Chapter 3

Cost-Volume-Profit Analysis

Cost-Volume-Profit Analysis

Managers need to estimate future revenues, costs, and profits to help them plan and monitor operations.

They use cost-volume-profit (CVP) analysis to identify the levels of operating activity needed to avoid losses, achieve targeted profits, plan future operations, and monitor organizational performance.

Managers also analyze operational risk as they choose an appropriate cost structure.

Cost-volume-profit (CVP) analysis :

is a method for analyzing how operating decisions and marketing decisions affect profit based on an understanding of the relationship between variable costs, fixed costs, unit selling price, and how they change in a predictable way as the volume of activity changes(the output level), CVP analysis has many applications:

- **1.** Setting prices for products and services.
- 2. Introducing a new product or service.
- **3. Replacing** a piece of equipment.
- 4. Determining the breakeven point.
- 5. Deciding whether to make or buy a given product or service.
- 6. Determining the best product mix.
- 7. Performing strategic what-if analyses.

Cost-Volume-Profit Analysis Assumptions

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

Strategic Role of CVP Analysis:

CVP analysis can help a firm execute its strategy by providing an understanding of how changes in its volume of sales affect costs and profits.

Many firms, especially cost leadership firms, compete by increasing volume (often through lower prices) to achieve lower overall operating costs, particularly lower unit fixed costs.

CVP analysis provides a means to predict the effect of sales growth on profits.

It also shows the risks in increasing fixed costs if volumes fall.

Strategic Questions Answered by CVP Analysis:

- 1. What is the expected level of profit at a given sales volume?
- 2. What additional amount of sales is needed to achieve a desired level of profit?
- 3. What will be the effect on profit of a given increase in sales?
- 4. What is the required funding level for a governmental agency, given desired service levels?
- 5. Is the forecast for sales consistent with forecasted profits?
- 6. What additional profit would be obtained from a given percentage reduction in unit variable costs?
- 7. What increase in sales is needed to make up a given decrease in price to maintain the present profit level?
- 8. What sales level is needed to cover all costs in a sales region or product line?
- 9. What is the required amount of increase in sales to meet the additional fixed charges from a proposed plant expansion?

CVP analysis begins with the basic profit equation.

Profit =Total revenue - Total costs

Separating costs into variable and fixed categories, we express profit as:

Profit = Total revenue -(Total variable costs +Total fixed costs)

We use the profit equation to plan for different volumes of operations.

CVP analysis can be performed using either:

- 1. Units (quantity) of product sold
- 2. Revenues (in dollars)

Contribution Margin :

Contribution margin per unit tells us how much revenue from each unit sold can be applied toward fixed costs it is:

C.M= P-V

contribution margin ratio (CMR) is the percent by which the selling price (or revenue) per unit exceeds the variable cost per unit, or contribution margin as a percent of revenue, it is

$$CMR = \frac{P - V}{P}$$

C.V.P Analysis applications: 1. The Break-Even Point:

The break-even point is the point in the volume of activity where the organization's revenues and expenses are equal.

Revenue= total cost

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SP × Q = (V × Q) + F
(SP×Q) - (V×Q)=F
Q (SP-V) = F
Q of B.E.P =F/(SP-V)
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c. Graphing Cost-Volume-Profit Relationships

Shows the relationship between total revenues and total costs; illustrates how an organization's profits are expected to change under different volumes of activity.

Consider the following information for X company.:

volume	fixed costs	variable costs	total costs	revenues	net profit(loss)
0	108000	0	108000	0	-108000
6000	108000	54000	162000	90000	-72000
12000	108000	108000	216000	180000	-36000
18000	108000	162000	270000	270000	0
24000	108000	216000	324000	360000	36000
30000	108000	270000	378000	450000	72000

Cost-Volume-Profit Graph



Profit-Volume Graph

Some managers like the profit-volume graph because it focuses on profits and volume. It is illustrates how the level of profits changes over different levels of output.



CVP Analysis application;

2. Target Net Profit

CVP analysis can be used to determine the level of sales needed to achieve a desired level of profit. Finding the desired profit involves:

- a. revenue planning: determine the revenue required to achieve a desired profit level.
- b. cost planning: find the value of the required variable cost or fixed cost to achieve the desired profit at the assumed sales quantity.
- c. accounting for the effect of income taxes.

We can determine the number of Unites that X must sell to earn a profit of \$100,000 using the contribution margin approach.

Units sold to earn the target profit

Fixed expenses+ Target profit Unit contribution margin

=

Trade-offs between Fixed and Variable Costs:

CVP analysis is used to determine the most cost effective trade-off between different types of costs.

Example:

Management is now considering the purchase of a new piece of production machinery that will reduce variable costs but also increase fixed costs by \$2,250 per month. How much must unit variable costs fall to maintain the current level of profit, assuming that:

Q = 2,700 units

v =an unknown (previously \$35)

F = \$5,000 + \$2,250 = \$7,250 per month (\$87,000 per year)

p = \$75

N = \$48,000 per year

$$p - v = \frac{F + N}{Q}$$

 $O = \frac{F + N}{1}$

$$v = p - \frac{F + N}{Q}$$

v = \$75 - (\$87,000 + \$48,000)/2,700 = \$25

Example:

Calista Company manufactures electronic equipment. It currently purchases the special switches used in each of its products from an outside supplier. The supplier charges Calista \$2 per switch. Calista's CEO is considering purchasing either machine X or machine Y so the company can manufacture its own switches. The projected data are Machine X Machine Y

The projected data are	Machine X	Machine Y
Annual fixed cost	\$135,000	\$204,000
Variable cost per switch	0.65	0.30

Required:

- 1. For each machine, what is the minimum number of switches that Calista must make annually for total costs to equal outside purchase cost?
- 2. What volume level would produce the same total costs regardless of the machine purchased?
- 3. What is the most profitable alternative for producing 200,000 switches per year?

2. CVP with Income Taxes

An organization's after-tax profit is calculated by subtracting income tax from pretax profit

After-tax profit can be calculated by:

Pretax profit =
$$\frac{\text{After-tax profit}}{(1 - \text{Tax rate})}$$

 $o = \frac{F + \text{Profit}}{P - V}$
Revenues = $\frac{F + \text{Profit}}{\text{CMR}}$

3. Margin of Safety:

The Margin of Safety is the difference between the expected level of sales and break-even sales.

It may be expressed in units or dollars of sales.

- 1. Margin of safety in units = Actual /estimated units of activity -Units at breakeven point
- 2. Margin of safety in revenues = Actual/ estimated revenue Revenue at breakeven point
- 3. The MOS Ratio removes the firm's size from the output, and expresses itself in the form of a percentage:

MOS Ratio = MOS ÷ Budgeted Sales

4. Sensitivity Analysis

- 1. CVP provides structure to answer a variety of "what-if" scenarios
- 2. "What" happens to profit "if":
 - A. Selling price changes
 - **B. Volume changes**
 - C. Cost structure changes
 - 1) Variable cost per unit changes
 - 2) Fixed cost changes

Sensitivity Analysis is based on

- 1. Changes in Fixed Costs
- 2. Changes in Unit Contribution Margin

6. CVP Analysis with Multiple Products

For a company with more than one product, sales mix is the relative combination in which a company's products are sold.

Different products have different selling prices, cost structures, and contribution margins. A weighted-average CM must be calculated (in this case, for two products)

This new CM would be used in CVP equations

Multi-Product BEP=Fixed CostsLet's assume X sells seeWeighted Average CM per unit
how we deal with break-even analysis.

Break-even	= <u>Fixed expenses</u> Weighted-average unit contribution margin			
Point in unit				
Weighted average CMu -	(Product #1 CMu x Product #1 Q) + (Product #2 CMu x Product #2 Q)			
Weighted average civid -	Total Units Sold (Q) for Products			
Break-even Point in dollar	= <u>Fixed expenses</u> Weighted-average unit contribution margin Ratio			
Weighted average CM percent	= (CM ratio Product #1) + (CM ratio x Product #2) Total revenue for Products			

Example:

X provides us with the following information:

Input section	Youth	Road	Mountain	Total
Expected sales volume-units	10,000	18,000	12,000	40,000
Price per unit	200	700	800	
Variable cost per unit	75	250	300	
Contribution Margin	125	450	500	
Fixed costs				14,700,000
Desired after-tax profit				100000
Income tax rate				30%

Contribution Margin	Youth Bikes	Road Bikes	Mtn. Bikes	Total Bikes
Units	10,000	18,000	12,000	40,000
Revenue	\$2,000,000	\$12,600,000	\$9,600,000	\$24,200,000
Variable costs	750,000	4,500,000	3,600,000	8,850,000
Contribution margin	<u>\$1.250.000</u>	<u>\$8.100.000</u>	<u>\$6.000.000</u>	\$15.350.000
Contrib. margin per unit	<u>\$125.00</u>	\$450.00	\$500.00	\$383.75
Contrib. margin ratio	<u>62.50%</u>	64.29%	<u>62.50%</u>	<u>63.43%</u>
Expected sales mix in units	25.00%	45.00%	30.00%	100.00%
Expected sales mix in revenues	8.26%	52.07%	39.67%	100.00%

7. Cost Structure and Operating Leverage

The cost structure of an organization is the relative proportion of its fixed and variable costs. Organizations with high operating leverage incur more risk of loss when sales decline. Operating Leverage (OL) : is the effect that fixed costs have on changes in operating income as changes occur in units sold, expressed as changes in contribution margin



Notice these two items are identical, except for fixed costs.

Operating leverage is:

a. the extent to which an organization uses fixed costs in its cost structure.

b. greatest in companies that have a high proportion of fixed costs in relation to

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Managers use the degree of operating leverage to measure the risk associated with their cost function and to explicitly calculate the sensitivity of profits to changes in sales (units or revenues):

<u>% change in profit = % change in sales × Degree of operating leverage</u>

• For example:

The variable cost per visit in Small Clinic was \$16.40 and the fixed costs were \$119,009. With budgeted visits of 3,800, the managers expected to earn a profit of \$46,671.

The expected degree of operating leverage using the contribution margin formula is then calculated as follows:

Degree of operating leverage =
$$\frac{(\$60 - \$16.40) \times 3,800 \text{ visits}}{\$46,671} = \frac{\$165,680}{\$46,671} = 3.55$$

Using the Degree of Operating Leverage to Plan and Monitor Operations

Managers need to consider the degree of operating leverage when :

- 1. they decide whether to incur additional fixed costs, such as purchasing new equipment or hiring new employees.
- 2. They need to consider the degree of operating leverage for potential new products and services that could increase an organization's fixed costs relative to variable costs.

If additional fixed costs cause the degree of operating leverage to reach what they consider an unacceptably high level, managers often use variable costs—such as temporary labor—rather than additional fixed costs to meet their operating needs.

Example:

The technicians are paid a salary and work 40-hour weeks. Suppose Clinic could hire parttime technicians at \$20 per hour instead of hiring full-time technicians at the current salaries of \$78,009.

If each visit requires about an hour of technician time, the new cost function would be :

TC = (\$119,009 - \$78,009) + (\$16.40 + \$20)Q

= \$41,000 + \$36.40*Q*

1. The breakeven point decreases considerably to:

1,738 visits [\$41,000 ÷ (\$60 - \$36.40) per visit] or \$104,280.

2. Profit at *Q* 3,800 visits is

\$48,680 [\$228,000 -\$41,000(3,800 visits × \$36.40 per visit)].

3. Operating leverage at 3,800 visits becomes 1.84:

[(\$41,000÷\$48,680)+1]

which is much lower than the 3.55 when technicians are a fixed cost.

Although operating leverage improved, the cost for technicians increased from \$18.75 per hour[\$78,009 ÷ (2 technicians ×2,080 hours per technician per year)] to \$20 per hour.

Advantages and Disadvantages of Fixed Costs

Common Advantages

Common Disadvantages

- 1. Fixed costs might cost less in total than variable costs.
- Companies might require unique assets (e.g., expert labor or specialized production facilities) that must be acquired through long-term commitments.
- 3. Fixed assets such as automation and robotics equipment can significantly improve operating efficiency.
- 4. Fixed costs are easier to plan; they do not fluctuate with levels of activity

- 1. Investing in fixed resources might divert management attention away from the organization's core competencies.
- 2. Fixed costs typically require a longer financial commitment; it can be difficult to reduce them quickly.
- 3. Underinvestment or overinvestment in fixed costs could affect profits and may not easily be changed in the short term.