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Learning Material for VM New Challenges for Management Accounting.

Chapter 3: Cost-Volume-Profit Analysis (CVP)

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Chapter 3: Cost-Volume-Profit Analysis (CVP)

Learning objectives

1. Explain the features of cost-volume-profit (CVP) analysis
2. Determine the breakeven point and output level needed to achieve a target operating income
3. Understand how income taxes affect CVP analysis
4. Explain how managers use CVP analysis in decision making
5. Explain how sensitivity analysis helps managers cope with uncertainty
6. Use CVP analysis to plan variable and fixed costs
7. Apply CVP analysis to a company producing multiple products, in service and not-for-profit organizations
8. Distinguish contribution margin from gross margin



Key words

break-even point, contribution margin, cost-volume-profit analysis, gross margin, margin of safety, operating leverage, sensitivity analysis, total cost, total revenue



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3.1 Cost–Volume–Profit (CVP) Analysis



Cost-volume-profit (CVP) analysis examines how total revenues, total costs, and operating income change with changes in units sold, selling price, variable cost per unit, or fixed costs.

CVP analysis is among the most basic tools available to managers. Managers commonly use CVP as a tool to help them answer such questions as: *How will revenues and costs be affected if we sell 1000 more units? If we raise or lower our selling prices, how will that affect the output level? If we expand into Far East markets, what will be the impact on costs?* These questions have a ‘what-if’ theme.

3.2 Terminology for CVP Analysis

Revenues are inflows of assets received in exchange for products or services provided to customers.

A **revenue driver** is a factor that affects revenues. Examples of revenue drivers are units of output sold, selling prices and levels of marketing costs.

Costs are resources sacrificed or forgone to achieve a specific objective.

A **cost driver** is any factor that affects cost – that is, a change in the cost driver will cause a change in the total cost of a related cost object. Examples of cost drivers include units of output manufactured, number of sales visits made and number of packages shipped.

The most detailed way of predicting total revenues and total costs is to consider multiple revenue drivers and multiple cost drivers. We call this the general case. It can require extensive analysis and is likely to be very time-consuming. In this material, we focus on a special case where we assume **a single revenue driver and a single cost driver**.¹

Total costs (also termed **total expenses**) are made up of only two categories: variable costs (variable with respect to units of output) and fixed costs.

$$\text{Total costs} = \text{Variable costs} + \text{Fixed costs}$$

Variable costs include both direct variable costs and indirect variable costs of a chosen cost object. Similarly, **fixed costs** include both direct fixed costs and indirect fixed costs of a chosen cost object.

¹ That single driver is units of output (either output units sold or output units manufactured). The term CVP analysis is widely used as representing this special case. A single revenue driver and a single cost driver are used in this analysis.

Operating profit is total revenues from operations minus total costs from operations (excluding income taxes):

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

Net profit is operating profit plus non-operating revenues (such as interest revenue) minus non-operating costs (such as interest cost) minus income taxes. For simplicity, throughout this chapter non-operating revenues and non-operating costs are assumed to be zero. Thus, net profit will be calculated as follows:

$$\text{Net profit} = \text{Operating profit} - \text{Income taxes}$$

Contribution margin is the difference between total revenues and total variable costs. It indicates why operating income changes as the number of units sold changes.

$$\text{Contribution margin per unit} = \text{Selling price per unit} - \text{Variable cost per unit}$$

Contribution margin per unit is the difference between the selling price and the variable cost per unit; that is, contribution margin per unit is the change in operating income for each additional unit sold.

A contribution income statement is an income statement that groups costs into their variable and fixed components. Variable costs are subtracted from revenues to determine contribution margin. Fixed costs are subtracted from contribution margin to arrive at operating income. Indicate that the change in contribution margin exactly equals the change in operating income. This is because the total fixed cost remains constant for all activity levels.

	A	B	C	D	E	F	G	H
1				Number of Packages Sold				
2				0	1	5	25	40
3	Revenues	\$ 200	per package	\$ 0	\$ 200	\$ 1,000	\$5,000	\$8,000
4	Variable costs	\$ 120	per package	0	120	600	3,000	4,800
5	Contribution margin	\$ 80	per package	0	80	400	2,000	3,200
6	Fixed costs	\$2,000		2,000	2,000	2,000	2,000	2,000
7	Operating income			\$(2,000)	\$(1,920)	\$(1,600)	\$ 0	\$1,200

Figure 3.1 Example of a Contribution Income Statement

Source: DATAR, S. M., RAJAN, M. V. Managerial Accounting, Making Decisions and Motivating Performance

The contribution margin percentage or ratio equals contribution margin per unit divided by the selling price. This indicates the percent of each sales dollar that is available to pay fixed costs and return a profit. It is a useful tool to calculate the effect of a change in revenues on operating income.

$$\text{Contribution margin percentage} = \text{Contribution margin} / \text{Revenues}$$

3.3 CVP assumptions

The CVP analysis is based on the following assumptions:

1. Total costs can be divided into a fixed component and a component that is variable with respect to the level of output.
2. The behaviour of total revenues and total costs is linear (straight line) in relation to output units within the relevant range.
3. The unit selling price, unit variable costs and fixed costs are known and are constant.
4. The analysis either covers a single product or assumes that the proportion of different products when multiple products are sold will remain constant as the level of total units sold changes.
5. All revenues and costs can be added and compared without taking into account the time value of money.
6. Changes in the level of revenues and costs arise only because of changes in the number of products (or service) units produced and sold. The number of output units is the only revenue and cost driver.

These CVP assumptions simplify organisational realities. Some managers may prefer a more sophisticated approach. Nevertheless, CVP provides a useful basis for exploring certain business decision situations in which cost–volume–profit relationships are highlighted.

3.4 The Breakeven Point

There are three related methods to think more deeply about and model CVP relationships:

1. **The equation method**
2. **The contribution margin method**
3. **The graph method**

The equation method and the contribution margin method are most useful when managers want to determine operating income at few specific levels of sales. The graph method helps managers visualize the relationship between units sold and operating income over a wide range of quantities of units sold.

1. The equation method

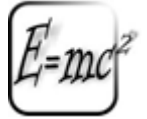
The equation method is based on the following formula (on the operating income equation):

$$\text{Operating income} = \text{Revenues} - \text{Variable costs} - \text{Fixed costs}$$

This equation can be further expanded as:

$$\text{Operating income} = [(\text{Selling price} \times \text{Quantity of units sold}) - (\text{Variable per unit} \times \text{Quantity of units sold})] - \text{Fixed costs}$$

Example 3.1: Calculation of the break-even point by the equation method



Mary Frost plans to sell Do-All Software, a software package, at a heavily attended two-day computer convention. Mary can purchase this software from a computer software wholesaler at €120 per package with the privilege of returning all unsold units and receiving a full €120 rebate per package. The units (packages) will be sold at €200 each. Mary has already paid €2000 to Computer Conventions Ltd for the booth rental for the two-day convention. What quantity of units will she need to sell in order to break even? Assume there are no other costs

Solution:

Setting operating profit equal to zero in the preceding equation, we obtain:

$$€200Q - €120Q - €2000 = €0$$

$$€80Q = €2000$$

$$Q = €2000 / €80 = 25 \text{ units}$$

If Mary sells fewer than 25 units, she will have a loss; if she sells 25 units, she will break even; and if she sells more than **25 units**, she will make a profit. This breakeven point is expressed in units.

It can also be expressed in sales euros: 25 units * €200 selling price = **€5000**.

2. The contribution margin method

This method uses the contribution margin to calculate the operating income at a given level. The equation is simply an algebraic manipulation of the *equation method formula*:

$$\left[\left(\frac{\text{Selling price} - \text{Variable cost}}{\text{per unit}} \right) \times \left(\frac{\text{Quantity of}}{\text{units sold}} \right) \right] - \frac{\text{Fixed}}{\text{costs}} = \frac{\text{Operating}}{\text{income}}$$

$$\left(\frac{\text{Contribution margin}}{\text{per unit}} \times \frac{\text{Quantity of}}{\text{units sold}} \right) - \frac{\text{Fixed}}{\text{costs}} = \frac{\text{Operating}}{\text{income}}, \text{ so:}$$

$$(\text{Contribution margin per unit} \times \text{Quantity of units sold}) - \text{Fixed costs} = \text{Operating income}$$

Contribution margin is equal to revenues minus all costs of the output (a product or service) that vary with respect to the units of output.

At the breakeven point, operating profit is, by definition, zero. Setting OP = 0, we obtain:

$$\text{Breakeven number of units} = \frac{\text{Fixed costs}}{\text{Unit contribution margin}}$$

The calculations in the equation method and the contribution margin method appear similar because one is merely a restatement of the other.

In our example, fixed costs are €2000 and the unit contribution margin is €80 (€200 - €120).

Therefore,

$$\text{Breakeven number of units} = \text{€}2000 / \text{€}80 = 25 \text{ units}$$

A contribution income statement groups line items by cost behaviour pattern to highlight the contribution margin. The following such statement confirms the preceding breakeven calculations:

Revenues, €200 × 25	€5000
Variable costs, €120 × 25	<u>3000</u>
Contribution margin, €80 × 25	2000
Fixed costs	<u>2000</u>
Operating profit	<u><u>€0</u></u>

3. The graph method

The graph method represents total costs and total revenues graphically. This helps managers visualize the relationships between total revenues and total costs. In the graph method, each relationship is shown as a line on a graph.

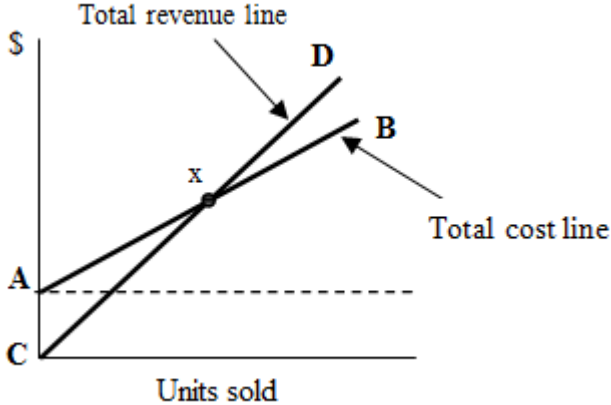


Figure 3.2 Break-even point graph
 Source: DATAR, S. M., RAJAN, M. V. Managerial Accounting, Making Decisions and Motivating Performance

Total costs line: The total costs line is the straight line from point A to point B. It is the sum of fixed costs and variable costs. The starting point of total cost line represents total fixed costs as variable costs will be zero when no units are sold. Total variable costs increase in proportion to the number of units sold. Total fixed costs is represented by the dotted line from point A. It remains constant for all units of quantities sold, within a relevant range.

Total revenues line: Point C is the starting point of the revenue line. The starting point indicates that total revenues earned will be zero when no units are sold. At any other sales level, total revenues can be determined by multiplying the number of units sold by the selling price per unit. The straight line from point C to point D is the total revenues line.

Profit or loss at any sales level can be determined by the vertical distance between the two lines at that level. The area covered by points A, X, and C is the operating loss area. In this area, the total costs exceed the total revenue.

Point X is **the breakeven point**. At this point, the total costs line intersects the total revenues line. Here, the total revenues are the same as total costs resulting in a no-loss, no-gain situation. After the breakeven point, the total revenues exceed the total cost, and the area covered by point X, D, and B indicates operating incomes.

Example 3.1: Calculation of the break-even point by the graph method

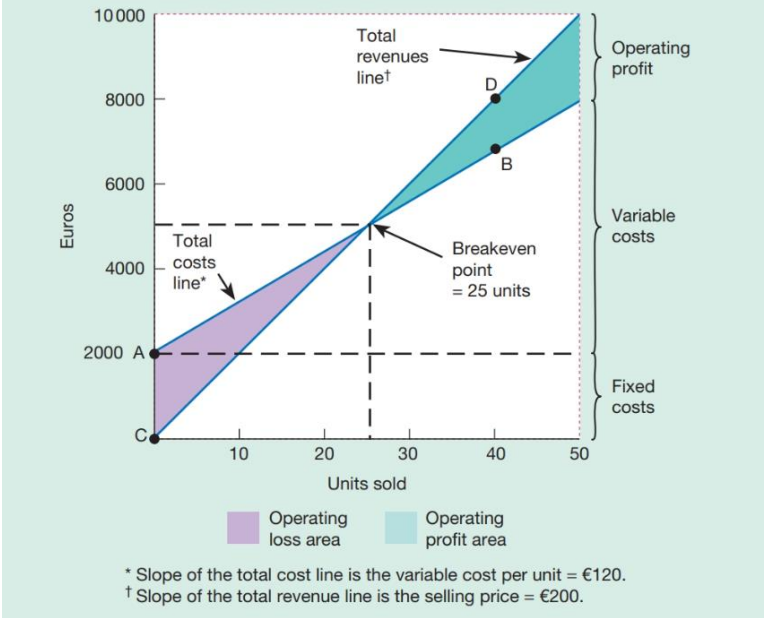
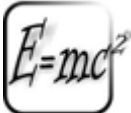


Figure 3.3 Break-even point – graph method
 Source: BHIMANI, A. et al. Management and Cost Accounting

3.5 A Target Operating Income

The breakeven point (BEP) is that quantity of output sold at which total revenues equal total costs.

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

But managers want to know how operating profit differs at many different output levels. Managers are concerned with how they can achieve their **goals for operating profit**.

Target operating income is the level of sales needed to attain a specified euro amount of operating income. In order to determine TOI, add the desired operating income to fixed cost in the breakeven calculation.

$$\frac{\text{Fixed costs} + \text{Target operating income}}{\text{Unit contribution margin}} = \text{Quantity of units to be sold}$$

We can introduce a profit element by asking the following question: *How many units must be sold to earn an operating profit of €1200?*

The equation method provides a straightforward way to answer this question. Let QT be the number of units sold to earn the target operating profit:

$$\begin{aligned} \text{Revenues} - \text{Variable costs} - \text{Fixed costs} &= \text{Target operating profit} \\ €200\text{QT} - €120\text{QT} - €2000 &= €1200 \\ €80\text{QT} &= €2000 + €1200 \\ €80\text{QT} &= €3200 \\ \text{QT} &= €3200 \div €80 \\ &= 40 \text{ units} \end{aligned}$$

Alternatively, we could use **the contribution margin method**. The numerator now consists of fixed costs plus target operating profit:

$$\begin{aligned} \text{QT} &= \frac{\text{Fixed costs} + \text{Target operating profit}}{\text{Unit contribution margin}} = \frac{\text{FC} + \text{TOP}}{\text{UCM}} \\ \text{QT} &= \frac{€2000 + €1200}{€80} \\ €80\text{QT} &= €3200 \\ \text{QT} &= €3200 \div €80 \\ &= 40 \text{ units} \end{aligned}$$

<i>Proof:</i> Revenues, €200 × 40	€8000
Variable costs, €120 × 40	<u>4800</u>
Contribution margin, €80 × 40	3200
Fixed costs	<u>2000</u>
Operating profit	<u>€1200</u>

A PV graph (a profit–volume graph) shows the impact on operating profit of changes in the output level.

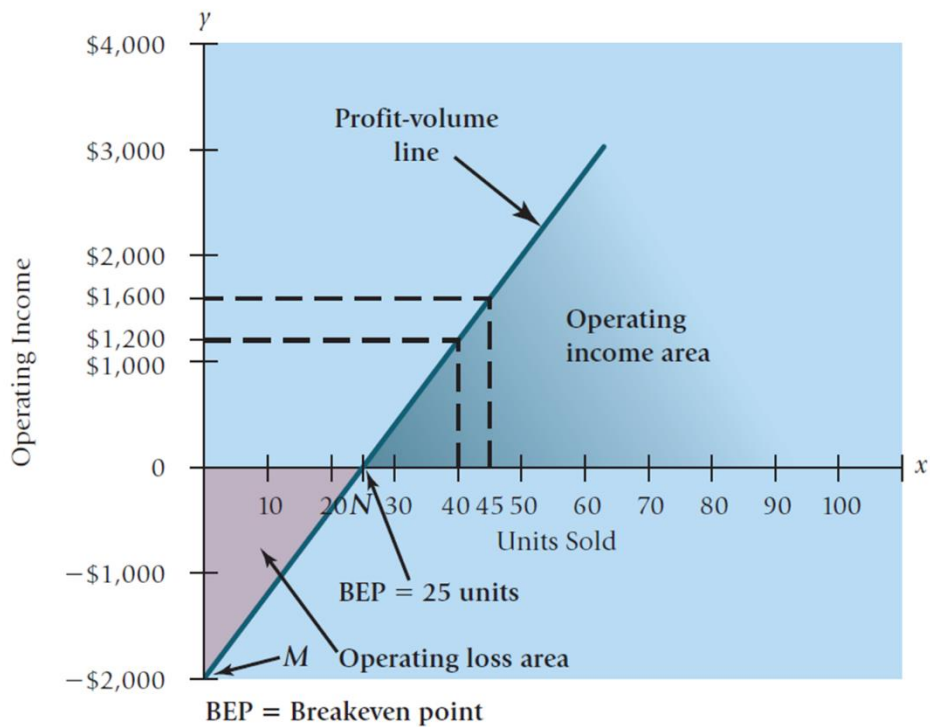


Figure 3.4 A profit–volume graph

Source: DATAR, S. M., RAJAN, M. V. *Managerial Accounting, Making Decisions and Motivating Performance*

While we can use the graph method to determine the number of units that should be sold to achieve a targeted income, but it is not easy to determine the precise point at which the difference between the total costs and total revenues line equals the targeted income. By charting only the operating profits at different levels of sales, a PV graph makes it convenient to determine the level of sales required to earn the target profit. Here, the point M indicates the amount of loss when there is no sales. This is equal to the amount of total fixed costs incurred. Point N is the breakeven point, where the operating profits are zero. The PV line is the straight line from point M through point N. To find the number of units that must be sold for a targeted level of operating income, draw a horizontal line parallel to the x-axis corresponding to the targeted income on the y-axis. At the point where this line intersects the PV line, draw a vertical line down to the x-axis. The point where the vertical line intersects the x-axis is the number of units that should be sold to achieve the targeted income.

3.5 Impact of Income Taxes

Net income is operating income plus non-operating revenues (such as interest revenues) minus non-operating expenses (such as interest expense) minus income taxes.

To this point, we have ignored the effect of income taxes in our CVP analysis. To make net income evaluations, however, we must state results in terms of target net income rather than target operating income.

The target operating income TOI calculation can easily be adjusted to accommodate this change:

$$\text{Target NI} = \text{TOI} - (\text{TOI} \times \text{Tax rate}) \text{ or}$$

$$\text{Target NI} = \text{TOI} \times (1 - \text{Tax rate})$$

However, the presence of income taxes **will not change the breakeven point**. Why? Because, by definition, operating profit at the breakeven point is zero, and thus no income taxes will be paid. Nevertheless, other types of tax may affect the breakeven point. For example, a sales tax paid by the seller that is a fixed percentage of revenues can be treated as a variable cost and hence will increase the breakeven point.

3.6 The Use of CVP Analysis for Decision Making

CVP analysis is useful in numerous situations to evaluate anticipated results from strategic decisions. In general, it helps managers make product decisions by estimating the expected profitability of these decisions. Managers use CVP analysis in making various decisions:

- **Decision to advertise:** Using CVP analysis managers can determine whether placing an advertisement of their product will be profitable in terms of the additional investments required for the advertisement. Managers analyze the differences in operating income arising from such decisions. Analyzing differences allows managers to get to the heart of CVP analysis and sharpens intuition by focusing only on the revenues and costs that will change as a result of a decision.
- **Decision to reduce selling price:** Instead of advertisement managers might also consider reducing the price of their product to increase demand of their product in the market. Managers use CVP analysis to see the effect that such decrease in prices has on the contribution margin and the operating income of the company.
- **Determining Target Prices:** Managers also use CVP analysis to answer questions such as *“At what price should a particular number of products be sold to earn a target level of operating income?”*

3.7 Sensitivity Analysis and Uncertainty

Sensitivity analysis is a technique that managers use to examine the effect of changes in the variables that will affect the outcome of the decision. This is also referred to as “what if” analysis; that is, asking: “What would happen if...?”

The margin of safety is another aspect of sensitivity analysis. It may be expressed in units, euros, or as a percentage. It is defined as the amount by which the current level of

sales exceeds the breakeven point; that is, it is a measure of how much sales can decline and have the company remain profitable.

Margin of safety in euros = Revenues – Breakeven revenues

Margin of safety in units = Sales in units – Breakeven units

Margin of safety percentage = Margin of safety in euros / Revenues

Sensitivity analysis recognizes uncertainty, the possibility that actual amounts of revenue and costs will differ from expected amounts.

3.8 Operating Leverage

Managers have the ability to choose the levels of fixed and variable costs in their cost structures. Sensitivity analysis can be utilized in making the decision to substitute fixed costs for variable costs in the cost structure. When the cost structure has higher fixed costs, there is a higher risk of loss and a higher breakeven point. However, the number of units required to be sold to achieve the target profits will be lesser.

Managers choose the variable-cost/fixed-cost structure strategically to balance the risk of losses if revenues are low and higher profits if revenues are high.

Operating leverage describes the effects of fixed costs on changes in operating income with changes in contribution margin or volume. It is defined as the percentage change in operating income from a given change in sales and is described as **degree of operating leverage (DOL)**. For example, a company that has a DOL of 4, will experience a change in operating income four times the change in revenues. If revenues increase 5%, operating income would increase 4×5 or 20%.

DOL is calculated as follows:

$$\text{Degree of operating leverage} = \frac{\text{Contribution margin}}{\text{Operating income}}$$

Organizations with high proportion of fixed costs will have higher operating leverage.

3.9 Application of CVP Analysis to a Company Producing Multiple Products

Sales mix is the quantities or proportions of various products or services that constitute the total sales of a company. CVP analysis discussed to this point assumes a single product. This is not reasonable, as most companies sell a large variety of products.

In contrast to the single-product (or service) situation, the total number of units that must be sold to break even in a multiproduct company depends on the sales mix.

CVP analysis with multiple products is performed by calculating a **weighted average contribution margin** based upon a constant sales mix percentage.

In general, for any given total quantity of units sold, as the sales mix shifts toward units with lower contribution margins, operating income will be lower. At no point should a manager focus on changing the sales mix to lower the break-even point without taking into account **customer preferences and demand**.

The description cost-volume-profit analysis might suggest that CVP principles only apply to for-profit organizations, but the CVP analysis can be adapted to service and **not-for-profit organizations** as well. For these organizations, the output measures are different from manufacturing or merchandising companies. Companies like airlines may measure their output in terms of passenger miles while universities are likely to measure their output based on student credit-hours.

3.10 Contribution Margin and Gross Margin

Gross margin measures how much a company can charge for its products over and above the cost of acquiring or producing them. It is calculated as:

$$\text{Gross margin} = \text{Revenues} - \text{Cost of goods sold}$$

Contribution margin indicates how much of a company's revenues are available to cover fixed costs. It helps in assessing risk of loss. It is calculated as:

$$\text{Contribution margin} = \text{Revenues} - \text{All variable costs}$$

Gross margin and contribution margin are related but they give different insights.

In the manufacturing sector, contribution margin and gross margin differ in two ways: fixed manufacturing costs and variable nonmanufacturing costs. Fixed manufacturing costs are not deducted from revenues when computing contribution margin but are deducted when computing gross margin. Cost of goods sold in a manufacturing company includes all variable manufacturing costs and all fixed manufacturing costs. Therefore, in a business where there are no fixed manufacturing costs, such as a merchandising company, gross margin will often equal contribution margin.

Summary



General profit planning in its full complexity assumes that there are many revenue drivers and many cost drivers.

Cost-Volume-Profit Analysis (CVP) is a special case that, in a restricted number of settings, can assist managers in understanding the behavior of total costs, total revenues and operating profit as changes occur in the output level, selling price, variable costs or fixed costs. Using CVP requires simplifying assumptions, including that costs are either fixed or variable with respect to the number of output units (units produced and sold) and that total sales and total cost relationships are linear.

Managers often select the method they find easiest for computing **the breakeven point**: the equation method, the contribution margin method or the graph method.

Income taxes can be incorporated into CVP analysis in a straightforward way by adjusting operating profit by the income tax rate. The breakeven point is unaffected by the presence of income taxes because no income taxes are paid if there is no operating profit.

Sensitivity analysis, a ‘what-if’ technique, can systematically examine the effect on operating profit and net profit of different levels of fixed costs, variable costs per unit, selling prices and output. CVP can highlight to managers the risk and potential reward of alternatives that differ in their fixed costs and variable costs.

When CVP is applied to a **multiple-product firm**, it is assumed that there is a constant sales mix of products as the total quantity of units sold changes.

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