

CHAPTER 3

Cost-Volume-Profit Analysis

WHAT IS CVP? HOW IS IT USED?

- Study of the behavior and relationship among total revenues, total costs and operating income as changes occur in:
 - Number of units sold (Q)
 - Selling price (P)
 - Variable cost per unit (VCU)
 - Total fixed costs (F)

BASIC INFORMATION

Bookstore - selling GMAT textbooks

- Selling price \$200
- VCU \$120
- F \$2,000
- Q 40

INCOME STATEMENT

- ❖ Variable Costing Approach for M.A purposes
- ❖ Full Absorption Costing for external financial reporting.

Sales	\$8,000
- Variable Costs	<u>4,800</u>
Contribution Margin	\$3,200
- Fixed costs	<u>2,000</u>
Operating Income	\$1,200

CVP: CONTRIBUTION MARGIN

- ◉ Contribution margin (CM) equals revenue less variable costs.

$$(\$8,000 - \$4,800 = \$3,200)$$

- ◉ Contribution margin per unit (UCM) equals unit selling price less unit variable costs or can be obtained by taking contribution margin divided by number of units sold.

$$(\$200 - \$120 = \$80)$$

CVP: CONTRIBUTION MARGIN ADDITIONAL CALCULATIONS

- ◉ Contribution margin (CM) which is equal to the contribution margin per unit multiplied by the number of units sold.
 $(\$80 * 40 = \$3,200)$
- ◉ Contribution margin percentage (CM%) which is the contribution margin per unit divided by unit selling price or Contribution margin divided by revenue.
 $\$80 / \$200 = 40\%$
OR
 $\$3,200 / \$8000 = 40\%$
- ◉ **Meaning of CM %?**
- ◉ If sales increase by \$3,000, CM will increase by -----

COST-VOLUME-PROFIT EQUATION

$$\text{REVENUE} - \text{VARIABLE COSTS} - \text{FIXED COSTS} = \text{OPERATING INCOME}$$

$$\left(\begin{array}{l} \text{Selling} \\ \text{Price} \end{array} * \begin{array}{l} \text{Quantity} \\ \text{of Units} \\ \text{Sold} \end{array} \right) - \left(\begin{array}{l} \text{Unit} \\ \text{Variable} \\ \text{Costs} \end{array} * \begin{array}{l} \text{Quantity} \\ \text{of Units} \\ \text{Sold} \end{array} \right) - \text{Fixed Costs} = \text{Operating Income}$$

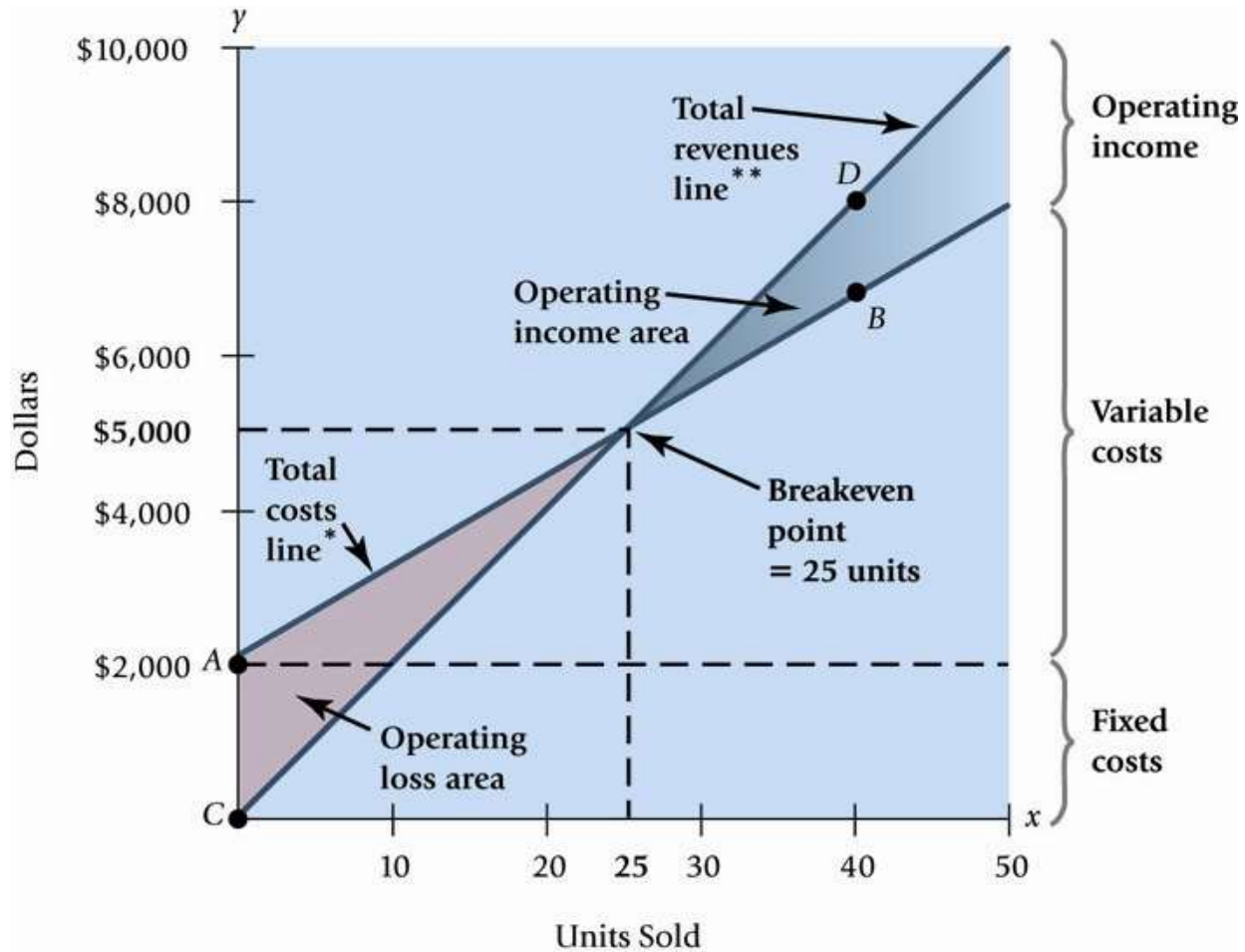
$$P*Q - VCU*Q - F = O.I$$

CVP Equation

$$O.I = (P - VCU)Q - F$$

- P-VCU : UCM
- P-VCU: CM (total)

CVP: GRAPHICALLY



* Slope of the total costs line is the variable cost per unit = \$120

** Slope of the total revenues line is the selling price = \$200

FOUNDATIONAL ASSUMPTIONS USED IN CVP ANALYSIS

- ⦿ Changes in production/sales volume are the sole cause for cost and revenue changes.
- ⦿ Total costs consist of fixed costs and variable costs.
- ⦿ Revenue and costs behave and can be graphed as a linear function (a straight line).
- ⦿ Selling price, variable cost per unit, and fixed costs are all known and constant.
- ⦿ In many cases only a single product will be analyzed. If multiple products are studied, their relative sales proportions are known and constant.
- ⦿ The time value of money (interest) is ignored.

BREAKEVEN POINT

- ⊙ At the breakeven point, a firm has *no profit or loss* at the given sales level. Breakeven is where O.I equal zero:
 - $O.I = (P - VCU)Q - F$
 - $0 = (P - VCU)Q - F$
- ⊙ Calculation of breakeven number of units
 - Breakeven Units =
$$\frac{\text{Fixed Costs}}{\text{Contribution Margin per Unit}}$$
- ⊙ **BEP (units) = 2,000 / (200 - 120) = 25 units**

BREAKEVEN POINT

○ Calculation of breakeven revenues

- Breakeven Revenue =
$$\frac{\text{Fixed Costs}}{\text{Contribution Margin Percentage}}$$

$$\text{BEP}(\$) = 2,000 / 40\% = \$5,000$$

OR

$$\text{BEP}(\$) = 25 \text{ units} * 200 = \$5,000$$

TARGET O.I

- If the company is planning to earn an O.I of \$2,800. How many units must be sold to achieve this target?

$$Q.I = (P-VCU)Q - F$$

$$\text{Target } Q = \frac{F + O.I}{P-VCU}$$

$$\text{Target } Q = (2,000 + 2,800) / 80 = 60 \text{ units}$$

- Calculate total revenues needed to achieve the target?

$$\text{Target revenues} = \frac{F + O.I}{(P-VCU)/P}$$

$$\text{Target revenues} = (2,000 + 2,800) / 40\% = \$12,000$$

OR

$$\text{Target revenues} = 60 * 200 = \$12,000$$

TARGET NET INCOME

- After-tax profit (Net Income) can be calculated by:
 - $\text{Net Income} = \text{Operating Income} * (1 - \text{Tax Rate})$
- Net income can be converted to operating income for use in CVP equation
 - $\text{Operating Income} = \frac{\text{Net Income}}{(1 - \text{Tax Rate})}$
- ✓ The CVP equation will continue to use operating income. We'll use this conversion formula to obtain the operating income value when provided with Net Income.

TARGET NET INCOME

- Net Income = Operating Income * (1-Tax Rate)
- Operating Income = $\frac{\text{Net Income}}{(1-\text{Tax Rate})}$

How many units must be sold to earn a net income of \$1,200, assuming that tax rate is 40%?

$$\text{Operating Income} = \frac{1200}{(1-40\%)} = \$2,000$$

$$\begin{aligned} \text{Target units} &= \frac{2,000 + 2000}{200 - 120} \\ &= 50 \text{ units} \end{aligned}$$

ADDITIONAL EXAMPLES

ONE: DECISION TO ADVERTISE

The company is considering advertising the product a fixed cost of \$500. This will increase sales by 10%.

Advertise or not?

$$\text{O.I (no adv.)} = (200-120)40 - 2,000 = \$1,200$$

$$\text{O.I (with Adv.)} = (200 - 120)44 - 2500 = \$1,020$$

No. O.I will decrease by \$180.

ADDITIONAL EXAMPLES

TWO: DETERMINING TARGET PRICE

At what selling price the company can sell 50 units purchased at \$115 to earn an O.I of \$1,200?

$$O.I = (P - VCU)Q - F$$

$$1,200 = (P - 115)50 - 2,000$$

$$P = \$179$$

SENSITIVITY ANALYSIS

- CVP provides structure to answer a variety of “what-if” scenarios.
- “What” happens to profit “if”:
 - Selling price changes.
 - Volume changes.
 - Cost structure changes.
 - Variable cost per unit changes.
 - Fixed costs change.

As an example, if a company determines that an adv. campaign costing \$15,000 is expected to increase sales 25%, should they proceed? That question cannot be properly answered without doing this type of analysis.

MARGIN OF SAFETY-DEFINED

- The margin of safety calculation answers a very important question:
- If budgeted or actual revenues are above the breakeven point, how far can they fall before the breakeven point is reached. In other words, how far can they fall before the company will begin to lose money.

MARGIN OF SAFETY

- An indicator of risk, the margin of safety (MOS), measures the distance between budgeted or actual sales and breakeven sales:
 - $MOS(Q) = \text{Budgeted Sales } Q - \text{BE Sales } Q$
 $= 40 - 25 = 15 \text{ units}$
 - $MOS(\$) = \text{Budgeted Sales} - \text{BE Sales}$
 $= 8,000 - 5,000 = \$3,000$
- The MOS ratio removes the firm's size from the output, and expresses itself in the form of a percentage:
 - $MOS \text{ Ratio} = MOS \div \text{Budgeted or actual Sales}$
 $= 3,000 / 8,000 = 37.5\%$

COST STRUCTURE

- ◉ Managers make strategic decisions that affect the cost structure of the company.
- ◉ The cost structure is simply the relationship of fixed costs and variable costs to total costs.
- ◉ We can use CVP-based sensitivity analysis to highlight the risks and returns as fixed costs are substituted for variable costs in a company's cost structure.
- ◉ The risk-return trade-off across alternative cost structures can be measured as operating leverage.

OPERATING LEVERAGE

- Operating leverage (OL) describes the effect that fixed costs have on changes in operating income as changes occur in units sold and contribution margin.
 - $OL = \frac{\text{Contribution Margin}}{\text{Operating Income}}$

Notice that the difference between the numerator and the denominator in our formula = our fixed costs.

USING OPERATING LEVERAGE TO ESTIMATE CHANGES IN OPERATING INCOME

The formula to estimate the change in operating income that will result from a percentage change in sales is:

Operating Leverage X % Change in Sales

If sales increase 50% and operating leverage is 1.67, you should expect operating income to increase 83.5%.

EFFECTS OF SALES MIX ON CVP

- ◉ The formulae presented to this point have assumed a single product is produced and sold.
- ◉ A more realistic scenario involves multiple products sold, in different volumes, with different costs and different margins.
- ◉ Sales mix and bundle
- ◉ $O.I = ((P-VCU)Q1 + (P-VCU)Q2) - F$

EFFECTS OF SALES MIX ON CVP

	Product 1	Product 2
Sales Q	60	40
P	\$200	\$100
VCU	\$120	\$70
F	\$4,500	

Calculate O.I

$$\begin{aligned} \text{O.I} &= ((P-VCU)Q_1 + (P-VCU)Q_2) - F \\ &= ((200-120)60 + (100-70)40) - 4,500 \\ &= \$1,500 \end{aligned}$$

EFFECTS OF SALES MIX ON CVP

	Product 1	Product 2
Sales Q	60	40
P	\$200	\$100
VCU	\$120	\$70
F	\$4,500	

Calculate BEP in \$ and in Q assuming a sales mix of 3:2.

$$\text{C.M / bundle} = 3*\$80 + 2*\$30 = \$300$$

$$\text{BEP} = 4,500/300 = 15 \text{ bundles}$$

BEP(Q)

$$\text{For Product 1} = 15*3 = 45 \text{ units}$$

$$\text{For Product 2} = 15*2 = 30 \text{ units}$$

$$\text{BEP (\$)} = 45*200 + 30*100 = \$12,000$$

EFFECTS OF SALES MIX ON CVP

	Product 1	Product 2
Sales Q	60	40
P	\$200	\$100
VCU	\$120	\$70
F	\$4,500	

Calculate BEP in \$ and in Q assuming a sales mix of 3:2.

C.M % for the bundle

= CM per bundle / sales per bundle

= 300 / 800 = 37.5%

BEP(\$) = 4,500 / 37.5% = \$12,000

BEP (Q) = 12,000 / 800 = 15 bundles

(45 of P1 and 30 of P2)

CVP FOR SERVICE AND NOT-FOR-PROFIT ORGANIZATIONS

- ◉ CVP isn't just for merchandising and manufacturing companies.
- ◉ Service and Not-for-Profit businesses need to focus on measuring their output which is different from the units sold that we've been dealing with.
- ◉ For example, a service agency might measure how many persons they assist or an airline might measure how many passenger miles they fly.

ALTERNATIVE INCOME STATEMENT FORMATS-ESPECIALLY SIGNIFICANT IN THE MANUFACTURING SECTOR

Contribution Income Statement Emphasizing Contribution Margin (in 000s)		Financial Accounting Income Statement Emphasizing Gross Margin (in 000s)	
Revenues	\$1,000	Revenues	\$1,000
Variable manufacturing costs	\$250	Cost of goods sold (variable manufacturing costs, \$250 + fixed manufacturing costs, \$160)	<u>410</u>
Variable nonmanufacturing costs	<u>270</u> <u>520</u>	Gross margin	590
Contribution margin	480	Nonmanufacturing costs (variable, \$270 + fixed \$138)	<u>408</u>
Fixed manufacturing costs	160	Operating income	<u>\$ 182</u>
Fixed nonmanufacturing costs	<u>138</u> <u>298</u>		
Operating income	<u>\$ 182</u>		



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