

BREAK-EVEN ANALYSIS

14.1. INTRODUCTION

(Break-even analysis or, what is also known as profit contribution analysis, is an important analytical technique used to study the relationship between the total cost, total revenue, and total profits, and losses over the whole range of stipulated output.) Thus, Break-even analysis focuses on cost-volume-profit relations that hold only over a short run. This analysis is a technique of having a preview of profit prospects and a tool of profit planning. It integrates the cost and revenue estimates to ascertain the profits and losses associated with different levels of output.

(Break-even analysis is, basically, concerned with finding the point at which revenues and costs agree exactly, i.e., they are equal.) (The break-even point is, therefore, the volume of output at which neither a profit is made nor a loss is incurred.) In other words, the break-even point is that level of sales volume at which there is neither profit nor loss. The main objective of break-even analysis is to find the cut-off production volume from where a firm will make profit. A concern is said to be break-even when its costs are equal to its revenue.

Break-even analysis is a limited form of sensitivity analysis in which we are interested in determining a set values for which an investment alternative is justified economically. In this sense break-even point is that point where the two alternatives are equal. The choice between the two, then, rests on a judgment about which side of the break-even point, the element will likely register. In this chapter, break-even analysis is directed to the point at which operations merely break-even, neither making nor losing money; changes in operations are evaluated according to their effect on this point.

14.2. BASIC CONCEPTS

In break-even analysis, costs and revenues are expressed as a function of production rates. The selling price per unit of output comprises *profit, variable costs and fixed costs*.

Thus, in break-even analysis variable costs and fixed costs are major categories of costs. *Fixed costs or indirect costs* refer to that cost which do not change with change in the level of activity. The

sources of fixed costs are rent, interest, research, insurance, depreciation, property taxes, advertising budget, technical services and executive salaries. Fixed costs, arise from measures taken to provide the means to produce a product or service. Before firm can produce output, it must have a plant building for which rent is to be paid. Whether the firm produces one unit or more units using that plant building, the rent has to be paid, and this is shown as a fixed cost.

Variable costs or Direct costs refer to that costs which are generally proportional to output. Such costs are directly associated with a specific product or service. When there is no output, variable costs are zero. Some sources for variable costs are royalties, spoilage, packaging, maintenance, direct labour, raw material, direct supplies, direct supervision, and sales commissions, etc.

Profit, the difference between revenue (results from sales of output) and total costs, is a handy yard stick of success. There are, basically three ways to increase profit:

- (a) increasing the selling price,
- (b) increasing the value to increase sales, and
- (c) decreasing the selling price to increase sales.

14.3. LINEAR BREAK-EVEN ANALYSIS

When revenue and variable costs are directly proportional to output, the analysis is known as linear break-even analysis. This linear analysis assumes the constancy of fixed costs, per unit variable costs, and per unit sales prices over time and over output. This analysis rests on the assumption that all units of output produced must be sold out. The linear break-even analysis may either be *graphical* or *algebraical*.

14.3.1 Graphical Approach:

The graphical approach to break-even analysis is generally in terms of *Break-even charts*.

The break-even chart depicts fixed costs, variable costs, total costs, break-even point, profit or loss, margin of safety and the angle of incidence. The procedure of constructing break-even chart is as follows:

- (a) Draw Co-ordinate axes on a graph sheet. X-axis will measure sales volume in money value or output in units. Y-axis will measure costs and revenue.
- (b) Select suitable scales for both.
- (c) Plot the sales volume or units when plotted, the sales revenue or the output will be a straight line from origin to the right. If the scales on both the axes are the same, the sales line will be at 45° angle to the base.
- (d) Draw the fixed cost line parallel to the x-axis to indicate that it is infinitely elastic within the installed capacity.

- (e) Plot the total cost line for a given sales volume or units.
- (f) The point at which the total cost line intersects the sales line is the break-even point. A line drawn perpendicular to the x-axis from the break-even point represents loss (below the point) and above the point, represents profit.
- (g) The angle formed at the point of intersection of the total cost and the sales line is called the angle of incidence.

Properties of a typical break-even chart are displayed below:

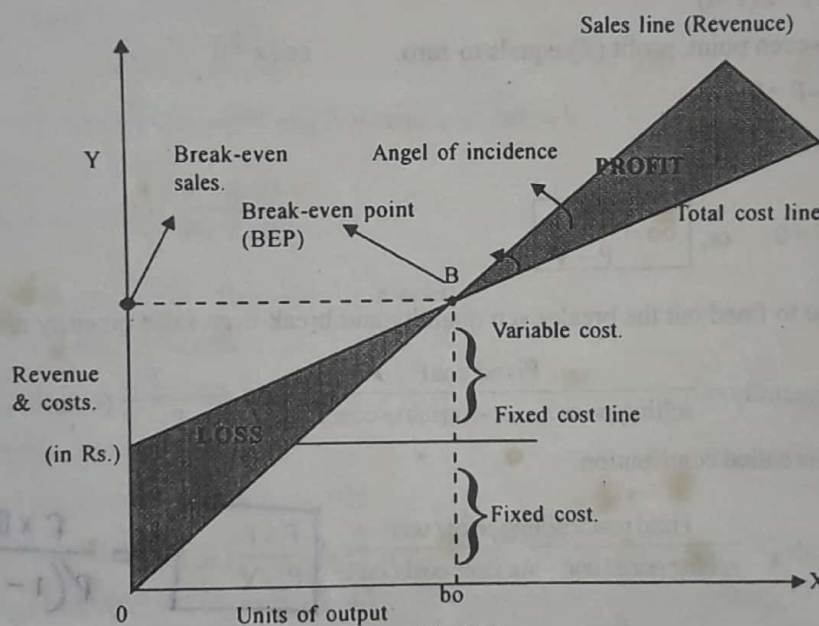


Fig.14.1

The break-even point (BEP), 'B', occurs at the intersection of the total cost and revenue lines. BEP is that level of sales or production at which the sales revenue is exactly equal to total cost, both variable and fixed. BEP is that level of activity at which the firm neither earns any profit nor suffers any loss. It is that point at which the contribution by a product just covers fixed cost. The vertical distance between the revenue line and the total cost line indicates a profit to the right of 'B' and a loss to the left.

The angle of incidence is the angle between sales and total cost line. This angle formed at the point of intersection of the sales and the total cost lines, indicates the profit earning capacity, and as such, the wider the angle, the greater is the profit and vice-versa.

14.3.2 Algebraic Approach:

The algebraic approach to break-even analysis can be developed on the basis on following notations

Let, n = Number of units produced, p = selling price per unit
 c = total cost, F = fixed cost, v = variable cost

z = total profit/gross profit, z' = net profit
 t = the rate of tax, R = sales revenue.

bo = Break-even quantity

Then, Revenue (R) = nP

Total cost (C) = $nV + F$

Gross profit (Z) = $R - C = nP - nV - F = n(P - V) - F$

Net profit (Z') = $Z(1 - t)$

At the break-even point, profit (Z) equals to zero. i.e., $z = 0$

i.e., $n(P - V) - F = 0$

let $n = bo$, then

$$bo(P - V) - F = 0 \quad \text{or,} \quad \boxed{bo = \frac{F}{P - V}}$$

The formulae to find out the break-even quantity and break-even sales quantity are:

$$\text{Break-even quantity} = \frac{\text{Fixed cost}}{\text{selling price / unit} - \text{variable cost / unit}} = \frac{F}{P - V} \text{ (in units).}$$

Where, $P - V$ is called contribution.

$$\begin{aligned} \text{Break-even sales} &= \frac{\text{Fixed cost} \times \text{selling price / unit}}{\text{selling price / unit} - \text{variable cost / unit}} = \boxed{\frac{F \times P}{P - V} \text{ (in Rs.)}} = \frac{F \times P}{P(1 - v/p)} = \frac{F}{1 - v/p} \\ &= \frac{F \times P}{P(1 - v/p)} \text{ (in Rs.)} = \frac{F}{1 - v/p} \text{ (in Rs.)} \end{aligned}$$

The margin of safety (M.S.) is the sales over and above the break-even sales. The margin of safety indicates the strength of business. A high margin of safety may mean that the concern will make profits even if there should be a fall in production or sales. A low margin indicates that fixed costs are high and profits can't be made unless sales are increased to absorb the fixed costs or, the selling price is increased or, costs are reduced or, a more profitable product is substituted.

$$\boxed{\text{M.S.} = \text{Actual sales} - \text{Break-even sales}} = \frac{\text{Profit} \times \text{sales}}{\text{contribution}} = \frac{\text{Profit} \times \text{Sales}}{\text{contribution}}$$

Where, Contribution = sales - variable costs

contribution/unit = selling price/unit - variable cost/unit.

$$\text{M.S as a percent of sales} = \frac{\text{M.S}}{\text{sales}} \times 100$$

$$\boxed{\text{M.S.} = \frac{\text{Profit}}{\text{P/V ratio}}}, \text{ P/V is the profit-volume ratio.}$$

$$\text{Where, P/V ratio} = \frac{\text{sale} - \text{variable cost}}{\text{sales}} \times 100$$

$$\boxed{\text{M.S.} = \frac{\text{Profit} + \text{contribution}}{\text{sales}}}$$

The relationship between, BEP and P/V ratio is as follows:

$$\text{BEP (sales volume)} = \frac{\text{fixed cost}}{\text{P/V ratio}}$$

Example - 14.1. A company has the following details:

Fixed cost = Rs. 20,00,000

variable cost per unit = Rs. 100

selling price per unit = Rs. 200

Find (a) the break-even sales quantity.

(b) the break-even sales

(c) the contribution and margin of safety, if the actual production quantity is 60,000 units.

Soln: Given that: F = Rs.20,00,000, V = Rs. 100 | unit

P = Rs. 200 | unit.

Q = actual sales = 60,000 units

$$\text{(a) Break-even quantity} = \frac{F}{P - V} = \frac{\text{Rs.20,00,000}}{\text{Rs.200} - \text{Rs.100}} = 20,000 \text{ units.}$$

$$\text{(b) Break-even sales} = \frac{F}{1 - V/P} = \frac{\text{Rs.20,00,000}}{1 - \frac{\text{Rs.100}}{\text{Rs.200}}} = \text{Rs. 40,00,000}$$

$$\begin{aligned} \text{(c) Contribution} &= \text{Sales} - \text{Variable cost} &= P.Q - V.Q &= (P - V)Q \\ &= (\text{Rs. 200} - \text{Rs. 100}) \times 60,000 = \text{Rs. 60,00,000} \end{aligned}$$

(d) margin of safety

$$= \text{Sales} - \text{Break-even sales} = \text{Rs.200} \times 60,000 - \text{Rs. 40,00,000} = \text{Rs.80,00,000}$$

$$(e) \text{ Profit} = \text{contribution} - \text{fixed cost} = \text{Rs. } 60,00,000 - \text{Rs. } 20,00,000 = \text{Rs. } 40,00,000$$

Example - 14.2. Calculate the break-even point from the following information:

Fixed cost : Rs 75,000

sales : Rs. 3,00,000

Direct materials : Rs. 1,00,000

Direct labour : Rs. 60,000

Direct expenses : Rs. 40,000

$$\text{Soln: Break-even point (in sales)} = \frac{\text{Fixed cost} \times \text{sales}}{\text{contribution}}$$

Where, contribution = sales – variable cost

and, variable cost = Direct material cost + direct labour cost + direct expenses.

$$= \text{Rs. } (1,00,000 + 60,000 + 40,000) = \text{Rs. } 2,00,000$$

$$\therefore \text{contribution} = \text{Rs. } 3,00,000 - \text{Rs. } 2,00,000 = \text{Rs. } 1,00,000$$

$$\text{Therefore, BE sales} = \frac{F \times S}{C} = \frac{\text{Rs. } 75,000 \times \text{Rs. } 3,00,000}{\text{Rs. } 1,00,000} = \text{Rs. } 2,25,000$$

$$\text{and profit} = C - F = \text{Rs. } 1,00,000 - \text{Rs. } 75,000 = \text{Rs. } 25,000$$

Example 14.3. The position of a company for the year 2003 was as follows:

Sales : Rs. 1,20,000

variable costs : Rs. 96,000

Fixed costs : Rs. 16,000

Find the net profit for the sales of Rs. 1,80,000

Soln: For Rs. 1,20,000 sales variable cost Rs. 96,000

$$\text{For Re.1, variable cost} = \frac{\text{Rs. } 96,000}{\text{Rs. } 1,20,000} = \frac{96}{120}$$

$$\text{For Rs. } 1,80,000 \text{ variable cost} = \frac{96}{120} \times \text{Rs. } 1,80,000 = \text{Rs. } 1,44,000$$

Thus, sales (s) = Rs. 1,80,000

variable cost (v) = Rs. 1,44,000

$$\text{Contribution} = S - V = \text{Rs. } 1,80,000 - \text{Rs. } 1,44,000 = \text{Rs. } 36,000$$

\therefore Profit = Contribution - Fixed costs

$$= \text{Rs. } 36,000 - \text{Rs. } 16,000 = \text{Rs. } 20,000$$

Example - 14.4. Selling price per unit : Rs. 150

variable cost per unit : Rs. 90

Fixed cost : Rs. 6,00,000

(a) What will be the selling price per unit, if the break-even point is 8,000 units?

(b) Compute the sales required to earn a profit of Rs. 2,20,000

$$\text{Soln: Break-even quantity} = \frac{\text{Fixed costs}}{\text{contribution}}, \text{ or, } 8,000 = \frac{\text{Rs. } 6,00,000}{P - \text{Rs. } 90}$$

Where P → selling price per unit.

$$\text{or, } 8,000 (P - \text{Rs. } 90) = \text{Rs. } 6,00,000$$

$$\text{or, } P = \text{Rs. } 165.$$

(b) Sales required to earn a profit of Rs. 2,20,000

$$= \frac{\text{Fixed cost} + \text{desired profit}}{\text{contribution per unit}} = \frac{\text{Rs. } 6,00,000 + \text{Rs. } 2,20,000}{\text{Rs. } 150 - \text{Rs. } 90} = \frac{\text{Rs. } 8,20,000}{\text{Rs. } 60} = 13,667 \text{ units.}$$

Example - 14.5. Given the following data,

Direct labour : Rs. 1,50,000

Direct materials : Rs. 4,10,000

Fixed overheads : Rs. 1,20,000

variable overheads : Rs. 2,00,000

Sales : Rs. 10,00,000

Study the effect on break-even sales, of

(a) an increase of 10% in fixed over heads

(b) an increase of 10% in variable overheads.

Soln: Variable cost = Direct material costs + Direct labour costs + variable overheads

$$= \text{Rs. } 4,10,000 + \text{Rs. } 1,50,000 + \text{Rs. } 2,00,000 = \text{Rs. } 7,60,000$$

Contribution = Sales – variable cost

$$= \text{Rs. } 10,00,000 - \text{Rs. } 7,60,000 = \text{Rs. } 2,40,000$$

Profit = Contribution – fixed cost.

$$= \text{Rs. } 2,40,000 - \text{Rs. } 1,20,000 = \text{Rs. } 1,20,000$$

$$\text{Break-even sales} = \frac{\text{Fixed costs} \times \text{sales}}{\text{contribution}} = \frac{\text{Rs. } 1,20,000 \times \text{Rs. } 10,00,000}{\text{Rs. } 2,40,000} = \text{Rs. } 5,00,000$$

(a) Effect on B. E sales of an increase of 10% in fixed overheads :

New fixed overheads = Rs. 1,20,000 + 10% of Rs. 1,20,000 = Rs. 1,32,000

$$\therefore \text{Break-even sales (new)} = \frac{\text{Rs. } 1,32,000 \times \text{Rs. } 10,00,000}{\text{Rs. } 2,40,000} = \text{Rs. } 5,50,000$$

(b) Effect on B-E sales of an increase of 10% in variable overheads.

New variable overheads = Rs. 2,00,000 + 10% of Rs. 2,00,000 = Rs. 2,20,000

Increased variable cost = Rs. 7,60,000 + Rs. 20,000 = Rs. 7,80,000

Contribution = Rs. 10,00,000 - Rs. 7,80,000 = Rs. 2,20,000

$$\therefore \text{Break-even sales} = \frac{\text{Rs. } 1,20,000 \times \text{Rs. } 10,00,000}{\text{Rs. } 2,20,000} = \text{Rs. } 5,45,454.55$$

Example - 14.6. From the following data, calculate:

(a) Break-even sales in rupees.

(b) Number of units that must be sold to earn a profit of Rs. 60,000 per year.

(c) How many units are to be sold to earn a net income of 10% of sales?

Sale price = Rs. 20 per unit

variable manufacturing costs = Rs. 11 per unit

variable selling costs = Rs. 3 per unit

Fixed factory overheads = Rs. 5,40,000 per year

Fixed selling costs = Rs. 2,52,000 per year.

Soln: Selling price = Rs. 20

Variable cost = Rs. 11 + Rs. 3 = Rs. 14

Contribution per unit = Rs. 20 - Rs. 14 = Rs. 6

Fixed costs = Rs. 5,40,000 + Rs. 2,52,000
= Rs. 7,92,000

$$\text{Break-even quantity} = \frac{\text{Rs. } 7,92,000}{\text{Rs. } 6} = 1,32,000 \text{ units}$$

(a) Break-even sales = Rs. 20 × 1,32,000
= Rs. 26,40,000

(b) Number of units to be sold for earning

$$\text{Rs. } 60,000 \text{ profit} = \frac{\text{Rs. } 7,92,000 + \text{Rs. } 60,000}{\text{Rs. } 6} = 1,42,000 \text{ units.}$$

(c) Number of units to be sold to earn a net income of 10% of sales:

Let 'x' be the number of unit sold.

10% profit on sales = (selling price per unit) (no. of units)

$$= (\text{Rs.}20)(x)(10\%) = \text{Rs. } 2x$$

$$\text{No. of units sold} = \frac{\text{Rs.}7,92,000 + \text{Rs.}2x}{\text{Rs.}6}$$

$$\text{or, } x = \frac{7,92,000 + 2x}{6}$$

$$\text{or, } x = 1,98,000 \text{ units}$$

Example.14. 7. Company-X has an overall P/V ratio of 60%. If the marginal cost (variable cost) of a certain product is assessed as Rs.12/-, what will be its selling price?

Soln. P/v ratio = 60% = 0.60

Marginal cost = Rs.12

$$P/V \text{ ratio} = \frac{p - v}{p}$$

$$\text{or, } 0.60 = \frac{p - \text{Rs.}12}{p}$$

$$\text{or, } \text{Rs.}12 = 0.40p$$

$$\text{or, } P = \text{Rs.}30/-$$

Example.14. 8. Utkal Ltd. has provided the following information

Year	Sales (Rs)	Cost (Rs)
2007	1,20,000	1,11,000
2008	1,40,000	1,27,000

Assuming that the cost structure and the selling prices remain the same, find out:

- BEP
- P/V ratio
- Fixed Cost
- Sales required to earn a profit of Rs.20,000/-

Soln. Profit for 2007 is Rs.1,20,000 – Rs.1,11,000 = Rs. 9,000/-

Profit for 2008 is Rs. 1,40,000 – Rs. 1,27,000 = Rs. 13,000/-

$$BEP = \frac{F}{P/V \text{ ratio}} = \frac{Rs. 15,000}{20\%} = Rs. 75,000$$

$$P/V \text{ ratio} = \frac{\Delta \text{profit}}{\Delta \text{sales}} \times 100 = \frac{13,000 - 9,000}{1,40,000 - 1,20,000} \times 100 = \frac{4000}{20000} \times 100 = 20\%$$

Fixed cost = (sales x P/V ratio) – profit

$$= (Rs. 1,20,000 \times 20\%) - Rs. 9,000 = Rs. 15,000/-$$

Sales required to earn a profit of Rs. 20,000/- is

$$= \frac{\text{fixed cost} + \text{desired profit}}{P/V \text{ ratio}}$$

$$= \frac{Rs. 15,000 + Rs. 20,000}{20\%} = \frac{Rs. 35,000}{0.5} = Rs. 1,75,000$$

Example.14.9. The following figures relate to a manufacturing company:

	2007 (Rs)	2008 (Rs)
Sales	50,000	80,000
Profit	10,000	25,000

Find out:

- P/V ratio
- Fixed cost
- BEP
- Margin of safety in 2008

Soln. $P/V \text{ ratio} = \frac{\Delta P}{\Delta S} \times 100 = \frac{15,000}{30,000} \times 100 = 50\%$

Fixed cost = (sales x P/V ratio) – profit = Rs. 15,000

$$BEP = \frac{F}{P/V \text{ ratio}} = \frac{Rs. 15,000}{50\%} = Rs. 30,000$$

Margin of safety = [Actual Sales – BES] = Rs. 50,000

Example.14. 10. Konark Ltd. has provided the following information:

Fixed cost = Rs. 8,000

BEP = Rs. 20,000

Variable cost = Rs. 60 per unit

Calculate:

- P/V ratio
- Profit when sales are Rs. 40,000
- New BEP if selling price is reduced by 10%

Soln.
$$P/V \text{ ratio} = \frac{F}{BEP} = \frac{Rs.8,000}{Rs.20,000} = 40\%$$

$$\text{Profit} = (\text{sales} \times P/V \text{ ratio}) - \text{Fixed Cost} = (Rs. 40,000 \times 40\%) - Rs. 8,000 = Rs. 8,000$$

$$\text{Selling price} = \frac{v}{1 - P/V \text{ ratio}} = \frac{Rs.60}{1 - 0.40} = Rs.100$$

If price is to reduce by 10%, then new price will be Rs.100 - (10% of Rs.100) = Rs.90/-

$$\text{New BEP} = \frac{F}{1 - \frac{v}{p}} = \frac{Rs.8,000}{1 - \frac{Rs.60}{Rs.90}} = Rs.24,000$$

Example. 14.11. Utkal Ltd. provides the following data for the year ended 31st March 2009:

Selling price = Rs.10/-

Production and sales = 400 units

Variable cost per unit = Rs.5/-

Fixed cost = Rs. 100/-

You are required to show the impact of the following actions on the P/V ratio, BEP and margin of safety:

- The variable cost increases to Rs.6 per unit
- The fixed cost increases to Rs. 1,500
- The selling price increases to Rs. 20 per unit.

Soln. $P/V \text{ ratio} = \frac{SP - VC}{SP} = \frac{Rs.10 - Rs.5}{Rs.5} = 50\%$

$$BEP \text{ (Sales)} = \frac{\text{fixed cost}}{P/V \text{ ratio}} = \frac{Rs.1,000}{0.5} = Rs.2,000$$

$$BEP \text{ (Units)} = \frac{BE \text{ Sales}}{SP} = \frac{Rs.2,000}{Rs.10} = 200 \text{ units}$$

$$\text{Margin of Safety} = \text{Actual Sales} - BE \text{ Sales} = (400 \times Rs.10) - Rs.2,000 = Rs.2,000/-$$

a) Impact of increase in variable cost to Rs.6 per unit:

$$P/V \text{ ratio} = \frac{Rs.10 - Rs.6}{Rs.10} = 40\%$$

$$BE \text{ Sales} = \frac{\text{fixed cost}}{P/V \text{ ratio}} = \frac{Rs.1,000}{40\%} = Rs.2,500$$

$$BE \text{ Quantity} = \frac{Rs.2500}{Rs.10} = 250 \text{ units}$$

$$\text{Margin of Safety} = (400 \times Rs.10) - Rs.2,500 = Rs.1,500$$

(b) Impact of increase in fixed cost to Rs.1,500:

$$P/V \text{ ratio} = 50\%$$

$$BE \text{ Sales} = \frac{\text{fixed cost}}{P/V \text{ ratio}} = Rs.3,000$$

$$BE \text{ Quantity} = 300 \text{ units}$$

$$\text{Margin of Safety} = (400 \times Rs.10) - Rs.3,000 = Rs.1,000$$

(c) Impact of increase in selling price to Rs. 20 per unit:

$$P/V \text{ ratio} = 75\%$$

$$BE \text{ Sales} = \frac{\text{fixed cost}}{P/V \text{ ratio}} = Rs.1,333.33$$

$$BE \text{ Quantity} = 66.67 \text{ units}$$

$$\text{Margin of Safety} = (400 \times Rs.10) - Rs.1,333.33 = Rs.6,666.67$$

Example.14.12. Raj. Ltd. manufactures three products – X, Y and Z. The unit selling prices of these products are Rs. 100, Rs. 160, and Rs. 75 respectively. The corresponding unit variable costs are Rs. 50, Rs. 80 and Rs. 30. The proportions (quantity wise) in which these products are manufactured and sold are 20%, 30% and 50% respectively. The total fixed costs are Rs. 14, 80,000. Calculate overall BE quantity and the product-wise break-up of such quantity.

Sol.

Particulars	Product-X	Product-Y	Product-Z	Total
Selling price:	Rs. 100	Rs. 160	Rs. 75	Rs. 335
variable cost per unit:	Rs. 50	Rs. 80	Rs. 30	Rs. 160
contribution (p-v):	Rs. 50	Rs. 80	Rs. 45	Rs. 175
P/V ratio: $\frac{P-v}{P} \times 100$	50%	50%	60%	52.23%
Total Fixed Cost:				Rs. 14,80,000
Overall BE Sales: $\frac{F}{P/V \text{ ratio}}$				$\frac{\text{Rs. } 14,80,000}{52.23\%} = \text{Rs. } 28,33,620.50$
Overall BE Quantity: $\frac{F}{\text{contribution}}$				$\frac{\text{Rs. } 14,80,000}{\text{Rs. } 175} = 8,457.14 \text{ units}$
Proportion of production and selling:	20%	30%	50%	100
Product-wise break-up of BEQ:	20% of 8457.14 = 1691.43	30% of 8457.14 = 2537.14	50% of 8457.14 = 4228.57	8457.14