

Chapter 5

Cost-Volume-Profit Analysis

SIERRA PLASTICS MANUFACTURES A patented plastic, Perlast, used to make milk, fruit juice, and water containers. Sierra's chief executive officer and founder, Ben Brady, started the company because scientific tests showed that Perlast did a better job than existing plastics in preserving freshness for longer periods.

While Sierra has always been profitable, Ben believes that the company could do better. He and his staff are considering three options to increase profit for the coming year (see the the Decision Framework box at right for details).

Ben is unsure how to evaluate these options and chart the best course of action. He believes it will be difficult for Sierra to pursue more than one option initially. Thus, Ben would like to start with the option that has the maximum profit impact, then revisit the other two options later. Ben seeks your help in selecting the best option.

APPLYING THE DECISION FRAMEWORK

What Is the Problem?	How can Sierra Plastics increase its profit?
What Are the Options?	Ben and his staff have identified three promising options: <ol style="list-style-type: none">1. Decrease the price of Perlast to increase demand.2. Purchase new inspection technology to reduce the unit variable cost of Perlast.3. Offer different grades of Perlast to meet the specific needs of individual market segments.
What Are the Costs and Benefits?	You will perform Cost-Volume-Profit (CVP) analysis to estimate the costs and benefits of each option.
Make the Decision!	After performing CVP analysis, you will be able to recommend the best option for Sierra.



Elle Wagner

Sierra Plastics is considering several options to increase profit.

LEARNING OBJECTIVES

After studying this chapter, you will be able to:

- 1 Understand the Cost-Volume-Profit (CVP) relation.
- 2 Use the CVP relation to plan profit.
- 3 Make short-term decisions using CVP analysis.
- 4 Measure risk using the CVP relation.
- 5 Perform CVP analysis with multiple products.
- 6 List the assumptions underlying CVP analysis.

How many tickets do the **Chicago Cubs** need to sell for a game to break even? How much will profit increase if **Starbucks** sells another 1 million cups of coffee a year? When facing lower than expected demand, would reducing the selling price be more profitable for **Nike** than increasing advertising? Cost-Volume-Profit analysis, the focus of this chapter, is the tool we use to answer such questions.

We begin this chapter by examining the Cost-Volume-Profit (CVP) relation. We then show you how to use the CVP relation for profit planning and for evaluating the profit impact of short-term decisions. Following this, we extend the CVP relation to include multiple products. Finally, we discuss the limitations of CVP analysis.



CHAPTER CONNECTIONS

CVP analysis is useful for profit planning and for making short-term decisions that pertain to the firm as a whole. However, it can be difficult to adapt CVP analysis to decisions that deal with individual products, resources, or customers. We consider such decisions in Chapters 6.

The Cost-Volume-Profit (CVP) Relation

LEARNING OBJECTIVE 1

Understand the CVP relation.

The Cost-Volume-Profit (CVP) relation follows directly from the contribution margin statement that we studied in Chapter 4. In this statement, we calculated profit by subtracting variable costs and fixed costs from revenue. In other words:

$$\text{Profit before taxes} = \text{Revenues} - \text{Variable costs} - \text{Fixed costs}$$

Both revenues and variable costs are proportional to sales volume. Revenues equal the number of units sold multiplied by the price per unit. Likewise, variable costs equal the number of units sold multiplied by the unit variable cost. Combining these observations, we can rearrange this profit equation to highlight the Cost-Volume-Profit relation:

$$\begin{aligned} \text{Profit before taxes} &= [(\text{Price} - \text{Unit variable cost}) \times \text{Sales volume in units}] \\ &\quad - \text{Fixed costs} \end{aligned}$$

Notice that, over the short term, fixed costs do not change with the number of units sold.

This expression captures the essence of the CVP relation because it relates sales volume with profit and costs.

Next, we define **unit contribution margin** = $\text{Price} - \text{Unit variable cost}$. Using this definition, we have:

$$\begin{aligned} \text{Profit before taxes} &= (\text{Unit contribution margin} \times \text{Sales volume in units}) - \text{Fixed costs} \\ &= \text{Contribution margin} - \text{Fixed costs} \end{aligned}$$

This final expression emphasizes that *contribution margin is the appropriate measure for evaluating short-term decisions*. Why does this conclusion follow? Because fixed costs generally do not change in the short term, increasing contribution margin increases profit by an identical amount. That is, for every unit sold, profit increases by an amount equal to the unit contribution margin.

For Sierra, Ben provides you with the information in Exhibit 5.1 for the most recent year of operations.

We can construct Sierra's CVP relation using the information in Exhibit 5.1. We have price = \$25, unit variable cost = \$10, sales volume in units = 100,000, and fixed costs = \$1,200,000. Thus, we express Sierra's profit as:

$$\begin{aligned} \text{Profit before taxes} &= [(\text{Price} - \text{Unit variable cost}) \times \text{Sales volume in units}] - \text{Fixed costs} \\ \text{Profit before taxes} &= [(\$25 - \$10) \times 100,000] - \$1,200,000 = \$300,000 \end{aligned}$$

Because we know the unit contribution margin is $\$25 - \$10 = \$15$, we can also write:

$$\text{Profit before taxes} = (\$15 \times 100,000) - \$1,200,000 = \$300,000$$

Exhibit 5.1		<i>Sierra Plastics: Key Operating Data</i>	
Item	Amount	Item	Amount
Sales of Perlast in pounds	100,000	Manufacturing capacity (in pounds)	200,000
Selling price per pound	\$25		
<u>Variable manufacturing costs</u>		<u>Fixed manufacturing costs</u>	
Direct materials per pound	\$3	Equipment	\$150,000
Direct labor per pound	\$4	Supervisory personnel	\$170,000
Packaging per pound	\$2	Factory rent	\$290,000
<u>Variable selling costs</u>		<u>Fixed selling & administration cost</u>	
Sales commissions per pound	\$1	Advertising	\$40,000
		Sales staff	\$250,000
		Office space rental and expenses	\$300,000
Total variable costs per pound	\$10	Total fixed costs	\$1,200,000

Exhibit 5.2 uses the data in Exhibit 5.1 to construct a contribution margin statement for Sierra. Notice that this statement shows the same profit we calculated using the CVP relation. This equivalence underscores the fact that the CVP relation is simply a convenient way to express the contribution margin statement.

HOW FIRMS USE THE CVP RELATION

Firms frequently use the CVP relation to estimate profit at different sales volumes. At the current sales volume of 100,000 pounds, Sierra's profit is \$300,000. As shown in Exhibit 5.3, you can use the CVP relation to calculate Sierra's profit before taxes at differing sales volumes.

Exhibit 5.2		<i>Sierra Plastics: Income Statement</i>	
Item	Detail	Amount	
Revenues		\$2,500,000	
Variable costs	100,000 pounds × \$25 per pound		
Manufacturing	100,000 pounds × \$9 per pound	\$900,000	
Selling	100,000 pounds × \$1 per pound	100,000	
Contribution margin		\$1,500,000	
Fixed Costs			
Manufacturing	From Exhibit 5.1	\$610,000	
Selling & administration	From Exhibit 5.1	590,000	
Profit before taxes		\$300,000	

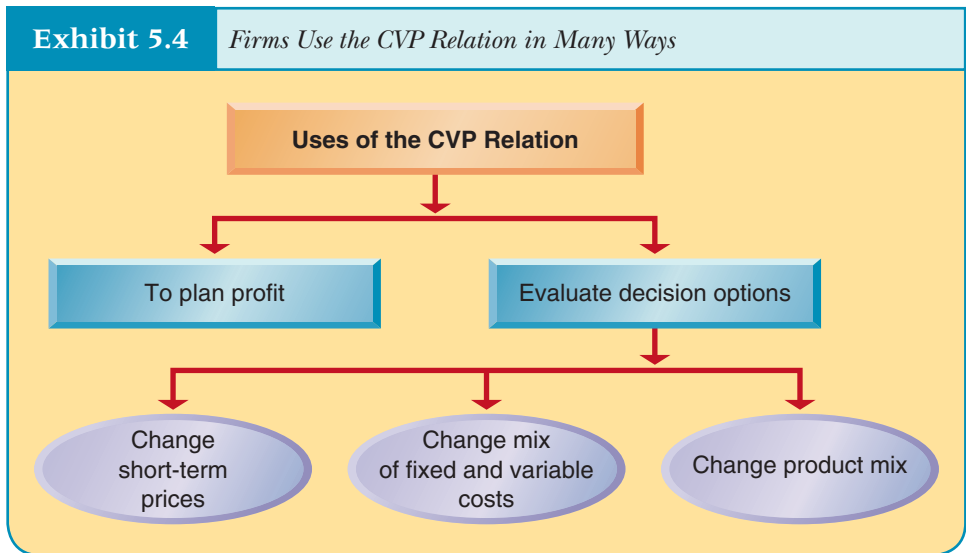
Exhibit 5.3		<i>Sierra's Expected Profit before Taxes at Differing Sales Volumes</i>			
		Sales Volume of Perlast in Pounds			
		90,000	100,000	120,000	140,000
Profit before taxes =	$(\$15 \times \text{Sales volume in pounds})$	\$150,000	\$300,000	\$600,000	\$900,000
	– \$1,200,000				

 **Check It! Exercise #1**

Verify that Sierra's expected profit before taxes is \$675,000 if it sells 125,000 pounds of Perlast.

Solution at end of chapter.

Exhibit 5.3 shows that a relatively modest increase in sales volume leads to a substantial increase in profit. For example, increasing Sierra's sales by 20%, from 100,000 pounds to 120,000 pounds, increases profit before taxes by 100%, from \$300,000 to \$600,000. Similarly, a modest decrease in sales volume reduces profit substantially. Decreasing quantity sold by 10%, from 100,000 pounds to 90,000 pounds, reduces profit before taxes by 50%, from \$300,000 to \$150,000. Such large changes in profit as the sales volume changes indicate that Sierra faces some risk in its operations. As shown in Exhibit 5.4, and as you will learn later, firms use the CVP relation for many purposes.



The CVP Relation and Profit Planning

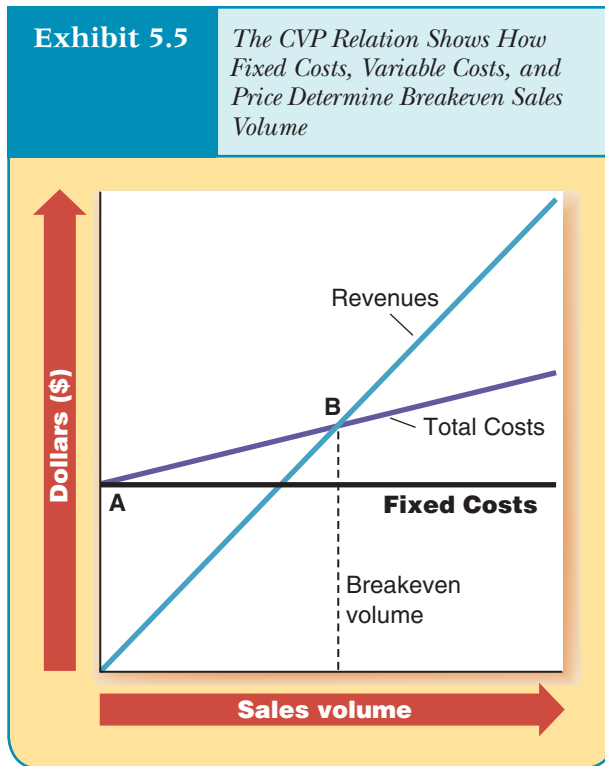
LEARNING OBJECTIVE 2

Use the CVP relation to plan profit.

While most organizations want to make a profit, at the very least they want to generate enough business to avoid making a loss. What volume of business must a company generate to guarantee that there will be no loss? What volume of business would yield a certain minimum profit? We refer to the use of the CVP relation to answer such questions as *profit planning*.

BREAKEVEN VOLUME

Breakeven volume is the sales volume at which profit equals zero. Exhibit 5.5 is useful in understanding the breakeven point. The line for total costs equals fixed costs



plus variable costs. Point A shows where the total costs line intercepts the y-axis. At this point, when there are no sales, revenues are zero and total costs equal fixed costs. As sales volume increases, total costs increase proportionally due to the variable costs associated with making and selling products.

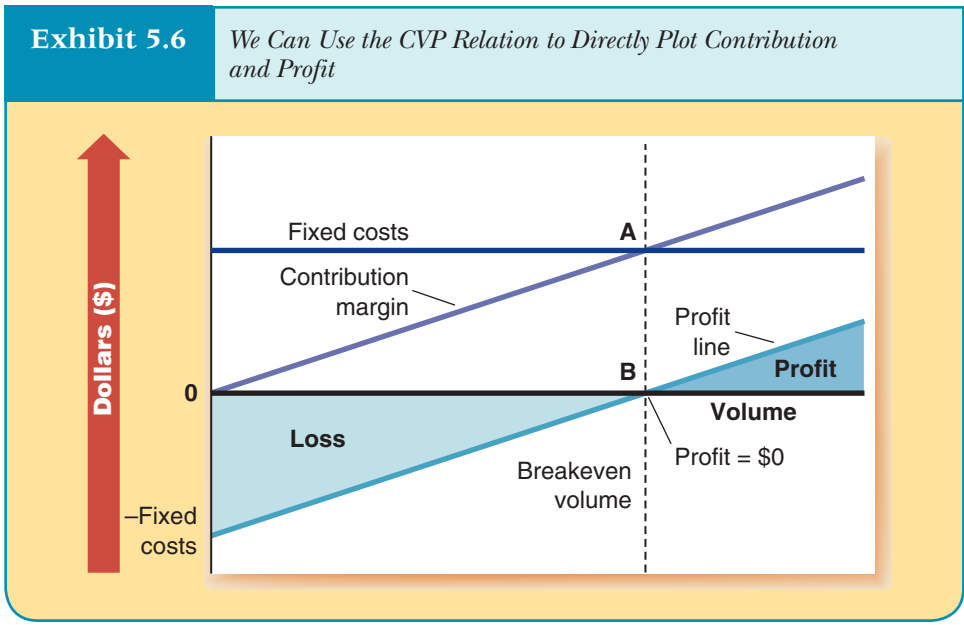
At the breakeven volume, point B, the firm makes zero profit, meaning that revenues equal total costs. The firm is profitable if the quantity sold exceeds the breakeven volume. However, the firm incurs a loss if sales dip below this level. Exhibit 5.5 also highlights that, for a viable business, the revenues line must be steeper than the total costs line. Why is this? If the total costs line is steeper than the revenues line, the two lines will never meet—profit will always be negative. Thus, to have any chance of making a profit, a firm must have a positive unit contribution margin; that is, price must exceed the unit variable cost.

Exhibit 5.6 shows another way to look at breakeven. In this graph, we directly plot contribution margin and profit. When sales volume is zero, the firm incurs a loss equal to its fixed costs. You can see this relationship where the contribution margin line and the profit line intercept the y-axis. For every unit sold, both contribution margin and profit increase at the same rate, by an amount equal to the unit contribution margin. When we sell enough units to make contribution margin equal to fixed costs (point A), profit equals zero (point B). This amount of units is the breakeven volume. The greater the unit contribution margin, the steeper the profit line and the more the firm's profit increases for a given increase in sales volume.

A positive unit contribution margin by itself does not guarantee profit, however. The firm must sell enough units so that the contribution margin at least covers fixed costs. For example, how many pounds of Perlant must Sierra sell to avoid a loss? We know that Sierra's unit contribution margin equals \$15 and its fixed costs are \$1,200,000. Because profit equals zero at the breakeven volume, we set profit equal to \$0 to calculate the breakeven volume as:

$$0 = \text{Breakeven volume} \times \text{Unit contribution margin} - \text{Fixed costs}$$

$$\text{Breakeven volume} = \frac{\text{Fixed costs}}{\text{Unit contribution margin}}$$



Thus, Sierra needs to sell 80,000 pounds (fixed costs of \$1,200,000 divided by the unit contribution margin of \$15) to break even. We can verify this answer by using the CVP relation to calculate that Sierra has zero profit at this volume: \$15 in unit contribution margin \times 80,000 units $-$ \$1,200,000 of fixed costs = profit of \$0.

 **Connecting to Practice**

RECYCLING



Variable costs for recyclers can be low because they often do not pay for their raw materials. (Pete Starman/Getty Images)

Tomra Corporation operates kiosks where consumers return aluminum cans. Located near supermarkets, these brightly lit and clean kiosks provide a convenient way for environmentally conscious consumers to recycle.

Tomra's business plan is straightforward. Each kiosk costs \$36,000 a year to operate in fixed costs. The kiosk receives \$0.02 in revenue for each can delivered to the scrap metal dealer, but consumes \$0.01 in processing costs. Accordingly, **Tomra** estimates that it needs to process 3,600,000 cans per year, or 300,000 cans per month, for a kiosk to break even.

The state of California goes a step further by providing **Tomra** with a subsidy of \$21,600 per year to cover fixed costs and \$0.01 per can toward processing costs. These subsidies reduce both **Tomra's** fixed costs and the unit variable cost, making it easier to reach breakeven. California hopes that **Tomra** will then open more kiosks, making it even more convenient for consumers to recycle.

COMMENTARY: With the information provided, we express **Tomra's** profit for a kiosk as, *Profit before taxes* = $[($0.02 - $0.01) \times \text{Sales volume in units}] - \$36,000$. Thus, each kiosk needs to process $\$36,000 / 0.01 = 3,600,000$ cans per year, or $3,600,000 / 12 = 300,000$ cans per month, to break even. With the California subsidies, **Tomra's** profit is *Profit before taxes* = $(\$0.02 \times \text{Sales volume in units}) - \$14,400$. In turn, we calculate the breakeven point as $\$14,400 / 0.02 = 720,000$ cans per year. This substantial reduction in the breakeven volume to 60,000 cans per month makes it more attractive for **Tomra** to open new kiosks.

BREAKEVEN REVENUES

Organizations frequently prefer to express the breakeven point in terms of *revenues* rather than in terms of units. Why? Well, money is the language of business. Ultimately, managers focus on dollars and the bottom line rather than on physical units.

Breakeven revenues are the sales dollars needed to break even:

$$\text{Breakeven revenues} = \text{Breakeven volume} \times \text{Price}$$

For Sierra, we know the breakeven volume is 80,000 pounds of Perlast and the price is \$25 per pound. Thus, we calculate breakeven revenues as:

$$\text{Breakeven revenues} = 80,000 \text{ pounds} \times \$25 \text{ per pound} = \$2,000,000$$

While this calculation is helpful, organizations often report only total revenue and cost data; they often do not report the unit-level data. The absence of such detail makes it difficult to determine a product's unit contribution margin or price. Thus, it may not be possible to calculate breakeven revenues as above.

Fortunately, we can compute breakeven revenues directly. To do so, it is necessary to understand the notion of a contribution margin ratio. The **contribution margin ratio** is simply the unit contribution margin divided by price. That is,

$$\text{Contribution margin ratio} = \frac{\text{Unit contribution margin}}{\text{Price}} = \frac{\text{Price} - \text{Unit variable cost}}{\text{Price}}$$

Sierra's contribution margin ratio is:

$$\text{Contribution margin ratio} = \frac{\$25 - \$10}{\$25} = \frac{\$15}{\$25} = 0.60 \text{ or } 60\%$$

Intuitively, the contribution margin ratio is the portion of every sales dollar that remains after covering variable costs—it is the portion that contributes toward covering fixed costs and, ultimately, to profit. For Sierra, 40% of the \$25 revenue from each pound of Perlast sold goes toward covering variable costs ($\$10/\$25 = 0.40$ or 40%). The remaining 60% contributes to covering fixed costs and to profit.

We can calculate the contribution margin ratio either using unit-level data or using total revenues and variable costs. If only total revenues and variable cost information are available, we calculate the contribution margin ratio as

$$\text{Contribution margin ratio} = \frac{\text{Contribution margin}}{\text{Revenues}} = \frac{\text{Revenues} - \text{Variable costs}}{\text{Revenues}}$$

For Sierra, we refer to Exhibit 5.2 and compute the contribution margin ratio as

$$\text{Contribution margin ratio} = \frac{\$2,500,000 - \$1,000,000}{2,500,000} = 0.60$$

The contribution margin ratio represents the portion of revenues that contribute to covering fixed cost and profit. Therefore, we can express a firm's profit as

$$\text{Profit before taxes} = (\text{Contribution margin ratio} \times \text{Revenues}) - \text{Fixed costs}$$

In turn, we can calculate breakeven revenues by setting profit equal to zero and solving as follows:

$$0 = \text{Breakeven revenues} \times \text{Contribution margin ratio} - \text{Fixed costs}$$

$$\text{Breakeven revenues} = \frac{\text{Fixed costs}}{\text{Contribution margin ratio}}$$

Given Sierra's contribution margin ratio of 60% and fixed costs of \$1,200,000, we calculate Sierra's breakeven revenues as $\$1,200,000/0.60 = \$2,000,000$. This amount is exactly what we found earlier when we multiplied the breakeven volume by the selling price.



Check It! Exercise #2

Suppose Sierra sells Perlast for \$50 a pound, the unit variable cost is \$30, and annual fixed costs equal \$1,500,000. Verify that the breakeven volume is 75,000 pounds and that breakeven revenues are \$3,750,000 under both the *unit contribution margin* and the *contribution margin ratio* approaches:

Unit contribution margin approach

Profit before taxes = (Unit contribution margin × Sales volume in units) – Fixed costs.

Unit contribution margin _____

Breakeven volume _____

Breakeven revenues _____

(= Breakeven volume × Price) _____

Contribution margin ratio approach

Profit before taxes = (Contribution margin ratio × Revenues) – Fixed costs.

Contribution margin ratio _____

Breakeven revenues _____

Breakeven volume _____

(= Breakeven revenue/Price) _____

Solution at end of chapter.

TARGET PROFIT

Organizations frequently specify annual, quarterly, and monthly profit goals for their product and divisional managers. These goals guide managers' actions during the period. For example, managers will want to know the level of sales required to achieve the targeted profit. Is this sales level possible at the current price? Is additional advertising necessary? Are price discounts necessary? Managers can use the CVP relation to answer such questions.

To illustrate, suppose Sierra wants to earn a profit before taxes of \$450,000 in the coming year. How many pounds of Perlast must the company sell? How much revenue does it need to generate? Let us first answer these questions using the unit contribution margin. As you know,

$$\text{Profit before taxes} = (\text{Unit contribution margin} \times \text{Sales volume in units}) - \text{Fixed costs}$$

Setting profit before taxes equal to \$450,000, we have:

$$\$450,000 = (\$15 \times \text{Sales volume in units}) - \$1,200,000$$

Solving, we find that Perlast needs a sales volume of 110,000 pounds to achieve a profit of \$450,000. At this volume, revenues equal \$2,750,000 (\$25 price per pound × 110,000 pounds).

We can also use the contribution margin ratio to answer these questions.

$$\text{Profit before taxes} = (\text{Contribution margin ratio} \times \text{Revenues}) - \text{Fixed costs}$$

From our earlier calculations, we know that the contribution margin ratio for Perlast is 0.60, or 60%. Therefore, setting profit before taxes equal to \$450,000,

$$\$450,000 = (0.60 \times \text{Revenues}) - \$1,200,000$$

Solving, we find that revenues of \$2,750,000 are necessary to achieve a profit of \$450,000, the same sales figure we obtained earlier!

CVP Analysis and Taxes

Taxes are an unavoidable part of doing business. As a result, firms usually are interested in earning a target profit *after* taxes. We can readily modify the CVP relation to include taxes:

$$\begin{aligned} \text{Profit after taxes} &= \text{Profit before taxes} - (\text{Profit before taxes} \times \text{Tax rate}) \\ &= \text{Profit before taxes} \times (1 - \text{Tax rate}) \end{aligned}$$

Keep in mind that we can calculate profit before taxes using either the unit contribution margin approach or the contribution margin ratio approach.

Suppose Ben wishes to make \$450,000 in profit *after* taxes and that Sierra faces a 40% tax rate. How many pounds of Perlast does Sierra need to sell? How much revenue must Sierra generate? Using the unit contribution margin approach, we have:

$$\$450,000 = [(\$15 \times \text{Sales volume in units}) - \$1,200,000] \times (1 - 0.40)$$

Solving, we find that the required sales volume is 130,000 pounds. Multiplying this volume by the price of \$25 per pound translates to \$3,250,000 in required revenues. These answers exceed our earlier answers of 110,000 pounds and \$2,750,000 in revenues because taxes reduce the profit retained.

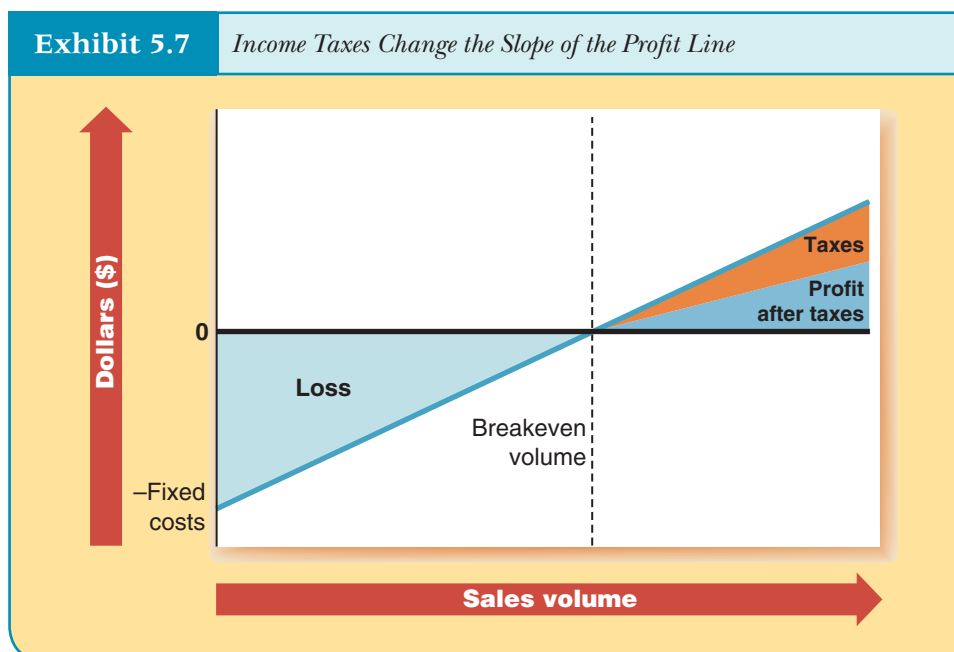
Let us verify these numbers using the contribution margin ratio approach:

$$\$450,000 = [(0.60 \times \text{Revenues}) - \$1,200,000] \times (1 - 0.40)$$

Solving, we find once again that revenues of \$3,250,000 are required to achieve \$450,000 in profit after taxes.

Exhibit 5.7 re-draws the profit graph from Exhibit 5.6 to show how taxes affect the CVP relation. Taxes reduce profit by a certain percentage beyond the breakeven point. In Exhibit 5.7, we see that, above the breakeven point, the slope of the profit line decreases by the taxes paid. Below the breakeven point, no tax is due; therefore, the CVP relation remains the same as in Exhibit 5.6.

Armed with an understanding of the CVP relation, let us now use it to evaluate Sierra's options.



Using the CVP Relation to Make Short-Term Decisions

LEARNING OBJECTIVE 3

Make short-term decisions using CVP analysis.

In addition to planning profits, the CVP relation helps organizations make short-term decisions. As noted in the opening paragraphs of this chapter, Sierra's current profitability gives Ben some comfort, yet he desires to improve profit. Recall that he and his staff identified three options:

1. Decrease the price of Perlast to increase demand.
2. Purchase new inspection technology to reduce the unit variable cost of Perlast.
3. Offer different grades of Perlast to meet the specific needs of individual market segments.

Under the first option, decreasing the selling price per pound reduces the unit contribution margin—the change reduces price, but not the unit variable cost. Because each pound sold contributes less to profit, Sierra's overall profit will increase only if the reduction in the unit contribution margin is more than offset by the additional sales volume that price cuts typically generate.

Under the second option, the unit contribution margin will increase because Sierra expects the inspection technology to reduce the unit variable cost. Consequently, each pound of Perlast sold will contribute more to profit. However, this option also increases fixed costs. Sierra can justify the expenditure only if the increased contribution margin exceeds the increase in fixed costs.

The final option is to tailor grades of Perlast to individual market segments, allowing Sierra to increase total sales volume and use existing capacity more effectively. Producing and marketing multiple products is likely to increase Sierra's fixed costs. As with the second option, Sierra can justify expanding its product offerings only if the increased contribution margin exceeds the increase in fixed costs.

In sum, we can analyze each option in terms of the CVP relation and its effect on various elements that make up Sierra's profit. Let us first evaluate Ben's pricing decision.

USING THE CVP RELATION TO EVALUATE PRICE CHANGES

In most markets, increases in price reduce sales volume. Conversely, retail companies such as JCPenney, Mattress Firm, and Sears reduce prices in an effort to stimulate sales. Thus far, we have not taken this "inverse" relation between price and sales volume into account. But it is relatively straightforward to do so.

Suppose that Sierra's marketing director draws on her considerable experience to estimate demand at various prices, as shown in Exhibit 5.8. Using the data in

Exhibit 5.8		Sierra Plastics: Demand at Various Prices
Price (per pound)	Expected Sales Volume (in pounds)	
\$25	100,000	
\$23	120,000	
\$20	160,000	
\$18	184,000	
\$16	200,000	

Exhibit 5.8 and Sierra's CVP relation, you can estimate profit at each price, quantity combination. Exhibit 5.9 shows the results of these calculations.

Notice that of the prices listed, a price of \$20 yields the highest profit even though reducing the price by \$5 decreases the unit contribution margin from \$15 to \$10. We obtain this result because the corresponding change in sales volume, from 100,000 pounds to 160,000 pounds, overcomes the negative effects of the lower unit contribution margin. The net result of this tradeoff is an increase in short-term profit before taxes of \$100,000.

Exhibit 5.10, which depicts the trade-off in a graph, shows two classic relations. As shown by the demand curve, increases in price reduce demand. Second, there is an inverted U shape relation between price and profit. At low prices, increasing prices to raise contribution overcomes the effect of lost demand. But, as prices increase even more, the demand loss overcomes the effect of gaining more contribution from each unit sold.

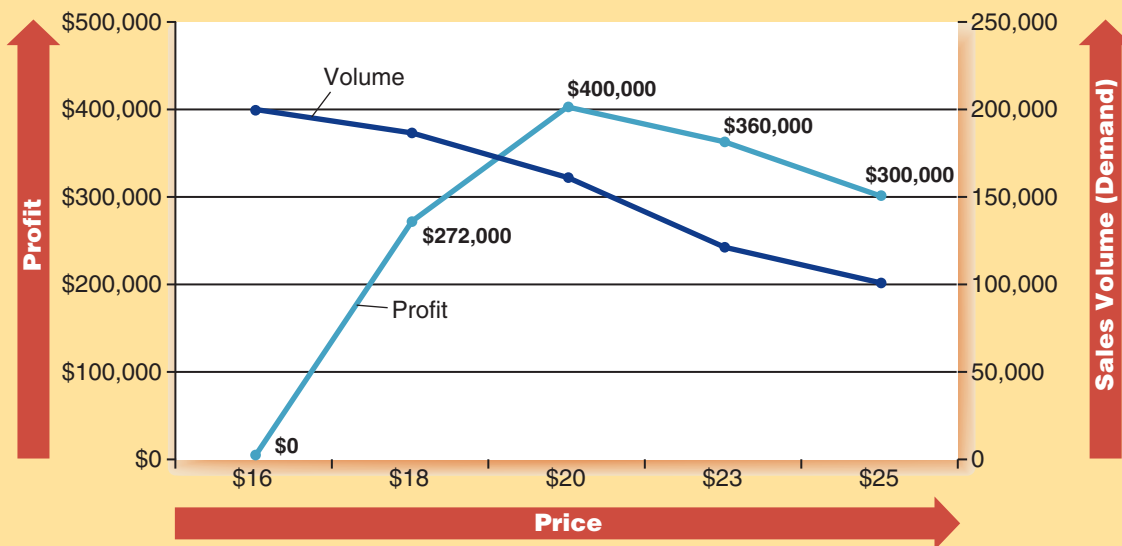
Exhibit 5.9

Sierra Plastics: Cost-Volume-Profit Analysis to Evaluate Price Changes

Price	Unit Variable Cost	Unit Contribution Margin	Fixed Costs	Expected Sales Volume	Profit before Taxes
\$25	\$10	\$15	\$1,200,000	100,000	\$300,000
\$23	\$10	\$13	\$1,200,000	120,000	\$360,000
\$20	\$10	\$10	\$1,200,000	160,000	\$400,000
\$18	\$10	\$8	\$1,200,000	184,000	\$272,000
\$16	\$10	\$6	\$1,200,000	200,000	\$0

Exhibit 5.10

Firms Trade Off Unit Contribution with Volume When Choosing Prices



Sierra's current price is \$25 per pound. Thus, lowering price to \$20 increases profit. However, reducing the price too much could hurt profit. If Ben sells Perlast for \$18 per pound, Sierra experiences high-capacity utilization (184,000 pounds/200,000 pounds of capacity = 92% utilization). However, even such a high volume is not sufficient to offset the effect of the lower unit contribution margin. Profit before taxes is \$272,000, less than the \$300,000 currently earned. This example demonstrates how CVP analysis allows firms to evaluate the trade-off between price and quantity, and their effect on profit.

A word of caution before we move on. When performing such computations, keep in mind the *short-term focus* of CVP analysis. Price reductions may pay off in the short term, but they often are not beneficial in the long term. For example, competing firms may decide to cut their prices as well. In that case, the demand estimates in Exhibit 5.8 may not hold in future periods. Ben must consider these longer-term consequences before reducing prices permanently.



CHAPTER CONNECTIONS

At the time Ben founded Sierra, he would have considered the long-term price, costs, and demand for Perlast. The outcome of this decision process resulted in Sierra installing capacity to make 200,000 pounds of Perlast annually. We consider such capital budgeting decisions in Chapter 13. However, the actual demand for a year might be higher or lower than the long-term average. If the actual demand falls short of the capacity of 200,000 pounds in a given year, Ben may have to reduce the selling price to stimulate demand. Thus, the focus of such short-term decisions is to respond to immediate demand conditions and to make the most profitable use of available capacity. The cost of the capacity itself is not controllable for these decisions.

Using the CVP Relation to Evaluate Operating Risk

LEARNING OBJECTIVE 4

Measure risk using the CVP relation.

The second option Ben is considering changes Sierra's cost structure. Suppose Sierra's production manager wants to purchase new inspection technology. The patent owner will supply Sierra with all of the needed equipment for a fee of \$40,000 per year. If Sierra acquires the technology, the license fee will increase Sierra's annual fixed costs to \$1,240,000. However, the action will also reduce Sierra's variable direct labor costs of \$4 per pound by 25%, or \$1 per pound. This savings reduces total variable costs from \$10 to \$9, thereby increasing the unit contribution margin from \$15 to \$16. Exhibit 5.11 presents data assuming Sierra purchases the new inspection technology.

The key question is whether acquiring the new technology will increase profit. Because we are evaluating each option separately, we perform this analysis using the original Perlast price of \$25 per pound. We start by calculating Sierra's revised breakeven volume:

$$\text{Breakeven volume} = \frac{\text{Fixed costs}}{\text{Unit contribution margin}} = \frac{\$1,240,000}{\$16} = 77,500 \text{ pounds}$$

With the new inspection technology, Sierra requires only 77,500 pounds of Perlast, rather than 80,000 pounds, to break even. With an expected demand of 100,000 pounds, a higher volume contributes directly to annual profit. In addition, each pound contributes one dollar more to profit than before (i.e., \$16 versus \$15 per pound).

As Exhibit 5.12 shows, these factors lead to a \$60,000 *increase* in Sierra's profit before taxes. Because it reduces the required volume to break even and increases profit, the new inspection technology seems like a good option. However, this option also changes Sierra's cost structure and adds to fixed costs. Firms are usually reluctant to add to fixed costs because they represent a sure outflow. In contrast, actual revenues and variable costs are uncertain because their amounts depend on the actual demand. Thus, the new technology might subject Sierra to greater risk. If the risk is "too much," Ben might even forego the additional profit from adopting the new technology.

How should we evaluate the risk arising from a firm's choice of cost structure? In this section, we discuss two common measures of *operating* risk. These two measures—margin of safety and operating leverage—originate from the CVP relation.

MARGIN OF SAFETY

The CVP relation allows firms to evaluate risk by considering the amount by which expected sales exceeds breakeven sales. We refer to this cushion, expressed in percentage terms, as the firm's **margin of safety**:

$$\text{Margin of safety} = \frac{\text{Sales in units} - \text{Breakeven volume}}{\text{Sales in units}} = \frac{\text{Revenues} - \text{Breakeven revenues}}{\text{Revenues}}$$

For Sierra, without adding in the new technology, current sales are 100,000 pounds and current revenues are \$2,500,000. The breakeven volume is 80,000 pounds, and breakeven revenues are \$2,000,000. Thus, we have:

$$\begin{aligned} \text{Margin of safety (current)} &= \frac{100,000 - 80,000}{100,000} = \frac{\$2,500,000 - \$2,000,000}{\$2,500,000} \\ &= 0.20 \text{ or } 20\% \end{aligned}$$

Exhibit 5.11 Sierra Plastics: Data with New Inspection Technology

Item	Amount	Item	Amount
Sales (in pounds)	100,000	Available capacity (pounds)	200,000
Selling price per pound	\$25		
Variable costs per pound		Fixed costs	
Variable cost per pound	\$10	Fixed costs (Exhibit 5.1)	\$1,200,000
<i>Decrease in variable cost</i>	<u>\$1</u>	<i>Increase in fixed costs</i>	<u>\$40,000</u>
New variable cost	\$9	New fixed costs	\$1,240,000

Exhibit 5.12 Sierra Plastics: CVP Analysis with and without New Inspection Technology

	Price	Unit Variable Cost	Unit Contribution Margin	Fixed Costs	Breakeven Volume	Expected Sales	Profit before Taxes
With new technology	\$25	\$9	\$16	\$1,240,000	77,500	100,000	\$360,000
Without new technology (current operations)	\$25	\$10	\$15	\$1,200,000	80,000	100,000	\$300,000

If Sierra maintains sales at the current level of 100,000 pounds and revenues of \$2,500,000, it has a 20 percent margin of safety.

With the new technology, breakeven volume is 77,500 pounds and breakeven revenues are \$1,937,500 ($77,500 \times \25). Thus, we have:

$$\begin{aligned} \text{Margin of safety (new technology)} &= \frac{100,000 - 77,500}{100,000} = \frac{\$2,500,000 - \$1,937,500}{\$2,500,000} \\ &= 22.5\% \end{aligned}$$

By reducing the breakeven point, and thereby increasing the margin of safety, the new technology lowers Sierra's operating risk at the expected level of operations.

To firm up our understanding, let us revisit the decision to reduce prices from the perspective of margin of safety. We know from Exhibit 5.9 that lowering the price of Perlast to \$20 will increase profit. But is there any downside to reducing the price? What happens to Sierra's margin of safety? Because the price reduction decreases Sierra's unit contribution margin to \$10, Sierra's breakeven volume increases to 120,000 pounds (fixed costs of \$1,200,000/unit contribution margin of \$10). Ben expects to sell 160,000 pounds of Perlast at the new price; therefore, Sierra's expected margin of safety is

$$\text{Margin of safety} = \frac{160,000 - 120,000}{160,000} = 0.25 \text{ or } 25\%$$

Thus, decreasing price increases both expected profit *and* the margin of safety (calculated earlier at 20%). However, in the final analysis of option 1, Ben will need to weigh the comfort he gains from the larger cushion against the pressure of needing to sell an additional 40,000 pounds to break even.

In general, the higher the margin of safety, the lower the risk of a loss should actual sales fall short of expectations. There is no hard and fast rule on what is an appropriate margin of safety. It varies from industry to industry and from firm to firm. In industries with stable demand conditions, a small margin of safety might be enough to reduce the risk of losses to acceptable levels. Conversely, firms that face highly variable demand conditions might require high margins of safety.

Margin of Safety and Profit Sensitivity

We can use the margin of safety to calculate the percent change in profit that results from any given percent change in sales, as follows:

$$\begin{aligned} \% \text{ change in profit before taxes} &= \% \text{ change in Sales volume} \times (1/\text{Margin of safety}) \\ &= \% \text{ change in Revenues} \times (1/\text{Margin of safety}) \end{aligned}$$

Using the current data (without the new technology and with the current price of \$25 per pound), we know that Sierra's current sales are 100,000 pounds and its margin of safety is 20%. Then, if sales were to increase by 10% to 110,000 pounds, this equation indicates that Sierra's profit change would be

$$\% \text{ change in profit before taxes} = 0.10 \times (1/0.20) = 0.50 \text{ or } 50\%$$



Check It! Exercise #3

Assume that Sierra sells Perlast for \$50 a pound, the unit variable cost is \$30, annual fixed costs equal \$1,500,000, and current sales total 80,000 pounds. Verify that the margin of safety = 6.25% using both sales volume in units and revenues. In addition, verify that if sales were to increase by 20%, profits would increase by 320%, from \$100,000 to \$420,000.

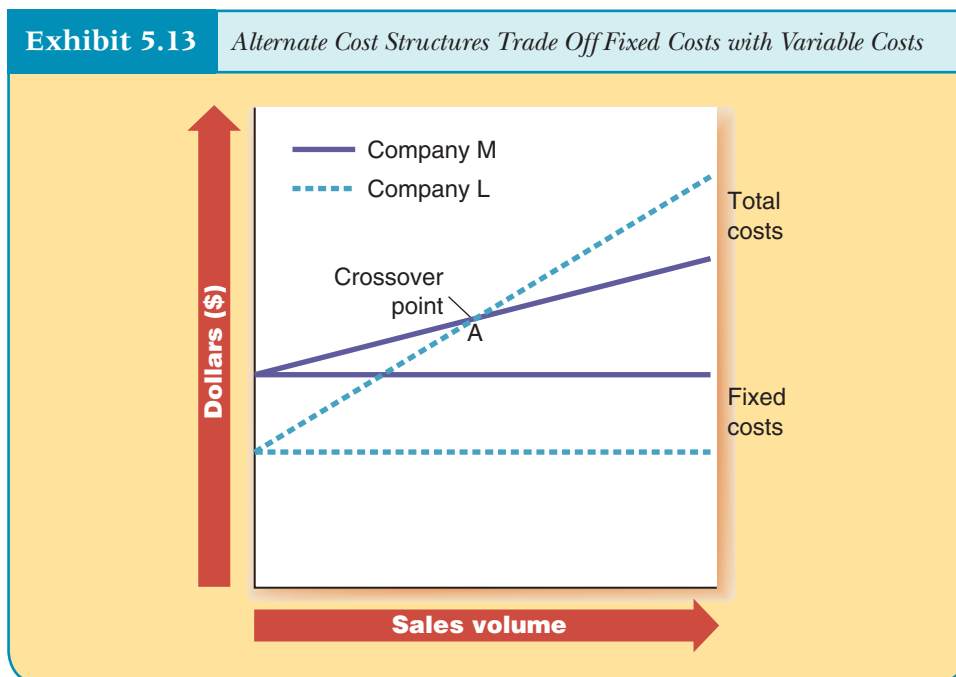
Sierra's profit before taxes would increase by 50% of \$300,000, or \$150,000. Adding this \$150,000 to the original profit of \$300,000 gives a revised profit before taxes of \$450,000. As we saw in Exhibit 5.3, a small change in sales can have a large impact on profit. The effect is particularly large for sales volumes near the breakeven point, where margins of safety are very low.

OPERATING LEVERAGE

By their choice of technology, firms can influence the proportion of fixed and variable costs they incur. Typically, firms with higher fixed costs have lower variable costs and, hence, higher contribution margins. However, at lower volumes, higher fixed costs impose higher risk because they result in greater total costs. Moreover, the greater the fixed cost, the more sensitive is profit to changes in volume.

Exhibit 5.13 is useful for understanding this trade-off between fixed and variable costs. This exhibit shows the total cost lines for two companies that have different cost structures. Company M, represented by the solid line, is machine intensive, whereas Company L, represented by the dotted line, is labor intensive. At zero sales volume, there are no variable costs—this is the point where each line intercepts the y-axis. At this point, total costs are higher for Company M because it has higher fixed costs from its investment in machinery. As sales volume increases, total costs increase at a smaller rate for Company M because its unit variable cost is lower than that for labor-intensive Company L. For low sales volumes, Company M has higher total costs than Company L.

As volume increases, the difference in total costs narrows and vanishes at some point. This point, marked in the graph as point A, represents the *crossover* volume. At this point, the total costs for the two companies are equal. Beyond this point, the total costs for Company L exceed those of Company M. Higher volumes favor Company M because the benefits from its lower variable costs more than offset the disadvantage it faces from higher fixed costs.



Firms use **operating leverage** as a measure of risk arising from having more fixed costs. We calculate operating leverage as follows:

$$\text{Operating leverage} = \frac{\text{Fixed costs}}{\text{Fixed costs} + \text{Variable costs}} = \frac{\text{Fixed costs}}{\text{Total costs}}$$

Let us consider how the technology changes Sierra's operating leverage. Exhibit 5.14 shows Sierra's operating leverages and profits for different sales volumes, with and without the new technology.

Exhibit 5.14 shows that while the new technology does increase operating leverage, the increase is not substantial. In general, we prefer the technology with a smaller operating leverage at lower sales volumes and technology with a larger operating leverage at higher volumes. To see this, notice that under both cost structures (with and without new technology), Sierra will report an identical profit (a loss of \$600,000) at the crossover volume of 40,000 pounds. At volumes below 40,000 pounds, Sierra prefers the current technology (with the lower operating leverage) because this choice results in a *lower* loss. If he expects sales beyond this level, however, Ben will want to select the new technology as it results in a lower loss or higher profit.

In summary, at the current sales level of 100,000 pounds, the new inspection technology creates only a small difference in Sierra's operating leverage. The additional risk associated with acquiring the new technology is small. In fact, the new technology substantially improves profit for sales volumes over 40,000 pounds. Overall, it appears that Ben should seriously consider the new technology. However, before he makes that decision, he needs information about the third option, expanding Sierra's product offerings. Evaluating this alternative will require us to perform *multiproduct CVP* analysis.

Exhibit 5.14 Sierra Plastics: Analysis of Operating Leverage with and without New Technology

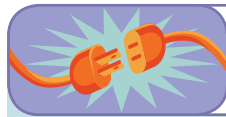
	Sales Volume	Unit Variable Cost	Variable Costs	Fixed Costs	Operating Leverage	Profit before Taxes
With new technology	30,000	\$9	\$270,000	\$1,240,000	0.82	(\$760,000)
	100,000	\$9	\$900,000	\$1,240,000	0.58	\$360,000
	170,000	\$9	\$1,530,000	\$1,240,000	0.45	\$1,480,000
Without new technology	30,000	\$10	\$300,000	\$1,200,000	0.80	(\$750,000)
	100,000	\$10	\$1,000,000	\$1,200,000	0.55	\$300,000
	170,000	\$10	\$1,700,000	\$1,200,000	0.41	\$1,350,000



Check It! Exercise #4

When comparing profits with and without the inspection technology, verify the crossover point of 40,000 pounds. You can determine the crossover point by solving for the sales volume at which both cost structures yield the same total cost. You can ignore revenues in your computation because it is the same for both decision alternatives.

Solution at end of chapter.

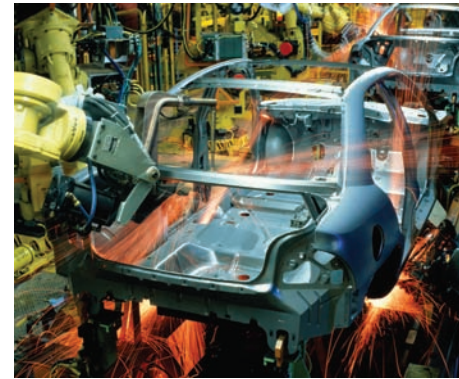


Connecting to Practice

OUTSOURCING AND OPERATING LEVERAGE

Chrysler outsources many of the components in its auto assembly lines rather than making the components in-house. In-house manufacturing requires higher fixed costs due to costly investments in plant and equipment. However, the variable costs of producing in-house are likely to be less than those from outsourcing because of economies of scale and scope.

COMMENTARY: A low operating leverage strategy allows companies such as **Chrysler** to offer new models, and not be limited by the capabilities of existing plant and equipment. A cost structure with less operating leverage offers companies *flexibility* because it involves fewer upfront cost commitments (i.e., fewer fixed costs). Companies confronting uncertain and fluctuating demand conditions are likely to opt for this flexibility because it allows them greater discretion in pricing and in offering product variations to stimulate sales. On the other hand, companies facing stable and predictable demand conditions might opt for high operating leverage by investing in fixed resources. Such a strategy allows them to benefit from economies of scale and scope and keep the variable costs of production down.



Outsourcing operations changes a firm's cost structure. (Mark Joseph/Getty Images)

Multiproduct CVP Analysis

In this section, we extend CVP analysis to settings in which a firm makes multiple products or many versions of the same product. Because products share resources such as the plant, equipment, and supervisors, and such costs are fixed in the short term, it does not make sense to allocate or assign these fixed costs to any particular product. Consequently, it is not advisable to perform CVP analysis on a product-by-product basis. Rather, it is necessary to perform CVP analysis by taking into consideration all products *at once* as a group. We refer to a group of products as a *portfolio* of products.

Fortunately, CVP analysis with many products is essentially the same as for a single product. Like the single-product CVP relation, the multiproduct CVP relation also stems from the contribution margin statement. However, each of a firm's many products usually has a different unit contribution margin. Therefore, we now have to consider a *segment* contribution margin statement, as in Chapter 4, where we separately computed Office Gallery's contribution margin derived from desks, chairs, and bookshelves. In addition, we total *all* of the fixed costs and represent them as one sum.

In the context of Sierra, recall that as a third option, Ben is considering offering many grades of Perlast. Specifically, in addition to selling Standard Perlast, Ben is considering producing and selling an economy version of Perlast. Because it will sell for only \$15 per pound, Ben expects that Economy Perlast will expand Sierra's customer base, increase sales volume, and better utilize existing capacity. The company already has most of the equipment to produce both products, but will need some new equipment to permit the greater variation in prepping the raw materials

LEARNING OBJECTIVE 5

Perform CVP analysis with multiple products.

and in finishing operations. Sierra can lease this equipment for \$75,000 per year. Exhibit 5.15 summarizes key information for this third option.

Combining Standard and Economy sales, the total sales volume of 164,000 pounds represents a significant increase over current sales. Ben estimates that for every three pounds of Standard Perlast sold, Sierra will sell five pounds of Economy Perlast. This mix underlies his estimate that he would sell 102,500 pounds ($5/8 \times 164,000$) of Economy and 61,500 pounds ($3/8 \times 164,000$) of Standard Perlast. Thus, while the introduction of Economy Perlast will add new customers, it also will take sales away from Standard Perlast. We refer to the relative proportion in which Sierra expects to sell the two products as the **product mix**—in this case, three pounds of Standard to five pounds of Economy. Knowledge of the product mix is crucial to performing multi-product CVP analysis.

We can now prepare Sierra’s segmented contribution margin statement, as in Exhibit 5.16, to evaluate the profit from adding Economy Perlast.

We learn that even though adding Economy Perlast will *increase* overall sales, the move will *lower* Sierra’s profit before taxes to \$262,500 from the current level of \$300,000. While Exhibit 5.16 answers Ben’s question about this specific option, how, in general, do we plan profit when multiple products exist? To address this question, we need a multiproduct version of the CVP relation—we tackle this topic next.

PROFIT PLANNING WITH MULTIPLE PRODUCTS

There are two equivalent methods for performing multiproduct CVP analysis: the *weighted unit contribution margin method* and the *weighted contribution margin ratio method*. We begin with the weighted unit contribution margin method.

Weighted Unit Contribution Margin Method

In a multiproduct CVP analysis, the **weighted unit contribution margin** is simply the contribution margin per average unit. From Exhibit 5.16, we can calculate the weighted unit contribution margin as the total contribution margin of \$1,537,500 divided by the total sales of 164,000 pounds, or \$9.375 per pound.

Exhibit 5.15 Sierra Plastics: Multiple-Product Data

	Type of Perlast		Fixed Costs	Amount
	Economy	Standard		
Unit (per pound) price	\$15	\$25	Current fixed costs	\$1,200,000
Unit variable cost	9	10	Lease—New equipment	75,000
Unit contribution margin	\$6	\$15	Total fixed costs	\$1,275,000
Sales volume (pounds)	102,500	61,500		

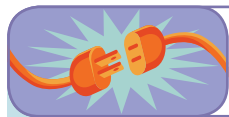
Exhibit 5.16 Sierra Plastics: Product-Level Contribution Margin Statement

	Economy	Standard	Total
Sales volume (in units)	102,500	61,500	164,000
Revenues	\$1,537,500	\$1,537,500	\$3,075,000
Variable costs	922,500	615,000	\$1,537,500
Contribution margin	\$615,000	\$922,500	\$1,537,500
Common fixed costs			\$1,275,000
Profit before taxes			\$262,500



CHAPTER CONNECTIONS

Whether to offer more grades of Perlast is a good example of the fuzzy boundaries between decision horizons. We would consider this option as a long-term decision if it substantially changes the firm's productive capacity and fixed costs. Such a decision to alter the firm's product portfolio allows it to target new markets and obtain new capabilities. We address these types of decisions in Chapters 9, 11, and 12. In contrast, a decision to alter the mix of current products to respond to changing demand is a short-term decision. This decision seeks the best way to use available capacity by changing the emphasis of products in the current portfolio. Sierra's decision lies between these two classes of decisions. Even though it leads to a small change in fixed costs and capabilities, it does not alter productive capacity.



Connecting to Practice

DIET COKE

In 1982, the **Coca-Cola Company** introduced Diet Coke (in some regions, Diet Coke is marketed as Coca-Cola Light). Since its inception, sales of the zero-calorie beverage have steadily increased. It currently ranks as the third largest-selling soft drink in the world (Coca-Cola® & Pepsi® are the number 1 and 2 selling soft drinks, respectively). The **Coca-Cola Company** markets and sells both Coke and Diet Coke in over 150 countries worldwide.

COMMENTARY: We could analyze **Coca-Cola's** decision to introduce Diet Coke within the context of the CVP relation. The decision to produce and sell Diet Coke increased **Coca-Cola's** overall fixed costs but added a new product that would contribute to covering fixed costs and profit. In essence, **Coca-Cola** hoped the increased contribution margin exceeded the increase in fixed costs. In hindsight, the decision to introduce Diet Coke worked out well for **Coca-Cola**. Not all of **Coca-Cola's** new-product decisions have been as successful, though, as evidenced by **Coca-Cola's** decision to replace Classic Coke with "New Coke" in 1985. The decision proved to be a disaster, and the firm quickly reversed it.

We can also calculate the weighted unit contribution margin using unit-level data. In Sierra's case, Ben expects *unit sales* to consist of 5/8 or 62.50% Economy Perlast and 3/8 or 37.50% Standard Perlast. Therefore, the weighted unit contribution margin is

$$\text{Weighted unit contribution margin} = (0.625 \times \$6) + (0.375 \times \$15) = \$9.375$$

Because the weighted unit contribution margin is the contribution margin of an average unit, we can write Sierra's profit in terms of the total number of pounds sold as:

$$\begin{aligned} \text{Profit before taxes} &= (\text{Weighted unit contribution margin} \times \text{Total sales volume in pounds}) \\ &\quad - \text{Fixed costs} \end{aligned}$$

For Sierra, we have,

$$\begin{aligned} \text{Profit before taxes} &= (\$9.375 \times \text{Total sales volume in pounds}) - \$1,275,000 \\ &= \$9.375 \times 164,000 - \$1,275,000 = \$262,500 \end{aligned}$$

Just as we did for a single product, we can use the multiproduct CVP relation to find Sierra's breakeven volume or the volume needed for target profit. Setting profit before taxes to zero (for breakeven), we divide its fixed costs of \$1,275,000 by the weighted unit contribution margin of \$9.375 to get 136,000 total units. In turn, 5/8 of these units should be Economy Perlast and 3/8 of them Standard Perlast. Thus, Sierra would break even by selling 85,000 pounds of Economy and 51,000 pounds of Standard Perlast. Exhibit 5.17 summarizes our calculations:

Check It Exercise #5 asks you to verify calculations for earning a target profit of \$225,000.

Weighted Contribution Margin Ratio Method

Thus far, we have defined product mix in terms of units sold. Frequently, managers find it more convenient to express product mix in terms of revenues. As with the single-product setting, managers of multiproduct firms usually work with the share of revenue from various products rather than units sold.

Comparing contribution margin ratios across products often makes more sense than comparing unit contribution margins. After all, comparing the unit contribution margin of a sports car such as a **Ford** Mustang with that of an entry-level vehicle such as a **Ford** Fusion is like comparing apples and oranges. Moreover, firms often use different units for their products. **John Deere** sells tractors and health insurance, and cannot express both products in the same unit. On the other hand, we can always compare contribution margin ratios because they represent the fraction of each sales dollar that goes toward covering fixed costs and profit.

As with the weighted unit contribution margin, we can compute the **weighted contribution margin ratio** either from the segment contribution margin statement or from unit-level data. From Exhibit 5.16, we know that total revenues are \$3,075,000 and the total contribution margin is \$1,537,500. Thus, the weighted contribution margin ratio, or the contribution ratio per average dollar, is $\$1,537,500/\$3,075,000 = 50\%$.

We also could obtain this value by weighting each individual product's contribution margin ratio by its expected share of *revenues*. For Sierra, the contribution margin ratios of Economy and Standard are 0.40 (\$6/\$15) and 0.60 (\$15/\$25), respectively. Moreover, from Exhibit 5.16 we know that each product contributes 50% of total revenue.

Exhibit 5.17

Sierra Plastics: Multiproduct CVP Analysis Weighted Unit Contribution Margin Method

Description	Economy	Standard
Expected product mix (in pounds)	5	3
Proportion of each product in the expected product mix	5/8	3/8
Selling price per pound	\$15	\$25
Variable cost per pound	9	10
Unit contribution margin	\$6	\$15
Weighted unit contribution margin	$(5/8 \times \$6) + (3/8 \times \$15) = \$9.375$	
Fixed costs	\$1,275,000	
Breakeven volume	$\$1,275,000/\$9.375 = 136,000$ total units	
Breakeven volume in individual products (= total units \times proportion of each product in the mix)	$136,000 \times 5/8 = 85,000$ lb	$136,000 \times 3/8 = 51,000$ lb



Check It! Exercise #5

Suppose the new product mix is that for every 2 pounds of Standard Perlast sold, Sierra will sell 5 pounds of Economy Perlast. Verify that if Sierra wants to earn a target profit before taxes of \$225,000, it must sell 175,000 weighted units. Then verify that at this volume of sales, Sierra will sell 50,000 pounds of Standard Perlast and 125,000 pounds of Economy Perlast.

<i>Item</i>	<i>Economy</i>	<i>Standard</i>
Expected product mix (in pounds)	5	2
Proportion of each product in the expected Product mix		
Unit contribution margin	\$6	\$15
Weighted unit contribution margin		
Fixed costs	\$1,275,000	
Target profit	\$225,000	
Required volume in pounds of weighted units		
Required volume of individual products		

Solution at end of chapter.

$$\text{Weighted contribution margin ratio} = (0.50 \times 0.40) \times (0.50 \times 0.60) = 0.50 \text{ or } 50\%$$

Using the weighted contribution margin ratio, we write profit as

$$\text{Profit before taxes} = (\text{Weighted contribution margin ratio} \times \text{Total revenues}) - \text{Fixed costs}$$

Let us consider an example to solidify our understanding. Suppose Sierra wants to earn \$315,000 after taxes in the coming year and that it faces a tax rate of 40%. How much total revenue must Sierra generate? What does this translate to in terms of sales of Economy and Standard?

For Sierra, because the weighted contribution margin ratio is 50%, we have:

$$\text{Profit before taxes} = (0.50 \times \text{Total revenues}) - \$1,275,000$$

In order to earn profit after taxes of \$315,000, Sierra must earn $\$315,000/0.60 = \$525,000$ in profit before taxes. (Note that $1 - \text{the tax rate of } 40\% = 60\% \text{ or } 0.60$.) We can now solve for the total revenue required:

$$\$525,000 = (0.50 \times \text{Total revenues}) - \$1,275,000$$

We find $\text{Total revenues} = \$3,600,000$. Each product contributes 50% to revenue or \$1,800,000 each for Economy and Standard. This level equals $\$1,800,000/\15 per pound = 120,000 pounds of Economy and $\$1,800,000/\25 per pound = 72,000 pounds of Standard.

Check It Exercise #6 allows you to develop your skills further. In this exercise, you will use the weighted contribution margin ratio approach to calculate breakeven revenues and verify that it is equivalent to the weighted unit contribution margin method.

MAKING DECISIONS USING CVP ANALYSIS

We have now completed evaluating Ben's three options using CVP analysis. The accompanying Decision Framework box summarizes our recommendation.

 **Check It! Exercise #6**

Using the weighted contribution margin ratio approach, verify that Sierra would break even by generating \$2,550,000 in total revenue. Further, verify that this translates to 85,000 pounds of Economy and 51,000 pounds of Standard.

<i>Item</i>	<i>Economy</i>	<i>Standard</i>
Proportion of revenue	0.50	0.50
Contribution margin ratio	0.40	0.60
Weighted contribution margin ratio	<hr/>	
Fixed costs	\$1,275,000	
Breakeven total revenues	<hr/>	
Breakeven revenues of individual products	<hr/>	<hr/>
Breakeven volume of individual products	<hr/>	<hr/>

Solution at end of chapter.

For administrative reasons, Ben did not want to consider multiple options at the same time. However, it seems logical to lower the price *and* to acquire the inspection technology. The inspection technology increases operating leverage because it increases fixed costs and reduces variable costs. Thus, its profit effect is greater at higher sales volumes. Because a price reduction leads to greater volume, a price cut also increases the attractiveness of the inspection technology. As such, you might recommend that Ben include the combined choice as a fourth option.

Decisions may not reinforce each other's profit impact. For example, if Ben decides to expand Sierra's product line, he may not want to invest in the new inspection technology unless he can also use the technology for Economy Perlast. Likewise, if Ben decides to expand Sierra's product line, reducing the selling price on Standard Perlast is probably unwise. Each of these combinations adds another twist to Ben's decision.

APPLYING THE DECISION FRAMEWORK

- What Is the Problem?** How can Sierra Plastics increase its profit?
- What Are the Options?** Ben and his staff have identified three promising options:
 1. Decrease the price of Perlast to increase demand.
 2. Purchase new inspection technology to reduce the unit variable cost of Perlast.
 3. Offer different grades of Perlast to meet the specific needs of individual market segments.
- What Are the Costs and Benefits?** Summarizing each option's profit impact, we have:

<i>Option</i>	<i>Effect on Profit before Taxes</i>
Reduce price to \$20	Increase to \$400,000.
Acquire inspection technology	Increase to \$360,000.
Offer more varieties of Perlast	Decrease to \$262,500.
- Make the Decision!** You recommend that Ben lower the price of Perlast to \$20 per pound, as this appears to be the best way to boost short-term profits.

Expanding the analysis to include every possible combination of stand-alone options usually is not advisable. Combining each choice with every other choice rapidly expands the opportunity set. Good managers excel in narrowing their choices to those that complement each other and are most promising.

CVP Analysis—A Critical Evaluation

As we have seen, the CVP relation crisply captures how revenues, costs, and profit vary as the volume of business varies. It enables decision makers to assess how much volume they need to avoid a loss (break even) or to maintain a certain margin of safety. Moreover, CVP analysis is useful for numerous short-term decisions related to pricing, advertising, cost structure, and more. However, any decision tool is only as good as the assumptions needed to make it work. Consequently, we need to understand the assumptions underlying CVP analysis and the extent to which they are likely to be valid.

LEARNING OBJECTIVE 6

List the assumptions underlying CVP analysis.

1. *Revenues increase proportionally with sales volume.* CVP analysis assumes that the selling price *per unit* is constant and does not vary with sales volume. This assumption reflects general practice, as most companies tend to adopt stable pricing policies. If needed, we can use CVP analysis to examine “flexible” pricing policies such as special-order pricing problems.
2. *Variable costs increase proportionally with sales volume.* CVP analysis assumes that the *unit variable cost* is constant and does not vary with sales volume. Referring to Chapter 4, this assumption says that the firm is operating in the “relevant range.” While batch- and product-level costs likely exist, most firms estimate costs via linear approximation, as we have done.
3. *Selling prices, unit variable costs, and fixed costs are known with certainty.* Managers deal with numerous sources of uncertainty all the time. Because managers cannot be sure when a machine will break down or when an employee will call in sick, they cannot be 100% sure about unit variable costs or fixed costs. Likewise, it is impossible to perfectly predict demand at a given price. Some of the end-of-chapter problems help you understand how to combine the basics of probability and expected value with CVP analysis.
4. *Single-period analysis.* The typical CVP analysis assumes that all revenues and costs occur in a single period. CVP analysis does not allow a role for inventory, which means that we might incur the costs of production this period but realize the associated sales revenue the next period. The tax assumption in CVP also assumes a single-period focus as it does not allow for complex tax provisions such as carrying losses to future periods. Finally, CVP analysis does not take into account the *time value of money*, which reflects the notion that the buying power of a dollar today is not the same as the buying power of a dollar a year from now. This assumption again underscores that CVP analysis is primarily a tool for *short-term* decision making.
5. *Product-mix assumption.* With many products, CVP analysis assumes a known and constant product mix. Companies generally base such estimates on a history of past sales data and input from the Marketing Department. Nevertheless, managers also extensively evaluate alternate product-mix assumptions to assess their confidence in estimated profit, as changes in product mix can significantly affect profit.
6. *CVP analysis does not always provide the “best” solutions to short-term decisions.* Rather, CVP analysis is a tool that helps managers improve profit by answering “what if” questions. For example, CVP analysis suggests that Sierra’s profit before taxes will decrease by \$37,500 if the company manufactures Economy Perlast

in addition to Standard Perlast. What CVP analysis does not do, however, is to determine the optimal product mix—in other words, whether Sierra could increase profit by producing and selling Economy and Standard Perlast in a proportion other than 3:5.

7. *Availability of capacity.* CVP analysis is not well suited for a setting in which available capacity is not sufficient to meet all demand, meaning that companies have to decide which products to cut back on. In these cases, companies turn to other methods, which we discuss in Chapter 6.

SUMMARY

In this chapter, we discussed how the Cost-Volume-Profit (CVP) relation expresses a firm's profit as a function of price, the unit variable cost, sales volume, and fixed costs. We then illustrated how to use the CVP relation for profit planning, assessing operating risk, and making short-term decisions. Finally, we extended the CVP relation to settings with many products and discussed the assumptions underlying CVP analysis.

While CVP analysis is extremely useful, it can be difficult to use the CVP relation when decisions deal with individual products, resources, or customers. We consider such settings in Chapter 6.

RAPID REVIEW

LEARNING OBJECTIVE 1

Understand the Cost-Volume-Profit (CVP) relation.

- The Cost-Volume-Profit (CVP) relation expresses profit before taxes as a function of the selling price per unit, the unit variable cost, sales volume, and fixed costs.

$$\text{Profit before taxes} = [(\text{Price} - \text{Unit variable cost}) \times \text{Sales volume in units}] - \text{Fixed costs} = (\text{Unit contribution margin} \times \text{Sales volume in units}) - \text{Fixed costs}$$
- Firms perform CVP analysis for three primary purposes: (1) profit planning; (2) calculating measures that help assess operating risk; and (3) evaluating the profit impact of short-term decision alternatives.

LEARNING OBJECTIVE 2

Use the CVP relation to plan profit.

- Breakeven volume is the volume of sales needed to avoid a loss. At breakeven, profit equals zero, and the contribution margin exactly equals fixed costs. Additional volume beyond breakeven contributes directly to profit.

$$\text{Breakeven volume} = \text{Fixed costs} / \text{Unit contribution margin}$$

- Managers calculate the breakeven point in terms of revenues using the contribution margin ratio. The contribution margin ratio is the unit contribution margin divided by the price per unit. The contribution margin ratio represents the fraction of each dollar in revenue that goes first toward covering fixed costs and then to profit.

$$\text{Breakeven revenues} = \text{Fixed costs} / \text{Contribution margin ratio}$$

- Just as firms use the CVP relation to compute breakeven volume and breakeven revenue, they use the CVP relation to calculate the sales volume or revenues required to earn a target profit, either before or after taxes.

LEARNING OBJECTIVE 3

Make short-term decisions using CVP analysis.

- When evaluating short-term decisions, organizations use the CVP relation to estimate the effects on price, unit variable cost, sales volume, and fixed costs.
- Marketing personnel in organizations often develop schedules showing the trade-off between price and demand. The CVP relation allows managers to compute profit at the various price-quantity combinations to identify the profit-maximizing choice.

LEARNING OBJECTIVE 4

Measure risk using the CVP relation.

- Organizations need to consider the effects of uncertainty, or risk, on their decisions. The CVP relation provides two measures of operating risk.
- Margin of safety is the percentage by which current sales exceed breakeven sales.

$$\text{Margin of safety} = \frac{\text{Sales (in units or dollars)} - \text{Breakeven sales (in units or dollars)}}{\text{Sales (in units or dollars)}}$$

$$\text{Percent change in profit} = \text{Percent change in sales} \times (1/\text{Margin of Safety})$$

- Higher operating leverage implies higher risk. We measure operating leverage as

$$\text{Operating leverage} = \frac{\text{Fixed Costs}}{\text{Total Costs}}$$

LEARNING OBJECTIVE 5

Perform CVP analysis with multiple products.

- Multiproduct firms perform CVP analysis at the portfolio, or aggregate, level. Firms do so because products share resources such as plant, equipment, and supervisors, and such costs are fixed in the short term. Thus, it does not make sense to allocate or assign fixed costs to any particular product.

- Product mix, or the relative proportion in which a firm expects to sell its products, is a crucial input to multiproduct CVP analysis.
- There are two arithmetically equivalent approaches for performing multiproduct CVP analysis: (1) the weighted unit contribution margin approach; and, (2) the weighted contribution margin ratio approach.

LEARNING OBJECTIVE 6

List the assumptions underlying CVP analysis.

- Revenues increase proportionally with sales volume.
- Variable costs increase proportionally with sales volume.
- Selling prices, unit variable costs, and fixed costs are known with certainty.
- Single-period analysis—all revenues and costs occur in a single period.
- In multiproduct CVP analysis, the product mix is known and constant.
- CVP analysis does not always provide the “best” solution to short-term decisions. While useful for answering “what if” questions, CVP analysis does not necessarily provide the optimal selling price or product mix.
- Availability of capacity—CVP analysis assumes that firms do not encounter capacity constraints that force them to ration capacity.

ANSWERS TO CHECK IT! EXERCISES

Exercise #1: \$675,000 = (\$15 per pound × 125,000 pounds) – \$1,200,000.

Exercise #2:

Unit contribution margin approach:

$$\begin{aligned} \text{Unit contribution margin} &= \$50 - \$30 = \$20; \text{ Breakeven volume} \\ &= \$1,500,000/\$20 = 75,000; \end{aligned}$$

$$\text{Breakeven revenues} = 75,000 \times \$50 = \$3,750,000$$

Contribution margin ratio approach:

$$\text{Contribution margin ratio} = \frac{\$50 - \$30}{\$50} = 0.40;$$

$$\text{Breakeven revenues} = \$1,500,000/0.40 = \$3,750,000;$$

$$\text{Breakeven volume} = \$3,750,000/\$50 = 75,000$$

Exercise #3:

Breakeven volume = \$1,500,000/\$20 = 75,000; Breakeven revenues = \$1,500,000/0.40 = \$3,750,000. In addition, current revenues = 80,000 × \$50 = \$4,000,000

$$\text{Margin of safety} = \frac{80,000 - 75,000}{80,000} = \frac{\$4,000,000 - \$3,750,000}{\$4,000,000} = 0.0625, \text{ or } 6.25\%$$

If sales were to increase by 20%, then the percent change in profit before taxes = 0.20 × (1/0.0625) = 3.20, or 320%. Because current profit before taxes = [(\$20 × 80,000) – \$1,500,000] = \$100,000, profit would increase by \$100,000 × 3.2 = \$320,000. In turn, \$100,000 + \$320,000 = \$420,000.

Exercise #4:

With the new technology, total costs = \$1,240,000 + (\$9 × Sales volume in units).

Without the new technology, total costs = \$1,200,000 + (\$10 × Sales volume in units).

Setting these two equations equal to each other, we have:

$$\$1,240,000 + (\$9 \times \text{Sales volume in units}) = \$1,200,000 + (\$10 \times \text{Sales volume in units})$$

Solving, we find *Sales volume in units* = 40,000 pounds.

Exercise #5:

$$\text{Weighted unit contribution margin} = (5/7 \times \$6) + (2/7 \times \$15) = \$60/7 = \$8.5714 \text{ (rounded)}$$

$$\text{Required volume in total units} = (\$1,275,000 + \$225,000) / \$8.5714 = 175,000 \text{ pounds}$$

Required volume of individual products: 175,000 pounds \times 5/7 = 125,000 pounds of Economy, and 175,000 \times 2/7 = 50,000 pounds of Standard.

Exercise #6:

Weighted contribution margin ratio = $(0.50 \times 0.40) + (0.50 \times 0.60) = 0.50$. Thus, Breakeven total revenues = $\$1,275,000 / 0.50 = \$2,550,000$. Breakeven revenues of individual products: $\$2,550,000 \times 0.50 = \$1,275,000$ for Economy, and $\$2,550,000 \times 0.50 = \$1,275,000$ for Standard.

Breakeven volume of individual products: $\$1,275,000 / \$15 = 85,000$ pounds of Economy, and $\$1,275,000 / \$25 = 51,000$ pounds of Standard.

SELF-STUDY PROBLEMS

SELF-STUDY PROBLEM #1:

Single-Product CVP Analysis

Silicon Cards makes a high-capacity memory card, SC-100, for use in electronic equipment. Silicon's owner, Monique Mejia, started the company because she believed that memory cards would gain widespread acceptance. Monique believed the demand for portable electronics would increase and, in turn, stimulate the demand for memory cards.

During the upcoming year, Silicon expects to sell 450,000 SC-100 cards at an average selling price of \$30 per card. Silicon's unit variable cost is \$18 per card, and its annual fixed costs equal \$4,800,000.

- a. What is Silicon's annual profit equation?

Using the information provided, we can write Silicon's profit equation as

$$\text{Profit before taxes} = [(\text{Price} - \text{Unit variable cost}) \times \text{Sales volume in units}] - \text{Fixed costs, or}$$

$$\text{Profit before taxes} = [(\$30 - \$18) \times \text{Sales volume in units}] - \$4,800,000$$

$$= (\$12 \times \text{Sales volume in units}) - \$4,800,000$$

- b. How many cards does Silicon need to sell to breakeven? What does this translate to in revenue?

Breaking even implies a profit of \$0. Using the CVP relation from part (a) and setting profit equal to \$0, we have:

$$\$0 = (\$12 \times \text{Breakeven volume}) - \$4,800,000$$

Solving, we find *Breakeven volume* = **400,000 cards**

We could also compute breakeven volume by dividing fixed costs by the unit contribution margin.

$$\text{Breakeven volume} = \frac{\text{Fixed costs}}{\text{Unit contribution margin}} = \frac{\$4,800,000}{\$12} = \mathbf{400,000 \text{ cards}}$$

Next, we calculate Silicon's breakeven point in revenue by multiplying the breakeven volume by price. We have:

$$\text{Breakeven revenues} = \text{Breakeven volume} \times \text{Price} = 400,000 \times \$30 = \mathbf{\$12,000,000}$$

- c. What is Silicon's contribution margin ratio? Compute Silicon's breakeven revenues using the contribution margin ratio approach.

Using the formula in the text, Silicon's contribution margin ratio is given by

$$\text{Contribution margin ratio} = \frac{\text{Unit contribution margin}}{\text{Price}} = \frac{\$12}{\$30} = 0.40, \text{ or } \mathbf{40\%}$$

Computing breakeven revenues directly using the formula in the text, we find:

$$\text{Breakeven revenues} = \frac{\text{Fixed costs}}{\text{Contribution margin ratio}} = \frac{\$4,800,000}{.40} = \mathbf{\$12,000,000}$$

This is exactly what we arrived at in part (b).

- d. *What is Silicon's expected margin of safety during the coming year? What would sales volume need to be if Monique desires a 20% margin of safety?*

We know from part (b) that the breakeven volume is 400,000 cards. Because Monique expects sales to be 450,000 cards, Silicon's expected margin of safety is

$$\text{Margin of safety} = \frac{450,000 - 400,000}{450,000} = \frac{50,000}{450,000} = 0.1111, \text{ or } \mathbf{11.11\%}$$

For a margin of safety of 20%, we work backward to find the necessary sales volume:

$$\frac{\text{Required sales} - 400,000}{\text{Required sales}} = 0.20, \text{ or } \text{Required sales} = \mathbf{500,000 \text{ cards}}$$

- e. *How many cards would Silicon need to sell to earn an annual after-tax profit of \$1,800,000? Assume Silicon pays income taxes equal to 40% of profit before taxes.*

We know that:

$$\text{Profit after taxes} = \text{Profit before taxes} \times (1 - \text{Tax rate})$$

Using the CVP relation we developed in part (a) and modifying it for the tax rate yield:

$$\text{Profit after taxes} = [(\$12 \times \text{Sales volume in units}) - \$4,800,000] \times (1 - .40)$$

Setting profit after taxes equal to \$1,800,000, we have:

$$\$1,800,000 = [(\$12 \times \text{Required sales volume}) - \$4,800,000] \times 0.60, \text{ or}$$

$$\text{Required sales volume} = \mathbf{650,000 \text{ cards}}$$

Silicon needs to sell 650,000 cards to generate profit after taxes of \$1,800,000.

- f. *Silicon's Marketing Manager is requesting an additional \$750,000 for advertising and promotion. How would Silicon's breakeven volume change if Monique agrees to this expenditure? Assume that the Marketing Manager believes that sales will increase by 100,000 cards if Silicon spends an additional \$750,000 on advertising and promotion. By how much will Silicon's profit after taxes increase or decrease due to the advertising? As with part (e), assume Silicon's tax rate is 40%.*

With the additional \$750,000 in advertising and promotion, Silicon's fixed costs increase from \$4,800,000 to \$5,550,000. To compute the new breakeven volume, we repeat part (b) with the new level of fixed costs. Doing so yields

$$\text{Breakeven volume} = \frac{\$5,550,000}{\$12} = \mathbf{462,500 \text{ cards}}$$

Alternatively, we can compute the *additional* number of cards to cover the *additional* fixed costs of \$750,000. We can then add this number to the breakeven volume we calculated in part (b). Following this approach, we find that Silicon needs to sell an additional $\$750,000/\$12 = 62,500$ cards. Because 400,000 cards are required to cover the original fixed costs of \$4,800,000, the new breakeven volume is $400,000 + 62,500 = 462,500$ cards.

Silicon's Marketing Manager expects sales volume to increase by 100,000 cards due to increased advertising and promotion. Out of this volume, 62,500 cards are required just to cover the additional advertising and promotion expenditure of \$750,000. The remaining 37,500 cards contribute directly to profit. Because the unit contribution margin on each card is \$12, the *additional* profit before taxes would be $37,500 \times \$12 = \$450,000$. After taxes, Silicon would have an increase in profit of $\$450,000 \times 0.6 = \mathbf{\$270,000}$. Assuming the marketing manager's demand estimate is accurate, spending an additional \$750,000 on advertising and promotion is justified.

SELF-STUDY PROBLEM #2: Multiproduct CVP Analysis

Refer to Self-Study Problem #1. The owner of Silicon Cards, Monique Mejia, wishes to evaluate the possibility of using existing excess production capacity to make another product—SC45 cards.

Monique expects to sell the proposed SC-45E cards for \$20 each and estimates that the unit variable cost of producing each SC-45E card will be \$10. Monique also believes that there is enough excess plant and equipment capacity to accommodate the expected sales volume of 300,000 SC-45E cards. Thus, for every three SC-100 cards sold, Silicon expects to sell two SC-45E cards. (Recall from Self-Study problem #1 that Silicon expects to sell 450,000 SC-100

cards; in turn, $450,000:300,000 = 3:2$.) In order to accommodate the increased sales volume, Monique will need to hire additional sales and administrative personnel, increasing annual fixed costs by \$800,000.

- a. *What is Silicon's annual profit equation (before taxes) if Monique decides to offer both SC-100 and SC-45E cards?*

Compared to Self-Study Problem #1, Silicon's profit will change in two ways.

First, fixed costs increase by \$800,000, from \$4,800,000 to \$5,600,000; Silicon's profit calculation needs to reflect this change. Second, introducing the SC-45E line will mean that another product is contributing to Silicon's overall profit. Each SC-45E card has a unit contribution margin of \$10 (\$20 selling price – \$10 unit variable cost). With these two modifications, we rewrite Silicon's profit before taxes as

$$\begin{aligned} \text{Profit before taxes} &= (\$12 \times \text{Sales volume of SC-100 cards}) \\ &\quad + (\$10 \times \text{Sales Volume of SC-45E cards}) - \$5,600,000 \end{aligned}$$

- b. *Assume Monique decides to offer both SC-100 and SC-45E cards. What is Silicon's breakeven volume in total cards and breakeven revenues for each type of card?*

Notice from the CVP relation in part (a) that multiple sales quantity combinations of SC-100 and SC-45E cards would satisfy the breakeven condition. Thus, with multiple products, we need to specify a product mix, which is the proportion (expressed in units) in which Silicon expects to sell the products. This proportion is 3:2, as Monique expects to sell three SC-100 cards for every two SC-45E cards.

This product mix allows us to calculate a weighted unit contribution margin, which is $(3/5 \times \$12) + (2/5 \times \$10) = \$11.20$.

Rewriting Silicon's profit in terms of total units, we have:

$$\text{Profit before taxes} = (\$11.20 \times \text{Sales volume in total units}) - \$5,600,000$$

We are now in a position to use the breakeven equation from the text. We have:

$$\begin{aligned} \text{Breakeven volume} &= \frac{\text{Fixed costs}}{\text{Weighted unit contribution margin}} = \frac{\$5,600,000}{\$11.20} \\ &= \mathbf{500,000 \text{ total cards}} \end{aligned}$$

Because three out of every five cards are SC-100, the breakeven volume is 300,000 SC-100 cards and 200,000 SC-45E cards. Breakeven revenue for the SC-100 cards is $300,000 \times \$30 = \$9,000,000$, and breakeven revenue for the SC-45E cards is $200,000 \times \$20 = \$4,000,000$.

- c. *Given the sales projections for the SC-45E card, does it make sense for Monique to expand her product line? What other considerations might weigh into Monique's decision to expand her product line? Assume that Silicon pays income taxes equal to 40% of profit before taxes.*

First, we rewrite Silicon's CVP profit to incorporate taxes:

$$\begin{aligned} \text{Profit after taxes} &= [(\$12 \times \text{Sales volume of SC-100 cards}) \\ &\quad + (\$10 \times \text{Sales volume of SC-45E cards}) - \$5,600,000] \times (1 - 0.40) \end{aligned}$$

According to Monique's sales projections, Silicon expects to sell 450,000 SC-100 cards and 300,000 SC-45E cards. Plugging these projections into the expression for profit, we have:

$$\begin{aligned} \text{Profit after taxes} &= [(\$12 \times 450,000) + (\$10 \times 300,000) - \$5,600,000] \\ &\quad \times (1 - 0.40) = \mathbf{\$1,680,000}. \end{aligned}$$

If Silicon does not introduce the SC-45E card, then it expects to sell 450,000 SC-100 cards (as in the previous year), and its profit after taxes would be \$360,000 (we can verify this number using the CVP relation from part (e) of Self-Study Problem #1). Thus, the incremental profit of introducing the SC-45E cards is $\$1,680,000 - \$360,000 = \$1,320,000$. It makes economic sense for Silicon to introduce the SC-45E line.

In general, introducing a new product line is a long-term decision that is subject to many strategic considerations. Monique should consider her competition's reaction, what other memory card manufacturers are likely to do, and whether introducing the SC-45E line will affect the demand for her popular SC-100 card. For example, do we really believe that demand for the SC-100 will equal 450,000 regardless of whether Silicon introduces the SC-45E line? Moreover, Silicon should not base such a decision on expectations formed for a single period. It is important to remember that CVP analysis is primarily a short-term decision aid; we should use it cautiously for decisions involving longer horizons.

- d. Compute Silicon's operating leverage with and without the SC-45E card. What can you conclude about the effect of introducing the SC-45E card on Silicon's operating leverage?

Recall that operating leverage is the ratio of fixed costs to total costs. Also recall that the unit variable cost of SC-100 is \$18 and that the unit variable cost of SC-45E is \$10. Annual fixed costs equal \$4,800,000 if Silicon produces only the SC-100 card and \$5,600,000 if Silicon produces both the SC-100 and SC-45E cards. Thus, the operating leverage with and without the SC-45E card is

$$\text{Operating leverage (SC-100 only)} = \frac{\text{Fixed costs}}{\text{Total costs}} = \frac{\$4,800,000}{\$4,800,000 + (\$18 \times 450,000)} = 0.372$$

$$\text{Operating leverage (SC-100 + SC-45E)} = \frac{\$5,600,000}{\$5,600,000 + (\$18 \times 450,000) + (300,000 \times \$10)} = 0.335$$

Silicon's operating leverage is expected to decrease if Monique introduces the SC-45E card. Intuitively, the decrease occurs because introducing the SC-45E line will allow Silicon to use its existing capacity more fully and gainfully. Moreover, producing the SC-45E card will not require any additional plant or equipment—the \$800,000 is for additional sales and administrative personnel. To the extent that operating leverage can be viewed as a measure of risk, we see that introducing the SC-45E line reduces Silicon's profit risk—lower operating leverage implies lower risk.

GLOSSARY

Breakeven revenues The sales volume in revenues at which profit equals zero.

Breakeven volume The sales volume in units at which profit equals zero.

Contribution margin ratio The unit contribution margin divided by the unit price. The contribution margin ratio represents the portion of each sales dollar that, after covering variable costs, goes toward covering fixed costs and, ultimately, profit.

Margin of safety The percentage by which current sales exceed breakeven sales.

Operating leverage The ratio of fixed costs to total costs (total costs = fixed costs plus variable costs).

Product mix The proportion, expressed in units, in which products are expected to be sold.

Unit contribution margin The contribution margin per unit.

Weighted unit contribution margin Unit contribution margin averaged across multiple products, with each product's unit contribution margin being weighted by the product mix (i.e., its share of total sales in units).

Weighted contribution margin ratio Contribution margin ratio averaged across multiple products, with each product's contribution margin ratio being weighted by its share of revenues (which is a function of both the product mix and prices).

REVIEW QUESTIONS

5.1 LO1. What is the CVP relation?

5.2 LO1. What does the CVP relation follow directly from?

5.3 LO2. What is breakeven volume?

5.4 LO2. What are breakeven revenues?

5.5 LO2. What is the contribution margin ratio?

5.6 LO2. How do taxes affect the CVP relation?

5.7 LO3. How can we use the CVP relation to analyze the profit effect of price changes?

5.8 LO4. What is the margin of safety?

5.9 LO4. How could we use the margin of safety to calculate the percent change in profit given a percent change in sales?

5.10 LO4. What is operating leverage?

5.11 LO5. What is a product mix?

5.12 LO5. What is a weighted unit contribution margin?

5.13 LO5. What is a weighted contribution margin ratio?

5.14 LO5. Why do managers often prefer to calculate CVP relations using the weighted contribution margin ratio approach?

5.15 LO6. What are the assumptions underlying CVP analysis?

DISCUSSION QUESTIONS

- 5.16 LO1.** Which action has a greater effect on the unit contribution margin: (1) increasing the unit selling price by 10% or (2) reducing the unit variable cost by 10%?
- 5.17 LO1.** In an article in the *Wall Street Journal*, you read that a firm reported a contribution margin equal to 40% of revenues and profit before taxes equal to 15% of revenues. If fixed costs were \$200,000, what were the firm's revenues?
- 5.18 LO2.** We could readily extend CVP analysis to consider cash breakeven by considering *cash* fixed costs only. That is, we exclude noncash items such as depreciation from the analysis. Which kinds of firms would value this approach?
- 5.19 LO2.** If fixed costs increase, but the unit contribution margin stays the same, can we calculate the additional volume needed to break even by dividing the change in fixed costs by the unit contribution margin? Why or why not?
- 5.20 LO2.** In the text, we refined the CVP relation to incorporate taxes that are proportional to pretax profit. How could we further refine the CVP relation to include multiple tax brackets, where the tax rate depends on the magnitude of the profit?
- 5.21 LO2 (Advanced).** Could we modify the CVP relation to include step costs? What complications might arise in the context of CVP analysis with step costs?
- 5.22 LO3.** Is the contribution margin ratio of a software firm such as Microsoft likely to be higher or lower than the contribution margin ratio of an auto maker such as Ford? What does this imply about the sensitivity of profit to sales?
- 5.23 LO3.** What do you think of the business practice of charging customers different prices for essentially the same good? Can you list some examples where you see this practice?
- 5.24 LO4.** How might managers use the margin of safety concept in decision making?
- 5.25 LO4.** Why does operating leverage decrease as sales volume increases?
- 5.26 LO4.** Why is operating leverage viewed as a measure of risk?
- 5.27 LO5.** Consider a large multidivisional firm such as John Deere or Johnson & Johnson. Does it make sense to perform CVP analysis for such firms as a whole? More generally, how could such firms use CVP insights effectively?
- 5.28 LO5.** The text suggests that comparing the unit contribution margin of a sports car with an entry-level vehicle is like comparing apples and oranges, but that comparing the contribution margin ratios is a fair comparison. Do you agree? Why? Can you think of an example where it may be more appropriate to compare unit contribution margins but not contribution margin ratios?
- 5.29 LO6.** Think about each of the assumptions underlying CVP analysis. Do you believe each assumption accurately depicts reality? Can you think of a setting where each assumption is likely to be violated?

EXERCISES

- 5.30 CVP relation and profit planning, unit contribution margin approach (LO1, LO2).** Ajay Singh plans to offer gift-wrapping services at the local mall during the month of December. Ajay will wrap each package, regardless of size, in the customer's choice of wrapping paper and bow for a price of \$3. Ajay estimates that his variable costs will total \$1 per package wrapped and that his fixed costs will total \$600 for the month.
- Required:*
- Express Ajay's profit before taxes in terms of the number of packages sold.
 - How many packages does Ajay need to wrap to break even?
 - How many packages must Ajay wrap to earn a profit of \$1,400?
- 5.31 CVP relation and profit planning, unit contribution margin approach (LO1, LO2).** From Exercise 5.30, we know that Ajay Singh's gift-wrapping service charges \$3 for each package wrapped. Ajay estimates that his variable costs will total \$1 per package wrapped and that his fixed costs will total \$600 for the month.
- Required:*
- Suppose Ajay's variable costs were to increase by 50% per package. What is Ajay's breakeven sales volume?
 - Suppose Ajay estimates that he will be able to wrap 3,000 packages in a month. Assume also that he wishes to earn \$2,400 in profit for the month. What is the minimum price that Ajay must charge to reach his profit goal?
 - How much profit would Ajay earn if December revenue were \$4,500 for the month?

5.32 CVP relation and profit planning, contribution margin ratio approach (LO1, LO2).

Gina Matheson owns and operates a successful florist shop in Bloomington, Indiana. Gina estimates that her variable costs are \$0.25 per sales dollar (i.e., variable costs represent 25% of revenue) and that her fixed costs amount to \$6,000 per month.

Required:

- How does Gina's monthly profit increase as revenue increases? (*Note:* given the absence of unit-level data, you will need to express Gina's monthly profit in terms of revenue.)
- How much revenue does Gina need to generate each month to break even?
- How much profit would Gina earn if her revenues were \$10,000 per month?

5.33 CVP and profit planning, Hercules (LO1, LO2, LO3). Tom and Lynda own Hercules Gym. An individual membership costs \$100 per month. Tom and Lynda estimate variable costs at \$35 per member per month and fixed costs at \$40,950 per month. They currently have 950 members.

Required:

- How many members does Hercules need to break even?
- Suppose Hercules pays income taxes that amount to 35% of income. How many members does Hercules need to report after tax profits of \$11,375?
- Using the contribution margin ratio, calculate the revenue required to earn an after-tax profit of \$11,375.
- What is Hercules' margin of safety?
- What is Hercules' operating leverage?

5.34 Contribution margin, unit level costs (LO1). J&R Audio Company manufactures digital keyboards. At a volume of 15,000 units, per-unit price and cost data for the year just ended follow:

<i>Item</i>	<i>Value per Unit</i>
Selling price	\$800
Variable manufacturing costs	440
Fixed manufacturing overhead	50
Gross margin	\$310
Variable selling costs	40
Fixed selling and administrative costs	110
Profit margin	\$160

Required

What is J&R Audio's breakeven point in units?

5.35 CVP relation and solving for unknowns, contribution margin ratio approach (LO1, LO2).

Gina Matheson owns and operates a successful florist shop in Bloomington, Indiana. Gina estimates that her variable costs are \$0.25 per sales dollar (i.e., variable costs represent 25% of revenue) and that her fixed costs amount to \$6,000 per month.

Required:

- How much revenue does Gina need to generate to earn a profit of \$3,600 per month?
- Suppose Gina estimates that she will be able to generate revenue of \$15,000 in a month. Assume also that she wishes to earn \$4,000 in profit each month. What is the maximum amount that she can spend on fixed costs?
- Suppose Gina's variable costs were to increase by 50%. What is Gina's breakeven revenue per month?

5.36 CVP relation and profit planning, unit contribution margin approach, taxes (LO1, LO2).

SpringFresh provides commercial laundry and linen services to local hospitals, hotels, and restaurants. SpringFresh charges its customers \$1.50 per pound laundered, regardless of the items to be cleaned (e.g., sheet, towel, garment, tablecloth). SpringFresh's variable costs equal \$0.50 per pound laundered, with fixed costs amounting to \$50,000 per month. SpringFresh's income tax rate is 25%.

Required:

- Write down the expression for SpringFresh's annual after-tax profit.
- How much will SpringFresh pay in taxes if it processes 750,000 pounds of laundry this year? What would SpringFresh's profit after taxes be?
- What is SpringFresh's annual breakeven volume in pounds of laundry processed?

5.37 Solving for unknowns, tax brackets, unit contribution margin approach, taxes (LO1, LO2). SpringFresh charges its customers \$1.50 per pound laundered, regardless of the items to be cleaned. SpringFresh's variable costs equal \$0.50 per pound laundered, with fixed costs amounting to \$50,000 per month. SpringFresh's income tax rate is 25%.

Required:

What is the volume of laundry (in pounds) that must be processed if SpringFresh desires to earn \$120,000 in profit after taxes for the year?

5.38 CVP relation in nonprofits, contribution margin ratio approach (LO1, LO2). The local chapter of the Rotary Foundation is planning a fundraiser. They estimate that renting the auditorium and paying for the sound system and performers and other costs would come to \$15,000. They expect to charge \$50 per person. Variable costs are negligible.

Required:

- What is the required attendance for the chapter to raise \$21,000 toward charity?
- The chapter also proposes to have a cash bar at the event. They estimate that the average patron would spend \$20 and that the contribution margin ratio would be 50%. How does this data change your answer to part (a)?

5.39 CVP and profit planning, contribution margin ratio approach, taxes (LO1, LO2). Arena Auto Body specializes in repairing automobiles involved in accidents. Arena has contracts with most insurance providers, enabling Arena to directly bill (and collect from) customers' insurance companies. Arena estimates that its variable costs equal 30% of billings and that fixed costs equal \$14,000 per month. Furthermore, Arena pays income taxes equal to 35% of profit.

Required:

- How does Arena's monthly after-tax profit increase as revenue increases? (*Note:* Given the absence of unit-level data, you will need to express the profit in terms of revenues, or billings.)
- What is Arena's monthly breakeven point in billings?
- Suppose Arena's billings for March were \$50,000. What is Arena's profit before taxes? What is Arena's profit after taxes?
- Suppose Arena wants to have profit after taxes of \$7,280 per month. What is the required level of monthly billings?

5.40 CVP relation, inferring cost structure, extension to decision making (LO2, LO3). Zap, Inc., manufactures an organic insecticide that is marketed and sold via television commercials. Each "ZAP" kit sells for \$22, which includes a base price of \$20 per "ZAP" kit plus \$2 in shipping and handling fees. Zap's contribution margin ratio is 60%. In addition, Zap expects to break even if it sells 17,500 "ZAP" kits per month.

Required:

- What is the unit variable cost of a "ZAP" kit?
- What are Zap's monthly fixed costs?
- Suppose Zap introduces an offer for "free" shipping and handling. How many additional "ZAP" kits must be sold each month to break even?

5.41 CVP relation and decision making, pricing based on a demand schedule (LO3). Greg Green is a schoolteacher who, during the summer months, operates a successful lawn-mowing business. Before advertising his services in the local newspaper, Greg needs to decide on his rate, or price per lawn. Greg is keenly aware that the lower his rate, the more business he will get and vice versa. He is determined to figure this relationship out and select the price that maximizes his summer profit. After conducting some market surveys, Greg believes that the local summer demand is as follows:

Price	Expected Demand (total # of lawns)
\$32.50	300
\$30.00	350
\$27.50	400
\$25.00	450
\$22.50	500

Greg's variable costs amount to \$6 per lawn mowed, and his fixed costs total \$3,000 for the summer.

Required:

What price should Greg charge to maximize his profit from mowing lawns?

- 5.42 CVP relation and decision making, choosing a cost structure, operating leverage (LO3, LO4).** Leticia Gonzalez is in charge of the concession stands division for all 100 theaters owned and operated by Midwest Cinema. Theaters range in size from single-screen (mostly in small towns) to multiplexes with 10 or more screens. Leticia wants to develop a system that will enable her to select the optimal popcorn machine for any given theater location. Leticia can rent commercial popcorn machines in small, medium, or large sizes. The fixed annual rental cost for each machine differs, as does the variable cost associated with operating and maintaining the machine. For example, the large popcorn machine costs the most to rent but requires minimal staff attention and maintenance. The following table shows the annual fixed costs and variable costs associated with operating each popcorn machine:

<i>Size of Popcorn Machine</i>	<i>Annual Fixed Operating Costs</i>	<i>Variable Costs per Patron</i>
Small	\$6,000	\$0.50
Medium	\$12,000	\$0.35
Large	\$18,500	\$0.25

Required:

- Help Leticia determine the optimal size popcorn machine for a given theater. In other words, how many moviegoers does a theater need to have before Midwest Cinema should rent the medium and large popcorn machines?
 - Assume one of Midwest Cinema's theaters expects 65,000 moviegoers in the coming year. What is the operating leverage for each popcorn machine?
- 5.43 CVP relation and decision making, margin of safety, operating leverage, cash-basis break-even analysis (LO3, LO4).** The Cottage Bakery sells a variety of gourmet breads, cakes, pies, and pastries. Although its wares are considerably more expensive than those available at supermarkets and other bakeries, the Cottage Bakery has a loyal clientele willing to pay a premium price for premium quality. In a typical month, the Cottage Bakery generates revenue of \$150,000 and earns a profit of \$7,500. The Cottage Bakery's contribution margin ratio is 40%.

Required:

- What is the Cottage Bakery's margin of safety at its current sales level?
 - What is the Cottage Bakery's operating leverage?
 - What is the revenue required for Cottage Bakery to break even on a cash basis? Assume that 30% of the Cottage Bakery's fixed costs represent noncash items (e.g., depreciation expense on the ovens, furniture, and fixtures). All other expenses are paid in cash and all revenues are received in cash.
- 5.44 Multiproduct CVP analysis, unit contribution margin approach (LO5).** Mountain Maples is a mail-order nursery dedicated to growing, selling, and shipping beautiful Japanese Maple trees. Located on a ridge-top in Mendocino County, northern California, Mountain Maples offers two distinctive types of Japanese Maples: Butterfly and Moonfire. The trees are sold after five growing seasons, and revenue and cost data for each tree type (for the most recent year) are as follows:

	<i>Butterfly</i>	<i>Moonfire</i>
Quantity sold	800	1,600
Selling price per tree	\$200	\$100
Variable cost per tree	\$100	\$50

Mountain Maples' fixed costs for the most recent year were \$75,000.

Required:

- How many Japanese Maples must Mountain Maples sell in a year to break even? At this sales volume, how many Butterfly and Moonfire trees are sold?
- At the current product mix, how many Butterfly trees must Mountain Maples sell in a year to earn a profit of \$50,000?
- Assume that Mountain Maples product mix changes to 50% Butterfly and 50% Moonfire. How does this information change your answer to part (a)?



- 5.45 Multiproduct CVP analysis, contribution margin ratio approach (LO5).** Select Auto Imports is a regional auto dealership that specializes in selling high-end imported luxury automobiles. Select Auto Imports sells both new and pre-owned (used) cars. Financial data for the most recent year of operations are as follows:

	<u>New Cars</u>	<u>Used Cars</u>	<u>Total</u>
Revenue	\$1,500,000	\$500,000	\$2,000,000
Variable costs	<u>750,000</u>	<u>200,000</u>	<u>950,000</u>
Contribution margin	\$750,000	\$300,000	\$1,050,000
Fixed costs			<u>840,000</u>
Profit before taxes			<u>\$210,000</u>

Required:

- Assuming the product mix remains constant, what is Select Auto Import's breakeven point in revenue? At the breakeven point, what is the revenue from new and used autos, respectively?
- What level of revenue is required to ensure that Select Auto Imports earns a profit of \$1,050,000 in the coming year? What is the revenue from new and used autos, respectively?



- 5.46 Multiproduct analysis, weighted contribution margin & weighted contribution margin ratio approach, Hercules (LO5).** Tom and Lynda operate Hercules Gym. The club currently has 900 individual members and 300 family memberships. The fee for individual memberships is \$100 per month, and families pay \$150 per month. Variable costs are \$35 per month for individual and \$60 per month for a family. Monthly fixed costs amount to \$42,750.

Required:

- Calculate Hercules' weighted contribution margin. Use this answer to calculate the number of individual and family memberships at breakeven volume
- Calculate Hercules' weighted contribution margin ratio. Use this answer to calculate the total revenue to achieve breakeven.

PROBLEMS

- 5.47 CVP relation, profit planning, unit contribution margin approach, extensions to decision making (LO1, LO2, LO3).** Garnet's Gym is a fitness and aerobic center located in Atlanta, Georgia. With over 25,000 square feet of space, Garnet's offers its customers an unparalleled fitness experience, including the finest equipment for cardiovascular training, resistance training, and free-weight training. Garnet's also features state-of-the-art aerobics, spinning, yoga, and tai chi classes taught by nationally certified instructors. Finally, when not working out, patrons can enjoy other amenities such as Garnet's tanning salon, hot tub, sauna, and juice bar.

The owners of Garnet's Gym currently are working on their operating plan for the coming year, and they have provided you with the following average membership and cost data for the previous year:

Membership fee	\$500 per member
Number of members	5,000
Variable costs (supplies, etc.)	\$200 per member
Fixed costs (equipment, salaries, etc.)	\$1,200,000

The owners anticipate that, for the coming year, both total fixed costs and the variable cost per member will remain unchanged from the previous year.

Required:

- Write down the expression for Garnet's annual profit.
- How many members must Garnet's Gym have to break even?
- Assuming the same number of members as last year, what is Garnet's expected profit for the coming year?

- d. The owners of Garnet's Gym are considering reducing the membership fee by 10%. They believe that this action will increase membership to 6,500 for the coming year. What will profit be if the owners adopt this alternative? (*Note:* The membership fee for all members will be reduced by 10%.) Does this seem like a good option?
- e. As an *alternative* to reducing the membership fee by 10%, the owners of Garnet's Gym could increase membership to 6,500 by adopting a special advertising campaign. What is the maximum amount that the owners should pay for the advertising campaign? (*Hint:* The amount you calculate will make the owners just indifferent between lowering the membership fee by 10% and adopting the advertising campaign.)
- f. The owners of Garnet's Gym noticed that you used the unit contribution margin approach in arriving at your answers. They wonder if your answers would change if you used a contribution margin ratio approach. Briefly explain to the owners why your answers would, or would not, change.

5.48 CVP relation, profit planning, contribution margin ratio approach, extensions to decision making (LO1, LO2, LO3). You are the chief financial officer of a jewelry manufacturing and wholesaling company, Precious Stone Jewelry, Inc. (Your company's motto is "Romantic selections to suit every budget.") At this morning's executive meeting, you distributed last month's income statement—which contained the following information:



<i>Precious Stone Jewelry</i>	
<i>Income Statement</i>	
Revenues	\$1,000,000
Variable costs	600,000
Contribution margin	<u>\$400,000</u>
Fixed costs	260,000
Profit before taxes	<u>\$140,000</u>
Taxes (25% of profit before taxes)	35,000
Profit after taxes	<u>\$105,000</u>

During the meeting, the various officers of the company made the following reports:

- The marketing director indicated that, due to a competitor leaving the market, Precious Stone could raise the unit selling price on all products by 20% without affecting demand.
- The operations director indicated that, due to recent advances in technology, the company's unit variable costs could be reduced by 20%.
- The controller distributed a new tax bill, just signed into law, that will increase the company's tax rate to 30% of profit before taxes.

Required:

- a. What is your company's current breakeven revenue? (For this question, ignore all of the changes announced at the meeting.)
 - b. Ignoring the other two changes, what effect would raising the unit selling price by 20% have on breakeven revenue?
 - c. Ignoring the other two changes, what effect would decreasing the unit variable cost by 20% have on the breakeven revenue?
 - d. Ignoring the other two changes, what effect does a change in the tax rate have on the breakeven point?
 - e. Suppose all of the changes announced at the meeting do take place. What will your company's profit after taxes be next month? Support your answer with a pro-forma income statement ("pro-forma" means the income statement for a time period that has not yet occurred).
- 5.49 CVP relation and profit planning, solving for unknowns (LO1, LO2).** You read an article in your local newspaper, *The Herald Times*, about your city's expenditures on snow removal for the most recent winter. *The Herald Times* reports that there were 20 major snowfalls this past winter and that snow removal costs totaled \$300,000. The article goes on to mention that the \$300,000 was comprised of both fixed costs (e.g., plows, trucks, and some salaries) and variable costs per major snowfall (e.g., salt and sand). The article concludes by noting that the heavy snowfall this past winter has placed the city in somewhat of an unexpected budget bind—the city's snow removal

budget for the current year was based on last year's snow removal costs of \$228,000 and 12 major snowfalls.

Assume that your city's cost structure for snow removal has remained the same in recent years. That is, the fixed costs have been the same each year and the variable costs per snowfall have been the same each year. Moreover, the city does not anticipate any change in its snow removal cost structure for the coming years.

Required:

- a. Fascinated by this article, you wonder if it is possible to back into your city's cost structure for snow removal costs using the two data points that the local newspaper provides. What are the city's fixed and variable costs for snow removal?
- b. The *Farmers' Almanac* predicts that next year's winter will be a real "doozy" and has forecasted 26 major snowfalls for your city. Based on this forecast, how much should your city budget for in snow removal costs?

5.50 Building a CVP relation that incorporates taxes and bonus payments using a contribution margin ratio approach (LO1, LO2). The Diamond Jubilee is a floating riverboat casino that operates on the Mississippi River. The casino is open 24 hours daily and features 675 slot machines, 25 blackjack tables, 8 poker tables, 3 craps tables, and 2 roulette tables.

On average, for every \$1.00 wagered at the Diamond Jubilee \$0.82 goes back to the gamblers as winnings, and \$0.08 covers the casino's variable costs. The remaining \$0.10 goes toward covering the casino's fixed costs and contributing toward profit. The Diamond Jubilee's fixed costs amount to \$27,500 per month, and the casino pays combined state and federal taxes equal to 25% of pretax profit.

For motivational purposes, the Diamond Jubilee links some of its general manager's compensation to the casino's profitability. Specifically, the riverboat's general manager, Sapphire Sally, receives a monthly bonus equal to 5% of the casino's pretax profit.

Required:

How much do Diamond Jubilee patrons have to wager in a month for the casino to earn an after-tax and after-bonus profit of \$28,500? (*Note.* The bonus is deductible for tax purposes, and, thus, taxes are paid on pre-bonus profit less the bonus.)

5.51 CVP relation and profit planning, choosing a cost structure (LO1, LO2, LO3). Cecelia's Custom Cabinets specializes in making handcrafted custom cabinets for the discriminating homeowner. Over time, the owner of Cecelia's Custom Cabinets, Cecelia Tyson, has developed a strong reputation for superior craftsmanship and attention to detail—Cecelia uses only the finest hardwood materials and employs only the most expert carpenters. Currently, Cecelia and her staff do most of their work with hand tools and only sparingly use sophisticated woodworking machines.

Given the recent advances in woodworking technology, Cecelia is considering buying some state-of-the-art planing and corning machines. Cecelia believes that these machines will not only reduce the amount of time she and her staff spend on making cabinets but also will significantly reduce the level of scrap and wasted materials.

Under her current cost structure (i.e., without the new machines), Cecelia estimates that her fixed costs average \$36,000 per month and that her contribution margin ratio is 40%. If Cecelia acquires the woodworking machines, then her fixed costs would increase to \$60,000 per month; however, her contribution margin ratio would also increase to 60%.

Required:

- a. What is Cecelia's monthly breakeven revenue under her current cost structure? What would Cecelia's monthly breakeven revenue be if she acquired the new machines?
- b. Which cost structure would you recommend to Cecelia if her monthly revenue was \$95,000? Which cost structure would you recommend to Cecelia if her monthly revenue was \$150,000?
- c. Calculate the sales level at which Cecelia is indifferent (that is, has the same profit) under both cost structures.

5.52 CVP relation and decision making, pricing based on a demand schedule (LO3). Innova Solutions has developed a software product that enables users to electronically prepare and file their state and federal tax returns. Innova Solutions has asked for your help in pricing this product. Preliminary market research indicates that if Innova Solutions prices its tax software at \$25 per copy, then it will sell 75,000 copies in the first year. Demand would increase to 150,000 copies in the first year if the selling price were \$15 per copy and to 300,000 copies in the first year if the selling price were \$5 per copy.

As you know, end-users invest considerable time in learning how to use new software packages. As a result, they tend to stick with the same software year after year. Moreover, initial acceptance is extremely important; you expect that the number of copies sold in the first year will equal the number of copies sold in the second year. Thus, if Innova Solutions sells 75,000/150,000/300,000 copies in the first year, it also expects to sell 75,000/150,000/300,000 copies in the second year (as long as the price in the second year is not outrageous—in this case, \$25 or less).

Innova Solutions is contemplating a strategy of setting a low introductory price in the first year followed by a more competitive price of \$25 per copy in the second year. The following table summarizes Innova Solutions' pricing options in years 1 and 2 and the corresponding demand for each year:

<i>Price (year 1)</i>	<i>Demand (year 1)</i>	<i>Price (year 2)</i>	<i>Demand (year 2)</i>
\$25	75,000	\$25	75,000
\$15	150,000	\$25	150,000
\$5	300,000	\$25	300,000

Innova Solutions' fixed costs amount to \$1,500,000 per year, and the variable costs associated with producing and distributing the software equal \$1 per copy.

Required:

- For each of the two years (and overall), calculate Innova Solutions' profit under each of three introductory pricing scenarios: \$25 per copy; \$15 per copy; and \$5 per copy. For each of the three scenarios, the price in the second year will be \$25 per copy.
- How would your answer to part (a) change if Innova Solutions' fixed costs amounted to \$200,000 per year and its variable costs associated with producing and distributing the software equaled \$15 per copy?
- What inferences can you draw about the wisdom of using low introductory prices (i.e., "low-balling") to gain market share? Does the effectiveness of this strategy change depending on the organization's cost structure?

5.53 CVP relation and margin of safety (LO4). Brenda Wong is a licensed real estate broker specializing in vacation homes and investment properties in the Sedona, Arizona area. Because of her affiliation with a large national real estate agency and her attention to detail, Brenda has been able to build a very successful business. Brenda receives a 3% commission, based on the property's selling price, for every successful transaction. (The realtor representing the other party also receives a 3% commission. Typically, the owner of the property being sold pays both commissions.) Brenda has a nice office and support staff to assist her in operating her business. Brenda's fixed costs equal \$18,000 per month; her variable costs are negligible and, thus, can be ignored.

Required:

- What is the volume of transactions (in dollars) that Brenda must successfully complete in a month to break even?
- Assume Brenda currently averages a transaction volume of \$1,000,000 per month. What is her margin of safety?
- What is Brenda's margin of safety if she averages a transaction volume of \$1,200,000 per month. What is Brenda's margin of safety if she averages a transaction volume of \$1,600,000 per month?
- What do you notice about the relation between Brenda's margin of safety and her monthly transaction volume?

5.54 CVP relation and decision making, operating leverage, margin of safety (LO3, LO4). Dan Wenman has approached your bank for a loan to start a hazardous waste management business. There are a number of biotechnology and chemical companies in Dan's community, and such companies generate a fair amount of hazardous medical, chemical, and radioactive waste. Dan wants to start a business that focuses on all aspects of the waste management process; his goal is to provide for the safe and cost-effective storage, transportation, and disposal of industrial waste.

Dan has approached your bank with two proposals. His first proposal calls for him to "go it alone." As such, Dan would be responsible for acquiring all of the necessary personnel, equipment, and facilities for waste treatment. Under this proposal, Dan expects to incur fixed costs of \$1,500,000 per year. His expected contribution margin ratio is 60%.

The second proposal calls for Dan to outsource the disposal portion of his business (i.e., Dan would focus on the containment and transportation of waste). Here, Dan would enlist (and pay for) the services of a privately owned landfill, waste combustor, and incinerator (rather than buying his own landfill, waste combustor, and incinerator). The benefit of this option is that it reduces Dan's fixed costs to \$675,000 per year. The cost, however, is that Dan's contribution margin ratio would decrease to 30%. Dan is confident that both options are comparable on all other dimensions, such as quality and safety.

Required:

- a. Suppose Dan estimates that revenues from his business will be \$2,750,000 per year. What is Dan's profit under each proposal? What is Dan's operating leverage under each proposal? What is Dan's margin of safety under each proposal? As Dan's potential lender, which proposal would you likely support?
- b. Suppose Dan estimates that sales revenue from his business will be \$4,500,000 per year. What is Dan's profit under each proposal? What is Dan's operating leverage under each proposal? What is Dan's margin of safety (in \$) under each proposal? As Dan's potential lender, which proposal would you likely support?

5.55 Multiproduct CVP analysis (LO5). Campus Bagels bakes and sells authentic New York-style kettle-boiled bagels. For the most recent year, Campus Bagels sold 250,000 bagels at a selling price of \$1 per bagel. During this same year, Campus Bagels incurred fixed costs of \$100,000 and variable costs of \$0.40 per bagel.

Management of Campus Bagels is considering extending their product line to include bagel sandwiches. Management estimates that adding bagel sandwiches would increase their total fixed costs by \$25,000 per year and that the variable cost per bagel sandwich would be \$1.25.

Required:

- a. Ignoring the new product line, how does Campus Bagels' profit increase or decrease with number of bagels sold? Using this model, what was Campus Bagels' profit for the most recent year?
- b. How would adding bagel sandwiches change Campus Bagels' profit? What information do you need before you can determine how introducing bagel sandwiches would affect Campus Bagels' overall profit? Is it reasonable to assume Campus Bagels will still sell 250,000 bagels?
- c. Assume Campus Bagels believes that, in addition to selling 250,000 bagels in the coming year, it also can sell 25,000 bagel sandwiches. What price should Campus Bagels charge per bagel sandwich if it wishes to increase overall profit by \$50,000?
- d. Assume Campus Bagels believes that it can sell 25,000 bagel sandwiches but that this will reduce the number of bagels sold by 25,000 to 225,000 (i.e., there is a one-for-one trade-off between bagels and bagel sandwiches). What price should Campus Bagels charge per bagel sandwich if it wishes to increase overall profit by \$50,000?

5.56 Multiproduct CVP analysis and fixed cost allocations. Jan Van Voorhis is a florist in Sedona, Arizona. Dividing his clients into two major categories, he provides the following income statement. He stresses that, for most florists (including himself), each segment accounts for 50% of total revenues.

	<i>Retail</i>	<i>Institutional</i>	<i>Total</i>
Revenues	\$450,000	\$450,000	\$900,000
Variable cost	150,000	270,000	420,000
Contribution margin	300,000	180,000	480,000
Traceable fixed costs	175,000	80,000	255,000
Segment margin	125,000	100,000	225,000
Common fixed costs			200,000
Profit before taxes			\$25,000

Required

- a. Suppose Jan allocates common fixed costs equally between the two segments. Treating each segment as a separate business, determine the breakeven revenue for institutional revenues and for retail revenues. Does Jan's shop, as a whole, break even with these revenues?

- b. Compute Jan's Weighted Contribution Margin Ratio using the product mix provided in the problem text. Determine breakeven revenues using this revenue shares.
- c. Why do the answers for parts (a) and (b) differ? What key feature of Jan's business is not captured in the answer to part (a)? What do you conclude about the wisdom of allocating common costs and performing breakeven analysis separately by segment?
- d. When would a firm perform breakeven analysis for a segment?

5.57 Multiproduct CVP analysis (LO5). Kim Kane sells lunches from a pushcart in a pedestrian mall near a busy office area. Over time, Kim has established a reputation for selling quality sandwiches, soups, and salads. Kim sells each sandwich for \$4, each bowl of soup for \$3, and each salad for \$3. Customers also can purchase a bottle of water or a can of soda from Kim for \$1.



For every ten customers, three customers purchase both a soup and a sandwich; three customers purchase both a soup and a salad; two customers purchase only a sandwich; one customer purchases only a bowl of soup, and one customer purchases only a salad. Six of every ten customers also purchase a bottled water or soda with their food. Kim does not offer any price discounts for purchasing multiple items; thus, a customer who purchases both a soup and a sandwich is charged \$7 (i.e., \$4 for the sandwich + \$3 for the soup.)

Kim estimates that her variable costs are as follows: \$1.25 for each sandwich; \$1.00 for each bowl of soup; and \$0.75 for each salad. She buys soda and water in bulk for \$0.25 a can (or bottle). Finally, Kim estimates that her fixed costs (which include the cost of her time, her pushcart license, plastic and paper products, condiments, and so on) total \$4,950 per month.

Required:

- a. How many customers does Kim need to serve in a month to break even? What does this mean in monthly revenue? (*Hint:* Use sales per 10 customers to determine Kim's weighted contribution margin ratio.)
- b. Suppose Kim decides to offer a free can of soda or bottle of water to customers who purchase a sandwich-soup-salad combo (as you know, no one currently purchases this combination). Assume that the three of every ten customers who currently purchase both a soup and a sandwich will be enticed by this offer. Also, assume that these three customers had always purchased a soda or water with their soup and sandwich. Kim's offer will have no effect on her other customer groups. How many customers does Kim need to serve in a month to break even? What does this translate to in monthly revenue?

5.58 Multiproduct CVP analysis, weighted contribution margin ratio approach (LO5). The University Bookstore sells both new and used textbooks. New textbooks are sold to students at the publisher's suggested retail price and are purchased from publishers for 75% of the suggested retail price. University Bookstore also incurs additional variable costs in selling a new textbook; variable selling costs amount to 5% of the publisher's suggested retail price.

University Bookstore sells used textbooks for 75% of the price of a new textbook. However, University Bookstore can purchase a used textbook for 25% of the suggested retail price of a new textbook. Variable selling costs (*in dollars per textbook*) are the same for both new and used textbooks. University Bookstore's annual fixed costs amount to \$360,000.

Required:

- a. If used books account for 40% of revenue, what is University Bookstore's breakeven revenue? (*Hint:* To calculate breakeven revenue, you will need to pick a number for the price of a new book—any number will do. Why?)
- b. When students purchase a textbook for a course, they purchase either a used book or a new book, but not both. On average, would University Bookstore prefer to sell a student a new textbook or a used textbook? Why? (Assume University Bookstore has yet to purchase books for the coming semester, so the cost of textbooks is not sunk).
- c. The University Bookstore has decided that, for fairness reasons, it should price used textbooks so that the contribution margin (\$ contributed toward profit) per used book is the same as the current contribution margin on a new book. To accomplish

this objective, what would the price of a used textbook be as a percentage of the price of a new textbook? (Recall that used textbooks currently sell for 75% of the price of a new textbook).

5.59 Multiproduct CVP analysis, how best to spend advertising dollars (LO3, LO5). The Tornado Vacuum Cleaner Company produces and sells three different types of upright vacuum cleaners: (1) the F1, (2) the F3, and (3) the F5. Each vacuum cleaner shares certain basic features such as a 15-inch cleaning width, edge groomers, headlight, and 31-foot power cord. However, the vacuums differ in the power offered (the F5 has a 12-amp motor and dual agitators), versatility (the F5 comes with five cleaning tools, whereas the F3 comes with three cleaning tools and the F1 has only one cleaning tool), and ease of use (both the F3 and the F5 are manufactured without belt drives—thus, customers do not need to purchase or install a replacement belt as they ultimately would have to for the F1).

Management of Tornado has provided you with the following data for their most recent year of operations:

	Vacuum Cleaner		
	F1	F3	F5
Selling price per unit	\$150	\$200	\$400
Variable cost per unit	\$75	\$110	\$240
Quantity sold	25,000	15,000	10,000

In addition, management has informed you that annual fixed costs amounted to \$3,860,000.

Required:

- What was Tornado's profit for the most recent year?
- Assume that Tornado wants to spend \$150,000 on advertising. To maximize impact, management believes it should focus all advertising dollars on one of the three vacuum cleaners. Regardless of the product chosen, Tornado estimates that sales of the targeted vacuum cleaner will increase by \$600,000, whereas sales for each of the other two vacuum cleaners are expected to decrease by \$60,000. Which vacuum cleaner should be the focus of the advertising campaign? By how much is profit expected to increase as a result of the advertising campaign?
- In part (b), Tornado's management assumed that, regardless of the product chosen for the advertising campaign, the increase in sales revenue will be constant at \$600,000. What assumption is management making? Likewise, management also assumed that the decline in sales revenue associated with the two vacuum cleaners not selected for the advertising campaign will be constant at \$60,000. Do you believe these assumptions accurately depict reality? Why?

5.60 CVP analysis—A critical evaluation: nonlinear cost function, linear approximation, and decision making (LO3, LO6, Advanced). Jackrabbit Trails is a family camp located in Kings Canyon National Park, California. Open from mid-May to Labor Day, Jackrabbit Trails offers week-long family summer vacation packages that include lodging, three meals a day, and numerous activities such as horseback riding, waterskiing, sailing, canoeing, archery, fishing, hiking, and mountain biking. To provide families with a restful experience, Jackrabbit Trails limits the number of families to 20 per week. Moreover, the camp motto is "Follow the fun without following the herd."

Jackrabbit Trails believes that the following function captures the "true" underlying relation between the number of families at the camp in a given week and the total costs of running the camp for a week:

$$\text{Total cost (\$)} = 1,000 + 300 (\text{Families}) - 20 (\text{Families})^2 + (\text{Families})^3$$

Required:

- Plot (graph) Jackrabbit Trails' weekly total costs as a function of the number of families for 0 to 20 families. Does the shape of this cost function look familiar to you (think back to microeconomics)? What are some of the properties of this cost function?
- Suppose Jackrabbit Trails approximates its cost function via a linear model using the endpoints of its relevant range from 4 families to 16 families per week. Write out the linear cost model and plot it on the same graph you developed in part (a). Over

what range does the linear cost function strike you as a reasonable approximation to Jackrabbit Trails' true underlying cost curve?

- c. Suppose Jackrabbit Trails believes that the following equation captures the relation between the price (per family), and weekly demand (number of families) for their summer camp:

$$Price = 1,200 - (50 \times Families)$$

What price and quantity maximize Jackrabbit Trails' weekly profit when the total cost is nonlinear? What price and quantity maximize Jackrabbit Trails' weekly profit when the total cost is linear? What does Jackrabbit Trails sacrifice and/or gain by adopting the linear cost model?

5.61 CVP analysis—A critical evaluation: Nonlinear CVP relation, pricing (LO3, LO6, Advanced). Chul Park & Sons manufacture and sell specialized automotive testing equipment, including alternator testers, solenoid testers, and voltage regulator testers. Over the past 15 years, Chul Park & Sons has established a national reputation as a producer of accurate, reliable, and functional computerized products for testing automotive electrical and electronic components.

Chul Park & Sons, however, is only one of many companies that manufacture automotive testing equipment. Customers can choose from among numerous automotive suppliers, and, as a result, Chul Park & Sons' sales are quite sensitive to the selling price it sets for each product. Mr. Park currently is working on setting the selling price for his main product, a universal (3 in 1) tester. He believes that the following equation nicely captures the relation between the selling price and demand for his universal tester:

$$Quantity = 32,500 - (10 \times Price)$$

where *Quantity* represents the demand for Chul Park & Sons' universal tester and *Price* represents the unit selling price established by Mr. Park. Mr. Park also informs you that the variable cost per universal tester is \$750 and that the fixed costs associated with producing and selling the universal tester equal \$14,000,000 per year.

Required:

- What is Chul Park & Sons' expression for annual profit for its universal tester? (*Hint:* Substitute the demand equation for quantity in the expression for profit in the text.)
- Determine the price at which Chul Park & Sons maximizes profit on its universal tester. What is the profit on the universal tester at this price? (*Hint:* If you are familiar with calculus, take the first derivative of the profit model [with respect to *Price*] and set it equal to 0; otherwise, plot the profit equation, varying the price between 0 and \$3,000 in increments of \$100.)

MINI-CASES

5.62 Made to order caps. Jessica James is considering a business venture—selling custom-embroidered baseball caps from a pushcart kiosk at College Mall. The caps will be available in 12 different colors and one-size fits all. The caps' unique feature is that almost any name, phrase, or logo, can be stitched onto the cap while the customer waits. Thus, a customer can obtain a cap with his or her own name, monogram, special saying, or favorite logo in a wide variety of thread colors, sizes, and fonts. Based on preliminary market research and input from the franchising company, Jessica plans on selling each embroidered cap for \$20.

Jessica plans to acquire the necessary technology (two industrial strength sewing machines hooked up to PCs with scanners and all of the necessary software) by obtaining a franchise from Made to Order Caps, Inc. Made to Order Caps, Inc., sells all of the necessary equipment and technology and provides the inventory of caps and other supplies. In addition, Made to Order Caps, Inc., trains prospective franchisees such as Jessica in the basics of running the business and operating the machines.

Jessica will need to buy the caps from Made to Order Caps, Inc., for \$4 per cap and pay a royalty to the franchising company of \$2 per cap sold. In addition, Jessica believes



that each cap will use about \$2.50 worth of supplies (including thread, replacement of sewing needles, machine maintenance, etc.). Finally, Made to Order Caps, Inc., requires that each franchisee invest \$250 per month on leaflets and brochures to advertise the product.

Jessica discovers that College Mall would supply her with the pushcart and all of the necessary equipment for proper display. The license from the mall also allows Jessica to use several electrical outlets and two telephone outlets. College Mall will pay for Jessica's electricity consumption, but she will have to obtain two business telephone lines at a cost of \$50 per line per month. College Mall is willing to license the space and equipment to Jessica on a monthly basis for \$1,970 per month.

To generate maximum sales, Jessica wants to keep the pushcart open for business from 10 A.M. to 10 P.M. Monday through Friday, and from 10 A.M. to 6 P.M. on Saturday and Sunday. Jessica is willing to put in 50 hours at the kiosk, and she can obtain additional part-time help at \$10 per hour (only one individual is required to operate the business). Jessica's only other significant expense is setting up to accept credit cards. Jessica anticipates that 75% of her sales will be credit card sales, and the credit card company charges Jessica a fee of 2% of the selling price.

Required:

- a. Write down the expression for Jessica's monthly profit. (Assume that there are exactly four weeks per month.)
- b. Calculate Jessica's monthly breakeven point in baseball caps. What does this translate to in revenue?
- c. How much profit would Jessica earn in a month if she sold 1,000 caps? How many caps would Jessica have to sell to earn a target profit of \$4,032 per month?
- d. Jessica has been toying around with how the quantity of caps she can sell is likely to vary inversely with the selling price. Jessica is keenly aware that the lower the price per cap, the more caps she can sell and vice versa. She is determined to figure this relationship out and find the best price. After conducting extensive market surveys, Jessica believes that the local monthly demand for embroidered baseball caps is as follows:

<i>Price per Cap</i>	<i>Demand</i>
\$20	300
\$25	250
\$28	220
\$30	200
\$32	180
\$34	160

How does this piece of information alter Jessica's profit calculation? What price per cap should Jessica charge to maximize profit? How much profit does she earn at this price?

- e. Jessica is almost done—she realizes that she forgot to include taxes as part of her decision model. Jessica believes that combined local, state, and federal taxes will be 25% of her profit before taxes. Does this piece of information affect Jessica's decision in part (d)? Does this change the profit-maximizing price? Does it change Jessica's profit?
- f. What do you think of Jessica's business venture?



5.63 Short-term decisions, multiproduct CVP, service firm (LO1–LO5). Rick's English Hut (Rick's) is a restaurant located in North Myrtle Beach, South Carolina on a salt-water marsh, surrounded by stately oak trees. Rick's appetizers and entrees run the gamut, from tasty burgers and sandwiches to authentic Mexican plates and succulent ribs. Rick's also has two bars that feature a dozen beers on tap and a wide-variety of wines and mixed drinks. With 15 televisions and seating for 250 patrons, Rick's is *the* place to enjoy good food and warm hospitality with friends while watching your favorite sports team.

For the most recent month, Rick's generated \$60,000 in revenue, 55% of which came from the sale of alcoholic beverages and 45% of which came from the sale of food items. On average, alcoholic beverages sell for \$4 and have a variable cost of \$2; the average food item sells for \$5 and has a variable cost of \$4. Rick's fixed costs for the month totaled \$10,950.

Rick's recent operating results present the proprietors with a dilemma. Specifically, for state licensing purposes Rick's currently is classified as a "restaurant" and, as such, has the appropriate liquor license associated with this status—Class B. With a Class B liquor license, Rick's is allowed to sell alcohol on the premises. However, alcohol sales must not exceed 50% of total revenue—otherwise Rick's would be classified as a bar, a classification that requires a Class A liquor license. Currently, Rick's pays \$150 per month for its Class B liquor license; this cost is included in the fixed costs of \$10,950 above.

Rick's proprietors would have to pay an additional \$850 a month for a Class A liquor license. Furthermore, Rick's liquor liability insurance premiums would increase due to the increased liabilities associated with a higher proportion of alcohol sales (e.g., increased possibility of injury on the premises due to inebriation, increased chance of serving alcohol to minors, and so on). Rick's insurance provider has informed the proprietors that their insurance premiums will increase by \$318 per month if the establishment is licensed as a bar rather than a restaurant.

The South Carolina State Liquor and Alcoholic Beverage Control Agency closely monitors alcohol consumption in the state and has informed Rick's that if it continues operating at the current sales mix level, Rick's will need to operate under a Class A license. The agency has informed Rick's that it will not impose any penalties on the restaurant as a result of the most recent month's operating performance. The agency has, though, informed Rick's that it needs to get its business in order starting this month.

In terms of moving forward, the proprietors of Rick's have discussed the following three options.

- *Option 1:* Change the licensing status of the establishment from restaurant to bar. This option would entail obtaining a Class A liquor license and paying the increased monthly licensing fees and insurance premiums. Rick's would plan on selling alcohol and food at their current sales-mix percentages and levels (i.e., total revenue and the proportion associated with food and alcohol would not change).
- *Option 2:* Close the restaurant one-half hour earlier each night. This option would reduce alcohol sales such that alcohol sales exactly equal the *current* level of food sales (i.e., the revenues from both products would be equal). In addition, it would reduce Rick's fixed costs by \$450 per month. Finally, Rick's would continue to operate as a restaurant under its Class B license.
- *Option 3:* Offer a brunch on Saturday and Sunday mornings (no alcohol would be served at the brunch). To ensure that revenues from the brunch are sufficient to *bring up* food sales to equal current alcohol revenue, Rick's would need to price each brunch at \$4. Unfortunately, Rick's has determined that the variable cost of offering the brunch (including labor, food, etc.) will be \$4.08 per brunch and that fixed costs will increase by \$105 per month. However, a benefit of offering the brunch is that Rick's could continue to operate as a restaurant under its Class B license.

Rick seeks your expertise in evaluating the efficacy of each option.

Required:

- a. Calculate Rick's profit and breakeven point in revenue for the most recent month (i.e., before considering the options).
- b. Calculate Rick's monthly profit and breakeven point in revenue under *option 1*.
- c. Calculate Rick's monthly profit and breakeven revenue under *option 2*.
- d. Calculate Rick's monthly profit and breakeven revenue under *option 3*.
- e. Prepare a brief paragraph or two discussing the key insights Rick's has learned. Can you link these insights to some commonly observed business practices? Try listing some examples.

5.64 Constructing and interpreting CVP graphs (LO1, LO2). The Yin-Yang Yogurt Shoppe serves the best chocolate-vanilla frozen yogurt in the city. Each cup of yogurt sells for \$4, with variable costs amounting to \$2 per cup. Yin-Yang's fixed costs equal \$3,000 per month.



Required:

- a. Graph Yin-Yang Yogurt Shoppe's total costs as a function of the number of cups of yogurt sold (going from 0 to 2,500 cups of yogurt in increments of 500 cups). What does the *y*-intercept (i.e., the point where the total cost line crosses the *y*-axis) represent? What does the slope of the total cost line represent?

- b. Add a plot of the Yin-Yang Yogurt Shoppe's total revenue (as a function of the number of cups of yogurt sold) to your graph from part (a). Identify the breakeven point in your graph. Identify the profit and loss areas.
- c. Construct a profit graph for the Yin-Yang Yogurt Shoppe. Form a single line that depicts Yin-Yang's profit as a function of the number of cups of yogurt sold. What does the intercept of the profit line represent? What does the slope of the profit line represent? How do you interpret the point at which the profit line crosses the horizontal (i.e., x) axis? Identify the profit and loss areas.
- d. Suppose Yin-Yang pays taxes at the rate of 40% of profit. How does this affect the profit line?
- e. (*Advanced*) Assume you do not have unit-level data; in other words, assume you only know that Yin Yang's monthly fixed costs equal \$3,000 and that its contribution margin ratio is 50% (you gather this information from Yin Yang's financial statements). Construct a profit graph that allows you to identify Yin Yang's breakeven point and profit and loss areas. (*Hint*: Without unit-level data, you will need to measure a variable other than units on the x -axis.) Ignore taxes.

5.65 CVP analysis with alternative cost structures, demand uncertainty, and risk (LO3, LO4, LO6, Advanced). Sally Sturgeon owns a company that manufactures and sells fishing rods. Sally's latest creation is the Bass-O-Matic, a graphite fishing rod designed with a trigger-stick Portuguese cork handle and Sally's revolutionary titanium guide system. Compared to other fishing rods on the market, Sally believes her Bass-O-Matic not only will reduce hand and arm fatigue but also will allow anglers to make longer and more precise casts with smoother retrieves.

Sally can make the Bass-O-Matic with one of two available technologies. The first technology is a labor-intensive technology; if Sally chooses this technology, then she will incur fixed costs of \$500,000 per year and a variable cost of \$50 per fishing rod. The second technology is a capital-intensive technology; if Sally chooses this technology, then she will incur fixed costs of \$2,500,000 per year and a variable cost of \$25 per fishing rod. Both technologies lead to identical product quality and an identical selling price of \$75 per fishing rod.

Required:

- a. What is Sally's breakeven point in units with the labor-intensive technology? What is Sally's breakeven point in units with the capital-intensive technology?
- b. Which technology is preferred if sales are expected to be 40,000 units? Which technology is preferred if sales are expected to be 90,000 units? At what sales level would the two technologies yield identical profit?
- c. On the same graph, draw a profit line for each of the two technologies (*Hint*: Measure profit on the y -axis and quantity in units on the x -axis; allow quantity to range from 0 to 100,000 units in increments of 20,000 units.) Using your graph, intuitively explain your answer to part (b) above.
- d. Suppose Sally believes that there is a 50% chance that sales will equal 40,000 units and a 50% chance that sales will equal 90,000 units. What is Sally's expected profit with the labor-intensive technology? What is Sally's expected profit with the machine-intensive technology? (*Hint*: Expected profit is the average of the profit for the two demand estimates.)
- e. What is the range of profit (using 40,000 and 90,000 as the lowest and highest possible demand estimates) under each technology? Which technology has the greater range in profit? Explain your answer using the profit graph you constructed earlier. What inference do you draw about the variability of profit under the two technologies? (*Hint*: Range is a statistical term for the difference between the highest and lowest values of a distribution.)

5.66 CVP relation and profit planning, taxes, ethics (LO1, LO2, Advanced). Ganesh Bidi manufactures bidis in Andhra Pradesh, India. A bidi is a blended-tobacco product that is hand-wrapped in a tendu (type of plant) leaf, then roasted in charcoal to remove moisture and provide flavor. In India, bidis often are referred to as the "poor person's cigarette."

Ganesh sells his bidis directly to wholesalers for 3.00 Indian Rupees per pack of 20 (1 Indian Rupee = approximately \$0.02). Each pack of bidis costs Ganesh 0.75 Indian Rupees in materials and 0.25 Indian Rupees in labor. Ganesh's fixed costs amount to 1,075,000 Indian Rupees per month.

Required:

- a. Assume Ganesh does not pay any taxes. How many packs of bidis must Ganesh sell to earn a profit of 750,000 Indian Rupees per month?
- b. Assume Ganesh pays income taxes equal to 40% of profit. How many packs of bidis must Ganesh sell to earn a profit after taxes of 750,000 Indian Rupees per month?
- c. In addition to income taxes equal to 40% of profit, assume Ganesh also pays a value-added tax (VAT) of 20% per pack of bidis. The Indian government assesses the 20% value-added tax based on the selling price less the cost of the materials. (A value-added tax is levied on the difference between the price of outputs and the value of materials input.) How many packs of bidis must Ganesh sell to earn a profit of 750,000 Indian Rupees per month?
- d. In addition to income taxes equal to 40% of profit and a value-added tax of 20%, assume the Indian government requires Ganesh to pay an excise tax of 0.05 Indian Rupees per pack of bidis. (An excise tax is a manufacturing tax usually levied as a percentage of manufacturing cost. Sometimes, it is a fixed amount per unit of the product.) How many packs of bidis must Ganesh sell to earn a profit of 750,000 Indian Rupees per month?
- e. Briefly discuss how you modified the standard CVP relation to include income, value-added, and excise taxes. What does each tax vary with? Do you think sales taxes would affect the CVP model?