3. **Project Appraisal**

3.1. **INTRODUCTION**

Project appraisal is a process of detailed examination of several aspects of a given project before recommending the same. The institution that is going to fund the project has to satisfy itself before providing financial assistance for the project. The lending institution has to ensure that the investment on the proposed project will generate sufficient returns on the investments made and that loan amount disbursed for the implementation of the project will be recovered along with interest within a reasonable period of time. The concept of security oriented lending has given way for the introduction of purpose oriented lending. Purpose oriented lending can be successful only if a detailed appraisal of the project is done before committing funds on the project. The various aspects of project appraisal are explained in this chapter.

3.2 **TECHNICAL APPRAISAL**

Technical appraisal broadly involves a critical study of the following aspects, **viz.,**

1. Selection of process/technology
2. Scale of operations
3. Raw material
4. Technical know-how
5. Collaboration agreements
6. Product mix
7. Selection and procurement of plant and machinery
8. Plant layout
9. Location of the project
10. Project scheduling and implementation.

3.2.1 **Selection of Process/Technology**

For manufacturing a product, more than one process/technology may be available. For example, steel can be manufactured either by the Bessemer process or by the open-hearth process. Cement can be manufactured either by the wet process or by the dry process.

The choice of technology also depends upon the quality and quantity of the product proposed to be manufactured. If the quantity required to be produced is large, mass production techniques should be followed and the relevant technology is to be adopted. The quality of the product depends upon
the use to which it is meant for. A product of pharmaceutical grade or laboratory grade should have high quality and hence sophisticated production technology is required to achieve the desired quality. Products of commercial grade do not need such high quality and the technology can be chosen accordingly. There is no point in choosing a sophisticated technology meant for getting high quality products, where the product is meant for commercial use for which high quality is not required. Such unwarranted emphasis on quality will only land the project in trouble since the consumers will not be ready to pay higher price merely for the sake of high quality which they do not really need.

In the choice of technology, as far as possible, the latest technology should be chosen provided there are no other constraints. However, in choosing the latest technology it must be seen that the technology has been proved successful for large-scale production at factory level. Relying only on the technology proven in the laboratory is to be avoided.

A new technology that is protected by patent rights etc., can be obtained either by licensing arrangement or the technology can be purchased outright. Under licensing arrangement, the right to use the patented technology and to get the related technical know-how are mutually agreed upon between the licensor and the licensee. Getting a technology under licensing arrangement is suited when the cost of purchasing the technology outright is huge/when there is a rapid technological advancement in the field with the result that there is every possibility of the technology becoming outdated shortly.

Technology can be purchased outright if the cost of acquisition is affordable, if there is no likelihood of significant improvement in technology in the foreseeable future and if the technology can be implemented and maintained without the need for continuous support from the seller of the technology.

**Appropriate technology:** A technology appropriate for one country may not be the ideal one for another country. Even within a country, depending upon the location of the project and other features, two different technologies may be ideal for two similar projects set up by two different firms at two different locations. The choice of a suitable technology for a project calls for identifying what is called the ‘appropriate technology’.

The term ‘appropriate technology’ refers that technology that is suitable for the local economic, social and cultural conditions. Appropriate technology can be identified by asking the following questions.

- Does the technology make use of the locally available raw material?
- Can the technology be implemented and maintained by the locally available manpower?
- Is the technology in tune with the local social and cultural conditions?
- Does the technology protect ecological balance etc.?

For example, textile yarn spinning frames manufactured in Europe were designed in such a way that the manual labour requirement to operate the machine is kept at the minimum while the electric power consumption by the machine is allowed to stand at a higher level. This technology is suited for European conditions where the cost of electric power is comparatively cheaper while getting manual labour is comparatively costlier. Indian conditions demand an opposite proposition since manual labour can be procured at a comparatively cheaper cost while the cost of electric power is comparatively higher. Hence, the choice of appropriate technology should be dealt with adequate care.
3.2.2 Scale of Operations

Scale of operations is signified by the size of the plant. The plant size mainly depends on the market for the output of the project. Economic size of the plant varies from project to project. Economic size of the plant for a given project can be arrived at by an analysis of capital and operating costs as a function of the plant size. Though the economic size of the plant for a given project can be theoretically arrived at by the above process, the final decision on the plant size is circumscribed by a number of factors, the main factor being the promoter’s ability to raise the funds required to implement the project. If the funds required to implement the project at its economic size is beyond the promoter’s capacity to arrange for and if the economic size is too big a size for the promoter to manage, the promoter is bound to limit the size of the project that will suit his finance and managerial capabilities. Whenever a project is proposed to be set up at a size below its economic size, it must be analyzed carefully as to whether the project will survive at the proposed size (which is below the economic size). Performance of existing units operating at below economic size will throw some light on this aspect.

Other factors like special problems of fabrication of equipments, transportation and erection of equipments, problems associated with availability of production inputs on a sustained basis etc., also impose restrictions on the plant size.

3.2.3 Raw Material

Selection of raw material: A product can be manufactured using alternative raw materials and with alternative processes. The process of manufacture may sometimes vary with the raw material chosen. If a product can be manufactured by using alternative raw materials, the raw material that is locally available may be chosen. Since the manufacturing process and the machinery/equipment to be used also to a larger extent depend upon the raw material, the type of raw material to be used should be chosen carefully after analyzing various factors like the cost of different raw materials available, the transportation cost involved, the continuous availability of raw material etc. Since the process of manufacture and the machinery/equipments required depend upon the raw material used, the investment on plant and machinery will also to some extent depend upon the raw material chosen. Hence the cost of capital investments required on plant and machinery should also be studied before arriving at a decision on the choice of raw material.

For example, precipitated calcium carbonate can be produced using either lime stone or shell-lime as the raw material. Shell-lime will be available near seashore while lime store will be available in areas with lime stone deposit. Since the quantity of raw material to be handled is comparatively large, the cost of transporting the raw material from the place of availability to the factory site will also be considerable. Also, though the end product is the same, there will be minor changes in the plant and machinery requirement for processing the different raw materials viz. limestone and shell lime. All these factors are to be analyzed before choosing the raw material to be used and the appropriate process of manufacture.

3.2.4 Technical Know-how

When technical know-how for the project is provided by expert consultants, it must be ascertained whether the consultant has the requisite knowledge and experience and whether he has already executed similar projects successfully. Care should be exercised to avoid self-styled, inexperienced consultants. Necessary agreement should be executed between the project promoter and the
know-how supplier incorporating all essential features of the know-how transfer. The agreement should be specific as to the part played by the know-how supplier (like taking out successful trial run, acceptable quality of final product, imparting necessary training to employees in the production process, taking out successful commercial production, performance guarantee for a specified number of years after the start of commercial production etc). The agreement should also include penalty clauses for non-performance of any of the conditions stipulated in the agreement. Payment of know-how fee should as far as possible be made in stages along with the progress of the project and it is the normal practice to retain a portion of the know-how fee and to release the same only after compliance of all the conditions stipulated in the agreement.

3.2.5 Collaboration Agreements

If the project promoters have entered into agreement with foreign collaborators, the terms and conditions of the agreement may be studied as explained above for know-how supply agreement. Apart from this, the following additional points deserve consideration.

(a) The competence and reputation of the collaborators needs to be ascertained through possible sources including the Indian embassies abroad and the collaborator’s bankers.

(b) The technology proposed to be imported should suit to the local conditions. A highly sophisticated technology, which does not suit local conditions, will be detrimental to the project.

(c) The collaboration agreement should have necessary approval of the Government of India.

(d) There should not be any restrictive clause in the agreement that import of equipment/machinery required for the project should be channelised through the collaborators. There should also be no clause for payment of commission and fee for the procurement of imported equipment/machinery.

(e) The design of the machinery should be made available to the project promoter to facilitate future procurement and/or fabrication of the machinery in India at a later stage. A knowledge of the design of the machinery will also help in proper maintenance of the machinery.

(f) The agreement should provide a clause that any dispute arising out of interpretation of the agreement, failure to comply with the clauses contained in the agreement etc., shall be decided only by courts within India.

(g) The collaboration agreement should not impose any restriction on the exports of goods produced. It must be open to the project promoter to explore any market that is advantageous to him, including export markets in any part of the globe.

(h) It must be ensured that the collaboration agreement does not infringe upon any patent rights.

(i) If there is financial participation in the projects by the collaborator, its effect on the management of the unit and transfer of payment/payment of interest to the collaborator may be studied.

(j) It is better to have a buy-back arrangement with the technical collaborator. This is to ensure that the collaborator would be serious about the transfer of correct know-how and would ensure quality of the output. Buy-back arrangement also helps the unit to release the pressure on the need for valuable foreign exchange. Since there is an assured market for the output, the promoter need not worry about identifying market for his product immediately after the project is on stream. Market for the product, both indigenous and export markets, can be explored during the course of time.
3.2.6 Product Mix

Customers differ in their needs and preferences. Hence variations in size and quality of products are necessary to satisfy the varying needs and preferences of customers. In order to enable the project to produce goods of varying size nature and quality as per the requirements of the customers, the production facilities should be planned with an element of flexibility.

Such flexibility in the production facilities will help the organization to change the product mix as per customer requirements, which is very essential for the survival and growth or any organization. Adding flexibility to the production facilities is not without any cost. It involves additional cost. However, a cost benefit analysis keeping in view the long-term benefits will indicate the need for such additional cost to be incurred.

For example, a plastic container manufacturing industry can be planned to have more number of dies of different sizes, so that goods of different sizes can be produced according to the market requirement. This will give the unit a competitive edge.

3.2.7 Selection and Procurement of Plant and Machinery

Selection of machinery: The machinery and equipment required for a project depends upon the production technology proposed to be adopted and the size of the plant proposed.

Capacity of each machinery is to be decided by making a rough estimate, as under; thumb rules should be avoided.

(a) Take into consideration the output planned.

(b) Arrive at the machine hours required for each type of operation.

(c) Arrive at the machine capacity after giving necessary allowances for machinery maintenance/ break down, rest time for workers, setup time for machines, time lost during change of shifts etc.

(d) After having arrived at the capacity of the machinery as above, make a survey of the machinery available in the market with regard to capacity and choose that capacity which is either equal to or just above the capacity theoretically arrived at.

In case of process industries, the capacity of the different machines used in various stages should be so selected that they are properly balanced. The following points should be considered for selection of machinery.

(a) Apart from the main process machinery, equipment required for supply of utilities, quality control, effluent disposal, material handling equipment shall also be identified and purchased.

(b) Along with the purchase of main machinery, adequate numbers of tools and spares are also to be purchased and stocked.

(c) If necessary, stand by arrangements may be made for critical equipment.

(d) Where the investment on a particular machine is high and its utility does not justify the huge investment, the chances of getting such work done through job orders from other outside agencies should be explored so that the heavy investment can be avoided safely.

(e) As far as possible, machinery suppliers or their authorized agents shall be asked to attend to the erection work of the machinery since they will be knowing the intricacies involved.

(f) Practical constraints that exist are to be given due attention before selecting certain machinery. If availability of power is limited in the proposed location of the factory, care should be
exercised in selecting power intensive equipments like electric ovens, electric furnaces etc., so that their power requirements matches with the power availability. If necessary, replacing such electric power intensive machinery with oil fired machinery (which use furnace oil as fuel instead of electricity) may be thought of. Similarly while selecting highly sophisticated machinery which require highly skilled personnel to operate them, the availability of skilled manpower should be studied.

If the promoters propose to purchase second hand machinery, it's working condition, estimated future life and its value are to be ascertained through a competent engineer. It must be ensured that the machinery is free from any charge to banks, financial institutions or other creditors.

**Procurement of machinery:** Plant and machinery form the backbone of any industry. The quality of output depends upon the quality of machinery used in processing the raw materials (apart from the quality of raw material itself). Uninterrupted production is again ensured only by high quality machines that do not break down so often. Hence, no compromise should be made on the quality of the machinery and the project promoter should be on the look out for the best brand of machinery available in the market. The performance of the machinery functioning elsewhere may be studied to have a first hand information before deciding upon the machinery supplier. Comparison of price quoted by a few standard and reputed machinery suppliers is normally done before deciding upon the supplier. It is not always necessary to choose the supplier who has quoted the least price among all. Other factors like reputation of the supplier, delivery schedule, after sales-service offered, performance guarantee, payment terms etc., need consideration before choosing a supplier.

### 3.2.8 Plant Layout

The efficiency of a manufacturing operation depends upon the layout of the plant and machinery. Plant layout is the arrangement of the various production facilities within the production area. Plant layout should be so arranged that it ensures steady flow of production and minimizes the overall cost.

The following factors should be considered while deciding plant layout.

1. The layout should be such that future expansion can be done without much alteration of the existing layout.
2. The layout should facilitate effective supervision of work.
3. Equipments causing pollution should be arranged to be located away from other plant and machinery. For example generator is a major source of noise pollution. Generator cannot be placed amidst other machinery since the noise generated will spoil the entire atmosphere of the plant. Hence generally generator is housed in a separate shed away from the main plant. Equipments that generate fumes are normally placed separately, preferably along the side of walls so that proper exhaust and ducting arrangements can be made easily for driving out the fumes.
4. There should be adequate clearance between adjacent machinery and between the wall and machinery to enable undertaking of regular inspection and maintenance work.
5. The plant layout should ensure smooth flow of men and material from one stage to another.
6. The plant layout should be one that offers maximum safety to the personnel working inside the plant.
7. The plant layout should provide for proper lighting and ventilation.
8. The plant layout should properly accommodate utilities like power and water connections and provisions for effluent disposal.
3.2.9 Location of Projects

Choosing the location for a new project is to be done taking many factors into account.

The study for plant location is done in two phases. First a particular region/territory is chosen that is best suited for the project. Then, within the chosen region, the particular site is selected. Thus, we may say that there are two major factors viz., Regional factors and site factors, to be considered.

Regional Factors: (a) Raw materials: Raw materials normally constitute about 50 to 60 per cent of the cost of the final product. Hence, it is important that the cost of the raw material should be minimum. To procure raw material at minimum cost, the plant must be located nearer to the place where raw material is available so that transportation cost will be reduced and the number of middle men involved in the procurement process also will be reduced. The transportation cost will constitute a major portion of the raw material cost if the raw material is bulky and procured from distant places. This is the reason why sugar factories are located in sugarcane growing areas, cement factories are located nearer to areas where lime stone is available and steel mills are located nearer to places where iron ore and coal deposits are available. Another common example is brick and tile industry which is set up on the land where clay suitable for the manufacture of brick/tile is available. If the raw material is bulky and is imported from abroad, the ideal location of plant will be nearer to port. Thus, when the raw material is bulky nearness to the place of availability of raw material acts as a major deciding factor in choosing the plant location.

(b) Proximity to market: If transportation of the finished product is more difficult (due to the special nature of the finished product) than transporting the raw material and also if the cost of transporting the finished product is more as compared to the transportation cost of raw material, it is advantageous to locate the plant nearer to the consumers i.e., nearer to the market. ‘Special nature of finished product’ mentioned above deserves special consideration. The finished product may be one that is fragile and difficult to handle (glassware, clayware/porcelain products); the finished product may be one that is perishable in short duration (cake, bread, pastry products). Such products of special nature make it mandatory to locate the plant nearer to the market.

Soft drink bottling plant is another example for locating the plant nearer to the market. The soft drink concentrate which is the main raw material is not bulk in quantity and can be transported to the plant with ease, whereas after manufacture, the quantity of soft drink increases manifold (since the soft drink concentrate is diluted during the manufacturing process) and more over, transportation of soft drink in bottles is to be done with care.

(c) Availability of labour: Though unemployed people are in plenty in our country, this does not mean that there will be no problem in getting the labour force required for the project. Availability of skilled labour is what is the criterion rather than availability of unemployed who are unemployable! If the project needs skills of general nature, people can be recruited and trained to the requirement. If the project needs skills of special nature, getting adequate skilled labour will not pose any problem if the plant is located in areas where skilled labour force is available. People in different areas develop special skills in different activities by virtue of the work culture prevailing in their respective areas. Skilled labourers required for running hosiery garment making factories are available in plenty in Tirupur (a town situated near Coimbatore). This is because of the reason hosiery garment industry is in existence in Tirupur for over 40 years. It is not always impossible to hire skilled labourers from distant places. However, the following difficulties may be encountered.

1. The labourers may demand a higher wage since they would like to be compensated for leaving their birth place and migrating to a new location.
2. Continuous availability of skilled labourers may be affected.

3. The organization may have to provide additional benefits like housing and recreational facilities in order to retain the labourers.

This may add to the cost of the project as well as cost of production.

(d) Availability of supporting industries: If a firm has proposed to get some of the production operations done from outside, there must be suitable industries existing in the surrounding area to undertake such subcontracting works. For example, a project may envisage to produce a product that may require a smooth finish for which it may need a surface finishing machine. The promoter may feel that the cost of the surface finishing machine is on the higher side and it is more economical to get surface finishing job done from outside by subcontractors, instead of investing heavily on the machine. This can be made possible only if there are firms around that are ready to undertake such subcontract works.

The reverse phenomenon is also true i.e., if a project is set up mainly with the idea of doing subcontract work to a major industrial establishment, the project should be located as far as possible nearer to the major industry that is going to offer subcontracts. This can be seen by the existence of many ancillary industrial units surrounding major industrial establishments like BHEL, NTPC, etc.

(e) Availability of infrastructural facilities: Availability of power, water, and transport facilities are the important aspects to be considered under this head.

Power: Power intensive industries should be located at places where regular power supply is available. It must be seen whether power supply in the area is made available through industrial feeder line. (There are places where power lines may be agricultural feeder lines. Power supply through agricultural feeder lines are available only for a shorter period of time in a day).

If the manufacturing process is such that sudden power failure may disturb the manufacturing activities and may cause considerable losses, it is always advisable to keep power generators as a standby. In such cases, the cost of generator should be included in the project cost. For example in plastic goods manufacturing industries, if there is sudden power failure, the molten material in the extruder will get cooled and solidified. After the resumption of power supply, the extruder is required to be heated up for a considerable length of time to bring the machine into operation. This also will result in wastage of raw material. In such situations, if power generator is available, the production can be continued without any interruption even if there is sudden power failure. In case of power intensive industries, power supply is given from high tension power lines for which a voltage step-down transformer is required to be erected. The cost of the step-down transformer and other related installations are to be borne only by the project promoters and hence these should be provided for while arriving at the project cost.

Water: Water requirement for the project should be correctly arrived at. After having arrived at the water requirement, it must be checked if the required quantity of ground water can be obtained from the site. The level of ground water table may be checked by observing the open wells nearby. The likely depth of water table and the likely yield of water from the site can be ascertained with the services of qualified water diviners. Apart from the quantity of water, the quality of water also must be suitable. If the industry is going to use water in its manufacturing process and if the quality of water to be used has a bearing on the quality of the output, the quality of the ground water is to be tested in the laboratory to ascertain its suitability. For example, dyeing industries need soft water for their manufacturing process. If the ground water available is hard it cannot be straightaway used for the dyeing process. The chances of getting soft water suitable for the process from outside is to be
found out. Alternatively, the hardness of the groundwater can be removed by installing a water softening plant. The comparative cost advantages of the two alternatives are to be worked out before deciding upon the alternative best suited for the industry.

Steam boilers that are used in many processing industries need only soft water. If the water available is not soft in nature, a water softening unit to treat the feed water to be used in the boiler is to be necessarily included in the project. Using of hard water for boilers will lead to formation of scales inside the boiler which will reduce the efficiency of the boiler and may even jeopardize the safety of boiler operation.

**Transport Facilities:** Transportation costs are incurred in two stages. Firstly, for the transport of raw materials and fuel into the factory site and secondly for the movement of the finished goods from the factory site. Thus, if a site is so located that the industry is to incur additional transportation cost (which is recurring in nature), this will add to the cost of finished product. Hence easy and cheap transport facilities are the most desired features.

**Locating industries in backward/most-backward areas, growth centre areas:** Government identifies regions which are lacking in industrial development and notify them as backward areas, most-backward areas, etc., Government also notifies growth centres which have potential for high growth. The Government offers many incentives in the form of capital subsidy, sale tax concessions, concessional financial assistance etc., for industries set up in these areas with the objective of ensuring dispersal of industrial activity throughout the country and to reduce regional disparities in industrial development. The incentives offered by the Government can be availed by setting up projects in such notified areas. However, the project promoter should not merely get carried away by the attractiveness of the incentives and concessions available, but should make a judicious and unbiased analysis of all other factors. Normally such notified areas lack in infrastructure and other facilities, which is the reason why these areas remain undeveloped and industrially backward. If the advantages out weigh the shortcomings, locations coming under such notified backward areas can be chosen for the project.

**Climatic factors:** Climatic factors have some influence in certain type of industries. Textile spinning mills, for example require high humidity for the spinning of cotton yarn. Hence places with high ranges of humidity are suitable for locating cotton-spinning mills. Though in areas of lesser humidity, cotton spinning mills can be set up by installing humidification plants, this will only add to the capital investment on plant and machinery and will also increase the cost of production due to increased expenses towards electric power for operating the humidification plant. Similarly, paperboard industries find hot and dry climate more suitable since paperboards that are in wet condition immediately after production can be sun-dried in open atmosphere.

**Site Factors:** After having chosen a region that is comparatively more advantageous for the location of a project, for choosing a particular site in the chosen region, considerations like cost of land, suitability of land, availability and suitability of ground water, facilities for effluent disposal etc., are to be taken into account.

In general, industrial projects require considerable extent of land. If the unit cost of land is high, the investment required to be made on land may become prohibitively high, which should be looked into. Apart from cost of land, the soil suitability also plays a major role. Since industrial projects mostly involve heavy machinery which need strong foundations, the load bearing capacity of the soil should be sufficient to withstand the pressure. Clay and black cotton soil are not suitable because of poor load bearing capacity and because of swelling nature when exposed to moisture.
The nature of effluent depends upon the type of the industry. If the effluent is of polluting nature, it has to be properly treated before disposal. Necessary consent for effluent disposal should be obtained from the concerned authorities. If the effluent is of polluting nature (as in the case of leather industries, chemical industries, paper plants etc.) there may be restrictions even for the disposal of the treated effluent if the location of the factory is nearer to water courses. Pollution control authorities some times stipulate conditions that major polluting industries should not be located within a minimum stipulated distance from natural watersources. Hence, before choosing the site location for polluting industries, the possibility of getting consent from the concerned authorities should be ascertained beforehand. In case of projects that produce effluents that are permitted to be disposed off only after proper treatment, necessary effluent treatment plants should be included in the cost of the project.

Choice of location: Decision on the choice of location for the given project is to be made after considering the points enumerated above. In view of the number of factors involved, deciding upon the project location is a complex problem. The problem is compounded further because of the existence of both tangible and intangible factors. If there are only tangible factors, the solution to the problem can be arrived at by mathematical means. Arriving at a decision combining the tangible and intangible factors involve subjective estimate.

Choice of location based on tangible factors: When tangible factors alone are considered, an ideal location is one for which the cost of setting up the project, cost of procuring raw materials, cost of processing the raw material into finished product and cost of distributing the finished product to the customers are minimum.

Let us study the concept by way of an example.

Illustration 3.1
A team of five entrepreneurs have joined together and constituted a partnership firm for setting up a new project for the manufacture of dry cell batteries. They have studied many different locations for the project and finally, after weighing the pros and cons have arrived at four different locations A, B, C and D which rank in the top. The tangible and intangible factors related to the four locations are as under:

<table>
<thead>
<tr>
<th>Factors</th>
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<th>B</th>
<th>C</th>
<th>D</th>
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<tbody>
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<td>(a) Investment on land and land development</td>
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<td>8,00,000</td>
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<td>8,00,000</td>
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<td>24,00,000</td>
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<td>(e) Salaries and wages (per annum)</td>
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<tr>
<td>Intangible factors:</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(a) Attitude of labourers</td>
<td>Poor</td>
<td>Indifferent</td>
<td>Good</td>
<td>Good</td>
</tr>
<tr>
<td>(b) Recreational facilities</td>
<td>Good</td>
<td>Good</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(c) Community facilities like hospital,</td>
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<td>Poor</td>
<td>Fair</td>
<td>Good</td>
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<tr>
<td>education, communications,</td>
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<tr>
<td>transportation</td>
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Identify the suitable location considering only the tangible factors.

Solution:

When tangible factors of the different locations are considered, rate of return on investment comes handy as a leading indicator to decide upon the choice of the location.

<table>
<thead>
<tr>
<th>Locations</th>
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<tbody>
<tr>
<td>[Amount in rupees]</td>
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<th>B</th>
<th>C</th>
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<tbody>
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<td>Total expenses (d + e + f + g)</td>
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<td>41,00,000</td>
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<td>Profit (\text{Sales} - \text{Total expenses})</td>
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<td>15,00,000</td>
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<td>25,50,000</td>
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<td>Total investment (a + b + c)</td>
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<td>41,20,000</td>
<td>43,00,000</td>
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<td>Return of investment [%]</td>
<td>53.66%</td>
<td>36.41%</td>
<td>32.56%</td>
<td>53.13%</td>
</tr>
<tr>
<td>(i.e., \frac{\text{Profit} \times 100}{\text{Total investment}})</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Based on the return on investment, locations 'B' and 'C' score comparatively less and hence either of location 'A' or 'D' can be chosen. Out of these two locations, a final decision can be arrived at taking the intangible factors into account.

Choice of location based on tangible and intangible factors: When the choice of location is to be made taking into account both the tangible and intangible factors, the solution to the problem takes the nature of a subjective decision in view of the reason that the intangible factors can not be accurately quantified. The technique devised by P.W. Bridgeman (called Bridgeman’s Dimensional Analysis) can be best applied to arrive at a solution for the choice of location combining tangible and intangible factors.

Dimensional Analysis: This method of analysis is used for comparing two locations and deciding the better of the two locations, keeping in view both tangible and intangible factors.

Let

A and B are the two locations

\(CA_1, CA_2, CA_3, \ldots\) are the different costs associated with tangible factors of location ‘A’ and/or the different scores’ associated with intangible factors of location ‘A’.

[*The scores are allotted from 1 to 10, giving score 1 for the best condition and score 10 for the worst condition*]
Project Management

CB₁, CB₂, CB₃ ..... are the different costs associated with tangible factors of location ‘B’ and/or the different scores* associated with intangible factors of location ‘B’.

W₁, W₂, W₃, ..... are the weights given to the tangible and intangible factors.

Then the relative merit of location A and location B is given by,

\[
\left( \frac{CA₁}{CB₁} \right)^{W₁} \times \left( \frac{CA₂}{CB₂} \right)^{W₂} \times \left( \frac{CA₃}{CB₃} \right)^{W₃} \times \ldots.
\]

If the value of the above relationship is more than 1, it means that location ‘A’ gains more points when both tangible and intangible factors are combined which in turn means that location ‘A’ is comparatively costlier than location ‘B’ and hence location ‘B’ is preferable to location ‘A’.

Illustration 3.2

From Illustration 3.1 choose the ideal location between ‘A’ and ‘D’ using dimensional analysis.

Solution:

For applying dimensional analysis, scores for the intangible factors (in the range of 1 to 10) and weights for the tangible and intangible factors are to be assigned.

Let us assign scores for the intangible factors for location A and D.

<table>
<thead>
<tr>
<th>Intangible factors</th>
<th>A</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attitude of labourers</td>
<td>Adequate</td>
<td>Good</td>
</tr>
<tr>
<td></td>
<td>(5)</td>
<td>(2)</td>
</tr>
<tr>
<td>Recreational facilities</td>
<td>Good</td>
<td>Bad</td>
</tr>
<tr>
<td></td>
<td>(2)</td>
<td>(8)</td>
</tr>
<tr>
<td>Community facilities</td>
<td>Fair</td>
<td>Good</td>
</tr>
<tr>
<td></td>
<td>(4)</td>
<td>(2)</td>
</tr>
</tbody>
</table>

Assigning scores is a subjective phenomenon and has to done judiciously. It is like giving marks to a feature. If a feature is very good, excellent and rare to find it is treated as the best and score is assigned as 1. On the other extreme if a feature is very bad and highly unfavorable it is treated as the worst and score is assigned as 10. Features having qualities in-between the best and the worst conditions are assigned scores in the range of 2 to 9. After having assigned the scores for the intangible factors, weights for the tangible and intangible factors are to be assigned. The weight for all tangible factors is assigned as ‘1’ since all the tangible factors are measured in terms of the common unit, viz., money. The intangible factors are compared among themselves and weights are assigned depending upon their relative importance.

If we assume weights for the intangible factors as under:

<table>
<thead>
<tr>
<th>Intangible factor</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attitude of labourers</td>
<td>2</td>
</tr>
<tr>
<td>Recreational facilities</td>
<td>3</td>
</tr>
<tr>
<td>Community facilities</td>
<td>2</td>
</tr>
</tbody>
</table>
then, the relative merit of site A to D is given by the following relationship:

\[
\begin{align*}
\left[ \frac{1,00,000}{70,000} \right]^l & \times \left[ \frac{7,00,000}{8,00,000} \right]^l \times \left[ \frac{33,00,000}{33,00,000} \right]^l \times \left[ \frac{20,00,000}{22,00,000} \right]^l \\
\times \left[ \frac{8,00,000}{9,00,000} \right]^2 & \times \left[ \frac{7,00,000}{3,00,000} \right]^2 \times \left[ \frac{3,00,000}{5,00,000} \right]^2 \times \left[ \frac{5}{2} \right]^2 \times \left[ \frac{2}{8} \right]^3 \times \left[ \frac{4}{2} \right]^3
\end{align*}
\]

\[= 5.5239\]

Since the factor works out to be more than 1.00, location-D is preferable to location-A.

**Observation**

When only the tangible factors are considered location-A scored marginally higher over location-D, as evidenced by marginally higher return on investment. However, when both tangible and intangible factors are considered, location-D becomes preferable to location-A.

### 3.2.10 Project Scheduling

Scheduling is nothing but an arrangement of the activities of the project in the order of time in which they are to be performed.

The schedule which broadly indicates the logical sequence of events would be as under:

- Land acquisition.
- Site development.
- Preparing building plans, estimates, designs, getting necessary approvals and entrusting the construction work to contractors.
- Construction of building, machinery foundation and other related civil works and completion of the same.
- Placing order for machinery.
- Receipt of machinery at site.
- Erection of machinery.
- Commissioning of plant and taking trial runs.
- Commencement of regular commercial production.

Each of the above mentioned activities consume resources *viz.*, time, money and effort. The sequence of activities should be so planned as to minimize the resource consumption. Without proper scheduling, resources are very likely to be wasted. As a part of technical appraisal, the financial institutions call for a detailed project implementation schedule indicating therein the various steps to be taken up in the project implementation in chronological order and time required for the completion of each stage. Detailed study of project scheduling techniques are given in subsequent chapters.

### 3.3 COMMERCIAL APPRAISAL OR MARKET APPRAISAL

The Commercial appraisal is concerned with market for the product/service. The very idea of promoting a project is to produce some product/service and to market the same to the consumers and earning a profit thereby. Hence, market appraisal occupies a prime place in project appraisal. In fact in modern management concept, marketing management receives more attention than in earlier
years. This is because of the reason that the very survival and success of any project depends on the question as to whether the product/service offered by the project is successful commercially.

Commercial appraisal (or market appraisal) of a project is done studying the commercial successfullness of the product/service offered by the project from the following angles.

(a) Demand for the product.
(b) Supply position for the product.
(c) Market share
(d) Distribution channels.
(e) Pricing of the product.
(f) Location of customers and their demographic factors like age-group, gender, economic status etc.
(g) Government policies.

3.3.1 Demand

Economists define demand for a commodity as the desire backed by the necessary purchasing power.

One of the most important determinants of a firm’s profitability is the demand for its products. Inspite of an efficient and technologically advanced production process and inspite of efficient financial management and cordial inter-personnel relationship between the employees and the management, the firm will find it difficult to earn profit if its products are not demanded by the consumers.

Because of the important role played by demand as a determinant of profitability, estimate of expected future demand for the product proposed to be manufactured constitutes a key element in all planning processes. Hence demand analysis forms a major part of project appraisal.

The term ‘demand’ can be defined as the number of units of a particular good or service that consumers are willing to purchase during a specified period under a given set of conditions.

3.3.2 Demand Forecasting Techniques

A forecast is a prediction or estimation of a future situation. No forecast can be cent per cent correct, however scientifically designed the forecasting techniques are, in view of the reason that future is uncertain!

Broadly speaking, there are two approaches to the problem of business forecasting. One approach is to obtain information about the intentions of consumers through collecting views and opinions of experts in the field or by conducting interviews with the consumers. This approach is called survey method. The other approach is to use the past experience as a guide and to arrive at the future demand by extrapolating the past ‘statistical data’. This approach is called statistical approach. While the survey method is suitable for short term forecasting, the statistical method is suitable for long term forecasting. Estimating future demand for existing products can be done by either method. But, demand for a new product can be estimated only by the survey method since past statistical data are not available for extrapolation.

Survey methods

1. Jury of expert’s opinion method: In this method, experts in the particular field are requested to give their views on the likely demand for the product in future. They are the persons who have been dealing in this product and in related products for a long time and thus are able to predict the future trend. This method is also called the hunch method since the experts give their opinions after weighing pros and cons of all factors affecting the product demand and arrive at an estimate, which is nothing but a hunch; the hunch of course is backed by knowledge and experience of the experts.
If the views of a more number of experts are obtained, and if their views differ significantly, then a forecast can be safely arrived at by taking the average of the expert’s predictions. Though this method is simple and does not employ extensive statistical work, the disadvantage is that it is only a subjective approach and the experts may have their own personal bias. Also, in this approach, no regard is given to the relative importance of the opinions of different experts.

An alternative approach is to ask the experts to reach consensus in a face-to-face deliberation. In this approach, the experts can offer their opinions orally and arrive at a consensus after observing and deliberating the rationale behind the many different views. However, in this approach, the result may not be a highly reliable one due to problems associated with group interaction dynamics. A participant who has better communication skills may drive home his views more effectively and his views may get undue weight (though it may be neither the majority view nor the correct view). Similarly, one who is not able to present his view effectively may not impress the group though his view really requires active consideration.

2. **Delphi technique**: This is a group decision by experts in which the individual experts act separately. Their views are pooled together and an attempt is made to arrive at consensus. If the views of the experts differ significantly, the individual experts are fed with the views of other experts in areas where there is distinct difference and they are asked to further analyze the problem and to revise/improve upon their views in the light of the views of the other experts in the group. The process can be repeated till a near coincidence of views is achieved. The important aspect of Delphi technique is that the experts who offer their opinions do not have face-to-face interaction and hence they are free to express their views. If at all they change their views in response to the views offered by other experts, it is only after due consideration and analysis without any external pressure from whomsoever. Hence, Delphi technique is found to give more accurate results as compared to Jury of expert’s opinion method.

3. **Consumer’s survey method**: This is the most direct approach to demand forecasting. In this method, consumers are approached and asked to express their opinion of a particular product. The survey can cover all the consumers if the consumers are smaller in number (e.g., Medical practitioners). If the number of consumers is large, a selected group of consumers is chosen for the survey. The principal merit of this method is that the forecaster does not add any bias of his own. The forecaster merely collects information from consumers and aggregates the information collected. The sales forecast by this method is likely to be more accurate since no assumptions are made. Why do companies spend a lot of money, time, and manpower in customer surveys, while simple, less expensive statistical forecasting techniques are available? Statistical data will only indicate the trend. It will not answer key questions like as to why consumers prefer a particular product etc. Surveying consumer intentions requires application of marketing research techniques. For forecasting the acceptance and the likely demand for a new product, elaborate verbal and pictorial descriptions of the product are to be given to the prospective consumers; they must be demonstrated about its actual use and free samples may be offered for trials.

Analysis of survey response involves pooling of consumers’ opinions on their planned purchases and arriving at a sales forecast using the following formula.

\[
\text{Sales forecast} = \left( \frac{\text{Total respondents who said 'yes'}}{\text{Sample size}} \right) \times \frac{\text{No. of respondents who said 'yes'}}{\text{[Sample size]}} \times \frac{\% \text{ of those who said 'yes'} \text{ who will actually purchase}}{\text{[Average quantity that will be purchased by a buyer]}}
\]
4. **Sales forecast composite:** This method of sales forecasting relies on the judgement of sales personnel. The field level sales personnel are requested to offer their forecast in their respective geographic area, to their sales managers. The forecasts of sales personnel are pooled together and the estimate given by each person is adjusted by applying appropriate weights and the adjusted forecasts are combined to arrive at the composite forecast. It is likely that some of the sales personnel may be too optimistic and provide a higher estimate while the pessimistic sales personnel will offer a lower estimate. The past accuracy of each sales person’s opinion should be assessed to identify those who tend to offer consistently high or low estimates and suitable weights are applied to their estimates to correct the deviations in their estimates. In complex situations, the sales personnel may not be aware of the likely changes that may take place in the general economic conditions, likely advancements in technology which may have an impact on sales, the likely shift in the consumer preferences etc. Under such situations, the sales managers have to take into account such macro level indicators and adjust the estimates provided by the sales personnel accordingly.

**Statistical Methods:** Statistical methods make use of past data. The past data are arranged in a chronological order and some statistical methods are used to identify the trend indicated by the past data. The trend is then extended to the future period. This process of extending the past trend to the future is called extrapolation. The statistical methods are of two types, namely: (1) **trend analysis** and (2) **regression technique.**

1. **Trend analysis:** The following are some of the methods used in trend analysis to estimate the future demand based on the past data.

   (a) Curve fitting.
   
   (b) Moving average method.
   
   (c) Weighted moving average method.
   
   (d) Exponential smoothing method.

   This basic assumption of trend analysis is that in future all the factors that were responsible for the past movements will be present and will exert influence in the same way as had been in the past. The relationship is often expressed in the form of a mathematical formula or model. With the help of the formula, the future trend is projected and forecasts are made on the assumption that the same trend would continue in the future also.

   (a) **Curve fitting:** Suppose there are two variables ‘x’ and ‘y’ that are related to each other. For example, the consumption level (‘y’) of a particular good might increase with the increase of time (‘x’). For instance, the consumption level in the year 1985 might be 2.00 tonnes, in the year 1986 — 2.4 tonnes, in the year 1987 — 3.3 tonnes, in the year 1988 — 4.7 tonnes, in the year 1989 — 5.9 tonnes and in the year 1990 — 7.10 tonnes. Such a trend in the consumption level indicates that there is a relationship between the consumption level (‘y’) and time (‘x’). If we are in the year 1991 and if there are indications that the increasing trend in consumption would continue for another, say, 10 years, we can arrive at the demand pattern for the next ten years, by fitting a curve with the available data.

   Fitting a curve using the available data can be done with minimum error, using the principle of least squares. The principle of least squares fits a straight line in such a way that the error of estimation is minimum.

   Referring to Fig. 3.1, let ‘AB’ is the straight line that offers the best fit with minimum error. The sample points 1, 2, 3, 4, . . . etc., lie on either side of the straight line.
Fitment error at point - 1 : \((y_1 - y_1')\)
Fitment error at point - 2 : \((y_2' - y_2)\)
Fitment error at point - 3 : \((y_3' - y_3)\)

\[
\text{etc.,}
\]

The best fitting straight line will be one for which the absolute value of fitment error is minimum. In fact, the best line would be the line that passes through all the points. However, this is not possible. Hence, our aim would be to find a line that is closest to all the points. A line will be the closest to all the points if the total distance between the line and all the points is minimum. Since some of the points will be above the line and some below the line, the difference between the line and the points above the line would be positive, while the difference between the line and the points below the line would be negative. Thus, the differences would cancel out one another and hence total sum of differences as a measure of best fit would be incorrect. Instead, if we calculate the differences individually and square them up, this would eliminate the problem of positive and negative differences and the total sum of squares of differences would be positive. Since we are looking for a line that is closest to all the points, for such a line, the sum of squares of differences would be minimum. Hence, this method of arriving at the line of best fit is known as “the method of least squares”.

If \(y = a + bx\) is the relation for the best fitting line, using the principles of least squares, the value of the parameters \(a\) and \(b\) can be determined. (Refer Fig. 3.2)
It can be shown, using the principles of least squares that the values of ‘a’ and ‘b’ can be determined by the following two equations:

\[ \Sigma y = n \cdot a + b \cdot \Sigma x \]

and \( \Sigma xy = a \cdot \Sigma x + b \cdot \Sigma x^2 \)

The above two equations are called ‘normal equations’ and these two equations can be used for arriving at the line of best fit from the available data.

**Illustration 3.3**

Fit a straight line trend to the following data, using the method of least squares. From the straight line trend, estimate the demand in the year 1995.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Demand for house hold water heaters (y)</td>
<td>600</td>
<td>825</td>
<td>970</td>
<td>1,210</td>
<td>1,440</td>
<td>1,790</td>
<td>2,070</td>
</tr>
<tr>
<td>(number in 1000’s)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Solution:**

The given data represents the actual demand for water-heaters that existed in the past seven years. Since the demand has consistently increased over the years, a relationship can be established by fitting a straight line for the demand curve, using the method of least squares.

Let \( y = a + b \cdot x \) is the line of best fit for the given data.

Using the principle of least squares, we have the following two relationships,

\[ \Sigma y = n \cdot a + b \cdot \Sigma x \]

and \( \Sigma xy = a \cdot \Sigma x + b \cdot \Sigma x^2 \)

Since \( \Sigma x, \Sigma x^2, \Sigma xy \) etc., are to be calculated from the available data, the calculations can be made simpler by making simple assumptions as under:

Let \( X = x - 1982 \)

and \( Y = y \)

With the above two assumptions, the normal equations take the following form

\[ \Sigma Y = n \cdot a + b \cdot \Sigma X \]

and \( \Sigma XY = a \cdot \Sigma X + b \cdot \Sigma X^2 \)

<table>
<thead>
<tr>
<th>Year (X)</th>
<th>Demand (Y)</th>
<th>X</th>
<th>X^2</th>
<th>XY</th>
</tr>
</thead>
<tbody>
<tr>
<td>1979</td>
<td>600</td>
<td>-3</td>
<td>9</td>
<td>-1,800</td>
</tr>
<tr>
<td>1980</td>
<td>825</td>
<td>-2</td>
<td>4</td>
<td>-1,650</td>
</tr>
<tr>
<td>1981</td>
<td>970</td>
<td>-1</td>
<td>1</td>
<td>-970</td>
</tr>
<tr>
<td>1982</td>
<td>1,210</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1983</td>
<td>1,440</td>
<td>1</td>
<td>1</td>
<td>1,440</td>
</tr>
<tr>
<td>1984</td>
<td>1,790</td>
<td>2</td>
<td>4</td>
<td>3,580</td>
</tr>
<tr>
<td>1985</td>
<td>2,070</td>
<td>3</td>
<td>9</td>
<td>6,210</td>
</tr>
</tbody>
</table>

\[ \Sigma = 8905 \]

Number of observations (n) = 7

\[ \Sigma X = 0; \Sigma X^2 = 28; \Sigma XY = 6810 \text{ and } \Sigma Y = 8905 \]
Substituting the values in the normal equations,
\[ \Sigma Y = n \cdot a + b \cdot \Sigma X \]
\[ 8905 = 7a + 0 \]
\[ i.e., \]
\[ 7a = 8905 \]
\[ a = 1272.14 \]
\[ \Sigma XY = a \cdot \Sigma X + b \cdot \Sigma X^2 \]
\[ 6810 = 0 + b \cdot (28) \]
\[ i.e., \]
\[ 28b = 6810 \]
\[ b = 243.21 \]

The equation for the trend line is,
\[ Y = a + bX \]
\[ Y = 1272.14 + 243.21X \]

Substituting \((x - 1989)\) for 'X' and \(y\) for 'Y',
\[ y = 1272.14 + 243.21(x - 1982) \]
\[ = 1272.12 + 243.21x - 482042.22 \]
\[ i.e., \]
\[ y = 243.21x - 480770.88 \]

Estimated demand in the year 1995:
\[ y = 243.21x - 480770.88 \]
\[ = 243.21 \cdot (1995) - 480770.88 \]
\[ = 485203.95 - 480770.88 = 4433.07 \]

Since the demand is given in terms of 1000's,
\[ y = 4433.07 \times 1000 = 44,33,070 \]
\[ \therefore \text{Estimated demand for household water heaters in the year 1995} = 44,33,070 \]
\[ \text{say, 44,33,000 Nos.} \]

(b) Moving average method: According to moving average method of forecasting, the forecast for the next year is arrived at by taking the average of the actual data for a few immediately preceding years. It the data of preceding three years are considered for arriving at the forecast for the fourth year, it is called a 'three year moving average'.

For example,

<table>
<thead>
<tr>
<th>Year</th>
<th>Actual Sales</th>
<th>Forecast</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sales</td>
<td></td>
</tr>
<tr>
<td>1994</td>
<td>2,219</td>
<td></td>
</tr>
<tr>
<td>1995</td>
<td>2,302</td>
<td></td>
</tr>
<tr>
<td>1996</td>
<td>2,007</td>
<td></td>
</tr>
<tr>
<td>1997</td>
<td>(2,219 + 2,302 + 2,007) ÷ 3 = 2,176</td>
<td></td>
</tr>
</tbody>
</table>

The forecast made for the year 1997 is 2176, taking three year moving average. If the actual sale achieved in the year 1997 is, say, 2198, the three year moving average for the year 1998 is arrived
at by taking the average of the actual sales during the immediately three preceding years.

<table>
<thead>
<tr>
<th>Year</th>
<th>Actual Sales</th>
<th>Forecast</th>
</tr>
</thead>
<tbody>
<tr>
<td>1994</td>
<td>2,219</td>
<td></td>
</tr>
<tr>
<td>1995</td>
<td>2,302</td>
<td></td>
</tr>
<tr>
<td>1996</td>
<td>2,007</td>
<td></td>
</tr>
<tr>
<td>1997</td>
<td>2,198</td>
<td></td>
</tr>
<tr>
<td>1998</td>
<td></td>
<td>((2,302 + 2,007 + 2,198) ÷ 3 = 2,169)</td>
</tr>
</tbody>
</table>

Determining the period of moving average is an important factor in calculating the trend values in the moving average method. This method is used when the past data do not exhibit a steady increase or decrease in trend over time, but show fluctuations. If the actual data of previous years show fluctuations in a uniform period, this uniform period is taken as the period of moving average. For instance, if the sales data of previous years indicate a steady growth for a continuous three years, followed by a drop in the fourth year, a ‘four year moving average’ can be assumed for forecasting. In other words, if the trend is cyclical in a period of every four years, a four year moving average is considered for arriving at the forecast.

Sometimes, though the actual data of previous years may be fluctuating, it may be difficult to find any distinct cyclical trend in the movement of data. In such cases, determining the period of moving average will be a difficult thing and can be done only on experimental basis, by making different trials and verifying the results of forecasts with the actuals before deciding upon the period of moving average.

(c) **Weighted moving average method:** In the moving average method of forecasting, only the simple arithmetic average of a few previous years’ data is taken as the forecast for the next year. When we take simple arithmetic average, it means that we are assigning equal weight to all the data. It is obvious that the most recent data will a better representative data than the earlier years’ data. The older the data, the less representative it will be. This is because of the fact that recent data take into account the latest happenings. Hence, it will be quite logical if we assign a greater weight to the recent data and a lesser weight to the older data. The importance and relevance of data will decrease as we move backward to the past data, the more recent data getting maximum weight and vice versa. Let there are three past data available with us. If we assume that the most recent past data should have a weight of 50%, The other two data put together should have a weight of 50%, since the total weight to be distributed among the available data is 100%. Under such conditions, we may assign weights as under:

- Most recent data : 50% (or 0.50)
- Oldest data : 20% (or 0.20)
- Data pertaining to the middle period : 30% (or 0.30)

(The oldest data is the least relevant and hence given the least weight; the sum of weights assigned to all the past data should be equal to 1.00)

In a four year moving average, for example, the weight for the past four year data might be as under:
<table>
<thead>
<tr>
<th>Actual Sales</th>
<th>Weights</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year</td>
<td>Sales</td>
</tr>
<tr>
<td>1999</td>
<td>3,560</td>
</tr>
<tr>
<td>2000</td>
<td>3,998</td>
</tr>
<tr>
<td>2001</td>
<td>4,201</td>
</tr>
<tr>
<td>2002</td>
<td>4,322</td>
</tr>
<tr>
<td>2003</td>
<td>4,706</td>
</tr>
<tr>
<td>2004</td>
<td>4,908</td>
</tr>
</tbody>
</table>

Forecasted sales for the year 2005 is arrived at as shown below:

<table>
<thead>
<tr>
<th>Actual Sales</th>
<th>Weights</th>
<th>Forecast</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year</td>
<td>Sales</td>
<td></td>
</tr>
<tr>
<td>1999</td>
<td>3,560</td>
<td></td>
</tr>
<tr>
<td>2000</td>
<td>3,998</td>
<td></td>
</tr>
<tr>
<td>2001</td>
<td>4,201</td>
<td>0.10</td>
</tr>
<tr>
<td>2002</td>
<td>4,322</td>
<td>0.20</td>
</tr>
<tr>
<td>2003</td>
<td>4,706</td>
<td>0.30</td>
</tr>
<tr>
<td>2004</td>
<td>4,908</td>
<td>0.40</td>
</tr>
</tbody>
</table>
| 2005 (Forecast) | ? | Forecast for 2005 : \( \Sigma \) (weight \times actual sales for the past years)  
\( i.e., (0.10 \times 4201) + (0.20 \times 4322) + (0.30 \times 4706) + (0.40 \times 4908) = 4659.50 \)

Deciding the appropriate weights for the past data is a ticklish issue and can be arrived at only by extensive experimentation.

(d) Exponential smoothing method: The speciality of exponential smoothing method is that forecasts are modified in the light of observed errors. This method takes into account the decreasing influence of the past time periods as we move further into the past data. This decreasing trend as we move down into the past time periods is found to be exponentially distributed and hence this method is designated as exponential smoothing method.

The forecasts for the next time period is given by the following relationship:

\[
F_{(t+1)} = \alpha \cdot A_t + (1 - \alpha) \cdot F_t
\]

Where,
- \( F(t + 1) \) = forecast for the time period \( (t + 1) \)
- \( \alpha = \) smoothing factor (which lies between 0 and 1, \( i.e., \alpha \geq 0 \) and \( \leq 1.00 \))
- \( A_t = \) Actual value for the time period ‘t’
- \( F_t = \) forecast for the time period ‘t’

Referring to the relationship given above, the forecast for a particular time period depends on the forecast as well the actual value of the immediately preceding period. In any series of data, the forecast for the first data in the series will not be available as this is the starting point for the series. For instance, if we want to estimate the likely demand of a particular product for a particular period, say for year 1995, we may be having the actual data for the previous year. \( i.e., \) for the year 1994. Since we want the forecast for the year 1995, the forecast for the previous year (1994) will not be available.
Since the forecast for the previous year is required as per the relationship given above, for assuming the forecasted value for the year 1994, the usual procedure is to make a few observations in the period prior to 1994 and the average of these observed values is taken as the forecasted value for the year 1994. For instance, if observations are done for the years 1989 to 1993, the forecast for the year 1994 is the average of the actual observed values during the period 1989–1993. This period of 1989–1993 is called the warm-up period and the sample of observations made during the warm-up period is called the warm-up sample. Thus, for the first period in the time series, we will be having both the actual value and a forecasted value (based on the warm-up sample).

Another parameter in the relationship that needs a careful assessment is the smoothing factor ‘α’. The value of the smoothing factor is also determined with the help of the observations made during the warm-up period i.e., (the warm-up sample). Using different values of ‘α’ in the range “0 to 1.00”, forecasted values for the warm-up period are calculated and are compared with the actual values. The value of ‘α’ that shows the minimum Mean Squared Error (MSE) is chosen.

Mean Squared Error (MSE) is given by the following relationship:

\[ \text{MSE} = \frac{\sum (A_i - F_i)^2}{n} \]

Where,
- \( A_i \) = actual value for the period ‘i’
- \( F_i \) = forecasted value for the period ‘i’

Suppose 1989–1992 is the warm-up period and the actually observed values during the warm-up period are 2005, 2920, 3210 and 3795 respectively. Different values for ‘α’ are assumed and the forecasted values for the warm-up period are calculated. The MSE for each set of forecasts are then calculated and the value of ‘α’ for which the MSE is minimum is chosen as the correct value for ‘α’.

<table>
<thead>
<tr>
<th>Warm-up period</th>
<th>( A_i )</th>
<th>( F_i )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1989</td>
<td>2,005</td>
<td></td>
</tr>
<tr>
<td>1990</td>
<td>2,920</td>
<td></td>
</tr>
<tr>
<td>1991</td>
<td>3,210</td>
<td></td>
</tr>
<tr>
<td>1992</td>
<td>3,795</td>
<td></td>
</tr>
</tbody>
</table>

Even while making forecast in the warm-up period, we come across the problem of ‘\( F_i \)’ for the first time period in the warm-up sample. ‘\( F_i \)’ for the first period in the warm-up sample is assumed to take the same value as ‘\( A_i \)’ for the first period. Accordingly,

<table>
<thead>
<tr>
<th>Warm-up period</th>
<th>( A_i )</th>
<th>( F_i )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1989</td>
<td>2,005</td>
<td>2,005</td>
</tr>
<tr>
<td>1990</td>
<td>2,920</td>
<td></td>
</tr>
<tr>
<td>1991</td>
<td>3,210</td>
<td></td>
</tr>
<tr>
<td>1992</td>
<td>3,795</td>
<td></td>
</tr>
</tbody>
</table>

The forecasts for the years 1990, 1991 and 1992 are made assuming a certain value for ‘α’. The exercise is repeated for several assumed values of ‘α’ in the range of 0 to 1.00 and the value of ‘α’ for which the MSE is minimum is chosen for further forecast in the actual time series.
Illustration 3.4

The actual demand for a consumer product for the year 1991 is 20,500. The value of ‘α’ is 0.32. The average demand of the warm-up period is 19980. Construct a table of forecasts using exponential smoothing method for the period 1992–2000. The actual demand for the period 1992–2000 are found to be 20,200, 20,310, 20,450, 20,610, 20,720, 20,815, 21,005, 21,090 and 21,180 respectively.

Solution:

<table>
<thead>
<tr>
<th>Year</th>
<th>$A_t$</th>
<th>$F_t$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1991</td>
<td>20,500</td>
<td>19,980</td>
</tr>
</tbody>
</table>

[the average demand for the warm-up period is taken as the forecast for the first year in the time series]

<table>
<thead>
<tr>
<th>Year</th>
<th>$A_t$</th>
<th>$F_t$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1991</td>
<td>20,500</td>
<td>19,980</td>
</tr>
<tr>
<td>1992</td>
<td></td>
<td>20,146</td>
</tr>
</tbody>
</table>

Forecast for the year 1992 [$F_{1992}$] = $0.32 \times A_{1991} + (1 - 0.32) \times F_{1991}$

= 0.32 (20,500) + (1 - 0.32) 19,980

= 20,146.4

say 20,146

The actual demand for the year 1992 will be known by the end of that year. The actual demand for the year 1992, as given in the problem is 20,200.

<table>
<thead>
<tr>
<th>Year</th>
<th>$A_t$</th>
<th>$F_t$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1991</td>
<td>20,500</td>
<td>19,980</td>
</tr>
<tr>
<td>1992</td>
<td>20,200</td>
<td>20,146</td>
</tr>
</tbody>
</table>

Forecast for the year 1993 [$F_{1993}$] = $0.32 \times A_{1992} + (1 - 0.32) \times F_{1992}$

= 0.32 (20,200) + (1 - 0.32) 20,146

= 20,164

<table>
<thead>
<tr>
<th>Year</th>
<th>$A_t$</th>
<th>$F_t$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1991</td>
<td>20,500</td>
<td>19,980</td>
</tr>
<tr>
<td>1992</td>
<td>20,200</td>
<td>20,146</td>
</tr>
<tr>
<td>1993</td>
<td>20,164</td>
<td></td>
</tr>
</tbody>
</table>

The forecast for the year 1993 is made at the end of the year 1992, after knowing the actual demand for the year 1992. The forecasted demand for the year 1993, of 20164 is made use of for all the managerial decision making purposes during the 1993. The actual demand for the year 1993 (which is known at the end of the year 1993) is 20130. The process of forecasting is repeated for further periods. It may be noted that as per the method of exponential smoothing, we can forecast only for the immediate next year.

The table of forecasts are as under:
Regression technique

A regression model is an equation relating a dependent variable to many independent variables. For example, anticipated sales (dependent variable) may be expressed as a function of independent variables like disposable income of consumers, price relative to the price of competitive products, level of advertising etc., and the relationship can be expressed as

\[ Y = a_1 + (b_1 \cdot x_1) + (b_2 \cdot x_2) + (b_3 \cdot x_3) + \ldots + (b_n \cdot x_n) \]

where \( Y \) represents sales

\( a_1, b_1, b_2 \ldots b_n \) are constants

and \( x_1, x_2, x_3 \ldots x_n \) are independent variables which affect the dependent variable \( Y \). With the time series data collected, a relationship is established as above. After establishing the relationship, values for the independent factors for the future period are estimated. Substituting these values in the relationship, estimate for the future years can be made.

When the number of independent variables are more, multiple regression analysis can be undertaken with the help of computers.

Other methods of forecasting

1. **End use method**: This method of forecasting is used for forecasting the demand for intermediate products. An intermediate product can have more than one uses, resulting in more than one final product. The demand for the various possible final products are projected. The likely consumption level at each of the final product is determined by determining the consumption co-efficient for the various uses. Consumption co-efficient is the number of intermediate products used in one final product.

   Project demand for the intermediary product

   \[ \text{Consumption co-efficient} \times \text{Projected output for the final product}. \]

   Where \( n = \) the number of final products in which the intermediate product finds its use.

For example two wheeler automobile horn is an intermediate product. It has no independent use of its own. It becomes useful when it is attached to the final product viz., the two wheeler automobile. The horn can find its use in mopeds, scooters, motorbikes etc., which are the different end products. The consumption co-efficient for horns is 1 since every unit of the two wheelers is fitted with only one horn. If the output of different varieties of two wheeler automobiles are projected, the projected demand for the horns can be arrived at since the co-efficient of consumption is 1.
<table>
<thead>
<tr>
<th>Final product</th>
<th>Consumption Co-efficient</th>
<th>Projected output of final product</th>
<th>Projected demand for the intermediate product (Horn)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mopeds</td>
<td>1</td>
<td>25,000</td>
<td>25,000</td>
</tr>
<tr>
<td>Scooters</td>
<td>1</td>
<td>40,000</td>
<td>40,000</td>
</tr>
<tr>
<td>Motor cycle</td>
<td>1</td>
<td>45,000</td>
<td>45,000</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>1,10,000</strong></td>
<td><strong>1,10,000</strong></td>
</tr>
</tbody>
</table>

If the intermediate product is say, indicator lamps used in two wheeler automobiles, since four numbers of indicator lamps are fixed to one two wheeler (two at the front and two at the rear) the consumption co-efficient is four i.e., for each unit of output of a two wheeler, four units of the indicator lamps would be consumed.

<table>
<thead>
<tr>
<th>Final product</th>
<th>Consumption Co-efficient</th>
<th>Projected output of final product</th>
<th>Projected demand for the intermediate product (indicator lamp)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mopeds</td>
<td>4</td>
<td>25,000</td>
<td>1,00,000</td>
</tr>
<tr>
<td>Scooters</td>
<td>4</td>
<td>40,000</td>
<td>1,16,000</td>
</tr>
<tr>
<td>Motor cycle</td>
<td>4</td>
<td>45,000</td>
<td>1,80,000</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>1,10,000</strong></td>
<td><strong>3,96,000</strong></td>
</tr>
</tbody>
</table>

The consumption co-efficient can be also a fractional figure. For example paper board is an intermediate product which can have many uses. One such use is the manufacture of paper cones used in textile spinning mills for winding of yarn. If the weight of each finished paper cone is say 30 grams and if the weight of paper required for one paper cone is say, 40 grams (the difference is due to wastage of paper board in cutting the board to the required size for the manufacture of paper cone) the consumption co-efficient is 1.33 (i.e., 40/30).

2. Leading indicator method: In an economy there are many factors (or variables) that are interrelated and interdependent. The change in one variable affects the other interdependent variables. Those variables that change ahead of their dependent variable are known as leading indicators. The variables that change in response to a change in their leading indicators are known as lagging indicators.

A few examples will make the idea clear. If the personal income of a society increases, the demand for consumer goods is bound to increase. Here ‘Personal income’ is the leading indicator and ‘demand for consumer goods’ is the lagging indicator.

If the agricultural income increases, it is most likely that the demand for fertilizers, manures, agricultural implements etc., are bound to increase. Here ‘agricultural income’ is the leading indicator and demand for fertilizers, manures, agricultural implements etc., are the lagging indicators.

The idea can be extended to all areas of demand forecasting. The demand for educational books (a lagging indicator) depends on growth of educational institutions (a leading indicator). The demand for automobile spare parts (a lagging indicator) is reflected by the number of automobiles being registered with the transport authorities (a leading indicator).

From the above, we get the understanding that the future demand for a lagging indicator can be predicted by observing the way in which its leading indicator behaves at present.

There are two steps involved in forecasting the demand by the use of leading indicator method, viz.,

(a) Identification of the appropriate leading indicator for a variable (lagging indicator) whose demand is to be forecasted.

(b) Establishing a relationship between the leading and the lagging indicators and reducing the relationship in the form of a regression equation.
Merits

The main advantage of this method is that it does not require detailed market survey for the proposed product. As this method gives the trend and magnitude of movement of the lagging indicator based on the behavior of the leading indicator, in all probability, the prediction of the trend is not likely to be reversed if the leading indicators are correctly chosen. In other words, the direction of movement of market factors is well reflected by the leading indicators, though there may be minor deviations in the magnitude of movements in view of the difficulties involved in arriving at the exact lead-lag relationship.

Demerits

- The crux of the problem is finding out the appropriate leading indicator. If a wrong leading indicator is chosen, the forecast may prove to be wrong.
- Since so many factors play in an economy, the lead-lag relationship, once established is not final, and requires continuous revision.

The leading indicators may change or the lead-lag relationship may get altered due to changes in market conditions. Hence the identifying the leading indicator and establishing the lead-lag relationship is to be a continuous process.

3. Chain-Ratio method: This method makes use of secondary data for forecasting the demand for a particular product. Macro level data are gathered and the data are reduced sequentially by applying appropriate reduction factors until the required information is obtained. The method can be better explained with the aid of an illustration.

Let a company has proposals to manufacture mopeds to suit the requirement of female customers and decides to use chain-ratio method to assess the demand. The following steps illustrate the method of assessment.

Total population of the targeted market : 4,00,00,000
Proportion of females in the population : 0.49
Total female population : 1,96,00,000 [4,00,00,000 × 0.49]
Proportion of employed women in female population : 0.15
Number of employed women : 29,40,000 [1,96,00,000 × 0.15]
Proportion of college students in female population : 0.19
Number of female college students : 37,24,000 [1,96,00,000 × 0.19]
Proportion of employed women who do not own a moped : 0.68
Number of employed women who do not own a moped : 19,99,200 [29,40,000 × 0.68]
Proportion of female college students who do not own a moped : 0.78
Number of female college students who do not own a moped : 29,04,720 [37,24,000 × 0.78]
Proportion of employed women who can afford to buy a moped : 0.55
Number of potential customers from employed women : 10,99,560 [19,99,200 × 0.55]
Proportion of female college students who can afford to buy a moped: 0.30
Number of potential customers from college students: 8,71,416 [29,04,720 × 0.30]
Total potential customers for mopeds: 19,70,976 [10,99,560 + 8,71,416]
Proportion of market share that the firm is estimated to capture: 0.20
Estimated sales potential: 3,19,195 [0.20 × 19,70,976]

Say, 3,19,200 numbers of mopeds

Since the chain-ratio method arrives at the forecast on the basis of many factors/assumptions, the accuracy of the result depends upon the accuracy of different factors/assumptions made in the assessment.

### 3.3.3 Other Aspects to be Considered in Demand Forecasting of a Product

(a) There may be certain products that are entirely imported. If a project proposes to set up a unit for the manufacture of this kind of product, the demand pattern can be identified by studying the past trends in imports.

(b) The product proposed to be manufactured may have export potentials. If so, apart from the demand in the indigenous market, the demand from abroad can also be taken into account. For assessing the export potential for the product, the following details may be gathered and analyzed:

(i) Past trends in the volume of world trade for the product.
(ii) Major importing countries and the quantum of import by these countries.
(iii) Duties and tariff barriers/tariff concessions if any, existing in the importing countries.
(iv) The trends in international prices for the product etc.

### 3.3.4 Industry Demand vs Firm Demand

'Industry' refers to a particular line of activity. 'Steel industry', for example, refers to the line of activity of producing steel and steel products. There will be many firms operating in a particular industry. There may be hundreds or thousands of firms producing steel/steel products. When we plan a project in a particular line of activity, we are interested in knowing only the demand that our proposed firm will get for its products i.e., we are interested in knowing the firm demand. The individual enterprises are known as firms and all the enterprises existing in a particular line of activity together constitute the industry. Hence firm demand and industry demand reflect two different parameters. While the industry demand refers to the demand for the product of the whole industry (say, for example the total demand for steel in a particular country) the firm demand refers to the demand for the product of a particular firm in that industry.

Though we are interested in knowing the firm demand, it is only derived from industry demand. In other words, it is a share of industry demand. Hence knowing the industry demand gives an overall picture. If there is good industry demand, the firm demand is also most likely to be good. This is because of the demand-supply gap existing for the product.

If there is no demand-supply gap for a particular product, it means that the output of all the existing enterprises producing that product is sufficient to meet the aggregate demand for that product. If the overall production capacity exceeds the aggregate demand, it means that there is excess production capacity in the industry. In both these situations, if a new enterprise is planned to be started in that industry, it is very unlikely that the firm's products will have any demand. If at all
a new enterprise in such an industry is to be successful, it should design its product in such a way that its product has different features than the products of other enterprises so that it can grab a portion of market share. However it will only be a risky venture and it will be very difficult to estimate a firm’s demand in such a situation.

3.4 ECONOMIC APPRAISAL

Economic appraisal measures the effect of the project on the whole economy. Economic appraisal is concerned with macro level factors like costs and benefits to the society, income distribution in the society, employment generation, putting the available resources into best possible use, level of savings and investment etc. Developing countries and underdeveloped countries face scarcity of capital and foreign exchange. Hence in the overall interest of the country, the limited stocks of capital and foreign exchange should be put into the best possible use. Hence, policy makers are concerned as to where the scarce resources can be directed to maximize economic growth of the country. So, among the alternative projects, the policy makers make a choice based on the economic return. This is true irrespective of whether resources are committed to a large project under taken by the Government or to a smaller project under taken by an individual entrepreneur. But an individual entrepreneur, when left free to choose, is more likely to be interested in his profit rather than having a broader perspective of the economic returns of the project.

Consider the hypothetical example given below, which will make the idea clear.

Let an entrepreneur own a granite quarry consisting of high quality granite stone. If the entrepreneur is not aware of the potentials of granite stone as its use in the form of polished slabs/tiles, he may choose to exploit the granite quarry by setting up a stone crushing unit which will produce stone jelly to be used as a raw material for say, laying of road, preparing concrete mix etc. Even if the entrepreneur is aware of the potential of granite stone, if he is not mentally prepared to venture into a high-tech project for the production of polished granite slabs/tiles which can have very good export potential, he may settle for a low-tech stone crushing project, producing stone jelly. He may be even satisfied with the return from the stone crushing unit though setting up an unit for the production of polished granite slabs/tiles will maximize the economic growth of the country as a whole by earning valuable foreign exchange in view of its export potential. [This is only a hypothetical example.]

In otherwords a private entrepreneur may not be interested in studying the social cost-benefit analysis of a project. Social cost-benefit analysis is also referred to as socio-economic analysis which deserves consideration especially in public projects. A detailed description of social cost-benefit analysis is given under Para 3.7.

In order to regulate the deployment of scarce resources for the economic upliftment of the country by channelising the use of scarce resources to the best possible use, the Government enforces control through its policies and regulations.

In India, the development banks function within the overall framework of the Government's policies and regulations of industrialization and direct their lending to projects that are in accordance with the priorities of the Government.

3.5 FINANCIAL APPRAISAL

Financial appraisal of project consists of two major areas viz., arriving at the cost of the project and arriving at the appropriate means of financing the project. By means of financing, we mean the combination of equity and debt. The proper equity-debt combination for a project depends upon the revenue earning capacity of the project. Though equity does not attract any interest and does not involve any repayment obligation, the debt obtained for financing the project is to be repaid along
with interest. Hence, the revenue earning capacity of the project should be sufficient enough to meet the repayment of debt with interest. Moreover, the project should also generate additional revenue to meet the cost of equity capital. Though equity is contributed by the project promoters, it is not without any cost. An entrepreneur invests his capital in a project with a hope of getting returns on his capital invested apart from meeting debt obligations. Financial appraisal deals with profitability of the project, break-even point, cash flows over time, internal rate of return/payback period, risk-return characteristics etc. [A detailed account of financial appraisal is available in Chapters 6 and 7]

3.6 MANAGEMENT APPRAISAL

Management is the most important factor that can either make a project a success or a failure. A good project at the hands of a poor management may fail while a not-so-good project at the hands of an effective management may succeed.

The American Institute of Management which conducted an appraisal of management as a method of ascertaining a company’s health and prospects has assigned a weight of only 6% of the total to ‘earnings’. A far greater weight of 22% has been assigned to the quality of the executive managing the affairs of the company. The board of directors of a company and its corporate structure gets a weight of 13%.

Hence, banks and financial institutions that lend money for financing projects lay more emphasis on management appraisal. Lending institutions look at two points before committing their funds to project financing. They look at the capacity of the project to repay the loan along with interest within the stipulated period of time and also they observe the willingness of the borrower to repay the loan. While the ‘capacity to repay’ is assessed by technical, commercial and financial appraisals, the ‘willingness to repay’ (or propensity to repay or intention to repay) is assessed by way of management appraisal.

While other appraisal techniques are quantitative and objective in nature, management appraisal is purely qualitative and subjective in nature.

The persons who are to be evaluated for the purpose of management appraisal depends upon the constitution of the enterprise. Very small projects that are promoted by sole proprietors, are managed by the proprietors themselves. In such cases the management appraisal is to be done obviously on the proprietors. In respect of partnership firms, there may be partners who have only contributed capital, but keep themselves away from the day-to-day management of the enterprises. Hence, in the case of the partnership firms, the management appraisal shall be done on the managing partners of the firm (i.e., those partners who actually manage the affairs of the enterprise). Mutual understanding and trust among the partners is a key factor for the success of an enterprise.

Persons who maintained a cordial, long term relationship in the past either in business or in other areas, make good partners. Persons who join together for the first time with the sole intention of promoting a new project are often found to lack in mutual understanding and this will show up shortly after the project has taken shape, or at times, even during the implementation stage of the project itself. There are many instances where misunderstanding and dispute among the partners has led to the failure of projects than any other internal/external factors. Hence, mutual trust among the partners is a prerequisite for successful implementation and management of projects. The management appraisal shall give due importance to this aspect.

In private limited companies, it will be the managing directors/executive directors who are to be appraised. The affairs of closely held public limited companies are mostly looked after by the promoter directors. For such companies also, the managing directors/executive directors are the persons to be appraised who manage the affairs of the enterprises.
In respect of widely held public limited companies, the management appraisal shall be done on the
directors who are in the board of the company, on the chief executive officer of the company and
also on key functional managers. Appraisal of the chief executive officer carries more importance
since he is the king-pin of a company.

Integrity, foresightedness, leadership qualities, interpersonal relationship, technical and financial
skills, commitment, perseverance etc., are some of the parameters that need to be studied in
management appraisal.

If management appraisal of persons who are already managing the affairs of some other enterprise(s)
is required to be done, a visit to such enterprise(s) that is (are) managed by them will throw light.
The industrial relations prevailing in that enterprise, morale of the employees, the prevailing superior-
subordinate relationship, labour turnover, labour unrest, productivity of employees are some of the
factors that will reflect the managerial capabilities of the persons concerned.

The importance of management appraisal is being increasingly felt now a days in view of the
growing number of units that have become sick due to mismanagement. Though management
appraisal is a vital aspect of project appraisal, it still remains more of a subjective exercise and it will
continue to remain so, though refinements are possible. This is because, management appraisal is
concerned with the appraisal of human qualities.

3.7 SOCIAL COST BENEFIT ANALYSIS

The main objective of an individual, a firm or a company in investing on a project is to earn the
maximum possible returns for the investment. Accordingly, the project promoters are solely inter-
ested in wealth maximisation. Hence the project promoters tend to evaluate only the commercial
profitability of a project.

There are some projects that may not offer attractive returns as far as commercial profitability is
concerned, but still such projects are undertaken since they have social implications. Such projects
are public projects like road, railway, bridge and other transport projects, irrigation projects, power
projects etc., for which socio-economic considerations play a significant part rather than mere
commercial profitability. Such projects are analysed for their net socio-economic benefits and the
profitability analysis of such projects is known as national profitability analysis, which is nothing but
the socio-economic cost-benefit analysis done at the national level.

Every project imposes certain costs and produces certain benefits to the nation. The costs may be
of two types viz., direct costs and indirect costs. So also, the benefit derived from any project will
also be of two types, viz., direct benefits and indirect benefits.

For analysing the commercial profitability of projects, only the direct costs and direct benefits are
taken into account. Further, for assessing the commercial profitability, the direct costs and direct
benefits are reckoned at the market prices. The national profitability analysis, in other words, the
social cost-benefit analysis differs from commercial profitability analysis in two ways viz.,

(a) As against the market prices of direct cost and direct benefits considered in commercial
profitability analysis, the social cost-benefit analysis takes into account the ‘real cost’ of direct
costs and ‘real benefit’ of direct benefits. For example, some of the inputs, (say, power
charges) may be subsidised. Only the subsidised prices of inputs is what is relevant for
assessing commercial profitability. However, the social cost-benefit analysis takes into account
the real cost of inputs i.e., the cost of inputs had they not been subsidised. Accordingly, the
required adjustments to direct costs of inputs are made for social cost-benefit analysis. Simi-
larly, cost adjustments may also be required for the benefits. For example, the output may be a
product whose price is controlled by the Government. The Commercial profitability analysis
will take into account the controlled price (which is the market price fixed by the Government)
while its actual benefit to the nation may be more or less than the controlled price, which is what is relevant for social cost-benefit analysis.

(b) As against the direct cost and direct benefits that are alone considered for commercial profitability analysis, socio-economic cost-benefit analysis takes into account the indirect costs and indirect benefits to the nation. While a nation bears the indirect cost, the people of the nation enjoy the indirect benefits. Hence, indirect costs/benefits are given due recognition and accounted for in social cost-benefit analysis. It is however difficult to assess exactly the quantum of indirect costs and indirect benefits (which has always remained as a subject for debate!). For example, consider a project of a pharmaceutical unit producing life saving drugs. For the pharmaceutical company, the benefit it derives out of the project is nothing but the returns that the project earns on the investment. Thus, the market price of the life saving drug is what the pharmaceutical company will be concerned with. As against this, the drug might be one that improves the well being of the society. It’s contribution to the society might be more than what the society pays as price for the drug. Thus the social benefit might be much more than the benefit that accrue to the pharmaceutical company by way of returns.

Just as benefit has two different meanings to the project promoters and to the society, cost also has two different meanings to these two categories of persons. The cost, as far as the pharmaceutical company is concerned is only the financial cost which is nothing but the direct-cost. Apart from this, there are indirect costs to the society viz., the environmental pollution caused by the pharmaceutical industry, the harmful side effects of the drugs produced etc., if any. Consider another example viz., construction of a bridge over a river. It’s indirect benefits may include improved communication facilities, reduction in transportation costs, reduction in travelling time etc., while the indirect costs may include acquisition of private land by the State, removal of industrial/commercial/agricultural activities that prevailed in the land that was acquired, disturbance of ecological balance etc.

Social cost-benefit analysis can thus be regarded as a refinement over commercial appraisal, taking the hidden factors into account. Social cost-benefit analysis is mainly used for evaluating public investment projects.

### 3.7.1 Objectives of Social Cost Benefit Analysis

SCBA aims to appraise the total impact that a project will have on an economy. Accordingly, SCBA focuses on the following objectives that a project is expected to fulfill:

- Contribution of the project to the GDP (Gross Domestic Product) of the economy.
- Contribution of the project to improve the benefits to the poorer sections of the society and to reduce the regional imbalances in growth and development.
- Justification of the use of scarce resources of the economy by the project.
- Contribution of the project in protecting/improving the environmental conditions.

### 3.7.2 Approach to Social Cost Benefit Analysis

There are two main approaches to Social Cost Benefit Analysis, viz., the UNIDO Approach and the Little-Mirrlees Approach. Though the UNIDO approach is more popular, none of the approaches can be said to have universal applications. The suitability of an approach to a project depends upon many factors such us the present level of development of the country, the extent and nature of future development that the country strives to achieve etc. Sometimes modifications of the approaches are necessary to be in tune with the ground realities. A detailed approach to SCB analysis is beyond the scope of this book. This is an interesting and at the same time more involved area of study and readers who are interested to know more about this are referred to books on Welfare Economics by renowned economists.
3.7.3 UNIDO Approach to SCB Analysis

Famous economists Stephen Marglin, Amartya Sen and Partha Dasgupta prepared a manual based on UNIDO’s experience in cost-benefit analysis of projects. UNIDO published this manual in 1972 under the title “Guidelines for Project Evaluation”. Subsequently, UNIDO brought out another manual titled “Guide to Practical Project Appraisal” to simplify the cost-benefit analysis of projects for practical application.

The UNIDO approach places emphasis on ‘aggregate consumption’ for the reason that it is one of the important parameters for the measurement of the standard of living. As per UNIDO approach, the raising of the standard of living of people, and hence the raising of aggregate consumption is an important objective for social projects.

However, ‘aggregate consumption’ is a very broad term that evades clear definition. This is because, consumption levels of people differ. Further, people consume a number of goods. Hence, calculation of aggregate consumption involves converting a heterogeneous bundle of goods into a single homogeneous measure which is a difficult proposition. Therefore, the consumption level is measured by measuring ‘consumer’s surplus’ and ‘consumer’s willingness to pay’.

The UNIDO approach to Social Cost Benefit Analysis consists of the following stages:
1. Arriving at the financial profitability of the project based on market prices.
2. Using shadow prices for the resources to arrive at the net benefit of the project at economic prices.
3. Adjustment of the net benefit for the project’s impact on savings and investment.
4. Adjustment of the net benefit for the project’s impact on income distribution.
5. Adjustment of the net benefit for the goods produced whose social values differ from their economic values.

The measurement of financial profitability of the project based on market prices is nothing but the financial appraisal (or financial evaluation) of projects discussed elsewhere in this book. The financial analysis when done at market prices serves its purpose for private sector projects. For public sector projects, the objective is the maximisation of social welfare. Financial appraisal of public sector projects and national level projects that are carried out with social objective is first carried out on similar lines as private sector projects and then the results obtained are adjusted to reflect the social welfare implications. Hence, after the first stage of financial profitability analysis at market prices is completed, the next phase is considering the effect of shadow prices and adjustments.

**Shadow Prices:** As explained already, for social cost-benefit analysis, the market prices of both inputs and outputs of a project are required to be corrected suitably if they do not represent the ‘real’ prices of inputs/outputs. Such corrected price of inputs/outputs is known as shadow price. Hence, the shadow price takes care of the distortions in the market price by suitably adjusting the market price.

For example, newly set up Small Scale Industries in India are granted subsidy on electricity charges by the Government, for the initial few years. The State Electricity Boards (SEB) may produce electricity at a cost of, say ₹ 2.50 per unit. A newly set up Small Scale Industry may be charged at a rate of say ₹ 1.50 per unit of electric power consumed in its first year of operation, ₹ 1.75 per unit, in its second year of operation ₹ 2.00 per unit in its third year of operation etc., In such a situation, the cost of electric power for the Small Scale Industry is ₹ 1.50 per unit, ₹ 1.75 per unit and ₹ 2.00 per unit for the first, second and third year of operation respectively.
However the cost for the SEB is ₹ 2.50 per unit which is the actual cost, though the SEB charges a lower price. The price of electric power to be used for social cost-benefit analysis is only ₹ 250 per unit which is the shadow price of electric power.

The above example of price distortion and the correction needed to arrive at the shadow price is a too simple instance. There are a few important basic issues connected to shadow pricing which are discussed below.

**Numeraire**: ‘Numeraire is the unit of account in which the values of inputs and outputs are expressed. The numeraire used in UNIDO approach is the domestic accounting rupee. The domestic accounting rupee takes in to account the shadow price relationships. The definition of the UNIDO numeraire is ‘the net present consumption in the hands of the people at the basic level of consumption in the private sector in terms of constant price in domestic accounting rupees.’

**Tradeability of goods/services**: A deciding factor in shadow pricing is the tradeability of goods/services. A tradeable good is one which would be traded between countries without any restrictions. The shadow price for tradeable goods is the international price (also known as ‘border price’) for such goods. This is because it is possible to substitute import for domestic production and export for domestic consumption.

A non-traded good is one that is not traded due to trade policies of the country. A non-traded good is appraised at its marginal economic value; the marginal economic value is the amount the domestic consumers are willing to pay for an additional unit. A non-traded good may become a tradeable good if the policy of the Government changes.

The domestic production cost of a good plus transportation cost to the destination may be too low to substitute it with an imported good. In such instances, there won’t be any import of goods as imported goods will be costlier. Similarly, the domestic production cost of a good plus transportation cost to the destination may be too high that export is not possible. In such instances, there won’t be any export of goods as the cost of goods will be cheaper abroad. Such goods that can neither be imported nor exported due to price differences are called non-tradeable goods. Non-tradeable goods can become tradeable goods only if the domestic cost becomes cheaper as compared to international price.

**Shadow pricing of resources**

(a) **Tradeable inputs and tradeable outputs**: A good can be considered fully traded when an increase in its consumption results in a corresponding increase in import or corresponding decrease in export. Another way of looking at it is from the production point of view. A good can be considered fully traded when an increase in its domestic production results in a corresponding increase in export or a corresponding decrease in import.

For fully traded goods, the shadow price is the border price (international price) of goods translated in terms of the domestic currency at the exchange rate prevailing in the market. The definition of traded goods as given above implies that the domestic changes in demand or supply affect only the level of imports of exports. For this to be true, the following conditions must prevail.

1. Import and export are not restricted.
2. Supply of imported goods is perfectly elastic over the range of import volume.
3. The domestic industry has no surplus capacity; hence, any increase in domestic demand is to be met only through imports.
4. Even if the domestic industry has surplus capacity, it cannot be put to use due to shortage of necessary inputs.

5. The cost of goods imported to meet additional domestic demand inclusive of the cost of transportation till the point of domestic consumption, is less than the marginal cost of domestic production.

6. The cost of imported inputs is less than the domestic marginal production cost.

For all practical purposes, all tradeable inputs and outputs are regarded as fully traded inputs and outputs even if all the above mentioned conditions are not simultaneously satisfied.

(b) Non-traded inputs and outputs: A good that is tradeable, but to which all the conditions (1) to (6) mentioned above are not satisfied is not traded. For such non-traded goods, the border price does not reflect the economic value (shadow price). The economic value of a non-traded good is measured as under:

- If the output of the project adds to the domestic supply, the domestic consumer's willingness to pay is taken as the economic value of good produced.

- If the output of the project causes reduction in production of less efficient units, such good is valued at its marginal cost of production.

(c) Non-tradeable inputs and outputs: As we have seen already, a good is considered non-tradeable if

(a) its import price (CIF price) is greater than the domestic cost of production or

(b) its export price (FOB price) is less than the domestic cost of production. (Lower FOB price as compared to domestic production cost is due to the reason that the international price is lower than the domestic cost of production.)

The valuation of non-tradeable goods, as per the principle of shadow pricing is done using the “consumers” willingness to pay as under

- If the impact of the project is to reduce the availability of input to other users, their willingness to pay for that input represents the economic value of that good.

- If the input requirements of the project are met by production of additional units, the production cost of such additional units represents the economic value of that good.

- If the impact of the project is to increase the consumption of the good in the economy, the consumer’s willingness to pay is the measure of the economic value.

- If the impact of the project is to substitute the consumption of other similar non-tradeable goods, the measure of economic value is only the savings in the cost of production between the two goods (i.e., the good that was substituted and the good that substituted.).

Externalities: Certain effects of the project do not impose a cost or do not confer a benefit within the domain of the project itself. But, if these effects have a bearing on the achievement of the country’s objectives, they need to be taken into consideration for economic analysis. Such effects that are external to the project domain, but have an impact on the country's objectives are known as ‘Externalities’.

Externalities may affect the country’s objective either positively or negatively. The characteristics of externalities can be summarized as under:

- They are not created by the project sponsor deliberately, but they are the incidental outcomes of the project.
Their effect may be either beneficial or harmful to the society.
Irrespective of whether beneficial or harmful, the externalities are beyond the control of those who are benefited/affected by them.
They are sometimes difficult to identify and almost always difficult to measure.
Some examples of beneficial effects of externalities are as under:
- The construction of a dam across a river also provides a communication link between the two shores of the river.
- The construction of approach roads to a project improves the overall transport facility of the surrounding area.
- A road improvement project results in reduction of accidents.
- A road improvement project results in better fuel efficiency of vehicles, lesser traveling time and lesser wear and tear of vehicles.
Some examples of harmful effects of externalities are as under:
- Air pollution, water pollution, and noise pollution are caused by projects.
- Small pox eradication programme brought the side effect of affecting the fertility of human beings.
- Improved transportation facility and reduced transportation time may induce unwarranted migration to towns causing further congestion; there is also the danger of cultivable lands in villages being left unattended as farmers migrate to towns.

As we observe, the external effects are intangible in nature and hence it is very difficult to value their costs/benefits. They are valued by using indirect means wherever possible. In situations where the effects of externalities cannot be measured in monetary terms, at least some form of qualitative evaluation should be done and incorporated in the project analysis.

**Capital inputs:** When capital inputs are made in a project, financial resources are used up for the creation of physical assets. The value (shadow price) of physical assets is calculated following the principles already explained. (Let us recapitulate the principle: (a) for fully traded goods, the shadow price is equal to the border price, and (b) for non traded goods, the shadow price is measured in two different ways, viz., the shadow price is equal to the consumers’ willingness to pay, if the project adds to the domestic supply and the shadow price is equal to the marginal cost of production if the output of the project causes reduction in production by less efficient units).

Apart from the shadow prices of physical assets, the other important aspect is the opportunity cost of capital. The opportunity cost of capital is the benefit foregone by sacrificing (i.e., not choosing) the best alternative project. However, it is difficult to estimate the opportunity cost of investment on social projects. In principle, the possible alternative uses of the investment should be studied and the best alternative should be identified. In practice, this is hard to achieve since all possible alternatives cannot be examined.

In conventional investment analysis, either the internal rate of return is obtained or the benefits accrued out of the investment are discounted at an appropriate rate of interest and the net present value of the investment is obtained. The IRR or NPV offers a measure of the profitability of the project. In the neo-classical world of capital markets, controversy over the appropriate interest rate never arises. There is one market rate that simultaneously represents the social marginal efficiency of the investment and the consumption rate of interest. Using this rate of interest, the benefits that would accrue over the years are discounted and the net present value is arrived at. Choosing a
suitable rate of discount for social projects is of crucial importance. If a too low rate is chosen, socially inefficient projects will be undertaken. If too high an interest rate is chosen, the 'desirable' projects will not pass acceptability criterion. The consumption rate of interest (CRI) is used in UNIDO approach as the discount rate since this approach is based on consumption objective. If the average level of consumption is increasing over time and if diminishing marginal utility is accepted, future consumption must be discounted by a rate that reflects the growth rate of consumption and the rate of diminishing marginal utility. Further, if the Govt. considers future consumption less valuable than the present consumption, the discount rate must also contain an element reflecting pure time preference. The resulting rate is known as the consumption rate of interest (CRI). The CRI is nothing but the social discount rate. The rate of diminishing marginal utility and the element reflecting pure time preference are subjective parameters and hence arriving at the CRI applicable for a project involves subjective issues. The CRI can be given by the following relationship:

\[
\text{CRI} = \left[ \frac{\text{Parameter of utility function}}{\text{Growth rate of per capita consumption}} \right] + \left[ \text{Rate of pure time preference} \right]
\]

The purpose of CRI in project selection is to ensure that the Government's preferences concerning future consumption (growth) and current consumption are adequately incorporated in the shadow prices. Countries that are more committed to growth employ a low CRI. This will ensure that the future consumption benefits from present investment are not heavily discounted.

[For a detailed account of CRI and the method of arriving at the same, interested readers are referred to the World Bank Research Publication "Economic Analysis of Projects" by Lyn Squire and Herman G. Van der Tak].

UNIDO approach recommends an indirect procedure for determining the CRI. According to this procedure, the project analyst arrives at the IRR of the social project and presents the project to the decision-makers. For social projects, normally the Government is the decision-maker and decision is taken by a planning committee constituted by the Government. If the project presented to the planning committee is rejected, the project analyst can come to the conclusion that the IRR arrived at for the project is above the CRI. If the project is accepted, it indicates that the IRR is either below or equal to the CRI. By successive application of this process, the project analyst can narrow down the range for the estimated CRI. This procedure can be useful only if the planners (decision-makers) behave rationally and consistently.

**Shadow wage rate:** The use of labour in one project prevents its use elsewhere. When labour is engaged in one project, its use in its best alternative project is ruled out. The forgone output of this labour in its best alternative use is a major component of the social cost of using that labour in the project. Therefore, an estimate of the output foregone is needed. If the market for the labour is active and efficient, then market wage provides a good measure of the marginal product of that labour at market prices as well as the foregone output.

The formula suggested by UNIDO approach to arrive at the Shadow Wage Rate (SWR) is as under:

\[
\text{Shadow Wage Rate} = \text{Labour's forgone marginal product at accounting prices} + \text{Net social cost of increased consumption} + \text{Social cost of reduced leisure}
\]
Foreign exchange: UNIDO method uses domestic currency as the numeraire. Hence, costs and benefits in terms of foreign exchange are to be valued at domestic currency. For traded goods the following guidelines apply:

(a) Imports:

C.I.F price + Clearing charges + Internal transport charges to the destination.

(b) Exportable goods:

- If the F.O.B (Free on Board) price of exports are higher than the actual domestic market price, the F.O.B. price should be used since it indicates the real social value and the opportunity cost of not exporting.
- If the actual domestic market price is higher than the F.O.B. price, use the former.
- If the F.O.B. price and the actual domestic market price are the same, there is a tie and either of the two prices can be used provided the F.O.B. price does not have any hidden, external price component. For example, if the export is subsidized, the F.O.B. price would have been arrived at after deducting the subsidy component. Hence, the subsidy component is to be added to the F.O.B. price.
- Similarly, if the Govt. has imposed export duty, the F.O.B. price less export duty should be the price that should be taken for comparison with the actual domestic market price. The “F.O.B. price less duty” and the actual domestic market price are to be compared and the higher value should be taken.

For importable, but domestically produced goods, use the C.I.F. (Carriage, Insurance, Freight) price or the actual domestic market price whichever is lower.

3.7.4 The Little-Mirrlees Approach


The Numeraire: L-M’s numeraire is “present uncommitted social income measured in terms of convertible foreign exchange of constant purchasing power”. Little and Mirrlees rejects the ‘Consumption’ numeraire of UNIDO approach, since they feel that the consumption of all groups is valuable. However, as per the UNIDO approach, specific group is singled out to be treated as the base to the numeraire.

The definition of L-M’s numeraire is worth noting. L-M uses the term “uncommitted social income”. All public income are not equally valuable. For example, the public income generated by a particular project may be earmarked for a specific purpose (say, the collection of toll may be earmarked for the maintenance of highway). Such public incomes that are earmarked to pre-determined usage are less valuable than the public income that is not so earmarked. L-M approach recognise only “uncommitted social income”.

L-M uses the term “convertible foreign exchange”. Public income may accrue in the form of domestic currency or foreign currency or in the form that is freely convertible into foreign exchange. The rationale for measuring the public income in terms of convertible foreign exchange is due to the reason that foreign aid and loans account for a large part of investment in the developing countries
and hence this numeraire makes the Accounting Rate of Interest comparable with interest on loans payable in foreign currency or with lending abroad.

L-M uses the term "constant purchasing power". The numeraire is useful as a yardstick only if its value remains constant over time. The value of public income will become constant over time, only if its purchasing power remains constant.

**L-M’s shadow price:** L-M’s approach measures costs and benefits in terms of international price (also represented as border price) as against UNIDO method that measures costs and benefits in terms of domestic prices. The argument in favour of using international price as shadow price is that it helps offset the fluctuations in domestic price and justifies the project from the economy’s point of view. It also helps to improve productive efficiency and trade efficiency.

**L-M shadow price for traded goods:** For goods that are exported, the shadow price is the F.O.B. price while for goods that are imported, the shadow price is the C.I.F. price.

**L-M shadow price for non-tradeable goods:** Non-tradeables (excluding labour) include goods like land, building and services like power, internal transport etc., Shadow price for non-tradeables (except labour) is arrived at in terms of marginal social cost and marginal social benefit. The marginal social cost and marginal social benefit are estimated in terms of border prices. By using border prices even for non-tradeables, L-M approach only ensures that a common yardstick is used for valuing both tradeables and non-tradeables.

It is in fact difficult to measure the marginal social cost and the marginal social benefit of non-tradeables and that too at the border prices. L-M approach suggests breaking down the cost component of non-tradeables into tradeable component, labour and residual component and applying a suitable Standard Conversion Factor (SCF) for tradeable and residual components and using Standard Wage Rate (SWR) for the labour component. The difficulty however is the selection of an appropriate SCF since this involves an element of subjectivity.

**L-M Standard Wage Rate (SWR):** L-M approach suggests the following relationship:

\[
SWR = C - \frac{1}{s} [c - m]
\]

Where,  
\( SWR \) = Standard Wage Rate  
\( C \) = Additional resources devoted to consumption  
\( 1/s \) = Social value of a unit of consumption so committed  
\( c \) = Consumption of wage earner  
\( m \) = Marginal productivity of wage earner.

**UNIDO approach Vs L-M approach:** There is considerable similarity between UNIDO approach and L-M approach. Both the approaches use shadow price and discounted cash flow technique and also both the approaches are based on the principle of equity. However, there are a few differences between the two approaches. As mentioned above in the previous paragraph, UNIDO approach measures shadow price in terms of domestic price while L-M approach measures shadow price in terms of international price.

While UNIDO approach measures costs and benefits in terms of consumption, the L-M approach measures costs and benefits in terms of uncommitted social income. The argument in favor of using uncommitted social income as the yardstick instead of consumption is as under:

Savings are at below the optimal level in many developing countries. Due to low level of savings, the investment level is small. The inadequate investment retards growth rate and adequate future
consumption is not generated. Hence, it is imperative for the developing countries to sacrifice present consumption for present savings. The present savings can be converted into present investment for improving future consumption. Since present savings is more valuable than present consumption, the L-M approach prefers to use present savings as the yardstick of the entire approach.

**S.C.B. analysis — the Indian scenario:** All India term lending financial institutions like ICICI, IFCI and IDBI, apart from appraising the projects from financial point of view, also give consideration to social aspects. These institutions follow a ‘partial L-M approach’ in the sense that some of the recommendations of L-M approach are followed and some are modified. The approach followed by Indian financial institutions can be termed ‘partial’ L-M approach for the reason that international prices are used for the valuation of tradeable inputs and outputs as recommended by the L-M approach while for non-tradeables, the valuation is done by using Social Conversion Factors (SCF) instead of following the method suggested by the L-M approach, since following the recommendations of L-M approach for the valuation of non-tradeables is considered not worth the effort. Indian financial institutions use the following criteria.

- Economic rate of return
- Domestic resource cost
- Effective rate of protection

**Economic Rate of Return (ERR):** Economic Rate of Return measures the rate of return to the society. The current market prices and costs, when taken into account to arrive at the financial viability of a project does not represent the true value of the project from economic point of view. This method of financial evaluation may be of help only for private project promoters and not for social projects. ERR is the rate of discount that equates the economic cost of the project to the economic benefits that would accrue during the life of the project. For the calculation of ERR, shadow prices are used both for inputs (costs) and for outputs (benefits) instead of market prices. Social projects are compared on the basis of ERR before choosing one for implementation. A project may have a better ERR though it may have a comparatively lower financial rate of return and vice versa.

**Domestic Resource Cost (DRC):** Domestic Resource Cost measures the domestic resource cost of manufacturing a product as against the cost of importing it *i.e.*, the DRC attempts to measure the cost of import substitution. If the production of a product contemplated by the project results in import substitution, there is saving of foreign exchange. By measuring the DRC of such a project, an attempt is made to calculate the amount of domestic resources required to be expended for saving the foreign exchange.

Also, a commodity produced may be exported which results in foreign exchange earnings. Thus, when a product produced by a project substitutes import, foreign exchange is saved due to reduced imports and when a commodity produced is exported, foreign exchange is earned to the extent there is an increase in exports. Setting up of the project and manufacturing the product may involve import of machinery and/or raw material which will result in outflow of foreign exchange and this effect is to be accounted for in the calculation of DRC.

\[
DRC = \frac{\text{Value added at domestic prices}}{\text{Value added at world prices}} \times \text{Exchange rate}
\]

DRC may be taken as a measure of total rupees spent to save a unit of foreign currency. (This definition is applicable where the goods produced are import substitutes.) Similarly, DRC may also
be taken as a measure of the total rupees spent to earn a unit of foreign currency. (This definition is applicable where goods produced are meant for exports).

DRC acts as an indicator to decide if it is worthwhile to manufacture a product in the country. If the DRC is less than the exchange rate of the unit of foreign currency, it indicates that manufacturing the product indigenously is advisable. This is because, it is possible to manufacture the product at a cost which is lower than the cost of foreign exchange. Hence, it is worthwhile to implement the project.

Let us see an example to clarify our understanding.

Let,

Value added at domestic price per unit of the proposed product : ₹ 50
Value added at world price per unit of the proposed product : ₹ 100
Exchange rate : 1 US$ = ₹ 50
Therefore, Domestic Resource Cost

\[
\text{Therefore, Domestic Resource Cost} = \left( \frac{50}{100} \right) \times 50 = ₹ 25
\]

Since the DRC (₹ 25) is less than the exchange rate (₹ 50), it is worthwhile to implement the project for the manufacture of the proposed product.

On similar lines, it is not worthwhile to manufacture a product, if the DRC is more than the exchange rate. However, keeping in view the scarcity of foreign exchange and social/economic benefits like the creation of employment opportunity, utilization of indigenously available resources etc., the Government of a country may decide to set up public sector projects even if the DRC is slightly higher than the exchange rate.

**Effective Rate of Protection (ERP):** Effective Rate of Protection attempts to measure the net protection offered to domestic projects. The domestic price of a product is affected by the concessions, tariffs, subsidies, quantitative controls etc., that are in force in a country. Thus, the costs of inputs that go into a product are affected by such controls and concessions. The competitive strength of a product in the world market is revealed only by costs and prices after excluding concessions and controls. In the absence of concessions and controls, the value added to a product when measured at domestic prices and when measured at international prices will be the same. If there is any difference in value addition when measured in terms of domestic prices and international prices, it indicates the measure of protection.

ERP is measured by the following relationship:

\[
ERP = \frac{\text{Value added at domestic prices} - \text{Value added at world prices}}{\text{Value added at world prices}}
\]

When the value added at domestic prices is the same as the value added at world prices, the ERP is zero. ERP of zero indicates that the project does not enjoy any protection from international competition. When the value added at domestic prices is higher than the value added at world prices, the ERP takes a positive value. Positive value of ERP indicates that the project enjoys protection from international competition. Higher the positive value of ERP, higher the protection enjoyed by the product.
Let us see an example:

<table>
<thead>
<tr>
<th>Domestic prices</th>
<th>World prices</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost of inputs</td>
<td>₹ 550</td>
</tr>
<tr>
<td>Sales realization</td>
<td>₹ 620</td>
</tr>
<tr>
<td>Value added</td>
<td>₹ 70</td>
</tr>
<tr>
<td>Effective Rate of Protection : (70 - 40) / 40 = 0.75 i.e., 75%</td>
<td></td>
</tr>
</tbody>
</table>

The protection available for the product given in the example is 75%.

In case the ERP is equal to 1.00, the protection available is 100%.

Projects with a higher ERP require careful analysis as to whether the protection available against international competition is likely to continue. It may be possible that the project may have a higher ERP because of subsidized cost of inputs. If in future, there is possibility of the Government withdrawing the subsidies presently allowed on inputs, the ERP will come down and the project may get exposed to international competition.

**Illustration 3.5**

The following are the details of a project:

- Value of tradeable inputs at domestic prices : ₹ 750 crores
- Value of tradeable inputs at world prices : ₹ 625 crores
- Value of non-tradeable inputs at domestic prices : ₹ 220 crores
- Sales realisation at domestic prices : ₹ 1,400 crores
- Sales realization at world prices : ₹ 1,150 crores

US $ is taken as the currency for measuring the world costs/prices which are then converted into domestic currency using the exchange rate of 1 US $ = ₹ 50.

Calculate the Domestic Resource Cost and the Effective Rate of Protection.

**Solution:**

**Value added at domestic prices:**

Benefit (i.e., sales realization) : ₹ 1,400 crores

Cost:

- Cost of tradeables : ₹ 750 crores
- Cost of non-tradeables : ₹ 220 crores

Value added : ₹ 970 crores [1400−970]

**Value added at world prices:**

Benefit (i.e., sales realization) : ₹ 1,150 crores

Cost:

- Cost of tradeables : ₹ 625 crores
- Cost of non-tradeables : ₹ 220 crores

*Cost of non-tradeables at domestic prices and at world prices are assumed equal.
Value added

Domestic Resource Cost (DRC)
- ₹ 845 crores
- ₹ 305 crores [1150–845]
- \((430/305) \times 50\)^{*}
- ₹ 70.79

Effective Rate of Protection (ERP)
- \(\frac{430 - 305}{305}\)
- 0.4098
- 40.98\% (expressed as a percentage)

**Exchange rate = (50/1 = 50)**

**Social desirability of a project for Indian conditions:** The social desirability of a project depends upon the features of a country. A project that is socially desirable for one country may not be so for another country. In fact, a project that is socially desirable for one country may even be socially undesirable for another country. This is because countries differ in many aspects such as the stage of development, the natural resources available, the population, the human resources available, climatic conditions, geographical location etc.

For Indian conditions, the following are some of the factors that decide upon the social desirability of a project.

- India being a country with a huge unemployed and under employed population, a project that offers substantial employment potential is a desirable one.

- India is a country with a vast area of land and the level of development varies widely across the country. There are under-developed and undeveloped regions as well as developed pockets. The unbalanced development across the country leads to unequal distribution of income. Hence, a project that comes up in a backward region is a socially desirable one as it will achieve the social objective of balanced development.

- Energy conservation projects and projects that tap alternative/non-conventional energy potential of the country are desirable projects.

- Compared to many highly industrialised countries, the environmental pollution caused by industries in India is low. However, this can not be taken for granted since the pollution level is likely to increase with the growth and development of new projects. As a developing country, the resources available at the disposal of the country to be spent on pollution control measures is rather limited as compared to developed countries. Hence, obviously, pollution-free projects will be an added advantage to Indian conditions.

- India is a country that is strong in natural resources. Any project that exploits the available natural resources of the country without having any adverse impact on the society/environment will be preferred.

- Projects that use indigenous technology are also worth considering since the required expertise will be locally available.

- In the arena of international business, the need for strengthening foreign exchange reserve can not be under estimated. Hence, projects that bring in foreign exchange for the country and projects that stop flow of foreign exchange out of the country are desirable projects.
3.8 PROJECT RISK ANALYSIS

In project appraisal, risk analysis play an important part. All projects are prone to some kind of risk or the other. All projects are appraised making certain assumptions. Assumptions in project appraisal are unavoidable since no two projects are unique in all respects and hence a new project cannot be compared with an identical project that was executed in the past. Though there may be similarity between two different projects, exactly identical projects do not exist. There are many elements of a project which contain assumed values. The following list of elements will give an idea of the assumptions on which any project appraisal is based on:

- Periodic cash inflows (the cash inflows are assumed by assuming the selling price of the product over a period of time and the plant output over the said period).
- Periodic cash outflows (the cash outflows are assumed by assuming the purchase price of raw materials, the cost of power, labour etc.).
- Life of machinery.
- Salvage value of machinery etc.

Since, a project is appraised making use of such assumptions, the appraisal is very much prone to the risk of yielding results that may deviate from reality.

3.8.1 Risk vs Uncertainty

‘Risk’ can be defined as the variability of return from an investment. If the probabilities of possible outcomes of a given problem are known, we can conclude that the problem contains risk; in other words the problem is risky. On the other hand, if the probabilities of possible outcomes of a given problem are not known, we can conclude that the problem has an element of uncertainty, i.e., the outcome cannot be predicted.

3.8.2 Kinds of Project Risks

Projects face a host of risks. Some important project risks are as under:

**Project Completion Risk:** Completing the project in time and within the estimated cost itself is a major achievement. A project that is delayed will result in time over-run which will consequently result in cost over-run. If the project promoters are not able to pump in additional funds required to meet the cost over-run, the project runs the risk of coming to a grinding halt. Also, delayed implementation means increase in interest commitments on the borrowed funds. When the project promoters find it difficult to meet the interest commitment during the implementation period, the lenders may not be prepared to fund the project additionally to meet the cost over-run. As the saying goes, “..... the banker will lend his umbrella when the whether is fine, but will get back the umbrella when it starts raining .....” Hence, once symptoms of delay in project implementation surfaces, mobilizing additional funds becomes difficult which will add to the problem of project completion. There can be also technology failures, which may result in non-completion of projects. For projects with long gestation period in the fields of fast developing technology, there is risk of project not being completed due to technological obsolescence during the course of project implementation.

**Resource Risk:** Raw material, power, fuel, manpower etc., are the resources used by a project. Shortage of raw material may lead to reduction in capacity utilization and higher cost of production, which will make all profitability estimates wrong. Similarly, shortage of power, fuel, and shortage of
skilled manpower will also jeopardize the project profitability calculations and the project may run the risk of not earning the estimated returns.

**Price risk:** Price fluctuations of both inputs and outputs (i.e., raw material and finished products) affect the project. Unforeseen happenings such as Government’s interventions in price fixation, ability of competitors to offer their product to customers at a comparatively cheaper price etc., are likely to have an adverse effect.

**Technology risk:** Technology risk may appear in two forms. A project that is based on unproven technology (i.e., a technology that is proved at laboratory level but not proved at commercial level) may have hidden defects which may make the project a non-starter. Rapid growth in technology may make a project obsolete in technology due to the evolution of latest technology.

**Political risk:** The saying goes .... “Do not fight with King and God.....” The King (i.e., the Government) acts as a watch dog of the country’s economy and frames rules and regulations for regulating the country’s economy. The Government intervenes in many forms such as levying and regulating taxes, regulating monopolistic trade practices, imposing import duties, promoting exports, prohibiting export of certain commodities, issuing import licences, controlling foreign exchange transactions, price controls, expropriation, nationalization etc. Political risk is a major risk since it cannot be predicted easily.

**Interest rate risk:** Fluctuations in interest rate may bring in an adverse effect. For example, if a project is funded by way of long-term borrowings at a particular rate of interest, and if the interest rate falls down subsequently, the project that availed long-term borrowing at a higher interest rate has to service the loan only at the higher rate of interest, unless it makes alternative arrangements to mobilize funds at the prevailing interest rate and swap the old borrowings which is a difficult proposition. New entrants who set up similar projects may have access to long-term loans at the prevailing rate of interest which may be cheaper. In such a situation, projects that were implemented with high-cost borrowings will find it difficult to compete with new entrants.

On the other hand, if the interest rate increases in future, the interest on working capital finance (which normally carries a floating interest rate) increases which will result in lower profit margins than estimated at the time of project appraisal. Interest rate risks can be managed to some extent by entering into interest rate hedging agreements like ‘interest cap’, ‘interest swap’ etc.

**Exchange rate risk:** Exchange rate risk (also called currency risk) is the risk arising from currency fluctuations. Volatile exchange rates can reduce cost and productivity advantages gained over years of hard work. Firms exposed to international economy face this risk. When a firm has already committed to a foreign currency denominated transaction (i.e., the firm has entered into an agreement agreeing to make foreign currency denominated payments or agreeing to receive payments in foreign currency), the firm is exposed to exchange rate risk. The firm will incur loss if the exchange rate of the foreign currency has moved adversely and will earn profit if the exchange rate has moved favourably. Many exchange rate risk hedging tools such as forward cover, leads and lags, currency options, currency swaps etc., are available which can be efficiently made use of to manoeuvre exchange rate risk.

### 3.8.3 Techniques of Risk Analysis

Though there are many mathematical techniques available for risk analysis, the following are the simple tools that come handy for analyzing small and medium sized projects.
- Break Even analysis
- Sensitivity analysis
- Decision tree analysis
- Monte-carlo technique
- Game theory.

**Break even analysis:** The financial viability of a project is estimated by making various assumptions like the cost of raw material, cost of consumables, cost of labour, expected sales realisation, expected capacity utilization of the plant etc. The proof of pudding is in eating. After implementation, the project starts earning profit or starts incurring loss depending on the actual sales volume that it could achieve, the actual cost of inputs, the actual sales realisation etc. Of these factors, the costs of inputs and the price of outputs are decided by the influence of market forces. The only thing that is under the control of the project promoter is the level of output (*i.e.*, capacity utilization). Hence, it is very essential to know the level of operation below which the project will incur losses. Break Even Point (BEP) refers to the level of operation at which the project neither earns profit nor incurs loss. Calculation of BEP for the given cost and price levels indicate the minimum capacity utilization that the project should aim at in order to be in a no-profit, no-loss situation. BEP also helps in identifying the level of profit/loss for a specified level of operation and the level of operation required to attain a specified profit/to avoid a specified loss etc.

Break even analysis starts with dividing the costs into two broad heads, *viz.*, fixed costs and variable costs.

**Fixed costs:** All projects incur certain costs that are fixed in nature. These costs remain constant irrespective of the changes in the volume of output. Following are some of the fixed costs:

- Rent payable for land
- Rent payable for factory/office premises
- Insurance premium on fixed assets
- Interest payable on long-term borrowing/deposits
- Administrative expenses
- Annual Maintenance Charges payable for machinery maintenance
- Depreciation
- Property tax etc.

**Variable costs:** These are those costs that vary directly with the level of output. Raw material cost is a variable cost since it depends on the level of output. Some other variable costs are as under.

- Consumable stores
- Power, fuel, water charges
- Selling expenses etc.

Referring to Fig. 3.3,

At the break even point,

\[
\text{Sales realization} = \text{Fixed cost} + \text{variable cost}
\]
Referring to Fig 3.3,
At the break even point,

Sales realization = Fixed Cost + Variable cost

i.e., \((\text{Output}) \times \text{Selling price per unit} = \text{Fixed cost} + (\text{output}) \times \text{Variable cost per unit}\)

i.e., \(\text{Output} \times (\text{Selling price per unit} - \text{Variable cost per unit}) = \text{Fixed cost}\)

\[ \therefore \text{output} = \frac{\text{Fixed cost}}{(\text{Selling price per unit} - \text{Variable cost per unit})} \]

\(\text{i.e., Break Even Point}\)
\((\text{in terms of no. of units}) = \frac{\text{Fixed cost}}{(\text{Selling price per unit} - \text{Variable cost per unit})}\)

**Contribution:** Contribution is the difference between the sales realisation and the variable cost. Excess of selling price over variable cost is called by the term ‘contribution’ since it contributes towards fixed cost and profit. For example, if the selling price per unit of a product is ₹ 12 and the variable cost per unit is ₹ 7, the contribution per unit is ₹ 5 \((12 - 7)\) i.e., one unit of production contributes ₹ 5 towards fixed cost and profit. If the fixed cost is say, ₹ 50,000, the BEP (in terms of no. of units) is 10,000 \([50,000/5]\). This means that at the level of output of 10,000 units, the contribution covers exactly the fixed cost. Hence, this is a no-profit, no-loss situation. Contribution first goes to meet the fixed cost up to BEP and subsequent to reaching of BEP, contribution adds to profit.

\[ \text{BEP (in terms of no. of units)} = \frac{\text{Fixed cost}}{(\text{Selling price per unit} - \text{Variable cost per unit})} \]

\[ = \frac{\text{Fixed cost}}{\text{Contribution per unit}} \]

\[ \text{B.E.P. (in terms of rupees)} = \frac{\text{Fixed cost}}{\text{Contribution per unit}} \times \text{Selling price per unit} \]
Illustration 3.6
The details of production costs and revenues of a project are as under:
Total cost: ₹ 65,000
Fixed cost: ₹ 25,000
Sales (8,000 units): ₹ 80,000

Find the BEP in terms of no. of units. What should be the output if the profit desired is ₹ 20,000?

Solution:
Variable cost (for 8,000 units): Total cost – Fixed cost
= ₹ 65,000 − ₹ 25,000
= ₹ 40,000

Variable cost per unit:
= ₹ 40,000/8,000
= ₹ 5

BEP (in terms of no. of units):
\[
\frac{\text{Fixed cost}}{(\text{Selling price per unit} - \text{Variable cost per unit})}
\]
= \[
\frac{25000}{10 - 5}
\]
= 5000 units

Output for a desired profit of ₹ 20,000
Let 'X' be the no. of units required to be produced for achieving a profit of ₹ 20,000
Profit = Sales – Total cost
= Sales – (Fixed cost + Variable cost)
= (10X) – (25,000 + 5X)

I.e.,
20,000 = 15X − 25,000
15X = 45,000
X = 9,000

Therefore, the output required for achieving a profit of ₹ 20,000 is 9,000 units. (Refer Fig. 3.4)
Sensitivity analysis: It is a technique that measures the change in the profitability of a project caused by changes in the factors that affect the cash inflows of the project. If a small change in one factor leads to a major change in the profitability of the proposed investment, the project is considered more sensitive to that factor; in other words, the project is more risky. Other things being equal, a project that is less sensitive is preferable to projects that are more sensitive. This is because a small change in a factor will affect a more sensitive project very much and may reduce the estimated profit, or may even change the estimated profit into loss. Sensitivity of a project is checked by observing the response of any measure of profitability (NPV, DSCR, BEP or any other measure) to changes in critical factors. For example, the sensitivity of a project can be studied as under:

- What happens to the NPV if the demand for the product drops down?
- What happens to the NPV if the economic life of the project reduces?
- What happens to the DSCR if the selling price for the product falls down?
  etc.

Sensitivity analysis provides the management the much needed information as to which are the critical factors that are prone to affect the profitability of the project.

Illustration 3.7

ABC company limited proposes to start a new venture for the manufacture of fluorescent bulbs. The estimates of the new venture are as under:

Output of bulbs per annum : 3,00,000 nos
Expected sales revenue per annum : ₹ 1,50,00,000
Fixed costs : ₹ 35,00,000
Variable costs : ₹ 66,00,000

(a) If the selling price comes down to ₹ 40.00 per unit, find out its effect on BEP
(b) If the fixed cost increases to ₹ 40,00,000, find out its effect on BEP
(c) If the variable cost increases by 10%, find out its effect on BEP

Solution:

Fixed cost : ₹ 35,00,000
Sales revenue : ₹ 1,50,00,000
Selling price per unit (1,50,00,000/3,00,000) : ₹ 50
Variable cost : ₹ 66,00,000
Variable cost per unit (66,00,000/3,00,000) : ₹ 22

Break Even Point (BEP) = \[
\frac{\text{Fixed cost}}{\left(\text{Selling price per unit} - \text{Variable cost per unit}\right)}
\]

\[
= \frac{35,00,000}{50 - 22} = \frac{35,00,000}{28} = 1,25,000 \text{ units}
\]

(a) Selling price per unit comes down to ₹ 40.00

BEP = \[
\frac{35,00,000}{40 - 22} = \frac{35,00,000}{18} = 1,94,444 \text{ units}
\]
(b) Fixed cost increases to ₹ 40,00,000

\[ \text{BEP} = \frac{40,00,000}{50 - 22} = \frac{40,00,000}{28} = 1,42,857 \text{ units} \]

(c) Variable cost increases by 10%

Revised variable cost per unit

\[ (1.1 \times 22) = ₹ 24.20 \]

\[ \text{BEP} = \frac{35,00,000}{50 - 24.20} = \frac{35,00,000}{25.80} = 1,35,659 \text{ units} \]

Results:

(a)

<table>
<thead>
<tr>
<th>Selling price Per unit (₹)</th>
<th>BEP</th>
<th>Reduction in (Selling price)</th>
<th>Increase in BEP</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>1,25,000 units</td>
<td>((50 - 40) \times 100)</td>
<td>((1,94,444 - 1,25,000) \times 100)</td>
</tr>
<tr>
<td>40</td>
<td>1,94,444 units</td>
<td>20%</td>
<td>56%</td>
</tr>
</tbody>
</table>

(b)

<table>
<thead>
<tr>
<th>Fixed cost (₹)</th>
<th>BEP</th>
<th>Increase in fixed cost</th>
<th>Increase in BEP</th>
</tr>
</thead>
<tbody>
<tr>
<td>35,00,000</td>
<td>1,25,000 units</td>
<td>((40,00,000 - 35,00,000) \times 100)</td>
<td>((1,42,857 - 1,25,000) \times 100)</td>
</tr>
<tr>
<td>40,00,000</td>
<td>1,42,875 units</td>
<td>14.29%</td>
<td>14.29%</td>
</tr>
</tbody>
</table>

(c)

<table>
<thead>
<tr>
<th>Variable cost per unit (₹)</th>
<th>BEP</th>
<th>Increase in variable cost</th>
<th>Increase in BEP</th>
</tr>
</thead>
<tbody>
<tr>
<td>22</td>
<td>1,25,000 units</td>
<td>((24.20 - 22) \times 100)</td>
<td>((1,35,659 - 1,25,000) \times 100)</td>
</tr>
<tr>
<td>24.20</td>
<td>1,35,659 units</td>
<td>10%</td>
<td>9%</td>
</tr>
</tbody>
</table>

Observations:

- 20% decrease in selling price results in 56% increase of BEP.
- 14.29% increase in fixed cost results in 14.30% increase of BEP.
- 10% increase in variable cost results in 9% increase of BEP.

Out of the three factors (selling price, fixed cost, variable cost), BEP is more sensitive to selling price.
DECISION TREE ANALYSIS

Decision tree approach is a graphical technique that can be used for analysing the pros and cons of alternative decisions and choosing the best possible course of action. In real life situation, business decisions are taken under conditions of uncertainty. A company, for example, might have to decide whether to go for investment in a large sized plant or in a smaller plant; whether to invest in a new venture or to acquire an existing company; whether to produce goods indigenously or to import them from abroad etc. All such decisions are made taking into account the various factors that influence the decision. Before arriving at a decision, the available alternative courses of actions are studied, their cost and benefits are analysed and the decision that offers the maximum net benefit is chosen.

A decision tree is made up of nodes and branches. Nodes are of two types, viz.,
Decision node (or Decision point) and Chance node (or ‘Chance event’).

A decision point is represented by a square (□) and a chance node is represented by a circle (O). The different alternatives available for the given situation emerges from the decision point. Chance node represents the result of a decision. Each decision alternative has an EMV. The EMV at each of the chance node is calculated and marked on the diagram.

Example
The chief executive of a company wants to introduce a new product in the market. He has two alternatives available before him, viz., importing the product from abroad or setting up a plant for the manufacture of the product. The decision tree is represented as below (Fig. 3.5).

![Decision Tree Diagram](image)

Fig. 3.5 Decision tree

The two alternative courses of actions available at the decision point are marked as ‘branches’ emanating from the decision point.

The two alternative courses of actions will yield some result. The result, expressed in monetary terms is the ‘EMV’. The EMV of each alternative course of action is calculated and entered at the chance node.

Fig. 3.6 shows the chance nodes.
EMV refers to the net benefit.

For example, if importing the product from abroad will result in a net benefit of, say ₹ 5,00,000 the same is marked at the chance node-1; if setting up a new plant and manufacturing the product will result in a net benefit of say 6,00,000 the same is marked at chance node-2. The EMVs are marked inside an inverted triangle at the chance nodes for easy identification (Fig. 3.7).

There are different alternative courses of action available at a decision point. Each alternative course of action may have different possible outcomes and different possible net benefits. For example, let us consider that a company has some investible surplus and it has two options available to invest the same, viz.,

(a) Investing is Government guaranteed securities.
(b) Investing in a new business venture.
[There can also be other possible avenues for investment. Let us restrict our discussion for the above two options for the sake of simplicity.]

Any investment has its own associated risk.

Investing in Government guaranteed securities is risk free since the return from the investment is assured and guaranteed. Hence, we can assume that the probability of getting the guaranteed return is 100% (i.e., \( p = 1.00 \)). Let the guaranteed return is ₹ 1,00,000.

Investing is a new business venture will have risks associated with it. There may be many factors influencing the expected return from investment in a new business venture.

Let us assume that the company opts to invest, in say a consumer goods manufacturing plant. The success of the venture will depend upon the demand for the product. Let us understand that the following are the estimated returns depending upon the nature of demand.

<table>
<thead>
<tr>
<th>Type of demand</th>
<th>Expected return</th>
</tr>
</thead>
<tbody>
<tr>
<td>High demand</td>
<td>₹ 2,00,000</td>
</tr>
<tr>
<td>Normal demand</td>
<td>₹ 1,50,000</td>
</tr>
<tr>
<td>Low demand</td>
<td>₹ 50,000</td>
</tr>
</tbody>
</table>

The above three types of demands will have their likely chances of occurring. In other words, the above types of demands will have their own probabilities of occurrence. Let us assume that these probabilities have been assessed as shown in the table below:

<table>
<thead>
<tr>
<th>Type of demand</th>
<th>Probability of occurrence</th>
<th>Expected return</th>
</tr>
</thead>
<tbody>
<tr>
<td>High demand</td>
<td>0.50</td>
<td>₹ 2,00,000</td>
</tr>
<tr>
<td>Average demand</td>
<td>0.30</td>
<td>₹ 1,50,000</td>
</tr>
<tr>
<td>Low demand</td>
<td>0.20</td>
<td>₹ 50,000</td>
</tr>
</tbody>
</table>

Let us draw the decision tree indicating the decision point and chance nodes (Fig. 3.8).

![Decision Tree](image-url)

Fig. 3.8 Decision tree
EMV at chance node 1

\[= 1,00,000 \times 1\]

\[= \text{₹} 1,00,000\]

EMV at chance node 2

\[= (2,00,000 \times 0.5) + (1,50,000 \times 0.3) + (50,000 \times 0.2)\]

\[= \text{₹} 1,55,000.\]

The EMVs at chance nodes 1 & 2 are marked in Fig. 3.9.

![Decision Tree Diagram](attachment:decision_tree.png)

At the decision point we have only two options. Each option has an EMV. The option with the highest EMV is the optimal choice to be made.

Hence the optimal choice is to choose option 2 viz., starting a new business venture, as this gives a higher EMV of ₹ 1,55,000 as compared to the EMV of ₹ 1,00,00 expected from option 1.

**Rules for drawing decision tree**
- Identify all the alternative decisions (or courses of actions) available at the initial decision point.
- Keep the initial decision point at the left extreme position.
- Indicate the alternative courses of actions as straight lines emerging from the first decision point.
- Mark the chance points at the end of each alternative courses of actions.
- The decision points are indicated by a square and the chance points are indicated by a circle.
- Identify the possible outcomes at each chance point and mark them. The possible outcomes at a chance point can be either a monetary reward or another decision situation involving further subsequent courses of decisions (or possible courses of actions).
- Develop the decision tree diagram following the above logic and construct the diagram from the left to the right, till all the possible decision situations are exhausted.

- After construction of the decision tree, work backwards (i.e., from the right to the left) computing the EMV at each chance point and at each decision point. The EMV at a chance point is the net monetary benefit arising out of all possible situations. The EMV at a decision point is the monetary benefit from the best possible course of action.

- Working backwards from the right to the left arrive at the EMV at the initial decision point. EMV at the initial decision point is the monetary benefit from the best possible course of action. At the initial decision point, two or more alternative courses of actions will be available. The alternative that offers the maximum benefit is the one that we are going to choose. The EMV at the first (or initial) decision point corresponds to this alternative that offers the maximum benefit. Once we choose the best alternative at the initial decision point, the problem gets solved. We worked backwards from the right to the left, considered all possible alternatives at each decision point and the best alternative is chosen at each decision point till we reach the initial decision point that lies at the left extreme of the decision tree diagram. Hence, the choice of the best alternative at the initial decision point will be the optimal choice for the given problem.

**Illustration 3.8**

M/s ABC Company Limited is currently engaged in the manufacture of industrial chemicals and is earning a profit of ₹5.00 lakhs per annum after paying for materials and labour. The company has the following alternatives and wants to choose the alternative that is most beneficial to it.

**Alternatives**

- The company can pay a royalty of ₹1.00 lakh for getting the technical know-how for the production of a new chemical. Production of the new chemical will bring additional gross income of ₹4.00 lakhs.

- The company can carry out research for identifying the formulation of the proposed new chemical. The research activity will cost the company ₹80,000. There is a 80% probability of achieving success in the research. Once the research comes out successful, the company will generate additional gross income of ₹8.00 lakhs.

- The company can invest ₹75,000 in a special marketing programme to promote alternative uses for the chemicals presently being manufactured by the company. Such an attempt, if successful will generate additional gross income of ₹12.00 lakhs. The probability of success of the attempt is only 40% in view of the stiff competition from existing competitors who are already well-established in the field.

The company can opt for only any one of the alternatives in view of the limited resources available with the company. Identify the strategy most suited for the company using decision tree analysis.
Solution:

Let

Strategy-A = Maintaining status-quo and not opting for any of the three alternatives
Strategy-B = Acquiring technical know-how by paying royalty.
Strategy-C = Carrying out Research.
Strategy-D = Carrying out special marketing programme.

The structure of the Decision Tree will be as shown below (Fig. 3.10):

[Diagram of Decision Tree]

We are required to calculate the EMVs at the different nodes.

**EMV at Chance node ①**

Chance node ① pertains to strategy-A, which is maintaining status-quo. Maintaining status-quo will not bring any additional profit or loss. Hence, the EMV for this option is zero.

**EMV at chance node ②**

Expected income for strategy B

Gross income : ₹ 4.00 lakhs
Cost (Royalty) : ₹ 1.00 lakhs
Net income : ₹ 3.00 lakhs
Probability of earning the net income of
\[ ₹3.00 \text{ lakhs} = 1.00 \]
EMV at chance node (2) = \[ 3.00 \times 1.00 \]
= ₹3.00 lakhs

**EMV at chance node (3)**

Chance node (3) pertains to strategy (C)

Expected income when the strategy is proved successful
\[ (8,00,000 - 80,000) = ₹7,20,000 \]

Expected income when the strategy fails = ₹ -80,000

Probability of success = 0.80
Probability of failure = 0.20

Hence, EMV at chance node (3)
\[ = (7,20,000 \times 0.80) + (-80000 \times 0.20) \]
\[ = 5,76,000 - 16,000 \]
\[ = ₹5,60,000 \]

**EMV at chance node (4)**

Chance node (4) pertains to strategy (D)

Expected income when the strategy is proved successful
\[ (12,00,000 - 75,000) = ₹11,25,000 \]

Expected income when the strategy fails = ₹ -75,000

Probability of success = 0.40
Probability of failure = 0.60

Hence, EMV at chance node (4)
\[ = (11,25,000 \times 0.40) + (-75,000 \times 0.60) \]
\[ = 4,50,000 - 45,000 \]
\[ = ₹4,05,000 \]

**EMV at Decision Point-D₁**

At the decision point-D₁ there are four options available, with each option having its own EMV. At the decision point we are going to take only one decision that is the most appropriate from among the available decisions. Hence, the alternative that offers the highest EMV is the optimal decision.
From among the alternative strategies, strategy (c) gives the highest EMV and hence it will be the optimal one.

Hence, carrying out research for the new product is the strategy that is best suited for the company. The decision tree with EMVs at the chance nodes and decision node is shown in Fig. 3.11.

**Illustration 3.9**

A bulk drug manufacturing company has proposed to introduce a new drug in its production line. The production technique for the new drug has been tested in the laboratory. Commercial production of the new drug has not yet been taken up by any of the manufacturers.

The company has the following options available before it.

(a) To set up additional manufacturing facilities and go for commercial production of the new drug on the strength of the successful production of the drug reported at the laboratory.
(b) To set up a pilot plant for the production of the new drug and to setup additional manufacturing facilities required for the commercial production of the new drug after studying the performance of the pilot plant.

When the company goes for setting up new production facilities without going through the process of setting up the pilot plant, the probability of producing the new drug with the required quality is 55% and the probability getting inferior quality is 45%.

The pilot plant is estimated to cost ₹ 5,00,000 and it is estimated to have 80% probability of giving output of the required quality and 20% probability of giving output of inferior quality.

In the event of getting the required quality of output from the pilot plant and setting up additional production facilities on the strength of the successful production in the pilot plant, the commercial production from the newly setup production facility is expected to have a 90% probability of giving the required quality of output and 10% probability of giving output of inferior quality.

When the output from the pilot plant is of inferior quality, the probability that the newly setup production facility meant for commercial production will give the required quality of output is only 5%.

The company is expected to earn a profit of ₹ 1,50,00,000 when the new plant gives output of the required quality and a loss of ₹ 20,00,000 when the new plant gives output of inferior quality.

With the aid of decision tree, find out the better choice out of the two options, viz., (a) Going for commercial production without ascertaining the feasibility though a pilot plant and

(b) Going for commercial production after ascertaining the feasibility through a pilot plant.

Solution:

At the first decision point \(D_1\) the company has two alternatives, viz.,

(a) Going for commercial production without the aid of a pilot plant.

(b) Going for commercial production after testing the quality in a pilot plant.

Alternative (a) above has the following two probabilities:

(i) 55% probability of getting the product with the required quality.

(ii) 45% probability of getting the product with inferior quality.

Alternative (b) will lead to two possibilities, viz.,

(iii) 80% probability of the pilot plant giving the output with the required quality.

(iv) 20% probability of the pilot plant giving the output of inferior quality.

The possibility (iii) above will lead to two more possibilities viz., (v) 90% probability of the commercial production giving the required quality of output and (vi) 10% probability of the commercial production giving inferior quality output.

The possibility (iv) above leads to a decision. When the pilot plant fails to give the required quality of output, we should decide whether to go for commercial production or not. This is because, there is still a 5% probability of getting the output of the required quality inspite of the pilot plant giving an inferior quality output.
Thus, the structure of the decision tree diagram will be as shown in fig. 3.12.

**EMV of chance node ①**

Expected income when the commercial production gives product with the required quality: \( \text{₹ 1,50,00,000} \)

Expected income when the commercial production gives inferior quality product: \( \text{₹ -20,00,000} \)

Probability of getting the required quality = 0.55

Probability of getting inferior quality = 0.45

Hence, EMV at chance node ①

\[
\text{EMV} = (1,50,00,000 \times 0.55) + (-20,00,000 \times 0.45)
\]

\[
= 82,50,000 - 9,00,000
\]

\[
= \text{₹ 73,50,000}
\]

**EMV at chance node ③**

Expected income when the commercial production gives product with the required quality: \( \text{₹ 1,50,00,000} \)

Expected income when the commercial production gives inferior quality product: \( \text{₹ -20,00,000} \)

Probability of getting the required quality = 0.90

Probability of getting inferior quality = 0.10

Hence, EMV at a chance node ③

\[
\text{EMV} = (1,50,00,000 \times 0.90) + (-20,00,000 \times 0.10)
\]

\[
= 1,35,00,000 - 2,00,000
\]

\[
= \text{₹ 1,33,00,000}
\]

**EMV at chance node ④**

Expected income when the commercial production gives product with the required quality: \( \text{₹ 1,50,00,000} \)
Expected income when the commercial production gives inferior quality product: ₹ -20,00,000
Probability of getting the required quality = 0.05
Probability of getting inferior quality = 0.95
Hence, EMV at chance node 4

\[
= (1,50,00,000 \times 0.05) + (-20,00,000 \times 0.95)
= 7,50,000 - 19,00,000
= ₹ -11,50,000
\]

**EMV at decision point** \( D_2 \)

At decision point \( D_2 \), there are two options, viz.,

(a) To give up the new product

(b) To go for commercial production. Option (a) at this stage does not involve any further outlay of money. Hence EMV for this option is zero. Option (b) leads to chance node 4 which gives an EMV of ₹ -11,50,000. The better of the above two options is option (a).

Hence at Decision point \( D_2 \) the company should not go for commercial production. The EMV at \( D_2 \) is ₹ 0 (zero).

**EMV at chance node** \( 2 \)

EMV at chance node \( 2 \)

\[
= \left\{ \begin{array}{l}
\text{EMV at chance node } 3 \times 0.80 \\
\text{EMV at decision point } D_2 \times 0.20
\end{array} \right.
= (1,33,00,000 \times 0.80) + (0 \times 0.20)
= ₹ 1,06,40,000
\]

**EMV at decision point** \( D_1 \)

We have two options at decision point \( D_1 \). The best of the two options is to be chosen.

**Option-I**

Going for commercial production without setting up a pilot plant, which gives an EMV of ₹ 73,50,000.

[i.e., EMV at chance node \( 1 \)]

**Option-II**

Setting up a pilot plant, checking the quality of the product from the pilot plant and then deciding to go for commercial production.
Fig. 3.12 Decision tree

1. Required quality: $p = 0.55$
   - Commercial production gives inferior quality: $p = 0.45$
   - Set up pilot plant: EMV

2. Pilot plant gives inferior quality: $p = 0.20$
   - Commercial production gives inferior quality: $p = 0.70$
   - Go for commercial production: EMV

3. Commercial production gives inferior quality: $p = 0.90$
   - Go for commercial production: EMV

4. EMV
EMV at chance node \( \pi \) = ₹1,06,40,000

Less cost of setting up
pilot plant = ₹(-) 5,00,000
Net benefit = ₹1,01,40,000

Thus, at Decision point \( D_1 \), we have the following two options.

The option that offers maximum net benefit is the optimal choice. Hence, the company has to set up the pilot plant and test the quality of the product before going for commercial production, which gives a higher EMV.

Fig. 3.13 gives the decision free diagram with EMVs at the decision points and at the chance nodes.

**Illustration 3.10**

A contractor has the following options and wants to choose the one that is most suited to him:

(a) A railway contract that promises a profit of ₹40 lakhs with a probability of 0.7 and a profit of ₹50 lakhs with a probability of 0.3.

(b) A highway contract that offers a profit of ₹60 lakhs with a probability of 0.6 and a profit of ₹80 lakhs with a probability of 0.4.

Construct a decision tree diagram and arrive at the optimal decision for the contractor. Use EMV criteria for evaluation.

**Solution:**

The decision tree for the given problem (illustration 3.10) is given below (Fig. 3.14).
Note: The EMVs are indicated in the diagram in terms of ₹ in lakhs.
EMV at chance node (or event node)-1
\[ = (40 \times 0.7) + (50 \times 0.3) \]
\[ = 43 \]

EMV at chance node (or event node)-2
\[ = (60 \times 0.6) + (80 \times 0.4) \]
\[ = 68 \]

Coming to the decision node D₁, there are two options with EMV of 43 and 68 respectively.

At the decision note, we have to make a decision about the choice of option. The option with the highest EMV will be the optimal decision. Hence, the choice is Highway contract with an EMV of ₹68 lakhs with is the higher of the two EMVs.

Hence, the contractor has to opt for Highway Contract.

**Illustration 3.11**

A company is engaged in the manufacture of textile machinery spares. The projections for the next year showed increased demand for textile machinery spares. The probabilities of demand for the next year were assessed as below.

- Low demand : 0.10
- Average demand : 0.20
- High demand : 0.70

The company has the following three options to meet the increased demand, viz.,

(a) Asking the employees to work overtime.

(b) Carrying out expansion of the existing production facility.

(c) Sub-contracting part of the production to meet the demand.
For the above three options, the profits vary depending on the volume of production (which, in turn depends on the nature of demand). The estimated profits for the above three options of meeting the demand are given in the table below:

<table>
<thead>
<tr>
<th>Nature of expected demand</th>
<th>Probability (p)</th>
<th>Alternative courses available</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Overtime</td>
</tr>
<tr>
<td>Low</td>
<td>0.10</td>
<td>-0.50</td>
</tr>
<tr>
<td>Average</td>
<td>0.20</td>
<td>1.90</td>
</tr>
<tr>
<td>High</td>
<td>0.70</td>
<td>3.70</td>
</tr>
</tbody>
</table>

The figures in the last three columns indicate the expected profits (र in lakhs). Draw a decision tree and find out the optimal course of action to be followed. Arrive at the EMV for the optimal course of action.

**Solution:**

The decision tree for the given problem is shown below (Fig. 3.15).

**Fig. 3.15 Decision tree**

EMV at chance node 1

\[
\text{EMV} = (-0.50 \times 0.10) + (1.90 \times 0.20) + (3.70 \times 0.70)
\]

\[= ₹ 2.92 \text{ lakhs}\]
EMV at chance node \( 2 \)
\[
= (-1.20 \times 0.10) + (0.80 \times 0.20) + (3.80 \times 0.70)
\]
\[
= ₹ \ 2.70 \text{ lakhs}
\]

EMV at chance node \( 3 \)
\[
= (1.80 \times 0.10) + (2.80 \times 0.20) + (4.10 \times 0.70)
\]
\[
= ₹ \ 3.91 \text{ lakhs}
\]

The EMVs for the three alternative courses of action available are indicated at the respective chance nodes (Fig. 3.16).

![Decision tree with EMVs](image)

Fig. 3.16 Decision tree with EMVs

At decision point \( \square D_1 \), there are three options available. The EMVs of the three alternative courses of action are known. Only one of the available options can be selected. Obviously the option that offers the highest EMV will be the optimal one.

Hence, ‘sub contracting’ is the optimal course of action that gives the highest EMV of ₹ 3.91 lakhs.

**Illustration 3.12**

Cotton fab is a newly established company that proposes to manufacture textile machinery and textile machinery spares. The company has the following two options:

(a) To build a plant of large capacity that can comfortably take care of the demand for textile machinery and spares for a long time.

(b) To build a small plant that can satisfy the present demand and to expand the production capacity in future when the demand for textile machinery and spares increases.
The company entrusted the task of carrying out a market research to assess the future demand for textile machinery and spares to a consultant. The market research report offered by the consultant shows three different levels of demands, viz., low, average and high with probabilities of 0.3, 0.5 and 0.2 respectively.

When a plant of large capacity is built, the plant cost will come to ₹ 500 lakhs. This plant size will be sufficient enough that it can handle any volume of production that is reasonably expected in the near future. Hence, when a plant of large capacity is built, the need for expansion is not expected to arise.

The operating returns, discounted to the present value for low, average and high demands are estimated at ₹ 220 lakhs, 880 lakhs and 1700 lakhs respectively.

If a plant of smaller capacity that satisfies the present demand alone is built, it is estimated to cost ₹ 150 lakhs. This small plant can meet only the low level of future demand and needs to be expanded if the future demand is either average or high.

If the future demand is low, the small plant need not be expanded since, its production capacity can meet the low level future demand.

If the future demand is average, the small plant cannot meet the demand and needs to be expanded. This medium sized expansion will cost ₹ 100 lakhs. If the future demand is high, the small plant will need a greater expansion and this large sized expansion of the small plant will cost ₹ 325 lakhs.

The operating returns, discounted to the present value for the medium sized expansion is ₹ 900 lakhs and for the large sized expansion is ₹ 1600 lakhs.

Draw a decision tree depicting all the decision points and chance nodes and arrive at the size of the plant which will be optimal.

**Solution:**

The decision tree for the given problem is drawn (Fig. 3.17) following the logics stated in the problem.

**EMV at chance node**

When the demand is low, net return

\[ \text{EMV} = 220 - 500 = (-) 280. \] (This has got a probability of 0.3)

When the demand is average, net return

\[ \text{EMV} = 880 - 500 = 380 \] (This has got a probability of 0.5)

When the demand is high, net return

\[ \text{EMV} = (1700 - 500) = 1200 \] (This has got a probability of 0.2)
Hence, EMV at chance node $D_1$

$$= (-280 \times 0.3) + (380 \times 0.5) + (1200 \times 0.2)$$

$$= ₹346 \text{ lakhs}$$

**EMV at decision point $D_2$**

When there is no expansion

$$\text{EMV} = 220 - 150 = 70$$

When there is medium sized expansion

$$\text{EMV} = 900 - 100 - 150 = 650$$

EMV at decision point $D_2$ is the highest of the above two EMUs.

Hence,

$$\text{EMV at decision point } D_2 = ₹650 \text{ lakhs}.$$
When there is medium sized expansion

\[
EMV = 900 - 100 - 150
= 650
\]

When there is large sized expansion

\[
EMV = 1600 - 325 - 150
= 1125
\]

Fig. 3.18 Decision tree with EMVs at decision points and chance nodes

EMV at decision point- \( D_3 \) is the highest of the above three EMVs.

Hence, EMV at decision point- \( D_3 \) = ₹ 1125 lakhs

**EMV at chance node 2**

\[
= 70 \times 0.3 + (650 \times 0.5) + (1125 \times 0.2)
= 21 + 325 + 225
= ₹ 571 lakhs
\]

**Decision at decision point- \( D_1 \)**

Fig. 3.18 shows the EMVs at the different chance nodes and decision points.

In decision point- \( D_1 \), we have to choose between the following two options, viz.,

(a) To build a large plant

(or)

(b) To build a small plant.
Building a large plant is expected to give on EMV of ₹ 346 lakhs while building a small plant is expected to give an EMV of ₹ 571 lakhs.

Hence, the optimal decision is to build the small plant.

**Illustration 3.13**

A client has approached an investment consultant with an investment proposal. The client wants to choose between investments in equity shares of companies, corporate bonds, real estates and Government guaranteed saving certificates. The client wants to lock his investment for one year and asks the consultant to suggest the best option.) The consultant analysed the performance of the above four avenues of investment and has arrived at the following conclusions about the future performance of these four investment avenues.

**Equity Shares**

There is a 50% chance that the equity shares will increase in value by 20%. There is a 35% chance that the increase in the value of equity shares will be 25%. There is a 15% chance that the share prices will remain unchanged. (Assume that the shares being considered for investment do not pay any dividends).

**Corporate Bonds**

Corporate bonds offer an interest of 13% p.a. There is a 60% chance of increases in the value of bonds by 15% and 40% chance of the value remaining unchanged (or stable).

**Real Estates**

The fortunes of real estate investments are more fluctuating.

There is a 25% chance of the value increasing by 30%, a 20% chance of the value increasing by 20%, a 35% chance of the value increasing by 10%, a 15% chance of the value remaining stable and a 5% chance of the value decreasing by 5%.

**Government guaranteed saving certificates**

They offer a fixed annual return of 8.75%.

**Solution:**

There is only one decision node $D_1$. At $D_1$, there are four alternatives. Choosing every alternative leads to some returns with different probabilities.

The investment consultant has to advise his client on the best possible (or optimal) investment avenue among the four investment avenues available.

Since we are going to compare the four investment avenues on the basis of EMVs, we need to know the amount that the client is prepared to invest. Since this is not given in the problem, we can arbitrarily assume some amount and proceed with the calculation of EMVs.

Let us assume that the amount available for investment is say ₹ 1000. [If a different figure is assumed, the EMVs will differ; however the solution will remain the same.]

There is one decision point- $D_1$ and four chance nodes $1$, $2$, $3$ and $4$. The decision tree is shown in Fig. 3.18.
**EMV at chance node 1**

When the share value increases by 20%, the investment of ₹ 1000 will become ₹ 1200 after one year. This has got a probability of 0.50.

When the share value increases by 25% the investment of ₹ 1000 will become ₹ 1250 after one year. This has got a probability of 0.35.

When the share value remains stable the investment of ₹ 1000 will remain at ₹ 1000 after one year. This has got a probability of 0.15.

Hence, EMV at chance node 1

\[
EMV = (1200 \times 0.5) + (1250 \times 0.35) + (1000 \times 0.15)
\]

\[= ₹ 1187.50\]
EMV at chance node

Corporate bonds offer an interest of 13% p.a. (as given in the problem).

When the value of the bond remains stable, only the coupon rate of interest will be available. The amount of ₹1000 invested will become ₹1130 along with interest after one year. This has got a probability of 0.40.

When the value of the bond increases by 15%, the amount of ₹1000 invested will fetch ₹1150 after one year if sold in the open market. In addition, the bond will give interest of ₹130 at the coupon rate of 13%. Thus, ₹1000 invested in the bond will be equivalent to ₹1280 (1150 + 130) after one year. This has got a probability of 0.60.

Note: Market value of a bond will increase above the face value when the market interest rate on bonds drop. This makes the bonds with a higher coupon rate than the prevailing market interest rate, more attractive which leads to the increase in their market value.

EMV at chance node

\[
EMV = (1280 \times 0.6) + (1130 \times 0.4)
\]

\[
= ₹1218
\]

EMV at chance node

When the real estate value increases by 30%, the investment of ₹1000 will become ₹1300 after one year. This has got a probability of 0.25.

When the real estate value increases by 20%, the investment of ₹1000 will become ₹1200 after one year. This has got a probability of 0.20.

When the real estate value increases by 10%, the investment of ₹1000 will become ₹1100 after one year. This has got a probability of 0.35.

Hence EMV at chance node

\[
EMV = (1300 \times 0.25) + (1200 \times 0.20) + (1100 \times 0.35) + (1000 \times 0.15) + (950 \times 0.05)
\]

\[
= ₹1150.50
\]

EMV at chance node

Investment in Government guaranteed saving certificates is risk free. The return (or yield) of 8.75% is guaranteed and hence this has got a probability of 1.00.

Hence, an investment of ₹1000 will become ₹1087.50 after one year. The EMV at chance node is ₹1087.50.

Decision at decision point \(D_1\).

At decision point \(D_1\) there are four different investment options available. We have calculated the EMVs for the four investment options. The optimal investment option is the one that gives the highest EMV.

Hence, investing in corporate bonds is the optimal decision that gives an EMV of ₹1218 for an investment of ₹1000.
3.9 DECISION MAKING UNDER CONFLICT

Any decision taken at any level has to take into account the conflicting needs of the different stakeholders who are affected by the decision. Hence, conflict resolution is an essential part of the decision-making process.

Since most decisions involve, in some form or the other, sharing of limited resources among different groups, decisions should be taken by balancing the conflicting interests of the different groups. In any organization, there are scarce resources that need to be allocated between competing groups and hence the decision-maker has to ensure that all the needs and concerns of the different groups are taken into consideration when taking decisions. Consensual decision making ensures that most concerns of the different groups are heard and taken into account.

Mostly in organizations, it is common for the decision-makers to elicit as much information as possible from the concerned parties/groups before taking decisions. Such an attempt will act as a grievance redressal mechanism for the affected parties. In extreme cases when the competing groups do not agree to arrive at a consensus, it is left to the higher-ups in the organization to play the role of peace-makers to arrive at a consensus. Mathematical treatment of decision-making under conflicting situations is beyond the scope of this book.

Monte Carlo simulation: ‘Monte Carlo’ is a code name given by Von Neumann and Ulam to the technique of solving problems using random numbers. Monte Carlo technique can be used to solve a variety of problems involving stochastic situations. (a stochastic situation is one where some or all parameters of the problem are described by random variables.) It is a very popular technique and it uses random numbers to solve problems requiring decision-making under uncertainty where a mathematical solution is highly complex/impossible.

The steps involved in Monte Carlo technique are as under:
- From the given probability of occurrence of events, establish cumulative probability.
- Assign tag numbers to the events in such a way that the tag numbers represent the cumulative probability.
- Obtain random numbers from a random number table.
- Correlate the random numbers with the tag numbers assigned to the events and identify the value for the respective events.

Illustration: 3.14

It is observed that the demand for a product varies in a random fashion. The demand per day is observed to have the following probability:

<table>
<thead>
<tr>
<th>Demand per day</th>
<th>25</th>
<th>33</th>
<th>42</th>
<th>51</th>
</tr>
</thead>
<tbody>
<tr>
<td>Probability</td>
<td>0.15</td>
<td>0.25</td>
<td>0.45</td>
<td>0.15</td>
</tr>
</tbody>
</table>

Simulate the demand for the ensuing 30 days using Monte Carlo simulation technique.

Solution:

The demand is said to vary in a random fashion. The demand may get influenced by both internal and external factors. In the absence of any mathematical relationship to evaluate the demand over a period of time, the management of the firm would be very much interested to know the demand pattern for which Monte Carlo simulation technique is useful.
<table>
<thead>
<tr>
<th>Demand per day</th>
<th>Probability</th>
<th>Cumulative probability</th>
<th>Tag number</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>0.15</td>
<td>0.15</td>
<td>0 to 14</td>
</tr>
<tr>
<td>33</td>
<td>0.25</td>
<td>0.40</td>
<td>15 to 39</td>
</tr>
<tr>
<td>42</td>
<td>0.45</td>
<td>0.85</td>
<td>40 to 84</td>
</tr>
<tr>
<td>51</td>
<td>0.15</td>
<td>1.00*</td>
<td>85 to 99</td>
</tr>
</tbody>
</table>

*Please note that the cumulative probability of all the events should always be equal to 1.00.*

Tag numbers are assigned from 0 to 99, both numbers inclusive, so that there will be 100 tag numbers representing a cumulative probability of 1.00. A cumulative probability of 0.15 will have 15 tag numbers and accordingly tag numbers of 0 to 14 are assigned. Tag numbers for the subsequent events are assigned on similar lines.

After assigning tag numbers, the next step is to choose a set of two digits random numbers (two digits because the tag numbers are from 0 to 99) for conducting a series of trials. The number of random numbers to be chosen depends upon the accuracy required. More the number of random numbers, more the accuracy.

Let us choose, say, thirty random numbers.

(For choosing the set of random numbers from a random number table, one can start at any point on the table and proceed in any direction. A two digits random number table is given at the end of this chapter.)

Referring to the two digits random number table given at the end of this chapter, let us choose arbitrarily any number, say, 40 (ninth row, first column of the table) and proceed, say, in the horizontal direction towards the right. The set of 30 random numbers chosen in this way are as under:

40, 47, 01, 60, 05, 69, 79, 09, 66, 77, 69, 45, 18, 93
99, 17, 22, 62, 70, 28, 51, 68, 22, 46, 30, 23, 76, 33

The first random number of 40 lies in the range ‘40 to 84’ (the range of random numbers as referred from the range of tag numbers). Hence, the simulated demand for the first trial is 42.

The second random number of 92 lies in the range ‘85 to 99’. Hence, the simulated demand for the second trial is 51; the third random number is 47 which lies in the range ‘40 to 84’ and hence the simulated demand for the third trial is 42. On similar lines, the demand is simulated by carrying out thirty trials. The simulated demand in thirty trials represent the simulated demand for a continuous period of 30 days.

<table>
<thead>
<tr>
<th>Trial No.</th>
<th>Random No.</th>
<th>Simulated Demand/day</th>
<th>Trial No.</th>
<th>Random No.</th>
<th>Simulated Demand/day</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>40</td>
<td>42</td>
<td>16</td>
<td>99</td>
<td>51</td>
</tr>
<tr>
<td>2.</td>
<td>92</td>
<td>51</td>
<td>17</td>
<td>17</td>
<td>33</td>
</tr>
<tr>
<td>3.</td>
<td>47</td>
<td>42</td>
<td>18</td>
<td>22</td>
<td>33</td>
</tr>
<tr>
<td>4.</td>
<td>01</td>
<td>25</td>
<td>19</td>
<td>62</td>
<td>42</td>
</tr>
<tr>
<td>5.</td>
<td>60</td>
<td>42</td>
<td>20</td>
<td>70</td>
<td>42</td>
</tr>
<tr>
<td>6.</td>
<td>05</td>
<td>25</td>
<td>21</td>
<td>28</td>
<td>33</td>
</tr>
<tr>
<td>7.</td>
<td>69</td>
<td>42</td>
<td>22</td>
<td>31</td>
<td>33</td>
</tr>
<tr>
<td>8.</td>
<td>79</td>
<td>42</td>
<td>23</td>
<td>07</td>
<td>25</td>
</tr>
<tr>
<td>9.</td>
<td>09</td>
<td>25</td>
<td>24</td>
<td>68</td>
<td>42</td>
</tr>
<tr>
<td>10.</td>
<td>66</td>
<td>42</td>
<td>25</td>
<td>22</td>
<td>33</td>
</tr>
<tr>
<td>11.</td>
<td>77</td>
<td>42</td>
<td>26</td>
<td>46</td>
<td>42</td>
</tr>
<tr>
<td>12.</td>
<td>69</td>
<td>42</td>
<td>27</td>
<td>30</td>
<td>33</td>
</tr>
<tr>
<td>13.</td>
<td>45</td>
<td>42</td>
<td>28</td>
<td>23</td>
<td>33</td>
</tr>
<tr>
<td>14.</td>
<td>18</td>
<td>33</td>
<td>29</td>
<td>76</td>
<td>42</td>
</tr>
<tr>
<td>15.</td>
<td>93</td>
<td>51</td>
<td>30</td>
<td>33</td>
<td>33</td>
</tr>
</tbody>
</table>
**Illustration 3.15**

Company ‘A’ is considering the proposal to take over company ‘B’. Based on the observations, company ‘A’ estimates the probability distributions of costs and revenues of the takeover proposal as under:

<table>
<thead>
<tr>
<th>Cost per day (₹)</th>
<th>Probability</th>
<th>Revenue per day (₹)</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>18,000</td>
<td>0.15</td>
<td>20,000</td>
<td>0.15</td>
</tr>
<tr>
<td>20,000</td>
<td>0.20</td>
<td>25,000</td>
<td>0.15</td>
</tr>
<tr>
<td>35,000</td>
<td>0.25</td>
<td>45,000</td>
<td>0.25</td>
</tr>
<tr>
<td>45,000</td>
<td>0.35</td>
<td>55,000</td>
<td>0.35</td>
</tr>
<tr>
<td>60,000</td>
<td>0.05</td>
<td>70,000</td>
<td>0.10</td>
</tr>
</tbody>
</table>

Obtain the probability distribution of net revenue to company ‘A’ if it takes over company ‘B’.

**Solution:**

For arriving at the probability distribution of net revenue, we should first arrive at a simulated set of net revenues. Since the data available is with regard to cost and revenue, we can first simulate ‘cost’ and ‘revenue’ and then arrive at the simulated ‘net revenue’.

The number of trails to be conducted is not given. Let us conduct, say, 20 trails.

Using two digits random number table, the following are the two sets of random numbers chosen. (one set for simulating ‘cost’ and another set for simulating ‘revenue’)

The first set of random numbers (for ‘cost’):

40, 12, 82, 65, 74, 92, 47, 60, 01, 62, 28, 29, 69, 69, 00, 11, 81, 86, 05, 36

The second set of random numbers (for ‘revenue’):

12, 98, 31, 86, 87, 38, 88, 19, 09, 44, 56, 35, 78, 02, 58, 06, 77, 23, 05, 01

Using the sets of random numbers, tag numbers are assigned to costs and revenues as under:

<table>
<thead>
<tr>
<th>Cost</th>
<th>Probability</th>
<th>Cumulative probability</th>
<th>Tag No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>18,000</td>
<td>0.15</td>
<td>0.15</td>
<td>0 to 14</td>
</tr>
<tr>
<td>20,000</td>
<td>0.20</td>
<td>0.35</td>
<td>15 to 34</td>
</tr>
<tr>
<td>35,000</td>
<td>0.25</td>
<td>0.60</td>
<td>35 to 59</td>
</tr>
<tr>
<td>45,000</td>
<td>0.35</td>
<td>0.95</td>
<td>60 to 94</td>
</tr>
<tr>
<td>40,000</td>
<td>0.05</td>
<td>1.00</td>
<td>95 to 99</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Revenue</th>
<th>Probability</th>
<th>Cumulative probability</th>
<th>Tag No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>20,000</td>
<td>0.15</td>
<td>0.15</td>
<td>0 to 14</td>
</tr>
<tr>
<td>25,000</td>
<td>0.15</td>
<td>0.30</td>
<td>15 to 29</td>
</tr>
<tr>
<td>45,000</td>
<td>0.25</td>
<td>0.55</td>
<td>30 to 54</td>
</tr>
<tr>
<td>55,000</td>
<td>0.35</td>
<td>0.90</td>
<td>55 to 89</td>
</tr>
<tr>
<td>70,000</td>
<td>0.10</td>
<td>1.00</td>
<td>90 to 99</td>
</tr>
</tbody>
</table>

Costs and revenues are simulated correlating the tag numbers with the random numbers which is given in the table below:
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>40</td>
<td>35,000</td>
<td>1</td>
<td>12</td>
<td>20,000</td>
</tr>
<tr>
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<td>12</td>
<td>18,000</td>
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<td>70,000</td>
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<td>3</td>
<td>82</td>
<td>45,000</td>
<td>3</td>
<td>31</td>
<td>45,000</td>
</tr>
<tr>
<td>4</td>
<td>65</td>
<td>45,000</td>
<td>4</td>
<td>86</td>
<td>55,000</td>
</tr>
<tr>
<td>5</td>
<td>74</td>
<td>45,000</td>
<td>5</td>
<td>87</td>
<td>55,000</td>
</tr>
<tr>
<td>6</td>
<td>92</td>
<td>45,000</td>
<td>6</td>
<td>38</td>
<td>45,000</td>
</tr>
<tr>
<td>7</td>
<td>47</td>
<td>35,000</td>
<td>7</td>
<td>88</td>
<td>55,000</td>
</tr>
<tr>
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<td>62</td>
<td>45,000</td>
<td>10</td>
<td>44</td>
<td>45,000</td>
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<td>11</td>
<td>28</td>
<td>20,000</td>
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<td>56</td>
<td>55,000</td>
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<td>35</td>
<td>45,000</td>
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<td>45,000</td>
<td>13</td>
<td>78</td>
<td>55,000</td>
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<tr>
<td>14</td>
<td>00</td>
<td>18,000</td>
<td>14</td>
<td>02</td>
<td>20,000</td>
</tr>
<tr>
<td>15</td>
<td>11</td>
<td>18,000</td>
<td>15</td>
<td>58</td>
<td>55,000</td>
</tr>
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<td>16</td>
<td>81</td>
<td>45,000</td>
<td>16</td>
<td>06</td>
<td>20,000</td>
</tr>
<tr>
<td>17</td>
<td>86</td>
<td>45,000</td>
<td>17</td>
<td>77</td>
<td>55,000</td>
</tr>
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<td>18</td>
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<td>36</td>
<td>35,000</td>
<td>19</td>
<td>05</td>
<td>20,000</td>
</tr>
<tr>
<td>20.</td>
<td></td>
<td></td>
<td>20.</td>
<td>01</td>
<td>20,000</td>
</tr>
</tbody>
</table>

'Trial No: 1 (Simulated cost) The random number 40 lies in the range '35 to 59'. The corresponding cost is ₹ 35,000. Other trials are conducted on similar lines and the costs for 20 days are simulated.

'Trial No: 1 (Simulated revenue) The random number 12 lies in the range of '00 to '14. The corresponding revenue is ₹ 20,000. Other trials are conducted on similar lines and the revenues for 20 days are simulated.

Using the simulated costs and revenues for 20 days, the simulated net revenue in view of the take over proposal can be obtained. (net revenue = revenue–cost)

<table>
<thead>
<tr>
<th>Trial No.</th>
<th>Cost</th>
<th>Revenue</th>
<th>Net revenue</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>35,000</td>
<td>20,000</td>
<td>(-)15,000</td>
</tr>
<tr>
<td>2</td>
<td>18,000</td>
<td>70,000</td>
<td>52,000</td>
</tr>
<tr>
<td>3</td>
<td>45,000</td>
<td>45,000</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>45,000</td>
<td>55,000</td>
<td>10,000</td>
</tr>
<tr>
<td>5</td>
<td>45,000</td>
<td>55,000</td>
<td>10,000</td>
</tr>
<tr>
<td>6</td>
<td>45,000</td>
<td>45,000</td>
<td>0</td>
</tr>
<tr>
<td>7</td>
<td>35,000</td>
<td>55,000</td>
<td>20,000</td>
</tr>
<tr>
<td>8</td>
<td>45,000</td>
<td>25,000</td>
<td>(-)20,000</td>
</tr>
<tr>
<td>9</td>
<td>18,000</td>
<td>20,000</td>
<td>2,000</td>
</tr>
<tr>
<td>10</td>
<td>45,000</td>
<td>45,000</td>
<td>0</td>
</tr>
<tr>
<td>11</td>
<td>20,000</td>
<td>55,000</td>
<td>35,000</td>
</tr>
<tr>
<td>12</td>
<td>20,000</td>
<td>45,000</td>
<td>25,000</td>
</tr>
<tr>
<td>13</td>
<td>45,000</td>
<td>55,000</td>
<td>10,000</td>
</tr>
<tr>
<td>14</td>
<td>45,000</td>
<td>20,000</td>
<td>(-)25,000</td>
</tr>
<tr>
<td>15</td>
<td>18,000</td>
<td>55,000</td>
<td>37,000</td>
</tr>
<tr>
<td>16</td>
<td>18,000</td>
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<td>2,000</td>
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<tr>
<td>17</td>
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<td>10,000</td>
</tr>
<tr>
<td>18</td>
<td>45,000</td>
<td>25,000</td>
<td>(-)20,000</td>
</tr>
<tr>
<td>19</td>
<td>18,000</td>
<td>20,000</td>
<td>2,000</td>
</tr>
<tr>
<td>20.</td>
<td>35,000</td>
<td>20,000</td>
<td>(-)15,000</td>
</tr>
</tbody>
</table>
We have been asked to obtain a probability distribution for the net revenue. The table above gives the simulated net revenue for a period of 20 days. To arrive at the probability distribution of net revenue, note down the frequency of occurrences of same net revenues and tabulate them as under:

<table>
<thead>
<tr>
<th>Net revenue</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>(-)125,000</td>
<td>1</td>
</tr>
<tr>
<td>(-)20,000</td>
<td>2</td>
</tr>
<tr>
<td>(-)15,000</td>
<td>2</td>
</tr>
<tr>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>2,000</td>
<td>3</td>
</tr>
<tr>
<td>10,000</td>
<td>4</td>
</tr>
<tr>
<td>20,000</td>
<td>1</td>
</tr>
<tr>
<td>25,000</td>
<td>1</td>
</tr>
<tr>
<td>35,000</td>
<td>1</td>
</tr>
<tr>
<td>37,000</td>
<td>1</td>
</tr>
<tr>
<td>52,000</td>
<td>1</td>
</tr>
</tbody>
</table>

(The sum of frequencies = 20)

From the frequency of occurrences of each net revenue, the probability distribution for net revenue is arrived at as under:

<table>
<thead>
<tr>
<th>Net revenue</th>
<th>Frequency</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>(-)25,000</td>
<td>1</td>
<td>1/20 = 0.05</td>
</tr>
<tr>
<td>(-)20,000</td>
<td>2</td>
<td>2/20 = 0.10</td>
</tr>
<tr>
<td>(-)15,000</td>
<td>2</td>
<td>2/20 = 0.10</td>
</tr>
<tr>
<td>0</td>
<td>3</td>
<td>3/20 = 0.15</td>
</tr>
<tr>
<td>2,000</td>
<td>3</td>
<td>3/20 = 0.15</td>
</tr>
<tr>
<td>10,000</td>
<td>4</td>
<td>4/20 = 0.20</td>
</tr>
<tr>
<td>20,000</td>
<td>1</td>
<td>1/20 = 0.05</td>
</tr>
<tr>
<td>25,000</td>
<td>1</td>
<td>1/20 = 0.05</td>
</tr>
<tr>
<td>35,000</td>
<td>1</td>
<td>1/20 = 0.05</td>
</tr>
<tr>
<td>37,000</td>
<td>1</td>
<td>1/20 = 0.05</td>
</tr>
<tr>
<td>52,000</td>
<td>1</td>
<td>1/20 = 0.05</td>
</tr>
</tbody>
</table>

20 1.00

**Game theory**: In real life situation, business firms compete with one another. Game theory deals with situations in which two intelligent opponents have conflicting interests. For example, two business firms may compete for attracting the consumers towards their products. To achieve their goals, the two firms will form strategies. The strategy that one firm forms will depend upon the strategy that the other firm has already formed/in the process of forming. The approach to such competitive problems was developed by Von Neumann who named it 'Game Theory'.

The following are the properties of a competitive game:

- The number of competitors are finite. (the competitors are also known as ‘players’)
- Each player has a finite number of strategies.
- All the players need not necessarily have the same number of strategies.
- Each player chooses a single course of action from the list of strategies available to him. All the players are assumed to make their choice simultaneously so that no player knows the choices
of his opponents until he is already committed to his choice. When all the players select their strategy simultaneously, a play of the game results.

- The outcome of the play depends upon the strategies followed by the players.

The objective of the ‘Game Theory’ is to develop a rational criterion for the selection of a strategy/strategies by each player. Since games are rooted in conflict of interests, the optimal solution selects one or more strategies for each player in such a way that any change in the chosen strategies does not improve the benefit to either player.

Explaining the mathematical treatment involved in ‘Game Theory’ is beyond the scope of this book. Interested readers are referred to standard books on ‘Operations Research’.

**SWOT analysis:** In a dynamic environment, a company must always keep vigil to ensure that its competitive position is maintained or improved upon so that it can exploit the situation for profit. Every organization operates in an environment that is subject to constant changes. Hence, unless an organization adapts itself to the changing environment, success cannot be guaranteed. SWOT analysis provides an opportunity for introspection into the organisation’s strengths, weaknesses, opportunities and threats. Of these four aspects, strengths and weaknesses refer to the organisation’s inner strengths and weaknesses while opportunities and threats refer to factors external to the organization over which the organization has no control.

SWOT analysis is done in many situations like mergers and acquisitions, takeovers, declining trends in profits, growing competition in the field, expansion/diversification of activities, product range extension, vertical integration etc. SWOT analysis can also be done in the absence of the above situations to improve upon the competitive edge of an organisation and also to avoid any pitfalls lying ahead that may hamper the growth of the organisation.

**SWOT analysis applied to project appraisal:** Project appraisal is an area where SWOT analysis is of immense help, particularly when project appraisal is done for expansion/diversification activities. Though SWOT analysis is primarily done as a subjective estimate of the strengths, weaknesses, opportunities and threats, it throws light on the important factors that are in support of the proposed project or that work against the interests of the proposed project so that the project can be planned suitably. Some of the factors that are worth considering with regard to strengths, weaknesses, opportunities and threats of an organization that envisages an expansion or diversification project are enumerated below:

**Strengths:**

- Locational advantage of the organization—nearness to the sources of raw material, nearness to location of end users etc.
- Goodwill developed among clients.
- Buy-back arrangements.
- Lower capital investment on the existing plant (*i.e.*, setting up a similar plant would have become much costlier).
- Good network of dealers and distributors already established.
- Qualified, committed, motivated, reliable work force.
- Professional top management team.

• Unutilized capacity (utilization).
• Globalised operations.
• High-tech area/high initial investment required which act as a barrier to new entrants.

Weaknesses:
• Technological obsolescence.
• Scarcity of raw material.
• Comparatively less international price for similar products.
• Locational disadvantage resulting in higher freight costs for transportation of raw materials/finished products.
• Labour unrest.
• Absence of entry barriers to new entrants.

Opportunities:
• Cost of raw material becoming cheaper.
• Liberalisation of import of raw material (where the cost of imported raw material is cheaper).
• Growth in per capita income and growth in consumption level.
• Advent of cost saving production technology.
• Imports of competitive products becoming costlier.
• Product finding alternate uses, leading to increase in demand.
• Withdrawal of incentive offered by the Government to new entrants.
• Chances of competitors changing their line of activity.

Threats:
• Import of competitive products becoming cheaper.
• Liberalisation of import of competitive products (when the cost of imported goods is cheaper).
• Withdrawal of existing incentives by the Government.
• Raw material becoming costlier.
• General recession in the economy resulting in slowing down of consumption.
• New entrants entering the field in a big way.
• Stringent pollution control measures adopted by the Government.
• Possible hike in electric power charges, hike in duties, taxes etc.
• Government’s populist measures that may have adverse impact.
• Product at the fag end of its life cycle.
• Emergence of cheaper alternative products.

Though SWOT analysis applied to project appraisal is subjective in nature, it throws light on important points that need to be considered before taking an investment decision. Certain factors like liberalization of import of competitive products that are cheaper might have a heavy implication and may even suggest shelving off the project idea. Factors like possible hike in the production expenses, possible reduction in selling price to fight the competition etc. will have to be accounted for while arriving at the profitability estimate by suitably adjusting the anticipated expenditures and incomes. SWOT analysis, thus comes first, before detailed financial projections are attempted upon.
<table>
<thead>
<tr>
<th>29</th>
<th>64</th>
<th>52</th>
<th>40</th>
<th>93</th>
<th>67</th>
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<th>17</th>
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<th>28</th>
<th>27</th>
<th>69</th>
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</thead>
<tbody>
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