

Chapter 10

Cost Estimation and Cost-Volume-Profit Relationships



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Learning Objectives

- Understand the significance of cost behavior to decision making and control.
- Identify the interacting elements of cost-volume-profit analysis.
- Explain the break-even formula and its underlying assumptions.
- Calculate the effect on profits of changes in selling prices, variable costs, or fixed costs.
- Calculate operating leverage, determine its effects on changes in profit, and understand how margin of safety relates to operating leverage.
- Find break-even points and volumes that attain desired profit levels when multiple products are sold in combination.
- Obtain cost functions by account analysis and the high-low method.

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Introduction

Managers need to understand cost behavior and cost estimation to be in a better position to plan, make decisions, and control costs. As we discussed in Chapter 9, cost behavior describes the relationship between costs and an activity as the level of activity increases or decreases. Determining cost behavior is important to management's

understanding of overhead costs, marketing costs, and general and administrative expenses, as well as for proper implementation of budgets and budgetary controls. With knowledge of cost behavior, managers can also estimate how costs are affected as future activity levels change, which can lead to better decisions. In addition, knowledge of cost behavior can assist managers in analyzing the interactions among revenues, costs, and volume for profit-planning purposes. These interactions are covered later in this chapter.

10.1 Significance of Cost Behavior to Decision Making and Control

To understand more fully the significance of a manager's analysis of cost behavior, we look at three areas: decision making, planning and control, and trends in fixed costs.

Decision Making

Cost behavior affects the decisions management makes. Variable costs are the incremental or differential costs in most decisions. Fixed costs change only if the specific decision includes a change in the capacity requirement, such as more floor space.

Cost-based pricing requires a good understanding of cost behavior because fixed costs pose conceptual problems when converted to per unit amounts. Fixed costs per unit assume a given volume. If the volume turns out to be different from what was used in determining the cost-based price, the fixed cost component of the total cost yields a misleading price. Managers must know which costs are fixed, as well as anticipated volume, to make good pricing decisions.

Planning and Control

A company plans and controls variable costs differently than it plans and controls fixed costs. Variable costs are planned in terms of input/output relationships. For example, for each unit produced, the materials cost consists of a price per unit of materials times the number of units of materials; the labor cost consists of the labor rate times the number of labor hours. Once operations are underway, levels of activities may change. The input/output relationships identify changes in resources necessary to respond to the change in activity. If activity levels increase, this signals that more resources (materials, labor, or variable overhead) are needed. If activity levels decrease, the resources are not needed, and procedures can be triggered to stop purchases and reassign or lay off workers. In cases where more materials or labor time are used than are necessary in the input/output relationship, inefficiencies and waste are in excess of the levels anticipated, and managers must investigate causes and eliminate or reduce the financial impact of the unfavorable variances.

Fixed costs, on the other hand, are planned on an annual basis, if not longer. Control of fixed costs is exercised at two points in time. The first time is when the decision is made to incur a fixed cost. Management evaluates the necessity of the cost and makes the decision to move forward or reject the proposal. Once fixed costs are incurred, another point of control enters, that being the daily decision of how best to use the capacity provided by the cost. For example, a university makes a decision to build a new classroom and faculty

office building. That decision is the first point of control. After construction, control is implemented in using the building to its maximum capacity. This will occur if classes are scheduled throughout the day and evening.

Another difference in the planning and control of variable and fixed costs is the level at which costs are controllable. Variable costs can be controlled at the lowest supervisory level. Fixed costs are often controllable only at higher managerial levels.

Trends in Fixed Costs

Organizations are finding that an increasing portion of their total costs are fixed costs. The following are a few of the more critical changes taking place.

Implementation of more automated equipment is replacing variable labor costs and a major share of the variable overhead costs. Thus, fixed costs are becoming a more significant part of total costs. Costs associated with the additional automated equipment such as depreciation, taxes, insurance, and fixed maintenance charges are substantially higher. Some industries, like steel and automobile, are becoming essentially fixed cost industries, with variable costs playing a less important role than was once the case.

In most healthcare businesses, automation cannot replace labor, so this is not necessarily a trend throughout healthcare. This trend does impact people working in the pharmaceutical and medical equipment industries. But fixed costs are rising in medical facilities, as medical equipment needed for patient care increases in price. Staffing costs can be more variable, as some facilities do use temporary or contracted staff to have more flexibility in costs.

Another factor that has helped to increase fixed costs significantly in a manufacturing environment is the movement in some industries toward a guaranteed annual wage for production workers. Employees who were once hourly wage earners are now becoming salaried. With the use of more automated equipment, the workers of a company may not represent “touch labor,” that is, work directly on the product. Instead, the production worker may merely observe that the equipment is operating as it should and is properly supplied with materials or may monitor production by means of a television screen. The production line employee is handling more of the functions normally associated with indirect labor, and the cost is a fixed cost.

10.2 Cost-Volume-Profit (CVP) Analysis

The separation of fixed costs from variable costs contributes to an understanding of how revenues, costs, and volume interact to generate profits. With this understanding, managers can perform any number of analyses that fit into a broad category called **cost-volume-profit (CVP) analysis** or, more commonly, **break-even analysis**. Examples of such analyses include finding the:

1. patient volume required to break even;
2. dollars of sales (i.e., fees from procedures performed) needed to achieve a specified profit level;

3. effect on profits if selling prices and variable costs increase or decrease by a specific amount per unit; and
4. increase in selling price needed to cover a projected fixed cost increase.

CVP analysis, as its name implies, examines the interaction of factors that influence the level of profits. Although the name gives the impression that only cost and volume determine profits, several important factors exist that determine whether we have profits or losses and whether profits increase or decrease over time. The key factors appear in the basic CVP equation:

$$\begin{aligned} & (\text{Selling price})(\text{Sales volume}) - (\text{Unit variable cost})(\text{Sales volume}) - \\ & \text{Total fixed cost} = \text{Pretax profit.} \end{aligned}$$

The basic CVP equation is merely a condensed income statement, in equation form, where total variable costs (Unit variable cost \times Sales volume) and total fixed costs are deducted from total sales revenues (Selling price \times Sales volume) to arrive at pretax profit. This equation, as well as other variations that will be discussed later, appears as formula (1) in Figure 10.1.

Figure 10.1: Formulas for CVP analysis

1. Basic CVP equation:	$(p - v)x - FC = PP$
2. CVP equation taxes:	$[(p - v)x - FC](1 - t) = AP$
3. Break-even point in units:	$\frac{FC}{(p - v)}$
4. Break-even point in dollars:	$\frac{FC}{CM\%}$
5. Target pretax profit, in dollars:	$\frac{FC + PP}{p - v}$
6. Target pretax profit, in units:	$\frac{FC + PP}{CM\%}$
7. Target aftertax profit, in units:	$\frac{FC + \frac{AP}{(1 - t)}}{p - v} = \frac{FC + PP}{p - v}$
8. Target aftertax profit, in dollars:	$\frac{FC + \frac{AP}{(1 - t)}}{CM\%} = \frac{FC + PP}{CM\%}$

Where:

FC = Fixed cost dollars

p = Selling price per unit

v = Variable cost per unit

$CM\%$ = Contribution margin ration $(p - v) / p$

AP = Aftertax profit

PP = Pretax profit

t = Income tax rate

x = Sales volume in units

The excess of total sales revenue over total variable cost is called the contribution margin or, more precisely, variable contribution margin. From the basic CVP equation, we see that the contribution margin contributes to covering fixed costs as well as generating net income. The contribution margin, as well as the **contribution margin ratio**, often plays an important role in CVP analysis. The latter measure is the ratio of the contribution margin to total sales revenue (or, equivalently, the ratio of the contribution margin per unit to the selling price).

Before proceeding, several fundamental assumptions are made to strengthen CVP analysis:

1. Relevant range—CVP analysis is limited to the company's relevant range of activity;
2. Cost behavior identification—fixed and variable costs can be identified separately;
3. Linearity—the selling price and variable cost per unit are constant across all sales levels within the company's relevant range of activity;
4. Equality of production and sales—all units are produced and sold and inventory changes are ignored;
5. Activity measure—the primary cost driver is volume of units; and
6. Constant sales mix—the sales of each product in a multiproduct firm are a constant percentage.

Assumptions 1, 2, and 3 are straightforward. Assumption 4 is required because if sales and production are not equal, then some amount of variable and fixed costs are treated as assets (inventories) rather than expenses. As long as inventories remain fairly stable between adjacent time periods, this assumption does not seriously limit the applicability of CVP analysis. Regarding assumption 5, factors other than volume may drive costs, as we have discussed earlier in this chapter, and as we will discuss further in later chapters. Costs that vary with cost drivers other than volume can be added to the fixed-cost component. Assumption 6 is discussed in detail later in this chapter. In many cases, these assumptions are and must be violated in real-world situations, but the basic logic and analysis adds value. While our discussion may appear to presume that CVP analysis is applicable only to companies that sell physical products, these techniques are just as applicable to service organizations.

Basics of CVP Analysis

CVP analysis is often called break-even analysis because of the significance of the **break-even point**, which is the volume where total revenue equals total costs. It indicates how many units of product must be sold or how much revenue is needed to at least cover all costs. All break-even analyses can be approached by using formula (1) and by creating its derivations, as shown in Figure 10.1.

Each unit of product sold is expected to yield revenue in excess of its variable cost and thus contribute to the recovery of fixed costs and provide a profit. The point at which profit is zero indicates that the contribution margin is equal to the fixed costs. Sales volume must increase beyond the break-even point for a company to realize a profit.

Let's look at CVP relationships in the context of Felsen Medical Supplies, a wholesale distributor of healthcare supplies. Assume that price and costs for one of its products, back braces, are as follows:

	Dollars per Unit	Percentage of Selling Price
Selling price	\$ 25	100%
Variable cost	<u>15</u>	<u>60%</u>
Contribution margin	\$ 10	40%
Total fixed cost	<u>\$100,000</u>	

Each product sold contributes \$10 to covering fixed costs and the creation of a profit. Hence, the company must sell 10,000 back braces to break even. The 10,000 back braces sold will result in a total contribution margin of \$100,000, equaling total fixed cost.

The break-even point can be calculated by using the basic CVP equations that appear as formulas (3) and (4) in Figure 10.1. For Felsen Medical Supplies, the break-even point is determined as follows:

$$\begin{aligned}
 \text{Break-even point in units} &= \text{Total fixed cost} / \text{Contribution margin per unit} \\
 &= \$100,000 / \$10 \text{ per unit} \\
 &= 10,000 \text{ units.}
 \end{aligned}$$

A break-even point measured in sales dollars can be computed by directly using formula (4) of Figure 10.1, as follows:

$$\begin{aligned}
 \text{Total fixed cost} / \text{Contribution margin ratio} &= \text{Break-even point in sales dollars} \\
 \$100,000 / 0.40 &= \$250,000.
 \end{aligned}$$

To use this in a service environment, such as a medical clinic, the sales price would be the net fee expected from patient and insurer, the variable costs would be those costs that change as the clinic provides the services, such as medical supplies directly related to the treatment and personnel costs. The fixed costs would be the medical equipment and furnishings needed to provide patient care, as well as some portion of the costs to run the facility, such as utilities, rent, administrative, and so on. Most medical clinics will set a certain overhead cost for this calculation. If you don't have a usable fixed cost for your department, check with your accounting liaison to find out how to determine fixed costs in order to do this calculation.

A Desired Pretax Profit

In business, only breaking even is not satisfactory, but the break-even relationships do serve as a base for profit planning. If we have a target profit level, we can insert that number into the basic CVP equation. This yields the following general formulas, which appear as formulas (5) and (6) in Figure 10.1:

$$\text{(Total fixed cost + Pretax profit)/Contribution margin ratio} = \text{Sales dollars required}$$

$$\text{(Total fixed cost + Pretax profit)/Contribution margin per unit} = \text{Unit sales required.}$$

Continuing with the Felsen Medical Supplies illustration, suppose that Enoch Goodfriend, the president, had set a profit objective of \$200,000 before taxes. The units and revenues required to attain this objective are determined as follows:

$$(\$100,000 + \$200,000)/\$10 = 30,000 \text{ back braces}$$

or

$$(\$100,000 + \$200,000)/0.40 = \$750,000.$$

A Desired Aftertax Profit

The profit objective may be stated as a net income after income taxes. Rather than changing with volume of units, income taxes vary with profits after the break-even point. When income taxes are to be considered, the basic CVP equation is altered using formulas (2), (7), and (8) in Figure 10.1. Formula (7) works as follows:

$$\text{Target aftertax profit in units} = \text{(Fixed costs + (Aftertax profit/(1 - Tax rate)))/Contribution margin per unit.}$$

Formula (8) yields the sales dollars needed to earn the desired aftertax profit.

Suppose Enoch Goodfriend had budgeted a \$105,000 aftertax profit and that the income tax rate was 30%. We use the above general formulas to obtain the following volume and sales:

$$(\$100,000 + (\$105,000/(1 - 0.30)))/\$10 = 25,000 \text{ back braces}$$

or

$$(\$100,000 + (\$105,000/(1 - 0.30)))/0.40 = \$625,000.$$

10.3 Graphical Analysis

Total sales dollars and total costs at different sales volumes can be estimated and plotted on a graph. The information shown on the graph can also be given in conventional reports, but it is often easier to grasp the fundamental facts when they are presented in graphic or pictorial form. Let's look at two common forms of graphical analysis—the break-even chart and the profit-volume graph.

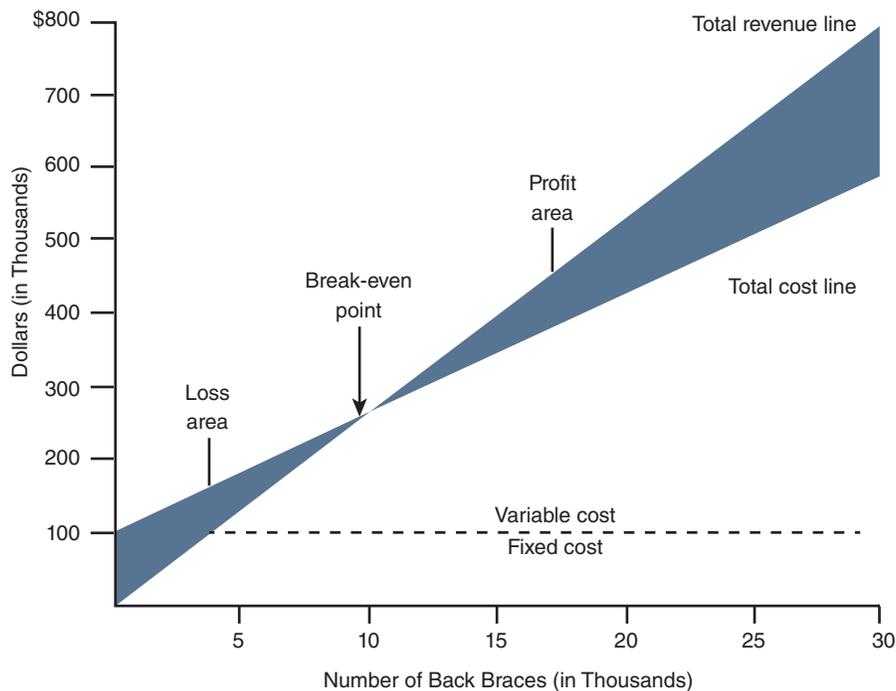
The Break-Even Chart

Dollars are shown on the vertical scale of the **break-even chart**, and the units of product to be sold are shown on the horizontal scale. The total costs are plotted for the various quantities to be sold and are connected by a line. This line is merely a combination of the fixed and variable cost diagrams from Chapter 9. Total sales at various levels are similarly entered on the chart.

The break-even point lies at the intersection of the total revenue and total cost lines. Losses are measured to the left of the break-even point; the amount of the loss at any point is equal to the dollar difference between the total cost line and the total revenue line. Profit is measured to the right of the break-even point and, at any point, is equal to the dollar difference between the total revenue line and the total cost line. This dollar difference equals the contribution margin per unit multiplied by the volume in excess of the break-even point.

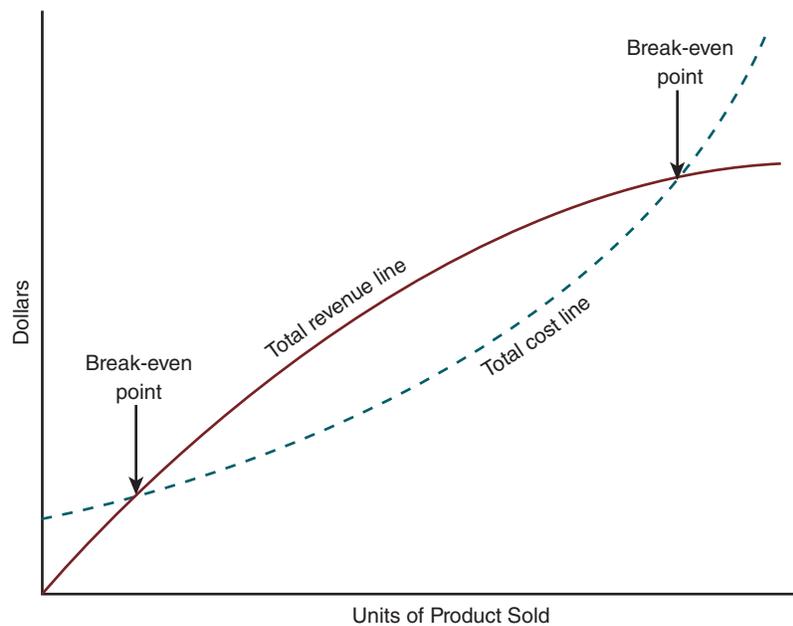
In Figure 10.2, a break-even chart has been prepared for Felsen Medical Supplies using the following data associated with sales levels between 5,000 and 30,000 back braces.

	Number of Back Braces Produced and Sold					
	<u>5,000</u>	<u>10,000</u>	<u>15,000</u>	<u>20,000</u>	<u>25,000</u>	<u>30,000</u>
Total revenue	\$125,000	\$250,000	\$375,000	\$500,000	\$635,000	\$750,000
Cost:						
Variable	75,000	150,000	225,000	300,000	375,000	450,000
Fixed	100,000	100,000	100,000	100,000	100,000	100,000
Total cost	<u>175,000</u>	<u>250,000</u>	<u>325,000</u>	<u>400,000</u>	<u>475,000</u>	<u>550,000</u>
Profit (loss)	<u>\$(50,000)</u>	<u>0</u>	<u>\$ 50,000</u>	<u>\$100,000</u>	<u>\$150,000</u>	<u>\$200,000</u>

Figure 10.2: Break-even chart

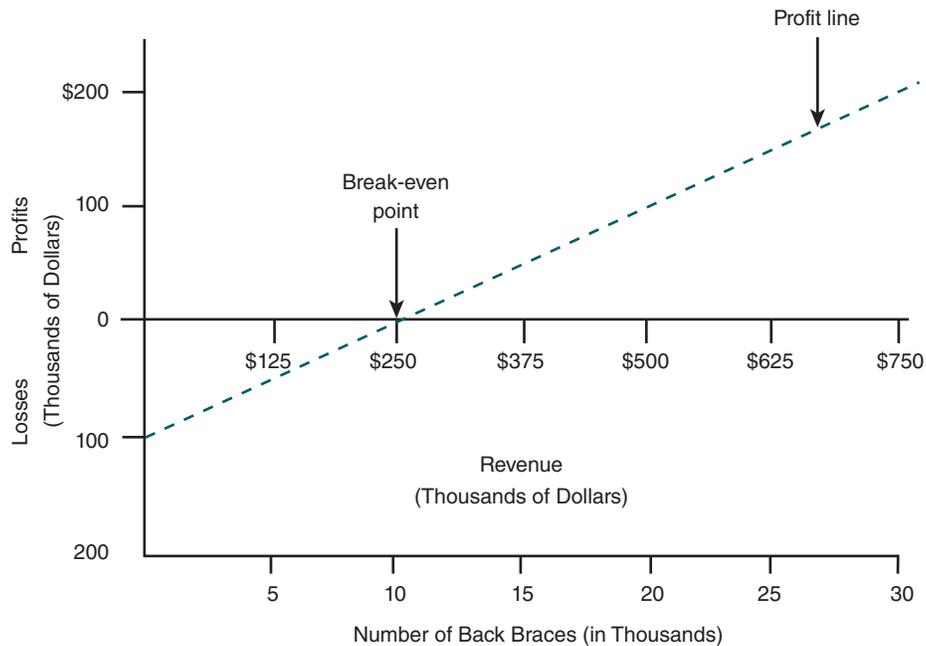
Curvature of Revenue and Cost Lines

In some cases, revenues and costs cannot be represented by straight lines. If more units are to be sold, management may have to reduce selling prices. Under these conditions, the revenue function is a curve instead of a straight line. Costs may also be nonlinear depending on what changes take place as volume increases. The cost curve may rise slowly at the start, then more steeply as volume is expanded. This occurs if the variable cost per unit becomes higher as more units are manufactured. Also, fixed costs might change as volume increases. For example, volume increases might cause a jump in supervision, equipment, and space costs. Therefore, it may be possible to have two break-even points, as shown in Figure 10.3.

Figure 10.3: Break-even chart with two break-even points

The Profit-Volume Graph

A **profit-volume (P/V) graph** is sometimes used in place of, or along with, a break-even chart. Data used in the earlier illustration of a break-even chart in Figure 10.2 have also been used in preparing the P/V graph shown in Figure 10.4. In general, profits and losses appear on the vertical scale; units of product, sales revenue, and/or percentages of capacity appear on the horizontal scale. A horizontal line is drawn on the graph to separate profits from losses. The profit or loss at each of various sales levels is plotted. These points are then connected to form a profit line. The slope of the profit line is the contribution margin per unit if the horizontal line is stated as units of product and is the contribution margin ratio if the horizontal line is stated as sales revenue.

Figure 10.4: Profit-volume graph

The break-even point is the point where the profit line intersects the horizontal line. Dollars of profit are measured on the vertical scale above the line, and dollars of loss are measured below the line. The P/V graph may be preferred to the break-even chart because profit or loss at any point is shown specifically on the vertical scale. However, the P/V graph does not clearly show how cost varies with activity. Break-even charts and P/V graphs are often used together, thus obtaining the advantages of both.

10.4 Analysis of Changes in CVP Variables

Break-even charts and P/V graphs are convenient devices to show how profit is affected by changes in the factors that impact profit. For example, if unit selling price, unit variable cost, and total fixed cost remain constant, how many more units must be sold to realize a greater profit? Or, if the unit variable cost can be reduced, what additional profit can be expected at any given volume of sales? The effects of changes in sales volume, unit variable cost, unit selling price, and total fixed cost are discussed in the following paragraphs. In all these cases, the starting point for analysis is the CVP formulas in Figure 10.1.

Sales Volume

For some companies, substantial profits depend on high sales volume. For example, if each unit of product is sold at a relatively low contribution margin, then high profits are a function of selling in large quantities. This is more significant when the fixed cost is high.

For an illustration, consider a company that handles a product with a selling price of \$1 per unit. Assume a variable cost of \$0.70 per unit and a fixed cost of \$180,000 per year. The contribution margin, therefore, is \$0.30 per unit ($\$1 - \0.70). Before any profit is realized, the company must sell enough units for the total contribution margin to recover the fixed cost. Therefore, 600,000 units must be sold just to break even:

$$\$180,000 \div \$0.30 = 600,000 \text{ units.}$$

For every unit sold in excess of 600,000, a \$0.30 profit before tax is earned. In such a situation, the company must be certain that it can sell substantially more than 600,000 units to earn a reasonable profit on its investment.

When products sell for relatively high contribution margins per unit, the fixed cost is recaptured with the sale of fewer units, and a profit can be made on a relatively low sales volume. Suppose that each unit of product sells for \$1,000 and that the variable cost per unit is \$900. The fixed cost for the year is \$180,000. The contribution margin ratio is only 10%, but this is equal to \$100 from each unit sold. The break-even point will be reached when 1,800 units are sold. The physical quantity handled is much lower than it was in the preceding example, but the same principle applies. More than 1,800 units must be sold if the company is to produce a profit.

A key relationship between changes in volume and pretax profit is the following:

$$\text{Contribution margin per unit} - \text{Change in sales volume} = \text{Change in net income.}$$

This relationship presumes that the contribution margin per unit remains unchanged when the sales volume changes. It also presumes that fixed costs have not been changed. Suppose that Enoch Goodfriend of Felsen Medical Supplies wishes to know how the sale of an additional 500 back braces would impact profits. The above relationship reveals that net income would increase by \$5,000 ($\10 contribution margin per unit \times 500 units).

Variable Costs

The relationship between the selling price of a product and its variable cost is important in any line of business. Even small savings in variable cost can add significantly to profits. A reduction of a fraction of a dollar in the unit cost becomes a contribution to fixed cost and profit. If 50,000 units are sold in a year, a \$0.10 decrease in the unit cost becomes a \$5,000 increase in profit. Conversely, a \$0.10 increase in unit cost decreases profit by \$5,000.

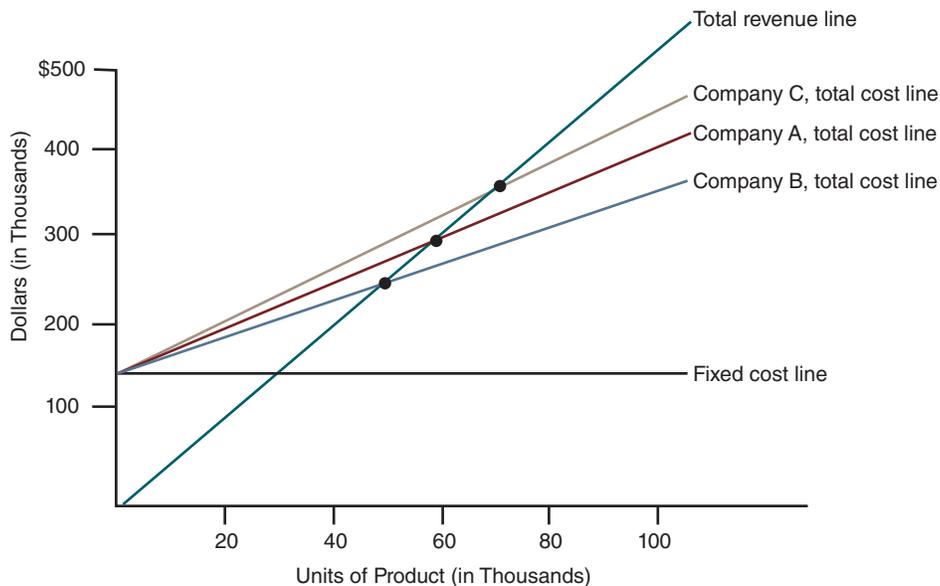
Management is continually searching for opportunities to make even small cost savings. What appears trivial may turn out to be the difference between profit and loss for the year. In manufacturing, it may be possible to save on materials cost by using cheaper materials that are just as satisfactory. Using materials more effectively can also result in savings. Improving methods of production may decrease labor and overhead costs per unit.

A small savings in unit cost can give a company a competitive advantage. If prices must be reduced, the low-cost producer will usually suffer less. At any given price and fixed cost structure, the low-cost producer will become profitable more quickly as sales volume increases.

The following operating results of three companies show how profit is influenced by changes in the variable cost pattern. Each of the three companies sells 100,000 units of one product line at a price of \$5 per unit. Each has an annual fixed cost of \$150,000. Company A can manufacture and sell each unit at a variable cost of \$2.50. Company B has found ways to save costs and can produce each unit for a variable cost of \$2, while Company C has allowed its unit variable cost to rise to \$3.

	Company A	Company B	Company C
Number of units sold	100,000	100,000	100,000
Unit selling price	\$ 5.00	\$ 5.00	\$ 5.00
Unit variable cost	2.50	2.00	3.00
Unit contribution margin	2.50	3.00	2.00
Contribution margin ratio	50%	60%	40%
Total sales revenue	<u>\$500,000</u>	<u>\$500,000</u>	<u>\$500,000</u>
Total variable cost	\$250,000	\$200,000	\$300,000
Total contribution margin	250,000	300,000	200,000
Fixed cost	<u>150,000</u>	<u>150,000</u>	<u>150,000</u>
Income before income tax	<u>\$100,000</u>	<u>\$150,000</u>	<u>\$ 50,000</u>

A difference of \$0.50 in unit variable cost between Company A and Company B or between Company A and Company C adds up to a \$50,000 difference in profit when 100,000 units are sold. The low-cost producer has a \$1 per unit profit advantage over the high-cost producer. If sales volume should fall to 60,000 units per company, Company B would have a profit of \$30,000, Company A would break even, and Company C would suffer a loss of \$30,000. The same results are shown in the break-even chart in Figure 10.5.

Figure 10.5: Effects of variable cost changes

The fixed cost line for each company is drawn at \$150,000, the amount of the fixed cost. When 40,000 units are sold, a difference of \$20,000 occurs between each total cost line. The lines diverge as greater quantities are sold. At the 100,000-unit level, the difference is \$50,000 between each total cost line. Company B can make a profit by selling any quantity in excess of 50,000 units, but Company C must sell 75,000 units to break even. With its present cost structure, Company C will have to sell in greater volume if it is to earn a profit equal to profits earned by Company A or Company B. Company C is the inefficient producer in the group and, as such, operates at a disadvantage. When there is enough business for everyone, Company C will earn a profit, but will most likely earn less than the others. When business conditions are poor, Company C will be more vulnerable to losses.

Price Policy

One of the ways to improve profit is to get more sales volume; to stimulate sales volume, management may decide to reduce prices. Bear in mind, however, that if demand for the product is inelastic or if competitors also reduce prices, volume may not increase at all. Moreover, even if the price reduction results in an increase in sales volume, the increase may not be enough to overcome the handicap of selling at a lower price. This point is often overlooked by optimistic managers who believe that a small increase in volume can compensate for a slight decrease in price.

Price cuts, like increases in unit variable costs, decrease the contribution margin. On a unit basis, price decreases may appear to be insignificant, but when the unit differential is multiplied by thousands of units, the total effect may be tremendous. Many more units may need to be sold to make up for the difference. Company A, for example, hopes to increase profit by stimulating sales volume; to do so, it plans to reduce the unit price by 10%. The following tabulation portrays its present and contemplated situations:

	Present Situation	Contemplated Situation
Selling price	\$5.00	\$4.50
Variable cost	<u>2.50</u>	<u>2.50</u>
Contribution margin	<u>\$2.50</u>	<u>\$ 2.00</u>
Contribution margin ratio	50%	44.4%

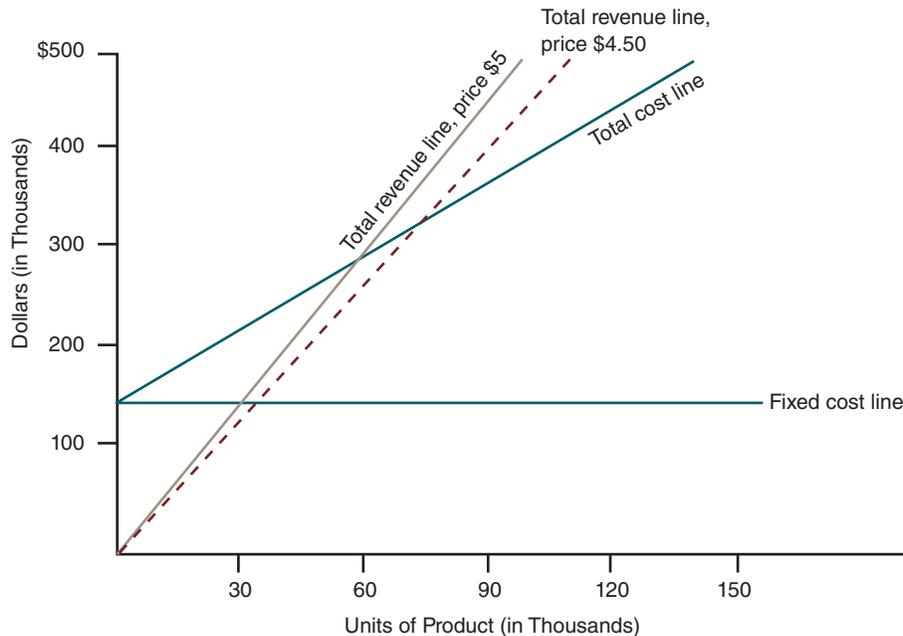
At present, one half of each revenue dollar can be applied to fixed cost and profit. When revenues are twice the fixed cost, Company A will break even. Therefore, 60,000 units yielding revenues of \$300,000 must be sold if fixed cost is \$150,000. But when the price is reduced, less than half of each dollar can be applied to fixed cost and profit. To recover \$150,000 in fixed cost, unit sales must be 75,000 (\$150,000 divided by the \$2 contribution margin per unit). Thus, to overcome the effect of a 10% price cut, unit sales must increase by 25%:

$$(75,000 - 60,000) \div 60,000 = 25\% \text{ increase.}$$

Similarly, revenue must increase to \$337,500 (75,000 units \times \$4.50 per unit). This represents a 12.5% increase, as follows:

$$(\$337,500 - \$300,000) \div \$300,000 = 12.5\% \text{ increase.}$$

Not only must total revenue be higher, but with a lower price, more units must also be sold to obtain that revenue. A break-even chart showing these changes appears in Figure 10.6.

Figure 10.6: Effects of price reduction

The present pretax income of \$100,000 can still be earned if 125,000 units are sold. This is obtained using formula (5) of Figure 10.1:

$$(\$150,000 + \$100,000) \div \$2 = 125,000 \text{ units.}$$

Fixed Costs

A change in fixed cost has no effect on the contribution margin. Increases in fixed cost are recovered when the contribution margin from additional units sold is equal to the increase in fixed cost. Presuming that the contribution margin per unit remains unchanged, the following general relationship holds:

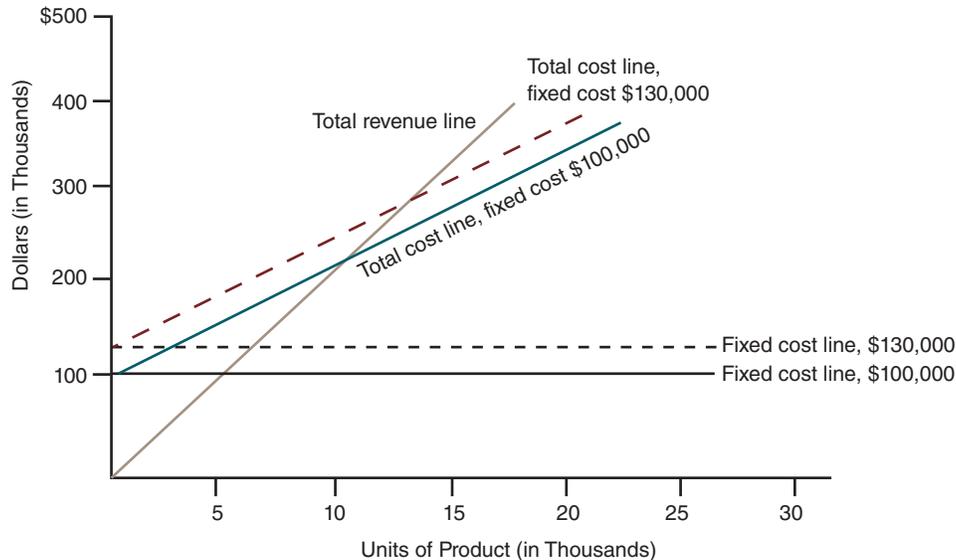
$$(\text{Contribution margin per unit} \times \text{Change in sales volume}) - \text{Change in fixed cost} = \text{Change in net income.}$$

Suppose Enoch Goodfriend estimates that, if he spends an additional \$30,000 on advertising, he should be able to sell an additional 2,500 back braces. The above equation reveals that profits would decrease by \$5,000 or $[(\$10 \times 2,500) - \$30,000]$.

Because fixed cost is not part of the contribution margin computation, the slope of the total cost line on a break-even chart is unaffected by changes in fixed cost. The new total cost line is drawn parallel to the original line, and the vertical distance between the two lines, at any point, is equal to the increase or the decrease in fixed cost.

The break-even chart in Figure 10.7 shows the results of an increase in fixed cost from \$100,000 to \$130,000 at Felsen Medical Supplies. Under the new fixed cost structure, the total cost line shifts upward, and, at any point, the new line is \$30,000 higher than it was originally. To break even or maintain the same profit as before, Felsen Medical Supplies must sell 3,000 more back braces.

Figure 10.7: Effects of an increase in fixed cost



Decreases in fixed cost would cause the total cost line to shift downward. The total contribution margin can decline by the amount of the decrease in fixed cost without affecting profit. The lower sales volume now needed to maintain the same profit can be calculated by dividing the unit contribution margin into the decrease in fixed cost.

Ethical Considerations When Changing CVP Variables

Managers are often under pressure to reduce costs—both variable and fixed costs. Many companies have downsized in recent years by eliminating jobs and even closing plants. Managers must be careful not to cut costs in an unethical manner. Changing a price can also involve ethical issues. For instance, immediately after a hurricane hit southern Florida several years ago, some sellers of building supplies were accused of “price gouging.”

10.5 Measures of Relationship Between Operating Levels and Break-Even Points

Companies want to know where they are with respect to the break-even point. If they are operating around the break-even point, management may be more conservative in its approach to implementing changes and mapping out new strategies. On the other hand, if they are operating well away from the break-even point, management will be

more aggressive because the downside risk is not as great. Two measures that relate to this distance between a break-even point and the current or planned operating volume are operating leverage and margin of safety. These measures are the subject of the following sections.

Operating Leverage

Operating leverage measures the effect that a percentage change in sales revenue has on pretax profit. It is a principle by which management in a high fixed cost industry with a relatively high contribution margin ratio (low variable costs relative to sales revenue) can increase profits substantially with a small increase in sales volume. We typically call this measure the operating leverage factor or the degree of operating leverage, and it is computed as follows:

$$\frac{\text{Contribution margin}}{\text{Net income before taxes}} = \text{Operating leverage factor.}$$

As profit moves closer to zero, the closer the company is to the break-even point. This will yield a high operating leverage factor. As sales volume increases, the contribution margin and pretax profit both increase; consequently, the operating leverage factor becomes progressively smaller. Hence, the operating leverage factor is related to the distance between the break-even point and a current or expected sales volume. With an increase in sales volume, profits will increase by the percentage increase in sales volume multiplied by the operating leverage factor.

Suppose Felsen Medical Supplies is currently selling 15,000 back braces. With its unit contribution margin of \$10 and fixed costs of \$100,000, its operating leverage factor is 3, computed as follows:

$$\frac{(15,000)(10)}{(15,000)(10) - 100,000} = \frac{150,000}{50,000} = 3.$$

At a sales volume of 15,000, if sales volume can be increased by an additional 10%, profit can be increased by 30%:

$$\frac{\text{Percentage increase in sales volume}}{10} \times \frac{\text{Operating leverage factor}}{3} =$$

$$\frac{\text{Percentage increase in pretax profit}}{30\%}.$$

A 10% increase in sales volume will increase sales from 15,000 units to 16,500 units. Operating leverage suggests that the pretax profit should be \$65,000 (\$50,000 × 1.3). Indeed, when we deduct the \$100,000 fixed cost from the new contribution margin of \$165,000 (16,500 × \$10), we obtain a pretax profit of \$65,000.

A company with high fixed costs will have to sell in large volume to recover the fixed costs. However, if the company also has a high contribution margin ratio, it will move into higher profits very quickly after the break-even volume is attained. Hence, a fairly small percentage increase in sales volume (computed on a base that is already fairly large) will increase profits rapidly.

Margin of Safety

The **margin of safety** is the excess of actual (or expected) sales over sales at the break-even point. The excess may also be computed as a percentage of actual (or expected) sales. The margin of safety, expressed either in dollars or as a percentage, shows how much sales volume can be reduced without sustaining losses. The formulas for calculating margin of safety are:

Margin of safety in dollars = Actual (or expected) sales – Break-even sales

Margin of safety in percentage form = $\frac{\text{Margin of safety in dollars}}{\text{Actual (or expected) sales}}$

For our purposes, margin of safety is the percentage form. Therefore, unless otherwise specified, a reference to margin of safety will mean a percentage.

Recall that the break-even sales level for Felsen Medical Supplies was \$250,000. At an actual sales level of 15,000 back braces, its safety margin is one-third, calculated as follows:

$$\frac{(15,000)(\$25) - \$250,000}{(15,000)(\$25)} = \frac{\$125,000}{\$375,000} = 33\% \text{ or } 1/3.$$

Note that one-third is the reciprocal of the operating leverage factor computed earlier for Felsen Medical Supplies. The margin of safety will always be the reciprocal of the operating leverage factor.

10.6 The Sales Mix

When selling more than one product line, the relative proportion of each product line to the total sales is called the **sales mix**. With each product line having a different contribution margin, management will try to maximize the sales of the product lines with higher contribution margins. However, a sales mix results because limits on either sales or production of any given product line may exist.

When products have their own individual production facilities and fixed costs are specifically identified with the product line, cost-volume-profit analysis is performed for each

product line. However, in many cases, product lines share facilities, and the fixed costs relate to many products. For such a situation, cost-volume-profit analysis requires averaging of data by using the sales mix percentages as weights. Consequently, a break-even point can be computed for any assumed mix of sales, and a break-even chart or P/V graph can be constructed for any sales mix.

Let's consider cost-volume-profit analysis with a sales mix. Suppose that Bijan's Discount Eyeglasses offers three eyeglass options: regular, sunglasses, and bifocals. Assume that the following budget is prepared for these three product lines. Fixed costs are budgeted at \$500,000 for the period:

Product Lines	Sales Volume (Units)	Price per Unit	Unit Variable Cost	Contribution Margin	
				Dollars	Ratio
Regular	20,000	\$50	\$20	\$30	60%
Sunglasses	10,000	50	30	20	40%
Bifocals	<u>10,000</u>	50	40	10	20%
Total	<u>40,000</u>				

The break-even point in units is computed using a weighted average contribution margin as follows:

Product Lines	Sales Mix Proportions		Contribution Margin per Unit		Weighted Contribution Margin
Regular	50%	×	\$30	=	\$15.00
Sunglasses	25%	×	20	=	5.00
Bifocals	25%	×	10	=	<u>2.50</u>
Weighted contribution margin					<u>\$22.50</u>

$$\frac{\text{Fixed cost}}{\text{Weighted contribution margin}} = \frac{\$500,000}{\$22.50} = 22,222 \text{ total units.}$$

The detailed composition of this overall break-even point of 22,222 units (and contribution margins at this level) is as follows:

Product Lines	Sales Mix Proportions		Total Units		No. of Units		Margin per Unit		Contribution Margin
Regular	50%	×	22,222	=	11,111	×	\$30	=	\$333,330
Sunglasses	25%	×	22,222	=	5,556	×	20	=	111,120
Bifocals	25%	×	22,222	=	5,556	×	10	=	<u>55,560</u>
Break-even contribution margin*									<u>\$500,010</u>

* Approximately equal to fixed cost of \$500,000. Difference is due to rounding.

To obtain the sales revenue at the break-even point directly, we calculate it as we did earlier in the chapter. Simply divide the weighted contribution margin ratio into the fixed costs. Individual product line revenues will be total revenues multiplied by individual sales mix proportions. Continuing with our illustration, we have:

	Product Lines			
	Regular	Sun-glasses	Bifocals	Total
Units (number of glasses)	<u>20,000</u>	<u>10,000</u>	<u>10,000</u>	<u>40,000</u>
Revenues	\$1,000,000	\$500,000	\$500,000	\$2,000,000
Variable cost	<u>400,000</u>	<u>300,000</u>	<u>400,000</u>	<u>1,100,000</u>
Contribution margin	<u>\$ 600,000</u>	<u>\$200,000</u>	<u>\$100,000</u>	\$ 900,000
Less fixed cost				<u>500,000</u>
Budgeted net income before taxes				<u>\$ 400,000</u>

As shown in the following calculations, the weighted contribution margin ratio is 45%, and revenue at the break-even point is \$1,111,111.

$$\frac{\text{Total contribution margin}}{\text{Total revenues}} = \frac{\$900,000}{\$2,000,000} = 45\%$$

$$\frac{\text{Fixed cost}}{\text{Weighted contribution margin ratio}} = \frac{\$500,000}{45\%} = \$1,111,111$$

Another way to obtain the number of eyeglasses needed to break even is by using an equations approach. Let r represent the number of regular glasses, s represent the number of sunglasses, and b represent the number of bifocals. The following equation is an extension of the basic CVP equation to this scenario with multiple products:

$$\$30r + \$20s + \$10b = \$500,000.$$

Next, we need to write the equation in terms of one variable rather than three by using the information from the sales mix proportions. Since there are half as many sunglasses and bifocals sold, we can rewrite the equation as follows:

$$\$30d + \$20(0.5d) + \$10(0.5d) = \$500,000.$$

Solving this equation, we obtain $d = 11,111$, and therefore, $s = b = 0.5(11,111) = 5,556$. These are the same numbers of eyeglasses we derived earlier.

If the actual sales mix changes from the budgeted sales mix, the break-even point and other factors of cost-volume-profit analysis may change. Suppose that Bijan's Discount Eyeglasses actually operated at the budgeted capacity with fixed costs of \$500,000. The unit selling prices and variable costs were also in agreement with the budget. Yet, with the same volume of 40,000 units and total revenue of \$2,000,000, the pretax profit was considerably lower than anticipated. The difference was due to a changed sales mix. Assume the following actual results:

Product Lines	Sale Volume (Units)	Unit Contribution Margin	Total Contribution Margin	Revenue
Regular	5,000	\$30	\$150,000	\$ 250,000
Sunglasses	20,000	20	400,000	1,000,000
Bifocals	<u>15,000</u>	10	<u>150,000</u>	<u>750,000</u>
Total	<u>40,000</u>		\$700,000	<u>\$2,000,000</u>
Less fixed cost			<u>(500,000)</u>	
Actual net income after taxes			<u>\$200,000</u>	

Instead of earning \$400,000 before taxes, the company earned only \$200,000. Sales of sunglasses and bifocals, the less profitable products, were much better than expected. At the same time, sales of the best product line, regular, were less than expected. As a result, the total contribution margin was less than budgeted, so net income before taxes was also less than budgeted.

One way to encourage the sales force to sell more of the high contribution margin lines is to compute sales commissions on the contribution margin rather than on sales revenue. If sales commissions are based on sales revenue, a sales force may sell a high volume of less profitable product lines and still earn a satisfactory commission. But if sales commissions are related to contribution margin, the sales force is encouraged to strive for greater sales of more profitable products and, in doing so, will help to improve total company profits.

10.7 Cost Estimation

Cost estimation is the process of determining a cost relationship with activity for an individual cost item or grouping of costs. We typically express this relationship as an equation that reflects the cost behavior within the relevant range. In Chapter 9, we referred to this equation as a cost function: $a + b(X)$. The **dependent variable** (Y) of the equation is what we want to predict (i.e., costs, in our case). The **independent variable** (X) (i.e., the activity) is used to predict the dependent variable. The cost function can be written as follows:

$$Y = a + b(X).$$

This equation states that Y , the total cost, is equal to a value a plus a factor of variability applied to the activity level X . The value a represents the fixed cost. The factor b represents the change in Y in relation to the change in X (i.e., the variable cost per unit of activity).

Although a number of techniques exist for estimating a cost-to-activity relationship, we will discuss two techniques: (1) account analysis and (2) high-low method.

Account Analysis

In **account analysis**, accountants estimate variable and fixed cost behaviors of a particular cost by evaluating information from two sources. First, the accountant reviews and interprets managerial policies with respect to the cost. Second, the accountant inspects the historical activity of the cost. All cost accounts are classified as fixed or variable. If a cost shows semivariable or semifixed cost behavior, the analyst either (1) makes a subjective estimate of the variable and fixed portions of the cost or (2) classifies the account according to the preponderant cost behavior. Unit variable costs are estimated by dividing total variable costs by the quantity of the cost driver.

As an example, suppose for cost control purposes the managing partner of Azran & Associates, a medical equipment delivery company, wishes to estimate the drivers' truck expenses as a function of miles driven. Costs for the past quarter, during which 58,000 miles were driven, are classified as follows:

Item	Cost	Classification
Fuel	\$ 3,200	Variable
Depreciation	11,200	Fixed
Insurance	3,900	Fixed
Maintenance	1,800	Variable
Parking	2,100	Fixed

The fixed costs total \$17,200, while the variable cost per mile is 8.62 cents $[(\$3,200 + \$1,800) \div 58,000]$. Hence, the cost function would be expressed as:

$$Y = \$17,200 + \$0.0862 (X).$$

The managing partner believes that costs should be stable for the coming quarter for which the brokers' auto travel budget would be 65,000 miles. Accordingly, the truck expenses should total \$22,803 $[\$17,200 + (\$0.0862 \times 65,000)]$. The managing partner intends to investigate any significant deviation from this total cost.

Account analysis is fairly accurate for determining cost behavior in many cases. Vendor invoices, for instance, show that direct materials have a variable cost behavior; leasing costs are fixed. A telephone bill is a semivariable cost. One portion is fixed for the minimum monthly charge, and the remainder may be variable with usage.

Account analysis has limited data requirements and is simple to implement. The judgment necessary to make the method work comes from experienced managers and accountants who are familiar with the operations and management policies. Because operating results are required for only one period, this method is particularly useful for new products or situations involving rapid changes in products or technologies.

The two primary disadvantages of this method are its lack of a range of observations and its subjectivity. Using judgment generates two potential issues: (1) Different analysts may develop different cost estimates from the same data, and (2) the results of analysis may have significant financial consequences for the analyst; therefore, the analyst will likely show self-serving estimates. Another potential weakness in the method is that data used in the analysis may reflect unusual circumstances or inefficient operations, as is likely to occur with new products. These factors then become incorporated in the subsequent cost estimates. This method is also dependent on the quality of the detailed chart of accounts and transaction coding.

High-Low Method

Another method for obtaining rough approximations to fixed and variable costs is the **high-low method**. The first step is to list the observed costs for various levels of activity from the highest level in the range to the lowest. This method chooses observations associated with the highest and the lowest activity levels, not the highest and lowest costs. The second step is to divide the difference in activity between the highest and the lowest levels into the difference in cost for the corresponding activity levels in order to arrive at the variable cost rate. As an example, suppose a manager for Edlin's Home Nurse Services wishes to estimate supplies costs as input for bidding on jobs. Its costs of supplies for several recent jobs, along with the hours of activity, are as follows:

	Hours of Activity	Supplies Cost
High	95	\$397
	90	377
	87	365
	82	345
	78	329
	75	317
	66	281
	58	239
Low	50	217

The difference in hours is 45 (95 – 50), and the difference in cost is \$180 (\$397 – \$217). The variable supplies cost per hour is computed below:

$$\frac{\text{Cost at highest activity} - \text{Cost at lowest activity}}{\text{Highest activity} - \text{Lowest activity}} = \frac{\$180}{45} =$$

\$4 Variable cost per hour.

The fixed cost is estimated by using the total cost at either the highest or lowest level and subtracting the estimated total variable cost for that level:

$$\begin{aligned} \text{Total fixed cost} &= \\ \text{Total cost at highest activity} &- (\text{Variable cost per unit} \times \text{Highest activity}) \end{aligned}$$

or

$$\begin{aligned} \text{Total fixed cost} &= \\ \text{Total cost at lowest activity} &- (\text{Variable cost per unit} \times \text{Lowest activity}). \end{aligned}$$

If the variable cost is calculated correctly, the fixed cost will be the same at both the high and low points. For the above illustration, the calculation of total fixed cost is as follows:

$$\begin{aligned} \text{Total fixed cost} &= \$397 - (\$4 \text{ Variable cost per hour} \times 95 \text{ hours}) \\ &= \$397 - \$380 \\ &= \$17 \end{aligned}$$

or

$$\begin{aligned} \text{Total fixed cost} &= \$217 - (\$4 \text{ Variable cost per hour} \times 50 \text{ hours}) \\ &= \$217 - \$200 \\ &= \$17. \end{aligned}$$

The cost function that results from the high-low method is:

$$Y = \$17 + \$4(X).$$

If Edlin's manager forecasts that a particular job would require 75 hours, then the bid would include an estimate of \$317 for supplies cost.

Occasionally, either the highest or lowest activity or the cost associated with one of those points is obviously an outlier to the remaining data. When this happens, use the next highest or lowest observation that appears to align better with the data. Sometimes only two data points are available, so, in effect, these are used as the high and low points.

The high-low method is simple and can be used in a multitude of situations. Its primary disadvantage is that two points from all of the observations will only produce reliable estimates of fixed and variable cost behavior if the extreme points are representative of the points in between. Otherwise, distorted results may occur.

If enough quality data are available, statistical techniques can provide more objective cost estimates than we have discussed thus far.

Ethical Considerations in Estimating Costs

All cost estimation methods involve some degree of subjectivity. With account analysis, managers judgmentally classify costs. With the high-low method, one must decide whether the high and low points are representative data points.

The subjectivity inherent in cost estimation can lead to biased cost estimates. Indeed, in certain instances, incentives exist for managers to bias cost estimates. In developing budgets or cost-based prices, managers may want to overestimate costs. In developing proposals for projects or programs, incentives may exist to underestimate costs. Managers must take care not to use subjectivity as an opportunity to act unethically.

Other Issues for Cost Estimation

An overriding concern with any cost estimation technique is that of extrapolating beyond the relevant range of activity. Cost behavior may change drastically once the activity falls below or rises above the relevant range. For instance, assume the relevant range of activity for Edlin's Home Nurse Services is 40 to 100 hours. We wish to predict the supplies cost for the coming time period, during which 130 hours of activity are expected. Since this level is above the relevant range, the cost function we derived earlier may not be appropriate to use.

We have presumed that our cost data are suitably represented by a straight line (linear) and not by a curve. In some situations, the linear relationship may not be appropriate. Costs, for example, may not increase at a constant rate but instead may change at an increasing or a decreasing rate as the measure of activity increases. Hence, the cost data would be represented by a curve rather than a straight line. The shape of the line or curve can be revealed by plotting a sufficient amount of data for various volumes of activity.

Case Study: Mendel Medical Supplies Company

Mendel Medical Supplies Company produces four basic medical disposable paper product lines at one of its plants: headrest paper sheets, headrest paper rolls, exam table rolls, and face cradle covers. Materials and operations vary according to the line of product. The market has been relatively good. The demand for its products has been growing steadily, and, with the implementation of the Affordable Healthcare Act, demand could increase dramatically.

The plant superintendent, Marlene Herbert, while pleased with the prospects for increased sales, is concerned about costs:

“Our big problem now is the high fixed cost of production. As we have automated our operation, we have experienced increases in fixed overhead and even variable overhead. And, we will have to add more equipment since it appears that we need even more plant capacity. We are operating over our normal capacity as it is.

“The headrest paper sheets market concerns me. We may have to discontinue that market. Our specialty printing is driving up the variable overhead to the point where we may not find it profitable to continue with that line at all.”

Cost and price data for the next fiscal quarter are as follows:

	Exam Table Rolls	Headrest Paper Rolls	Headrest Paper Sheets	Face Cradle Covers
Estimated sales volume in units	30,000	120,000	45,000	80,000
Selling prices	\$14.00	\$7.00	\$12.00	\$8.50
Materials costs	\$ 6.00	\$4.50	\$ 3.60	\$2.50

Variable overhead includes the cost of hourly labor and the variable cost of equipment operation. The fixed plant overhead is estimated at \$420,000 for the quarter. Direct labor, to a large extent, is salaried; the cost is included as a part of fixed plant overhead. The superintendent’s concern about the eventual need for more capacity is based on increases in production that may reach and exceed the practical capacity of 60,000 machine hours.

In addition to the fixed plant overhead, the plant incurs fixed selling and administrative expenses per quarter of \$118,000.

“I share your concern about increasing fixed costs,” the supervisor of plant operations replies. “We are still operating with about the same number of people we had when we didn’t have this sophisticated equipment. In reviewing our needs and costs, it appears to me that we could cut fixed plant overhead to \$378,000 a quarter without doing any violence to our operation. This would be a big help.”

(continued)

Case Study: Mendel Medical Supplies Company (*continued*)

"You may be right," Herbert responds. "We forget that we have more productive power than we once had, and we may as well take advantage of it. Suppose we get some hard figures that show where the cost reductions will be made."

Data with respect to production per machine hour and the variable cost per hour of producing each of the products are given as follows:

	Exam Table Rolls	Headrest Paper Rolls	Headrest Paper Sheets	Face Cradle Covers
Units per hour	6	10	5	4
Variable overhead per hour	\$9.00	\$6.00	\$12.00	\$8.00

"I hate to spoil things," the vice president of purchasing announces. "But the cost of our materials for exam table rolls is now up to \$7. Just got a call about that this morning. Also, headrest paper sheet materials will be up to \$4 a unit."

"On the bright side," the vice president of sales reports, "we have firm orders for 35,000 rolls of exam table sheets, not 30,000 as we originally figured."

Case Study Exercises

- From all original estimates given, prepare estimated contribution margins by product line for the next fiscal quarter. Also, show the contribution margins per unit.
- Prepare contribution margins as in part (1) with all revisions included.
- For the original estimates, compute each of the following:
 - break-even point for the given sales mix.
 - margin of safety for the estimated sales volume.
- For the revised estimates, compute each of the following:
 - break-even point for the given sales mix.
 - margin of safety for the estimated sales volume.
- Comment on Herbert's concern about the variable cost of the headrest paper sheets.

Key Terms

account analysis A method of estimating fixed and variable costs by classifying accounts into one of these two categories.

break-even analysis An approach that examines the interaction of factors that influence the level of profits.

break-even chart A graph showing cost and revenue functions together with a break-even point.

break-even point The point where total revenues equal total costs.

contribution margin ratio Contribution margin divided by sales revenues.

cost estimation Determining expected or predicted costs.

cost-volume-profit analysis An approach that examines the interaction of factors that influence the level of profits.

dependent variable The item one is attempting to estimate or predict from one or more other variables.

high-low method An approach for estimating costs that uses only two data points.

independent variable The item that is being used to predict or estimate another item.

margin of safety The difference between sales revenue and the break-even point.

operating leverage Using fixed costs to obtain higher percentage changes in profits as sales change.

profit-volume (P/V) graph A break-even chart that uses profits for the vertical axis.

sales mix A combination of sales proportions from the various products.

Review Questions

The following questions relate to several issues raised in the chapter. Test your knowledge of these issues by selecting the best answer. (The odd-numbered answers appear in the answer appendix.)

1. Identify the interrelated factors that are important to profit planning.
2. If the total fixed cost and the contribution margin per unit of product are given, explain how to compute the number of units that must be sold to break even.
3. If the total fixed cost and the percentage of the contribution margin to sales revenue are given, explain how to compute the sales revenue at the break-even point.
4. Can two break-even points exist? If so, describe how the revenue and cost lines would be drawn on the break-even chart.
5. Is it possible to compute the number of units that must be sold to earn a certain profit after income tax? Explain.
6. What does the slope of the P/V graph represent?
7. Define "margin of safety." How is a margin of safety related to operating leverage?
8. Why is cost estimation so important?
9. Describe the two major steps involved in the account analysis method of cost estimation.

10. Describe the steps for preparing an estimate of fixed and variable costs using the scattergraph and visual fit method.
11. Describe the high-low method of cost estimation.

Exercises

1. **Break-even point and changes in fixed costs.** Spira Medical Supplies sells a set of grab bars for bathrooms for \$50. The variable costs are 60% of revenue. The fixed costs amounted to \$120,000 per year. Last year, the store sold 7,500 of these grab bars. During the current year, Spira plans to sell 8,700 sets of grab bars, and fixed costs will increase by \$36,000.
 - a. What was the break-even point last year?
 - b. This year, the break-even point will increase by how many grab bars?

2. **Break-even analysis and cost changes.** At Houston Medical Supplies, the following costs are known for 10,000 units:

Selling price	\$13 per unit
Variable costs	5 per unit
Fixed costs	6 per unit

The operations manager, Wendy Solon, is thinking of buying new equipment to automate certain operations. The new equipment will add \$20,000 to fixed costs and cut variable costs by \$2 per unit.

- a. What is the current break-even point in units?
 - b. By what number of units will the break-even point change, and in what direction? Why would you or would you not advise the manager to add this new equipment?
3. **Changes to break-even variables.** Brasch Eyeglass Company sees its profit picture changing. Variable cost will increase from \$4 per unit to \$4.50. Competitive pressures will allow prices to increase only by \$0.30 per unit to \$8. Fixed costs (\$200,000) and sales volume (60,000 units) likely will remain constant.
 - a. What will likely happen to the break-even point?
 - b. To maintain the same profit level, fixed costs will have to change to what amount?
 - c. To maintain the same profit level, volume will have to change to what amount?
4. **Break-even point and variable cost increase.** Lydia Perl, the owner of Schloss Medical Supplies in Frankfurt, Germany, is concerned about increased costs to purchase a hardware item that is sold by the company through one of its retail outlets. This year the variable cost per unit of product was €28. Next year, the

- variable cost is expected to increase to €32 per unit. The selling price per unit, however, cannot be increased and will remain at €39 per unit. The fixed costs amount to €90,000.
- What was the break-even point in units of product this year?
 - What was the break-even point in revenues for this year?
 - How many units of product must be sold next year to break even?
 - How much revenue will generate break-even volume for next year?
5. **Effects of changes in volume and costs.** Marnie's Discount Eyeglasses sells glasses that have a contribution margin ratio of 35% of \$440,000 annual sales (40,000 units). Annual fixed expenses are \$95,000.
- Calculate the change in net income if sales were to increase by 850 units.
 - The store manager, Laura Romain, believes that if the advertising budget were increased by \$18,000, annual sales would increase by \$75,000. Calculate the additional net income (or loss) if the advertising budget is increased.
 - Laura Romain believes that the present selling price should be cut by 15% and the advertising budget should be raised by \$12,000. She predicts that these changes would boost unit sales by 30%. Calculate the predicted additional net income (or loss) if these changes are implemented.
6. **Break-even point and profits.** Sheila Hershey has noticed that a demand for basic wheelchairs is increasing. Medical supply outlets are charging from \$400 to \$600 for a wheelchair. Sheila believes that she can manufacture and sell a dependable wheelchair that will serve the purpose for \$210. The cost per wheelchair of materials, labor, and variable overhead is estimated at \$110. The fixed costs consisting of rent, insurance, taxes, and depreciation are estimated at \$25,000 for the year. She already has orders for 180 wheelchairs and has established contacts that should result in the sale of 150 additional wheelchairs.
- How many wheelchairs must Sheila make and sell to break even?
 - How much profit can be made from the expected production and sale of 330 wheelchairs?
 - How many wheelchairs are needed for a profit objective of \$11,000?
7. **Target profit and taxes.** Fizon, Inc. had the following results for October:

	Fixed	Variable	Total
Sales (\$200 per unit)			\$600,000
Cost of sales	\$180,000	\$360,000	<u>(540,000)</u>
Net income before taxes	\$ 60,000	Taxes (40%)	<u>\$ 24,000</u>
Net income after taxes			<u>\$ 36,000</u>

- For net income to be \$60,000 after taxes in November, what will Fizon's sales in units need to be?

8. **Multiple product analysis.** The Lane Division of Stefan Medical Products, Inc. manufactures and sells two grades of grab bars. The contribution margin per bar of Lite-Weight aluminum is \$25, and the contribution margin per roll of Heavy-Duty stainless steel is \$75. Last year, this division manufactured and sold the same amount of each grade of grab bar. The fixed costs were \$675,000, and the profit before income taxes was \$540,000.

During the current year, 14,000 rolls of Lite-Weight grab bars were sold, and 6,000 rolls of Heavy-Duty grab bars were sold. The contribution margin per roll for each line remained the same; in addition, the fixed cost remained the same.

- How many bars of each grade of grab bar were sold last year?
 - Assuming the same sales mix experienced in the current year, compute the number of units of each grade of grab bar that should have been sold during the current year to earn the \$540,000 profit that was earned last year.
9. **Cost segregation by high-low method.** Betty Grus provides nursing services in her area. She uses a motor home for transportation and lodging. She recognizes that travel costs with the motor home are relatively high and would like to estimate costs so that she can decide how far she can travel and still operate at a profit. Records from one round trip of 150 miles show that the total cost was \$320. On another round trip of 340 miles, the total cost was \$472. A local round trip of 50 miles cost \$240. She is convinced that the time and cost for trips of more than 300 miles are too high unless the sales potential is very high.
- Calculate the variable cost per mile and the fixed cost per trip by the high-low method.

Problems

1. **Costs estimations and break-even points.** Rodbell Outpatient Surgery Center removes gallstones at the price of \$30,000. In 2013, the company performed 145 surgeries at an average price of \$30,000 per surgery. Variable costs were \$18,000 per surgery, and total fixed costs were \$1,200,000.

In 2014, fixed costs are expected to increase to \$1,350,000, while variable costs should decline to \$16,000 per surgery due to a new source of materials and supplies. The company forecasts a 20% increase in number of surgeries for 2014; however, the average price charged to customers is not planned to change.

The 2015 forecast is for 20 more surgeries than in 2014, and fixed costs are expected to jump by \$240,000 more than in 2014. The average price and variable cost is not expected to change from 2014.

Instructions

- For 2013, calculate the number of surgeries needed to break even.
- For 2014, calculate the operating leverage factor.
- Determine the expected amount of profit change from 2014 to 2015.

2. **CVP with changes in prices and costs.** Data with respect to a basic product line sold by Carson Medical Supply Stores are as follows:

Selling price per unit	\$50
Cost per unit	<u>30</u>
Contribution margin per unit	<u>\$20</u>

The fixed costs for the year are \$360,000. The income tax rate is 40%.

Instructions

- Determine the number of units that must be sold in order to break even.
 - If a profit before income taxes of \$270,000 is to be earned, how many units of product must be sold?
 - If a profit after income taxes of \$180,000 is to be earned, how many units of product must be sold?
 - If the selling price per unit is reduced by 10%, how many units must be sold to earn a profit of \$8 per unit before income taxes?
 - Assume that the selling price remains at \$50. How many units must be sold to earn a profit of \$8 per unit before income taxes if the variable cost per unit increases by 10%?
 - Why does a 10% decrease in the selling price have more effect on the contribution margin than a 10% increase in the variable unit cost?
3. **Break-even comparisons.** Dan and Elaine Miller, owners of Senior Day Care want to know potential maximum profits and the break-even occupancy for the operation. Senior Day Care is a low-cost operation to attract families who need help with elderly relatives on low budgets. A study of costs shows a difference between summer and winter operations. Swimming pool maintenance adds to summer costs while utilities (heat and light) add to winter costs. Variable costs have been determined on the basis of cost per patient per day and are as follows:

	Cost per Room
Laundry	\$1.90
Heat and light (summer)	1.10
Heat and light (winter)	2.20
Repairs	0.75
Supplies	1.60
Taxes and insurance	3.60
Maintenance	1.50
Pool maintenance (summer only)	0.60

Fixed costs per month have been estimated as follows:

Staffing	\$14,000
Management	17,000
Desk service	2,700
Repairs and maintenance	1,600
Taxes	1,430
Insurance	1,120
Heat and light	1,000
Depreciation— building	26,000
Depreciation— furnishings	12,500
Pool maintenance and personnel (summer only)	1,800

Senior Day Care can handle 300 patients and charges \$40 per room per day. Summer is relatively short and is defined as June, July, and August. All other months are designated as winter months. A month consists of 30 days for making calculations. Maximum capacity for a month would be 9,000 patient days (300 patients \times 30 days).

Instructions

- a. Compare the maximum operating net incomes that can be expected for a summer month versus a winter month.
 - b. How do the break-even points (in terms of room days) compare for summer versus winter? Also, state the break-even points as percentages of total capacity.
 - c. Based on signed contracts with ongoing patients and normal expectations, Senior Day Care plans for 5,000 patient days in August. Determine the estimated operating income for August. Also, determine the percentage of capacity expected for August.
4. **CVP with a sales mix.** Sharon Medical Supplies Show rents four types of booths to exhibitors, providing them with space, tables, chairs, and some pre-festival publicity. Stan Harris, the show organizer, has indicated that the booth rental fee is three times the amount of variable costs associated with the particular type of booth. Harris expects that the show will incur fixed costs of \$9,200. The number of booths expected to be rented this year, as well as the related variable costs, are:

Booth Size	Variable Cost per Booth	Number of Booths
8' × 10'	\$25	15
10' × 12'	28	10
10' × 15'	30	20
15' × 15'	35	5

Instructions

- a. Assuming that booths are rented according to the expected mix, determine the number of each type of booth that needs to be rented for the festival to break even.
5. **Account analysis.** The following is a partial list of account titles appearing in the chart of accounts for Lee Caplan Medical Equipment:
- a. Direct Materials
 - b. Supervisory Salaries—Factory
 - c. Heat, Light, and Power—Factory
 - d. Depreciation on the Building
 - e. Depreciation on Equipment and Machinery (units-of-production method)
 - f. Janitorial Labor
 - g. Repair and Maintenance Supplies
 - h. Pension Costs (as a percentage of employee wages and salaries)
 - i. FICA Tax Expense (employer's share)
 - j. Insurance on Property
 - k. Sales Commission
 - l. Travel Expenses—Sales
 - m. Telephone Expenses—General and Administrative
 - n. Magazine Advertising
 - o. Bad Debt Expense
 - p. Photocopying Expense
 - q. Audit Fees
 - r. Dues and Subscriptions
 - s. Depreciation on Furniture and Fixtures (double-declining-balance method)
 - t. Group Medical and Dental Insurance Expense

Instructions

- a. Discuss each account title in terms of whether the account represents a variable, fixed, or semivariable cost.
- b. For accounts designated as variable or semivariable, indicate the most likely cost driver with which the cost varies.
- c. Explain the problems associated with using the account analysis approach to establish cost behavior patterns.

6. **High-low method.** Kathleen Otwell, a medical insurance claims adjuster for Shoenfield Casualty Company, notes that the cost to process a claim has both fixed and variable components. She believes that she can estimate costs more accurately if she can separate the costs into their variable and fixed components. The monthly record of the number of claims and the costs for the past year is as follows:

Month	Number of Claims	Cost
January	120	\$20,600
February	134	20,670
March	142	20,710
April	156	20,780
May	160	20,800

Month	Number of Claims	Cost
June	220	21,100
July	250	21,250
August	330	21,650
September	114	20,570
October	280	21,400
November	274	21,370
December	230	21,150

Instructions

- a. Estimate the variable costs per claim and the fixed costs per month by the high-low method.

