UNIT 9 COST-VOLUME-PROFIT ANALYSIS

Objectives

The aims of this unit are to:

- acquaint you with the nature of Cost-Volume-Profit analysis
- illustrate the factors which affect Cost-Volume-Profit relationships
- examine the role of break-even analysis by elaborating the Cost-Volume-Profit framework.
- discuss the applications of Cost-Volume-Profit relationships in specific decisions

Structure

9.1 INTRODUCTION

Managers have to take frequent decision which involve considerations of selling prices, variable costs, and fixed costs. Many of these decisions are a part of their planning responsibilities and have, as such, to be based on predictions about costs and revenues. Almost every question that is posed has a `cost-profit' aspect. you may react to what Horngren (1985, p43) states about cost-volume-profit relationships:

"Cost -volume-profit analysis is a subject inherently appealing to most students of management because it gives a sweeping overview of the planning process and because it provides a concrete example of the importance of understanding cost behaviour-the response of costs to a wide variety of influences."

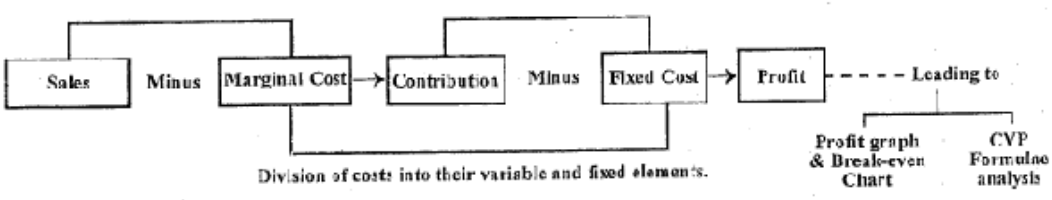
Probably, you belong to the category of management students identified by Horngren. If you have a propensity to know about the planning process and the cost behaviour, you are sure to get at once interested in the study of cost-volume-profit relationship.

9.2 WHAT IS *CVP* ANALYSIS?

The Cost -Volume-Profit (CVP) analysis is an attempt to measure the effect of changes in volume, cost, price and products-mix on profits. You will appreciate that while these variables are inter-related, each one of them, in turn, is affected by a number of internal and external factors. For instance, costs vary due to choice of plant, scale of operations, technology, efficiency of work-force and management efficiency. Etc

Also, cost of inputs bought externally is affected by market forces. While many wide-ranging factors influence costs and profits, the largest single variable affecting them in the short-run is the volume of output. Hence, the CVP relationship acquires a vital significance for the manager facing a wide spectrum of short-run decisions like: what are the most profitable and what are the least profitable products? How does a reduction in selling prices affect profits? How does volume or product-mix affect product costs and profits? What will be the break-even point if volume and costs change? How an increase in wages and /or other operating expenses will affect profit? What will be the effect of plant expansion on costs, profit and volume of sales? Answers to all such questions will have to be formulated in a cost-benefit framework and CVP analysis will offer the technique for doing it.

You may, in fact, perceive CVP analysis as one ofthe decision-models which managers employ to choose among alternative courses of action. The basic (simplified) CVP model may be outlined as follows:



You may now be getting ready to comprehend the CVP concept. You will observe that profits are a function of the interplay of costs, prices, and each one of them is relevant to profit planning. In fact, variance between actual and budgeted profit arises due to one or more of the following factors: selling price, volume of sales, variable costs, and fixed costs.

You will also appreciate that these four factors which cause deviations in planned profits, differ from each other in terms of controllability by management. It is obvious that selling prices largely depend upon external farces. Costs, of course, are more controllable. But they pose a problem of measurement. This is more so when a firm manufactures two or more products. Nevertheless, a knowledge of fixed and variable costs is essential if costs are to be controlled. Consider a tenuous cost - volume-profit transit.

"Sales price change → volume change → unit cost change → profit structure change"

You may try an answer to the question: How will costs change in the foregoing situation? Would you succeed? Probably, not quite so at this stage! But the CVP decision model will of course have an answer within its own assumptive framework

9.3 INTERPLAY AND IMPACT OF FACTORS ON PROFIT

We have said above that costs and volume do influence profit. You wilhat observe more objectively the extent and nature of this impact with the help of an illustration. It is proposed to evaluate the effect of

- Price changes on net profit,
- volume changes on net profit,
- price and volume changes on net profit,
- an increase or decrease in variable costs on net profit,
- an increase or decrease in fixed costs on net profit,
- all four factors viz., price, volume, variable costs, and fixed costs on net profit.

Illustration 9.1

The following assumptions are made in the illustration: normal sales volume is 2,00,000 units at a selling price of Rs. 2 per unit; capital investment is Rs. 2,00,000 and management expects to earn a fair return on it: fixed costs are Rs. 1,60,000; variable expenses are Re. 1 per unit.

Solutions for the three situations are tabulated separately. The control column of each table shows, normal volume' and a decrease in volume/price by 10% and 20% is shown on the left, while an increase in volume/price by the same percentages is shown on the right of the `central column', calculations show not only net profit or loss for each set of conditions but also the net profit per unit, the percentage return of investment, and the break-even point.

Influence of price changes on Net Profit.

Table 9.1

Particulars	Decrease in price		Normal	Increase in Price	
	20%	10%	Volume	10%	20%
Units	2,00,000	2,00,000	2,00,000	2,00,000	2,00,000
Sale (Rs.)	3,20,000	3,60,000	4,00,000	4,40,000	4,80,000
Variable cost (Rs)	2,00,000	2,00,000	2,00,000	2,00,000	2,00,000
Marginal Income (Rs.)	1,20,000	1,60,000	2,00,000	2,40,000	2,80,000
Fixed costs (Rs.) '	1,60,000	1,60,000	1,60,000	1,60,000	1,60,000
Net Profit (Net Loss) Rs	(40,000)	0	40,000	80,000	1,20,000
Net Profit (Net loss)	(.20)	-	.20	.40	.60
per unit (Rs.)	- 200 %	100%		+ 100%	+ 200 %
% change in profit					
Return on investment	-20%	0%	20%	40%	60%
Break-even point rupee sales	4.26.667	3.60.000	3.20.000	2.93.333	2.74.286

You may note the following from the above situation: (a) a 10% decrease in price reduces profit to zero, while a 10% increase in price increases profit by 100%.
(b) with lower selling prices and a constant volume, the break-even point increases.

This happens because a reduction in sales revenue on account of decrease in sales price reduces the marginal income (contribution). A much greater number of units have to be sold in order to recover the fixed costs.

Influence of volume changes on Net Profit.

Table 9.2

Particulars	Decrease in volume		Normal	Increase in Volume	
	20%	10%	Volume	10%	20%
Units	1,60,000	1,80,000	2,00,000	2,20,000	2,40,000
Sales (Rs.)	3,20,000	3,60,000	4,00,000	4,40,000	4,80,000
Variable cost (Rs.)	1,60,000	1,80,000	2,00,000	2,20,000	2,40,000
Marginal income (Rs.)	1,60,000	1,80,000	2,00,000	2,20,000	2,40,000
Fixed costs (Rs)	1,60,000	1,60,000	1,60,000	1,60,000	1,60,000
Net Profit (Rs.)	-	20,000	40,000	60,000	80,000
Net Profit per unit (Rs.)	-100%	.11	.20	.273	.33
% change in profit	0%	-50%	-	+50%	+100%
Break-even point (Rs.) in sales	3,20,000	3,20,000	3,20,000	3,20,000	3,20,000

You may note here the following: (a) a 20% decrease in volume reduces sales to the break-even point which remains constant because variable costs change in proportion to sales. (b) a 20% increase in volume improves profit by 100% . A similar increase in price (viz., by 20%) increases profit by 200% (see above).

Influence of changes in prices and volume on Net Profit.

Table 9.3

Particulars	Increase in price and Decrease in Volume		Normal Volume	Decrease in Price and Increase in Volume	
	20%	10%		10%	20%
	20%	10%		10%	20%
Units	1,60,000	1,80,000	2,00,000	2,20,000	2,40,000
Sales (Rs)	3,84,000	3,96,000	4,00,000	3,96,000	3,84,000
Variable costs (Rs.)	1,60,000	1,80,000	2,00,000	2,20,000	2,40,000
Marginal income (Rs)	2,24,000	2,16,000	2,00,000	1,76,000	1,44,000
Fixed costs (Rs.)	1,60,000	1,60,000	1,60,000	1,60,000	1,60,000
Net profit/(Net loss) Rs	64,000	56,000	40,000	16,000	(16,000)
Net profit per unit Rs.	.40	.31	.20	.0727	(.066)
% change in profit	+60%	+40%	-	-60%	-140%
Return on investment	32%	28%	20%	8%	8 % loss
Break-even point (Rs.)	2,74,286	2,93,333	3,20,000	3,60,000	4,26,667

Please note in this situation that (a) the prices increase, as assumed would result in higher profits, even if it is accompanied by a decrease in volume of the same order. The reverse, however, is true of a price decrease accompanied by a volume increase,. (b) that the break-even point would be at its lowest when prices are increased and volume decreased because higher rupee volume with lower unit volume reduces the variable cost ratio.

Activity 9.1

You may continue your computations for the remaining three situations referred to at the beginning of this section and list your conclusions. The break-even point may be calculated with the help of the following formula:

You will observe from the conclusions derived from the above exercises that such operations would be found quite useful in all such cases where irrational tendencies for price-cutting or for achieving high sales volume exist.

Please note the following in our discussion so far with a view to develop under-standing for subsequent sections

1. CVP analysis explores the fundamental relationships between cost -volume-profiit variables. You will observe that changes in volume influence cost and profit and, while this process gets underway, a stage is reached when cost is equated with revenue at acertain level of output or at a certain volume of sales. This is recognised as `break-even point.' You must understand that 'break-even point',

   is a point which is incidental to CVP analysis and, therefore, attempts to define CVP analysis as break-even analysis, should be considered only restrictive. It must be admitted that break-even analysis does become an integral part of CVP analysis but the two are not co-terminus.

2. You will grasp the CVP fundamentals along the following routes

   a) First, the profit -volume relationship will be analysed and the basic framework *of* `Profit Graph' will be presented.

   b) The assumptions underlying the construction and analysis of a `Profit Graph' will be postulated and the concept of " Planned range of activity' will be discussed.

   c) A crucial step in the understanding of CVP analysis would be a segregation of costs into fixed and variable components. Procedures for doing this would be briefly examined.

   d) The concepts of `marginal cost' and `contribution' will be introduced and this will lead to `break-even analysis ' and `margin of safety'.

   e) After a look at the conventional break-even chart the use of such charts for various purposes will be demonstrated.

   f) Finally, CVP analysis will be presented in mathematical formulations. With this, you should be in a position to understand practical applications of CVP analysis for business decisions. You will be expected to do assignments on these aspects.

9.4 PROFIT GRAPH

A business Firm usually pursues a profit objective. In a way, it plans for maximising its profit. Both the operations plan and the over-all plan of the firm are couched in terms *of* this `profit objective; and their primary variables are cost, volume, and profit forecast for the planning period (or horizon). The critical variable is usually the `volume *of* sales forecast' around which costs and profit estimates are built.

A question often faced in the planning stage itself is: what will happen to profit if the forecast level of sales changes? Such a question will not always be irrelevant because conditions change so rapidly. A manager seeking an appropriate answer to this question would obviously want to get some guidance. The profit graph which shows the relationship between profit and volume (P/V relationship) helps to provide the questioning manager a possible answer.

You will recall from the calculations presented in the previous section about gauging the impact of changes in price, volume, etc., on profit that a term called 'marginal income' was calculated (please see item number 4 in each of the Tables 9.1, 9.2 and 9.3). Please note that, `marginal income' is the difference between sales and variable expenses and represents total contribution to fixed expenses and profit. This term may be understood in another way as well. If variable expenses are expressed as a per cent of sales we get the variable cost ratio. Then, total contribution or marginal income is equal to "1-variable cost ratio". In all the three situations given in Section 9.3, the variable cost ratio for the normal volume of sales is 50% or .50. Total contribution or marginal income would , therefore, be 1-.50 = .50 or 50%. Another term for `marginal income' is P/V ratio or the profit -volume ratio. **You must note that the P/V ratio is not obtained by dividing sales volume by profit but by deducting the variable cost ratio from unity (1)**

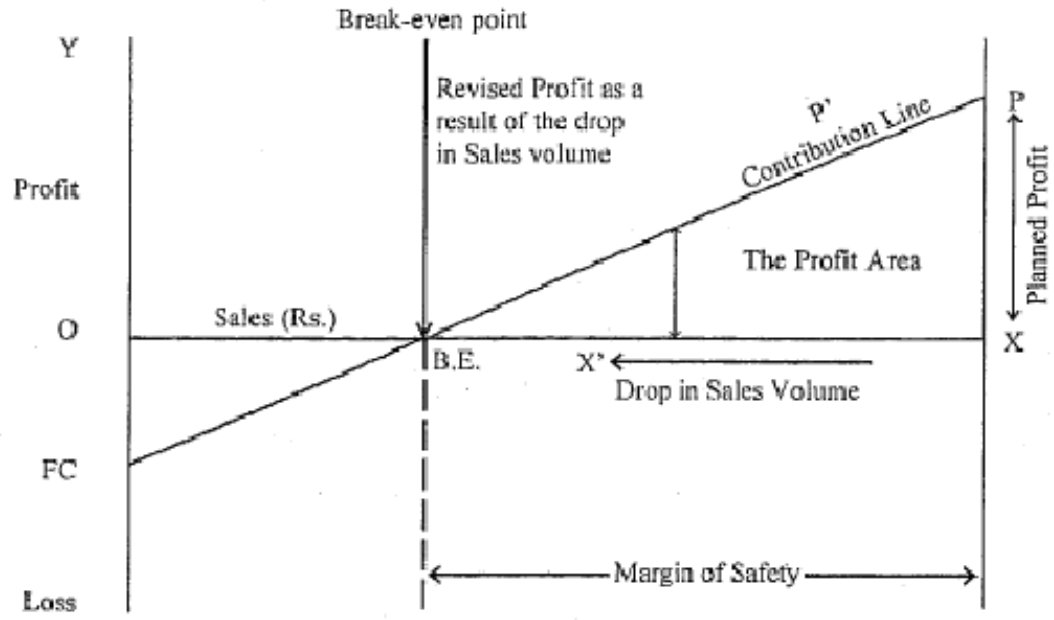


Figure 9.1: Profit Graph

With the basic purpose of the profit graph and some of its vital variables having been clarified, you may now move on to a hypothetical profit graph with a view to comprehending relationships involved .Figure 9.1 provides this graph. We may explain the construction of the graph to you and will then specify the assumptions behind this graph in the following section. OX on the X-axis provides sales volume, and OY on the Y -axis plots profit above 0 and loss below O.OFC measures the fixed cost. The line FCP joins two points viz. FC the fixed cost and P the profit expected to be released as the profit-volume plan. The area encompassed by XBE is the margin of safety while the point BE is the break-even point. BEPX is the profit area and the line FCBEP is the total contribution or the PV line. If the sales volume does not materialise at point X, as per the plan, and drops to X' the profit zone will shrink to a new profit area BEX'. Further declines in sales volume will be absorbed by the margin of safety after which losses will begin showing up. All these points will come up for further clarification in subsequent sections.

Activity 9.2

		Yes	No
1	The cost -Volume-Profit analysis is another name given to break-even analysis	[ ]	[ ]
2	CVP relationships aid in planning	[ ]	[ ]
3	CVP analysis is on a profit-volume graph; hence cost is an irrelevant variable.	[ ]	[ ]
4	Profit responses to price increases are greater than to price reductions.	[ ]	[ ]
5	P/V ratio is obtained by dividing sales volume by profit.	[ ]	[ ]
6	Lower selling prices will push up the break-even point if:	[ ]	[ ]

a) Volume remains constant

b) profit targets are raised

c) plant capacity is expanded

d) new products are added

e) none of the above.

7 The margin of safety is the difference between [ ] [ ]

a) planned sales and actual sales

b) planned sales and break -even sales

c) planned profit and realised profit

d) planned profit and fixed profit

e) none of the above.

8 If sales volume of a firm is Rs. 10 lakhs, variable costs are Rs. 6 lakhs, profit is Rs. 2 lakhs, the P/V ratio will be [ ] [ ]

a) 20 per cent

b) 33 per cent

c) 40 per cent

d) 60 per cent

e) none of these

9 The proposition that the break-even point would be at its lowest when prices are increased and volume decreased is [ ] [ ]

a) generally true

b) seldom true

c) true in the case of a multi-product firm only

d) never true

e) none of these

10 To be able to control, costs must be segregated into fixed and variable.

[ ] [ ]

Assumptions in Profit Graph

You have seen the Profit Graph and have got your first exposure to it. May be, few doubts have started bothering you. Your queries may take the following form: "How will the total contribution line emerge as straight line if variable costs per Unit do not remain constant, or if efficiency of operations improves within the planned range of activities, and so on?" You are probably right in thinking so.

We have already stated that the CVP is a decision-model and, as with most such models, there are some simplifying assumptions which undoubtedly make the underlying analysis a bit unreal but nevertheless easier to comprehend.

You may consider the following assumptions in particular:

a) Variable costs are a constant cost per unit of volume. This will mean that the variable cost rate is constant even if the total variable costs will increase in direct proportion to increase in output volume or sales quantum.

b) Total fixed costs remain constant throughout this planned range of activity.

c) Efficiency of operations remains unchanged throughout the planned range of activity..

d) All costs and particularly, the semi-variable and mixed costs can be separated into fixed and variable elements.

e) Selling prices per unit of sale remain constant

f) Sales-mix for a multi-product firm remains constant.

g) Volume is the only relevant factor affecting cost.

h) Factor prices e.g. material prices, wage rates etc., remain unchanged.

i) Costs and revenue are being compared on a single activity base e.g., sales value of output or units produced. Further, stock levels will not vary significantly in the period covered by the plan.

j) Variations in opening and closing inventories are insignificant. The important implications are: there is a relevant range of activity over which cost behaviour is linear; all prices remain unchanged; and costs can be classified into fixed and variable costs.

Activity 9.3

You have studied cost behaviour patterns in the unit on `Understanding and Classifying Costs'. This behaviour is relevant to CVP analysis as you must have noted. If it is taken that the set assumptions about cost behaviour are nowhere near the real life situation, the whole exercise is reduced to a hypothetical pictorial presentation. With this backdrop, examine the truth of the following statement:

The idea of a relevant range to justify linear rather than non-linear cost patterns may not be correct but "a linear expression of total cost may often be a reasonable reflection of reality". (Middleton, 1980)

(Hint: It is plain that the accountant's assumptions are unrealistic. But he does not seem to be very much in error; firstly, because obtaining more accurate cost functions is both difficult and expensive. Often, the cost of obtaining more accurate data would exceed the value of any additional information that may be gained from such accurate data: secondly, because most decisions that managers take are within the relevant range of volume where the linearity assumption may not appear unreasonable).

9.5 COST SEGREGATION

Some broad guidelines may be suggested to divide costs into two dominant groups viz., fixed and variable. They are listed below:

a) Costs which remain invariant to volume of activity would be considered fixed. In fact, no costs are fixed forever. The concept is relative to the planning horizon (usually a short-run one) and to the relevant range of activity.

b) Costs which vary in direct proportion to volume of activity will be classified as variable costs.

c) Costs which otherwise belong to a mixed category, i.e., which neither belong neatly to category (a) nor to category (b) above, would, in fact, be apportioned to one of the two categories viz., fixed or variable.

If a mixed cost varies in some (not direct) proportion to output or volume of activity, it will be classed as variable cost. If a mixed cost, on the other hand, is predominantly fixed, it would be classed as a fixed cost.

Activity 9.4

Give some examples (other than you gave in Unit 7) of each of the cost categories stated in this Section.

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Methods to segregate costs

In the previous unit, various methods of segregating semi-variable costs into fixed and variable elements were discussed. Here, we repeat two statistical techniques which may be employed to separate fixed costs and variables costs.

- Least squares
- Scatter Diagram

We illustrate these methods.

Illustration 1

Least Squares: Power charges are a semi-variable or a mixed cost of Aravali Ltd. It is proposed to segregate them into fixed and variable components, using the method of least squares.

Monthly data regarding direct labour hours and electricity charges are given below:

Month	Direct Labour hours (000)	Electricity Charges Rs.
January	34	640
February	30	620
March	34	620
April	39	590
May	42	500
June	32	530
July	26	500
August	26	500
September	31	530
October	35	550
November	-43	530
December	48	680
Total:	420	6,840

The following calculations are made for the variable rate and the fixed element of electricity charges:

$$\text{Variable rate: } \frac{\sum xy}{\sum x^2}$$

Fixed element : Y = a+bx

Where Y is the dependent variable, x is the independent variable, (i.e., direct labour hours in the example), a is the constant i.e, the fixed cost element to be solved, and b is the slope of the regression line i.e., the variable cost per unit.

Calculation of Fixed and Variable Elements

Month	Direct labour Flours X (`000)	Deviation from mean x=35	Electricity Expenses Y	Deviation From mean y=570	x^2	xy
January	34		640	+70	1	-70
February	30	-5	620	+50	25	-250
March	34	-1	620	+50	1	-50
April	39	+4	590	+50	16	+80
May	42	+7	500	-70	49	-490
June	32	-3	530	-40	9	+120
July	26	-9	500	-70	81	+630
August	26	-9	500	-70	81	+630
September	31	-4	530	-40	16	+160
October	35	0	550	-20	0	0
November	43	+8	580	+10	64	+80
December	48	+13	680	+110	169	+1430
					$\sum x^2=512$	$\sum xy=2,270$

$$\text{Variable electricity rate } b = \frac{\sum xy}{\sum x^2}$$

$$= \frac{2270}{512} = 4.4 \text{ paise per thousand labour hours}$$

= 44 Paise per 100 labour hours

or .0044 per labour hour.

Fixed element of electricity charges `a' can be found out by substituting values in the equation, a + bx, where

Y=570

X = 35,000 labour hours

we get : Rs. 570 = a + .0044 (35000)

Rs. 570 = a + Rs. 154

Rs. 570 – Rs: 154 = a

Rs. 416 = a (the fixed element)

Scatter Diagram: The regression equation calculated above may be fitted by free hand on a diagram where direct labour hours are plotted on the X-axis and electricity charges are plotted on the Y-axis. There will be 12 points scattered within the quadrant space of the graph. A line may be made to pass through these points so that there is roughly an equal member of points above and below the line. The vertical intercept of the regression line thus drawn (i.e., the point at which the line intersects the Y-axis) will measure the fixed element of the electricity charges.

The slope of the regression line may be found to ascertain the variable rate per 100 labour hours. Alternatively, the fixed expense as given by the vertical intercept may be multiplied by 12 to get the annual fixed expenses on electricity. This may be deducted from the total electricity charges of Rs.6,840. The balance may be divided by the total annual labour hours viz. 4,20,000 hr., and that quotient would be the approximate rate per labour hour.

Activity 9.5

You may draw the scatter diagram using the data given in the example and follow the procedure outlined above. Then, determine the fixed and variable elements of electricity charges. Verify your results with the results computed above.

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9.6 MARGINAL COST AND CONTRIBUTION

Once the fixed and variable costs are segregated it becomes possible to calculate the total contribution as well as total contribution per unit. You will recall that total contribution is equal to the difference between sales and variable (marginal) costs. Total contribution per unit is expressed in per unit terms by dividing both sales and variable costs by the total number of units and deducting per unit variable cost from per unit selling price. Total contribution may be directly divided by total number of units to obtain similar results.

You should remember that total contribution is the contribution of sales revenue to fixed cost recovery and profit after meeting the total variable costs.

You may also recapitulate that total contribution may also be expressed as a percentage in which case it is recognised as P/V ratio. This is '1-variable cost' ratio. And variable cost ratio is sales divided by total variable cost.

You must understand now the basic thrust of the Profit Graph presented in an earlier section. So far, you must be wondering how the contribution line was plotted on that graph. Now, probably, it is easier to comprehend. **The contribution line is, in fact, obtained by plotting contribution per unit figures against different levels of sales values.**

You may switch back to the Profit Graph and have a closer look at the contribution line. This line originates from the loss zone and raises up to the break-even point BE on the sales volume line. You may interpret this part of the contribution line up to BE i. e. the break-even point as indicative of the recovery of fixed costs only. It is only after this point that the contribution line combines itself with the X-axis and the right Y-axis to form a triangle PXBE which has been marked as the profit area.

Break-even Point

We had earlier stated that the break-even point is not all that is contained in the CVP analysis. It is only incidental to such an analysis. You have already seen that the break-even point is just one point on the whole journey of the contribution line as it transits from the fixed cost point F to the profit point P via the sales revenue line viz, the X-axis . The horizontal intercept of the contribution line at BE is the break-even point. At this point, total costs and total revenues are held in equilibrium and a no-profit no loss position emerges.

Margin of Safety

The Profit Graph, while revealing the estimated profit or loss at different levels of activity also suggests the magnitude by which the planned activity level can fall before a loss is experienced. This is known as the Margin of Safety and is obtained by deducting the break-even sales from the planned sales.

A graphical glimpse into cost-volume -profit structures: Two cases of companies A and B are presented. You may examine the sales and total cost lines and offer your comments. You should note the differences between these graphs and the profit graph presented earlier.

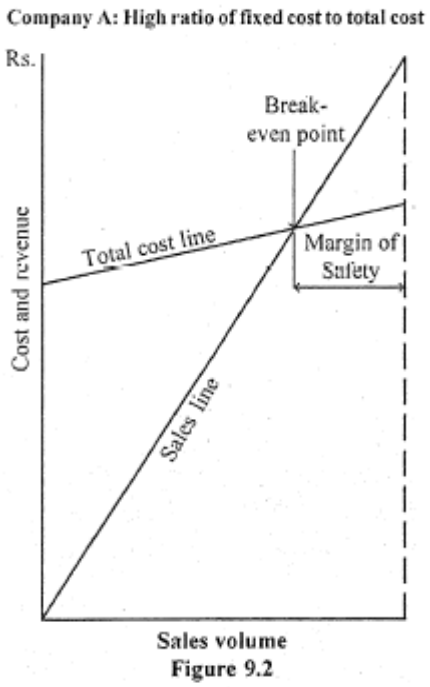

Figure 9.2

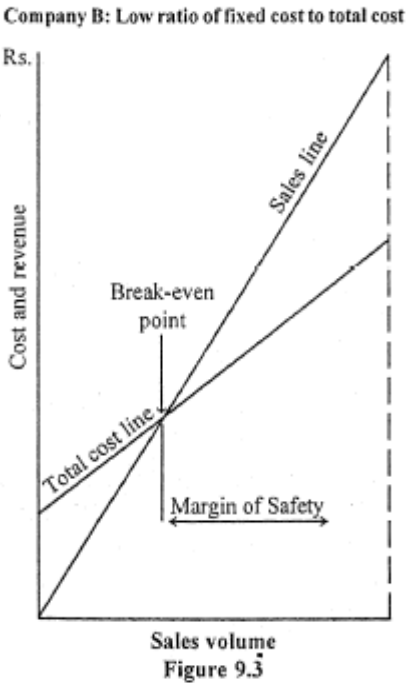

Figure 9.3

A major difference between companies. A and B is in terms of the location and slope of their respective total cost line. Company A has a high ratio of fixed cost to total cost because the vertical intercept of its total cost line is very high. In contrast, company B's vertical intercept is quite low and it has accordingly a low ratio of fixed costs to total costs. The following results follow:

a) Once the break-even point is reached for company A, large profits are made quickly as volume rises. The profit growth for company is slower after this break-even point.

b) Company B, however, has larger Margin of Safety than company A and can, therefore, sustain difficult business spells without immediately cutting down on its level of activity. Company A cannot hazard a similar course and may have to shut down much earlier.

Break-even Chart

You will appreciate the break-even analysis is a transitional stage of CVP analysis. Many authors in fact, discuss the interchangeability of these two because the derivation of break-even analysis from CVP analysis is very subtle.

The break-even chart also emerges from the Profit Graph, but the contribution line is replaced by the total cost. The new relationships which must receive attention in the wake of this major change, viz., replacement of the contribution line by the total cost line are presented in the two graphs below:

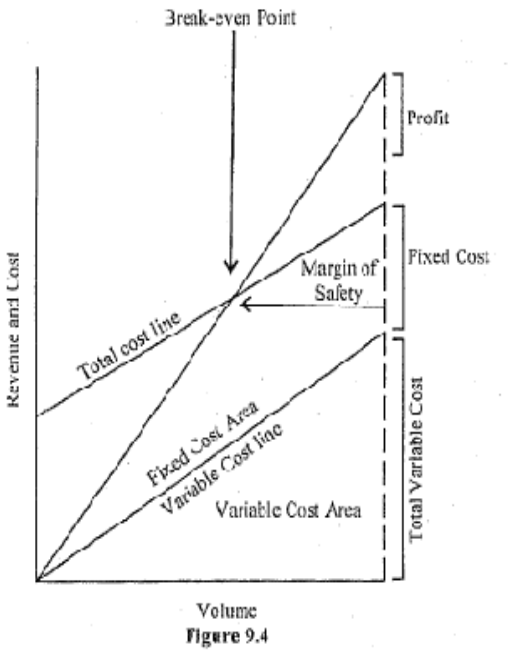

Figure 9.4

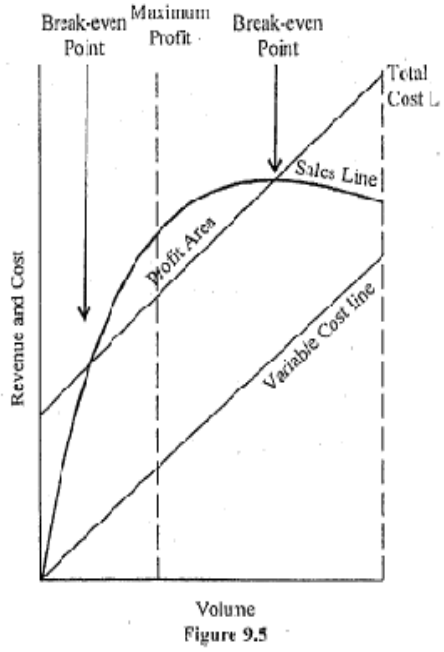

Figure 9.5

Figure 9.4 provides an idea of a conventional break-even chart. Figure 9.5, however, depicts a situation where sales revenue may have declined as a result of lowering selling prices to liquidate a higher volume of goods and the company moves into a situation where loss is incurred. The point of maximum profit is also shown on the graph.

Purpose of Break-even Charts

The figures presented in this sub-section provide a glimpse of the uses to which break-even analysis can be put to. The objective is to offer a visual comprehension of a few illustrative situations. This will hopefully make the mathematical section more comprehensible.

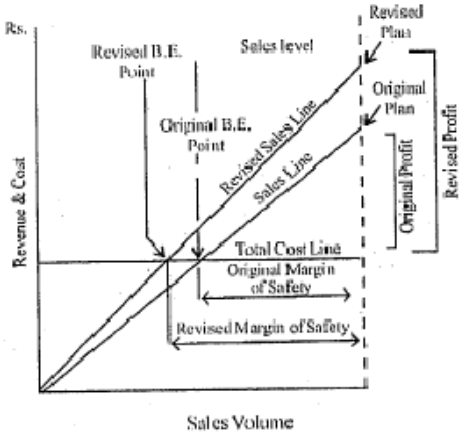

Fig. 9.6 : Effect of Sales price changes on Profits.

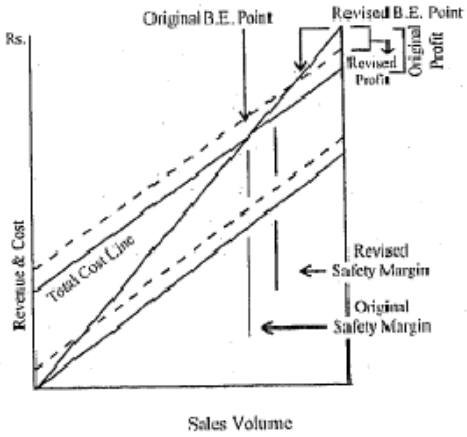

Fig. 9.7 : Effect of increase in variable cost

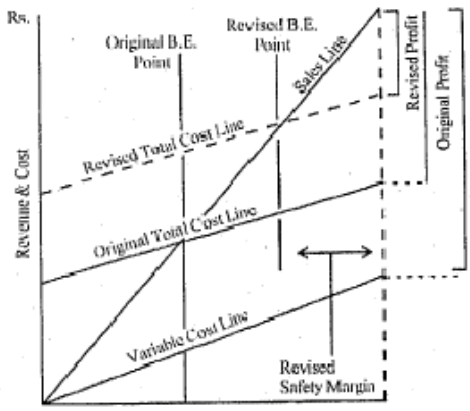

Fig. 9.8 : Effect of increase in fixed cost

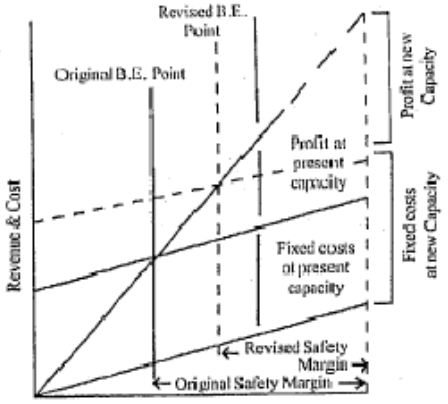

Fig. 9.9 : Effect of increase in capacity

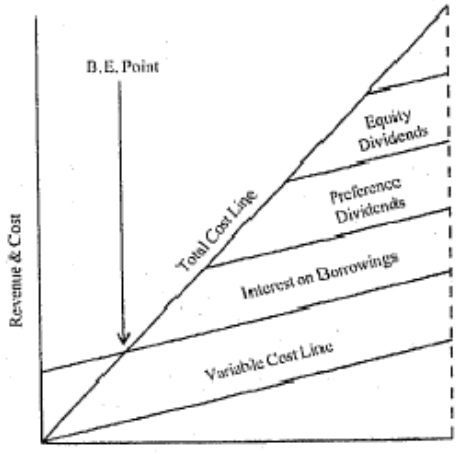

Fig. 9.10 : Effect of profit appropriation

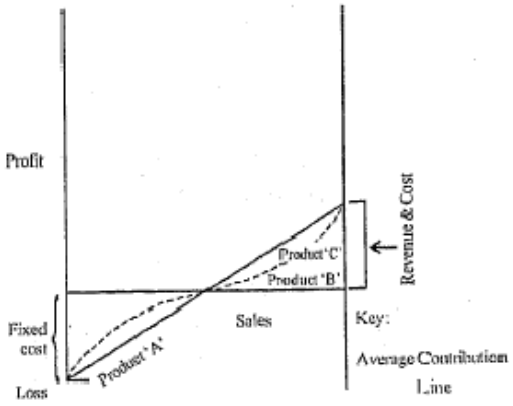

Fig. 9.11 : Contribution effect of three products to overall profitability

Activity 9.6

Study Figures 9.6 through 9.11 and note your comments on important conclusions that you would arrive at from each Figure.

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CVP and Break-even Analysis : A resume

This concluding section of the unit presents CVP relationship and break-even application in the form of mathematical formulations.

The following abbreviations are used:

FC = Fixed Cost

C = Contribution

P = Profit

S = Sales

P/V ratio = profit-volume ratio

BE point = Break-even point

MS = Margin of Safety

VC = Total Variable Cost

1 FC = C- P or alternatively (P/V ratio x S) P

2 C = FC + P or alternatively P/V ratio x S

3 BE point:

a) In terms of sales value (Rs.)

$$BE = \frac{FC}{C} \times S \quad \text{or alternatively} \quad \frac{FC}{P/V \text{ ratio}} \text{ or } \frac{FC}{1 - \frac{VC}{S}}$$

b) In terms of sales volume (Units)

$$BE = \frac{FC}{C \text{ per unit of product}}$$

4 MS = S – BE point

5 P = C – FC or alternatively P/V ratio × MS

6 $MS \text{ ratio} = \frac{P}{P/V}$ or alternatively

$$\frac{\text{Actual sales} - \text{BE sales}}{\text{Actual sales}}$$

Illustration 9.2

The following data relates to a firm for an accounting period:

	Rs.
Sales	20,000
Variable cost	12,000

Contribution	8,000
Fixed cost	6,000
Profit	2,000

$$\text{P/V ratio} = \frac{8,000}{20,000} = 40\%$$

Units manufactured and sold 10,000

The following changes have been planned:

a) Fixed cost increases to Rs. 7,000

b) Selling price per unit reduced to Rs. 1.50

c) Rs. 2,000 minimum additional profit is required for additional fixed cost of Rs. 1,000.

d) Extra profit is also required and this is put at Rs. 1,000.

The new P/V ratio is $\frac{3,000}{15,000} = 20\%$

Applications of CVP Formulae:

A Determination of the level of sales (Rs.)

a) To achieve a given profit when fixed cost and P/V ratio are known:

$$\frac{\text{Given profit} + \text{fixed cost}}{\text{P/V ratio \%}}$$

Example: $\frac{2,000 + 6,000}{40\%} = \text{Rs. } 20,000$

b) To maintain the current profit after an increase in fixed cost when the new fixed cost and original P/V ratio are know:

$$\frac{\text{Current profit} + \text{New Fixed cost}}{\text{P/V ratio \%}}$$

Example: Using change in information as given in (a):

$$\frac{\text{Rs. } 2,000 + \text{Rs. } 7,000}{40\%} = \text{Rs. } 22,500$$

Proof :	Contribution = 40% of Rs. 22,500	Rs. 9,000
	Less fixed cost	Rs, 7,000
	Profit	Rs. 2,000

c) To earn a minimum return on a new investment in plant and machinery as well as the current profit when new fixed cost and original P/V ratio are known :

$$\frac{\text{Current profit} + \text{Minimum return on additional profit} + \text{New Fixed cost}}{\text{P/V ratio \%}}$$

Example : Using change in information as given in (c) :

$$\frac{\text{Rs. } 2,000 + 2,000 + 7,000}{40\%} = \text{Rs. } 27,500$$

Proof :	Contribution = 40% of Rs. 27,500	Rs. 11,000
	Less fixed cost	Rs, 7,000
	Profit	Rs. 4,000

d) To achieve an increased profit when current sales level and P/V ratio are know and when no change is envisaged in fixed cost.

$$\text{Current sales level} + \frac{\text{Increased profit required}}{\text{P/V ratio \%}}$$

Example: Using change in information in (d):

$$\text{Rs. } 20{,}000 + \frac{1{,}000}{40\%} = \text{Rs.}22{,}500$$

Proof:	Contribution = 40% of Rs. 22,500	Rs. 9,000
	Less fixed cost	Rs. 6,000
	Profit	Rs. 3,000

B Determination of Sales Volume in units:

e) To maintain the current profit when a reduction in selling price is contemplated, given current contribution, new P/V ratio, new selling price per unit:

$$\frac{\text{Total Contribution before price reduction}}{\text{New P/V ratio as a result of the price reduction}} \div \text{New selling price per unit}$$

Example: Using change in information in (b):

$$\text{Rs. } \frac{8{,}000 \div \text{Rs. } 1.50}{20\%}$$ 26,667 units

Proof:	Sales 26,667 × 1.50	Rs. 40,000
	Variable Cost 26,667 × 1.20	32,000
	Contribution	8,000
	Fixed Cost	6,000
	Profit	2,000

f) To maintain the current profit after an increase in fixed costs, given the new fixed cost, contribution per unit, and constant P/C ratio.

$$\frac{\text{New fixed cost} + \text{Profit before increase in fixed cost}}{\text{Contribution per unit}}$$

Example: Using change in information in (a):

$$\frac{\text{Rs.}7{,}000 + 2{,}000}{.80}$$ 11,250 units

Proof:	Contribution = 11,250 × . 80	Rs. 9,000
	Less fixed cost	7,000
	Profit	2,000

9.7 SUMMARY

Cost volume profit analysis provides a framework within which the impact of volume changes in the short-run may be examined on profit. Cost behaviour is added as a dimension and corresponding changes in profit, break-even point, and margin of safety are observed.

Break-even analysis is an integral part of CVP analysis, even though the former is just incidental to the latter.

CVP analysis is used as a tool of planning. A profit plan is essentially to be based on it. A number of managerial decisions are often premised on this vital tool of analysis. Examples of such decision are: distribution channels, outside contracting, sales promotion expenditures, and pricing strategies.

The conventional break-even chart is based on a number of assumption, the most relevant being the 'planned range of activity', The `short-run,, and `linearity of cost functions'.

Many useful conclusions can be drawn from CVP and break-even analysis. Notice, for example, the following:

a) A firm with a high proportion of fixed cost to total cost is accompanied by a high break-even point, and carries a potential for substantial profits once the break-even point is reached.

b) A company with a low proportion of fixed cost to total cost, on the other hand, commands greater flexibility in terms of profitable operation.

c) An increase in sales prices lowers the break-event point and increases the margin of safety.

d) An increase in costs pushes up the break-event point and lowers the margin of profit.

9.8 KEY WORDS

CVP analysis is a technique of analysis to study the effects of costs and volume variations on profit.

Break-even point is a level of sales (volume or value) where total costs and total revenues are equal.

Margin of safety is the excess of sales, budgeted or actual, over the break-even sales volume. It shows the amount by which sales may decrease before losses occur.

Margin of safety ratio is a relative expression of margin of safety and is obtained by dividing the sales with actuahat (or budgeted) sales.

Unit contribution line is the relationship between contribution (i.e., sales minus variable costs) per unit and different sales levels shown on a profit graph.

Profit Graph is a depiction of the unit contribution hatine on a graph with sales on the horizontal scale and profit/fixed cost/ loss on the vertical scale.

PV ratio is the percentage of contribution to sales.

Variable cost ratio is the percentage of variable costs to sales value.

Mixed costs are costs which carry both fixed and variable element. These are also known as semi-variable costs.

9.9 SELF-ASSESSMENT QUESTIONS/EXERCISES

1 What is CVP analysis? Does it differ from break-even analysis?

2 How do you compute the break-even point?

3 Though the break-even chart and profit graph intend to show the same information, they seem to differ from each other'. Examine and explain the statement

4 'This break-even approach is great stuff. All you need to do is worry about variable costs. The fixed costs will take care of themselves.' Discuss.

5 What is meant by margin of safety? How is it determined?

6 You are asked to employ break-even analysis for suggesting likely profits and losses at different levels of sales activity. Do you think your report would be invalidated by certain factors? Give your answer with examples.

7 Please state whether the following statements are true or false:(T/F)

a) Mixed costs are used independent of fixed and variable costs in cost-volume profit analysis

b) The variable cost ratio is 1-P/V ratio.

c) The higher the break-even point the lower the fixed costs.

d) An increase in total costs unaccompanied by a change in sales reduce the margin of safety.

e) Semi- variable costs cannot be separated into fixed and variable elements.

f) Break-even analysis is invalid for a multi-product firm.

8 Increase in capacity reduces the margin of safety if

a) total costs remain unchanged.

b) fixed costs at new capacity are increased.

c) fixed costs increase and sales grow.

d) variable costs per unit increase.

e) none of the above.

9 If sales and fixed costs remain unchanged, contribution will remain unchanged only when.

a) revised profit increases

b) margin of safety is increased

c) fixed costs increase

d) total variable costs remain constant

e) none of the above

10 An increase in variable costs

a) reduces the contribution

b) increases the P/V ratio

c) increases the margin of safety

d) increases the new profit

e) none of above

11 An increase in sales price

a) does not affect the break-even point

b) lowers the break-even point

c) increases the break-even point

d) lowers the new profit

e) none of the above

12 Budget sales of a firm are Rs. 1 crore, fixed expenses are Rs. 10 lakhs, and variable expenses are Rs. 50 lakhs. The expected profit in the event of 10 % increase in total contribution margin and constant sales would be

a) Rs. 40,00,000
b) Rs, 60,00,000
c) Rs. 45,00,000
d) Rs. 55,00,000
e) None of the above

13 If the ratio of variable costs to sales of a firm is 30% and its fixed expenses are Rs. 63,000, the break-even point would be

a) Rs. 90,000
b) Rs. 18,900
c) Rs. 71,100
d) Rs. 81,900
e) None of the above

14 Total fixed costs of firm are Rs. 9,000 total variable costs are Rs, 15,000 total sales are Rs. 30,000 and units sold are 10,000. The margin of safety is

a) 5,000 units
b) 8,000 units
c) 4,000 units
d) 6,500 units
e) None of the above.

15. If the variable cost per unit is Rs.10, fixed costs are Rs. 1,00,000 and selling price per unit is Rs.20 and if the break-even point is lowered to 8000 units, the selling price would be

a) Rs.25.00
b) Rs.30.00
c) Rs.27.50
d) Rs.22.50
e) None of the above

16. Where total costs are Rs.60,000, fixed costs are Rs. Rs.30,000 and sales are Rs.1,00,000 the break-even point in Rs. would be

a) Rs.50,450
b) Rs. 42,857
c) Rs.45,332
d) Rs.60,000
e) None of the above.

17. A company manufactures and sells four types of products under brand names A, B, C and D. The sales mix in terms of value is 33 3 %, 413 %, 16 3 **%o** and 8 3 % for A, B, C and D respectively. The total budgeted sales are Rs. 60,000 per month.

Operating costs are:

Product A 60% of selling price

Product B 68% selling price

Product C 80% of selling price

Product D 40% of selling price

Fixed costs amount to Rs.14,700 per month

You are required to

a) calculate the break even point for the products on an overall basis, and

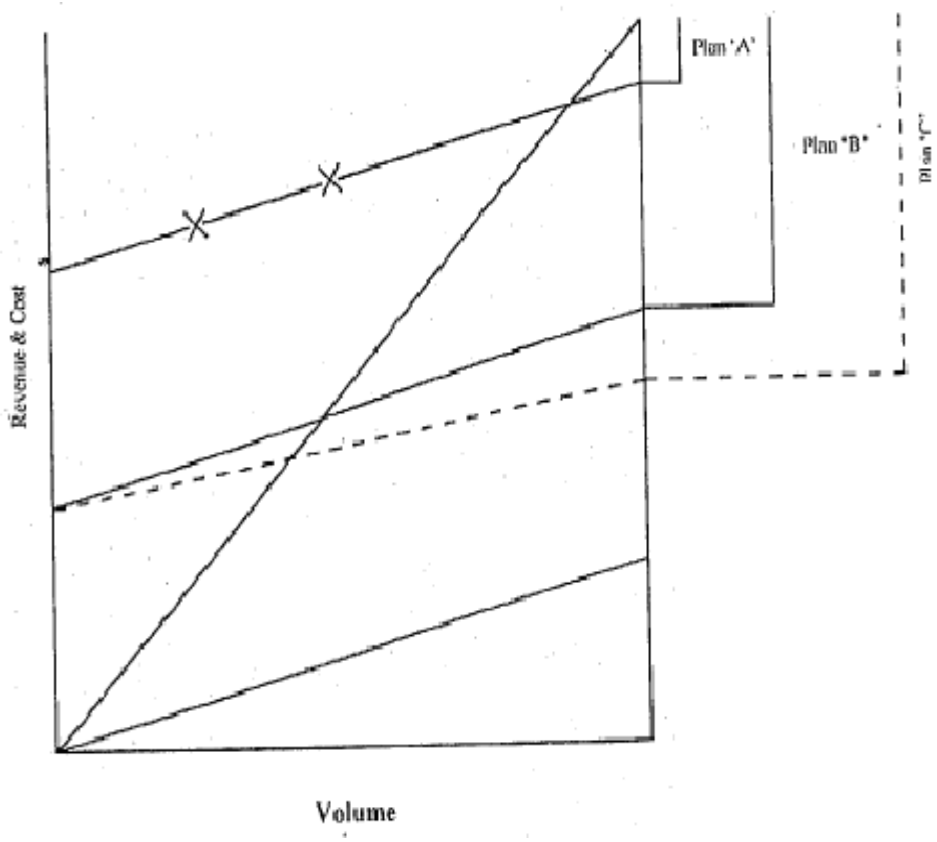
b) calculate the new break even point if the sales mix undergoes the following change:

Products	**Sales mix**
A	25%
B	40%
C	30%
D	5%

c) describe and explain the main factor which contributes to a shift in the break-even point in the new position.

18. Janata Ltd. reported poor profits for the previous year. This point came up to discussion at a management meeting convened to discuss profitability in the following year. Bhasker Mitter, the Sales Manager, has attended the said meeting. He stressed his belief that greater volume in terms of sales was the answer to the problem of the company. An increase in volume in the previous year had not materialised. In fact, the sales value was the same as the year before with no major volume change, and yet the profit had dropped. Bhaske Mitter mentioned that products 423 had not sold in the current year as well as it did in the previous year. Acharya, the factory manager, expressed the hope that Bhasker Mitter would achieve a higher sales level next year because he had taken delivery of a costly and new pieces of plant and machinery and this should an increased rate of production.

Purnendu Kumar, the Managing Director, presented the following chart submitted by his accountant, Naveen Sethi, in his efforts to discuss a plan for the future:



Naveen Sethi explained the chart and then the meeting adjourned for lunch:

You are required to

a) Describe the cost-volume -profit relationships implied in the statements of Analysis Bhasker Mitter and Acharya.

b) Give a possible explanation of the chart prepared by Naveen Sethi.

Answers and Approaches to Activities

Activity 9.1

Influence of change in variable costs	Decrease 20%	Decrease 10%	Normal Volume	Increase 10%	Increase 20%
Net profit per unit (Rs.)	.40	.30	.20	.10.	0
% change in profit	+100%	+50%	-	-50%	-100%
Return of Investment	40%	30%	20%	10%	0%
Break -even point (Rs.)	2,66,667	2,90,909	3,20,000	3,55,556	4,00,000

Conclusions

a) 20% increase in variable costs raises break even point to the present normal sales volume leaving no profit at all.

b) 20% decrease in variable cost doubles profit per unit, lowers the break even point to almost Rs.1,50,000 below the normal sales volume, and yields 100% more profit.

Influence of change in fixed costs:

Influence of change in fixed costs:					
Net profit per Unit (Rs.)	.36	.28	.20	.12	.04
% change in Profit	+80%	+40%	–	–40%	–80%
Return on investment	36%	28%	20%	12%	4%
Break-even point (Rs.)	2,56,000	2,88,000	3,20,000	3,52,000	3,84,000

Conclusions

a) A 20% increase in fixed costs still preserves the profit but a 20% decrease lowers the break-even point to the lowest of any situation so far.

b) Decrease in fixed costs does not yield the same profit as does the decrease in variable costs.

Influence of all four factors	Left column		Normal Volume	Right Column	
	Decrease in Price	10%		Increase in price	10%
	Increase in volume	12%		Decrease in volume	12%
	Increase in variable costs	4%		Decrease in variable costs	4%
	Increase in fixed costs	5%		Decrease in fixed costs	5%
Net profit per unit (Rs.)		.01	.20		.3763
% change in profit		-94.4%	-		+65.6%
Return on investment		,1.12%	20%		33.1%
Break-even point (Rs.)		3,97,100	3,20,000		2,69,600

Conclusions

a) Break-even point is quickly reached when prices are reduced, costs increased and yet volume remains insufficient to overcome changes.

b) Increase in price accompanied by a decrease in volume coupled with a cost reduction programme will lead to most satisfactory results.

Activity 9.2

1. No 2. Yes 3. No 4. Yes 5. No 6. (a) 7. (b) 8. (c) 9. (a) 10. Yes

Solution:

P/V ratio = 1- variable cost ratio

$$= 1 - \frac{6 \text{ lakhs}}{10 \text{ lakhs}} = 1 - .6 = .4 \text{ or } 40\%$$

Activity 9.4

Fixed Costs:	Rent, rates and taxes
	Executive salaries
	Insurance
	Audit fees
	Insurance
Variable Costs	Direct materials
	Direct labour
	Power and fuel
	Discount on sales
	Salesman's commission
Semi-variable costs:	Maintenance and supervision
	Telephone
	Inventory carrying costs
	Publicity and Advertising
	Transport and vehicles

Activity 9.6

Figure 9.6: Rise in sales level, increase in profit, break-even point lowered, and margin of safety increased.

Figure 9.7: Variable cost rises, total cost rises, revised profit declines, break-even point rises, margin of safety is lowered.

Figure 9.8: Fixed cost rises (please note that the vertical intercept of the total cost line shifts upwards in contrast with Figure 9.7 where the revised total cost line commences form the same point as the original total cos line), total costs rise, revised profit declines, break-even point rises, am margin of safety is reduced.

Figure 9:9: Capacity expansion increases both profits and fixed costs. The break even point is increased and the safety margin is decreased.

Figure 9.10: Shows how the profit zone beyond the break-even point is appropriate among suppliers of capital. It also shows the profits retained in business.

Figure 9.11: Note the steepness of the slope of individual product contribution lines. This indicates relative profitability. The figure is a profit graph with average and individual product contribution lines. The break-even point and margin of safety can be determined. They are not marked on the graph.

Answers to Self-assessment Questions/Exercises

7. (a) False (b) True (c) False (d) True (e) False (f) False 8. (c) 9. (d) 10. (a)

11. (b)

12.

	Old profit	New Profit
Sales	1,00,00,000	1,00,00,000
Variable expenses	50,00,000	45,00,000
Contribution	50,00,000	55,00,000
Fixed expenses	10,00,000	10,00,000
	40,00,000	45,00,000

13. (a) Solution

$$BE = \frac{\text{Fixed expenses}}{\text{P/V ratio}}$$

PV ratio = 1 – variable cost ratio

= 1–.30 = .70 or 70%

$$\text{Hence, BE} = \frac{\text{Rs. } 63,000}{70\%} = \text{Rs. } 90,000$$

14. (c) Solution

Selling price per unit = Rs. 30,000/10,000 = Rs. 3

Variable cost per unit = Rs. 15,000/10,000 = RS. 1.50

Contribution per unit = Rs. 3.00– Rs 1.50 = Rs. 1.50

$$\text{B.E. point (unit)} = \frac{\text{Fixed expenses}}{\text{Contribution per unit}}$$

$$= \frac{\text{Rs. } 9,000}{1.50} = 6,000 \text{ units}$$

Margin of safety = Units sold - break-even sales (units)

= 10,000 – 6,000= 4,000

15 (d) Solution

$$BEP = \frac{\text{Fixed Costs}}{\text{Contribution per unit}}$$

$$BEP = \frac{\text{Rs. } 1,00,000}{10} = 10,000 \text{ units}$$

If BEP is reduced to 8,000 units

$$\text{Contribution} = \frac{\text{Fixed Costs}}{\text{New Break even point}} = \frac{1,00,000}{8,000 \text{ units}}$$

= Rs. 12.5 per unit

Selling price = variable expenses + Contribution

= Rs.10+ Rs. 12.50 = Rs.22.50

16 **(b) Solution**

$$\text{B.E. point (unit)} = \frac{\text{Fixed Costs} \times \text{sales}}{\text{Sales} - \text{variable costs}}$$

$$= \frac{30{,}000 \times 1{,}00{,}000}{1{,}00{,}000 - 30{,}000} = \text{Rs. } 42{,}857$$

$$\text{Alternatively, BEP (Rs.)} = \frac{\text{Total fixed expenses}}{1 - \frac{\text{Total variable expenses}}{\text{Total sales}}}$$

$$= \frac{30{,}000}{1 - \frac{30{,}000}{1{,}00{,}000}} = \frac{30{,}000}{7} = \text{Rs. } 42{,}857$$

17 Solution

(a) Calculation of Break -even point

Product	**A**	**B**	**C**	**D**	**TOTAL**
Sales mix	$33^1/_3\%$	$41^2/_3\%$	$16^2/_3\%$	$8^1/_3\%$	100%
Sales (Rs.)	20,000	25,000	10,000	5,000	60,000
Variable cost (Rs.)	12,000	17,000	8,000	2,000	39,000
Contribution	8,000	8,000	2,000	3,000	21,000
Fixed costs	-	-	-	-	14,700
Profit	-	-	-	-	6,300

$$\text{BEP (Rs.)} = \frac{\text{Fixed costs}}{1 - \frac{\text{Total variable costs}}{\text{Total sales (Rs.)}}}$$

$$= \frac{14{,}700}{1 - \frac{39{,}000}{60{,}000}} = \frac{14{,}700}{1 - .65} = \frac{14{,}700}{35}$$

= Rs. 42,000 or 70% capacity

b) Effect of change in sales mix

Products	**Sales (Rs.)**	**Variable Cost (Rs.)**	**Contribution (Rs.)**	**Fixed Cost (Rs.)**	**Profit (Rs.)**
A (25%)	15,000	9,000	6,000	-	-
B (40%)	24,000	16,320	7,680	-	-
C (30%)	18,000	14,400	3,600	-	-
D (5%)	3,000	1,200	1,800	-	-
Total (100%)	60,000	40,920	19,080	14,700	380

$$\text{EP (Rs.)} = \frac{14{,}700}{1 - \frac{40{,}920}{60{,}000}} = \text{Rs. } 46226.42 \text{ or } 77\% \text{ of total capacit}$$

c) P/V ratio plays a very important role in shifting the break-even point. This r io is given by

$$\frac{\text{Contribution}}{\text{Sales}}$$

Alternative formulations would be : $\text{Sales} = \frac{\text{Contribution}}{\text{P/V ratio}}$

$$\text{Contribution} = \text{P/V ratio} \times \text{sales.}$$

$$\text{BEP will be} = \frac{\text{Fixed costs}}{\text{P/V ratio}}$$

18.(a) The CVP relationships implied in the statements are as follows:

Bhasker Mitter:

Greater volume in terms of sales was the answer to the problem of the company'

High volume would aim at lowering the total unit cost per product. A low contribution per unit with high fixed costs would require high volume to obtain a reasonable profit. A low volume with high fixed costs would be serious for company profitability.

" The sales value was the same as the year before with no major volume change yet the profit had dropped ..... product 423 had not sold in the current year as well as in the previous year'. This result appears to be due to a change in the mix of sales with greater volume of less profitable products than product 423 making up the total volume of sales in units:

Acharya:

'Delivery of an expensive raw piece of plant and machinery and this should mean an increased production rate'. This machinery will increase fixed costs. Although the increased production rate will reduce unit cost, the profit implied in the increased contribution per unit is dependent on the increased volume . Higher fixed costs will have reduced the margin of safety.

b) A possible explanation of the chart supplied by Naveen Sethi is as follows:

Plan A gives the highest costs with the resultant highest break-even point and the lowest margin of safety. Variable costs and revenue are indicated as a constant per unit. Fixed costs are indicated as a constant amount for the range of activity shown.

Plan B gives a lower level of fixed costs than plan A and this lowers the break-even point with a corresponding increase in the margin of safety.

Plan C gives increased profit for the same level of fixed costs as plan 13, thus lowering the break-even point further and giving the highest margin of safety.

The increased profit may be explained by a reduction of variable costs or a possibly improved mix of sales, or perhaps both.

9.10 FURTHER READINGS

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Dopuch, N Birnbirg J.G. and Joel Demiski, 1974, *Cost Accounting* Harcourt Brace Javanovich: New York (Chapter4)

Video Programme
Accounting in Decision Making