



COST-VOLUME-PROFIT (CVP) ANALYSIS

Accountancy 2203 Review Workshop

Sindhu Bala

COST-VOLUME-PROFIT (CVP) ANALYSIS

CVP analysis examines the interaction of a firm's sales volume, selling price, cost structure, and profitability. It is a powerful tool in making managerial decisions including marketing, production, investment, and financing decisions.

- How many units of its products must a firm sell to break even?
- How many units of its products must a firm sell to earn a certain amount of profit?
- Should a firm invest in highly automated machinery and reduce its labor force?
- Should a firm advertise more to improve its sales?

One Product Cost-Volume-Profit Model

Net Income (NI) = Total Revenue – Total Cost

Total Revenue = Selling Price Per Unit (P) * Number of Units Sold (X)

Total Cost = Total Variable Cost + Total Fixed Cost (F)

Total Variable Cost = Variable Cost Per Unit (V) * Number of Units Sold (X)

$$\mathbf{NI = P X - V X - F}$$

$$\mathbf{NI = X (P - V) - F}$$

One Product Cost-Volume-Profit Model

Net Income (NI) = Total Revenue – Total Cost

Total Revenue = Selling Price Per Unit (P) * Number of Units Sold (X)

Total Cost = Total Variable Cost + Total Fixed Cost (F)

Total Variable Cost = Variable Cost Per Unit (V) * Number of Units Sold (X)

$$\mathbf{NI = P X - V X - F}$$

$$\mathbf{NI = X (P - V) - F}$$

This is an Income Statement

Sales Revenue (P X)
- <u>Variable Costs (V X)</u>
Contribution Margin
- <u>Fixed Costs (F)</u>
Net Income (NI)

CVP Model – Assumptions

Key assumptions of CVP model

- Selling price is constant
- Costs are linear and can be divided into variable and fixed elements.
- In multi-product companies, sales mix is constant
- In manufacturing companies, inventories do not change.

Contribution Margin Ratio

Or, in terms of **units**, the contribution margin **ratio** is:

$$\text{CM Ratio} = \frac{\text{Unit CM}}{\text{Unit selling price}}$$

For Racing Bicycle Company the ratio is:

$$\frac{\$4}{\$16} = 25\%$$

Changes in Fixed Costs and Sales Volume

What is the profit impact if Chocolate Co. can increase unit sales from 12000 to 13000 by increasing the monthly advertising budget by 5,000?

$$(1000 \times 4 \text{ CM}) - \$5,000 = -\$1,000$$

Change in Variable Costs and Sales Volume

What is the profit impact if Chocolate Co. can use higher quality raw materials, thus, increasing variable costs per unit by \$2, to generate an increase in unit sales from 12000 to 28000?

$$28000 \times \$2 \text{ CM/unit} = \$56000 - \$40,000 = \$16000 \text{ vs. } \$8000, \text{ increase of } \$8000$$

Change in Fixed Cost, Sales Price and Volume

What is the profit impact if Chocolate Co. (1) cuts its selling price \$2 per unit, (2) increases its advertising budget by \$4,000 per month, and (3) increases unit sales from 12000 to 40,000 units per month?

$$40,000 \times \$2 \text{ CM/unit} = \$80,000 - \$40,000 - \$4,000 = \$36,000, \text{ increase of } \$28,000$$

Break-Even Analysis

Break-even analysis can be approached in two ways:

1. Equation method
2. Contribution margin method


Equation Method

Profits = (Sales – Variable expenses) – Fixed expenses

OR

Sales = Variable expenses + Fixed expenses + Profits

**At the break-even point
profits equal zero**



Equation Method

We calculate the break-even point as follows:

$$\text{Sales} = \text{Variable expenses} + \text{Fixed expenses} + \text{Profits}$$

$$\$16Q = \$12Q + \$40,000 + \$0$$

Where:

Q = Number of chocolates sold

\$16 = Unit selling price

\$12 = Unit variable expense

\$40,000 = Total fixed expense

Equation Method

- We calculate the break-even point as follows:

$$\text{Sales} = \text{Variable expenses} + \text{Fixed expenses} + \text{Profits}$$

$$\$500Q = \$300Q + \$80,000 + \$0$$

$$\$200Q = \$80,000$$

$$Q = \$80,000 \div \$200 \text{ per bike}$$

$$Q = 400 \text{ bikes}$$

Equation Method

- The equation can be modified to calculate the break-even point in sales dollars.

$$\text{Sales} = \text{Variable expenses} + \text{Fixed expenses} + \text{Profits}$$

$$X = 0.75X + \$40,000 + \$0$$

Where:

X = Total sales dollars

0.75 = Variable expenses as a % of sales

\$40,000 = Total fixed expenses

Equation Method

- The equation can be modified to calculate the break-even point in sales dollars.

$$\text{Sales} = \text{Variable expenses} + \text{Fixed expenses} + \text{Profits}$$

$$X = 0.75X + \$40,000 + \$0$$

$$0.25X = \$40,000$$

$$X = \$40,000 \div 0.25$$

$$X = \$160,000$$

Contribution Margin Method

The contribution margin method has two key equations.

$$\text{Break-even point in units sold} = \frac{\text{Fixed expenses}}{\text{Unit contribution margin}}$$

$$\text{Break-even point in total sales dollars} = \frac{\text{Fixed expenses}}{\text{CM ratio}}$$

Contribution Margin Method

Let's use the contribution margin method to calculate the break-even point in total sales dollars at Racing.

$$\text{Break-even point in total sales dollars} = \frac{\text{Fixed expenses}}{\text{CM ratio}}$$

$$\frac{\$40,000}{25\%} = \$160,000 \text{ break-even sales}$$

Target Profit Analysis

The equation and contribution margin methods can be used to determine the sales volume needed to achieve a target profit.

Suppose Chocolate Co. wants to know how many bikes must be sold to earn a profit of \$50,000.

The CVP Equation Method

Sales = Variable expenses + Fixed expenses + Profits

$$\text{\$16Q} = \text{\$12Q} + \text{\$40,000} + \text{\$50,000}$$

$$\text{\$4Q} = \text{\$90,000}$$

$$Q = \textit{22,500 chocolates}$$

The Contribution Margin Approach

The contribution margin method can be used to determine that 900 bikes must be sold to earn the target profit of \$100,000.

$$\text{Unit sales to attain the target profit} = \frac{\text{Fixed expenses} + \text{Target profit}}{\text{Unit contribution margin}}$$

$$\frac{\$40,000 + \$50,000}{\$4/\text{chocolate}} = 22500 \text{ chocolates}$$

The Margin of Safety

The margin of safety is the excess of budgeted (or actual) sales over the break-even volume of sales.

Margin of safety = Total sales - Break-even sales

Let's look at Chocolate Co. and determine the margin of safety.

Multi-Product CVP Model

Suppose a firm makes two products (printers and copiers). To allow for two products, the CVP model can be modified as follows:

$$NI = (P_1 - V_1) X_1 + (P_2 - V_2) X_2 - F$$

NI = Profit

P_1 = Price per unit of product 1 (printers)

P_2 = Price per unit of product 2 (copiers)

V_1 = Variable cost per unit of product 1 (printers)

V_2 = Variable cost per unit of product 2 (copiers)

X_1 = Quantity sold and produced of product 1 (printers)

X_2 = Quantity sold and produced of product 2 (copiers)

Sales Mix or Product Mix – the relative proportion of each type of product sold by a company (i.e. $\frac{X_1}{X_1 + X_2}$ and $\frac{X_2}{X_1 + X_2}$)

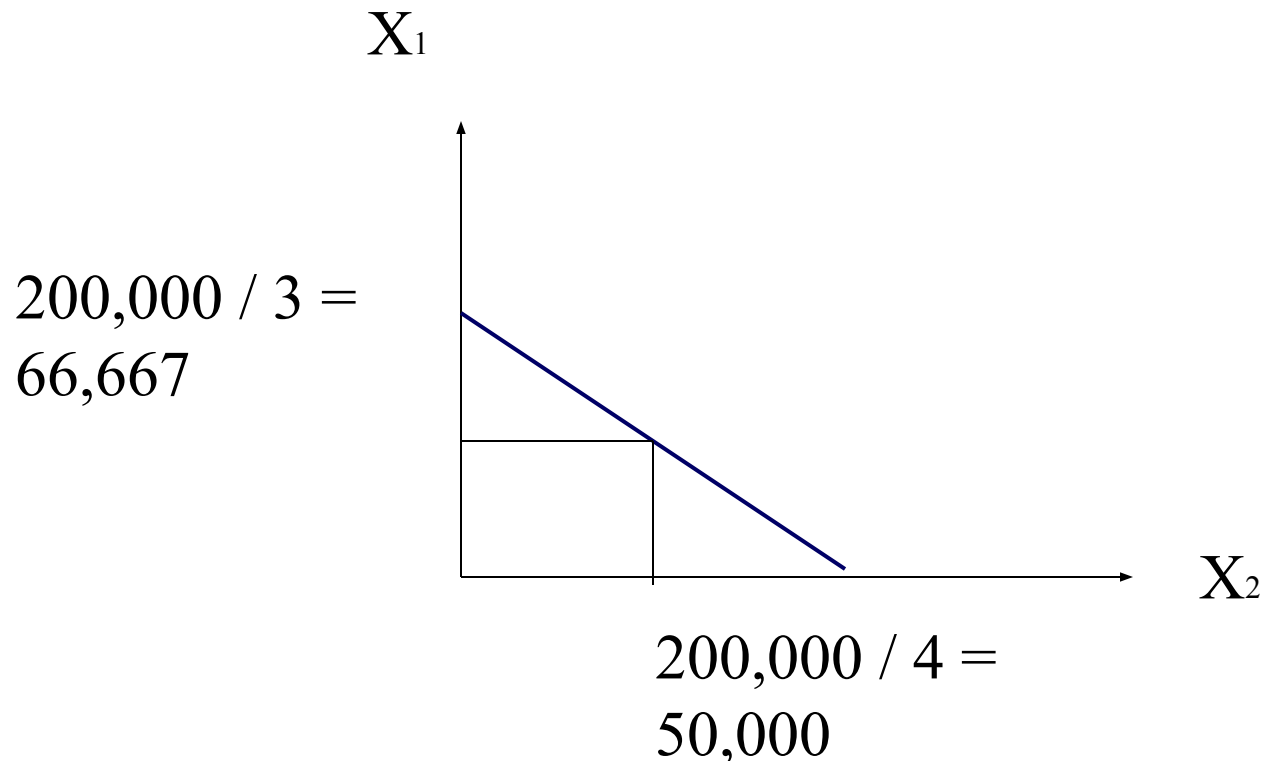
Multi-Product CVP Model - Example

Example: Suppose $FC = \$200,000$; $P_1 = \$5$; $V_1 = \$2$; $P_2 = \$10$; $V_2 = \$6$. Find all the breakeven points.

- $NI = (P_1 - V_1)X_1 + (P_2 - V_2)X_2 - FC$
- $0 = (5 - 2)X_1 + (10 - 6)X_2 - 200,000$
- $0 = 3X_1 + 4X_2 - 200,000$

We get 1 equation and 2 unknowns

Multi-Product CVP Model - Example



- Any point on the line is a possible combination of X_1 and X_2
- We need more information to solve the BE point

Multi-Product CVP Model - Example

Suppose the firm produces and sells the same number of the two products. Find the breakeven point.

$$\text{Let } X = X_1 = X_2$$

$$\text{So } 0 = 3X + 4X - \$200,000$$

$$0 = 7X - \$200,000$$

$$X = \$200,000 / 7 \approx 28,572 \text{ units}$$

Multi-Product CVP Model

If the sales mix is constant, CVP problems with multiple products can be solved using the following equations:

$$\begin{aligned}\text{Overall Contribution Margin Ratio} &= \frac{\text{Overall Contribution Margin}}{\text{Total Sales}} \\ &= \frac{(P_1 - V_1)X_1 + (P_2 - V_2)X_2}{P_1X_1 + P_2X_2}\end{aligned}$$

$$\text{NI} = (\text{Overall CM ratio}) (\text{Total Sales}) - F$$

$$\begin{aligned}(P_1 - V_1) X_1 &= \text{total contribution margin of product 1} \\ (P_2 - V_2) X_2 &= \text{total contribution margin of product 2}\end{aligned}$$

- Amount of sales revenue required to achieve a target profit:

$$(\text{NI} + F) / \text{Overall CMR} = \text{Sales}$$

- Breakeven sales volume:

$$\text{BE Sales} = F / \text{Overall CMR}$$

Note that if the sales mix changes, the overall contribution margin changes; a new overall contribution margin ratio has to be calculated to solve a CVP problem.

Multi-Product CVP Model - Example

Problem: Trop Co. produces 3 kinds of fruit juice, whose costs, prices, and expected sales levels are provided below:

	Apple	Orange	Cranberry
Sales price per unit	\$1.50	\$2.00	\$2.50
Variable cost per unit	\$0.50	\$0.50	\$0.50
Expected sales units	20,000 units	20,000 units	10,000 units

Trop Co. has a total fixed cost of \$84,000.

Given the current sales mix, what is the overall contribution margin ratio?

$$\text{TCM} / \text{Sales} = [20,000 (1.5 - 0.5) + 20,000 (2 - 0.5) + 10,000 (2.5 - 0.5)] / [20,000 * 1.5 + 20,000 * 2 + 10,000 * 2.5] = 70,000 / 95,000 = 0.73684$$

If Trop's sales mix remains constant, what is the breakeven sales volume?

$$\text{BE Sales} = 84,000 / 0.73684 = \$ 114,000$$

$$\text{BE Sales} = 2/5 X * 1.5 + 2/5 X * 2 + 1/5 X * 2.5 = 114,000$$
$$X = 60,000 \text{ units in total}$$

Operating Leverage

Operating Leverage – a measure of how sensitive operating income is to percentage changes in sales.

With high operating leverage, even a small percentage increase (decrease) in sales can cause a large percentage increase (decrease) in operating income.

$$\text{Degree of Operating Leverage (DOL)} = \frac{\text{Contribution Margin}}{\text{Operating Income}}$$

$$\text{Percentage increase in profits} = \text{DOL} * \text{Percentage increase in Sales}$$

Example: The following data pertains to Extreme Bike Co.

Sales	\$500,000
Variable costs	<u>\$300,000</u>
Contribution Margin	\$200,000
Fixed Costs	<u>\$160,000</u>
Operating Income	\$40,000

Operating Leverage - Example

- Calculate Extreme's degree of operating leverage

$$\text{DOL} = \$200,000 / \$40,000 = 5$$

- Calculate Extreme's operating income, if Extreme achieves a 20% increase in its sales

$$20\% * 5 = 100\% \text{ increase in NI}$$

$$\$40,000 * 100\% = \$40,000$$

$$\text{New NI} = \$40,000 + \$40,000 = \$80,000$$

Operating Leverage - Example

Sales	\$600,000
VC	<u>360,000</u>
CM	240,000
FC	<u>160,000</u>
NI	\$ 80,000

Operating Leverage - Example

- Calculate Extreme's operating income, if Extreme experiences a drop of 30% in its sales

$$-30\% * 5 = -150\%$$

$$\$40,000 * -150\% = -\$60,000$$

$$\text{New NI} = \$40,000 - \$60,000 = -\$20,000$$

Operating Leverage - Example

Sales	\$350,000
VC	<u>210,000</u>
CM	140,000
FC	<u>160,000</u>
NI	\$ (20,000)

Review Problem: CVP Relationships

Voltar Company manufactures and sells a specialized cordless telephone for high electromagnetic radiation environments. The company's contribution format income statement for the most recent year is given below:

	Total	Per Unit	Percent of Sales
Sales (20,000 units)	\$1,200,000	\$60	100%
Variable expenses	900,000	45	? %
Contribution margin	300,000	\$15	? %
Fixed expenses	240,000		
Net operating income	\$ 60,000		

Required:

Compute the company's CM ratio and variable expense ratio.

Compute the company's break-even point in both units and sales dollars. Use the equation method.

Assume that sales increase by \$400,000 next year. If cost behavior patterns remain unchanged, by how much will the company's net operating income increase? Use the CM ratio to compute your answer.

Refer to the original data. Assume that next year management wants the company to earn a profit of at least \$90,000. How many units will have to be sold to meet this target profit?

Refer to the original data. Compute the company's margin of safety in both dollar and percentage form.

Review Problem: CVP Relationships

Voltar Company manufactures and sells a specialized cordless telephone for high electromagnetic radiation environments. The company's contribution format income statement for the most recent year is given below:

	Total	Per Unit	Percent of Sales
Sales (20,000 units)	\$1,200,000	\$60	100%
Variable expenses	900,000	45	? %
Contribution margin	300,000	\$15	? %
Fixed expenses	240,000		
Net operating income	\$ 60,000		

Required:

Compute the company's CM ratio and variable expense ratio.

$CMR = 25\%; VC \text{ ratio} = 75\%$

Compute the company's break-even point in both units and sales dollars. Use the equation method.

$60 Q = 45Q + 240,000 \rightarrow 15 Q = 240,000 \rightarrow Q = 16,000 \text{ units}$

$16,000 * 60 = \$960,000$

Assume that sales increase by \$400,000 next year. If cost behavior patterns remain unchanged, by how much will the company's net operating income increase? Use the CM ratio to compute your answer.

Increase in sales	\$400,000
CMR	25%
Increase in NOI	\$100,000

Refer to the original data. Assume that next year management wants the company to earn a profit of at least \$90,000. How many units will have to be sold to meet this target profit?

$$(240,000 + 90,000) / 15 = 22,000 \text{ units}$$

Refer to the original data. Compute the company's margin of safety in both dollar and percentage form.

$$\text{Margin of safety} = 1,200,000 - 960,000 = \$240,000 \text{ or } 20\%$$

Review Problem: CVP Relationships

Voltar Company manufactures and sells a specialized cordless telephone for high electromagnetic radiation environments. The company's contribution format income statement for the most recent year is given below:

	Total	Per Unit	Percent of Sales
Sales (20,000 units)	\$1,200,000	\$60	100%
Variable expenses	900,000	45	? %
Contribution margin	300,000	\$15	? %
Fixed expenses	240,000		
Net operating income	\$ 60,000		

Required:

Compute the company's degree of operating leverage at the present level of sales.

$$\text{DOL} = 300,000 / 60,000 = 5$$

Assume that through a more intense effort by the sales staff, the company's sales increase by 8% next year. By what percentage would you expect net operating income to increase? Use the degree of operating leverage to obtain your answer.

$$5 * 8\% = 40\%$$

Verify your answer to (b) by preparing a new contribution format income statement showing an 8% increase in sales.

- Sales \$1,296,000
- VC 972,000
- CM 324,000
- FC 240,000
- NOI \$84,000
- 40% increase

Review Problem: CVP Relationships

Voltar Company manufactures and sells a specialized cordless telephone for high electromagnetic radiation environments. The company's contribution format income statement for the most recent year is given below:

	Total	Per Unit	Percent of Sales
Sales (20,000 units)	\$1,200,000	\$60	100%
Variable expenses	<u>900,000</u>	<u>45</u>	<u>? %</u>
Contribution margin	300,000	\$15	? %
Fixed expenses	<u>240,000</u>	<u></u>	<u></u>
Net operating income	<u>\$ 60,000</u>		

In an effort to increase sales and profits, management is considering the use of a higher-quality speaker. The higher-quality speaker would increase variable costs by \$3 per unit, but management could eliminate one quality inspector who is paid a salary of \$30,000 per year. The sales manager estimates that the higher-quality speaker would increase annual sales by at least 20%.

Assuming that changes are made as described above, prepare a projected contribution format income statement for next year. Show data on a total, per unit, and percentage basis.

Compute the company's new break-even point in both units and dollars of sales. Use the contribution margin method.

$$\text{BE units} = \text{FC} / \text{CM per unit} = 210,000 / 12 = 17,500 \text{ units}$$
$$17,500 * 60 = \$1,050,000$$

Would you recommend that the changes be made?

$$\text{Margin of safety} = 1,440,000 - 1,050,000 = \$390,000. \text{Yes.}$$