

DECISION MAKING

PART

4

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CHAPTER

Cost-Volume-Profit Analysis

AFTER STUDYING THIS CHAPTER, YOU SHOULD BE ABLE TO:

1. Determine the number of units that must be sold to break even or to earn a targeted profit.
2. Calculate the amount of revenue required to break even or to earn a targeted profit.
3. Apply cost-volume-profit analysis in a multiple-product setting.
4. Prepare a profit-volume graph and a cost-volume-profit graph, and explain the meaning of each.
5. Explain the impact of risk, uncertainty, and changing variables on cost-volume-profit analysis.
6. Discuss the impact of activity-based costing on cost-volume-profit analysis.

Cost-volume-profit analysis (CVP analysis) is a powerful tool for planning and decision making. Because CVP analysis emphasizes the interrelationships of costs, quantity sold, and price, it brings together all of the financial information of the firm. CVP analysis can be a valuable tool in identifying the extent and magnitude of the economic trouble a company is facing and helping pinpoint the necessary solution. For example, **General Motors**' European division faced losses in the early 2000s. To approach break even, the division acted to reduce production capacity by 15 percent and to slash the number of dealers from 870 to 470.¹ These moves decreased fixed costs and set the stage for projected break even by 2004. At the same time, GM worked to increase the profitability of its North American division by boosting sales rev-

1. "GM Europe Chases Elusive Break-Even," *Detroit Free Press News Services*, http://www.auto.com/industry/gme5_20030305.htm as of March 5, 2003.

venues through the introduction of rebates and discounts on new cars and the rollout of new GM products.² CVP analysis can address many issues, such as the number of units that must be sold to break even, the impact a given reduction in fixed costs can have on the break-even point, and the impact an increase in price can have on profit. Additionally, CVP analysis allows managers to conduct sensitivity analyses by examining the impact of various price or cost levels on profit.

While this chapter deals with the mechanics and terminology of CVP analysis, your objective in studying CVP analysis is more than to learn the mechanics. You should keep in mind that CVP analysis is an integral part of financial planning and decision making. Every accountant and manager should be thoroughly conversant in its concepts.

OBJECTIVE 1
Determine the number of units that must be sold to break even or to earn a targeted profit.

The Break-Even Point in Units

Since we are interested in how revenues, expenses, and profits behave as volume changes, it is natural to begin by finding the firm's break-even point in units sold. Two frequently used approaches to finding the break-even point in units are the operating income approach and the contribution margin approach. We will first discuss these two approaches to find the **break-even point** (the point of zero profit) and then see how each can be expanded to determine the number of units that must be sold to earn a targeted profit.

The firm's initial decision in implementing a units-sold approach to CVP analysis is the determination of just what a unit is. For manufacturing firms, the answer is obvious. **Procter & Gamble** may define a unit as a bar of Ivory soap. Service firms face a more difficult choice. **Southwest Airlines** may define a unit as a passenger mile or a one-way trip. **Disney's** Animal Kingdom counts the number of visitor-days. The **Jacksonville Naval Supply Center**, which provides naval, industrial, and general supplies to U.S. Navy ships stationed in northeastern Florida and the Caribbean, defines "productive units" to measure the activities involved in delivering services. In this way, more complicated services are assigned more productive units than are less complicated services, thereby standardizing service efforts.³

A second decision centers on the separation of costs into fixed and variable components. CVP analysis focuses on the factors that effect a change in the components of profit. Because we are looking at CVP analysis in terms of units sold, we need to determine the fixed and variable components of cost and revenue with respect to units. (This assumption will be relaxed when we incorporate activity-based costing into CVP analysis.) It is important to realize that we are focusing on the firm as a whole. Therefore, the costs we are talking about are all costs of the company: manufacturing, marketing, and administrative. Thus, when we say variable costs, we mean all costs that increase as more units are sold, including direct materials, direct labor, variable overhead, and variable selling and administrative costs. Similarly, fixed costs include fixed overhead and fixed selling and administrative expenses.

Operating Income Approach

The operating income approach focuses on the income statement as a useful tool in organizing the firm's costs into fixed and variable categories. The income statement can be expressed as a narrative equation:

$$\text{Operating income} = \text{Sales revenues} - \text{Variable expenses} - \text{Fixed expenses}$$

Note that we are using the term **operating income** to denote income or profit *before* income taxes. Operating income includes only revenues and expenses from the

2. Jeffrey McCracken, "GM Expects Sales, Net to Show Gains," *Detroit Free Press*, http://www.freep.com/money/autonews/gm9_20040109.htm as of January 9, 2004.

3. David J. Harr, "How Activity Accounting Works in Government," *Management Accounting* (September 1990): 36-40.

firm's normal operations. We will use the term **net income** to mean operating income minus income taxes.

Once we have a measure of units sold, we can expand the operating income equation by expressing sales revenue and variable expenses in terms of unit dollar amounts and number of units. Specifically, sales revenue is expressed as the unit selling price times the number of units sold, and total variable costs are the unit variable cost times the number of units sold. With these expressions, the operating income statement becomes:

$$\text{Operating income} = (\text{Price} \times \text{Number of units}) - (\text{Variable cost per unit} \times \text{Number of units}) - \text{Total fixed costs}$$

Suppose you were asked how many units must be sold in order to break even, or earn a zero profit. You could answer that question by setting operating income equal to zero and then solving the operating income equation for the number of units.

Let's use the following example to solve for the break-even point in units. Assume that More-Power Company manufactures a variety of power tools. The Topeka plant is devoted to the production of sanders. For the coming year, the controller has prepared the following projected income statement:

Sales (72,500 units @ \$40)	\$2,900,000
Less: Variable expenses	<u>1,740,000</u>
Contribution margin	\$1,160,000
Less: Fixed expenses	<u>800,000</u>
Operating income	<u>\$ 360,000</u>

We see that for More-Power Company, the price is \$40 per unit, and the variable cost is \$24 (\$1,740,000/72,500 units). Fixed costs are \$800,000. At the break-even point, then, the operating income equation would take the following form:

$$\begin{aligned} 0 &= (\$40 \times \text{Units}) - (\$24 \times \text{Units}) - \$800,000 \\ 0 &= (\$16 \times \text{Units}) - \$800,000 \\ \$16 \times \text{Units} &= \$800,000 \\ \text{Units} &= 50,000 \end{aligned}$$

Therefore, More-Power must sell 50,000 sanders just to cover all fixed and variable expenses. A good way to check this answer is to formulate an income statement based on 50,000 units sold.

Sales (50,000 units @ \$40)	\$2,000,000
Less: Variable expenses	<u>1,200,000</u>
Contribution margin	\$ 800,000
Less: Fixed expenses	<u>800,000</u>
Operating income	<u>\$ 0</u>

Indeed, selling 50,000 units does yield a zero profit.

An important advantage of the operating income approach is that all further CVP equations are derived from the variable-costing income statement. As a result, you can solve any CVP problem by using this approach.

Contribution Margin Approach

A refinement of the operating income approach is the contribution margin approach. In effect, we are simply recognizing that at break-even, the total contribution margin equals the fixed expenses. The **contribution margin** is sales revenue minus total variable costs. If we substitute the unit contribution margin for price minus unit variable

cost in the operating income equation and solve for the number of units, we obtain the following break-even expression:

$$\text{Number of units} = \text{Fixed costs} / \text{Unit contribution margin}$$

Using More-Power Company as an example, we can see that the contribution margin per unit can be computed in one of two ways. One way is to divide the total contribution margin by the units sold for a result of \$16 per unit (\$1,160,000/72,500). A second way is to compute price minus variable cost per unit. Doing so yields the same result, \$16 per unit (\$40 – \$24). Now, we can use the contribution margin approach to calculate the break-even number of units.

$$\begin{aligned} \text{Number of units} &= \$800,000 / (\$40 - \$24) \\ &= \$800,000 / \$16 \text{ per unit} \\ &= 50,000 \text{ units} \end{aligned}$$

Of course, the answer is identical to that computed using the operating income approach.

Profit Targets

While the break-even point is useful information, most firms would like to earn operating income greater than zero. CVP analysis gives us a way to determine how many units must be sold to earn a particular targeted income. Targeted operating income can be expressed as a dollar amount (e.g., \$20,000) or as a percentage of sales revenue (e.g., 15 percent of revenue). Both the operating income approach and the contribution margin approach can be easily adjusted to allow for targeted income.

Targeted Income as a Dollar Amount

Assume that More-Power Company wants to earn operating income of \$424,000. How many sanders must be sold to achieve this result? Using the operating income approach, we form the following equation:

$$\begin{aligned} \$424,000 &= (\$40 \times \text{Units}) - (\$24 \times \text{Units}) - \$800,000 \\ \$1,224,000 &= \$16 \times \text{Units} \\ \text{Units} &= 76,500 \end{aligned}$$

Using the contribution margin approach, we simply *add* targeted profit of \$424,000 to the fixed costs and solve for the number of units.

$$\begin{aligned} \text{Units} &= (\$800,000 + \$424,000) / (\$40 - \$24) \\ &= \$1,224,000 / \$16 \\ &= 76,500 \end{aligned}$$

More-Power must sell 76,500 sanders to earn a before-tax profit of \$424,000. The following income statement verifies this outcome:

Sales (76,500 units @ \$40)	\$3,060,000
Less: Variable expenses	<u>1,836,000</u>
Contribution margin	\$1,224,000
Less: Fixed expenses	<u>800,000</u>
Income before income taxes	<u>\$ 424,000</u>

Another way to check this number of units is to use the break-even point. As was just shown, More-Power must sell 76,500 sanders, or 26,500 more than the break-even volume of 50,000 units, to earn a profit of \$424,000. The contribution margin per sander is \$16. Multiplying \$16 by the 26,500 sanders *above* break-even produces the profit of \$424,000 (\$16 × 26,500). This outcome demonstrates that contribution margin per unit for each unit above break-even is equivalent to profit per unit. Since the break-even point had already been computed, the number of sanders to be sold to yield a \$424,000 operating income could have been calculated by dividing the unit

contribution margin into the target profit and adding the resulting amount to the break-even volume.

In general, assuming that fixed costs remain the same, the impact on a firm's profits resulting from a change in the number of units sold can be assessed by multiplying the unit contribution margin by the change in units sold. For example, if 80,000 sanders instead of 76,500 are sold, how much *more* profit will be earned? The change in units sold is an increase of 3,500 sanders, and the unit contribution margin is \$16. Thus, profits will increase by \$56,000 ($\$16 \times 3,500$).

Targeted Income as a Percent of Sales Revenue

Assume that More-Power Company wants to know the number of sanders that must be sold in order to earn a profit equal to 15 percent of sales revenue. Sales revenue is selling price multiplied by the quantity sold. Thus, the targeted operating income is 15 percent of selling price times quantity. Using the operating income approach (which is simpler in this case), we obtain the following:

$$\begin{aligned} 0.15(\$40)(\text{Units}) &= (\$40 \times \text{Units}) - (\$24 \times \text{Units}) - \$800,000 \\ \$6 \times \text{Units} &= (\$40 \times \text{Units}) - (\$24 \times \text{Units}) - \$800,000 \\ \$6 \times \text{Units} &= (\$16 \times \text{Units}) - \$800,000 \\ \$10 \times \text{Units} &= \$800,000 \\ \text{Units} &= 80,000 \end{aligned}$$

Does a volume of 80,000 sanders achieve a profit equal to 15 percent of sales revenue? For 80,000 sanders, the total revenue is \$3.2 million ($\$40 \times 80,000$). The profit can be computed without preparing a formal income statement. Remember that above break-even, the contribution margin per unit is the profit per unit. The break-even volume is 50,000 sanders. If 80,000 sanders are sold, then 30,000 ($80,000 - 50,000$) sanders above the break-even point are sold. The before-tax profit, therefore, is \$480,000 ($\$16 \times 30,000$), which is 15 percent of sales ($\$480,000/\$3,200,000$).

After-Tax Profit Targets

When calculating the break-even point, income taxes play no role. This is because the taxes paid on zero income are zero. However, when the company needs to know how many units to sell to earn a particular net income, some additional consideration is needed. Recall that net income is operating income after income taxes and that our targeted income figure was expressed in before-tax terms. As a result, when the income target is expressed as net income, we must add back the income taxes to get operating income. Therefore, to use either approach, the after-tax profit target must first be converted to a before-tax profit target.

In general, taxes are computed as a percentage of income. The after-tax profit is computed by subtracting the tax from the operating income (or before-tax profit).

$$\begin{aligned} \text{Net income} &= \text{Operating income} - \text{Income taxes} \\ &= \text{Operating income} - (\text{Tax rate} \times \text{Operating income}) \\ &= \text{Operating income}(1 - \text{Tax rate}) \end{aligned}$$

or

$$\text{Operating income} = \text{Net income}/(1 - \text{Tax rate})$$

Thus, to convert the after-tax profit to before-tax profit, simply divide the after-tax profit by the quantity $(1 - \text{Tax rate})$.

Suppose that More-Power Company wants to achieve net income of \$487,500 and its income tax rate is 35 percent. To convert the after-tax profit target into a before-tax profit target, complete the following steps:

$$\begin{aligned} \$487,500 &= \text{Operating income} - 0.35(\text{Operating income}) \\ \$487,500 &= 0.65(\text{Operating income}) \\ \$750,000 &= \text{Operating income} \end{aligned}$$

In other words, with an income tax rate of 35 percent, More-Power Company must earn \$750,000 before income taxes to have \$487,500 after income taxes.⁴ With this conversion, we can now calculate the number of units that must be sold.

$$\begin{aligned}\text{Units} &= (\$800,000 + \$750,000)/\$16 \\ &= \$1,550,000/\$16 \\ &= 96,875\end{aligned}$$

Let's check this answer by preparing an income statement based on sales of 96,875 sanders.

Sales (96,875 @ \$40)	\$3,875,000
Less: Variable expenses	<u>2,325,000</u>
Contribution margin	\$1,550,000
Less: Fixed expenses	<u>800,000</u>
Income before income taxes	\$ 750,000
Less: Income taxes (35% tax rate)	<u>262,500</u>
Net income	<u>\$ 487,500</u>

OBJECTIVE 2

Calculate the amount of revenue required to break even or to earn a targeted profit.

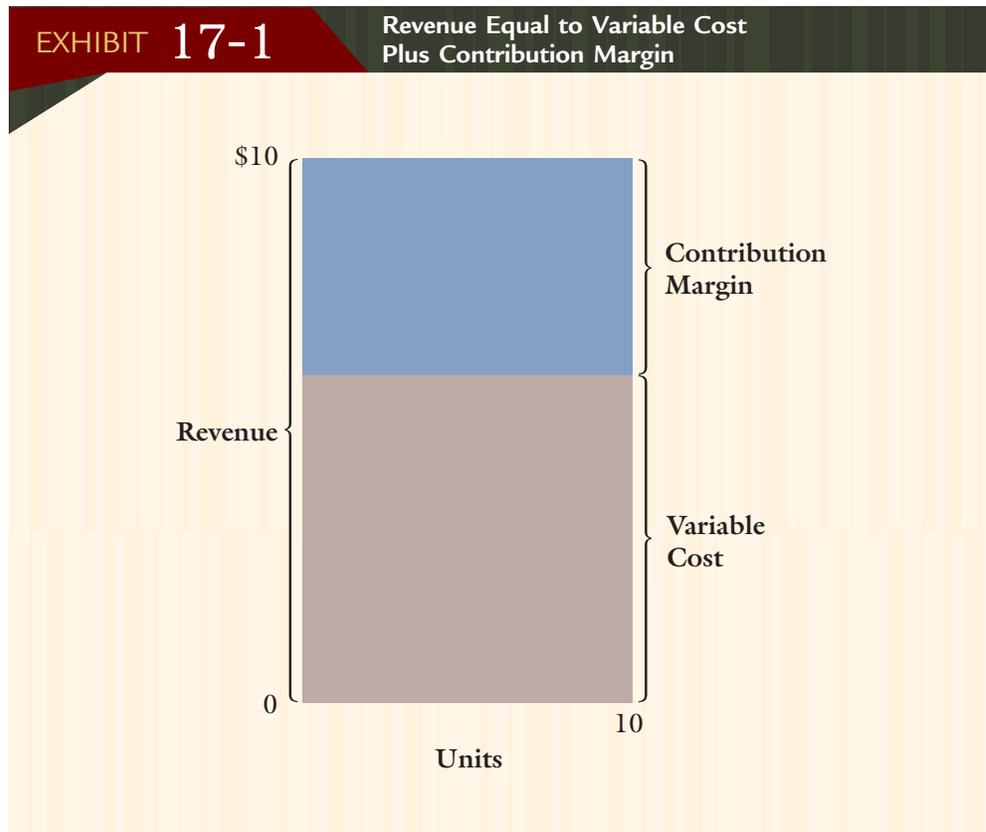
Break-Even Point in Sales Dollars

In some cases when using CVP analysis, managers may prefer to use sales revenue as the measure of sales activity instead of units sold. A units-sold measure can be converted to a sales-revenue measure simply by multiplying the unit sales price by the units sold. For example, the break-even point for More-Power Company was computed to be 50,000 sanders. Since the selling price for each sander is \$40, the break-even volume in sales revenue is \$2,000,000 ($\$40 \times 50,000$). Any answer expressed in units sold can be easily converted to one expressed in sales revenue, but the answer can be computed more directly by developing a separate formula for the sales-revenue case. In this case, the important variable is sales dollars, so both the revenue and the variable costs must be expressed in dollars instead of units. Since sales revenue is always expressed in dollars, measuring that variable is no problem. Let's look more closely at variable costs and see how they can be expressed in terms of sales dollars.

To calculate the break-even point in sales dollars, variable costs are defined as a percentage of sales rather than as an amount per unit sold. Exhibit 17-1 illustrates the division of sales revenue into variable cost and contribution margin. In this exhibit, price is \$10, and variable cost is \$6. Of course, the remainder is contribution margin of \$4 ($\$10 - \6). Focusing on 10 units sold, total variable costs are \$60 ($\6×10 units sold). Alternatively, since each unit sold earns \$10 of revenue, we would say that for every \$10 of revenue earned, \$6 of variable costs are incurred, or, equivalently, that 60 percent of each dollar of revenue earned is attributable to variable cost ($\$6/\10). Thus, focusing on sales revenue, we would expect total variable costs of \$60 for revenues of \$100 ($0.60 \times \$100$).

In expressing variable cost in terms of sales dollars, we computed the **variable cost ratio**. It is simply the proportion of each sales dollar that must be used to cover variable costs. The variable cost ratio can be computed by using either total data or unit data. Of course, the percentage of sales dollars remaining after variable costs are covered is the contribution margin ratio. The **contribution margin ratio** is the proportion of each sales dollar available to cover fixed costs and provide for profit. In Exhibit 17-1, if the variable cost ratio is 60 percent of sales, then the contribution margin must be the remaining 40 percent of sales. It makes sense that the complement of the variable cost ratio is the contribution margin ratio. After all, the proportion

4. To practice the after-tax to before-tax conversion, calculate how much before-tax income More-Power would need to have \$487,500 in after-tax income if the tax rate were 40 percent. [Answer: \$812,500]



of the sales dollars left after variable costs are covered should be the contribution margin component.

Just as the variable cost ratio can be computed using total or unit figures, the contribution margin ratio (40 percent in our exhibit) can also be computed in these two ways. That is, one can divide the total contribution margin by total sales ($\$40/\100), or one can use unit contribution margin divided by price ($\$4/\10). Naturally, if the variable cost ratio is known, it can be subtracted from one to yield the contribution margin ratio ($1 - 0.60 = 0.40$).

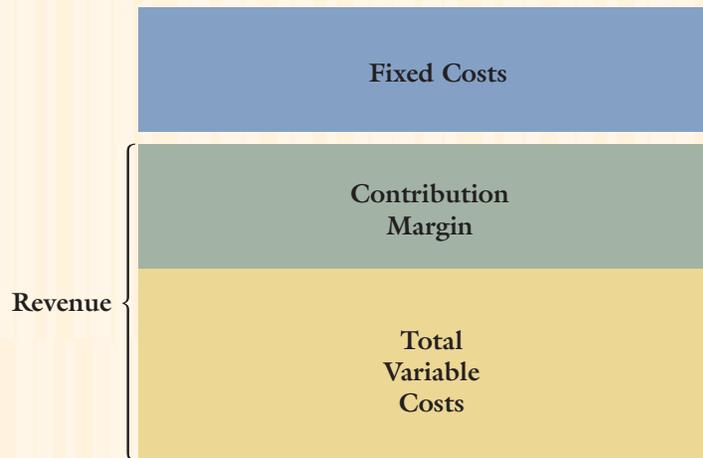
Where do fixed costs fit into this? Since the contribution margin is revenue remaining after variable costs are covered, it must be the revenue available to cover fixed costs and contribute to profit. Exhibit 17-2 uses the same price and variable cost data from Exhibit 17-1 to show the impact of fixed costs on profit. Panel A of Exhibit 17-2 shows the amount of fixed costs equal to the contribution margin. Of course, profit is zero. (The company is at break-even.) Panel B shows fixed costs less than the contribution margin. In this case, the company earns a profit. Finally, Panel C shows fixed costs greater than the contribution margin. Here, the company faces an operating loss.

Now, let's turn to a couple of examples based on More-Power Company to illustrate the **sales-revenue approach**. Restated below is More-Power Company's variable-costing income statement for 72,500 sanders.

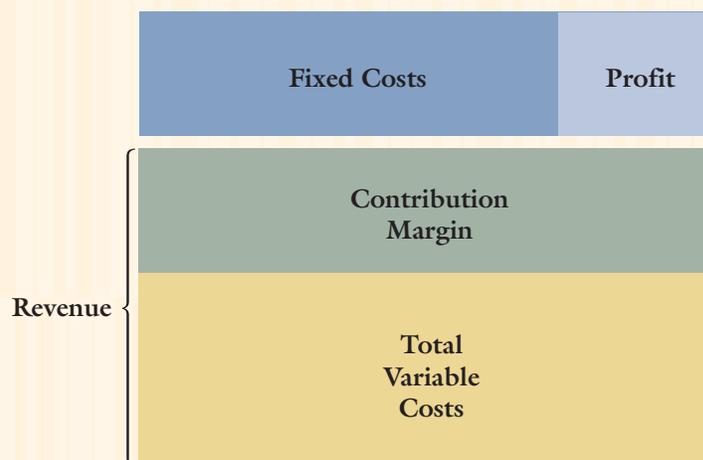
	<i>Dollars</i>	<i>Percent of Sales</i>
Sales	\$2,900,000	100%
Less: Variable costs	<u>1,740,000</u>	<u>60</u>
Contribution margin	\$1,160,000	<u>40%</u>
Less: Fixed costs	<u>800,000</u>	
Operating income	<u>\$ 360,000</u>	

EXHIBIT 17-2**Impact of Fixed Costs on Profit**

Panel A: Fixed Costs = Contribution Margin; Profit = 0



Panel B: Fixed Costs < Contribution Margin; Profit > 0



Panel C: Fixed Costs > Contribution Margin; Profit < 0



Notice that sales revenue, variable costs, and contribution margin have been expressed in the form of percent of sales. The variable cost ratio is 0.60 (\$1,740,000/\$2,900,000); the contribution margin ratio is 0.40 (computed either as $1 - 0.60$ or as $\$1,160,000/\$2,900,000$). Fixed costs are \$800,000. Given the information in this income statement, how much sales revenue must More-Power earn to break even?

$$\begin{aligned}\text{Operating income} &= \text{Sales} - \text{Variable costs} - \text{Fixed costs} \\ 0 &= \text{Sales} - (\text{Variable cost ratio} \times \text{Sales}) - \text{Fixed costs} \\ 0 &= \text{Sales}(1 - \text{Variable cost ratio}) - \text{Fixed costs} \\ 0 &= \text{Sales}(1 - 0.60) - \$800,000 \\ \text{Sales}(0.40) &= \$800,000 \\ \text{Sales} &= \$2,000,000\end{aligned}$$

Thus, More-Power must earn revenues totaling \$2,000,000 in order to break even. (You might want to check this answer by preparing an income statement based on revenue of \$2,000,000 and verifying that it yields zero profit.) Note that $1 - 0.60$ is the contribution margin ratio. We can skip a couple of steps by recognizing that $\text{Sales} - (\text{Variable cost ratio} \times \text{Sales})$ is equal to $\text{Sales} \times \text{Contribution margin ratio}$.

What about the contribution margin approach used in determining the break-even point in units? We can use that approach here as well. Recall that the formula for the break-even point in units is as follows:

$$\text{Break-even point in units} = \text{Fixed costs}/(\text{Price} - \text{Unit variable cost})$$

If we multiply both sides of the above equation by price, the left-hand side will equal sales revenue at break-even.

$$\begin{aligned}\text{Break-even units} \times \text{Price} &= \text{Price} [\text{Fixed costs}/(\text{Price} - \text{Unit variable cost})] \\ \text{Break-even sales} &= \text{Fixed costs} \times [\text{Price}/(\text{Price} - \text{Unit variable cost})] \\ \text{Break-even sales} &= \text{Fixed costs} \times (\text{Price}/\text{Contribution margin}) \\ \text{Break-even sales} &= \text{Fixed costs}/\text{Contribution margin ratio}\end{aligned}$$

Again, using More-Power Company data, the break-even sales dollars would be computed as $\$800,000/0.40$, or \$2,000,000. Same answer, just a slightly different approach.

Profit Targets

Consider the following question: How much sales revenue must More-Power generate to earn a before-tax profit of \$424,000? (This question is similar to the one we asked earlier in terms of units, but the question is phrased directly in terms of sales revenue.) To answer the question, using the contribution margin approach, add targeted operating income of \$424,000 to the \$800,000 of fixed costs and divide by the contribution margin ratio.

$$\begin{aligned}\text{Sales} &= (\$800,000 + \$424,000)/0.40 \\ &= \$1,224,000/0.40 \\ &= \$3,060,000\end{aligned}$$

More-Power must earn revenues equal to \$3,060,000 to achieve a profit target of \$424,000. Since break-even is \$2,000,000, additional sales of \$1,060,000 ($\$3,060,000 - \$2,000,000$) must be earned above break-even. Notice that multiplying the contribution margin ratio by revenues above break-even yields the profit of \$424,000 ($0.40 \times \$1,060,000$). Above break-even, the contribution margin ratio is a profit ratio; therefore, it represents the proportion of each sales dollar assignable to profit. For this example, every sales dollar earned above break-even increases profits by \$0.40.

In general, assuming that fixed costs remain unchanged, the contribution margin ratio can be used to find the profit impact of a change in sales revenue. To obtain the total change in profits from a change in revenue, simply multiply the contribution margin ratio by the change in sales. For example, if sales revenue is \$3,000,000 instead of

\$3,060,000, how will the expected profits be affected? A decrease in sales revenue of \$60,000 will cause a decrease in profits of \$24,000 ($0.40 \times \$60,000$).

Comparison of the Two Approaches

For a single-product setting, converting the break-even point in units answer to a sales-revenue answer is simply a matter of multiplying the unit sales price by the units sold. Then why bother with a separate formula for the sales-revenue approach? For a single-product setting, neither approach has any real advantage over the other. Both offer much the same level of conceptual and computational difficulty.

However, in a multiple-product setting, CVP analysis is more complex, and the sales-revenue approach is significantly easier. This approach maintains essentially the same computational requirements found in the single-product setting, whereas the units-sold approach becomes more difficult. Even though the conceptual complexity of CVP analysis does increase with multiple products, the operation is reasonably straightforward.

OBJECTIVE 3

Apply cost-volume-profit analysis in a multiple-product setting.

Multiple-Product Analysis

More-Power Company has decided to offer two models of sanders: a regular sander to sell for \$40 and a mini-sander, with an assortment of drill-like tips that will fit into tight corners and grooves, to sell for \$60. The marketing department is convinced that 75,000 regular sanders and 30,000 mini-sanders can be sold during the coming year. The controller has prepared the following projected income statement based on the sales forecast:

	<i>Regular Sander</i>	<i>Mini-Sander</i>	<i>Total</i>
Sales	\$3,000,000	\$1,800,000	\$4,800,000
Less: Variable expenses	<u>1,800,000</u>	<u>900,000</u>	<u>2,700,000</u>
Contribution margin	\$1,200,000	\$ 900,000	\$2,100,000
Less: Direct fixed expenses	<u>250,000</u>	<u>450,000</u>	<u>700,000</u>
Product margin	<u>\$ 950,000</u>	<u>\$ 450,000</u>	\$1,400,000
Less: Common fixed expenses			<u>600,000</u>
Operating income			<u>\$ 800,000</u>

Note that the controller has separated direct fixed expenses from common fixed expenses. The **direct fixed expenses** are those fixed costs which can be traced to each segment and would be avoided if the segment did not exist. The **common fixed expenses** are the fixed costs that are not traceable to the segments and that would remain even if one of the segments was eliminated.

Break-Even Point in Units

The owner of More-Power is somewhat apprehensive about adding a new product line and wants to know how many of each model must be sold to break even. If you were given the responsibility to answer this question, how would you respond?

One possible response is to use the equation we developed earlier in which fixed costs were divided by the contribution margin. This equation presents some immediate problems, however. It was developed for a single-product analysis. For two products, there are two unit contribution margins. The regular sander has a contribution margin per unit of \$16 ($\$40 - \24), and the mini-sander has one of \$30 ($\$60 - \30).⁵

5. The variable cost per unit is derived from the income statement. For the mini-sander, total variable costs are \$900,000 based on sales of 30,000 units. This yields a per-unit variable cost of \$30 ($\$900,000/30,000$). A similar computation produces the per-unit variable cost for the regular sander.

One possible solution is to apply the analysis separately to each product line. It is possible to obtain individual break-even points when income is defined as product margin. Break-even for the regular sander is as follows:

$$\begin{aligned} & \text{Regular sander break-even units} \\ &= \text{Fixed costs}/(\text{Price} - \text{Unit variable cost}) \\ &= \$250,000/\$16 \\ &= 15,625 \text{ units} \end{aligned}$$

Break-even for the mini-sander can be computed as well.

$$\begin{aligned} & \text{Mini-sander break-even units} \\ &= \text{Fixed costs}/(\text{Price} - \text{Unit variable cost}) \\ &= \$450,000/\$30 \\ &= 15,000 \text{ units} \end{aligned}$$

Thus, 15,625 regular sanders and 15,000 mini-sanders must be sold to achieve a break-even product margin. But a break-even product margin covers only direct fixed costs; the common fixed costs remain to be covered. Selling these numbers of sanders would result in a loss equal to the common fixed costs. No break-even point for the firm as a whole has yet been identified. Somehow, the common fixed costs must be factored into the analysis.

Allocating the common fixed costs to each product line before computing a break-even point may resolve this difficulty. The problem with this approach is that allocation of the common fixed costs is arbitrary. Thus, no meaningful break-even volume is readily apparent.

Another possible solution is to convert the multiple-product problem into a single-product problem. If this can be done, then all of the single-product CVP methodology can be applied directly. The key to this conversion is to identify the expected sales mix, in units, of the products being marketed.

Sales Mix

Sales mix is the relative combination of products being sold by a firm. Sales mix can be measured in units sold or in proportion of revenue. For example, if More-Power plans on selling 75,000 regular sanders and 30,000 mini-sanders, then the sales mix in units is 75,000:30,000. Usually, the sales mix is reduced to the smallest possible whole numbers. Thus, the relative mix 75,000:30,000 can be reduced to 75:30 and further to 5:2. That is, for every five regular sanders sold, two mini-sanders are sold.

Alternatively, the sales mix can be represented by the percent of total revenue contributed by each product. In that case, the regular sander revenue is \$3,000,000 ($\$40 \times 75,000$), and the mini-sander revenue is \$1,800,000 ($\$60 \times 30,000$). The regular sander accounts for 62.5 percent of total revenue, and the mini-sander accounts for the remaining 37.5 percent. It may seem as though the two sales mixes are different. The sales mix in units is 5:2; that is, of every five sanders sold, about 71 percent are regular sanders and about 29 percent are mini-sanders. However, the revenue-based sales mix is 62.5 percent for the regular sanders. There is really no difference. The sales mix in revenue takes the sales mix in units and weights it by price. Therefore, even though the underlying proportion of sanders sold remains 5:2, the lower priced regular sanders are weighted less heavily when price is factored in. In the remaining discussion, we will use the sales mix expressed in units.

A number of different sales mixes can be used to define the break-even volume. For example, a sales mix of 2:1 will define a break-even point of 41,935 regular sanders and 20,968 mini-sanders. The total contribution margin produced by this mix is \$1,300,000 [$(\$16 \times 41,935) + (\$30 \times 20,968)$]. Similarly, if 28,261 regular sanders and 28,261 mini-sanders are sold (corresponding to a 1:1 sales mix), the total contribution margin is also \$1,300,000⁶ [$(\$16 \times 28,261) + (\$30 \times 28,261)$]. Since total

6. Actually, the contribution margin is \$1,300,006 due to rounding.

fixed costs are \$1,300,000, both sales mixes define break-even points. Fortunately, every sales mix need not be considered. Can More-Power really expect a sales mix of 2:1 or 1:1? For every two regular sanders sold, does More-Power expect to sell a mini-sander? Or for every regular sander, can More-Power really sell one mini-sander?

According to More-Power's marketing study, a sales mix of 5:2 can be expected. This is the ratio that should be used; the others can be ignored. The sales mix that is expected to prevail should be used for CVP analysis.

Sales Mix and CVP Analysis

Defining a particular sales mix allows us to convert a multiple-product problem to a single-product CVP format. Since More-Power expects to sell five regular sanders for every two mini-sanders, it can define the single product it sells as a package containing five regular sanders and two mini-sanders. By defining the product as a package, the multiple-product problem is converted into a single-product one. To use the break-even-point-in-units approach, the package selling price and variable cost per package must be known. To compute these package values, the sales mix, the individual product prices, and the individual variable costs are needed. Given the individual product data found on the projected income statement, the package values can be computed as follows:

<i>Product</i>	<i>Price</i>	<i>Unit Variable Cost</i>	<i>Unit Contribution Margin</i>	<i>Sales Mix</i>	<i>Package Unit Contribution Margin</i>
Regular sander	\$40	\$24	\$16	5	\$ 80 ^a
Mini-sander	60	30	30	2	<u>60^b</u>
Package total					<u>\$140</u>

^aFound by multiplying the number of units in the package (5) by the unit contribution margin (\$16).

^bFound by multiplying the number of units in the package (2) by the unit contribution margin (\$30).

Given the package contribution margin, the single-product CVP equation can be used to determine the number of packages that need to be sold to break even. From More-Power's projected income statement, we know that the total fixed costs for the company are \$1,300,000. Thus, the break-even point is computed as follows:

$$\begin{aligned}
 \text{Break-even point} &= \text{Fixed cost/Package contribution margin} \\
 &= \$1,300,000/\$140 \\
 &= 9,285.71 \text{ packages}
 \end{aligned}$$

More-Power must sell 46,429 regular sanders ($5 \times 9,285.71$) and 18,571 mini-sanders ($2 \times 9,285.71$) to break even. (Notice that the packages are not rounded off to a whole number. This is because the number of packages is not an end in itself. The decimal amount may be important when it is multiplied by the sales mix. However, it is important to round the number of sanders to whole units, since no one will buy a fraction of a sander.) An income statement verifying this solution is presented in Exhibit 17-3 on the following page.

For a given sales mix, CVP analysis can be used as if the firm were selling a single product. However, actions that change the prices of individual products can affect the sales mix because consumers may buy relatively more or less of the product. Accordingly, pricing decisions may involve a new sales mix and must reflect this possibility. Keep in mind that a new sales mix will affect the units of each product that need to be sold in order to achieve a desired profit target. If the sales mix for the coming period is uncertain, it may be necessary to look at several different mixes. In this way, a manager can gain some insight into the possible outcomes facing the firm.

The complexity of the break-even-point-in-units approach increases dramatically as the number of products increases. Imagine performing this analysis for a firm with

EXHIBIT 17-3		Income Statement: Break-Even Solution		
	Regular Sander	Mini-Sander	Total	
Sales	\$1,857,160	\$1,114,260	\$2,971,420	
Less: Variable expenses	<u>1,114,296</u>	<u>557,130</u>	<u>1,671,426</u>	
Contribution margin	\$ 742,864	\$ 557,130	\$1,299,994	
Less: Direct fixed expenses	<u>250,000</u>	<u>450,000</u>	<u>700,000</u>	
Product margin	<u>\$ 492,864</u>	<u>\$ 107,130</u>	\$ 599,994	
Less: Common fixed expenses			<u>600,000</u>	
Operating income*			<u>\$ (6)</u>	

*Operating income is not exactly equal to zero due to rounding.

several hundred products. This observation seems more overwhelming than it actually is. Computers can easily handle a problem with so much data. Furthermore, many firms simplify the problem by analyzing product groups rather than individual products. Another way to handle the increased complexity is to switch from the units-sold to the sales-revenue approach. This approach can accomplish a multiple-product CVP analysis using only the summary data found in an organization's income statement. The computational requirements are much simpler.

Sales Dollars Approach

To illustrate the break-even point in sales dollars, the same examples will be used. However, the only information needed is the projected income statement for More-Power Company as a whole.

Sales	\$4,800,000
Less: Variable costs	<u>2,700,000</u>
Contribution margin	\$2,100,000
Less: Fixed costs	<u>1,300,000</u>
Operating income	<u>\$ 800,000</u>

Notice that this income statement corresponds to the total column of the more detailed income statement examined previously. The projected income statement rests on the assumption that 75,000 regular sanders and 30,000 mini-sanders will be sold (a 5:2 sales mix). The break-even point in sales revenue also rests on the expected sales mix. (As with the units-sold approach, a different sales mix will produce different results.)

With the income statement, the usual CVP questions can be addressed. For example, how much sales revenue must be earned to break even? To answer this question, we divide the total fixed costs of \$1,300,000 by the contribution margin ratio of 0.4375 (\$2,100,000/\$4,800,000).

$$\begin{aligned}
 \text{Break-even sales} &= \text{Fixed costs} / \text{Contribution margin ratio} \\
 &= \$1,300,000 / 0.4375 \\
 &= \$2,971,429
 \end{aligned}$$

The break-even point in sales dollars implicitly uses the assumed sales mix but avoids the requirement of building a package contribution margin. No knowledge of individual product data is needed. The computational effort is similar to that used in the single-product setting. Moreover, the answer is still expressed in sales revenue. Unlike the break-even point in units, the answer to CVP questions using sales dollars is still ex-

pressed in a single summary measure. The sales-revenue approach, however, does sacrifice information concerning individual product performance.

OBJECTIVE 4

Prepare a profit-volume graph and a cost-volume-profit graph, and explain the meaning of each.

Graphical Representation of CVP Relationships

Visual portrayals may further our understanding of CVP relationships. A graphical representation can help managers see the difference between variable cost and revenue. It may also help managers understand quickly what impact an increase or decrease in sales will have on the break-even point. Two basic graphs, the profit-volume graph and the cost-volume-profit graph, are presented here.

The Profit-Volume Graph

A **profit-volume graph** visually portrays the relationship between profits and sales volume. The profit-volume graph is the graph of the operating income equation [Operating income = (Price \times Units) – (Unit variable cost \times Units) – Fixed costs]. In this graph, operating income (profit) is the dependent variable, and units is the independent variable. Usually, values of the independent variable are measured along the horizontal axis and values of the dependent variable along the vertical axis.

To make this discussion more concrete, a simple set of data will be used. Assume that Tyson Company produces a single product with the following cost and price data:

Total fixed costs	\$100
Variable cost per unit	5
Selling price per unit	10

Using these data, operating income can be expressed as follows:

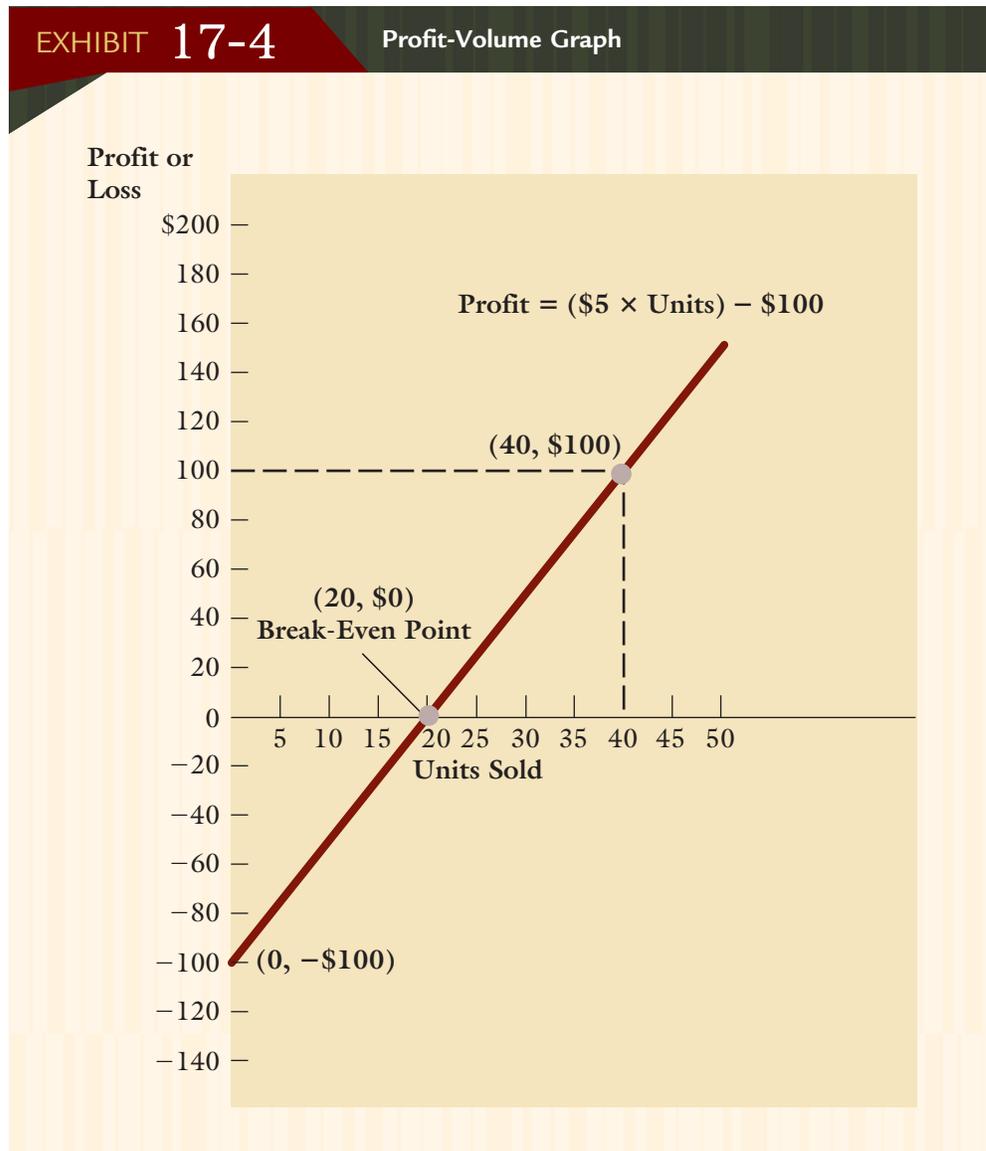
$$\begin{aligned}\text{Operating income} &= (\$10 \times \text{Units}) - (\$5 \times \text{Units}) - \$100 \\ &= (\$5 \times \text{Units}) - \$100\end{aligned}$$

We can graph this relationship by plotting units along the horizontal axis and operating income (or loss) along the vertical axis. Two points are needed to graph a linear equation. While any two points will do, the two points often chosen are those that correspond to zero sales volume and zero profits. When units sold are zero, Tyson experiences an operating loss of \$100 (or a profit of $-\$100$). The point corresponding to zero sales volume, therefore, is (0, $-\$100$). In other words, when no sales take place, the company suffers a loss equal to its total fixed costs. When operating income is zero, the units sold are equal to 20. The point corresponding to zero profits (break-even) is (20, \$0). These two points, plotted in Exhibit 17-4 on the following page, define the profit graph shown in the same figure.

The graph in Exhibit 17-4 can be used to assess Tyson's profit (or loss) at any level of sales activity. For example, the profit associated with the sale of 40 units can be read from the graph by (1) drawing a vertical line from the horizontal axis to the profit line and (2) drawing a horizontal line from the profit line to the vertical axis. As illustrated in Exhibit 17-4, the profit associated with sales of 40 units is \$100. The profit-volume graph, while easy to interpret, fails to reveal how costs change as sales volume changes. An alternative approach to graphing can provide this detail.

The Cost-Volume-Profit Graph

The **cost-volume-profit graph** depicts the relationships among cost, volume, and profits. To obtain the more detailed relationships, it is necessary to graph two separate lines:



the total revenue line and the total cost line. These lines are represented, respectively, by the following two equations:

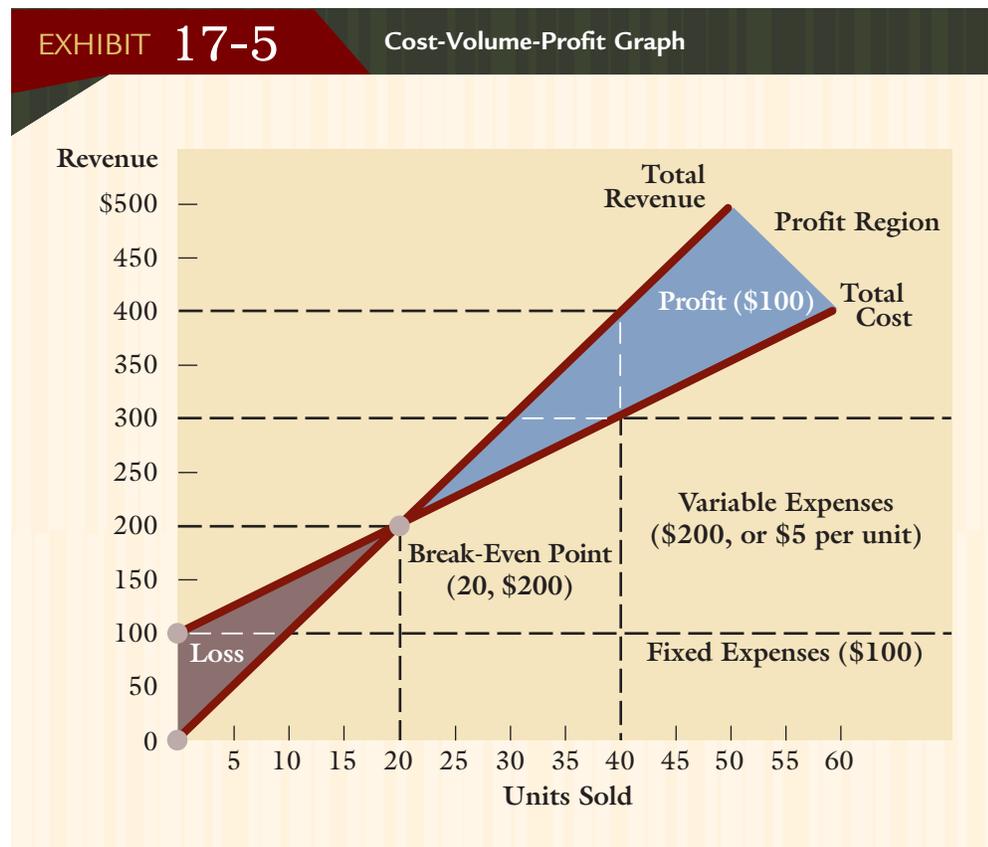
$$\begin{aligned} \text{Revenue} &= \text{Price} \times \text{Units} \\ \text{Total cost} &= (\text{Unit variable cost} \times \text{Units}) + \text{Fixed costs} \end{aligned}$$

Using the Tyson Company example, the revenue and cost equations are as follows:

$$\begin{aligned} \text{Revenue} &= \$10 \times \text{Units} \\ \text{Total cost} &= (\$5 \times \text{Units}) + \$100 \end{aligned}$$

To portray both equations in the same graph, the vertical axis is measured in dollars and the horizontal axis in units sold.

Two points are needed to graph each equation. We will use the same x-coordinates used for the profit-volume graph. For the revenue equation, setting number of units equal to zero results in revenue of \$0; setting number of units equal to 20 results in revenue of \$200. Therefore, the two points for the revenue equation are (0, \$0) and (20, \$200). For the cost equation, units sold of zero and units sold equal to 20 produce the points (0, \$100) and (20, \$200). The graphs of both equations appear in Exhibit 17-5.



Notice that the total revenue line begins at the origin and rises with a slope equal to the selling price per unit (a slope of 10). The total cost line intercepts the vertical axis at a point equal to total fixed costs and rises with a slope equal to the variable cost per unit (a slope of 5). When the total revenue line lies below the total cost line, a loss region is defined. Similarly, when the total revenue line lies above the total cost line, a profit region is defined. The point where the total revenue line and the total cost line intersect is the break-even point. To break even, Tyson Company must sell 20 units and thus receive \$200 in total revenues.

Now, let's compare the information available from the CVP graph to that available from the profit-volume graph. To do so, consider the sale of 40 units. Recall that the profit-volume graph revealed that selling 40 units produced profits of \$100. Examine Exhibit 17-5 again. The CVP graph also shows profits of \$100, but it reveals more than that. The CVP graph discloses that total revenues of \$400 and total costs of \$300 are associated with the sale of 40 units. Furthermore, the total costs can be broken down into fixed costs of \$100 and variable costs of \$200. The CVP graph provides revenue and cost information not provided by the profit-volume graph. Unlike the profit-volume graph, some computation is needed to determine the profit associated with a given sales volume. Nonetheless, because of the greater information content, managers are likely to find the CVP graph a more useful tool.

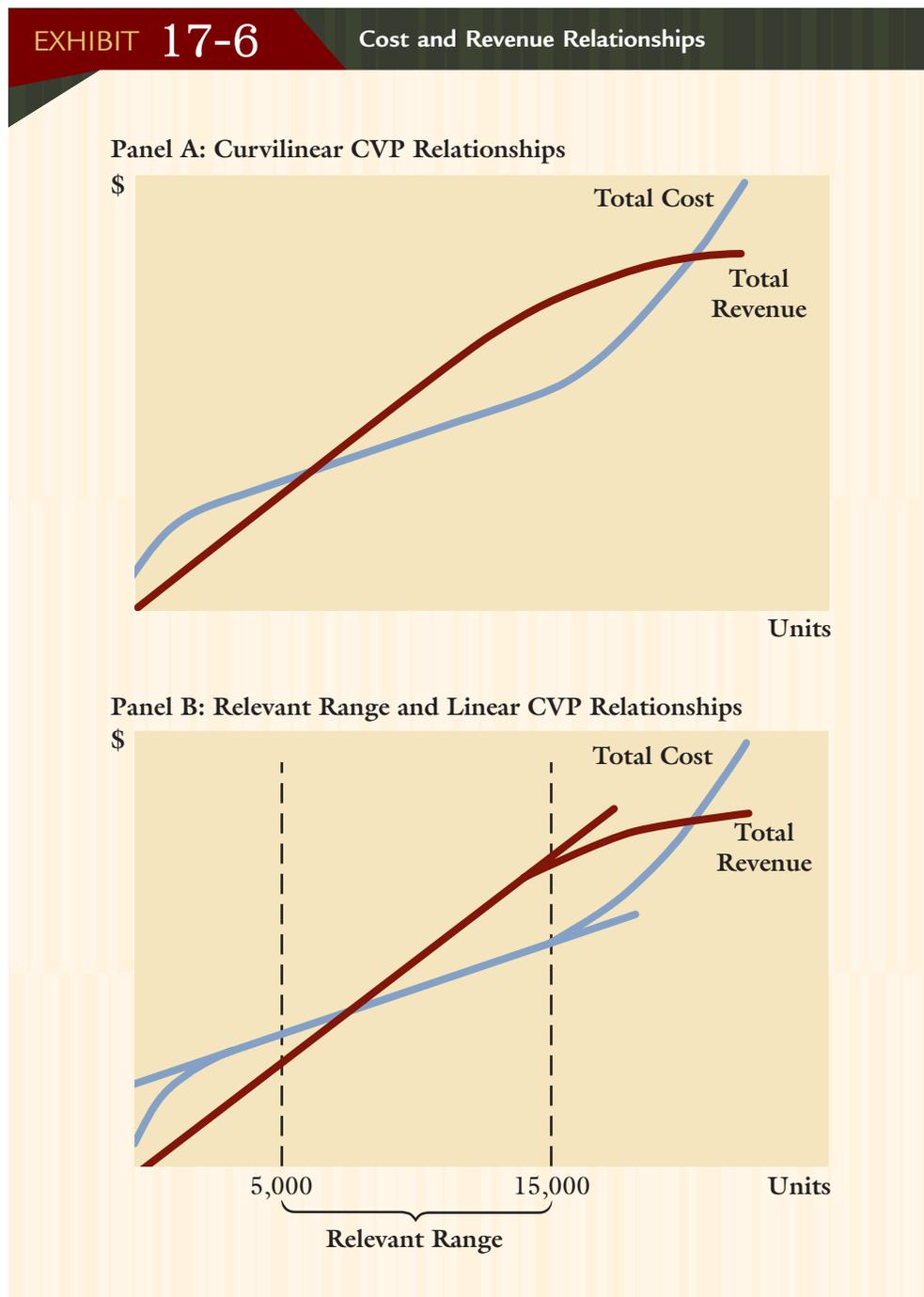
Assumptions of Cost-Volume-Profit Analysis

The profit-volume and cost-volume-profit graphs just illustrated rely on some important assumptions. Some of these assumptions are as follows:

1. The analysis assumes a linear revenue function and a linear cost function.
2. The analysis assumes that price, total fixed costs, and unit variable costs can be accurately identified and remain constant over the relevant range.
3. The analysis assumes that what is produced is sold.

4. For multiple-product analysis, the sales mix is assumed to be known.
5. The selling prices and costs are assumed to be known with certainty.

The first assumption, linear cost and revenue functions, deserves additional consideration. Let's take a look at the underlying revenue and total cost functions identified in economics. Exhibit 17-6, Panel A, portrays the curvilinear revenue and cost functions. We see that as quantity sold increases, revenue also increases, but eventually revenue begins to rise less steeply than before. This is explained quite simply by the need to decrease price as many more units are sold. The total cost function is more complicated, rising steeply at first, then leveling off somewhat (as increasing returns to scale develop), and then rising steeply again (as decreasing returns to scale develop). How can we deal with these complicated relationships?



Relevant Range

Fortunately, we do not need to consider all possible ranges of production and sales for a firm. Remember that CVP analysis is a short-run decision-making tool. (We know that it is short run in orientation because some costs are fixed.) It is only necessary for us to determine the current operating range, or **relevant range**, for which the linear cost and revenue relationships are valid. Exhibit 17-6, Panel B, illustrates a relevant range from 5,000 to 15,000 units. Note that the cost and revenue relationships are roughly linear in this range, allowing us to use our linear CVP equations. Of course, if the relevant range changes, different fixed and variable costs and different prices must be used.

The second assumption is linked to the definition of relevant range. Once a relevant range has been identified, then the cost and price relationships are assumed to be known and constant.

Production Equal to Sales

The third assumption is that what is produced is sold. There is no change in inventory over the period. The fact that inventory has no impact on break-even analysis makes sense. Break-even analysis is a short-run decision-making technique, so we are looking to cover all costs of a particular period of time. Inventory embodies costs of a previous period and is not considered.

Constant Sales Mix

The fourth assumption is a constant sales mix. In single-product analysis, the sales mix is obviously constant—100 percent of sales is applied to one product. Multiple-product break-even analysis requires a constant sales mix. However, it is virtually impossible to predict the sales mix with certainty. Typically, this constraint is handled in practice through sensitivity analysis. By using the capabilities of spreadsheet analysis, the sensitivity of variables to a variety of sales mixes can be readily assessed.

Prices and Costs Known with Certainty

Finally, the fifth assumption is that prices and costs are known. In actuality, firms seldom know variable costs and fixed costs with certainty. A change in one variable usually affects the value of others. Often, there is a probability distribution with which to contend. Furthermore, there are formal ways of explicitly building uncertainty into the CVP model. Exploration of these issues is introduced in the next section.

OBJECTIVE 5

Explain the impact of risk, uncertainty, and changing variables on cost-volume-profit analysis.

Changes in the CVP Variables

Because firms operate in a dynamic world, they must be aware of changes in prices, variable costs, and fixed costs. They must also account for the effects of risk and uncertainty. We will take a look at the effects on the break-even point of changes in price, unit variable cost, and fixed costs. We will also look at ways managers can handle risk and uncertainty within the CVP framework.

Let's return to the More-Power Company example before the mini-sander was introduced. (That is, only the regular sander is produced.) Suppose that the Sales Department recently conducted a market study that revealed three different alternatives.

Alternative 1: If advertising expenditures increase by \$48,000, sales will increase from 72,500 units to 75,000 units.

Alternative 2: A price decrease from \$40 per sander to \$38 per sander would increase sales from 72,500 units to 80,000 units.

Alternative 3: Decreasing prices to \$38 and increasing advertising expenditures by \$48,000 will increase sales from 72,500 units to 90,000 units.

Should More-Power maintain its current price and advertising policies, or should it select one of the three alternatives described by the marketing study?

Consider the first alternative. What is the effect on profits if advertising costs increase by \$48,000 and sales increase by 2,500 units? This question can be answered without using the equations but by employing the contribution margin per unit. We know that the unit contribution margin is \$16. Since units sold increase by 2,500, the incremental increase in total contribution margin is \$40,000 ($\$16 \times 2,500$ units). However, since fixed costs increase by \$48,000, profits will actually decrease by \$8,000 ($\$48,000 - \$40,000$). Exhibit 17-7 summarizes the effects of the first alternative. Notice that we need to look only at the incremental increase in total contribution margin and fixed expenses to compute the increase in total profits.

EXHIBIT 17-7		Summary of the Effects of the First Alternative	
	Before the Increased Advertising	With the Increased Advertising	
Units sold	72,500	75,000	
Unit contribution margin	<u>× \$16</u>	<u>× \$16</u>	
Total contribution margin	\$1,160,000	\$1,200,000	
Less: Fixed expenses	<u>800,000</u>	<u>848,000</u>	
Profit	<u>\$ 360,000</u>	<u>\$ 352,000</u>	
Difference in Profit			
Change in sales volume		2,500	
Unit contribution margin		<u>× \$16</u>	
Change in contribution margin		\$40,000	
Less: Increase in fixed expenses		<u>48,000</u>	
Decrease in profit		<u>\$ (8,000)</u>	

For the second alternative, fixed expenses do not increase. Thus, it is possible to answer the question by looking only at the effect on total contribution margin. For the current price of \$40, the contribution margin per unit is \$16. If 72,500 units are sold, the total contribution margin is \$1,160,000 ($\$16 \times 72,500$). If the price is dropped to \$38, then the contribution margin drops to \$14 per unit ($\$38 - \24). If 80,000 units are sold at the new price, then the new total contribution margin is \$1,120,000 ($\$14 \times 80,000$). Dropping the price results in a profit decline of \$40,000 ($\$1,160,000 - \$1,120,000$). The effects of the second alternative are summarized in Exhibit 17-8.

The third alternative calls for a decrease in the unit selling price and an increase in advertising costs. Like the first alternative, the profit impact can be assessed by looking at the incremental effects on contribution margin and fixed expenses. The incremental profit change can be found by (1) computing the incremental change in total contribution margin, (2) computing the incremental change in fixed expenses, and (3) adding the two results.

As shown, the current total contribution margin (for 72,500 units sold) is \$1,160,000. Since the new unit contribution margin is \$14, the new total contribution margin is \$1,260,000 ($\$14 \times 90,000$ units). Thus, the incremental increase in total contribution margin is \$100,000 ($\$1,260,000 - \$1,160,000$). However, to achieve this incremental increase in contribution margin, an incremental increase of \$48,000 in fixed costs is needed. The net effect is an incremental increase in profits of \$52,000. The effects of the third alternative are summarized in Exhibit 17-9.

EXHIBIT 17-8**Summary of the Effects of the Second Alternative**

	Before the Proposed Price Increase	With the Proposed Price Increase
Units sold	72,500	80,000
Unit contribution margin	× \$16	× \$14
Total contribution margin	<u>\$1,160,000</u>	<u>\$1,120,000</u>
Less: Fixed expenses	<u>800,000</u>	<u>800,000</u>
Profit	<u>\$ 360,000</u>	<u>\$ 320,000</u>
Difference in Profit		
Change in contribution margin (\$1,160,000 – \$1,120,000)		\$(40,000)
Less: Change in fixed expenses		<u>—</u>
Decrease in profit		<u><u>\$(40,000)</u></u>

EXHIBIT 17-9**Summary of the Effects of the Third Alternative**

	Before the Proposed Price and Advertising Change	With the Proposed Price Decrease and Advertising Increase
Units sold	72,500	90,000
Unit contribution margin	× \$16	× \$14
Total contribution margin	<u>\$1,160,000</u>	<u>\$1,260,000</u>
Less: Fixed expenses	<u>800,000</u>	<u>848,000</u>
Profit	<u>\$ 360,000</u>	<u>\$ 412,000</u>
Difference in Profit		
Change in contribution margin (\$1,260,000 – \$1,160,000)		\$100,000
Less: Change in fixed expenses (\$848,000 – \$800,000)		<u>48,000</u>
Increase in profit		<u><u>\$ 52,000</u></u>

Of the three alternatives identified by the marketing study, the only one that promises a benefit is the third. It increases total profits by \$52,000. Both the first and second alternatives actually decrease profits.

These examples are all based on a units-sold approach. However, we could just as easily have applied a sales-revenue approach. The answers would be the same.

Introducing Risk and Uncertainty

An important assumption of CVP analysis is that prices and costs are known with certainty. This is seldom the case. Risk and uncertainty are a part of business decision making and must be dealt with in some manner. Formally, risk differs from uncertainty in

that with risk, the probability distributions of the variables are known. With uncertainty, the probability distributions are not known. For our purposes, however, the terms will be used interchangeably.

How do managers deal with risk and uncertainty? A variety of methods may be used. First, of course, management must realize the uncertain nature of future prices, costs, and quantities. Next, managers move from consideration of a break-even point to what might be called a break-even band. In other words, given the uncertain nature of the data, perhaps a firm might break even when 1,800 to 2,000 units are sold—instead of the point estimate of 1,900 units. Further, managers may engage in sensitivity or what-if analyses. In this regard, a computer spreadsheet is helpful, as managers set up the break-even (or targeted profit) relationships and then check to see the impact that varying costs and prices have on quantity sold. Two concepts useful to management are *margin of safety* and *operating leverage*. Both of these may be considered measures of risk. Each requires knowledge of fixed and variable costs.

Margin of Safety

The **margin of safety** is the units sold or expected to be sold or the revenue earned or expected to be earned above the break-even volume. For example, if the break-even volume for a company is 200 units and the company is currently selling 500 units, the margin of safety is 300 units ($500 - 200$). The margin of safety can be expressed in sales revenue as well. If the break-even volume is \$200,000 and current revenues are \$350,000, then the margin of safety is \$150,000.

The margin of safety can be viewed as a crude measure of risk. There are always events, unknown when plans are made, that can lower sales below the original expected level. If a firm's margin of safety is large given the expected sales for the coming year, the risk of suffering losses should sales take a downward turn is less than if the margin of safety is small. Managers who face a low margin of safety may wish to consider actions to increase sales or decrease costs. For example, **Walt Disney Company** faced lower theme park earnings in the last quarter of 2004 due to the unprecedented number of hurricanes that hit Florida during August. Disney's CFO explained that "near-term local attendance could be impacted as people put their lives together" after the disasters. He also noted that the company would focus on "increasing occupancy at theme park hotels, per capita spending by visitors to the theme parks, and managing costs." The objective is to reach an operating margin of at least 20 percent over the next three to four years.⁷ A more robust operating margin at all theme parks would cushion Disney in the event of unforeseen events.

Operating Leverage

In physics, a lever is a simple machine used to multiply force. Basically, the lever magnifies the amount of effort applied to create a greater effect. The larger the load moved by a given amount of effort, the greater the mechanical advantage. In financial terms, operating leverage is concerned with the relative mix of fixed costs and variable costs in an organization. It is sometimes possible to trade off fixed costs for variable costs. As variable costs decrease, the unit contribution margin increases, making the contribution of each unit sold that much greater. In such a case, the effect of fluctuations in sales on profitability increases. Thus, firms that have lowered variable costs by increasing the proportion of fixed costs will benefit with greater increases in profits as sales increase than will firms with a lower proportion of fixed costs. Fixed costs are being used as leverage to increase profits. Unfortunately, it is also true that firms with a higher operating leverage will also experience greater reductions in profits as sales decrease. Therefore, **operating leverage** is the use of fixed costs to extract higher percentage changes in profits as sales activity changes.

7. Dwight Oestricher, "Disney CFO Staggs Sees Theme Park 1Q Hurt by Storms," *The Wall Street Journal* (September 30, 2004): B1 and B2.

The greater the degree of operating leverage, the more that changes in sales activity will affect profits. Because of this phenomenon, the mix of costs that an organization chooses can have a considerable influence on its operating risk and profit level.

The **degree of operating leverage** can be measured for a given level of sales by taking the ratio of contribution margin to profit, as follows:

$$\text{Degree of operating leverage} = \text{Contribution margin} / \text{Profit}$$

If fixed costs are used to lower variable costs such that contribution margin increases and profit decreases, then the degree of operating leverage increases—signaling an increase in risk.

To illustrate the utility of these concepts, consider a firm that is planning to add a new product line. In adding the line, the firm can choose to rely heavily on automation or on labor. If the firm chooses to emphasize automation rather than labor, fixed costs will be higher, and unit variable costs will be lower. Relevant data for a sales level of 10,000 units follow:

	<i>Automated System</i>	<i>Manual System</i>
Sales	\$1,000,000	\$1,000,000
Less: Variable expenses	<u>500,000</u>	<u>800,000</u>
Contribution margin	\$ 500,000	\$ 200,000
Less: Fixed expenses	<u>375,000</u>	<u>100,000</u>
Operating income	<u>\$ 125,000</u>	<u>\$ 100,000</u>
Unit selling price	\$100	\$100
Unit variable cost	50	80
Unit contribution margin	50	20

The degree of operating leverage for the automated system is 4.0 ($\$500,000 / \$125,000$).

The degree of operating leverage for the manual system is 2.0 ($\$200,000 / \$100,000$). What happens to profit in each system if sales increase by 40 percent? We can generate the following income statements to see.

	<i>Automated System</i>	<i>Manual System</i>
Sales	\$1,400,000	\$1,400,000
Less: Variable expenses	<u>700,000</u>	<u>1,120,000</u>
Contribution margin	\$ 700,000	\$ 280,000
Less: Fixed expenses	<u>375,000</u>	<u>100,000</u>
Operating income	<u>\$ 325,000</u>	<u>\$ 180,000</u>

Profits for the automated system would increase by \$200,000 ($\$325,000 - \$125,000$) for a 160 percent increase. In the manual system, profits increase by only \$80,000 ($\$180,000 - \$100,000$), for an 80 percent increase. The automated system has a greater percentage increase because it has a higher degree of operating leverage.

In choosing between the two systems, the effect of operating leverage is a valuable piece of information. As the 40 percent increase in sales illustrates, this effect can bring a significant benefit to the firm. However, the effect is a two-edged sword. As sales decrease, the automated system will also show much higher percentage profit decreases. Moreover, the increased operating leverage is available under the automated system because of the presence of increased fixed costs. The break-even point for the automated system is 7,500 units ($\$375,000 / \50), whereas the break-even point for the manual system is 5,000 units ($\$100,000 / \20). Thus, the automated system has greater operating

risk. The increased risk, of course, provides a potentially higher profit level (as long as units sold exceed 9,167).⁸

In choosing between the automated and manual systems, the manager must assess the likelihood that sales will exceed 9,167 units. If, after careful study, there is a strong belief that sales will easily exceed this level, the choice is obvious: the automated system. On the other hand, if sales are unlikely to exceed 9,167 units, the manual system is preferable. Exhibit 17-10 summarizes the relative difference between the manual and automated systems in terms of some of the CVP concepts.

EXHIBIT 17-10		Differences between Manual and Automated Systems	
	Manual System	Automated System	
Price	Same	Same	
Variable costs	Relatively higher	Relatively lower	
Fixed costs	Relatively lower	Relatively higher	
Contribution margin	Relatively lower	Relatively higher	
Break-even point	Relatively lower	Relatively higher	
Margin of safety	Relatively higher	Relatively lower	
Degree of operating leverage	Relatively lower	Relatively higher	
Down-side risk	Relatively lower	Relatively higher	
Up-side potential	Relatively lower	Relatively higher	

COST MANAGEMENT

A partnership between supply chain optimization software and the Web can help companies understand and manage the dynamic relationships among costs, prices, and volume. **Manugistics Group** is a global provider of supply chain optimization and e-commerce solutions. Its clients, including **Amazon.com**, **Boeing**, **Ford**, **Harley-Davidson**, and **Levi Strauss & Company**, use Manugistics's software to manage supply chain complexity.

Recently, Manugistics teamed up with **PricewaterhouseCoopers** to deliver fully integrated solutions to the pharmaceutical industry. Previously, the pharmaceutical industry focused on drug discovery and marketing. However, the ability to respond swiftly to market opportunities—through focused manufacturing and distribution—can do much to enhance a company's profitability. For example, a manufacturer that could respond rapidly to a flu epidemic could realize a return from the perishable flu vaccine. This use of supply chain software leads to an earlier break-even on new drugs.

Talus Solutions, a company that recently combined with Manugistics, developed dynamic pricing and revenue

Technology in Action

optimization (PRO) software. PRO works on the revenue side of cost-volume-profit models by optimizing prices for products and services that companies sell. The software uses advanced statistical techniques powered by the immense volume and variety of data made available by the Internet to examine a number of variables, including product availability, shifting demand, competitor pricing, production costs, inventory, market share objectives, and customer buying behavior. It then forecasts the response of different customer market segments to prices of products throughout their life cycles. **Tickets.com** is an example of a company that uses PRO to respond quickly to changes in demand for a perishable product—live entertainment. A particular number of seats are available for an event, and once the event is over, the product ceases to exist. The PRO software analyzes consumer behavior to construct a case-specific pricing structure. This enables Tickets.com to set ticket prices on the basis of customer demand, rather than on the basis of a preset price. The objectives are to fill the venue to capacity and to maximize the revenue for each event.

Source: Taken from the Web site, <http://www.Tickets.com>.

8. This benchmark is computed by equating the profit equations of the two systems and solving for X: $\$50X - \$375,000 = \$20X - \$100,000$ so $X = 9,167$.

Sensitivity Analysis and CVP

The pervasiveness of personal computers and spreadsheets has made cost analysis within reach of most managers. An important tool is **sensitivity analysis**, a what-if technique that examines the impact of changes in underlying assumptions on an answer. It is relatively simple to input data on prices, variable costs, fixed costs, and sales mix and set up formulas to calculate break-even points and expected profits. Then, the data can be varied as desired to see what impact changes have on the expected profit.

In the example given previously for operating leverage, a company analyzed the impact on profit of using an automated versus a manual system. The computations were essentially done by hand, and too much variation was cumbersome. Using the power of a computer, it would be an easy matter to change the sales price in \$1 increments between \$75 and \$125, with related assumptions about quantity sold. At the same time, variable and fixed costs could be adjusted. For example, suppose that the automated system has fixed costs of \$375,000, but that those costs could easily range up to twice as much in the first year and come back down in the second and third years as bugs are worked out of the system and workers learn to use it. Again, the spreadsheet can effortlessly handle the many computations.

Finally, we must note that the spreadsheet, while wonderful for cranking out numerical answers, cannot do the most difficult job in CVP analysis. That job is determining the data to be entered in the first place. The accountant must be familiar with the cost and price distributions of the firm, as well as with the impact of changing economic conditions on these variables. The fact that variables are seldom known with certainty is no excuse for ignoring the impact of uncertainty on CVP analysis. Fortunately, sensitivity analysis can also give managers a feel for the degree to which a poorly forecast variable will affect an answer. That is also an advantage.

OBJECTIVE 6

Discuss the impact of activity-based costing on cost-volume-profit analysis.

CVP Analysis and Activity-Based Costing

Conventional CVP analysis assumes that all costs of the firm can be divided into two categories: those that vary with sales volume (variable costs) and those that do not (fixed costs). Furthermore, costs are assumed to be a linear function of sales volume.

In an activity-based costing system, costs are divided into unit- and non-unit-based categories. Activity-based costing admits that some costs vary with units produced and some costs do not. However, while activity-based costing acknowledges that non-unit-based costs are fixed with respect to production volume changes, it also argues that many non-unit-based costs vary with respect to other cost drivers.

The use of activity-based costing does not mean that CVP analysis is less useful. In fact, it becomes more useful, since it provides more accurate insights concerning cost behavior. These insights produce better decisions. CVP analysis within an activity-based framework, however, must be modified. To illustrate, assume that a company's costs can be explained by three variables: a unit-level cost driver, units sold; a batch-level cost driver, number of setups; and a product-level cost driver, engineering hours. The ABC cost equation can then be expressed as follows:

$$\text{Total cost} = \text{Fixed costs} + (\text{Unit variable cost} \times \text{Number of units}) + (\text{Setup cost} \times \text{Number of setups}) + (\text{Engineering cost} \times \text{Number of engineering hours})$$

Operating income, as before, is total revenue minus total cost. This is expressed as follows:

$$\text{Operating income} = \text{Total revenue} - [\text{Fixed costs} + (\text{Unit variable cost} \times \text{Number of units}) + (\text{Setup cost} \times \text{Number of setups}) + (\text{Engineering cost} \times \text{Number of engineering hours})]$$

Let's use the contribution margin approach to calculate the break-even point in units. At break-even, operating income is zero, and the number of units that must be sold to achieve break-even is as follows.

$$\text{Break-even units} = [\text{Fixed costs} + (\text{Setup cost} \times \text{Number of setups}) + (\text{Engineering cost} \times \text{Number of engineering hours})] / (\text{Price} - \text{Unit variable cost})$$

A comparison of the ABC break-even point with the conventional break-even point reveals two significant differences. First, the fixed costs differ. Some costs previously identified as being fixed may actually vary with non-unit cost drivers, in this case setups and engineering hours. Second, the numerator of the ABC break-even equation has two non-unit-variable cost terms: one for batch-related activities and one for product-sustaining activities.

Example Comparing Conventional and ABC Analysis

To make the previous discussion more concrete, a comparison of conventional cost-volume-profit analysis with activity-based costing is useful. Let's assume that a company wants to compute the units that must be sold to earn a before-tax profit of \$20,000. The analysis is based on the following data:

Data about Variables		
<i>Cost Driver</i>	<i>Unit Variable Cost</i>	<i>Level of Cost Driver</i>
Units sold	\$ 10	—
Setups	1,000	20
Engineering hours	30	1,000
Other data:		
Total fixed costs (conventional)	\$100,000	
Total fixed costs (ABC)	50,000	
Unit selling price	20	

The units that must be sold to earn a before-tax profit of \$20,000 are computed as follows:

$$\begin{aligned} \text{Units} &= (\text{Targeted income} + \text{Fixed costs}) / (\text{Price} - \text{Unit variable cost}) \\ &= (\$20,000 + \$100,000) / (\$20 - \$10) \\ &= \$120,000 / \$10 \\ &= 12,000 \end{aligned}$$

Using the ABC equation, the units that must be sold to earn an operating income of \$20,000 are computed as follows:

$$\begin{aligned} \text{Units} &= (\$20,000 + \$50,000 + \$20,000 + \$30,000) / (\$20 - \$10) \\ &= \$120,000 / \$10 \\ &= 12,000 \end{aligned}$$

The number of units that must be sold is identical under both approaches. The reason is simple. The total fixed cost pool under conventional costing consists of non-unit-based variable costs plus costs that are fixed regardless of the cost driver. ABC breaks out the non-unit-based variable costs. These costs are associated with certain levels of each cost driver. For the batch-level cost driver, the level is 20 setups; for the product-level variable, the level is 1,000 engineering hours. As long as the levels of activity for the non-unit-based cost drivers remain the same, then the results for the conventional and ABC computations will also be the same. But these levels can change, and because of this, the information provided by the two approaches can be significantly different. The ABC equation for CVP analysis is a richer representation of the underlying cost behavior and can provide important strategic insights. To see this, let's use the same data provided previously and look at a different application.

Strategic Implications: Conventional CVP Analysis versus ABC Analysis

Suppose that after the conventional CVP analysis, marketing indicates that selling 12,000 units is not possible. In fact, only 10,000 units can be sold. The president of the company then directs the product design engineers to find a way to reduce the cost of making the product. The engineers also have been told that the conventional cost equation, with fixed costs of \$100,000 and a unit variable cost of \$10, holds. The variable cost of \$10 per unit consists of the following: direct labor, \$4; direct materials, \$5; and variable overhead, \$1. To comply with the request to reduce the break-even point, engineering produces a new design that requires less labor. The new design reduces the direct labor cost by \$2 per unit. The design would not affect direct materials or variable overhead. Thus, the new variable cost is \$8 per unit, and the break-even point is calculated as follows:

$$\begin{aligned}\text{Units} &= \text{Fixed costs}/(\text{Price} - \text{Unit variable cost}) \\ &= \$100,000/(\$20 - \$8) \\ &= 8,333\end{aligned}$$

The projected income if 10,000 units are sold is computed as follows:

Sales (\$20 × 10,000)	\$200,000
Less: Variable expenses (\$8 × 10,000)	<u>80,000</u>
Contribution margin	\$120,000
Less: Fixed expenses	<u>100,000</u>
Operating income	<u>\$ 20,000</u>

Excited, the president approves the new design. A year later, the president discovers that the expected increase in income did not materialize. In fact, a loss is realized. Why? The answer is provided by an ABC approach to CVP analysis.

The original ABC cost relationship for the example is as follows:

$$\begin{aligned}\text{Total cost} &= \$50,000 + (\$10 \times \text{Units}) + (\$1,000 \times \text{Setups}) \\ &\quad + (\$30 \times \text{Engineering hours})\end{aligned}$$

Suppose that the new design requires a more complex setup, increasing the cost per setup from \$1,000 to \$1,600. Also, suppose that the new design, because of increased technical content, requires a 40 percent increase in engineering support (from 1,000 hours to 1,400 hours). The new cost equation, including the reduction in unit-level variable costs, is as follows:

$$\begin{aligned}\text{Total cost} &= \$50,000 + (\$8 \times \text{Units}) + (\$1,600 \times \text{Setups}) \\ &\quad + (\$30 \times \text{Engineering hours})\end{aligned}$$

The break-even point, setting operating income equal to zero and using the ABC equation, is calculated as follows (assume that 20 setups are still performed):

$$\begin{aligned}\text{Units} &= [\$50,000 + (\$1,600 \times 20) + (\$30 \times 1,400)]/(\$20 - \$8) \\ &= \$124,000/\$12 \\ &= 10,333\end{aligned}$$

And the income for 10,000 units is (recall that a maximum of 10,000 can be sold) as follows:

Sales (\$20 × 10,000)		\$200,000
Less: Unit-based variable expenses (\$8 × 10,000)		<u>80,000</u>
Contribution margin		\$120,000
Less non-unit-based variable expenses:		
Setups (\$1,600 × 20)	\$32,000	
Engineering support (\$30 × 1,400)	<u>42,000</u>	<u>74,000</u>
Traceable margin		\$ 46,000
Less: Fixed expenses		<u>50,000</u>
Operating income (loss)		<u>\$ (4,000)</u>

How could the engineers have been off by so much? Didn't they know that the new design would increase setup cost and engineering support? Yes and no. They were probably aware of the increases in these two variables, but the conventional cost equation diverted attention from figuring just how much impact changes in those variables would have. The information conveyed to the engineers by the conventional equation gave the impression that any reduction in labor cost—not affecting direct materials or variable overhead—would reduce total costs, since changes in the level of labor activity would not affect the fixed costs. The ABC equation, however, indicates that a reduction in labor input that adversely affects setup activity or engineering support might be undesirable. By providing more insight, better design decisions can be made. Providing ABC cost information to the design engineers would probably have led them down a different path—a path that would have been more advantageous to the company.

CVP Analysis and JIT

If a firm has adopted JIT, the variable cost per unit sold is reduced, and fixed costs are increased. Direct labor, for example, is now viewed as fixed instead of variable. Direct materials, on the other hand, is still a unit-based variable cost. In fact, the emphasis on total quality and long-term purchasing makes the assumption even more true that direct materials cost is strictly proportional to units produced (because waste, scrap, and quantity discounts are eliminated). Other unit-based variable costs such as power and sales commissions also persist. Additionally, the batch-level variable is gone (in JIT, the batch is one unit). Thus, the cost equation for JIT can be expressed as follows:

$$\text{Total cost} = \text{Fixed costs} + (\text{Unit variable cost} \times \text{Units}) + (\text{Engineering cost} \times \text{Number of engineering hours})$$

Since its application is a special case of the ABC equation, no example will be given.

SUMMARY

Cost-volume-profit analysis focuses on prices, revenues, volume, costs, profits, and sales mix. It can be used to determine the sales volume or revenue necessary to break even or achieve a targeted profit. Changes in the fixed and variable cost patterns affect the profitability of a firm. The firm can use CVP analysis to see just how a particular change in price or cost would affect the break-even point.

In a single-product setting, the break-even point can be computed in units or sales dollars. Two approaches were detailed: the operating income approach and the contribution margin approach.

Multiple-product analysis requires that an assumption be made concerning the expected sales mix. Given a particular sales mix, a multiple-product problem can be converted into a single-product analysis. However, it should be remembered that the answers change as the sales mix changes. If the sales mix changes in a multiple-product firm, the break-even point will also change. In general, increases in the sales of high contribution margin products will decrease the break-even point, while increases in the sales of low contribution margin products will increase the break-even point.

CVP is based on several assumptions that must be considered in applying it to business problems. The analysis assumes linear revenue and cost functions, no finished goods ending inventories, and a constant sales mix. CVP analysis also assumes that selling prices and fixed and variable costs are known with certainty. These assumptions form the basis for simple graphical analysis using the profit-volume graph and the cost-volume-profit graph.

Measures of risk and uncertainty, such as the margin of safety and operating leverage, can be used to give managers more insight into CVP answers. Sensitivity analysis

gives still more insight into the effect of changes in underlying variables on CVP relationships.

CVP can be used with activity-based costing, but the analysis must be modified. In effect, under ABC, a type of sensitivity analysis is used. Fixed costs are separated from a variety of costs that vary with particular activity drivers. At this stage, it is easiest to organize variable costs as unit-level, batch-level, or product-level. Then, the impact of decisions on batches and products can be examined within the CVP framework.

The subject of cost-volume-profit analysis naturally lends itself to the use of numerous equations. Some of the more common equations used in this chapter are summarized in Exhibit 17-11.

EXHIBIT 17-11**Summary of Important Equations**

1. Operating income = (Price × Number of units) – (Variable cost per unit × Number of units) – Total fixed costs
2. Break-even point in units = Fixed costs / (Price – Unit variable cost)
3. Revenue = Price × Units
4. Break-even point in sales dollars = Fixed costs / Contribution margin ratio
or = Fixed costs / (1 – Variable cost ratio)
5. Variable cost ratio = Total variable cost / Sales
or = Unit variable cost / Price
6. Contribution margin ratio = Contribution margin / Sales
or = (Price – Unit variable cost) / Price
7. Margin of safety = Sales – Break-even sales
8. Degree of operating leverage = Contribution margin / Profit
9. Percentage change in profits = Degree of operating leverage × Percentage change in sales
10. After-tax income = Operating income – (Tax rate × Operating income)
11. Income taxes = Tax rate × Operating income
12. Before-tax profit = After-tax profit / (1 – Tax rate)
13. ABC total cost = Fixed costs + (Unit variable cost × Number of units) + (Batch-level cost × Batch driver) + (Product-level cost × Product driver)
14. ABC break-even units = [Fixed costs + (Batch-level cost × Batch driver) + (Product-level cost × Product driver)] / (Price – Unit variable cost)

REVIEW PROBLEMS AND SOLUTIONS

1 BREAK-EVEN POINT, TARGETED PROFIT, MARGIN OF SAFETY

Cutlass Company's projected profit for the coming year is as follows:

	<i>Total</i>	<i>Per Unit</i>
Sales	\$200,000	\$20
Less: Variable expenses	<u>120,000</u>	<u>12</u>
Contribution margin	\$ 80,000	<u>\$ 8</u>
Less: Fixed expenses	<u>64,000</u>	
Operating income	<u>\$ 16,000</u>	

Required:

1. Compute the break-even point in units.
2. How many units must be sold to earn a profit of \$30,000?
3. Compute the contribution margin ratio. Using that ratio, compute the additional profit that Cutlass would earn if sales were \$25,000 more than expected.
4. Suppose Cutlass would like to earn operating income equal to 20 percent of sales revenue. How many units must be sold for this goal to be realized? Prepare an income statement to prove your answer.
5. For the projected level of sales, compute the margin of safety.

SOLUTION

1. The break-even point is as follows:

$$\begin{aligned}\text{Units} &= \text{Fixed costs}/(\text{Price} - \text{Unit variable cost}) \\ &= \$64,000/(\$20 - \$12) \\ &= \$64,000/\$8 \\ &= 8,000\end{aligned}$$

2. The number of units that must be sold to earn a profit of \$30,000 is as follows:

$$\begin{aligned}\text{Units} &= (\$64,000 + \$30,000)/\$8 \\ &= \$94,000/\$8 \\ &= 11,750\end{aligned}$$

3. The contribution margin ratio is $\$8/\$20 = 0.40$. With additional sales of \$25,000, the additional profit would be $0.40 \times \$25,000 = \$10,000$.
4. To find the number of units sold for a profit equal to 20 percent of sales, let target income equal $(0.20)(\text{Price} \times \text{Units})$ and solve for units.

$$\begin{aligned}\text{Operating income} &= (\text{Price} \times \text{Units}) - (\text{Unit variable cost} \times \text{Units}) - \text{Fixed costs} \\ (0.2)(\$20)\text{Units} &= (\$20 \times \text{Units}) - (\$12 \times \text{Units}) - \$64,000 \\ \$4 \times \text{Units} &= \$64,000 \\ \text{Units} &= 16,000\end{aligned}$$

The income statement is as follows:

Sales (16,000 × \$20)	\$320,000
Less: Variable expenses (16,000 × \$12)	<u>192,000</u>
Contribution margin	\$128,000
Less: Fixed expenses	<u>64,000</u>
Operating income	<u>\$ 64,000</u>

$$\text{Operating income}/\text{Sales} = \$64,000/\$320,000 = 0.20, \text{ or } 20\%$$

5. The margin of safety is $10,000 - 8,000 = 2,000$ units, or \$40,000 in sales revenues.

2 CVP WITH ACTIVITY-BASED COSTING

Dory Manufacturing Company produces T-shirts that are screen-printed with the logos of various sports teams. Each shirt is priced at \$10. Costs are as follows:

<i>Cost Driver</i>	<i>Unit Variable Cost</i>	<i>Level of Cost Driver</i>
Units sold	\$ 5	—
Setups	450	80
Engineering hours	20	500
Other data:		
Total fixed costs (conventional)	\$96,000	
Total fixed costs (ABC)	50,000	

Required:

1. Compute the break-even point in units using conventional analysis.
2. Compute the break-even point in units using activity-based analysis.
3. Suppose that Dory could reduce the setup cost by \$150 per setup and could reduce the number of engineering hours needed to 425. How many units must be sold to break even in this case?

SOLUTION

1. Break-even units = Fixed costs / (Price – Unit variable cost)
 $= \$96,000 / (\$10 - \$5)$
 $= 19,200$ units
2. Break-even units = [Fixed costs + (Setups \times Setup cost) + (Engineering hours \times Engineering cost)] / (Price – Unit variable cost)
 $= [\$50,000 + (\$450 \times 80) + (\$20 \times 500)] / (\$10 - \$5)$
 $= 19,200$ units
3. Break-even units = [\\$50,000 + (\\$300 \times 80) + (\\$20 \times 425)] / (\\$10 – \\$5)
 $= \$82,500 / \5
 $= 16,500$ units

KEY TERMS

Break-even point 737

Common fixed expenses 745

Contribution margin 738

Contribution margin ratio 741

Cost-volume-profit graph 749

Degree of operating leverage 757

Direct fixed expenses 745

Margin of safety 756

Net income 738

Operating income 737

Operating leverage 756

Profit-volume graph 749

Relevant range 753

Sales mix 746

Sales-revenue approach 742

Sensitivity analysis 759

Variable cost ratio 741

QUESTIONS FOR WRITING AND DISCUSSION

1. Explain how CVP analysis can be used for managerial planning.
2. Describe the difference between the units-sold approach to CVP analysis and the sales-revenue approach.
3. Define the term *break-even point*.
4. Explain why contribution margin per unit becomes profit per unit above the break-even point.
5. A restaurant owner who had yet to earn a monthly profit said, “The busier we are, the more we lose.” What do you think is happening in terms of contribution margin?
6. What is the variable cost ratio? The contribution margin ratio? How are the two ratios related?
7. If the contribution margin increases from 30 to 35 percent of sales, what will happen to the break-even point, and why will this occur?
8. Suppose a firm with a contribution margin ratio of 0.3 increased its advertising expenses by \$10,000 and found that sales increased by \$30,000. Was it a good decision to increase advertising expenses? Why is this simple problem an important one for business people to understand?

9. Define the term *sales mix*, and give an example to support your definition.
10. Explain how CVP analysis developed for single products can be used in a multiple-product setting.
11. Why might a multiple-product firm choose to calculate just overall break-even revenue rather than the break-even quantity by product?
12. How do income taxes affect the break-even point and CVP analysis?
13. Explain how a change in sales mix can change a company's break-even point.
14. Define the term *margin of safety*. Explain what is meant by the term *operating leverage*. What impact does an increase in the margin of safety have on risk? What impact does an increase in leverage have on risk?
15. Why does the activity-based costing approach to CVP analysis offer more insight than the conventional approach does?

EXERCISES

17-1 BREAK-EVEN IN UNITS



- LO1** Mello-Tote Company manufactures nylon arm-band carriers for use with popular portable MP3 devices. Variable costs are \$18 per arm-band carrier, the price is \$28, and fixed costs are \$43,000.

Required:

1. What is the contribution margin for one arm-band carrier?
2. How many arm-band carriers must Mello-Tote Company sell to break even?
3. If Mello-Tote Company sells 6,000 arm-band carriers, what is the operating income?

17-2 BREAK-EVEN IN UNITS

- LO1** Olmos Company manufactures room-sized air purifiers. Fixed costs amount to \$1,386,000 per year. Variable costs per air purifier are \$98, and the average price per air purifier is \$120.

Required:

1. How many air purifiers must Olmos Company sell to break even?
2. If Olmos Company sells 85,000 air purifiers in a year, what is the operating income?
3. If Olmos Company's variable costs decrease to \$70 per air purifier while the price and fixed costs remain unchanged, what is the new break-even point?

17-3 BREAK-EVEN IN UNITS, TARGET INCOME

- LO1** Glass-Works, Inc., makes and sells a variety of cut glass vases. Fixed costs are \$216,000 per year. The average price for a cut glass vase is \$24, and the average variable cost is \$16 per item.

Required:

1. How many vases must be sold to break even?
2. If Glass-Works wants to earn \$130,000 in profit, how many vases must be sold? Prepare a variable-costing income statement to verify your answer.

17-4 BREAK-EVEN FOR A SERVICE FIRM

LO1 Leota Mohrman owns and operates The Hassle-Free Hothouse (THH), which provides live plants and flower arrangements to professional offices. Leota has fixed costs of \$2,380 per month for office/greenhouse rent, advertising, and a delivery van. Variable costs for the plants, fertilizer, pots, and other supplies average \$25 per job. THH charges \$60 per month for the average job.

Required:

1. How many jobs must THH average each month to break even?
2. What is the operating income for THH in a month with 65 jobs? With 100 jobs?
3. Suppose that THH decides to increase the price to \$75 per job. What is the new break-even point in number of jobs per month?

17-5 BREAK-EVEN IN SALES DOLLARS

LO2, LO5 Green Bay Motors, Inc., employs 20 sales personnel to market its line of luxury automobiles. The average car sells for \$65,000, and a 6 percent commission is paid to the salesperson. Green Bay Motors is considering a change to the commission arrangement where the company would pay each salesperson a salary of \$1,500 per month plus a commission of 2 percent of the sales made by that salesperson. What is the amount of total monthly car sales at which Green Bay Motors would be indifferent as to which plan to select? (*CMA adapted*)

CMA



17-6 BREAK-EVEN IN SALES DOLLARS, MARGIN OF SAFETY

LO2, LO5 StarSports, Inc., represents professional athletes and movie and television stars. The agency had revenue of \$10,780,000 last year, with total variable costs of \$5,066,600 and fixed costs of \$2,194,200.

Required:

1. What is the contribution margin ratio for StarSports based on last year's data? What is the break-even point in sales revenue?
2. What was the margin of safety for StarSports last year?
3. One of StarSports's agents proposed that the firm begin cultivating high school sports stars around the nation. This proposal is expected to increase revenue by \$150,000 per year, with increased fixed costs of \$140,000. Is this proposal a good idea? Explain.

17-7 BREAK-EVEN IN UNITS, AFTER-TAX TARGET INCOME, CVP ASSUMPTIONS

LO1, LO4, LO5 Almo Company manufactures and sells adjustable canopies that attach to motor homes and trailers. The market covers both new unit purchases as well as replacement canopies. Almo developed its 2007 business plan based on the assumption that canopies would sell at a price of \$400 each. The variable costs for each canopy were projected at \$200, and the annual fixed costs were budgeted at \$100,000. Almo's after-tax profit objective was \$240,000; the company's effective tax rate is 40 percent.

CMA



While Almo's sales usually rise during the second quarter, the May financial statements reported that sales were not meeting expectations. For the first five months of the year, only 350 units had been sold at the established price, with variable costs as planned, and it was clear that the 2007 after-tax profit projection would not be reached unless

some actions were taken. Almo's president assigned a management committee to analyze the situation and develop several alternative courses of action. The following mutually exclusive alternatives, labeled A, B, and C, were presented to the president.

- Reduce the sales price by \$40. The sales organization forecasts that with the significantly reduced sales price, 2,700 units can be sold during the remainder of the year. Total fixed and variable unit costs will stay as budgeted.
- Lower the variable costs per unit by \$25 through the use of less expensive materials and slightly modified manufacturing techniques. The sales price will also be reduced by \$30, and sales of 2,200 units for the remainder of the year are forecast.
- Cut fixed costs by \$10,000, and lower the sales price by 5 percent. Variable costs per unit will be unchanged. Sales of 2,000 units are expected for the remainder of the year.

Required:

- Determine the number of units that Almo Company must sell in order to break even assuming no changes are made to the selling price and cost structure.
- Determine the number of units that Almo Company must sell in order to achieve its after-tax profit objective.
- Determine which one of the alternatives Almo Company should select to achieve its annual after-tax profit objective. Be sure to support your selection with appropriate calculations.
- The precision and reliability of CVP analysis are limited by several underlying assumptions. Identify at least four of these assumptions. (*CMA adapted*)

17-8 CVP, BEFORE- AND AFTER-TAX TARGETED INCOME

LO1 Head-Gear Company produces helmets for bicycle racing. Currently, Head-Gear charges a price of \$30 per helmet. Variable costs are \$20.40 per helmet, and fixed costs are \$38,680. The tax rate is 25 percent. Last year, 13,400 helmets were sold.

Required:

- What is Head-Gear's net income for last year?
- What is Head-Gear's break-even revenue?
- Suppose Head-Gear wants to earn before-tax operating income of \$153,320. How many units must be sold?
- Suppose Head-Gear wants to earn after-tax net income of \$150,000. How many units must be sold? (Round to the nearest unit.)

17-9 BREAK-EVEN IN SALES DOLLARS, CHANGES IN VARIABLES

LO2, LO5 Lauterbach Corporation manufactures skateboards and is in the process of preparing next year's budget. The pro forma income statement for the current year is as follows:

CMA

Sales		\$1,500,000
Cost of sales:		
Direct materials	\$250,000	
Direct labor	150,000	
Variable overhead	80,000	
Fixed overhead	<u>100,000</u>	<u>580,000</u>
Gross profit		\$ 920,000
Selling and administrative expenses:		
Variable	\$300,000	
Fixed	<u>250,000</u>	<u>550,000</u>
Operating income		<u>\$ 370,000</u>

Required:

1. What is the break-even point (rounded to the nearest dollar) for Lauterbach Corporation for the current year?
2. For the coming year, the management of Lauterbach Corporation anticipates a 10 percent increase in variable costs and a \$45,000 increase in fixed expenses. What is the break-even point in dollars for next year? (*CMA adapted*)

17-10 ASSUMPTIONS AND USE OF VARIABLES

LO1, LO5

Choose the *best* answer for each of the following multiple-choice questions.

1. Cost-volume-profit analysis includes some simplifying assumptions. Which of the following is **not** one of these assumptions?
 - a. Cost and revenues are predictable.
 - b. Cost and revenues are linear over the relevant range.
 - c. Changes in beginning and ending inventory levels are insignificant in amount.
 - d. Sales mix changes are irrelevant.
2. The term *relevant range*, as used in cost accounting, means the range
 - a. over which costs may fluctuate.
 - b. over which cost relationships are valid.
 - c. of probable production.
 - d. over which production has occurred in the past ten years.
3. How would the following be used in calculating the number of units that must be sold to earn a targeted operating income?

	<i>Price per Unit</i>	<i>Targeted Operating Income</i>
a.	Denominator	Numerator
b.	Numerator	Numerator
c.	Not used	Denominator
d.	Numerator	Denominator

4. Information concerning Korian Corporation's product is as follows:

Sales	\$300,000
Variable costs	240,000
Fixed costs	40,000

Assuming that Korian increased sales of the product by 20 percent, what should the operating income be?

- a. \$20,000
 - b. \$24,000
 - c. \$32,000
 - d. \$80,000
5. The following data apply to McNally Company for last year:

Total variable costs per unit	\$3.50
Contribution margin/Sales	30%
Break-even sales (present volume)	\$1,000,000

McNally wants to sell an additional 50,000 units at the same selling price and contribution margin. By how much can fixed costs increase to generate additional profit equal to 10 percent of the sales value of the additional 50,000 units to be sold?

- a. \$50,000
- b. \$57,500
- c. \$67,500
- d. \$125,000

6. Bryan Company's break-even point is 8,500 units. Variable cost per unit is \$140, and total fixed costs are \$297,500 per year. What price does Bryan charge?
- \$140
 - \$35
 - \$175
 - cannot be determined from the above data

17-11 CONTRIBUTION MARGIN, CVP, NET INCOME, MARGIN OF SAFETY

LO1, LO5 Chromatics, Inc., produces novelty nail polishes. Each bottle sells for \$3.60. Variable unit costs are as follows:

Acrylic base	\$0.75
Pigments	0.38
Other ingredients	0.35
Bottle, packing material	1.15
Selling commission	0.25

Fixed overhead costs are \$12,000 per year. Fixed selling and administrative costs are \$6,720 per year. Chromatics sold 35,000 bottles last year.

Required:

- What is the contribution margin per unit for a bottle of nail polish? What is the contribution margin ratio?
- How many bottles must be sold to break even? What is the break-even sales revenue?
- What was Chromatics's operating income last year?
- What was the margin of safety?
- Suppose that Chromatics, Inc., raises the price to \$4.00 per bottle, but anticipated sales will drop to 30,400 bottles. What will the new break-even point in units be? Should Chromatics raise the price? Explain.

17-12 OPERATING LEVERAGE

LO5 Income statements for two different companies in the same industry are as follows:

	<i>Trimax, Inc.</i>	<i>Quintex, Inc.</i>
Sales	\$500,000	\$500,000
Less: Variable costs	<u>250,000</u>	<u>100,000</u>
Contribution margin	\$250,000	\$400,000
Less: Fixed costs	<u>200,000</u>	<u>350,000</u>
Operating income	<u>\$ 50,000</u>	<u>\$ 50,000</u>

Required:

- Compute the degree of operating leverage for each company.
- Compute the break-even point for each company. Explain why the break-even point for Quintex, Inc., is higher.
- Suppose that both companies experience a 50 percent increase in revenues. Compute the percentage change in profits for each company. Explain why the percentage increase in Quintex's profits is so much greater than that of Trimax.

17-13 CVP ANALYSIS WITH MULTIPLE PRODUCTS



LO3

Reingold Company produces wireless phones. One model is the miniphone—a basic model that is very small and slim. The miniphone fits into a shirt pocket. Another model, the netphone, has a larger display and is Internet-ready. For the coming year, Reingold expects to sell 200,000 miniphones and 600,000 netphones. A segmented income statement for the two products is as follows:

	<i>Miniphone</i>	<i>Netphone</i>	<i>Total</i>
Sales	\$5,000,000	\$36,000,000	\$41,000,000
Less: Variable costs	<u>2,400,000</u>	<u>30,000,000</u>	<u>32,400,000</u>
Contribution margin	\$2,600,000	\$ 6,000,000	\$ 8,600,000
Less: Direct fixed costs	<u>1,200,000</u>	<u>960,000</u>	<u>2,160,000</u>
Segment margin	<u>\$1,400,000</u>	<u>\$ 5,040,000</u>	\$ 6,440,000
Less: Common fixed costs			<u>1,280,000</u>
Operating income			<u>\$ 5,160,000</u>

Required:

1. Compute the number of miniphones and netphones that must be sold to break even.
2. Using information only from the total column of the income statement, compute the sales revenue that must be generated for the company to break even.

17-14 AFTER-TAX TARGET INCOME, PROFIT ANALYSIS

LO1, LO5

CMA

Siberian Ski Company recently expanded its manufacturing capacity, which will allow it to produce up to 15,000 pairs of cross-country skis of the mountaineering model or the touring model. The sales department assures management that it can sell between 9,000 and 13,000 pairs of either product this year. Because the models are very similar, Siberian Ski will produce only one of the two models.

The following information was compiled by the accounting department:

	<i>Per-Unit (Pair) Data</i>	
	<i>Mountaineering</i>	<i>Touring</i>
Selling price	\$88.00	\$80.00
Variable costs	52.80	52.80

Fixed costs will total \$369,600 if the mountaineering model is produced but will be only \$316,800 if the touring model is produced. Siberian Ski is subject to a 40 percent income tax rate.

Required:

1. If Siberian Ski Company desires an after-tax net income of \$24,000, how many pairs of touring model skis will the company have to sell?
2. Suppose that Siberian Ski Company decided to produce only one model of skis. What is the total sales revenue at which Siberian Ski Company would make the same profit or loss regardless of the ski model it decided to produce?
3. If the sales department could guarantee the annual sale of 12,000 pairs of either model, which model would the company produce, and why? (*CMA adapted*)

PROBLEMS

17-15 BREAK-EVEN IN UNITS

LO1
CMA

Don Masters and two of his colleagues are considering opening a law office in a large metropolitan area that would make inexpensive legal services available to those who could not otherwise afford these services. The intent is to provide easy access for their clients by having the office open 360 days per year, 16 hours each day from 7:00 A.M. to 11:00 P.M. The office would be staffed by a lawyer, paralegal, legal secretary, and clerk-receptionist for each of the two 8-hour shifts.

In order to determine the feasibility of the project, Don hired a marketing consultant to assist with market projections. The results of this study show that if the firm spends \$500,000 on advertising the first year, the number of new clients expected each day would have the following probability distribution.

<i>Number of New Clients per Day</i>	<i>Probability</i>
20	0.10
30	0.30
55	0.40
85	0.20

Don and his associates believe these numbers are reasonable and are prepared to spend the \$500,000 on advertising. Other pertinent information about the operation of the office is as follows.

The only charge to each new client would be \$30 for the initial consultation. All cases that warranted further legal work would be accepted on a contingency basis with the firm earning 30 percent of any favorable settlements or judgments. Don estimates that 20 percent of new client consultations will result in favorable settlements or judgments averaging \$2,000 each. Repeat clients are not expected during the first year of operations.

The hourly wages of the staff are projected to be \$25 for the lawyer, \$20 for the paralegal, \$15 for the legal secretary, and \$10 for the clerk-receptionist. Fringe benefit expenses will be 40 percent of the wages paid. A total of 400 hours of overtime is expected for the year; this will be divided equally between the legal secretary and the clerk-receptionist positions. Overtime will be paid at one and one-half times the regular wage, and the fringe benefit expense will apply to the full wages.

Don has located 6,000 square feet of suitable office space, which rents for \$28 per square foot annually. Associated expenses will be \$22,000 for property insurance and \$32,000 for utilities.

It will be necessary for the group to purchase malpractice insurance, which is expected to cost \$180,000 annually.

The initial investment in office equipment will be \$60,000; this equipment has an estimated useful life of four years.

The cost of office supplies has been estimated to be \$4 per expected new client consultation.

Required:

- Determine how many new clients must visit the law office being considered by Don Masters and his colleagues in order for the venture to break even during its first year of operations.
- Using the information provided by the marketing consultant, determine if it is feasible for the law office to achieve break-even operations. (*CMA adapted*)

17-16 USING A COMPUTER SPREADSHEET TO SOLVE MULTIPLE-PRODUCT BREAK-EVEN, VARYING SALES MIX

LO2 The following projected income statement for More-Power Company is repeated for your convenience. Recall that the projection is based on sales of 75,000 regular sanders and 30,000 mini-sanders.

	<i>Regular Sander</i>	<i>Mini-Sander</i>	<i>Total</i>
Sales	\$3,000,000	\$1,800,000	\$4,800,000
Less: Variable expenses	<u>1,800,000</u>	<u>900,000</u>	<u>2,700,000</u>
Contribution margin	\$1,200,000	\$ 900,000	\$2,100,000
Less: Direct fixed expenses	<u>250,000</u>	<u>450,000</u>	<u>700,000</u>
Product margin	<u>\$ 950,000</u>	<u>\$ 450,000</u>	\$1,400,000
Less: Common fixed expenses			<u>600,000</u>
Operating income			<u>\$ 800,000</u>

Required:

1. Set up the given income statement on a spreadsheet (e.g., Excel™). Then, substitute the following sales mixes, and calculate operating income. Be sure to print the results for each sales mix (a through d).

	<i>Regular Sander</i>	<i>Mini-Sander</i>
a.	75,000	37,500
b.	60,000	60,000
c.	30,000	90,000
d.	30,000	60,000

2. Calculate the break-even units for each product for each of the preceding sales mixes.

17-17 CONTRIBUTION MARGIN, UNIT AMOUNTS

LO1 Consider the following information on four independent companies.

	<i>A</i>	<i>B</i>	<i>C</i>	<i>D</i>
Sales	\$10,000	\$?	\$?	\$9,000
Less: Variable costs	<u>8,000</u>	<u>11,700</u>	<u>9,750</u>	<u>?</u>
Contribution margin	\$ 2,000	\$ 3,900	\$?	\$?
Less: Fixed costs	<u>?</u>	<u>5,000</u>	<u>?</u>	<u>750</u>
Operating income	<u>\$ 1,000</u>	<u>\$?</u>	<u>\$ 400</u>	<u>\$2,850</u>
Units sold	?	1,300	125	90
Price/Unit	\$5	\$?	\$130	\$?
Variable cost/Unit	\$?	\$9	\$?	\$?
Contribution margin/Unit	\$?	\$3	\$?	\$?
Contribution margin ratio	?	?	40%	?
Break-even in units	?	?	?	?

Required:

Calculate the correct amount for each question mark.

17-18 BREAK-EVEN IN SALES DOLLARS, VARIABLE-COSTING RATIO, CONTRIBUTION MARGIN RATIO, MARGIN OF SAFETY

LO2, LO5 Gossimer, Inc., is a manufacturer of exercise equipment. The budgeted income statement for the coming year is as follows.

Sales	\$900,000
Less: Variable expenses	<u>342,000</u>
Contribution margin	\$558,000
Less: Fixed expenses	<u>363,537</u>
Income before taxes	\$194,463
Less: Income taxes	<u>77,785</u>
Net income	<u>\$116,678</u>

Required:

1. What is Gossimer's variable cost ratio? Its contribution margin ratio?
2. Suppose Gossimer's actual revenues are \$150,000 greater than budgeted. By how much will before-tax profits increase? Give the answer without preparing a new income statement.
3. How much sales revenue must Gossimer earn in order to break even? What is the expected margin of safety? (Round your answers to the nearest dollar.)
4. How much sales revenue must Gossimer generate to earn a before-tax profit of \$200,000? An after-tax profit of \$120,000? Prepare a contribution margin income statement to verify the accuracy of your last answer.

17-19 CHANGES IN BREAK-EVEN POINTS WITH CHANGES IN UNIT PRICES

LO5 Belmont produces and sells plastic storage containers. Last year, Belmont sold 125,000 units. The income statement for Belmont, Inc., for last year is as follows:

Sales	\$625,000
Less: Variable expenses	<u>343,750</u>
Contribution margin	\$281,250
Less: Fixed expenses	<u>180,000</u>
Operating income	<u>\$101,250</u>

Required:

1. Compute the break-even point in units and in revenues. Compute the margin of safety for last year.
2. Suppose that the selling price increases by 10 percent. Will the break-even point increase or decrease? Recompute it.
3. Suppose that the variable cost per unit increases by \$0.35. Will the break-even point increase or decrease? Recompute it.
4. Can you predict whether the break-even point increases or decreases if both the selling price and the unit variable cost increase? Recompute the break-even point incorporating both of the changes in Requirements 1 and 2.
5. Assume that total fixed costs increase by \$50,000. (Assume no other changes from the original data.) Will the break-even point increase or decrease? Recompute it.

17-20 BREAK-EVEN, AFTER-TAX TARGET INCOME, MARGIN OF SAFETY, OPERATING LEVERAGE

LO1, LO2,
LO5

Coastal Carolina Company produces a single product. The projected income statement for the coming year, based on sales of 100,000 units, is as follows:

Sales	\$2,000,000
Less: Variable costs	<u>1,100,000</u>
Contribution margin	\$ 900,000
Less: Fixed costs	<u>765,000</u>
Operating income	<u>\$ 135,000</u>

Required:

1. Compute the unit contribution margin and the units that must be sold to break even. Suppose that 30,000 units are sold above the break-even point. What is the profit?
2. Compute the contribution margin ratio and the break-even point in dollars. Suppose that revenues are \$200,000 greater than expected. What would the total profit be?
3. Compute the margin of safety.
4. Compute the operating leverage. Compute the new profit level if sales are 20 percent higher than expected.
5. How many units must be sold to earn a profit equal to 10 percent of sales?
6. Assume the income tax rate is 40 percent. How many units must be sold to earn an after-tax profit of \$180,000?

17-21 BASIC CVP CONCEPTS

LO1, LO5

Devonly Company produces a variety of products. One division makes gas grills for outdoor cooking. The division's projected income statement for the coming year is as follows:

Sales (120,000 units)	\$7,500,000
Less: Variable expenses	<u>3,450,000</u>
Contribution margin	\$4,050,000
Less: Fixed expenses	<u>3,375,000</u>
Operating income	<u>\$ 675,000</u>

Required:

1. Compute the contribution margin per unit, and calculate the break-even point in units. Repeat, using the contribution margin ratio.
2. The divisional manager has decided to increase the advertising budget by \$100,000 and cut the average selling price to \$58. These actions will increase sales revenues by \$1 million. Will the division be made better off?
3. Suppose sales revenues exceed the estimated amount on the income statement by \$540,000. Without preparing a new income statement, determine by how much profits are underestimated.
4. How many units must be sold to earn an after-tax profit of \$1.254 million? Assume a tax rate of 34 percent.
5. Compute the margin of safety in dollars based on the given income statement.
6. Compute the operating leverage based on the given income statement. If sales revenues are 20 percent greater than expected, what is the percentage increase in profits?

17-22 CVP ANALYSIS: SALES-REVENUE APPROACH, PRICING, AFTER-TAX TARGET INCOME

LO2, LO5

Kline Consulting is a service organization that specializes in the design, installation, and servicing of mechanical, hydraulic, and pneumatic systems. For example, some manufacturing firms, with machinery that cannot be turned off for servicing, need some type of system to lubricate the machinery during use. To deal with this type of problem for a client, Kline designed a central lubricating system that pumps lubricants intermittently to bearings and other moving parts.

The operating results for the firm for the previous year are as follows:

Sales	\$802,429
Less: Variable expenses	<u>430,000</u>
Contribution margin	\$372,429
Less: Fixed expenses	<u>154,750</u>
Operating income	<u>\$217,679</u>

In the coming year, Kline expects variable costs to increase by 5 percent and fixed costs by 4 percent.

Required:

1. What is the contribution margin ratio for the previous year?
2. Compute Kline's break-even point for the previous year in dollars.
3. Suppose that Kline would like to see a 6 percent increase in operating income in the coming year. What percent (on average) must Kline raise its bids to cover the expected cost increases and obtain the desired operating income? Assume that Kline expects the same mix and volume of services in both years.
4. In the coming year, how much revenue must be earned for Kline to earn an after-tax profit of \$175,000? Assume a tax rate of 34 percent.

17-23 MULTIPLE PRODUCTS, BREAK-EVEN ANALYSIS, OPERATING LEVERAGE, SEGMENTED INCOME STATEMENTS

LO3, LO5

Ironjay, Inc., produces two types of weight-training equipment: the jay-flex (a weight machine that allows the user to perform a number of different exercises) and a set of free weights. Ironjay sells the jay-flex to sporting goods stores for \$200. The free weights sell for \$75 per set. The projected income statement for the coming year follows:

Sales	\$600,000
Less: Variable expenses	<u>390,000</u>
Contribution margin	\$210,000
Less: Fixed expenses	<u>157,500</u>
Operating income	<u>\$ 52,500</u>

The owner of Ironjay estimates that 40 percent of the sales revenues will be produced by sales of the jay-flex, with the remaining 60 percent by free weights. The jay-flex is also responsible for 40 percent of the variable expenses. Of the fixed expenses, one-third are common to both products, and one-half are directly traceable to the jay-flex line.

Required:

1. Compute the sales revenue that must be earned for Ironjay to break even.
2. Compute the number of jay-flex machines and free weight sets that must be sold for Ironjay to break even.

3. Compute the degree of operating leverage for Ironjay. Now, assume that the actual revenues will be 40 percent higher than the projected revenues. By what percentage will profits increase with this change in sales volume?
4. Ironjay is considering adding a new product—the jay-rider. The jay-rider is a cross between a rowing machine and a stationary bicycle (like the Nordic rider™). For the first year, Ironjay estimates that the jay-rider will cannibalize 600 units of sales from the jay-flex. Sales of free weight sets will remain unchanged. The jay-rider will sell for \$180 and have variable costs of \$140. The increase in fixed costs to support manufacture of this product is \$5,700. Compute the number of jay-flex machines, free weight sets, and jay-riders that must be sold for Ironjay to break even. For the coming year, is the addition of the jay-rider a good idea? Why or why not? Why might Ironjay choose to add the jay-rider anyway?

17-24 BREAK-EVEN IN UNITS AND SALES DOLLARS, MARGIN OF SAFETY

LO1, LO2,
LO5

Drake Company produces a single product. Last year's income statement is as follows:

Sales (20,000 units)	\$1,218,000
Less: Variable costs	<u>812,000</u>
Contribution margin	\$ 406,000
Less: Fixed costs	<u>300,000</u>
Operating income	<u>\$ 106,000</u>

Required:

1. Compute the break-even point in units and sales dollars.
2. What was the margin of safety for Drake Company last year?
3. Suppose that Drake Company is considering an investment in new technology that will increase fixed costs by \$250,000 per year, but will lower variable costs to 45 percent of sales. Units sold will remain unchanged. Prepare a budgeted income statement assuming Drake makes this investment. What is the new break-even point in units, assuming the investment is made?

17-25 CVP ANALYSIS, IMPACT OF ACTIVITY-BASED COSTING

LO6 Salem Electronics currently produces two products: a programmable calculator and a tape recorder. A recent marketing study indicated that consumers would react favorably to a radio with the Salem brand name. Owner Kenneth Booth was interested in the possibility. Before any commitment was made, however, Kenneth wanted to know what the incremental fixed costs would be and how many radios must be sold to cover these costs.

In response, Betty Johnson, the marketing manager, gathered data for the current products to help in projecting overhead costs for the new product. The overhead costs follow. (The high and low production volumes as measured by direct labor hours were used to assess cost behavior.)

	<i>Fixed</i>	<i>Variable</i>
Materials handling	\$ —	\$18,000
Power	—	22,000
Engineering	100,000	—
Machine costs	30,000*	80,000
Inspection	40,000	—
Setups	60,000	—

*All depreciation.

The following activity data were also gathered:

	<i>Calculators</i>	<i>Recorders</i>
Units produced	20,000	20,000
Direct labor hours	10,000	20,000
Machine hours	10,000	10,000
Material moves	120	120
Kilowatt-hours	1,000	1,000
Engineering hours	4,000	1,000
Hours of inspection	700	1,400
Number of setups	20	40

Betty was told that a plantwide overhead rate was used to assign overhead costs based on direct labor hours. She was also informed by engineering that if 20,000 radios were produced and sold (her projection based on her marketing study), they would have the same activity data as the recorders (use the same direct labor hours, machine hours, setups, and so on).

Engineering also provided the following additional estimates for the proposed product line:

Prime costs per unit	\$ 18
Depreciation on new equipment	18,000

Upon receiving these estimates, Betty did some quick calculations and became quite excited. With a selling price of \$26 and just \$18,000 of additional fixed costs, only 4,500 units had to be sold to break even. Since Betty was confident that 20,000 units could be sold, she was prepared to strongly recommend the new product line.

Required:

1. Reproduce Betty's break-even calculation using conventional cost assignments. How much additional profit would be expected under this scenario, assuming that 20,000 radios are sold?
2. Use an activity-based costing approach, and calculate the break-even point and the incremental profit that would be earned on sales of 20,000 units.
3. Explain why the CVP analysis done in Requirement 2 is more accurate than the analysis done in Requirement 1. What recommendation would you make?

17-26 ABC AND CVP ANALYSIS: MULTIPLE PRODUCTS

LO3, LO6 Good Scent, Inc., produces two colognes: Rose and Violet. Of the two, Rose is more popular. Data concerning the two products follow:

	<i>Rose</i>	<i>Violet</i>
Expected sales (in cases)	50,000	10,000
Selling price per case	\$100	\$80
Direct labor hours	36,000	6,000
Machine hours	10,000	3,000
Receiving orders	50	25
Packing orders	100	50
Material cost per case	\$50	\$43
Direct labor cost per case	\$10	\$7

The company uses a conventional costing system and assigns overhead costs to products using direct labor hours. Annual overhead costs follow. They are classified as fixed or variable with respect to direct labor hours.

	<i>Fixed</i>	<i>Variable</i>
Direct labor benefits	\$ —	\$200,000
Machine costs	200,000*	262,000
Receiving department	225,000	—
Packing department	<u>125,000</u>	<u>—</u>
Total costs	<u>\$550,000</u>	<u>\$462,000</u>

*All depreciation.

Required:

- Using the conventional approach, compute the number of cases of Rose and the number of cases of Violet that must be sold for the company to break even.
- Using an activity-based approach, compute the number of cases of each product that must be sold for the company to break even.

17-27 COLLABORATIVE LEARNING EXERCISE

PART I: ABC AND CVP ANALYSIS, USE OF REGRESSION

LO6 Sorrentino Company, which has been in business for one year, manufactures specialty Italian pastas. The pasta products start in the mixing department, where durum flour, eggs, and water are mixed to form dough. The dough is kneaded, rolled flat, and cut into fettucine or lasagna noodles, then dried and packaged.

Paul Gilchrist, controller for Sorrentino Company, is concerned because the company has yet to make a profit. Sales were slow in the first quarter but really picked up by the end of the year. Over the course of the year, 726,800 boxes were sold. Paul is interested in determining how many boxes must be sold to break even. He has begun to determine relevant fixed and variable costs and has accumulated the following per-unit data:

Price	\$0.90
Direct materials	0.35
Direct labor	0.25

He has had more difficulty separating overhead into fixed and variable components. In examining overhead-related activities, Paul has noticed that machine hours appear to be closely correlated with units in that 100 boxes of pasta can be produced per machine hour. Setups are an important batch-level activity. Paul has accumulated the following information on overhead costs, number of setups, and machine hours for the past 12 months:

	<i>Overhead</i>	<i>Number of Setups</i>	<i>Machine Hours</i>
January	\$5,700	18	595
February	4,500	6	560
March	4,890	12	575
April	5,500	15	615
May	6,200	20	650
June	5,000	10	610
July	5,532	16	630
August	5,409	12	625
September	5,300	11	650
October	5,000	12	550
November	5,350	14	593
December	5,470	14	615

Selling and administrative expenses, all fixed, amounted to \$180,000 last year.

Required:

Form a group of three to four students. The group will work this exercise together, then designate one member of the group to present the results to the class.

1. Separate overhead into fixed and variable components using ordinary least squares (regression) analysis. Run three regressions, using the following independent variables: (a) number of setups, (b) number of machine hours, and (c) a multiple regression using both number of setups and machine hours. Which regression equation is best? Why?
2. Using the results from the multiple regression equation (from Requirement 1), calculate the number of boxes of pasta which must be sold to break even.

PART II: MULTIPLE-PRODUCT CVP ANALYSIS, ABC

**LO3, LO5,
LO6**

(This problem is an extension of Part I of **Problem 17-27**.) Sorrentino Company has decided to expand into the production of sauces to top its pastas. Sauces are also started in the mixing department, using the same equipment. The sauces are mixed, cooked, and packaged into plastic containers. One jar of sauce is priced at \$2 and requires \$0.75 of direct materials and \$0.50 of direct labor. Fifty jars of sauce can be produced per machine hour. The setup is identical to the setup for pasta and should cost the same amount. The production manager believes that with careful scheduling, he can keep the total number of setups (for both pasta and sauce) to the same number as used last year. The marketing director believes Sorrentino Company can sell two boxes of pasta for every one jar of sauce.

Required:

Maintain the same group that was formed in Part I. One to two members of your group should work Requirement 1, and the remaining members will work Requirement 2. The group will come together to discuss Requirement 3.

1. Using the data from **Problem 17-27**, Part I and the results of the multiple regression equation, calculate the break-even number of boxes of pasta and jars of sauce.
2. Suppose that the production manager is wrong and that the number of setups doubles. Calculate the new break-even number of boxes of pasta and jars of sauce.
3. Comment on the effect of uncertainty in the sales mix and in cost estimates and on risk for Sorrentino Company.

17-28 CYBER RESEARCH CASE

- LO1** Find five companies with home pages on the Internet. Be sure that there is at least one company from each of the following categories: manufacturing, service, and wholesale-retail. Determine how each of the companies would define its product(s) for the purposes of cost-volume-profit analysis. Write a brief description of each company and your assessment of its product/service structure. Give your rationale for choosing the type(s) of product or service.