Break-even and CVP analysis

Cost-volume-profit (CVP) analysis

CVP analysis examines how changes in costs, volume, and price affect a company's profit. It helps managers make decisions about pricing, product mix, and production levels.

Key definitions

Fixed Costs (FC): Costs that remain constant regardless of output (e.g., rent, salaries, insurance, equipment leases). These costs exist even if production is zero.
Variable Costs (VC): Costs that change in direct proportion to the level of production (e.g., raw materials, direct labour, packaging, sales commissions).
Mixed Costs: Some costs have both fixed and variable components (e.g., a phone plan with a base fee plus per-minute charges). For CVP analysis, these must be separated.
Selling Price (P): The price per unit charged to customers.

Fundamental equations

Total Variable Cost:

$$\text{TVC} = (\text{Variable Cost per unit}) \times x$$

Total Cost:

$$\text{TC} = \text{FC} + \text{TVC} = \text{FC} + (\text{VC per unit}) \times x$$

Total Revenue:

$$\text{TR} = (\text{Selling Price}) \times x = Px$$

Profit (Net Income):

$$\text{Profit} = \text{TR} - \text{TC} = Px - \text{FC} - (\text{VC per unit}) \times x$$

Contribution margin

The **contribution margin (CM)** is the amount each unit contributes toward covering fixed costs and generating profit.

$$\text{CM per unit} = \text{Selling Price} - \text{Variable Cost per unit} = P - \text{VC}$$

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The **contribution margin ratio (CM ratio)** expresses this as a percentage of selling price:

$$\text{CM Ratio} = \frac{\text{CM per unit}}{\text{Selling Price}} = \frac{P - \text{VC}}{P}$$

Example: A product sells for $80 with variable costs of $52 per unit.

$$\text{CM per unit} = \$80 - \$52 = \$28$$

$$\text{CM Ratio} = \frac{\$28}{\$80} = 0.35 = 35\%$$

This means 35 cents of every sales dollar contributes to covering fixed costs and profit.

Break-even point

The **break-even point** is where total revenue equals total cost—no profit, no loss.

Break-even in units:

$$x_{\text{BE}} = \frac{\text{Fixed Costs}}{\text{CM per unit}} = \frac{\text{FC}}{P - \text{VC}}$$

Break-even in dollars:

$$\text{TR}_{\text{BE}} = \frac{\text{Fixed Costs}}{\text{CM Ratio}}$$

Or simply: $\text{TR}_{\text{BE}} = x_{\text{BE}} \times P$

Example: A bakery sells cakes for $35 each. Variable costs are $14 per cake, and monthly fixed costs are $4,200. Find the break-even point.

$$\text{CM per unit} = \$35 - \$14 = \$21$$

$$x_{\text{BE}} = \frac{\$4{,}200}{\$21} = 200 \text{ cakes}$$

$$\text{TR}_{\text{BE}} = 200 \times \$35 = \$7{,}000$$

The bakery must sell 200 cakes (or generate $7,000 in revenue) to break even.

Target profit analysis

To find the sales volume needed to achieve a specific profit target:

$$x_{\text{target}} = \frac{\text{FC} + \text{Target Profit}}{\text{CM per unit}}$$

In dollars:

$$\text{TR}_{\text{target}} = \frac{\text{FC} + \text{Target Profit}}{\text{CM Ratio}}$$

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Example: Using the bakery example, how many cakes must be sold to earn a profit of $2,100?

$$x_{\text{target}} = \frac{\$4{,}200 + \$2{,}100}{\$21} = \frac{\$6{,}300}{\$21} = 300 \text{ cakes}$$

Example: A company has fixed costs of $120,000, a CM ratio of 40%, and wants to earn $60,000 profit. What revenue is needed?

$$\text{TR}_{\text{target}} = \frac{\$120{,}000 + \$60{,}000}{0.40} = \frac{\$180{,}000}{0.40} = \$450{,}000$$

Margin of safety

The **margin of safety** measures how far sales can drop before reaching break-even.

$$\text{Margin of Safety (units)} = \text{Actual Sales} - \text{Break-even Sales}$$

$$\text{Margin of Safety (\%)} = \frac{\text{Actual Sales} - \text{Break-even Sales}}{\text{Actual Sales}} \times 100\%$$

Example: The bakery currently sells 280 cakes per month. What is the margin of safety?

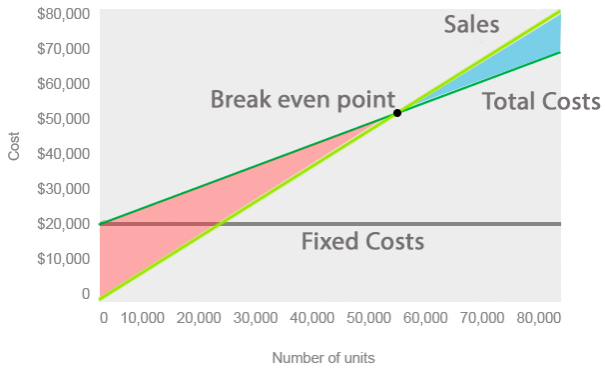
$$\text{Margin of Safety} = 280 - 200 = 80 \text{ cakes}$$

$$\text{Margin of Safety (\%)} = \frac{80}{280} \times 100\% = 28.6\%$$

Sales could decline by 28.6% before the bakery starts losing money.

Graphical representation

A CVP graph plots total revenue and total cost against volume:



Key features of the CVP graph:

- The **TR line** starts at the origin with slope equal to selling price P.

- The **TC line** starts at FC (the y-intercept) with slope equal to VC per unit.
- The **break-even point** is where TR and TC intersect.
- Above break-even: **profit area** (TR $>$ TC).
- Below break-even: **loss area** (TR $<$ TC).

Sensitivity analysis: what-if scenarios

CVP analysis helps evaluate the impact of changes:
Change in selling price: Example: If the bakery raises prices to $38 per cake:

$$\text{New CM} = \$38 - \$14 = \$24 \qquad x_{\text{BE}} = \frac{\$4{,}200}{\$24} = 175 \text{ cakes}$$

Change in variable costs: Example: If ingredient costs rise to $17 per cake:

$$\text{New CM} = \$35 - \$17 = \$18 \qquad x_{\text{BE}} = \frac{\$4{,}200}{\$18} = 234 \text{ cakes}$$

Change in fixed costs: Example: If rent increases fixed costs to $5,250:

$$x_{\text{BE}} = \frac{\$5{,}250}{\$21} = 250 \text{ cakes}$$

Common mistakes to avoid

Caution:

- If CM is negative (VC $>$ Price), every unit sold increases the loss. There is no break-even point.
- Don't confuse CM ratio with profit margin—CM covers fixed costs first, then profit.
- Break-even units should be rounded up (you can't sell partial units).
- Ensure fixed and variable costs are correctly classified before analysis.

Summary of formulas

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Measure	Formula
Contribution Margin	CM $= P -$ VC
CM Ratio	CM Ratio $=$ CM$\nabla \cdot P$
Break-even (units)	$x_{\text{BE}} =$ FC$\nabla \cdot$ CM
Break-even (dollars)	$\text{TR}_{\text{BE}} =$ FC$\nabla \cdot$ CM Ratio
Target Profit (units)	$x = (\text{FC} + \text{Profit})\nabla \cdot$ CM
Margin of Safety	Actual Sales $-$ BE Sales

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