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Break-Even Analysis

Break-Even Point

The break-even point means the level of output or sales at which no profit or loss is achieved. It indicates the position at which marginal profit or contribution is just sufficient to cover fixed overheads. In other words, a business is said to break-even when its income equals its expenditure. When production exceeds the "Break-even point", the business makes a profit and when it is below the "Break-even point", the business makes loss. This is shown in chart 69.1.

Break-Even Point Theory

The break-even point of any two variable situations is the point or the value at which they become equal as the result of a common variable.

There are following two methods to obtain break-even point :

(*a*) Mathematical method and (*b*) Graphical method.

(*a*) **Mathematical method.** Let cost be the common variable in two situations 1 and 2, then cost equations will be

$$C_1 = f_1(x) \quad \text{...a function of } (x) \qquad ...(1)$$

$$C_2 = f_2(x) \quad \text{...another function of } (x) \qquad ...(2)$$

C_1 - may be as total cost, annual cost, cost per item or cost per day etc. for situation 1.

C_2 - same as C_1 but application to situation 2.

x - variable effecting C_1 and C_2.

To solve for the value of x, let

$$C_1 = C_2$$

i.e

$$f_1(x) = f_2(x) \qquad ...(3)$$

Equation 3. can be solved for obtaining the value of x. The value of x making the cost equal in both the situations, is called "Break Even Value". Below this value of x one situation will be economical while above it another situation will be economical.

Example 1. *A 25 H.P. unit is required to drive a pump to remove water from a tunnel. The number of hours for which the power unit will run per year is dependent on weather conditions. The power unit is to be used for 4 years.*

For the supply of power following two plans are under consideration.

Plan I. *This plan requires the construction of power line and purchase of electric motor at a total cost of Rs. 16,000. The salvage value of which is Rs. 4000 after 4 years of working. Cost of electricity per hour of operation is Rs. 6.80. Equipment being automatic, no attendant is needed. Maintenance is estimated to Rs. 2400 per annum.*

Plan II. *This plan needs a gasoline engine, which costs Rs. 11,000. The engine will be condemned at the end of 4 years. The cost of fuel and oil per hour of operation is estimated as Rs. 8.40. Hourly wages of operator is Rs. 2.00. Maintenance is estimated at Rs. 3 per hour of operation.*

Solve by "Break-even point" theory, which of the plan will be economical ?

Solution

Plan I. Let, N = No. of hours of operation per year

Then, total annual cost

$$= \left\{\frac{16,000 - 4,000}{4}\right\} + 6.8\,N + 2400$$

$$= 5400 + 6.8\,N \quad \ldots(1)$$

Plan II. Similarly, total annual cost

$$= \frac{11,000}{4} + 8.4\,N + 2\,N + 3\,N$$

$$= 2750 + 13.4\,N \quad \ldots(2)$$

There is one value of N for which the cost of Plans I and II will be equal. Hence N may be determined by equating equations (1) and 2).

$$5400 + 6.8\,N = 2750 + 13.4\,N$$

$$13.4\,N - 6.8\,N = 5400 - 2750$$

$$6.6\,N = 2650$$

$$N = 401 \text{ hours.}$$

∴

For given conditions, annual costs of the two alternatives are calculated to be equal for 401 hours of usage per annum. If usage comes to be less than 401 hours per annum, selection of plan II is economical. For more than 401 hours, the selection for automatic equipment, *i.e.* plan I will be more economical.

(*b*) **Graphical method.** Although the break-even point may be calculated mathematically, but it is usually represented graphically because it enables manager to see more clearly the break-even point and the possibilities for profits and losses. By using these charts one can predict probable profits at various levels of output.

A break-even chart given in Fig. 69.1 is used to determine break-even point and amount of profit or loss under varying conditions of output and costs. Sales or expenditure in rupees is represented on vertical axis, while output (either in quantity or in percentage capacity) is represented on horizontal axis. Line *A* represents the "fixed cost", line *B* represents total cost or total expenses, while line C represents sales revenue and indicates income at various levels of output. The point where lines *B* and C intersect each other, is "Break Even Point". The space between lines *B* and *C* to the right of the "Break Even Point" represents potential profit, whereas to the left of the "Break Even Point" potential loss. The amount of loss or profit can be measured on vertical scale.

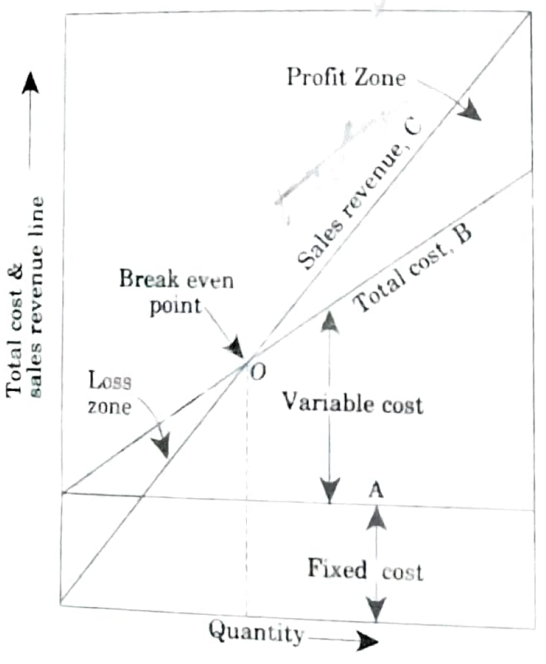

Fig. 69.1.

This method can be applied to various management problems. For example, suppose a manager wants to replace an old lathe machine being used for manufacturing screws by automatic screw machine. Then he must first know whether it will be profitable or not, for

which he must adopt break-even point theory and construct the chart as explained in Fig. 68.2. The figure shows that for a production less than Q, it must not be changed whereas for production more than Q automatic machine or new machine will be economical or in other words below Q manual lathe is cheaper beyond Q automatic machine is cheaper. This break-even point is also known as "cut even point".

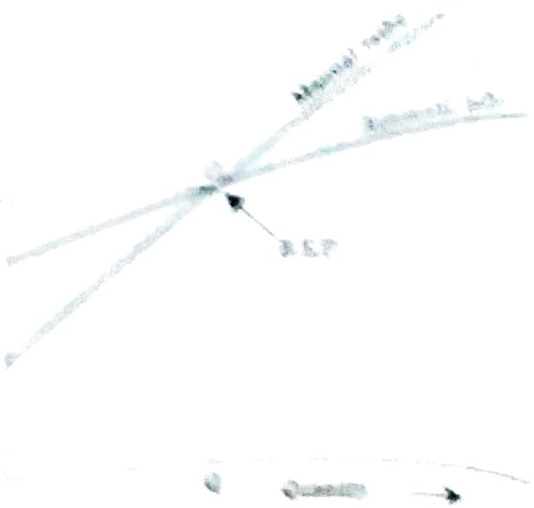

Fig 68.2

Some Important Definitions

(i) **Angle of incidence**. It is the angle at which income line or sales line cuts the total cost line. If the angle is large, it is an indication that profits are being made at a high rate, on the other hand, if the angle is small it indicates that less profits are being made and are achieved under less favourable conditions.

(ii) **Margin of safety**. It is the output at full capacity minus the output at "Break Even Point". It is expressed as percentage of output at full capacity. If the margin of safety is small, a small drop in production capacity will reduce the profit greatly. It can also be expressed as

$$\text{Margin of safety} = \left(\frac{\text{Sales at full capacity} - \text{Sales at B.E.P}}{\text{Sales at full capacity}}\right) \times 100$$

(iii) **Contribution**. It is the difference between sales and variable cost (marginal cost). It is also called as Marginal Profit or Gross Marginal. The marginal profit provides the contribution towards fixed cost and profit.

Contribution = (Sales-Variable cost) which in turn will be equal to Fixed cost + Profit.

Break-Even Point Calculations

Let S = Sales price,

V = Variable cost

F = Fixed cost and P = Profit

Now $$S = F + V + P$$

or $$S - V = F + P \quad \text{...(ii)}$$

At break-even point, $P = 0$.

$$S - V = F \quad \text{...(iii)}$$

Multiplying both sides of Eq. (iii) by S

$$S(S - V) = F \times S$$

or $$S = \frac{F \times S}{(S - V)} = \frac{F}{\left(\frac{S - V}{S}\right)} = \frac{\text{Fixed cost}}{\text{Contribution per unit}}$$

and Sales at B.E.P $$= \text{Rs. } \frac{F \times S}{(S - V)} \quad \text{...(iii)}$$

and No. of units at B.E.P $$= \frac{\text{Fixed cost}}{\text{Contribution/unit}} = \frac{\text{Fixed cost}}{\text{Marginal Profit unit}} \quad \text{...(iv)}$$

BREAK-EVEN ANALYSIS (Cost Analysis)

This is also known as cost analysis. Break-even analysis is concerned with finding the point at which revenues and costs are exactly equal. This point is known as BREAK-EVEN-POINT. Thus this is a volume of output at which neither a profit is made nor a loss is incurred. Therefore production or sale must not be allowed to fall beyond this point.

This analysis can be carried out either algebraically or graphically.

Break-even chart

A breakeven chart is a graphical representation of the relationship between costs and revenue at a given time and determines the break-even-point and profit potential under varying conditions of output and cost.

Functions of Breakeven Chart

(*i*) To represent economical position of production on graph.
(*ii*) To for tell likely profits or losses at various levels of output.
(*iii*) To help the management to decide the production level.
(*iv*) To indicate margin of safety.

Determination of the Break-Even-Point. It may be determined in terms of physical units or in money terms *i.e.* sales value in rupees:

(*i*) **Break-Even-Point in terms of physical units.** Break even volume is the number of units of a product which must be sold to earn enough revenue just to cover all expenses. The break-even-point (BEP) is reached when sufficient number of units have been sold so that the total contribution margin of the units sold is equal to the fixed costs.

$$\text{B.E.P} = \frac{\text{Fixed costs}}{\text{Selling Price} - \text{Variable cost per unit}}$$

(*ii*) **Break-Even-Point in terms of Sales Value.** Multi product firms are not in a position to measure the BEP in terms of any common unit of product. In these firms it is convenient to determine their BEP in terms of total rupee sales. In this case BEP would be the point where the contribution margin (Sales value-Variable costs) would be equal to fixed costs contribution margin is expressed as a ratio to sales.

$$\text{B.E.P} = \frac{\text{Fixed Costs}}{\text{Contribution ratio}}$$

where, $$\text{Contribution ratio} = \frac{\text{Sales value} - \text{Variable costs}}{\text{Sales Value}}$$

Margin of Safety. This is shown on the chart by the distance between B.E.P and the output being produced. It shows that if this distance is short then a small decrease in output or sales will reduce the profit greatly. If the distance is long it means the business could still be making profit after a great reduction in output.

Angle of Incidence. By cutting sales line on to a total cost line an angle known as "Angle of Incidence" is formed. Chart shows that if the angle is large it is an indication of large profits and if it is small it shows that profit are being earned under less favourable conditions.

Position of Break-Even Point

If B.E.P. is over to the left of the chart with a large angle of incidence it shows that output can be raised considerably. If B.E.P. is over to the right of the chart, the margin of safety is low, which means :

(b) Break-Even Point, B.E.P.

$$= \frac{F}{1 - V/S}$$

F = Fixed cost

(*i*) where,

V = Variable cost per unit or total variable cost also known as direct cost

S = Selling price.

and

Hence in question, F = Rs. 350,000

$V = 0.35 \times S$

$S = 600{,}000$

Hence B.E.P $$= \frac{350{,}000}{1 - \frac{0.35 \times 600{,}000}{600{,}000}} = \frac{350.000}{0.65} = \textbf{Rs. 538,461.53 Ans.}$$

(*ii*) Profit $= 80{,}000$

Sales = ?

Now, Sales $$= \frac{\text{Fixed cost+Profit}}{1 - V/S}$$

$$\therefore \quad \text{Sales} = \frac{350{,}000 + 80{,}000}{1 - 0.35} = \frac{430{,}000}{0.65} = \textbf{Rs. 661,538.46 Ans.}$$

Example 6. *An engine lathe costing Rs. 10,000 can produce components at the rate of 6 pieces per hour and another automatic lathe costing Rs. 20,000 can produce 20 pieces per hour. The operator on either of the machine is to be paid at the rate of Rs. 1.50 per hour. Determine the minimum number of pieces which will change the cost situation in favour of the automatic lathe.*

Solution. *First situation* :

Cost of engine lathe	= Rs. 10,000.
Production	= 6 pieces/hr.
Operator rate	= Rs. 1.50/hr.

Second situation :

Cost of automatic lathe	= Rs. 20,000.
Production	= 20 pieces/hr.
Operator rate	= 1.50/hr.

Let N be the production pieces at which cost equations are equal

Then, $$10{,}000 + \frac{N}{6} \times 1.50 = 20{,}000 + \frac{N}{20} \times 1.50$$

or $$\frac{N}{6} \times \frac{3}{2} - \frac{N}{20} \times \frac{3}{2} = 10{,}000$$

or $$7N = 10{,}000 \times 40$$

or $$N = \frac{10{,}000 \times 40}{7} = 57{,}142.86 \text{ say } 57{,}143 \text{ pieces.}$$

It means if production is more than 57,143 pieces than automatic machine will be economical.

Example 7. *The fixed costs for the year 1979-80 are Rs. 500,000 variable cost per unit is Rs. 25. The estimated sales for the period are valued at Rs. 1,500,000. Each unit sells at Rs. 150. Determine*

(*i*) *Break-even point*

(ii) Rs. 1,200,000 will be the likely sales turnover for the next budget period, calculate the estimated contribution and profit.

(iii) If a profit target of Rs. 650,000 has been budgeted, compute the turnover required.

Solution. (i) Break-even point

$$= \frac{F}{1-(V/S)}$$

where F = Fixed cost = 500,000

V = Variable cost = Rs.25/unit

S = Selling cost = Rs . 150/unit

$$\therefore \quad \text{B.E.P.} = \frac{500{,}000}{1-\frac{25}{150}} = \frac{500{,}000 \times 6}{5} = \textbf{Rs. 600,000. Ans.}$$

(ii) $$\text{Sales} = \frac{\text{Fixed cost + Profit}}{1 - V/S}$$

or $$\text{Profit} = 1{,}200{,}000 \times \frac{5}{6} - 500{,}000 = 1{,}000{,}000 - 500{,}000$$

$$= \textbf{Rs. 500,000. Ans.}$$

Now, estimated contribution

$$= \text{Fixed cost + Profit} = 500{,}000 + 500{,}000 = \textbf{Rs. 1,000,000. Ans.}$$

(iii) If profit is 650,000 then sales = ?

Now Sales $$= \frac{\text{Fixed cost + Profit}}{1 - V/S} = \frac{500{,}000 + 650{,}000}{1 - 1/6} = \frac{1{,}150{,}000 \times 6}{5}$$

$$= \textbf{Rs. 1,380,000. Ans.}$$

Example 8. *The fixed costs for the financial year 1980-81 are Rs. 40,000. The sales for this period are of Rs. 100,000. The variable cost per unit is Rs. 2. Selling price of each product is Rs. 10 and the number of units involved coincides with the expected volume of output. Construct the Break-even chart and determine :*

(a) *Break-even point*

(b) *How many minimum product should be sold to earn profit.*

(c) *Profit earned at a turnover of Rs. 80,000*

(d) *Margin of safety.*

(e) *Angle of incidence.*

Solution. Here

Fixed cost	F = Rs. 40,000
Variable cost	V = Rs. 2 per unit
Selling price	S = Rs. 10 per unit
Total Sales	= Rs. 100,000

$$\text{No. of products sold} = \frac{\text{Total sales}}{\text{Selling price of one product}} = \frac{100{,}000}{10} = 10{,}000 \text{ units}$$

Now draw the break-even chart, as described under :

1. Draw on the graph paper fixed cost line AB at Rs. 40,000.
2. Variable cost = No. of products × Variable cost/product = 10,000 × 2 = 20,000
3. Variable cost varies from zero at 0 unit sale to Rs. 20,000 at 10,000 units sale. Thus draw the variable cost line AC above the fixed cost line, as shown in the graph.
   Thus total cost = Fixed cost + Variable cost.

4. Sales is zero at 0 u
   Total cost line and
   on the break-ever

Break-even point is at 5

(b) The firm should

(c) Profit at sales of

(d) Margin of safety

It is marked at 10,000

Total sales (–) Sales at

100,0

P

(e) Angle of incidence

Example 9. *A compar*
unit, the fixed cost is Rs. 6,
larger equipment will be n
to Rs. 10 per unit. At any

(a) *What is the bre*

(b) *What is the pro*

(c) *What are the as*

Solution. (a) Here

Now

where P = Profit, but

$\therefore \quad Q(S - V) = F$

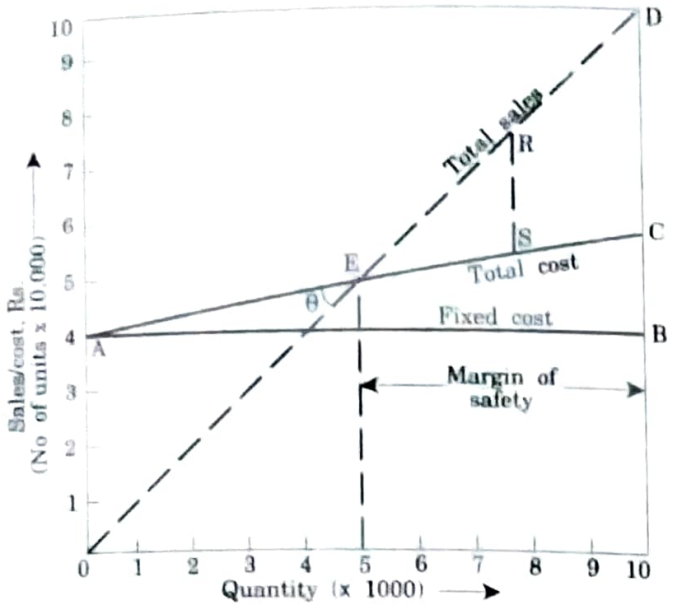

Fig. 69.10

4. Sales is zero at 0 unit and is Rs. 100,000 at 10,000 units sales. Thus draw the sales line *OD*. Total cost line and total sales line intersect at point *E*, which is known as Break-even point on the break-even chart.

Break-even point is at 5,000 units or Rs. 50,000 sales.

(*b*) The firm should sell more than 5,000 units to receive profit.

(*c*) Profit at sales of Rs. 80,000. This is denoted by *RS* in the chart and is equal to Rs. 24,000.

(*d*) Margin of safety

It is marked at 10,000 units and is equal to

Total sales (–) Sales at Break-even point

$$100{,}000 - 50{,}000 = \text{Rs. } 50{,}000$$

$$\text{Percentage} = \frac{50{,}000}{100{,}000} \times 100 = 50\%.$$

(*e*) Angle of incidence $\theta = 34^{\circ}$ (by measurement).

Example 9. *A company is planning to launch a new product. For any volume of production below 400 unit, the fixed cost is Rs. 6,000 and the variable cost is Rs. 20 per unit. If the volume is to be more than 400, larger equipment will be needed and the fixed cost will be Rs. 10,000. However, the variable cost will reduce to Rs. 10 per unit. At any volume the selling price is Rs. 30 per unit*

(*a*) *What is the break-even point ?*

(*b*) *What is the profit or loss if the volume is fixed at 500 units ?*

(*c*) *What are the assumptions made in your analysis ?*

Solution. (*a*) Here

Q = Quantity at Break-even point

F = Fixed costs = Rs. 6000

V = Variable costs = Rs. 20/unit

S = Selling price = Rs. 30/unit.

Now $Q(S - V) = F + P$

where P = Profit, but at Break-even point, $P = O$

$$\therefore \quad Q(S - V) = F \qquad \ldots(1)$$

Hence by substitution $Q = \frac{6000}{(30 - 20)} = 600$ units

It means Break Even Point will be at the production of 600 **units. Ans.**

(*b*) Here $Q_1 = 500$ units, $F_1 = 10{,}000$

$V_1 = $ Rs. 10/unit and $S_1 = S = $ Rs. 30/unit

$P = ?$

Now $Q_1 (S_1 - V_1) = F_1 + P$

or $500 (30 - 10) = 10{,}000 + P$

or $P = 0$

i.e. at 500 units production, neither there is any profit nor loss. That means with these changed conditions, break-even point has shifted to 500 units while initially it was at 600 units.

(*c*) **Assumptions**

1. The selling price in both the situations is assumed to be constant.
2. The volume of sales and the volume of production is assumed to be equal.

Example 10. *A tooth-paste company sold 250,000 packets for which the variable cost of manufacture was Rs. 4.20 per pocket. Each packet contributes 30% of its revenue to fixed costs and profit. This year the company decided to give a price reduction of 5%.*

How many more packets will the company have to sell at the 5% price reduction in order to earn the same profit.

Solution. Total Revenue = Fixed cost + profit + Variable cost

Selling price = Fixed cost per unit + Profit/unit + Variable cost/unit

Let Selling price = Rs. S.

It is given that 30% of contribution = (Fixed cost + Profit) per unit ...(1)

$0.3\ S = $ (Fixed cost + profit)/unit ...(2)

Putting the value of Eq. (2) in Eq. (1)

$\therefore$ Selling price $= 0.35 + 4.20$,

where 4.20 is variable cost. Now $S = 0.3\ S + 4.20$

$S =$ **Rs. 6.**

Putting this value of S in Eq. 2.

$0.3 \times 6 =$ (Fixed cost + Profit)/unit or (Fixed cost + Profit)/unit = 1.8

Now if price reduction is 5%, then

$$S_1 = 6 - \frac{6 \times 5}{100} = 5.70$$

$$Q_1 = Q \times \frac{F + P}{S_1 - V}$$

$$= \frac{1.8}{5.70 - 4.20} \times \frac{250{,}000}{1} = 300{,}000$$

$\therefore$ Additional production = 300,000 – 250,000 = **50,000 Ans.**

Example 11. (*a*) *What is meant by break-even analysis ? Discuss the assumptions that underline the technique and its uses.*

(*b*) *In the past two years it is observed in metal working industry that the material cost has risen by 20 whereas other costs have risen by 10%. Assuming that the selling prices have advanced by 10% and th*