,000	
Sales	$3,000,000	$2,400,000	+20% = $2.4 million/$3.0 million − 1
Less: Total variable costs	2,250,000	1,800,000	
Revenue before fixed costs	$ 750,000	$ 600,000	
Less: Total fixed costs	375,000	375,000	
NOI or (EBIT)	$ 375,000	$ 225,000	+40% = $225,000/$375,000 − 1

Calculating the DOL using Equation (13–3) requires that we compute NOI for two sales levels. However, there is a simpler way to do this calculation using Equation (13–4) as follows:

$$DOL_{Sales = \$3,000,000} = 1 + \frac{Fixed\ Costs}{NOI_{Sales = \$3,000,000}} = 1 + \frac{\$375,000}{\$375,000} = 1 + 1 = 2 \quad \textbf{(13–4)}$$

Interestingly, a firm's DOL not only is a function of its mix of fixed and variable costs but also depends on the level of firm sales in relation to its break-even sales level. Recall that the break-even sales level is where NOI equals zero. Thus, looking at Equation (13–4), we can see that because NOI is in the denominator, as NOI approaches 0, $\frac{Fixed\ Costs}{NOI_{Sales}}$ becomes very large. As a result, the DOL is most negative for sales levels just below the accounting break-even level and most positive for sales just above the break-even level. That only makes sense because the DOL measures the *percentage change* in NOI that results from a percentage change in sales, and when NOI is near zero, a small dollar change in Sales will result in a large percentage change in NOI. Thus, when firms are operating near their break-even level of sales, we would expect that small changes in sales would have the greatest impact on their NOIs.

We can summarize what we have learned about operating leverage as follows:

- Operating leverage is higher if fixed operating costs are high relative to variable operating costs.
- Higher operating leverage increases the sensitivity of operating income to changes in sales.
- The degree of operating leverage (DOL) is an indication of the firm's use of operating leverage and can be calculated as the ratio of the percentage change in NOI divided by the corresponding percentage change in sales. The DOL is not a constant but decreases as the level of sales increases beyond the break-even point.
- Finally, operating leverage is a double-edged sword; it magnifies both profits and losses, helping in the good times and causing pain in the bad times.

Tools of Financial Analysis—Degree of Operating Leverage

Name of Tool	Formula	What It Tells You
Degree of operating leverage (DOL_Sales)	$DOL_{Sales} = \dfrac{\%\ Change\ in\ Net\ Operating\ Profits\ (NOI)}{\%\ Change\ in\ Sales}$	• Measures the responsiveness of firm operating profits to a change in firm revenues or sales. • The higher the DOL, the greater the volatility of NOI in response to a given change in firm sales. • The DOL changes for different levels of firm revenues, so it is not fixed across all revenues for a firm.

Concept Check | 13.3

1. Explain the concepts of fixed and variable costs. Which is an indirect cost, and which is a direct cost?
2. What is accounting break-even analysis?
3. What is NPV break-even analysis, and why does it differ from accounting break-even analysis?
4. What is operating leverage?

13.4 Real Options in Capital Budgeting

The NPV provides the proper tool for evaluating whether a project is expected to add value to the firm. However, it is generally calculated using a static set of expected future cash flows that do not reflect the fact that managers are likely to make changes to the operation of the investment over its life in response to changing circumstances that alter the profitability of the investment. For example, if a project that had an expected life of 10 years generates better-than-expected cash flows, management may extend its life to 20 years, or if its cash flows do not meet expectations, management may decide to scale it back or shut it down prematurely.

Having the flexibility to alter an investment's scale, scope, and timing enhances the value of an investment. All else being equal, we would surely prefer an investment that allows managers substantial flexibility in how the project it is implemented. However, traditional estimates of investment NPVs often ignore the implications of this flexibility, and as a result, the analysis may understate project values.

Opportunities to alter the project's cash flow stream after the project has begun are commonly referred to as **real options**. For example, if you own land that can be developed at your discretion, we would say the ownership of the land includes an option to build. Although there are a number of different categories of real options, the most common sources of flexibility or real options that can add value to an investment opportunity include the following:

1. **Timing Options**—the option to delay a project until estimated future cash flows are more favorable;
2. **Expansion Options**—the option to increase the scale and scope of an investment in response to realized demand; and
3. **Contract, Shutdown, and Abandonment Options**—the options to slow down production, halt production temporarily, or stop production permanently (abandonment).

The Option to Delay the Launch of a Project

Because the economic environment changes over time, analyst estimates of project cash flows change. Let's consider Go-Power Batteries, a company that developed a high-voltage nickel–metal hydride battery that can be used to power hybrid automobiles. It is still relatively expensive to manufacture the nickel–metal hydride battery, and the market for hybrid cars is still relatively small. As a result, the cash flows associated with gearing up to manufacture the batteries are quite uncertain. However, owning the technology to produce these batteries may be quite valuable because it is quite possible that, in the future, the technology may improve and the demand for hybrid automobiles will increase if gasoline prices continue to rise. Hence, having the option to delay manufacturing the hydride battery until a time when the profitability of the venture is more certain is extremely valuable.

Before leaving our discussion of the timing option, let's consider its source. Do all projects have this option? Not at all! In some cases, the opportunity to make an investment is short-lived, and if one firm passes it up, another will take it. In the battery example, the option to delay probably rests on patent protection, which gives the owner the right to develop the new technology over the life of the patent. However, even here there are limits in that a competitor may develop a superior technology that makes the hydride battery obsolete.

The Option to Expand a Project

Just as we saw with the option to delay a project, the estimated cash flows associated with a project can change over time, making it valuable to expand its scale and scope. For example, if the new nickel–metal hydride battery project was launched and gasoline prices rose, the demand for the battery might increase dramatically. If this indeed happens, having the ability to expand the scale of production of the battery is quite valuable. Because this expansion option can have significant value, firms try to design their production facilities in ways that allow them to easily expand capacity in response to realized increases in demand.

The Option to Reduce the Scale and Scope of a Project

The option to reduce the scale and scope of an investment is the mirror image of the option to expand. In the face of worse-than-expected performance, it is very valuable to have the option to slow down production, shut it down temporarily until prospects for the investment improve, or abandon the investment altogether.

To illustrate, let's go back to our example of the new nickel–metal hydride battery used in hybrid automobiles and, this time, examine the option to abandon the project. Assume that after a few years of production, the cost of gasoline falls dramatically, while the cost of producing the batteries remains high. Under these circumstances, the manufacturer may decide first to scale back production and then, ultimately, to abandon the project and sell the technology, including all the patent rights it has developed. If the shutdown or liquidation value of the project is relatively high, then the option to abandon the project adds significantly to the project's value. In contrast, the option to scale back or abandon the project is worth very little if the factory producing the battery has no alternative use, and if the workers require severance pay or other forms of compensation for their job loss.
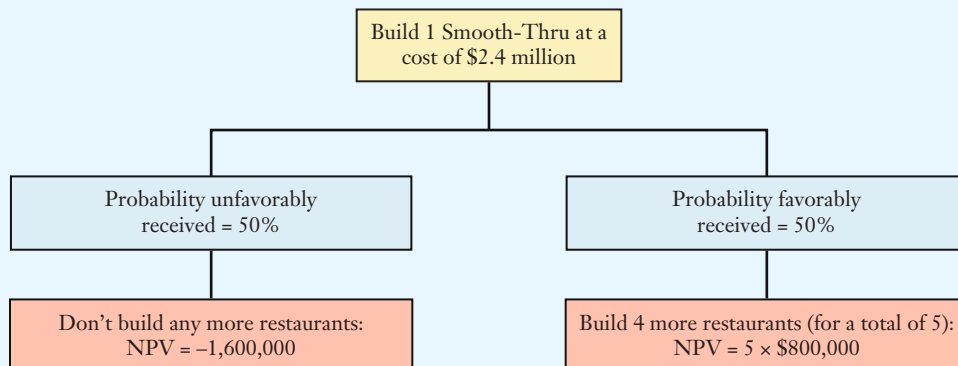

Checkpoint 13.5

Analyzing Real Options: Option to Expand

You are considering introducing a new drive-in restaurant called Smooth-Thru, featuring high-protein and vitamin-laced smoothies along with other organic foods. The initial outlay on this new restaurant is $2.4 million, and the present value of the free cash flows (excluding the initial outlay) is $2 million, so the project has an expected NPV of –$400,000. Looking closer, you find that there is a 50 percent chance that this new restaurant will be well received and will produce annual cash flows of $320,000 forever (a perpetuity) and a 50 percent chance that it will not be well received and will produce annual cash flows of only $80,000 forever (a perpetuity). The required rate of return you use to discount the project cash flows is 10 percent. If the new restaurant is successful, you will be able to build four more of them, and they will have costs and cash flows similar to those of the successful restaurant. If your new restaurant is not received favorably, you will not expand. Calculate the NPV of the initial restaurant taking into account the option to build additional new restaurants if the project is favorably received.

STEP 1: Picture the problem

Graphically, we can think of the situation as follows:

```
          ┌─────────────────────────────┐
          │  Build 1 Smooth-Thru at a   │
          │    cost of $2.4 million      │
          └─────────────────────────────┘
                        │
          ┌─────────────┴─────────────┐
┌──────────────────────────┐  ┌──────────────────────────┐
│  Probability unfavorably  │  │   Probability favorably   │
│     received = 50%        │  │      received = 50%       │
└──────────────────────────┘  └──────────────────────────┘
          │                              │
┌──────────────────────────┐  ┌──────────────────────────────┐
│ Don't build any more      │  │ Build 4 more restaurants     │
│ restaurants:              │  │ (for a total of 5):          │
│ NPV = –1,600,000          │  │ NPV = 5 × $800,000           │
└──────────────────────────┘  └──────────────────────────────┘
```

STEP 2: Decide on a solution strategy

Determine an NPV for this project, assuming you will build five identical Smooth-Thru restaurants if the initial patron reception for the restaurants is very favorable and only one Smooth-Thru restaurant if it is less favorable.

STEP 3: Solve

In this problem, we have an initial outlay of $2,400,000, a discount rate of 10 percent, and a 50 percent chance the new restaurant concept will be favorably received and a 50 percent chance it will be unfavorably received. If it is favorably received, it will produce a perpetuity of $320,000 per year, whereas if it is unfavorably received, it will produce a perpetuity of $80,000 per year. Thus,

NPV if favorably received $= (\$320,000 \div .10) - \$2,400,000 = \$800,000$

NPV if unfavorably received $= (\$80,000 \div .10) - \$2,400,000 = -\$1,600,000$

Assuming that we will open five Smooth-Thru restaurants if it is favorably received and only one if it is unfavorably received and that each of these outcomes has a 50 percent probability, the expected NPV is as follows:

Expected $NPV = (5 \times .50 \times \$800,000) + (1 \times .50 \times -\$1,600,000) = \$1,200,000$

STEP 4: Analyze

Without the option to expand, this project would have an NPV of –$400,000:

$NPV = (\$800,000 \times .50) + (-\$1,600,000 \times .50) = -\$400,000$

However, since the firm exercises the option to expand only when doing so is profitable, the option adds considerably to the NPV of the project. This partially explains why many large restaurant chains introduce new theme restaurants in the hopes that they succeed. If they do, the chain can open additional new restaurants or franchise them.

STEP 5: Check yourself

Suppose there is a 40 percent chance that the project is favorably received and a 60 percent chance that it is unfavorably received, and you have the option to introduce 10 restaurants if it is well received. What is the NPV of the investment?

ANSWER: $2,240,000.

Your Turn: For more practice, do related **Study Problem** 13–15 at the end of this chapter.   **>> END** Checkpoint 13.5

Before you begin end-of-chapter material

Concept Check | 13.4

1. What are real options, and how do they relate to the notion of managerial flexibility?
2. Define *timing options*, and describe how they add value to investments.
3. What is an expansion option?
4. What is an option to contract an investment? When would you expect this type of option to be most valuable?

Applying the Principles of Finance to Chapter 13

P Principle 1: **Money Has a Time Value** Project risk can result in the delay of cash flows, which decreases the present value of those cash flows.

P Principle 2: **There Is a Risk-Return Tradeoff** Different investment projects have different levels of risk associated with them, and these differences must be recognized when evaluating the project. In order to effectively deal with risk, we use sensitivity, scenario, and break-even analyses to evaluate project risk.

P Principle 3: **Cash Flows Are the Source of Value** Project risk can cause cash flows to be smaller than expected, which results in a decrease in the value of the project.

Chapter **Summaries**

13.1 Explain the importance of risk analysis in the capital-budgeting decision-making process. (pg. 442)

SUMMARY: The project's NPV estimate is simply that—an estimate. We perform a project risk analysis of the NPV before making the final accept/reject decision for the following reasons:

- **Project cash flows are risky.** Our NPV calculation is based on estimates of future cash flows, and the future probably will not look like our estimate. It is very helpful to explore the nature of the risks the project entails so that we can be better prepared to manage the project if it is accepted.
- **Forecasts are made by humans, and they can be either too optimistic or too pessimistic.** The fact that the analyst may not be totally objective about the analysis injects a source of bias into the investment decision-making process. Overly optimistic bias can result in the acceptance of investments that fail to produce the optimistic forecasts, and pessimistic bias can result in the firm's passing up worthwhile projects. Both types of bias are costly to the firm's shareholders, and a careful risk analysis of projects is one way to guard against such bias.

Concept Check | **13.1**

1. What are the reasons for performing a project risk analysis?
2. How does the optimism or pessimism of the manager doing a cash flow forecast influence the cash flow estimates?

13.2 Use sensitivity, scenario, and simulation analyses to investigate the determinants of project cash flows. (pgs. 443–453)

SUMMARY: We introduced two approaches to the evaluation of risky project cash flows—sensitivity analysis and scenario analysis. Both methods begin with an identification of the investment's value drivers, which are the key variables that determine project cash flows. For a new product offering, these drivers might include total market size, the estimated share of the market the new product can capture, product price, and unit variable and fixed costs.

With sensitivity analysis, the analyst changes one value driver at a time in an attempt to identify the most critical determinants of investment success or failure. With scenario analysis, the analyst develops alternative sets of estimates for each of the value drivers that correspond to sets of circumstances that the analyst thinks might occur in order to see how the investment might perform in those circumstances.

Simulation analysis provides the analyst with an even more powerful and sophisticated tool for exploring possible investment outcomes. Whereas sensitivity and scenario analyses involve the examination of a limited number of possible outcomes, computer-based simulations can examine hundreds of thousands of possible outcomes. Because this analysis requires repeated recalculation of a project's NPV or IRR, analysts typically use computer software that is now readily available for your personal computer.

Concept Check | **13.2**

1. What are value drivers, and how are they important in the analysis of project risk?
2. What is sensitivity analysis, and how does an analyst use this tool to evaluate the risk of project cash flows?
3. Describe scenario analysis, and contrast it with sensitivity analysis.
4. Describe the five-step process used to carry out simulation analysis. How is simulation analysis similar to scenario analysis?

KEY TERMS

Expected value, page 443 A probability-weighted average of all possible outcomes.

Scenario analysis, page 449 Analysis that allows the financial manager to simultaneously consider the effects of changes in the estimates of multiple value drivers on the investment opportunity's net present value.

Sensitivity analysis, page 445 The process of determining how the distribution of possible net present values or internal rates of return for a particular project is affected by a change in one particular value driver.

Simulation analysis, page 452 The process of imitating the performance of a risky investment

project through repeated evaluations, usually using a computer. This type of experimentation is designed to capture the critical realities of the decision-making situation.

Value drivers, page 445 The primary determinants of an investment's cash flows and its performance (e.g., number of units sold and cost per unit to produce).

13.3 Use break-even analysis to evaluate project risk. (pgs. 454–464)

SUMMARY: Accounting break-even analysis is a tool used by analysts to determine the level of sales that will result in net operating income of zero. The basic break-even model allows the analyst to investigate the effect of changes in unit price, cost structure, and level of output or sales on project profitability. However, accounting break-even is not the same thing as NPV break-even because accounting expenses do not include an opportunity cost for the capital invested in the project (i.e., for buildings and equipment as well as working capital). Both accounting break-even and NPV break-even analyses provide valuable tools the analyst can use to learn more about the determinants of investment risk and the prospects for success.

KEY TERMS

Accounting break-even analysis, page 455 A type of analysis to determine the level of sales necessary to cover total operating costs and produce net operating income (or earnings before interest and taxes) of zero.

Break-even analysis, page 454 A type of analysis used to identify the level of sales needed to meet the costs associated with a project.

Cash break-even point, page 459 The level of sales that covers total cash operating costs (specifically excluding consideration for depreciation expense).

Contribution margin, page 457 The difference between the selling price per unit and the variable cost per unit.

Degree of operating leverage (DOL), page 462 The percentage change in net operating income caused by a percentage change in sales.

Direct cost, page 455 Variable cost.

Fixed costs, page 455 Costs that do not vary with the level of sales or output, including both cash fixed costs (or fixed operating costs before depreciation) and depreciation.

Indirect cost, page 455 Fixed cost.

NPV break-even analysis, page 459 A type of analysis used to identify the level of sales necessary to produce a net present value of zero.

Operating leverage, page 462 The inclusion of fixed operating costs in a firm's cost structure that magnify the effect of changes in revenues on the firm's net operating income.

Variable costs, page 455 Costs that change with the level of sales or output.

1. Explain the concepts of fixed and variable costs. Which is an indirect cost, and which is a direct cost?
2. What is accounting break-even analysis?
3. What is NPV break-even analysis, and why does it differ from accounting break-even analysis?
4. What is operating leverage?

KEY EQUATIONS

$$\underset{\text{Income}(NOI)}{\text{Net Operating}} = \underset{\text{Revenues}}{\text{Total}} - \left(\underset{\text{Costs}}{\text{Total Variable}} + \underset{\text{Costs}}{\text{Total Fixed}} \right) = 0 \qquad \textbf{(13–1)}$$

$$\underset{\text{Income }(NOI)}{\text{Net Operating}} = \underbrace{\left(\underset{\text{Unit }(P)}{\text{Price per}} \times \underset{\text{Sold }(Q)}{\text{Units}} \right)}_{\text{Total Revenues}} - \underbrace{\left[\left(\underset{\text{per Unit }(V)}{\text{Variable Cost}} \times \underset{\text{Sold }(Q)}{\text{Units}} \right) + \underset{\text{Cost }(F)}{\text{Total Fixed}} \right]}_{\text{Total Costs}} = 0$$

$$\textbf{(13–1a)}$$

$$Q_{\text{Accounting break-even}} = \frac{\text{Total Fixed Costs }(F)}{\underset{\text{Unit }(P)}{\text{Price per}} - \underset{\text{per Unit }(V)}{\text{Variable Cost}}} = \frac{\text{Total Fixed Costs }(F)}{\underset{\text{per Unit}}{\text{Contribution Margin}}} \qquad \textbf{(13–2)}$$

$$Q_{\text{Cash break-even}} = \frac{\text{Fixed Operating Costs Other Than Depreciation per Year}}{\underset{\text{Unit }(P)}{\text{Price per}} - \underset{\text{per Unit }(V)}{\text{Variable Cost}}} \qquad \textbf{(13–2a)}$$

$$= \frac{\text{Total Fixed Costs }(F) - \text{Depreciation}}{\underset{\text{per Unit}}{\text{Contribution Margin}}}$$

$$DOL = \frac{\%\,\text{Change in Net Operating Income}\,(NOI)}{\%\,\text{Change in Sales}} \qquad \text{(13–3)}$$

$$DOL = 1 + \frac{\text{Fixed Costs}}{NOI} \qquad \text{(13–4)}$$

13.4 Describe the types of real options. (pgs. 464–466)

SUMMARY: Opportunities to alter the operations of a project after its initiation are referred to as real options. Three of the most common types of real options include:

(1) the option to delay a project until the future cash flows are more favorable;

(2) the option to expand a project, perhaps to increase its size or even to include new products that would not have otherwise been feasible; and

(3) the option to abandon a project if the future cash flows fall short of expectations.

KEY TERM

Real options, page 464 Opportunities that allow for the alteration of the project's cash flow stream after the project is initiated (e.g., changing the product mix, level of output, or mix of inputs).

Study Questions

13–1. *Regardless of Your Major: Project Risk for Entrepreneurs* on page 442 discussed the risks that entrepreneurs face, with about 40 percent of new businesses shutting their doors during their first year. If you had to pick a business to start, what would it be, and what type of risks might you face?

13–2. What is the objective of project risk analysis, and why is it critical to the investment decision-making process?

13–3. Which of the following sentences is true?

a. A sensitivity analysis will use repetition to test the validity of a risky project.
b. A simulation analysis will use repetition to test the validity of a risky project.
c. A scenario analysis will use repetition to test the validity of a risky project.

13–4. *Finance in a Flat World: Currency Risk* on page 454 discussed the currency risk that multinational firms face. Between July 2008 and December 2009, the value of the yen relative to the U.S. dollar went up by about 17 percent, and as a result, when companies traded dollars for yen, they got fewer dollars back. Which firms did this hurt more: Japanese firms that produced goods in Japan and sold them in the United States or U.S. firms that produced goods in the United States and sold them in Japan?

13–5. Describe each of the five steps involved in carrying out a simulation analysis to assess project risk.

13–6. What is the difference between accounting break-even and NPV break-even? Which will offer the higher break-even level of output, and why?

13–7. A project to build a new bridge with 50 percent government funding commenced operations three months ago. You have just found out that the government funding may be delayed by up to six months. Which real options considerations might be appropriate?

Study Problems

Tools for Analyzing the Risk of Project Cash Flows

13–1. **(Calculating expected revenues)** (**Related to Checkpoint 13.1 on page 444**) The owner of the Petreno Pharmaceuticals Company is evaluating the expected annual sales for a new line of facial care products and estimates that there is a 60 percent chance that the product line will be extremely successful, in which case it will generate sales next year of $8 million. However, because the new product line has a unique appeal that will require substantial advertising by its manufacturer to gain consumer acceptance, there is a 40 percent chance that revenues for next year will be a modest $1 million. What is the expected level of revenues for the new product line?

13–2. **(Forecasting cash flows using the expected value)** (**Related to Checkpoint 13.1 on page 444**) Koch Transportation is contemplating the acquisition of LH Transport, a competing trucking firm. Koch's CFO estimates that during the next year LH Transport's flows from the acquisition will vary depending on the state of the local economy:

	Scenario I: Recession	Scenario II: Normal	Scenario III: Expanding
Probability	20%	60%	20%
Cash flow	$(50,000)	$150,000	$250,000

   a. Calculate the expected cash flow for next year using the estimates provided above.

   b. Assume the probability of a recession increases to 30 percent, the normal scenario probability remains at 60 percent, and the expansion probability drops to only 10 percent. What is your estimate of the expected cash flow for next year under this circumstance?

   c. Your analysis of the acquisition suggests that for the investment to have at least a zero NPV, it must produce an annual expected cash flow of $100,000 per year over the next five years. Assuming that the cash flow you estimated in part a is the expected cash flow for Years 1 through 5, what would you like to know about the project cash flows to make you more comfortable with the idea that you can indeed generate the requisite $100,000 per year cash flow? (No computations required.)

13–3. **(Forecasting cash flows using the expected value)** Rao Roofing of Stillwater, Oklahoma, is also considering the acquisition of Simpkins Storage Company. Rao's management team has analyzed the annual cash flows for Simpkins and come up with these estimates for the three states of the economy:

	Scenario I: Recession	Scenario II: Normal	Scenario III: Expansion
Probability	25%	55%	20%
Cash flow for each scenario	$(50,000)	$150,000	$250,000

A rival firm, Mitchell Storage Company is also considering a bid for Simpkins and their estimated cash flow for Simpkins in each potential state of the economy are the same as those of Rao. However, Mitchell's management is much more optimistic about the economy. They estimate the probability of a recession next year at only 20 percent, the probability of a normal state of the economy at 50 percent, and the probability of expansion at 30 percent.

   a. Based on Rao's estimated probabilities for each state of the economy, what should be their estimate of expected cash flows for Simpkins?

   b. What should be Mitchell's estimate of the expected cash flow for Simpkins' year one cash flow?

   c. Which company do you think will ultimately be willing to pay the highest price for Simpkins, all else being equal other than their outlook for the economy?

13–4. **(Forecasting revenues using scenario analysis)** **(Related to Checkpoint 13.3 on page 451)** Floating Homes, Inc., is a manufacturer of luxury pontoon and houseboats that sell for $40,000 to $100,000. To estimate its revenues for the following year, Floating Homes divides its boat sales into three categories based on selling price (high, medium, and low) and estimates the number of units it expects to sell under three different economic scenarios. These scenarios include a recession (Scenario I), a continuation of current conditions in which the economy is level or unchanged (Scenario II), and a strong economy (Scenario III). These estimates are as follows:

	Scenario I: Recession	Scenario II: Level Economy	Scenario III: Strong Economy
Probability	25%	50%	25%
High-Priced Boats Category			
Unit sales	50	400	1,000
Average price per unit	$80,000	$90,000	$95,000
Medium-Priced Boats Category			
Unit sales	100	800	3,000
Average price per unit	$60,000	$70,000	$80,000
Low-Priced Boats Category			
Unit sales	200	1,500	5,000
Average price per unit	$50,000	$50,000	$50,000

Using these estimates, calculate the expected revenue for Floating Homes, Inc., for the following year.

13–5. **(Calculating the expected NPV of a project)** Managers at the Physicians' Bone and Joint (PB&J) Clinic are considering whether to purchase a newly developed MRI machine that the manufacturer tells them will provide the basis for better diagnoses of foot and knee problems. The new machine is quite expensive but should last for a number of years. The clinic's CFO asked an analyst to work up estimates of the NPV of the investment under three different assumptions about the level of demand for its use (high, medium, and low). To carry out the analysis, the CFO assigned a 60 percent probability to the medium-demand state, a 25 percent probability to the high-demand state, and the remaining 15 percent to the low-demand state. After forecasting the demand for the machine based on the CFO's judgment and past utilization rates for MRI scans, the analyst made the following NPV estimates:

Demand State	Probability of State	NPV Estimate
Low	15%	$(300,000)
Medium	60%	$200,000
High	25%	$400,000

a. What is the expected NPV for the MRI machine based on the above estimates? How would you interpret the meaning of the expected NPV? Does this look like a good investment to you?
b. Assuming that the probability of the medium-demand state remains 60 percent, calculate the maximum probability you can assign to the low-demand state and still have an expected NPV of zero or higher. (Hint: The sum of the probabilities assigned to all three states must be 100 percent.)
c. How does knowing the maximum probability of realizing the low-demand state help you assess the project? (No calculations required.)

13–6. **(Using scenario analysis)** **(Related to Checkpoint 13.3 on page 451)** Family Security is considering introducing a tiny GPS tracker that is inserted in the sole of a child's shoe, which would then allow for the tracking of that child if he or she was ever lost. You have prepared the following estimates for this new product but are concerned they might be off by 10 percent (either above or below):

Unit price	$125
Variable cost	$75
Fixed costs	$250,000 per year
Expected sales	10,000 per year

Because this is a new product line, you are not confident in your estimates and would like to know how the project will fare if your estimates on the items listed above are 10 percent higher or 10 percent lower than expected. Assume that this new product line will require an initial outlay of $1 million, will necessitate no working capital investment, will last for 10 years, and will be depreciated down to zero using straight-line depreciation. In addition, the firm's required rate of return or cost of capital is 10 percent, and its marginal tax rate is 34 percent. Calculate the project's NPV under the best-case scenario (that is, use the high estimates—unit price 10 percent above expected, variable costs 10 percent less than expected, fixed costs 10 percent less than expected, and expected sales 10 percent more than expected). Calculate the project's NPV under the worst-case scenario.

13–7. **(Conducting a comprehensive risk analysis)** **(Related to Checkpoint 13.2 on page 447 and Checkpoint 13.3 on page 451)** Blindfold Technologies Inc. (BTI) is considering whether to introduce a new line of hand scanners that can be used to copy material and then download it into a computer. These scanners are expected to sell for an average price of $100 each, and the company analysts performing the analysis expect that the firm can sell 100,000 units per year at this price for a period of five years, after which time they expect demand for the product to end as a result of a more advanced technology. In addition, the firm's management expects that variable costs will be $20 per unit, and fixed costs, not including depreciation, are forecast to be $1,250,000 per year. To manufacture this product, BTI will need to buy a computerized production machine for $10 million that has an expected life of five years and no residual or salvage value. In addition, the firm expects it will have to invest an additional $450,000 in working capital to support the new business. Other pertinent information concerning the business venture is as follows:

Initial cost of the machine	$10,000,000
Expected life	5 years
Salvage value of the machine	$0
Working-capital requirement	$450,000
Depreciation method	Straight-line
Depreciation expense	$2,000,000 per year
Cash fixed costs—excluding depreciation	$1,250,000 per year
Variable cost per unit	$22.50
Required rate of return or cost of capital	10%
Tax rate	20%

a. Calculate the project's NPV.
b. Determine the sensitivity of the project's NPV to a 10 percent decrease in the number of units sold.
c. Determine the sensitivity of the project's NPV to a 10 percent decrease in the cost per unit.
d. Determine the sensitivity of the project's NPV to a 10 percent increase in the variable cost per unit.
e. Determine the sensitivity of the project's NPV to a 10 percent increase in the annual fixed operating costs.
f. Use scenario analysis to evaluate the project's NPV under the worst- and best-case scenarios for the project's value drivers. The values for the expected or base-case, worst-case, and best-case scenarios are as follows:

	Expected or Base Case	Worst Case	Best Case
Unit sales	100,000	70,000	130,000
Price per unit	$ 100	$ 90	$ 120
Variable cost per unit	$ (22.50)	$ (25)	$ (18)
Cash fixed costs per year	$(1,000,000)	$(1,200,000)	$ (900,000)
Depreciation expense	$(2,000,000)	$(2,000,000)	$(2,000,000)

Break-Even Analysis

13–8. **(Using break-even analysis)** (**Related to Checkpoint 13.4 on page 457**) KBL are about to start a new production line for HDMI cables. They anticipate selling these for £10 each with variable costs of £6 per unit. Building alterations are required at a cost of £1,000,000, which would be depreciated on a straight-line basis across five years. The new process will incur fixed salary costs of £200,000 per annum. How many units of sale are required to deliver a profit break-even in Year 1? How many units of sale are required to deliver a cashflow break-even in Year 1 without taking the capital expenditure cashflow into consideration?

13–9. **(Using break-even analysis)** (**Related to Checkpoint 13.4 on page 457**)

Project	Accounting Break-Even Point (in units)	Price per Unit	Variable Cost per Unit	Fixed Costs	Depreciation
A	6,250	☐	$55	$100,000	$ 25,000
B	750	$1,000	☐	$500,000	$100,000
C	2,000	$ 20	$15	$ 5,000	☐
D	2,000	$ 20	$ 5	☐	$ 15,000

a. Calculate the missing information for each of the above projects.
b. Note that Projects C and D share the same accounting break-even. If sales are above the break-even point, which project do you prefer? Explain why.
c. Calculate the cash break-even for each of the above projects. What do the differences in accounting break-even and cash break-even tell you about the four projects?

13–10. **(Using break-even analysis)** (**Related to Checkpoint 13.4 on page 457**) Mayborn Enterprises, LLC runs a number of sporting goods businesses and is currently analyzing whether to start a new T-shirt printing business. Specifically, the company is evaluating the feasibility of this business based on its estimates of the unit sales, price per unit, variable cost per unit, and cash fixed costs. The company's initial estimates of annual sales and other critical variables are as follows:

	Base Case
Unit sales	7,500
Price per unit	$16.00
Variable cost per unit	10.00
Cash fixed cash expense per year	10,000
Depreciation expense	4,000

a. Calculate the accounting and cash break-even annual sales volumes in units.
b. Bill Mayborn is the grandson of the founder of the company and is currently enrolled in his junior year at the local state university. After reviewing the accounting break-even calculation done in part a, Bill wondered if the depreciation expense should be included in the calculation. Bill had just completed his first finance class and was well aware that depreciation is not an actual out-of-pocket

expense but rather an allocation of the cost of the printing equipment used in the business over its useful life. What do you think? What can you learn from the cash and accounting break-even points?

13–11. **(Using break-even analysis)** Alan decides to run a small private music teaching business alongside his full-time job with the permission of his current employer. He believes that he can charge £50 per hour for his lessons but will have direct travel and promotion costs of £30 per hour. He can rent a music studio for £1,500 per month, with a non-returnable up-front deposit of £4,800 (which he wants to treat financially as split across 12 months). He has 120 chargeable hours of teaching time available per month, and this will enable him to continue meeting his employer's expectations. Using the 12-month split of the studio deposit, how many hours will he need to work for to achieve an accounting break-even? If he would like to earn £5,000 from this business, how many months will he need to work at full reaching capacity to achieve this?

13–12. **(Using degree of operating leverage)** Take another look at Study Problem 13–8. The new marketing manager for KBL has predicted sales of 153,000 units at an average sales price of £9 per unit. What will be the projected profit for the year?

13–13. **(Using degree of operating leverage)** Take a further look at Study Problem 13–11. Alan's accountant suggests that the deposit on the studio should be treated as a one-off up-front cost to enable him to calculate the number of hours required for a cash break-even before Alan is in a position to retain any earnings. How many hours of teaching would be required to reach this position?

Options in Capital Budgeting

13–14. **(Identifying real options)** H17B is a new project being considered by the OPER8 organization to produce a key component that will remove its current reliance on one supplier for the output commodity of the proposed project. The project will be funded fully by debt, and the bank is looking to charge a premium for the first year, given the current debt/equity balance of OPER8 (with a tranche of bonds maturing in 10 months). The sector and the project will require employing 30 senior managers on a fixed-term two-year contract along with a more transient workforce as required. Fifty percent of the funding is required for an asset that will depreciate to zero across three years. The current projections show a cash positive situation in Year 2 and an accounting NPV after 30 months. The current supplier is aware of the H17B project. The loss of its current sales to OPER8 would be serious and possibly terminal. They have offered the directors of OPER8 a five-year fixed-term supply deal at a guaranteed fixed price. What are the real options for the directors of OPER8?

13–15. **(Incorporating real options in capital budgeting)** (**Related to Checkpoint 13.5 on page 465**) You are considering introducing a new Tex-Mex–Thai fusion restaurant. The initial outlay for this new restaurant is $6 million, and the present value of the free cash flows (excluding the initial outlay) is $5 million, so the project, as it is now envisioned, has an expected NPV of –$1 million. Given its negative NPV, you decide to take a closer look at firm cash flows. From this analysis, you estimate that there is a 50 percent chance that the new restaurant will be well received and will produce annual cash flows of $800,000 forever (a perpetuity); however, there is a 50 percent chance that the new restaurant will not be well received and will produce annual cash flows of only $200,000 forever (a perpetuity). If the new restaurant is successful, you will be able to build 10 more of them, and they will have costs and cash flows similar to those of the successful restaurant. The required rate of return you use to discount the project cash flows is 10 percent.

   a. In spite of the fact that the first restaurant has a negative NPV, should you build it anyway? Why or why not?
   b. What is the expected NPV for this project if only one restaurant is built but isn't well received? What is the expected NPV for this project if 10 more restaurants are built after one year and are well received?

13–16. **(Incorporating real options in capital budgeting)** You are half-way through a six-year project. All of the upfront funding has been spent, and you are running out of cash rapidly. Your projection suggests that without some significant change, you can only pay salaries for another four months. If you are forced to stop or pause the project, the current state of the infrastructure will deteriorate rapidly and incur additional costs within a nine-month period before the project could be recommenced. No approach has yet been made to the funders, and interest payments are up-to-date, but the next interest payment, due in two months, cannot be met if the salaries are to continue into Month 3 and Month 4. You believe that the funders could be persuaded to refinance the project with additional capital, and give you a cashflow output holiday of six-months. Suggest the different real options available.

Mini-Case

It's been four months since you took a position as an assistant financial analyst at Caledonia Products. During that time, you've had a promotion, and you are now working as a special assistant for capital budgeting, reporting directly to the CEO. Your latest assignment is your first assignment dealing with risk analysis. As a consequence you have been asked not only to provide a recommendation on the project but to respond to a number of questions aimed at judging your understanding of risk analysis and capital budgeting. The memorandum you received outlining your assignment follows:

TO: The Special Assistant for Capital Budgeting

FROM: Mr. V. Morrison, CEO, Caledonia Products

RE: Capital Budgeting and Risk Analysis

Provide a written response to the following questions:

1. Explain how sensitivity analysis and scenario analysis are useful tools for evaluating project risk.

2. What are real options? How does the presence of optionality in the investments that firms make cause the tradition-ally calculated NPV of a project to be underestimated?

3. Explain how simulation works. What is the value of using a simulation approach?

4. How can break-even analysis be helpful in evaluating project risk?

5. What is sensitivity analysis, and what is its purpose?

6. Now that management is comfortable with your skills, the company would like you to look at a new project. This project involves the purchase of a new $2,000,000 fully auto-mated plasma cutter that can be used in our metal works division. The products manufactured using the new technol-ogy are expected to sell for an average price of $300 per unit, and the company analyst expects that the firm can sell 20,000 units per year at this price for a period of five years. The cutter will have a residual or salvage value of $200,000

at the end of the project's five-year life. The firm also expects to have to invest an additional $300,000 in working capital to support the new business. Other pertinent information concerning the business venture is as follows:

Initial cost of equipment	$2,000,000
Project and equipment life	5 years
Salvage value of equipment	$200,000
Working-capital requirement	$300,000
Depreciation method	Straight-line
Depreciation expense	$360,000
Discount rate or required rate of return	12%
Tax rate	30%

In addition, estimates for unit sales, selling price, variable cost per unit, and cash fixed operating expenses for the base-case, worst-case, and best-case scenarios are as follows:

	Expected or Base Case	Worst Case	Best Case
Unit sales	20,000	15,000	25,000
Price per unit	$ 300	$ 250	$ 330
Variable cost per unit	$ (200)	$ (210)	$ (180)
Cash fixed costs per year	$(500,000)	$(450,000)	$(350,000)
Depreciation expense	$ 360,000	$ 360,000	$ 360,000

a. Estimate the cash flows for the investment under the listed base-case assumptions. Calculate the project NPV for these cash flows.

b. Evaluate the NPV of the investment under the worst-case assumptions.

c. Evaluate the NPV of the investment under the best-case assumptions.