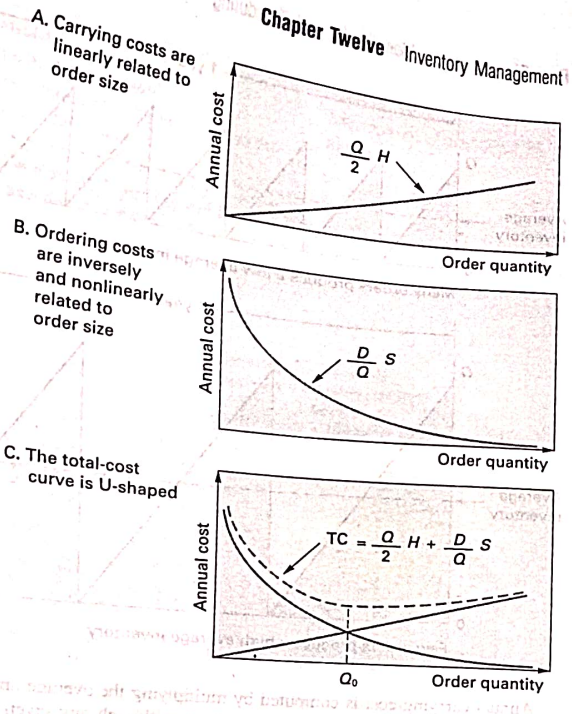

FIGURE 12.4 Carrying cost, ordering cost, and total cost curve

where

D = Demand, usually in units per year
S = Ordering cost

Because the number of orders per year, D/Q, decreases as Q increases, annual ordering cost is inversely related to order size, as Figure 12.4B illustrates.

The total annual cost (TC) associated with carrying and ordering inventory when Q units are ordered each time is

$$\text{TC} = \begin{matrix}\text{Annual}\\ \text{carrying}\\ \text{cost}\end{matrix} + \begin{matrix}\text{Annual}\\ \text{ordering}\\ \text{cost}\end{matrix} = \frac{Q}{2}H + \frac{D}{Q}S \qquad (12\text{–}1)$$

(Note that D and H must be in the same units, e.g., months, years.) Figure 12.4C reveals that the total-cost curve is U-shaped (i.e., convex, with one minimum) and that *it reaches its minimum at the quantity where carrying and ordering costs are equal.* An expression for the optimal order quantity, Q_0, can be obtained using calculus.[1] The result is the formula

$$Q_0 = \sqrt{\frac{2DS}{H}} \qquad (12\text{–}2)$$

[1]We can find the minimum point of the total-cost curve by differentiating TC with respect to Q, setting the result equal to zero, and solving for Q. Thus,

1. $\frac{dTC}{dQ} = \frac{dQ}{2}H + d(D/Q)S = H/2 - DS/Q^2$
2. $0 = H/2 - DS/Q^2$, so $Q^2 = \frac{2DS}{H}$ and $Q = \sqrt{\frac{2DS}{H}}$

Note that the second derivative is positive, which indicates a minimum has been obtained.

Thus, given annual demand, the ordering cost per order, and the annual carrying cost per unit, one can compute the optimal (economic) order quantity. The minimum total cost is then found by substituting Q_0 for Q in Formula 12–1.

The length of an order cycle (i.e., the time between orders) is

$$\text{Length of order cycle} = \frac{Q}{D} \qquad (12\text{–}3)$$

EXAMPLE 2

A local distributor for a national tire company expects to sell approximately 9,600 steel-belted radial tires of a certain size and tread design next year. Annual carrying cost is $16 per tire, and ordering cost is $75. The distributor operates 288 days a year.

a. What is the EOQ?
b. How many times per year does the store reorder?
c. What is the length of an order cycle?
d. What is the total annual cost if the EOQ quantity is ordered?

SOLUTION

D = 9,600 tires per year
H = $16 per unit per year
S = $75

a. $Q_0 = \sqrt{\frac{2DS}{H}} = \sqrt{\frac{2(9{,}600)75}{16}} = 300$ tires

b. Number of orders per year: $D/Q = \frac{9{,}600 \text{ tires}}{300 \text{ tires}} = 32.$

c. Length of order cycle: $Q/D = \frac{300 \text{ tires}}{9{,}600 \text{ tires/yr}} = 1/32$ of a year, which is $1/32 \times 288$, or nine workdays.

d. TC = Carrying cost + Ordering cost
$= (Q/2)H + (D/Q)S$
$= (300/2)16 + (9{,}600/300)75$
$= \$2{,}400 + \$2{,}400$
$= \$4{,}800$

Note that the ordering and carrying costs are equal at the EOQ, as illustrated in Figure 12.4C.

Carrying cost is sometimes stated as a percentage of the purchase price of an item rather than as a dollar amount per unit. However, as long as the percentage is converted into a dollar amount, the EOQ formula is still appropriate.

EXAMPLE 3

Piddling Manufacturing assembles security monitors. It purchases 3,600 black-and-white cathode ray tubes a year at $65 each. Ordering costs are $31, and annual carrying costs are 20 percent of the purchase price. Compute the optimal quantity and the total annual cost of ordering and carrying the inventory.

SOLUTION

D = 3,600 cathode ray tubes per year

S = $31

H = .20($65) = $13

$Q_0 = \sqrt{\frac{2DS}{H}} = \sqrt{\frac{2(3{,}600)(31)}{13}} \approx 131$ cathode ray tubes

METHODS OF CAPITAL BUDGETING

Capital budgeting decisions are made under different criteria. How are these criteria determined. These criteria differ in concepts. Some use thumb rules and some use logic and scientific approach. So, based on these criteria, the methods of capital budgeting can be classified as

(a) Traditional methods
  (i) Payback period
  (ii) Accounting rate of return method

(b) Discounted cash flow methods.
  (i) Internal rate of return (IRR) method
  (ii) Net present value (NPV) method.

Let us discuss these methods in detail.

Payback Method

Under payback method, the decision to accept or reject a proposal is based on its payback period. *Payback period* refers to the period within which the original cost of the project is recovered. It is calculated by dividing the cost of the project by the annual cash inflows.

$$\text{Payback period} = \frac{\text{Cost of the project}}{\text{Annual cash inflows}}$$

The shorter the length of the payback period, the better is the project in terms of paying back the original investment. Particularly where the future is uncertain, the companies favour this method. The earlier the original investment is recovered, the better it is, in terms of safety and liquidity. Where the cashflows are uniform throughout, they are said to even. Consider this example.

Where the cash inflows are even

Example 3

The cost of a project is Rs 50,000 the annual cash inflows for the next 4 years are Rs 25,000. What is the payback period for the project?

$$\text{Payback period} = \frac{\text{Cost of the project}}{\text{Annual cash inflows}}$$

$$= \frac{50{,}000}{25{,}000}$$

$$= 2 \text{ years.}$$

If another project has 3 years, for example, it is better to choose the above project because it has *less* payback period.

Where the cashflows are uneven

Where the cash flows are not uniform, they are said to be uneven. In such a case take the cumulative cash inflows and see how much time it takes to get back the original investment. Consider the following example.

Example 4

The cost of a project is Rs 50,000 which has an expected life of 5 years. The cash inflows for next 5 years are Rs 24,000; Rs 26,000; Rs 20,000; Rs 17,000 and Rs 16,000 respectively. Determine the payback period.

Table 16.1 Cash Inflows and Cumulative Cash Inflows for the Project

Year	*Cash inflows (Rs)*	*Cumulative cash inflows (Rs)*
1	24,000	24,000
2	26,000	50,000
3	20,000	70,000
4	17,000	87,000
5	16,000	1,03,000

Table 16.1 shows that the original investment can be recovered by the end of the second year and hence the project has 2 years of payback period.

So the payback period is 2 years.

Where the cash inflows are same, but timing is different

At times, the cash inflows may be different each year, but the total cash inflows over the life of the project may be the same. Sometimes, the payback period may be similar. In such a case, observe the timing of the cash inflows. Choose the project which has higher cash inflows in the initial years. Check the following example.

Example 5

Two projects, costing Rs 20,000 each, have the following cash inflows. Both have the same payback period. Which one do you choose and why?

Table 16.2 Same total cash inflows with a difference in size and timing

(Figure in Rupees)

Year	*Project A*	*Project B*
I	8,000	12,000
II	12,000	8,000
III	10,000	12,000
IV	9,000	7,000
V	7,000	7,000
Total	46,000	46,000

Solution

Table 16.2 shows equal cash inflows and also the equal payback of two years. But the timing of cash inflows is different. Project B yields Rs 12,000 as against Rs 8,000 by A. This has more value for next four years. Besides this, earlier cash inflows are likely to prove more accurate estimates than later cash flows.

Advantages

1. *Easy to calculate and understand* Calculation of payback period does not involve any complicated formulae. It is easy to calculate and understand.
2. *Liquidity is emphasised* It emphasises on the earlier cash flows which are more likely to be accurate than later cash flow. In other words, a short payback period also reduces the risk. (The more the risk, it is more likely that a part or whole of the investment will be lost).
3. *Reliable technique in volatile business conditions* It is a reliable technique for project appraisal, particularly in the areas of volatile business conditions such as change in technology, changing fashions or customer's tastes/preferences.

Disadvantages

1. *Post-payback earnings ignored* This method ignores the earnings after the payback period. It ignores the total life of the project and the total profitability of the investment.
2. *Timing of cash flows ignored* This method does not consider the timing of cash flows. All the cash flows are given equal weightage.
3. *Liquidity is over-emphasised* The liquidity of the proposal is over-emphasised by choosing only cash inflows. Other factors such as cost of proposal or cost of capital are ignored.

Despite the above limitations, the pay back method continues to be very popular and widely put to use particularly where there is a high degree of uncertainty.

Accounting Rate of Return (ARR) Method

Accounting rate of return refers to the ratio of annual profits after taxes to the average investment. The average investment is equal to half of the original investment. Accounting rate of return is also called average rate of return.

$$\text{ARR} = \frac{\text{Average annual profits after taxes}}{\text{Average investment}}$$

Where average investment is half of the capital outlay (that is, Capital outlay divided by 2). Average capital employed is calculated to the usual accounting convention that the original investment gets exhausted steadily to zero over the life of the project.

It is assumed that the asset is depreciated as per straight line method. Usually it is expressed in terms of percentage. The *higher the ARR is, the better is the profitability* and hence the projects with higher accounting rate of return are short-listed for implementation.

The above formula can be changed as per the needs of the appraisal. Average profits can be considered before or after depreciation, interest or taxes. At times, ARR is determined considering the original cost of the project as the denominator.

Example 6 Accounting rate of return

A firm is considering two projects each with an initial investment of Rs 20,000 and a life of 4 years. The following is the list of estimated cash inflows after taxes:

Table 16.3 Estimated Cash Inflows Proposals for I, II & III

Year	*Proposal I*	*Proposal II*	*Proposal III*
1	12,500	11,750	13,500
2	12,500	12,250	12,500
3	12,500	12,500	12,250
4	12,500	13,500	11,750
Total	50,000	50,000	50,000

Determine accounting rate of return on (a) average capital (b) original capital employed.

(a) ARR on average capital

	Proposal I	*Proposal II*	*Proposal III*
$ARR = \frac{\text{Average annual profits after taxes}}{\text{Average investment}}$	$= \frac{12,500}{10,000}$	$= \frac{12,500}{10,000}$	$= \frac{12,500}{10,000}$
	= 125%	= 125%	= 125%

(b) On original investment

	Proposal I	*Proposal II*	*Proposal III*
$ARR = \frac{\text{Average annual profits after taxes}}{\text{Original investment}}$	$= \frac{12,500}{20,000}$	$= \frac{12,500}{20,000}$	$= \frac{12,500}{20,000}$
	= 62.5%	= 62.5%	= 62.5%

From the Table 16.3, it is clear that the ARR gives equal priority to all the proposals though the timing of the cash in flows is different.

If There is Working Capital and Scrap, How is ARR Computed?

Where there is scrap resulting from the sale of the old asset and there is working capital, these two are added to the average investment. These are shown in the following formula:

Average investment = (Cost – Scrap)/2 + Scrap of old asset + Working capital

Example 7 Computation of ARR

Find out the average rate of return from the following data relating to CNC Machines 1 and 2.

Cost	Rs 300,000 each
Estimated life	3 years each
Estimated scrap	60,000 each
Income tax rate	50%
Additional working capital required	2,50,000 for each machine

The estimated cash inflows after taxes for each machine are as given below:

Year	*CNC Machine 1 Rs*	*CNC Machine 2 Rs*
1	1,50,000	2,00,000
2	3,00,000	3,00,000
3	1,50,000	2,50,000
4	—	1,50,000
Total	6,00,000	9,00,000

Solution

The average cash inflows after taxes for CNC Machine 1 = Rs 2,00,000 that is, (6,00,000/3)

The average cash inflows after taxes for CNC Machine 2 = Rs 2,25,000 that is, (9,00,000/4)

$$\text{Average Capital} = \frac{(\text{Cost} - \text{Scrap})}{2} + \text{working capital} + \text{Scrap}$$

$$= \frac{(3,00,000 - 60,000)}{2} + 2,50,000 + 60,000$$

$$= 1,20,000 + 250,000 + 60,000$$

$$= \text{Rs } 4,30,000$$

$$\text{ARR for Machine 1} = \frac{\text{Average annual profits after taxes}}{\text{Average investment}}$$

$$= \frac{2,00,000}{4,30,000} = 46.5\%$$

$$\text{ARR for Machine 2} = \frac{2,25,000}{4,30,000} = 52.32\%$$

Based on the accounting rate of return, the machine 2 is profitable.

Advantages

1. It is easy to understand and calculate.
2. It can be compared with the cut off point of return and hence the decision to accept or reject is made easier.
3. It considers all the cash inflows during the life of the project, not like payback method.
4. It is a reliable measure because it considers net earnings that is, earnings after depreciation, interest and taxes.

Disadvantages

1. The concept of time value of money is ignored.
2. Unless we have a cut-off point of return, accounting rate of return cannot be meaningful and effective.
3. The average concept is not reliable, particularly in times of high or wild fluctuations in the returns.
4. The average concept dilutes the profitability of the project. In other words, a project with greater aggregate returns is given lower ranking. For instance, take a project with a life of 3 years has an average annual cash inflows of Rs 20,000 (i.e. total cash inflows of Rs 60,000). If the same project has a life of one more year with a cash inflow of Rs 10,000, the average profitability gets reduced to Rs 17,500 (70,000/4) and consequently the project ranked lower.

Internal Rate of Return (IRR) Method

Internal rate of return is that rate of return at which the present value of expected cash flows of a project exactly equals the original investment. In other words, it equates the present value of a given project with its outlay. This is the cut-off point at which the income equals the expenditure or the investment breaks even.

At IRR, the net present value of a project is zero. The net present value refers to the excess of the present value of future cash flows over and above the original investment. IRR is denoted by 'r'. It is computed as shown below:

$$\therefore \quad C = \frac{CF_1}{(1+r)} + \frac{CF_2}{(1+r)^2} \cdots \frac{CF_n}{(1+r)^n}$$

Where C is the capital outlay, r is the internal rate of return and CF_n is the cash inflow at different time periods.

If we have scrap value and working capital adjustments, the above formula will change to:

This shows that IRR is that rate at which the difference between the present value of cash inflows and the original cost is equal to zero.

Evaluation of IRR

The internal rate of return is compared with the cost of the capital. If the IRR is more than the cost of capital, the project is profitable, otherwise it is not. Where there are two projects with different IRRs, select the project with higher IRR.

IRR and Even Cash Flows

Where cash inflows are even, it is relatively easy to compute IRR based on a factor located from the cumulative present value of Re 1 (See Table 16.5). It is explained as given below:

Example 9 Determination of IRR

A project costs Rs 1,44,000. The average annual cash inflows are likely to be Rs 45,000 for a period of 5 years. Calculate the IRR for the project.

$$\text{Factor} = \frac{\text{Project cost}}{\text{Annual cash inflows}}$$

$$= \frac{1,44,000}{45,000}$$

$$= 3.2$$

From Table 16.5 the cumulative present value of Re 1 received annually for n years, find out between which rates of return, the factor 3.2 is lying. From the Table, it can be seen that 3.2 is lying between 3.274 and 3.127 the corresonding rates of return are 16 percent and 18 percent respectively. Since 3.2 is close to 16 percent, the IRR can be considered as close to 16 percent. However, the exact percentage can be determined by interpolation method* as given below:

* In the formula used for interpolation, the notation is like this: R_L is the lower rate of return, PV_{CFAT} is the present value of future cash flows after taxes, PVc is the present value of original investment or capital, ΔR is the difference in the rates and ΔPV is the difference between the respective present values and IRR is the Internal Rate of a Return.

$$IRR(r) = R_L + \left[\frac{PV_{CFAT} - PV_C}{\Delta PV}\right] \times \Delta R$$

$$= 16 + \left[\frac{1,47,330 - 1,44,000}{1,47,330 - 1,40,715}\right] \times 2$$

$$= 16 + \left[\frac{3,330}{6,615}\right] \times 2$$

$$= 16 + (0.5) \times 2$$

$$= 16 + 1.0$$

$$= 17\%$$

The IRR can be represented by graph also as shown below:

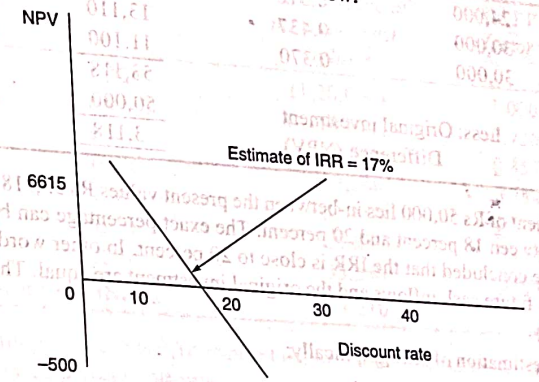

Fig. 16.1 Estimating IRR Graphically

IRR and Uneven Cash Flows

In most of the cases where the cash flows are uneven, computation of IRR is more by trial and error with respect to the discount factor. If the discount factor does not help to arrive at present value of cash inflows closer to the capital outlay, try with another possible discount factor.

Example 10 IRR from uneven cash inflows

Given that a project yields the following cash inflows for six years at an original cost of Rs 50,000 determine IRR.

Year	*Cash inflows after taxes (Rs)*
1	0
2	10,000
3	16,000
4	24,000
5	30,000
6	30,000

Solution

Here cash inflows are not even. So determine the IRR by trial and error process by attempting two possible different rates of interest 18 percent and say 20 percent

Year	*Cash inflow*	*18% PV factor*	*Present value of the future cash inflows*	*20% PV factor*	*Present value of the future cash inflows*
1	0	0	0	0	0
2	10,000	0.718	7,180	0.694	6,940
3	16,000	0.609	9,744	0.579	9,264
4	24,000	0.516	12,384	0.482	11,568
5	30,000	0.437	13,110	0.402	12,060
6	30,000	0.370	11,100	0.335	10,050
			53,118		49,882
	Less: Original investment		50,000		50,000
	Difference (NPV)		3,118		–118

The original investment of Rs 50,000 lies in-between the present values Rs 53,118 and Rs 49,882 which means the IRR is in between 18 percent and 20 percent. The exact percentage can be worked by interpolation method. It can be concluded that the IRR is close to 20 percent. In other words, at IRR 20 percent, the present value of the future cash inflows and the original investment are equal. The higher the IRR, the better is the profitability.

The following is the estimation of IRR graphically:

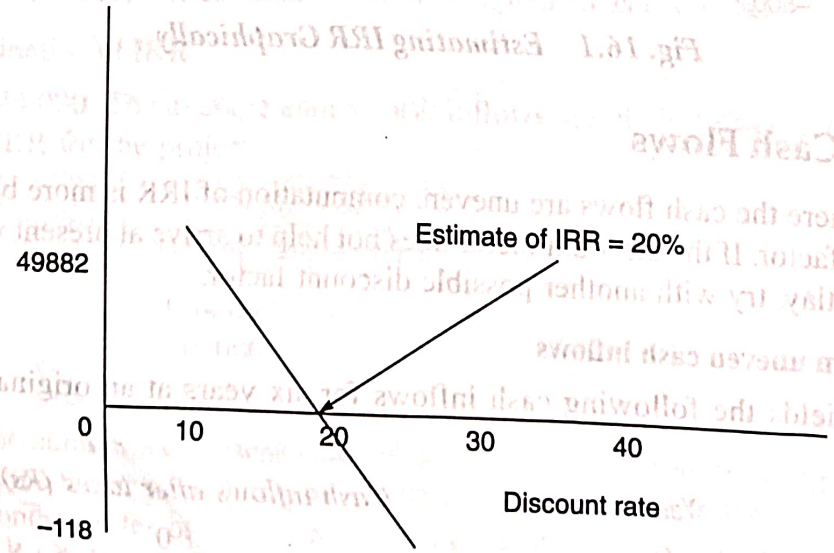

Fig. 16.2 Estimating an IRR Graphically

Example 11 Computation of IRR

It is estimated that an investment in a new

Advantages

1. IRR is based on time value of money.
2. It is based on the earnings of all the years of the project.
3. It is a valuable tool to compare the projects with different cash inflows and different life span.
4. It is independent of cost of capital.
5. Such projects with higher IRR are recommended. Hence it directly contributes to the 'wealth maximisation goal' of the finance manager.

Disadvantages

1. It is difficult to understand and tedious to calculate IRR by even trial and error.
2. It is based on certain assumptions, one of which is that the intermediate cash inflows are reinvested at IRR. Where the company has more than one project with different IRRs, this assumption may not hold good.
3. There could be cases of non-conventional projects with multiple IRRs, which are difficult to understand.
4. There are cases where higher IRR does not necessarily contribute to wealth maximisation (particularly in the case of mutually exclusive projects where NPV method is better).

Net Present Value Method

Net present value refers to the *excess* of present value of future cash inflows over and above the cost of original investment.

$NPV = (PV_{CFAT})$ minus (PVc)

Where PV_{CFAT} refers to the present value of future cash inflows after taxes

PVc refers to present value of original investment or capital

The concept of NPV is a logical extension to the concept of present value. Here the decision is based on the size of net present value. The projects with higher NPVs are selected. If the NPV is negative, that means the project is not profitable. In other words, the NPV should always be positive and should be maximum. The present value factor tables are used here to determine the present value of the future cash inflows.

How is NPV Calculated?

The following are the stages in the determination of NPV

1. From the PV factor table, identify the PV factors of Re 1 for the given discount rate (PV)
2. Multiply the cash flows (both outflows and inflows) with the corresponding PV factor to find the products DCF = (PV) × (CFAT)
3. Find the sum of the products
4. If the sum is positive, that means, the project is profitable. In case of projects with different NPVs, choose the project with the highest NPV because, the higher the NPV, the higher is the profitability.

Interpretation

NPV > 1 which means that the project earns more than the discount rate

NPV = 1 which means that the project earns the same as the discount rate

NPV < 1 which means that the project earns less than the discount rate

Example 12 NPV determination in case of even cash inflows

Given that a project costing Rs 40,000 has annual cash inflows of Rs 20,000 after taxes for a period of 6 years. How much is the net present value if the firm expects 15 percent per annum?

Net present Value = (PV_{CFAT}) minus (PVc)

PV (annuity) factor @ 15 percent for six years = 3.784

PV_{CFAT} = 20,000 × 3.784

= Rs 75,680

NPV = 75,680 – 40,000

= Rs 35,680

Example 13 NPV determination in case of uneven cash inflows

A firm has many projects. It wants to earn at least 6 percent per annum on this project with the following cash flows. Do you recommend?

Year end	0	1	2	3	4	5	6
Cash inflow			30,000	40,000	40,000	40,000	50,000
Cash outflow	1,00,000	20,000					

Solution

Year	*Cash inflow*	*6% PV factor*	*Present value of the future cash flows*
0	(1,00,000)	1.000	(1,00,000)
1	(20,000)	0.943	(18,860)
2	30,000	0.890	26,700
3	40,000	0.839	33,560
4	40,000	0.792	31,680
5	40,000	0.747	29,880
6	50,000	0.705	35,250
		Total Present value	1,57,070
		Less: Present value of original investment	1,18,860
		Net present value (NPV)	38,210

Since NPV is positive, the project can be recommended.

Example 14 NPV determination in projects with outflows during the project

From the following details relating to the two projects A and B, suggest which one is to be accepted under NPV method.

(ii) The Residual or Scrap Value of the Asset

The value of an asset at the end of its useful life is called as scrap value or residual value. This amount will be received only at the end of the useful life of the asset. The purpose of estimating the scrap value of an asset is to find out the net cost of the asset which is to be allocated over a number of years.

For eg., cost of the asset Rs.50,000/- scrap value Rs.5,000. for the purpose of calculating the amount of depreciation only Rs.45,000 (50,000 – 5,000) is to be considered.

(iii) Useful Life of the Asset

Useful life of the asset is another important factor to ascertain the amount of depreciation. The basic idea of ascertaining the useful life of an asset is to allocate the net cost of the asset over its useful life by means of depreciation.

Methods of Depreciation

(i) Straight Line Method or Equal Instalment Method

This is the most popular method. It is very simple to understand. Under this method, only a fixed amount is provided as depreciation every year.

Depreciation = (Cost of the asset – Scrap value)/Useful life of the asset

e.g., Cost Rs.1,00,000.

Scrap Value Rs.20,000

Life of the asset = 10 years

Depreciation = (1,00,000 – 20,000)/10 years

= Rs.8,000

Every year depreciation would be Rs.8,000 for a period of 10 years. If an asset renders uniform service throughout its useful life, this method is highly suitable.

This method is very simple to follow. Moreover, it can reduce the book value of the asset to zero.

(ii) Diminishing Balance Method or Written Down Value Method

Under this method, the rate of depreciation is fixed and it is applied on the book value of the asset in the beginning of every year.

For example,

Cost of the asset Rs. 1,00,000

Scrap value Rs. 20,000

Rate of depreciation 10%

Depreciation for year 1 will be = (1,00,000 – 20,000) = 80,000

10% on 80,000

Rs. 8,000

Second year beginning = Value of the asset = Rs. 80,000 – 8,000 = 72,000

depreciation for year 2 will be = 10% Rs.72,000/-

= Rs. 7,200

Third year beginning = Value of the asset = Rs.72,000 – 7,200

= 64,800

Depreciation for year 3 = 10% on Rs. 64,800 Rs. 6480.

Unlike in the previous method, here the amount of depreciation is gradually declining year after year. Under this method, as asset is depreciated more in the earlier year of use than later years. The rate of depreciation to be applied under this method can be ascertained by the following formula.

$$r = 1 - n\sqrt{S/C}$$

Where

n = the expected useful life in years

s = the residual value

c = the acquisition cost

r = rate of depreciation to be applied.

(iii) Sinking Fund Method or Depreciation Fund Method

Under normal circumstances, depreciation is debited to P & L account along with other items of expenses, and the profit arrived at, may be utilising in the different ways. If it is so, ready cash may not be available at the time of replacement of an asset. Under the sinking fund method, depreciation amount provided is kept aside and invested in readily marketable securities. When the life of the asset is over, the securities can be sold and the money can be used for replacement. An investment in securities can be sold and the money can be used for replacement. An investment in securities will earn some interest. Therefore, it is necessary ascertain the amount of yearly depreciation (which is to be invested in securities) by considering the rate of interest. The amount to be invested every year depends on the rate of interest. Sinking fund table shows how much is to be invested every year together with the interest earned so that at the end of the period one gets Rs.1.

Sinking fund table

Predict deposit

which will amount Rs. 1 $i/(1+i)^n - 1$

TABLE 7.1

Period in years	10%	11%	12%	13%	14%
1	1.000	1.000	1.000	1.000	1.000
2	0.476	0.474	0.471	0.469	0.467
3	0.302	0.299	0.296	0.294	0.290
4	0.215	0.212	0.209	0.206	0.203
5	0.163	0.160	0.157	0.154	0.151
6	0.129	0.126	0.123	0.120	0.117
7	0.105	0.102	0.099	0.096	0.93
8	0.087	0.084	0.081	0.078	0.075
9	0.0741	0.0741	0.067	0.064	0.062
10	0.063	0.059	0.057	0.054	0.051

For example, an asset is purchased for Rs.1,00,000. Its life is 10 years. It is expected that investment will earn interest at 12% per annum.

The sinking fund table shows that an investment of Rs.0.057 per year at 12% will become Re.1 at the end of 10 years. To get Rs.1,00,000 every year investment should be 1,00,000 × 0.057 = Rs.5700.

Total cost comprises fixed cost and variable cost. The significant variables on which the BEP is based are fixed cost, variable cost and total revenue.

Key Terms used in Break-even Analysis

(a) **Fixed cost** Fixed costs remain fixed in the short-run. Examples are rent, insurance, depreciation, factory supervisor's salaries, directors' salaries, and so on.

(b) **Variable costs** The variable cost per unit vary with the volume of production. The variable costs include cost of direct materials, direct labour, direct expenses, operating supplies such as lubricating oil, and so on.

(c) **Total cost** The total of fixed and variable costs

(d) **Total revenue** The sales proceeds (selling price per unit × number of units sold)

(e) **Contribution margin** The contribution margin is the difference between the selling price per unit and the variable cost per unit. It is also determined as (fixed cost per unit + profit per unit)

(f) **Profit** = Contribution – Fixed cost

(g) **Contribution margin ratio** It is the ratio between contribution per unit and the selling price per unit.

(h) **Margin of safety in units** The excess of actual sales (in units) *minus* the break-even point (in units)

(i) **Margin of safety in sales volume** The excess of actual sales (in rupees) *minus* the break-even point (in rupees)

(j) **Angle of incidence** The angle formed where total cost curve cuts the total revenue curve (see the BEP chart in Fig. 5.1).

(k) **P/V ratio** The ratio between the contribution and sales

Determination of Break-even Point

The following are the key terms used in determination of break-even point:

$$\text{Selling price} = \text{Fixed cost} + \text{Variable cost} + \text{Profit}$$

$$\text{Selling price} - \text{Variable cost} = \text{Fixed cost} + \text{Profit}$$

$$= \text{Contribution}$$

$$\text{Contribution per unit} = \text{Selling price per unit} - \text{Variable cost per unit}$$

Having studied the nature of fixed and variable costs in the earlier, we will now discuss how to determine break-even point.

(i) Determination of Break-even Point in Units:

$$\boxed{\text{Break-even point} = \frac{\text{Fixed costs}}{\text{Contribution margin per unit}}}$$

Where contribution margin per unit= (Selling price per unit – Variable cost per unit)

(ii) Determination of BEP in value:

$$\boxed{\text{BEP} = \frac{\text{Fixed costs}}{\text{Contribution margin ratio}}}$$

Where contribution margin ratio is the ratio of contribution margin per unit to selling price per unit.

Example 1

A firm has a fixed cost of Rs 10,000; selling price per unit is Rs 5 and variable cost per unit is Rs 3.

(i) Determine break-even point in terms of volume and also sales value

(ii) Calculate the margin of safety considering that the actual production is 8000 units.

Solution

(i) Determination of BEP:

$$\text{Break-even point in units} = \frac{\text{Fixed costs}}{\text{Contribution margin per unit}}$$

Where contribution margin per unit = Selling price per unit – Variable cost per unit

= 5 – 3

= 2

So, $\text{BEP in units} = \frac{10{,}000}{2}$

= 5000 units.

BEP can also be determined in terms of value (in rupees).

The formula is

$$\text{BEP in sales value} = \frac{\text{Fixed costs}}{\text{Contribution margin ratio}}$$

$$\text{where contribution margin ratio} = \frac{\text{Selling price} - \text{Variable cost}}{\text{Selling price}}$$

In the above example, the contribution margin ratio is (5 – 3)/5 = (2/5)

BEP in terms of sales value is calculated as below:

$$= \frac{10{,}000}{2/5}$$

= Rs 25,000

This can be verified by the formula:

Total revenue = Total cost

= (No. of units at BEP) × (Selling price per unit)

= 5000 units × Rs 5 per unit

Rs 25,000

In other words, at BEP Total revenue = Total cost. This implies that the profit or loss is zero. This is the reason why BEP is called no profit or no loss point.

BEP can be determined graphically as shown in Fig. 5.1.

(ii) Determination of margin of safety

Margin of safety (units) = Number of units sold – Break-even point in units

Margin of safety = 8000 – 5000

= 3000 units.

The margin of safety is 3000 units. If there is any unfavourable business conditions such as labour problem, the company can stand firm and continue discussions as long as volume of production does not fall below 5000 units. Once it reaches the BEP, it is advisable for the firm to reach an understanding as it cannot afford any more delay. If production falls below BEP, the firm suffers loss.

Example 2

A high-tech rail can carry a maximum of 36,000 passengers per annum at a fare of Rs 400. The variable cost per passenger is Rs 150 while the fixed costs are 25,00,000 per year. Find the break-even point in terms of number of passengers and also in terms of fare collections.

Solution

(a) Determination of BEP:

$$\text{Break-even point in units} = \frac{\text{Fixed costs}}{\text{Contribution margin per unit}}$$

Where contribution margin per passenger = Fare per passenger – Variable cost per passenger

= 400 – 150

= 250

So, BEP in number of passengers $\frac{25{,}00{,}000}{250}$

= 10,000 passengers

BEP in terms of collections (in rupees).

The formula is

$$\text{BEP in sales value} = \frac{\text{Fixed costs}}{\text{Contribution margin ratio}}$$

$$\text{where contribution margin ratio} = \frac{\text{Selling price} - \text{Variable cost}}{\text{Selling price}}$$

the contribution margin ratio is (400 – 150)/400 = (250)/(400)

BEP in terms of sales value is calculated as below:

$$= \frac{25{,}00{,}000}{(250/400)}$$

= Rs 40,00,000

Example 3

Srikanth Enterprises deals in the supply of hardware parts of computer. The following cost data is available for two successive periods:

	Year I (Rs)	*Year II (Rs)*
Sales	50,000	1,20,000
Fixed costs	10,000	20,000
Variable cost	30,000	60,000

Determine (a) Break-even point (b) Margin of safety.

Solution

Here the per unit data is not available. Hence use the formula of P/V ratio to find out BEP.

Profit-volume (P/V) ratio = (Contribution/Sales) × 100

Contribution and profit during the year II and I are calculated as below:

	Year I (Rs)	*Year II (Rs)*
Sales	50,000	1,20,000
Less Variable cost	30,000	60,000
Contribution	20,000	60,000
Less: Fixed costs	10,000	20,000
Net profit	10,000	40,000

	Year I (Rs)	*Year II (Rs)*
P/V ratio $= \frac{\text{Contribution}}{\text{Sales}} \times 100$	$= \frac{20,000}{50,000} \times 100$ = 40%	$= \frac{60,000}{1,20,000} \times 100$ = 50%
BEP $= \frac{\text{Fixed costs}}{\text{P/V ratio}}$	$= \frac{10,000}{40\%}$ = Rs. 25,000	$= \frac{20,000}{50\%}$ = Rs. 40,000
Margin of safety $= \frac{\text{Net Profit}}{\text{P/V ratio}}$	$= \frac{10,0000}{40\%}$ = 25,000	$= \frac{40,000}{50\%}$ = 80,000

The answers can be verified by using the following formula:

Sales = BEP sales + Margin of safety

Graphical representation of Break-even Point (BEP):

From the Fig. 7.1, we understand:

(i) TC = Total Variable Cost (TVC) + Total Fixed Cost + (TFC)

(ii) The variable cost line is drawn first. It varies proportionately with volume of production and sales.

(iii) The total cost line is derived by adding total fixed costs line to the total variable cost line. The total cost line is parallel to variable cost line.

(iv) The total revenue line starts from 0 point and increases along with volume of sales intersecting total cost line at point BEP.

(v) The zone below BEP is loss zone and the zone above BEP is profit zone.

(vi) OP is the quantity produced/sold at OC the cost/price at BEP.

(vii) The angle formed at BEP, that is, the point of intersection of total Revenue and total cost is called *angle of incidence*.

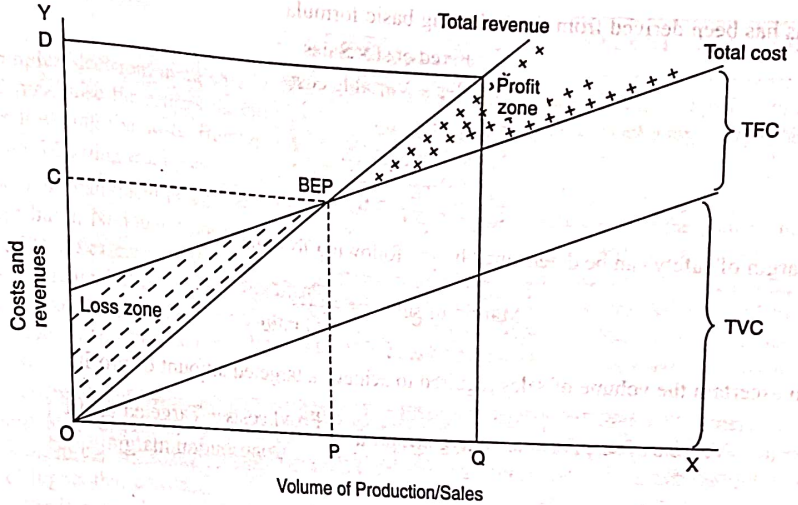

Fig. 7.1 Graphical Representation of Break-even Point

(viii) The larger the angle of incidence, the higher is the quantum of profit once the fixed costs ar absorbed.

(ix) Margin of safety refers to the excess of production or sales over and above the BEP of production sales. The margin of safety is OQ minus OP. The sales value at OQ is OD. It can be observed tha the firm reaches break even point at point BEP. At BEP, the total cost is equal to total revenue. OP i the volume of production/sales at the cost/revenue of OC. The zone below BEP is called loss zone and zone above BEP is called profit zone. Total cost curve is based on the total of fixed cost and variable cost.

Assumptions Underlying Break-even Analysis

The following are the assumptions underlying break-even analysis:

(a) Costs can perfectly be classified into fixed and variable costs.

(b) Selling price does not change with volume changes. It remains fixed. It does not consider the price discounts or cash discounts.

(c) All the goods produced are sold. There is no closing stock.

(d) There is only one product available for sale. In case of multi-product firms, the product mix does not change.

Different Formulae Used in Break-even Analysis and their Applications

The following are the variations of the formula of break-even analysis:

1. Profit-volume (P/V) ratio = (Contribution/Sales). If multiplied by 100, it can be expressed in terms of percentage.

This has been derived from the following basic formula:

$$\frac{\text{Fixed cost} \times \text{Sales}}{\text{Sales} - \text{Variable cost}}$$

or

$$\frac{\text{Fixed cost}}{P/V \text{ ratio}}$$

2. Margin of safety can be determined by the following formula:

$$\text{Margin of safety} = \frac{\text{Profit}}{P/V \text{ ratio}}$$

3. To ascertain the volume of sales required to achieve a targeted amount of profit:

$$\text{Volume of sales to attain a targeted profit} = \frac{\text{Fixed costs} + \text{Targeted profit}}{\text{Contribution margin}}$$

Application of Break-even Analysis

The following are some of the significant areas of applications of break-even analysis.

1. Make or Buy Decision Often, the manager is confronted with 'make or buy' decisions the necessary components or spare parts. Where the consumption is large, making may be economical. To illustrate,

Example 4

A lathe workshop owner uses 150 units of a certain spare part. He buys this from the market for Rs 250. The same can be manufactured in his workshop with a fixed cost of Rs 40,000 and a variable cost of Rs 50. Do you suggest him to make or buy from the market? It is possible that he can sell 500 units of the same spare part to other lathe shops in the town.

$$\text{BEP} = \frac{\text{Fixed costs}}{\text{Purchase price per unit} - \text{Variable cost per unit}}$$

$$= \frac{40{,}000}{250 - 50}$$

$$= \frac{40{,}000}{200}$$

$$= 200 \text{ units.}$$

The BEP is 200 units. This means that producing less than this is not economical. The total demand for the spare part is 650 units (150 + 500). It is recommended that this can be manufactured.

2. Choosing a Product Mix when there is a Limiting Factor It is very likely that the company may be dealing in more than one product and company wants to know, in view of the limited plant capacity,

What combination would yield maximum profits? To illustrate