I opened U-Develop because I love photography and I wanted to own my own business. I now get to spend most of my day working with employees and customers making sure that the photos they take are the best they can be. It also gives me a chance to encourage younger people who have an interest in photography, because I work with many of the school groups and after-school clubs here in town. That's the fun part of the job.

But I also have to think about the financial side of the business. I need a systematic way to understand the relation between my decisions and my profits. I've read that managers can calculate the price they need to charge to break even (see the *In Action* item on CVP analysis and airlines). I should be able to apply the same analysis to my business.

Jamaal Kidd was discussing the photo-finishing store that he owns and operates. Starting out five years ago with a small storefront in the mall offering only photo developing, he has expanded the business and moved to a larger store downtown, where he now offers a wide range of products and services, some made in his own workshop.

Our theme in this book is that the cost accounting system serves managers by providing them with information that supports good decision making. In this chapter and the next, we develop two common tools that managers can use to analyze situations and make decisions that will increase the value of the firm. We begin in this chapter by developing the relations among the costs, volumes, and profits of the firm. In the next chapter, we use these relations to make pricing and production decisions that increase profit.

cost-volume-profit (CVP) analysis
Study of the relations among revenue, cost, and volume and their effect on profit.

Cost-Volume-Profit Analysis

Managers are concerned about the impact of their decisions on profit. The decisions they make are about volume, pricing, or incurring a cost. Therefore, managers require an understanding of the relations among revenues, costs, volume, and profit. The cost accounting department supplies the data and analysis, called **cost-volume-profit (CVP) analysis,** that support these managers.

L.O. 1
Use cost-volume-profit (CVP) analysis to analyze decisions.

Cost-Volume-Profit Analysis and Airline Pricing — *In Action*

Cost-volume-profit analysis helps managers evaluate the impact of alternative product pricing strategies on profits. It can also be useful for evaluating competitors' pricing strategies and efforts to grow market share, as in the following examples:

> Aloha Airlines CEO David Banmiller and C. Thomas Nulty, senior vice president for marketing and sales, explain that their airline must charge $50 per seat to break even when planes are 62 percent full.
>
> Hawaiian Airlines, Aloha Airlines and go! are each losing money when they sell interisland tickets below $50, according to a study commissioned by Aloha Airlines.
>
> "Why would somebody come in and charge $19, and $29, and $39 when their costs were substantially higher? Why would somebody do it?" said Banmiller.
>
> The Sabre study showed that when planes are 62 percent full, Aloha's costs are $50 per seat, Hawaiian's are $55, and go!'s are $67.

However, managers at the parent company of go! (Mesa Airlines) disputed the estimates with a CVP analysis of their own:

> Jonathan Ornstein, Mesa's chief executive officer, said yesterday that Aloha's cost estimates are way off when it comes to his airline. He said go!'s expenses per passenger are about $40 when the planes are 80 percent full.

Note: Aloha Airlines is no longer in business.

Source: Rick Daysog, "Below-Cost Fares Puzzle Aloha Airlines CEO," *Honolulu Advertiser,* December 21, 2006.

Profit Equation

profit equation
Operating profit equals total revenue less total costs.

The key relation for CVP analysis is the **profit equation.** Every organization's financial operations can be stated as a simple relation among total revenues (*TR*), total costs (*TC*), and operating profit:

$$\text{Operating profit} = \text{Total revenues} - \text{Total costs}$$
$$\text{Profit} = TR - TC$$

(For not-for-profit and government organizations, the "profit" may go by different names such as "surplus" or "contribution to fund," but the analysis is the same.) Both total revenues and total costs are likely to be affected by changes in the amount of output.[1] We rewrite the profit equation to explicitly include volume, allowing us to analyze the relations among volume, costs, and profit. Total revenue (*TR*) equals average selling price per unit (*P*) times the units of output (*X*):

$$\text{Total revenue} = \text{Price} \times \text{Units of output produced and sold}$$
$$TR = PX$$

In our profit equation, total costs (*TC*) may be divided into a fixed component that does not vary with changes in output levels and a variable component that does vary. The fixed component is made up of total fixed costs (*F*) per period; the variable component is the product of the average variable cost per unit (*V*) multiplied by the quantity of output (*X*). Therefore, the cost function is

$$\text{Total costs} = (\text{Variable costs per unit} \times \text{Units of output}) + \text{Fixed costs}$$
$$TC = VX + F$$

Substituting the expanded expressions in the profit equation yields a form more useful for analyzing decisions:

$$\text{Profit} = \text{Total revenue} - \text{Total costs}$$
$$= TR - TC$$
$$TC = VX + F$$

Therefore,

$$\text{Profit} = PX - (VX + F)$$

Collecting terms gives

$$\text{Profit} = (\text{Price} - \text{Variable costs}) \times \text{Units of output} - \text{Fixed costs}$$
$$= (P - V)X - F$$

unit contribution margin
Difference between revenues per unit (price) and variable cost per unit.

total contribution margin
Difference between revenues and total variable costs.

We defined *contribution margin* in Chapter 2 as the difference between the sales price and the variable cost per unit. We will refer to this as the **unit contribution margin** to distinguish it from the difference between the total revenues and total variable cost, the **total contribution margin.** In other words, the total contribution margin is the unit contribution margin multiplied by the number of units (Price − Variable costs) × Units of output, or $(P - V)X$. It is the amount that units sold contribute toward (1) covering fixed costs and (2) providing operating profits. Sometimes we use the contribution margin, in total, as in the preceding equation. Other times, we use the contribution margin per unit, which is

$$\text{Price} - \text{Variable cost per unit}$$
$$P - V$$

[1] We adopt the simplifying assumption that production volume equals sales volume so that changes in inventory can be ignored in this chapter.

Recall from Chapter 2 that an important distinction for decision making is whether costs are fixed or variable. That is, for decision making, we are concerned about *cost behavior,* not the *financial accounting treatment,* which classifies costs as either manufacturing or administrative. Thus, V is the sum of variable manufacturing costs per unit and variable marketing and administrative costs per unit; F is the sum of total fixed manufacturing costs and fixed marketing and administrative costs for the period; and X refers to the number of units produced and sold during the period.

CVP Example

When Jamaal first opened U-Develop, he offered one service only, developing prints. He charged an average price of $.60. The average variable cost of each print was $.36, computed as follows:

Cost of processing (materials and labor)	$.30
Other costs (sales and support)	.06
Average variable cost per print	$.36

The fixed costs to operate the store for March, a typical month, were $1,500.

In March, U-Develop processed 12,000 prints. The operating profit can be determined from the company's income statement for the month, as shown in Exhibit 3.1.

As a manager, Jamaal might want to know how many units (prints) he needs to sell in order to achieve a specified profit. Assume, for example, that Jamaal is hoping for sales to improve in July, when the weather will improve and people take vacations. Given the data, price = $.60, variable cost per unit = $.36 (therefore, contribution margin per unit = $.24), and fixed costs = $1,500, the manager asks two questions: What volume is required to break even (earn zero profits)? What volume is required to make an $1,800 operating profit? Although we could use the income statement and guess at the answer to these questions, it is easier to set up an equation that summarizes the cost-volume-profit relation.

Recall that in March, U-Develop processed 12,000 prints. Using the profit equation, the results for March, therefore, were:

$$\begin{aligned}\text{Profit} &= \text{Contribution margin} - \text{Fixed costs}\\ &= (P - V)X - F\\ &= (\$.60 - \$.36) \times 12{,}000 \text{ prints} - \$1{,}500\\ &= \$1{,}380\end{aligned}$$

which is equal to the operating profit shown on the income statement in Exhibit 3.1. To simplify the equation, we use the term "Profit" in the equation to mean the same thing as "Operating Profit" on income statements.

Exhibit 3.1
Income Statement

U-DEVELOP
Income Statement
March

Sales (12,000 prints at $.60)		$7,200
Less		
Variable costs of goods sold (12,000 × $.30)	$3,600	
Variable selling costs (12,000 × $.06)	720	4,320
Contribution margin		$2,880
Less fixed costs		1,500
Operating profit		$1,380

Finding Break-Even and Target Volumes We can use the profit equation to answer Jamaal's questions about volumes needed to break even or achieve a target profit by developing the formulas discussed here. We start with the answer to the first question, which we call *finding a break-even volume.* Managers might want to know the break-even volume expressed either in units or in sales dollars. If the company makes many products, it is often much easier to think of volume in terms of sales dollars; if we are dealing with only one product, it's easier to work with units as the measure of volume.

break-even point
Volume level at which profits equal zero.

Break-Even Volume in Units We can use the profit equation to find the **break-even point** expressed in units:

$$\text{Profit} = 0 = (P - V)X - F$$

$$\text{If Profit} = 0, \text{ then } X = \frac{F}{(P - V)}$$

$$\text{Break-even volume (in units)} = \frac{\text{Fixed costs}}{\text{Unit contribution margin}}$$

$$= \frac{\$1{,}500}{\$\ \ .24}$$

$$= 6{,}250 \text{ prints}$$

To show this is correct, if U-Develop processes 6,250 prints, its operating profit is

$$\begin{aligned} \text{Profit} &= TR - TC \\ &= PX - VX - F \\ &= (\$.60 \times 6{,}250 \text{ prints}) - (\$.36 \times 6{,}250 \text{ prints}) - \$1{,}500 \\ &= \$0 \end{aligned}$$

contribution margin ratio
Contribution margin as a percentage of sales revenue.

Break-Even Volume in Sales Dollars To find the break-even volume in terms of sales dollars, we first define a new term, **contribution margin ratio.** The contribution margin ratio is the contribution margin as a percentage of sales revenue. For example, for U-Develop, the contribution margin ratio can be computed as follows:

$$\text{Contribution margin ratio} = \frac{\text{Unit contribution margin}}{\text{Sales price per unit}}$$

$$= \frac{\$.24}{\$.60}$$

$$= .40 \text{ (or 40\%)}$$

Using the contribution margin ratio, the formula to find the break-even volume follows:2

$$\text{Break-even volume sales dollars} = \frac{\text{Fixed costs}}{\text{Contribution margin ratio}}$$

---

2 We can derive the break-even point for sales dollars from the original formula for units:

$$X = \frac{F}{P - V}$$

The modified formula for dollars multiplies both sides of the equation by P:

$$PX = \frac{F \times P}{P - V}$$

Since multiplying the numerator by P is the same as dividing the denominator by P, we obtain:

$$PX = \frac{F}{(P - V)/P}$$

The term $(P - V)/P$ is the contribution margin ratio.

For U-Develop, the break-even volume expressed in sales dollars is

$$\text{Break-even sales dollars} = \frac{\$1{,}500}{.40}$$

$$= \$3{,}750$$

Note that $3,750 of sales dollars translates into 6,250 prints at a price of $.60 each. We get the same result whether expressed in units (6,250 prints) or dollars (sales of 6,250 prints generates revenue of $3,750).

Target Volume in Units To find the target volume, we use the profit equation with the target profit specified. The formula to find the target volume in units is

$$\text{Target volume (units)} = \frac{\text{Fixed costs} + \text{Target profit}}{\text{Contribution margin per unit}}$$

Using the data from U-Develop, we find the volume that provides an operating profit of $1,800 as follows:

$$\text{Target volume} = \frac{\text{Fixed costs} + \text{Target profit}}{\text{Contribution margin per unit}}$$

$$= \frac{\$1{,}500 + \$1{,}800}{\$.24}$$

$$= 13{,}750 \text{ prints}$$

U-Develop must sell 13,750 prints per month to achieve the target profit of $1,800. Each additional print sold increases operating profits by $.24.

Target Volume in Sales Dollars To find the target volume in sales dollars, we use the contribution margin ratio instead of the contribution margin per unit. The formula to find the target volume follows:

$$\text{Target volume (sales dollars)} = \frac{\text{Fixed costs} + \text{Target profit}}{\text{Contribution margin ratio}}$$

For U-Develop the target volume expressed in sales dollars is

$$\text{Target volume (sales dollars)} = \frac{\$1{,}500 + \$1{,}800}{.40}$$

Note that sales dollars of $8,250 translates into 13,750 prints at $.60 each. We get the same target volume whether expressed in units (13,750 prints) or dollars (sales of 13,750 prints generates revenue of $8,250).

Exhibit 3.2 summarizes the four formulas for finding break-even and target volumes.

Exhibit 3.2
Summary of Break-Even and Target Volume Formulas

Break-Even Volume

$$\text{Break-even volume (units)} = \frac{\text{Fixed costs}}{\text{Unit contribution margin}}$$

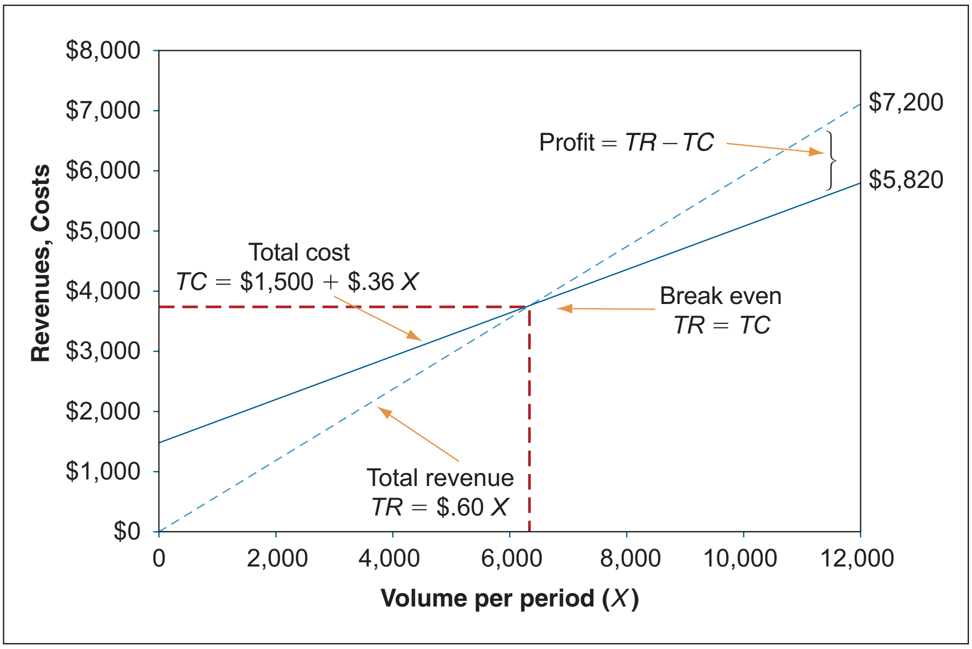
$$\text{Break-even volume (sales dollars)} = \frac{\text{Fixed costs}}{\text{Contribution margin ratio}}$$

Target Volume

$$\text{Target volume (units)} = \frac{\text{Fixed costs} + \text{Target profit}}{\text{Unit contribution margin}}$$

$$\text{Target volume (sales dollars)} = \frac{\text{Fixed costs} + \text{Target profit}}{\text{Contribution margin ratio}}$$

Exhibit 3.3
CVP Graph—U-Develop



Graphic Presentation

Exhibit 3.3 presents the cost-volume-profit (CVP) relations for U-Develop in a graph. Such a graph is a helpful aid in presenting cost-volume-profit relationships. We plot dollars on the vertical axis (revenue dollars or cost dollars, for example). We plot volume on the horizontal axis (number of prints sold per month or sales dollars, for example). The total revenue (*TR*) line relates total revenue to volume (for example, if U-Develop sells 12,000 prints in a month, its total revenue would be $7,200, according to the graph). The slope of *TR* is the price per unit, *P* (for example, $.60 per print for U-Develop).

The total cost (*TC*) line shows the total cost for each volume. For example, the total cost for a volume of 12,000 prints is $5,820 (= [12,000 × $.36] + $1,500). The intercept of the total cost line is the fixed cost for the period, *F*, and the slope is the variable cost per unit, *V*.

The break-even point is the volume at which *TR* = *TC* (that is, where the *TR* and *TC* lines intersect). Volumes lower than break even result in an operating loss because *TR* < *TC*; volumes higher than break even result in an operating profit because *TR* > *TC*. For U-Develop, 6,250 prints is the break-even volume.

Self-Study Question

1. The following information for Jennifer's Framing Supply is given for March:

Sales	$360,000
Fixed manufacturing costs	35,000
Fixed marketing and administrative costs	25,000
Total fixed costs	60,000
Total variable costs	240,000
Unit price	90
Unit variable manufacturing cost	55
Unit variable marketing cost	5

Compute the following:

a. Monthly operating profit when sales total $360,000 (as here).
b. Break-even number in units.
c. Number of units sold that would produce an operating profit of $120,000.
d. Sales dollars required to earn an operating profit of $20,000.
e. Number of units sold in March.
f. Number of units sold that would produce an operating profit of 20 percent of sales dollars.

The solution to this question is at the end of the chapter on page 109.

The amount of operating profit or loss can be read from the graph by measuring the vertical distance between *TR* and *TC*. For example, the vertical distance between *TR* and *TC* when $X = 12{,}000$ indicates Profit = $1,380 (= $7,200 − $5,820).

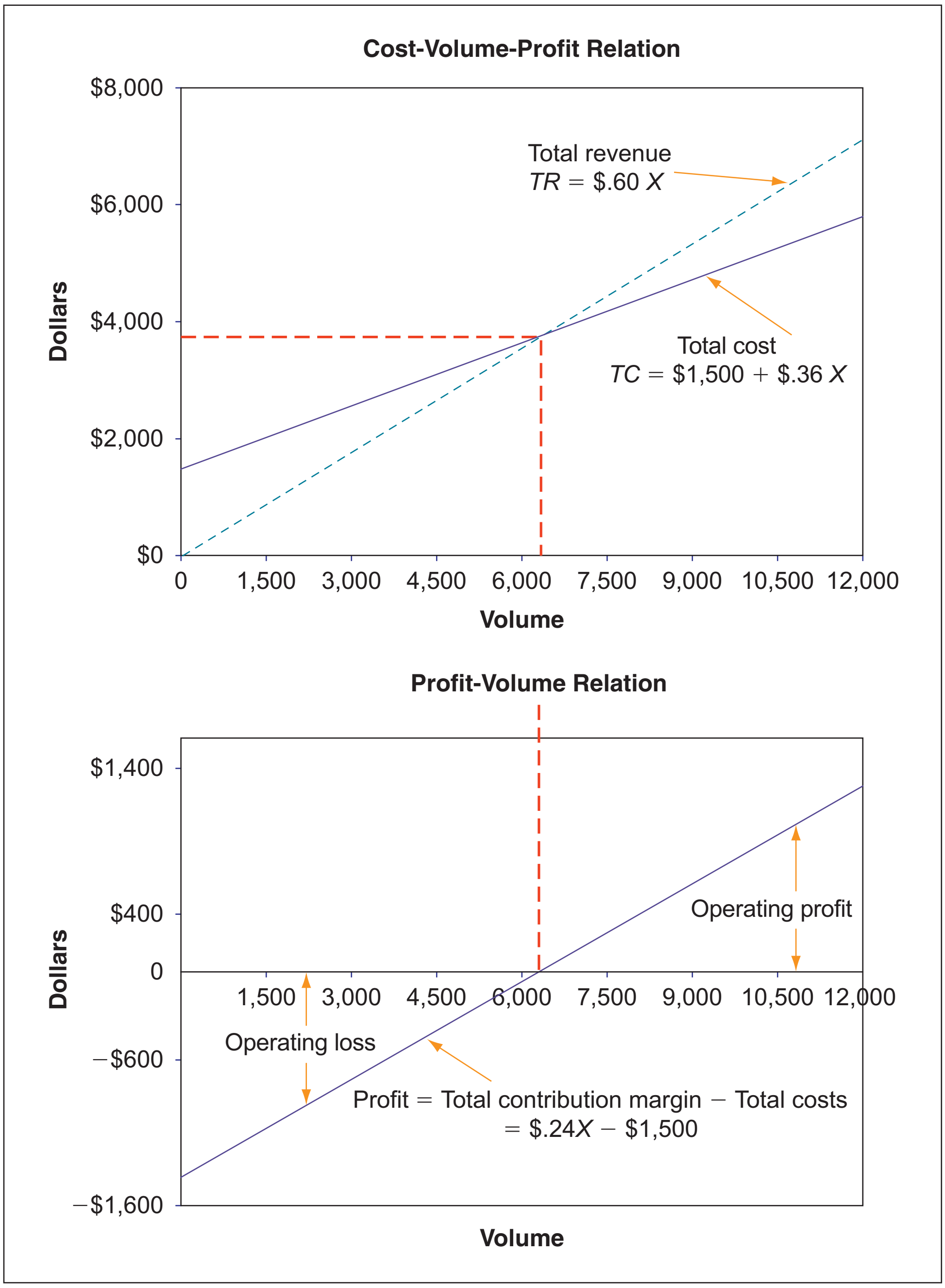
Profit-Volume Model

profit-volume analysis Version of CVP analysis using a single profit line.

L.O. 2 Understand the effect of cost structure on decisions.

Instead of considering revenues and costs separately, we can analyze the relation between profit and volume directly. This approach to CVP analysis is called **profit-volume analysis.** A graphic comparison of profit-volume and CVP relationships is shown in Exhibit 3.4. The cost and revenue lines are collapsed into a single profit line. Note that the slope of the profit-volume line equals the unit contribution margin. The intercept equals the loss at zero volume, which equals fixed costs. The vertical axis shows the amount of operating profit or loss.

Exhibit 3.4 Comparison of CVP Graph and Profit-Volume Graph—U-Develop



Use of CVP to Analyze the Effect of Different Cost Structures

cost structure
Proportion of an organization's fixed and variable costs to its total costs.

operating leverage
Extent to which an organization's cost structure is made up of fixed costs.

An organization's **cost structure** is the proportion of fixed and variable costs to total costs. Cost structures differ widely among industries and among firms within an industry. Electric utilities such as Southern California Edison or Public Service of New Mexico have a large investment in equipment, which results in a cost structure with high fixed costs. In contrast, grocery retailers such as Albertsons or Safeway have a cost structure with a higher proportion of variable costs. The utility is capital intensive; the grocery store is labor intensive.

An organization's cost structure has a significant effect on the sensitivity of its profits to changes in volume. **Operating leverage** describes the extent to which an organization's cost structure is made up of fixed costs. Operating leverage can vary within an industry as well as between industries. The airline industry in the United States, for example, consists of so-called legacy carriers, such as American Airlines and Continental Airlines, which have high fixed labor, pension, and other costs and which operate using a hub and spoke system. Newer carriers, such as Southwest Airlines and Jet Blue Airlines, have lower labor costs and operate out of lower cost and less-congested airports. Therefore, the operating leverage of American Airlines is higher than that of Jet Blue.

Operating leverage is high in firms with a high proportion of fixed costs and a low proportion of variable costs and results in a high contribution margin per unit. The higher the firm's fixed costs, the higher the break-even point. Once the break-even point has been reached, however, profit increases at a high rate. Exhibit 3.5 demonstrates the primary differences between two companies, Lo-Lev Company (with relatively high variable costs) and Hi-Lev Company (with relatively high fixed costs).

Different industries have different cost structures. Electric utilities (left) have high fixed costs and high operating leverage. Grocery stores (right) have lower fixed costs and low operating leverage.

Exhibit 3.5
Comparison of Cost Structures

	Lo-Lev Company (1,000,000 units)		Hi-Lev Company (1,000,000 units)	
	Amount	Percentage	Amount	Percentage
Sales	$1,000,000	100	$1,000,000	100
Variable costs	750,000	75	250,000	25
Contribution margin . .	$ 250,000	25	$ 750,000	75
Fixed costs	50,000	5	550,000	55
Operating profit	$ 200,000	20	$ 200,000	20
Break-even point . . .	200,000 units		733,334 units	
Contribution margin per unit	$0.25		$0.75	

Effect of Cost Structure on Operating and Investing Decisions

In Action

Different cost structures lead to different decisions that firms make concerning operations and investments. Consider the following two statements:

1. "Ahold now has about $23 billion in sales among its six U.S. supermarket chains—large but uncomfortably behind giants such as Wal-Mart, Kroger, and Albertson's. The logic of consolidation is that, in a business with such slim profit margins, bigger companies gain important competitive advantage by being able to negotiate better terms and prices from suppliers, better rents from landlords and better advertising deals from media outlets" (*Washington Post,* February 8, 2004).
2. "Many experts say the airlines throw planes on a route to grab market share from rivals. Robert L. Crandall, the former chief executive of American Airlines, said that airlines added planes because growth spreads fixed costs over more passenger miles. 'If everybody is growing to keep their costs down, then there's constantly a great deal of capacity in the market,' Mr. Crandall said. 'So long as there's lots of capacity, people have an incentive to cut prices'" (*The New York Times,* December 9, 2003).

In the case of firms with low operating leverage, such as grocery chains, the profit margins are small, so firms do what they can to improve those margins—even small savings translate to large improvements in profits. In the case of firms with high operating leverage, such as airlines, each additional unit (seat-mile) sold provides a large contribution to profit, so the emphasis is on increasing volume.

Note that although these firms have the same sales revenue and operating profit, they have different cost structures. Lo-Lev Company's cost structure is dominated by variable costs with a lower contribution margin ratio of .25. Every dollar of sales contributes $.25 toward fixed costs and profit. Hi-Lev Company's cost structure is dominated by fixed costs with a higher contribution margin of .75. Every dollar of sales contributes $.75 toward fixed costs and profit.

Suppose that both companies experience a 10 percent increase in sales. Lo-Lev Company's profit increases by $25,000 ($.25 × $100,000), and Hi-Lev Company's profit increases by $75,000 ($.75 × $100,000). Of course, if sales decline, the fall in Hi-Lev's profits is much greater than the fall in Lo-Lev's profits. In general, companies with lower fixed costs have the ability to be more flexible to changes in market demands than do companies with higher fixed costs and are better able to survive tough times.

Margin of Safety

The **margin of safety** is the excess of projected (or actual) sales over the break-even sales level. This tells managers the margin between current sales and the break-even point. In a sense, margin of safety indicates the risk of losing money that a company faces, that is, the amount by which sales can fall before the company is in the loss area. The margin of safety formula is

margin of safety
The excess of projected or actual sales over the break-even volume.

$$\text{Sales volume} - \text{Break-even sales volume} = \text{Margin of safety}$$

If U-Develop sells 8,000 prints and its break-even volume is 6,250, then its margin of safety is

$$\begin{aligned}\text{Sales} - \text{Breakeven} &= 8{,}000 - 6{,}250 \\ &= 1{,}750 \text{ prints}\end{aligned}$$

Sales volume could drop by 1,750 prints per month before it incurs a loss, all other things held constant. In practice, the margin of safety also may be expressed in sales dollars or as a percent of current sales.

The excess of the projected or actual sales volume over the break-even volume expressed as a percentage of actual sales volume is the **margin of safety percentage.** If U-Develop sells 8,000 prints and the break-even volume is 6,250 prints, the margin of safety percentage is 22 percent (= 1,750 ÷ 8,000). This means that volume can fall by 22 percent, a relatively large amount, before U-Develop finds itself operating at a loss.

margin of safety percentage
The excess of projected or actual sales over the break-even volume expressed as a percentage of actual sales volume.