CHAPTER FOUR

ECONOMIC APPRAISAL OF PROJECTS (ANALYSIS)

Desired Objectives

After studying this chapter, you should be able to

- Differentiate between financial and economic analysis
- Understand the rational for economic analysis
- Understand the shadow pricing, shadow official exchange rate and wage rate
- The traded and none traded inputs and outputs
- Differentiate between the world price (Little-Mirrlees method) and the domestic price (UNIDO Method) system of economic analysis.

SOCIAL COST BENEFIT ANALYSIS (ECONOMIC ANALYSIS OF PROJECTS)

Social Cost Benefit Analysis (SCBA), also known as economic analysis, is a methodology developed for evaluating investment projects from the point of view of the society (or economy) as a whole. In the economic analysis of projects, we are interested in the total return or productivity or profitability to the whole society or economy of all the resources committed to the project.

Used primarily for evaluating public investments, SCBA has received increasing emphasis in recent years in view of the growing importance of public investments in many countries, particularly in developing countries, where governments are playing a significant role in economic development. SCBA is also relevant, to a certain extent, to private investments, as these have now to be approved by various governmental and quasi-governmental agencies that bring to bear larger national considerations in their decisions.

In the context of planned economies, SCBA aids in evaluating individual projects within the planning framework which spells out national economic objectives and broad allocation of resources to various sectors. In other words, SCBA is concerned with tactical decision making within the framework of broad strategic choices defined by planning at the macro level. The perspectives and parameters provided by the macro level plans serve as the basis of SCBA which is a tool for analysing and appraising individual projects.

Basically, the procedures followed and the criteria used (NPV, IRR, BCR) are the same in economic and financial analysis of projects. But the values, which the NPV, IRR and BCR assume, are different in economic analysis and financial analysis. The main factors, which explain this difference, are:

1. The items considered as inputs and outputs of the project;
2. The prices used in the valuation of inputs and output
3. The treatment of taxes, subsidies and other transfer payments.

1. Items considered as inputs and outputs

Often, some real costs and benefits attributed to projects do not appear among its inputs and outputs when it is analyzed from the enterprises viewpoint and, therefore, they do not enter the calculations of financial NPV, IRR, and benefit cost ratio. The main reason for excluding certain cost and benefits is that they are considered "external" to the enterprise. But costs or benefits viewed as "external" to the enterprise are "internal" when they are considered from the economy's angle; somebody pays for these "external" costs and somebody receives these "external" benefits, even if it is not the enterprise. Consequently, to the extent that they can be measured and valued they are included in the calculations of the economic NPV, IRR, and BCR.

Good example of externalities is the costs incurred in providing the project area with infrastructure inputs, e.g.; access roads, energy lines, sewerage services; although these inputs are required by the project, often they serve other purposes too. Similarly, flood control benefits, for example, resulting from a hydroelectric power dam are real benefits to down stream farmers and the economy, but cannot be captured by the power authority for various reasons.

An externality, also referred to as an external effect, is a special class of good, which has the following characteristics:

(i) It is not deliberately created by the project sponsor but is an incidental outcome of legitimate economic activity.

(ii) It is beyond the control of the persons who are affected by it, for better or for worse.

(iii) It is not traded in the market place.

An external effect may be beneficial or harmful. Examples of beneficial external effects are:

- An oil company drilling in its own fields may generate useful information about oil potential in the neighboring.
- The approach roads built by a company may improve the transport system in that area.
- The training programme of a firm may upgrade the skills of its workers thereby enhancing their earning power in subsequent employments.

Examples of harmful external effects are:

- A factory may cause environmental pollution by emitting large volumes of smoke and dirt. People living in the neighborhood may be exposed to health hazards and put to inconvenience.
- The location of an airport in a certain area may raise noise level considerably in the neighborhood.
- A highway may cut a farmer's holding in two, separating his grazing land and his cowsheds, thereby adversely affecting his physical output.

Since SCBA seeks to consider all costs and benefits, to whomsoever they may accrue, external effects need to be taken into account. The valuation of external effects is rather difficult because they are often intangible in nature and there is no market price, which can be used as a starting point. Their value is estimated by indirect means. For example:

- The benefit of information provided by the oil field to neighboring oil fields may be equated with what the neighboring oil fields would have spent to obtain such information.
- The value of better transport provided by the approach roads may be estimated in terms of increased activities and benefits derived there from
- The benefit from the training programme may be estimated in terms of the increased earning power of workers.

- The cost of pollution may be estimated in terms of the loss of earnings .as a result of damage to health caused by it and the cost of time spent for coping with unhygienic surroundings.
- The cost of noise may be inferred from the differences in rent between the noise-affected area and that of some other area, which is comparable except for the level of noise.
- The harmful external effect of the highway may be measured by the consumer willingness to pay for the output of farmer, which has been reduced due to the highway.

The above examples serve to emphasize the difficulties in measuring external effects. [In view of this, some economists have suggested that these effects be ignored. In order to justify their suggestion, they argue that since a project is likely to have both beneficial and harmful external effects, one may not err much in assuming that the net effect would be zero. This argument, seemingly a rationalization for one's ignorance, lacks validity.] External effects must be taken into account wherever it is possible to do so. Even if these effects cannot be measured in monetary terms, some qualitative evaluation must be attempted.

2. **Prices used**

Another difference between financial and economic analysis is that even inputs and outputs "internal" to both the enterprise and the economy are valued differently. In financial analysis the rule is to value inputs and outputs at actual market prices, at the same time in economic analysis shadow or Efficiency or Accounting prices are employed. Consequently, using different prices will give different economic and financial NPV, IRR, and BCR even if the inputs and outputs are identical in physical terms. For example, the enterprise will have to pay workers the market wages in real Birrs (not in shadow ones), irrespective of what is believed to be their opportunity cost from the economy's viewpoint. Similarly, the enterprise will collect for its exports the equivalent of local currency calculated at the official exchange rate, even when it is believed that the foreign currency is under valued. Again, in financial analysis it is the actual expenditure and revenue, which matter, not shadow ones.

Market prices, which form the basis for computing the monetary costs and benefits from the point of view of project sponsor, reflect social values only under conditions of perfect competition, which are once in a blue moon, if ever, realized by developing countries. When imperfections are obtained, market prices do not reflect social values.

The common market imperfections found in developing countries are: (i) rationing, (ii) prescription of minimum wage rates, and (iii) foreign exchange regulation. Rationing of a commodity means control over its price and distribution. The price paid by a consumer under rationing is often significantly less than the price that would prevail in a competitive market. When minimum wage rates are prescribed, the wages paid to labour are usually more than what the wages would be in a competitive labour market free from such wage legislations. The official rate of foreign exchange in most of the developing countries, which exercise close regulation over foreign exchange, is typically less than the rate that would prevail in the absence of foreign regulation. This is why foreign exchange usually commands premium in unofficial transactions.

3.**Taxes, subsidies and other transfer payments**

The other reason why financial and economic NPV and IRR might differ emanates from the treatment of taxes, subsidies and other transfer payments. This issue relates to the valuation of inputs and outputs discussed above, but it is treated separately because of its importance in practice. Taxes and customs duties from which the enterprise is not exempted are taken as cost in financial analysis although they do not reflect commitment of real resources; for this reason they are excluded from the calculations of the economic NPV and IRR. Similarly, subsidies paid to the enterprises by the government are viewed as transfer payments and are excluded from consideration in economic analysis, but they are treated like any other revenue of the enterprise in computing the financial NPV or IRR or BCR.

In addition to the factors discussed above, the impact of the project on savings, its effect on redistribution, and the consideration for merit goods are also seen as the other factors that entail differences between financial and economic analysis of projects:

i. **Concern for Savings**: Unconcerned about how its benefits are divided between consumption and savings, a private firm does not put differential valuation on savings and consumption. From a social point of view, however, the division of benefits between consumption and savings (which leads to investment) is relevant, particularly in capital-scarce developing countries. One Birr of benefits saved is deemed more valuable than a birr of benefits consumed. The concern of society for savings and investment is properly reflected in SCBA wherein a higher valuation is placed on savings and a lower valuation is put on consumption

ii. **Concern for Redistribution**: A private firm does not bother how its benefits are distributed across various groups in the society. The society, however; is concerned about the distribution of benefits across different groups. One Birr of benefit going to a poor section is considered more valuable than a Birr of benefit going to an affluent section.

iii. **Merit Wants** Goals and preferences not expressed in the market place, but believed by policy makers to be in the larger interest, may be referred to as merit wants. For example, the government may prefer to promote an adult education programme or a balanced nutrition programme for school-going children even though, these are not sought by consumers in the market place. While merit wants are not relevant from the private point of view, they are important from the social point of view.

For the reasons discussed above the financial and economic analysis of a project will show a different picture, particularly as regards the NPV, IRR, and BCR. In analyzing public projects in particular both the financial analysis and the economic analysis should be conducted. This is especially user-to view a project from various angles and to obtain different perspectives. Decision makers need both profiles in order to evaluate a project and to design the necessary fiscal and monetary measures to meet its financial requirements.

In deciding on the acceptance or rejection of such projects, the economic criterion is superior to the financial one, and when a project passes the economic test it is an acceptable project for the country. It should be implemented provided that the government will take the necessary financial and other measures to ensure its smooth operation. A project, for example, that shows very low, or even negative financial returns as a result of the fact that the major benefits it generates are "external" to and cannot be captured by the enterprise, could show acceptable economic returns when these benefits are considered as "internal" to the economy and are valued accordingly. In this case the solution is to subsidize the enterprise sufficiently so that it will stay in operation and generate these benefits. However, although this is the economically rational approach, one should be careful with projects that pass the economic test but fail the financial test. The project analyst explaining the pass/fail situation with projects that pass/fail the financial and economic test should present convincing data and justification. in such a way that one can feel more comfortable.

4.2 **TWO APPROACHES TO SCBA**

Two principal approaches to SCBA have emerged in the late 1960s and early 1970s:the UNIDO approach and the Little and Mirrlees approach. The UNIDO[1] approach was first articulated in the Guidelines for Project Evaluation (1972) which provides a comprehensive framework for SCBA in developing countries. The rigor and length of this work created a demand for a concise and operational guide for project evaluation in practice. To fulfill this need, UNIDO came out with another publication, Guide to Practical Project Appraisal in 1978. The UNIDO approach was developed by Sen., Dasgupta, and Marglin.

The Little and Mirrlees approach (also known as the OECD[2] approach) was developed by I.M.D. Little and J.A. Mirrlees in their work Manual of Industrial Project Analysis for Developing Countries, Volume II, Social Cost-Benefit Analysis (1968) and Project

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[1] UNIDO = United Nations Industrial Development Organization
[2] OECD = Organization for Economic Cooperation and Development

Appraisal and Planning for Developing Countries (1974). We shall investigate the two approaches briefly in the following part.

4.2.1 **The UNIDO Approach**

The UNIDO approach to SCBA involves five stages, each stage of which measures the desirability of the project from a different angle:

1. Calculation of financial profitability of the project measured at market prices.
2. Obtaining the net benefit of project measured in terms of shadow or economic (efficiency) prices.
3. Adjustment for the impact of the project on savings and investment.
4. Adjustment for the impact of the project on income distribution.
5. Adjustment for the impact of project on merit goods and demerit goods whose social values differ from their economic values.

The measurement of financial profitability of the project in the first stage is similar to the financial analysis we have discussed in the first module, second chapter of the course; hence, no need to dwell into it here.

Stage two of the UNIDO approach is concerned with the determination of the net benefit of the project in terms of economic (efficiency) prices, also referred to as shadow prices. Market prices represent shadow prices only under conditions of perfect markets, which are almost invariably not fulfilled in developing countries. Hence, there is a need for developing shadow prices and measuring net economic benefit in terms of these prices.

4.2.1.1 **Shadow Pricing: Basic Issues**

Before we deal with shadow pricing of specific resources, certain basic concepts and issues must be discussed: choice of nume'raire, concept of tradability, source of shadow prices, treatment of taxes, and consumer willingness to pay.

1.*Choice of Numeraire*: Just as it is a great convenience to express market prices in terms of money, so it will be appropriate to measure shadow prices all in terms of a unit of account, which is called the numeraire. in economic analysis the value of inputs and outputs is expressed using this numeraire, or unit of account. In the UNIDO approach ‘aggregate consumption expressed in domestic prices’ is used as the unit of account; i.e., inputs and outputs are measured in terms of domestic prices that is used as a numeraire. In the Little and Mirrless approach, ‘uncommitted social income measured in border prices’ is the unit of account; i.e, values are expressed in terms of border prices that is used as the numeraire.

2.*Concept of Tradability*: A key issue in shadow pricing is whether a good is tradable or not. For a good that is tradable, the international price is a measure of its opportunity cost to the country. Why? For a tradable good, it is possible to substitute import for domestic production and vice versa; similarly it is possible to substitute export for domestic consumption and vice versa. Hence the international price, also referred to as the border price, represents the 'real' value of the good in terms of economic efficiency.

3.Sources of Shadow Prices The UNIDO approach suggests three sources of shadow pricing, depending on the impact of the project on national economy. A project, as it uses and produces resources, may for any given input or output (i) increase or decrease the total consumption in the economy, (ii) decrease or increase production in the economy, (iii) decrease imports or increase imports, or (iv) increase exports or decrease exports.

If the impact of the project is on consumption in the economy the basis of shadow pricing is consumer willingness to pay. If the impact of the project is on production in the economy, the basis of shadow pricing is the cost of production. If the impact of the project is on international trade - increase in exports, decrease in imports, increase in imports, or decrease in exports, and the basis of shadow pricing is the foreign exchange value.

4.Taxes when shadow prices are being calculated, usually pose difficulties. The general guidelines in the UNIDO approach with respect to taxes are as follows: (i) When a project results in diversion of non-traded inputs which are in fixed supply from other producers or addition to non-traded consumer goods, taxes should be included. (ii) When a project augments domestic production by other producers, taxes should be excluded. (iii) For fully traded goods, taxes should be ignored.

4.2.1.2 **Shadow Pricing of Specific Resources**

Tradable Inputs and Outputs: A good is fully traded when an increase in its consumption results in a corresponding increase in import or decrease in export or when an increase in its production results in a corresponding increase in export or decrease in import. For fully traded goods, the shadow price is the border price, translated in domestic currency at the market exchange rate.

The above definition of a fully traded good implies that domestic changes in demand or supply affect just the level of imports or exports. This means for an imported good, the following conditions should be met: (i) If there is an import quota, it is not restrictive. (ii) The import supply is perfect1y elastic over the relevant range of import volume. (iii) There is no surplus capacity in the domestic industry; all additional supply must be imported. If there is surplus domestic capacity it cannot be utilized for want of necessary inputs. (iv) If the additional demand exists inland, the imported goods, even after taking into account the cost of transport from the port of entry to the point of inland demand, cost less than the marginal cost of local production; (v) The imported input costs less than the domestic marginal cost of purchase.

When the above conditions are satisfied, additional demand will be met fully by external trade. Hence the input is considered fully traded. Similar conditions must be satisfied for importable outputs, exportable inputs, and exportable outputs, if they are to be considered fully traded. In practice, it is reasonable to regard tradable inputs and outputs as fully traded, even if the above-mentioned conditions are not fully satisfied.

A good is not traded if it is tradable but conditions (i) through (iv) above are not fulfilled. For non-traded goods the border price does not reflect its economic value. What then is the value of non-traded goods? The value of a non-traded good should be measured in terms of what domestic consumers are willing to pay, if the output of the project adds to its domestic supplies or if the requirement of the project causes reductions of its consumption by others. The value of a non-traded good should be measured in terms of its marginal cost of the project causes reduction of production by other units.

Non-tradable Inputs and Outputs A good is non-tradable when the following conditions are satisfied: (i) its import price (CIF price) is greater than its domestic cost of production and (ii) its export price (FOB price) is less than its domestic cost of production.

The valuation of non-tradable is done as per the principles of shadow pricing discussed earlier. On the output side, if the impact of the project is to increase the consumption of the product in the economy, the measure of value is the marginal consumers' willingness to pay; if the impact of the project is to substitute other production of the same non-tradable in the economy, the measure of value is the saving in cost of production. On the input side, if the impact of the project is to reduce the availability of the input to other users, their willingness to pay for that input represents social value; if the project's input requirement is met by additional production of it, the production cost of it is the measure of social value.

Labour Inputs: The principles of shadow pricing for goods may be applied to labour as well, though labour is considered to be service. When a project hires labour, it could have three possible impacts on the rest of the economy: it may take labour away from other employments; it may induce the production of new workers; and it may involve import of workers.

When a project takes labour away from other employments, the shadow price of labour is equal to what other users of labour are willing to pay for this labour. In a relatively free market this will be equal to the marginal product of such labour.

The social cost associated with inducing 'additional' production of workers consists of the following: (i) the marginal product of the worker in the previous employment - if the worker is previously unemployed, this would naturally be zero; (ii) the value assigned by the worker on the leisure that he may have to forego as a result of employment in the project -the value of this leisure is reflected in his reservation wage; (iii) the additional consumption of food when a worker is fully employed as opposed to when he is idle or only partly employed; (iv) the cost of transport and rehabilitation when a worker is moved from one location to another; (v) the increased consumption by the worker and its negative impact on savings and investment in the society when the worker is paid market wage rate by the project; and (vi) the cost of training a worker to improve his skills.

The social cost associated with import of foreign workers is the wage they command. In this case, however, a premium should be added on account of foreign exchange remitted abroad by these workers from their savings.

Capital Inputs When a capital investment is made in project two things happen: (i) financial resources are converted into physical assets. (ii) Financial resources are withdrawn from the national pool of savings and hence alternative projects are foregone. Thus, shadow pricing of capital investment involves two questions:

- What is the value of physical assets?
- What is the opportunity cost of capital (which reflects the benefit foregone by sacrificing alternative project/s)?

The value (shadow price) of physical assets is calculated the value of other resources is calculated. If it is a fully traded good, its shadow price equal to its border price. If it is a non-traded good its price is measured in terms of cost of production (if the project induces additional domestic production of the asset) or consumer willingness to pay (if the project takes the asset from other users).

The opportunity cost of capital depends on how the capital required for the project is generated. To the extent that it comes from additional savings, its opportunity cost is measured by the consumption rate of interest (which reflects the price the saver must be paid to sacrifice present consumption); to the extent that it comes from the denial of capital to alternative projects, its opportunity cost is the rate of return that would be earned from those alternative projects. This is also called the investment rate of interest. In practice, the consumption rate of interest may be used as the discount rate because in stage three of UNIDO) analysis an inputs and outputs are converted into their consumption equivalents.

There are, however, problems in determining the consumption rate of interest empirically. So the UNIDO approach recommends a 'bottom up' procedure. As per this procedure, the project analyst calculates the internal rate of return of a project and presents the project to the planners (or politicians) who are the decision makers. If the project is accepted, the analyst may assume that the planners judge the consumption rate of interest to be more than the internal rate of return. On the basis of a repetitive application of this process, the range for estimated consumption rate of interest can be sufficiently narrowed for practical use, provided, of course, the planners on the top are consistent.

Foreign Exchange The UNIDO method uses domestic currency as the nume'raire. So the foreign exchange input of the project must be identified and adjusted by an appropriate premium (as discussed below). This means that valuation of inputs and outputs that were measured in border prices has to be adjusted upward to reflect the shadow price of foreign exchange.

The premium on foreign exchange and the Shadow Exchange Rate

The official exchange rate, OER, will be equal to the true economic value placed on foreign exchange if it is able to move freely without intervention or control by the government and if there is no rationing of foreign exchange, no tariffs or non- tariff barriers on imports and no taxes or subsidies on exports. In countries where these conditions hold the market price of foreign exchange, the OER, should be a good measure of people's willingness to pay for the foreign exchange needed to buy imported inputs and the economic benefit the local economy receives from any foreign exchange earnings made by a project.

In many developing and developed countries, there are many distortions in the market for foreign exchange and traded goods. The market for foreign exchange may be strictly controlled and it may only be possible to purchase foreign exchange for permitted purposes. These controls will often be imposed because the fixed official exchange rate is overvalued, which results in the demand for foreign exchange greatly exceeding supply. A currency is overvalued if the official exchange rate understates the amount of domestic currency that residents of the country would be willing to pay for a unit of foreign currency, such as one dollar US, if they could freely spend it on duty-free goods - goods sold at their border prices. Obviously, in most countries, people would pay more for foreign currency if they could spend it freely on duty-free goods without having to travel internationally to do so. Most currencies in the world are therefore overvalued in this sense, with the exception of those of duty-free economies like Hong Kong and Singapore. Trade distortions such as import tariffs and quotas therefore result in a country's currency being overvalued.

If the official exchange rate, OER, expressed in terms of units of local currency needed to buy one unit of foreign exchange is fixed below the appropriate level it is said to be overvalued. This means that an unrealistically high value is placed on the local currency in terms of how much foreign exchange can be bought with a unit of currency.

Countries that have an overvalued exchange rate are said to place a premium on foreign exchange, or to have a foreign exchange premium. A foreign exchange premium, FEP, measures the extent to which the OER understates the true amount of local currency that residents would be willing to pay for a unit of foreign exchange, or its true opportunity cost to an economy. The FEP can be measured crudely by the ratio of the value of total trade, imports plus exports, valued in domestic prices and therefore including the effect of tariffs and other distortions, to the value of trade in border prices, minus one, as given in the equation below:

$$FEP = \left[\frac{M(1 + t) + X(1 - d + s)}{M + X} \right] - 1 \text{ X } 100 \text{ per cent}$$

where

- t are the tariffs, or tariff equivalents of non-tariff barriers, imposed on imports
- d are the export tax equivalents of any restraints and taxes imposed on exports
- s are the export subsidy equivalents of any support given to encourage exports

- M is the value of imports in border prices, (CIF)
- X is the value of exports in border prices, (FOB).

The numerator of this ratio measures the total amount in local currency that residents are actually paying to consume imports, including tariffs and taxes, plus the amount they are actually accepting for exports, excluding export taxes and including export subsidies. It therefore measures the true value put on traded goods consumed and produced by the country. The denominator of the ratio in the above equation shows the actual foreign exchange value of these traded goods when they are measured at their border prices, converted into local currency at the OER. The ratio of the domestic value to the border price value of trade therefore shows the true value placed on traded goods, relative to apparent economic value at the official exchange rate. The FEP is usually expressed as a percentage, so the ratio of value of trade in domestic prices to its value in border prices, minus one, is multiplied by 100. The FEP therefore shows the extra percentage local residents would be willing to pay for foreign exchange, above the official exchange rate, if they were able to buy currency freely and spend it on duty- free goods.

When estimating the economic prices of tradable in countries that have an overvalued exchange rate, it will not be correct to merely value traded goods (which may normally be subject to a tariff) at their border prices and then convert these values to local currency at an artificially low official exchange rate. Such a process would make them appear unrealistically cheap compared with locally produced non- traded goods. This is because the local price of non-traded goods will, over time, have adjusted upwards to equal the tariff inclusive price of traded goods, which consumers find equally attractive. Given a choice between a US dollar's worth of imported goods, valued at their tariff-free border price and converted to local currency at the official exchange rate, and a US dollar's worth of locally produced non-traded goods, valued at their domestic market price, the average consumer would prefer a dollar's worth of duty-free imported goods. The foreign exchange required to purchase these imported goods will therefore have a higher value to the local consumer than is indicated by the official exchange rate, OER. In this situation, the project analyst must correct for these distortions in the market for foreign exchange and traded goods that result in a premium being placed on foreign exchange.

Almost all projects include a mixture of traded and non-traded inputs and outputs. If no correction is made for this premium on foreign exchange in economic appraisals, projects that produce traded good outputs will yield an NPV that is undervalued, compared with those producing non-traded goods. This occurs because the traded good outputs would be valued at their fob (or cif) border prices, converted into local currency at the artificially low official exchange rate, in terms of local currency per $US. On the other hand, projects that use imported inputs will appear to have low costs when the border prices of these inputs are converted at the OER and will therefore have a NPV that is overvalued compared with projects using non-traded good inputs.

If a foreign exchange premium exists, it is therefore necessary to take account of it in all projects where both traded and non-traded goods and services are included among project inputs and outputs, or when comparing projects producing or using traded and non-traded goods and services. If both traded and non-traded commodities are used or produced in a project, they need to be valued in comparable prices before they can be added together in the net cash flow of the project. The reason for this can be seen from the following simple example. Assume that in a particular economy there are only two homogeneous consumer products produced and consumed. One is a non-traded good, housing, and the other is a traded good, automobiles. The average equilibrium price for both houses and automobiles in the domestic market is Br. 100 000. At this price, consumers are just as indifferent to purchasing more automobiles as to more housing, since both are equally valuable to them. However, automobiles are subject to a 100 per cent tariff and are sold on the international market for only $US 10 000, or Br.50 000 (converted at the OER of Br. 5 to $USl). Since automobiles are the only goods traded (imported) by this economy, from the equation above, the foreign exchange premium will be:

$$FEP = \left(1 \times 100 \text{ per cent} \right) = 100 \text{ per cent}$$

In this country, two alternative projects are being considered: one a housing construction program and the other an automobile factory. When an economic appraisal is made of the auto factory, if no account is taken of the foreign exchange premium, automobiles, which are traded goods, would be valued at their border price, Br. 50 000 per automobile. On the other hand, an economic analysis of the housing construction program would value housing, a non-traded good, at its local free market equilibrium price, Br. 100 000 per house. If the two projects had the same level of input costs per unit of output and the same project life, the housing construction program would appear to have the higher net present value. It would therefore be selected in preference to the automobile project if only one of two projects could be undertaken.

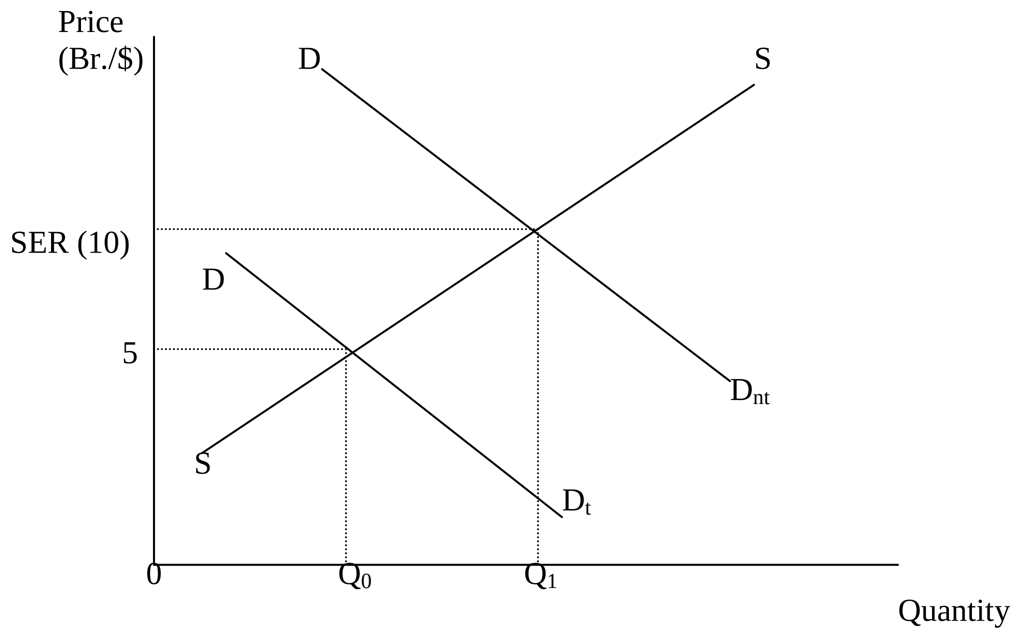

Fig. Demand and Supply of Foreign Exchange with no trade distortions

However, if the tariff were removed from automobiles and local residents could buy them for Br.50 000 each, domestic demand for cars would increase strongly. As there is only one traded good in this economy, at every exchange rate the demand for foreign exchange would rise, as can be seen from the figure above. The demand curve for foreign exchange, DD_t would move out to DD_{nt}, the tariff-free demand curve for foreign exchange and demand for foreign exchange would expand from Q_0 to Q_1. As a result, if the OER were allowed to float freely it would devalue increasing the units of local currency received for each US dollar of foreign exchange earned. This would encourage producers to export more and earn more foreign exchange, to the point where demand for and supply of foreign exchange would again be equal. In the figure above this occurs at an exchange rate of Br. 10 / $US1. At this new distortion-free equilibrium exchange rate, the border price of automobiles would rise to Br. 100 000 and their economic price would in fact equal the price of the non-traded housing.

Alternatively, if the project were designed to export automobiles, these could be sold for $US 10 000 of foreign exchange per automobile. If we continue the assumption that there is only one traded good in the economy, the foreign exchange would be used to import more automobiles for which people would be willing to pay Br. 100000. On the other hand, the project might produce automobiles that could be sold locally in competition with imported automobiles, also for Br.100 000 per automobile. The $US 10 000 of foreign exchange earned for each exported automobile from the project would actually have a value of Br.100 000 to the economy at local market prices. Thus, in this one-traded-good economy, the true value of each $US1 of foreign exchange earned would be Br. 10, not Br. 5. The results of this simple example can be used to show how the SER of the economy is calculated.

The shadow exchange rate, SER, is the foreign exchange rate that reflects the true economic value placed on foreign exchange in an economy. In an economy with no trade or foreign exchange market distortions the SER would be the equilibrium exchange rate. However, if distortions remain in the market for foreign exchange, the shadow exchange rate will be different. One way of correcting for an overvalued exchange rate in project appraisal is to use a shadow exchange rate, rather than the official exchange rate to value all foreign exchange earned and used by the project.

A simple definition of a country's SER involves addition of the percentage FEP to the OER, or more precisely, multiplication of the OER by one plus the FEP divided by 100:

$$SER = OER \times \left[\frac{FEP}{100} + \right]$$

In our example of the two-good economy, with a FEP of 100 per cent, the shadow exchange rate can be estimated by:

$$SER = \frac{Br.\ 5}{\$US1} \times \left[\quad \right]$$

$$SER = \frac{Br.\ 10}{\$US1}$$

The shadow exchange rate would therefore be $\frac{Br.\ 10}{\$US1}$

So foreign exchange in fact has twice the value indicated by the official exchange rate.

From the definition of the foreign exchange premium, the SER can also be defined as:

$$SER = OER \times \frac{\text{value of trade in domestic prices}}{\text{value of trade in border prices}}$$

$$SER = OER \times \left[\frac{M(l + t) + X(l - d + s)}{M+X} \right]$$

Where

X,M, t, d and s are as defined earlier

If the country imports 100 cars and its tariff on cars is 100 per cent, its SER will equal:

$$SER = \frac{Br.\ 5}{\$US1} \times \frac{100 \times \$10000 \times (1+1)}{100 \times 10000}$$

$$SER = \frac{Br.\ 10}{\$US1}$$

In this simple formula for measuring the SER, the OER is inflated by the ratio of the full amount people are actually willing to pay for traded goods in domestic market prices, to the value of these goods in border prices converted at the OER. The SER will always be higher than the OER, in terms of the local currency units people will pay for a unit of foreign exchange, if the value of traded goods in domestic prices, including taxes and tariffs is higher than their value in border prices (assuming export taxes do not outweigh import tariffs).

The Shadow Exchange Rate in the UNIDO Approach

In a similar fashion to the discussion presented above, the UNIDO (Guidelines) method determines the shadow price of foreign exchange on the basis of marginal social value as revealed by the consumer willingness to pay for the goods that are allowed to be imported at the margin. The shadow price of a unit of foreign exchange is equal to:

$$\sum_{i=1}^{n} Fi\ Qi\ Pi$$

Where:

Fi = Fraction of foreign exchange, at the margin, spent on importing commodity i

Qi = Quantity of commodity i that can be bought with one unit of foreign exchange (This will be equal to 1 divided by the CIF value of the good in question).

Pi = domestic market clearing price of commodity i

Example Commodities 1,2,3, and 4 are imported at the margin. The proportion of foreign exchange spent on them, the quantities that can be bought per unit of foreign exchange, and the domestic market clearing prices are as follows:

F1 = 0.3,	F2 = 0.4,	F3 = 0.2,	F4 = 0.1
Q1 = 0.6,	Q2 = 1.5,	Q3 = 0.25,	Q4 = 3.0
P1 = 16,	P2 = 8,	P3 = 40,	P4 = 5

The value of a unit of foreign exchange is:

(.3) (0.6) (16) + (0.4) (1.5) (8) + (02) (0.25) (40) + (0.1) (3.0) (5) = Br. 13.180

The calculation of the shadow price of foreign exchange in terms of consumer willingness to pay is based on the assumption that the foreign exchange requirement of a project is met from the sacrifice of others. The use of foreign exchange by a project, however, may also induce the production of foreign exchange through additional exports or import substitution. In such a case, the shadow price of foreign exchange would be based on the cost of producing foreign exchange, not consumer willingness to pay for foreign exchange.

One common misconception is that an economy's shadow exchange rate is equivalent to its black market foreign exchange rate. As only a small residual proportion of the total foreign exchange earnings of a country are traded in the black market and there are risks involved in illegal transactions, the black market rate will typically be above the undistorted equilibrium exchange rate, but may be lower than the SER if exchange controls and trade distortions stay in place. The smaller the risks involved and the greater the proportion of foreign exchange traded on the black market the closer will be the black market rate to the distortion-free equilibrium exchange of a currency.

The traditional method employed in cost benefit analysis to take account of the foreign exchange premium that was used in the 'UNlDO Guidelines' is to value all traded and non-traded goods and services in terms of domestic price equivalents. Domestic prices are used as the numeraire or common unit of account, in terms of which all project inputs and outputs are valued. For this reason, the UNIDO approach is sometimes known as the domestic price approach.

The project's traded good inputs and outputs are firstly valued in their fob and cif border prices. They are then converted from foreign currency to local currency using a shadow exchange rate, SER, rather than the official exchange rate, OER. This is done to better reflect the true economic value of foreign exchange to the economy.

In a situation where the local currency is overvalued and the foreign exchange premium is positive, the ratio of the shadow exchange rate to the official exchange rate will be greater than one (when both are expressed in terms of units of local currency per dollar of foreign exchange). Use of a shadow exchange rate to convert the border prices of traded goods into local prices will have the effect of inflating these border prices until they equal the amount that people are willing to pay, or receive, for traded goods. These inflated traded goods prices will then reflect the true value placed on traded goods vis-à-vis non-traded goods. As these traded goods will now be valued in domestic price equivalents they will be directly comparable with the project's non-traded inputs and outputs valued in domestic prices.

When using the domestic price approach, a project's non-traded inputs and outputs are simply valued in their domestic prices. As indicated earlier, adjustments should first be made to the prices of non-traded goods to ensure that they reflect the true marginal social costs and benefits of consuming and producing these goods. This will be done by including consumers' surplus, but excluding producer surplus, and deducting transfers where appropriate. No additional adjustment is made to non-traded goods prices to reflect their overvaluation in relation to traded goods, the foreign exchange premium, as this would involve double counting. Both traded and non-traded goods will then be valued in comparable, domestic price equivalents and it will therefore be possible to add them together in the project's cash flow.

The domestic price approach therefore corrects for the FEP by inflating the border price values of traded goods, using the economy's estimated SER, until these values correctly reflect the goods' relative worth compared with the domestic prices of non-traded goods.

In summary, the domestic price approach values:

Traded goods @ Border price x SER ⇓ Domestic price equivalent	Non-traded goods @ Domestic prices

Numeraire: domestic prices

Practical Examples using the UNIDO approach

(i) Imported input

Table 1 below illustrates how the economic value of a project's imported textile inputs will be measured using the UNIDO approach. It has been estimated that the country has a foreign exchange premium of 30 per cent and the shadow exchange rate is therefore (1 +0.3) x OER. All tariffs and taxes are deducted from the domestic retail price of textiles and their tradable (foreign exchange) component is inflated by the shadow exchange rate to obtain the domestic price equivalent of the cif import price. The economic cost of domestic transport and handling is then added.

Table1: Valuation of imported textile inputs using the UNIDO approach
(Millions of Br.)

	Financial Cost	Economic Cost
CIF import price (@ OER)	250	
(@ SER = 1.3 x OER)		325
Import Tariff (40 Per Cent)	100	0
Internal Transport	50	50
Handling and Distribution*	50	20
Total	450	395

Ratio of Economic Value to Financial Value = $\frac{395}{450}$ = 0.88

**60 per cent of these 'costs' represent rents earned from privileged access to foreign exchange, and are therefore not included in the economic cost of handling and distribution*

(ii) Exported output

Table 2 below gives an example of the economic valuation of a project's exported garment output, using the UNIDO approach. The country again has a foreign exchange premium of 30 per cent. The foreign exchange earnings are inflated by the shadow exchange rate and all export subsidies are deducted from the fob export price to obtain the domestic price equivalent of the border price.

Table 2: Valuation of exported garment output using the

UNIDO approach ($'000)

	Financial Cost	Economic Cost
FOB output value (@ OER)	1200	-
(@ SER = 1.3 x OER)	-	1560
Export Tax (10 Per Cent)	-120	0
Transport to port* (including 50 percent fuel tax)	-40	-30
Total	1040	1530

Ratio of Economic Value to Financial Value = $\frac{1530}{1040}$ = 1.47

*The market price of transport includes a 50 per cent fuel tax. Since fuel equals half of total transport costs its economic value = 40 - (40 x 0.5 x 0.5) = 30

(iii) Non-traded input

The domestic price approach to the valuation of a non-traded input such as electricity is shown in Table 3 below. The financia1 cost of the electricity is its domestic sales price, Br.2 million, plus Br. 300 000 sales tax. If the non-traded input's supply can be increased, its economic value will be measured by its domestic market supply price, after any adjustments have been made for market imperfections such as taxes, price fixing, subsidies or monopoly pricing. If the project uses electricity that must be bid away from existing consumers, then the electricity should be valued at the price that people are willing to pay for it, its demand price.

In the example above, electricity is a private monopoly and monopoly rents are found to represent Br. 500000 of the total Br. 2 Million supply price of electricity. If the project uses electricity that must be bid away from existing consumers, then the monopoly rents should be included when measuring its economic value, as people are willing to pay this total amount, including these rents for this electricity. Monopoly rents are only treated as a transfer and excluded if the supply of electricity can be expanded to meet the project's needs. In this case only the cost to the economy of producing additional electricity is the relevant economic cost.

Of the project's total electricity input requirements, 40 per cent will be met by displacing existing consumers, and 60 per cent will be met by expanding supply. The economic cost of this displaced consumption is the total amount that people were willing to pay for this electricity, including monopoly rents and sales tax. Approximately Br.200 000 (40 per cent of Br. 500 000) of the monopoly rents should therefore be included in the economic value of the input, but the remaining Br. 300 000 should not be included. Similarly, approximately 40 per cent of the sales tax (Br.120 000) should be included in the economic value of the input, the part that is met by displacing existing consumers, but the remaining Br. 180 000 of sales tax should not be included in the project's economic costs.

Table 3: Valuation of 1 gigawatt of electricity input using the
UNIDO approach (Br. '000)

	Financial Cost	Economic Cost
Domestic Sales price (before tax)	2000	-
Cost of new production	1200	900*
Cost of displaced consumption: Of which monopoly rents are:	800 (500)	800 (200)
Sales Tax	300	120
Total	2300	1820

$$\text{Ratio of Economic Value to Financial Value} = \frac{1820}{2300} = 0.79$$

*The economic cost of newly produced electricity; is obtained as (2000 x 0.6) - (500 x 0.6) = 1200 - 300 = 900, since that part of monopoly rents that is earned on newly produced electricity is only a transfer

(iv) Non-traded output

If instead the project is producing electricity a non-traded output, the UNIDO approach to valuing this electricity is as shown in the Table 4 below. If the entire project's output meets new demand its economic value is simply its domestic market demand-price, as long as there is no price fixing or rationing. In this case all new output represents an increment in supply. Consequently, all monopoly rents and sales taxes imposed should be included in measuring the economic benefits of the project, as this is the amount people are willing to pay for the electricity. The electricity authority does not receive the sales tax paid on electricity, so it is not a financial benefit to it.

Table 4: Valuation of 1 gigawatt of electricity output using the UNIDO approach (Br. '000)

	Financial Cost	Economic Cost
Domestic Sales price: Of which monopoly rents are:	2000 (500)	2000 (500)
Sales Tax*	0	300
Total	2000	2300

Ratio of Economic Value to Financial Value = $\frac{2300}{2000} = 1.15$

*Sales tax is included as an economic benefit because the country's government will receive the tax revenue even though the electricity authority will not

Impact on Distribution

Stages three and four of the UNIDO method are concerned with measuring the value of a project in terms of its contribution to savings and income redistribution. To facilitate such assessments, we must first measure the income gained or lost by individual groups within the society.

Groups: For income distribution analysis, the society may be divided into various groups. The UNIDO approach seeks to identify income gains and losses by the following: Project, Other private business, Government, Workers, Consumers, and External Sector There can, however be, other equally valid groupings.

Measure of Gain or Loss: The gain or loss to an individual group within the society as a result of the project is equal to the difference between the shadow price and the market price of each input or output in the case of physical resources or the difference between the price paid and the value received in the case of financial transaction.

Example1: Farmers in a certain area use 1 million units of electricity generated by a hydro-electric project. The benefit derived by them, measured in terms of the willingness to pay is equal to Br. 0.4 million. The tariff paid by them to the electricity board is Br. 0.25 million. So the impact of the project on the farmers gain of Br. 0.15 million. (0.4-0.25million)

Example2: A mining project requires 1000 laborers. These laborers are prepared to offer themselves for work at a daily wage rate of Br. 8.00. (This represents their supply price.) The wage rate paid to the laborers, however, is Br. 10 per day. So the redistribution benefit enjoyed by the group of 1000 laborers is Br. 2000 (1000 x (10 – 8) per day.

Savings impact and its value

Most of the developing countries face scarcity of capital. Hence, the governments of these countries are concerned about the impact of a project on savings and its value thereof. Stage three of the UNIOO method, concerned with this and seeks to answer the following questions: Given the income distribution impact of the project what would be its effects on savings? What is the value of such savings to the society?

Impact on Savings: The savings impact of a project is equal to:

$$\Sigma \Delta Y_i MPS_i$$

where ΔY_i = change in income of group i as a result of the project.

MPS_i = marginal propensity to save of group i

Example As a result of a project the change in income gained/lost by four groups is:

Group 1 = Br. 100000; Group 2 = Br. 500000; Group 3 = Br. –200000; and Group 4 = Br. -400000. The marginal propensity to save of these four groups is as follows:

MPS1 = 0.05; MPS2 = 0.10; MPS3 = 0.20; and MPS4 = 0.40.

The impact on savings of the project is thus given by:

100,000 X 0.05 + 500,000 X 0.10 - 2 00,000 x 020 – 400,000 x 0.40 = -<u>Br. 1 45000</u>.

Impact on Income Distribution

Many governments regard redistribution of income in favor of economically weaker sections or economically backward regions as a socially desirable objective. Due to practical difficulties in pursuing the objective of redistribution entirely through the tax, subsidy, and transfer measures of the government, investment projects are also considered as investments for income redistribution and their contribution toward this goal is considered in their evaluation. This calls for suitably weighing the net gain or loss by each group, measured earlier, to reflect the relative value of income for different groups and summing them.

Adjustment for merit and demerit goods

In same cases, the analysis has to be extended beyond stage four to reflect the difference between the economic value and social value of resources. This difference exists in the case of merit goods and demerit goods. A merit good is one for which the social value exceeds the economic value. For example, a country may place a higher social} value than economic value on production of all because it reduces dependence on foreign supplies. The concept of merit goods can be extended to include a socially desirable outcome like creation of employment. In the absence of the project, the government perhaps would be willing to pay unemployment compensation or provide more make-work jobs.

In the case of a demerit good, the social value of the good is less than its economic value. For example, a country may regard alcoholic products as having social value less than economic value.

The procedure for adjusting for the difference between social value and economic value is as follows: (i) Estimate the economic value. (ii) Calculate the adjustment factor as the difference between the ratio of social value to economic value and unity. (iii) Multiply the economic value by the adjustment factor to obtain the adjustment (iv) Add the adjustment to the net present value of the project.

To illustrate, consider a project for which the following information is available: (i) The present economic value of the output of the project is Br. 25 million. (ii) The output of the project has social value, which exceeds its economic value by 20 per cent. Given this information, the adjustment factor would be 0.2 (120 per cent/100 per cent - 1). Multiplying the present economic value by 0.2, we get an adjustment of Br. 5 million. This, then, is added to the present economic value of Br. 25 million.

Where the socially valuable output of the project does not appear as an output in the economic analysis - as is the case where the project generates employment - the procedure is somewhat different. In such a case the output is treated like an externality and its valuation in social terms is the adjustment. While the adjustment for the difference between the social value and economic value is seemingly a step in the fight direction, it is amenable to abuse. Once the analyst begins to make adjustment for social reasons, projects which are undesirable economically maybe made to appear attractive after such adjustment. Since the dividing line between 'political' and 'social' is rather nebulous, it becomes somewhat easy to push politically expedient projects, irrespective of their economic merit by investing them with social desirability. While there is no way to prevent such a manipulation, the stage-by-stage UNIDO approach mitigates its occurrence by throwing it in sharp relief.

4.3. LlTTLE and MIRRLEES APPROACH

The Little and Mirrlees approach (sometimes known as the border price approach), also values traded goods at their border prices, in the same way as the UNIDO (domestic price) approach. However, these border prices are then converted into local currency at the official exchange rate rather than at a shadow exchange rate. The project's traded good inputs and outputs are effectively kept in their border prices. However, if there is a foreign exchange premium in the country concerned the prices of non-traded goods will have risen to match the tariff inclusive prices of tradable. The price of non-tradable will therefore overstate the goods' true value to consumers, relative to the border prices of traded goods. The border price approach therefore revalues these non-traded goods in border price equivalents using commodity specific Conversion Factors[3]. These conversion factors are the ratio of the border price equivalent of each non-traded good to its domestic price. Multiplying the domestic price value of a non-traded good by its

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[3] For example the conversion for some goods in Ethiopia, as it appeared in the National Parameters for Ethiopia (1989) is given below (Note that this is old data, it is just used as an example):

Construction	0.75
Electric Power	0.85
Road transport	0.75
Water	1.00

conversion factor has the effect of converting the good's domestic price into its border price equivalent.

Both traded and non-traded goods are then valued in the same numeraire, i.e., border prices, so it will be possible to include them together in the project's cash flow. This is the reason why this method can also be called the border price approach. The Little-Mirrlees approach makes traded and non-traded goods prices comparable by precisely the inverse method to that used by the UNIDO approach, which values both traded and non-traded goods in comparable, domestic prices.

In summary this approach values:

Traded Goods	Non-Traded goods
@ Border price x OER	@ Domestic price i X Cf_i
	⇓
	Border price equivalent

Numeraire: border prices

$$CF_i = \text{conversion factor of good } i = \frac{\text{border price equivalent } i}{\text{Domestic price } i}$$

Practical Examples of the Little-Mirrless Approach

(i) **Imported input**

For purposes of comparison, we shall use similar examples to the ones used under the UNIDO approach. If the analyst decides to use the border price approach to incorporating the foreign exchange premium, a project's imported textile inputs would be valued as shown in Table 5 below. All tariffs and taxes are deducted from the domestic retail price but the foreign exchange component of the input is valued at the official exchange rate, so that it is expressed in border prices. Non-traded components such as transport and internal handling and distribution, on the other hand, are valued in border price equivalents using individual conversion factors.

Table5: Valuation of imported textile inputs using the L-M approach (Br.'000)

	Financial Cost	Economic Cost
CIF import price (@ OER)	250	250
Import Tariff (40 Per Cent)	100	0
Internal Transport*	50	40
Handling and Distribution**	50	14
Total	450	304

Ratio of Economic Value to Financial Value = $\frac{304}{450}$ = 0.68

*The conversion factor for transport, CF_t which puts the domestic price of transport into its border price, = 0.8, hence the transport's economic value = 50 x 0.8 =40

*60 per cent of this item represents rents earned from privileged access to foreign exchange. In addition, the conversion factor for handling, CF_h, = 0.7. Hence economic value = (financial value x 0.4) x CF_h = 20 x 0.7 = 14

(ii) **Exported output**

As shown in Table 6 below, to value the exported garment output of a project using the border price approach the foreign exchange component is converted into local currency using the official exchange rate and any export taxes and subsidies are treated as transfers and are deducted. Once again, non-traded components will be valued in their border price equivalents using their own conversion factors.

Table 6: Valuation of exported garment outputs using the L-M approach (Br.'000)

	Financial Cost	Economic Cost
FOB output price (@ OER)	1200	1200
Export Tax (10 Per Cent)	-120	0
Transport to Port*	-40	-24
Total	1040	1176

Ratio of Economic Value to Financial Value = $\frac{1176}{1040}$ = 1.13

*The 50 per cent fuel tax is deducted (fuel = half transport costs), and CF_t = 0.8, hence the transport's economic value = [40 - (40 x 0.5 x 0.5)] x 0.8 = 24

(iii) **Non-traded input**

The valuation of non-traded electricity inputs using the L-M approach is shown in Table 7 below. As in the example in Table3, 60 per cent of the project's electricity requirements will be met by new production and 40 per cent by displacing existing consumers. The electricity is valued at its border price equivalent by multiplying its corrected domestic prices, as calculated in Table 3, by its commodity specific demand and supply price conversion factors, CF_{dpi} and CF_{spi}. These conversion factors are the ratio of the economic price (border price equivalent) to the financial (market price) of electricity.

Table 7: Valuation of 1 gigawatt of electricity input using the L-M approach (Br.'000)

	Financial Cost	Economic Cost
Domestic Market Price: Of which monopoly rents are:	2000 (500)	
Sales Tax	300	0
Cost of new production*	1200	630
Supply Price Conversion Factor for Electricity, CF_{sp}		0.7
Sales Tax (0.6 x 300)	180	0
Cost of Displaced Consumption** (pre tax)	800	640
Demand Price Conversion Factor for electricity, CF_{dp} Of which monopoly rents are:	 (200)	0.8 (160)
Sales Tax (0.4 x 300)	120	48
Total	2300	1318

Ratio of Economic Value to Financial Value = $\frac{1318}{2300} = 0.57$

*Economic cost of new production in border prices = economic cost in domestic prices x CF_{sp} = 900 x 0.7 = 630, see notes at the bottom of Table.2 for an explanation of the derivation of the economic cost of new production and displaced consumption in domestic prices

**Economic cost of displaced consumption in border prices = economic cost in domestic prices (including sales taxes) x CF_{dp} = 800 x 0.8 = 640

(iv) **Non-traded output**

The method of valuing non-traded electricity output using the border price approach is shown in Table 8. If all of the project's electricity output meets new demand, its economic value is its domestic market demand price, including any monopoly rents and sales taxes, multiplied by the demand price conversion factor relevant to electricity output. This CF_{dp} for electricity has already been assumed to be 0.8.

Table 8: Valuation of 1 gigawatt of electricity output using the L-M approach (Br.'000)

	Financial Cost	Economic Cost
Domestic Market Price (pre tax): Of which monopoly rents are:	2000 (500)	
Sales Tax	300	
Value of new consumption (pre tax)	2000	1600
Demand Price Conversion Factor for Electricity, CF_{dp} Of which monopoly rents are:	 (500)	0.8 (400)
Sales Tax (0.8 x 300)	0	240
Total*	2000	1840

Ratio of Economic Value to Financial Value = $\frac{1840}{2000} = 0.92$

*Economic value of new electricity consumption in border prices = economic value in domestic prices (including sales taxes) x CF_{dp} = 2300 x 0.8 = 1840

CONCLUSIONS: Usage, Advantages and Disadvantages of the Two Approaches

The L-M approach is probably the more widely used of the two approaches, according to recent surveys of the practice of social cost benefit analysis. This is probably because it has been adopted by major international lending institutions like the World Bank and several of the regional development banks like the Asian Development Bank and Inter-American Development Bank. The border price approach is easier to use when analyzing projects that use mainly traded good inputs and produce traded good outputs, such as export-oriented industries. Tradable goods and services can be readily valued in border prices and converted to local currency at the official exchange rate. The main claim to superiority of the border price approach is that it may enable more precise estimates to be made of the economic value of the project by making use of individual conversion factors for non-traded goods. These show the precise impact of the project on welfare, in border prices. Because the L-M approach uses many individual conversion factors and the data requirements for estimating each conversion factor are less, the chance and consequences of making a major error may be reasonably low.

On the other hand, for projects that mainly use non-traded inputs and produce non-traded outputs, such as local infrastructure and social service projects, the UNIDO approach may be more appropriate and simpler to use. In this case these non-tradeables can be simply left in their domestic price values once corrections have been made for domestic distortions. It could be claimed that the UNIDO approach gives a less precise measure of the project's impact on economic welfare as a result of its use and production of traded goods. This is because the method uses only one parameter, the SER, to revalue traded goods in domestic price values. The SER is an average measure of the value placed on foreign exchange and consequently there are sound theoretical reasons for using it to revalue traded goods in domestic prices. However, there are empirical problems in accurately estimating a country's SER. As this parameter is so central to the UNIDO (domestic price) approach, there is scope for making substantial errors in a project appraisal if the analyst has made a mistake in the estimation of the SER. However, if a reliable estimate for the SER is available, this method may be simpler to implement, particularly if the project has many non- traded inputs and outputs.

In summary, because of the difficulty of obtaining accurate data on the ratio of domestic to border prices for all traded goods in an economy, empirical estimates of shadow exchange rates can be subject to considerable uncertainty and may not be very satisfactory. In addition, the use of a shadow exchange rate in project appraisals may be politically unacceptable to a country as it can be seen as an admission of sub-optimal trade and foreign exchange regulation policies. For these reasons, among others, the World Bank and many other international institutions prefer to use the Little and Mirrless approach to correct for the foreign exchange premium in an economic analysis. Nevertheless, both techniques are in common use and the analyst may vary the approach used depending on the nature of the project being appraised.

4.4 Cost-effectiveness

Thus far we have focused on cost-benefit analysis. This technique is appropriate for projects with benefits and costs that are measurable in monetary terms. A vast class of projects generates benefits that are not easily measurable in monetary terms. If the project measures its benefits in some non-monetary unit, the NPV criterion for deciding whether to implement it cannot be used.

In such cases, economic analysis can still be a great help in project design and selection. We use it to help select among programs that try to achieve a given result, such as choosing among several methods to improve mathematical skills. Economic analysis is also useful to select among methods that have multiple outcomes. For example, three methods might be available for raising reading speed, comprehension, and word knowledge. Each method may have a different impact on each of the three dimensions and on cost. Economic analysis enables us to compare the costs of various options with their expected benefits as a basis for making choices.

Two main techniques exist for comparing projects with benefits that are not readily measurable in monetary terms: **cost-effectiveness** and **weighted cost-effectiveness**. In all cases we measure costs as shown in the previous sections. The main difference between the approaches is in the measurement of benefits. If the benefits are measured in some single non-monetary units, such as number of vaccines delivered, the analysis is called cost-effectiveness. If the benefits consist of improvements in several dimensions, for example, morbidity and mortality, then the several dimensions of the benefits need to be weighted and reduced to a single measure. This analysis is known as weighted cost-effectiveness.

The choice of technique depends on the nature of the task, the time constraints, and the information available. We would use cost-effectiveness for projects with a single goal not measurable in monetary terms, for example, to provide education to a given number of children. When the projects or interventions aim to achieve multiple goals not measurable in monetary terms, we use weighted cost-effectiveness; for example, several interventions may exist that simultaneously increase reading speed, comprehension, and vocabulary, but that are not equally effective in achieving each of the goals. A comparison of methods to achieve these aims requires reducing the three goals to a single measure, for which we need some weighting scheme.

All evaluation techniques share some common steps. The analyst must identify the problem, consider the alternatives, select the appropriate type of analysis, and decide on the most appropriate course of action. This topic provides the tools for identifying the costs and benefits and assessing whether the benefits are worth the costs.

4.4.1: Cost-effectiveness Analysis

Cost effectiveness analysis is a technique closely related to cost benefit analysis .it differs in that it asks a different question, namely given a particular objective, which is the least cost way of achieving it? It aids choice between options but cannot answer the question whether or not any of the options are worth doing. It is utilized when there are difficulties in associating monetary values with the outcomes of projects but where the outcomes can be quantified along some non-monetary dimension.

In cost-effectiveness analysis, we measure the benefits in non-monetary units, such as test scores, number of students enrolled, or number of children immunized. As an example, suppose we want to evaluate the cost effectiveness of four options to raise mathematics skills (Levien 1983):

- Small remedial groups with a special instructor
- A self-instructional program supported with specially designed materials
- Computer-assisted instruction
- A program involving peer tutoring

We first estimate the effect of each intervention on mathematics skills as measured by, say, test scores, while controlling for initial levels of learning and personal characteristics. Suppose we find that students taught in small groups attain scores of 20 points, those undergoing the self-instructional program score 4 points, those with computer-assisted instruction score 15 points, and those in the peer-tutored group score 10 points (table 9). These results show that small group instruction is the most effective intervention.

Now consider cost-effectiveness. Suppose that the cost per student is US$300 for small group instruction, US$100 for the self-instructional program, US$150 for computer-assisted instruction, and US$50 for peer tutoring. The most cost-effective intervention turns out to be peer tutoring; it attains one-half the gain of small group instruction at only one-sixth the cost for a cost-effectiveness ration of only 5 (see table 9). Cost-effectiveness analysis can also be used to compare the efficiency of investment in different school inputs.

Table 9 Hypothetical cost-effectiveness ratios for interventions to improve mathematics skills

Intervention	**Size of effect on test scores**	**Cost per student (US$)**	**Cost effectiveness ratio**
Small group instruction	20	300	15
Self-instructional materials	4	100	25
Computer-assisted instruction	15	150	10
Peer tutoring	10	50	5

Source: Levin (1983)

Cost-effectiveness ratios must always be used with caution. In the above example, peer tutoring is the most cost-effective intervention. If we have several cost-effectiveness (CE) ratios and either the numerator or the denominator have exactly the same value in all cases, CE ratio can be used safely for decision-making. CE ratios would be safe to use if the benefits had differed, but the cost per student had been the same for each intervention. If, however, both the measure of benefits – test scores in this case – and the costs per student vary among interventions, the analyst should use CE ratios with caution. In the example above computer assisted instruction produces a gain of five points over peer tutoring at an additional cost of US$100, or US$20 per point. To choose peer tutoring over computer-assisted instruction solely on the basis of CE ratios would be tantamount to saying that the marginal gain in test scores is not worth the marginal expense. When using CE ratios, we advise analysts to ask the following three questions:

- Can I increase the intensity of an intervention and improve the results?
- Can I combine interventions and improve the results?
- Is the intervention's marginal gain worth the extra cost?

Cost-effectiveness in health

We can use cost-effectiveness in evaluating interventions that aim to improve the health of a population. Suppose that we want to design a program of immunization that would provide the maximum improvement in health for allocated program funds. The package could include only DPT (a combination of diphtheria, pertussis, and tetanus vaccines) for the child and T (tetanus toxoid) for the mother, or it could also include BCG (Bacille Calmette Guerin, used to prevent tuberculosis) for the child. We would want to examine the economic advisability of adopting a DPTT program, a BCG program, or a combined DPTT plus BCG program rather than continuing with the existing low level of immunization and treatment of morbidity for diphtheria, petrtussis, and tetanus. Having mounted a DPTT program, suppose we want to examine the advisability of adding a BCG program and vice versa.

Table 10 summarizes the incremental costs and benefits of adding an expanded program of immunization to the existing program of health services. We measure the benefits of the project in terms of the deaths prevented, as calculated from a simple epidemiological model. We base this model on the number of immunizations, the efficacy of the vaccines, and the incidence and case fatality rates of the diseases involved. The most effective alternative is a complete immunization program. A DPT only immunization program, however, is just as cost-effective. If the budget constraint were US$115 million, the most cost-effective feasible alternative would be a program of DPT immunization.

This example starkly illustrates the limitations of CE ratios. In line 1, DPT only is just as effective as line 3, a total immunization program. The cost per life saved for either program is about US$480. Adding BCG to an existing program of DPTT, however, saves an additional 29,500 lives at a cost of US$14 million, or US$475 dollars per life. Forgoing adding the BCG program to DPT on the grounds of CE ratios alone would be tantamount to saying that each additional life saved is not worth US$475.

Table 10 Cost-benefit comparison of immunization alternatives

Alternative	**Benefits (death prevented)**	**Costs (US$ millions)**	**Cost-benefit ratio**
DPTT only	231,900	111	478.7
BCG only	29,500	61	2,067.8
DPTT+BCG	261,400	125	478.1
Existing BCG,DPTT added	231,900	64	276.0
Existing DPTT,BCG added	29,500	14	474.6

Source: Authors

Assessing Unit Costs

We use unit costs for comparing the intervention's efficacy within and across countries. In education, for example, analysts often wish to know the average cost per student of a particular intervention. Calculating the unit costs of a mature intervention that has reached a steady state is the simplest of problems, as all the capital costs have already been incurred. The recurrent costs and the number of students enrolled are fairly stable.

Assessing unit costs for a new intervention is more difficult. Capital costs are typically higher in the initial years, and enrollment and graduates are typically higher once the project is working at full capacity. Thus, comparing costs and benefits that occur at different points in time is necessary. The tools of economic analysis are helpful in these instances as well. Given the cost and benefit profile of the project, the analysis can discount the benefit and costs flows and compare them at a single point in time.

Consider Higher and Technical Education Project. One of the purposes of this project was to increase the number of graduates coming out of the University of the country and the three polytechnic schools. The investment costs, which would be distributed over five years, amounted to Birr 343 million (present value discounted at 12 percent). The recurrent costs would be proportional to the number of students and would rise from about Birr 4 million in the initial year to about birr 21 million once full capacity had been reached. The discounted value of the recurrent costs over the life of the project was assessed at Birr 143 million. Enrollment, on the other hand, would rise slowly from 161 students in the initial years, to about 3700 at full capacity. To assess the cost per student, the number of students enrolled through out the life of the project was discounted at 12 percent. The discounted number of students was calculated at 13,575 students and the cost per enrolled student at US$2048 at the then prevailing market exchange rate. Similar calculations show the cost per graduate at about US$8700.

Analysts could use the same methodology to assess the unit costs of interventions in health or in any project where the output is not easily measured in monetary terms. For the moment, suffice it to say that by using this procedure, analysts are discounting the project's benefits. The number of students enrolled is a proxy for these benefits. In this sense, the procedure is, in principle, the same as for projects with benefits measurable in monetary terms.

4.4.2 Weighted ***Cost-Effectiveness***

Sometimes project evaluation requires joint consideration of multiple outcomes, for example, test scores in two subjects, and perhaps also their distribution across population groups. In such situations, the analyst must first assess the importance of each outcome with respect to single goal, usually a subjective judgment derived from one or many sources, including expert opinion, policymakers' preferences, and community views. These subjective judgments are then translated into weights. Once the weights are estimated, the next step is to multiply each of the outcomes by the weights to obtain a single composite measure. The final step is to divide the composite measure by the cost of the options being considered. The results are called weighted cost-effectiveness ratios.

Application in Education

Suppose that employing better-qualified teachers raises mathematics scores more than language scores. To evaluate the two options for improving student learning, the analyst must compare the effect of each option on mathematics and language performance. The analyst could apply equal weights to the gains in test scores, but if mathematics is judged to be more important than language, policy makers may prefer to weight scores differently to reflect the relative importance of the two subjects.

Owing to the many dimensions of learning, the need for weighting may arise even when only one subject is involved. Consider the data in table 11 which show the effects of two improvement strategies for three dimensions of reading skills, as well as the weights assigned by experts to these skills on a scale of 0-10 points. Assigning the weights is the trickiest part of the exercise; the rest of the calculation is mechanical. Dividing the weighted scores by the cost of the corresponding intervention gives the weighted cost-effectiveness ratio for comparing the interventions. At a cost of US$95 per pupil for intervention A and US$105 per pupil for intervention B, the option with the more favorable ratio is the latter.

Table 11 Weighting the outcomes of two interventions to improve reading skills

Category	**Weights assigned by expert opinion**	**Intervention A[a]**	**Intervention B[b]**
Reading speed	7	75	60
Reading comprehension	9	40	65
Word knowledge	6	55	65
Weighted test score [b]	n.a	1215	1395
Cost per pupil	n.a	95	105
Weighted cost-effectiveness ratio	n.a	12.8	13.3

n.a. Not applicable

a. the scores on each dimension of outcome are measured as percentile ranking

b. The weighted score is calculated by multiplying the score for reading speed, reading comprehension, and word knowledge by the corresponding weight and summing up the result. The weighted score of 1215 for intervention A equals (7x75+9x40+6x55).

Source: Adapted from Levin (1983)

Note that this procedure becomes meaningful only when the analyst scores outcomes on a comparable scale. We could not compare, say, reading speed in words per minute with reading comprehension in percentage of material understood. The reason is that the composite score would then depend on the scale used to measure the individual scores. The metric used must be the same for all dimensions being compared. One procedure is to express all the scores in terms of percentile rank, as in the earlier example. Applying the appropriate weights to the scores then provides the desired composite score.

Application in health

Weighted cost-effectiveness is also useful for assessing health projects. Going back to the immunization example considered before, the immunization interventions reduce morbidity as well as mortality. A given intervention might have different impacts on the reduction of these two indicators. To choose among several interventions would require weighting morbidity and mortality to produce a single measure of benefits. It has become increasingly common to measure and aggregate reduction in morbidity and premature mortality in terms of years of life gained.

Table 12 Benefits from interventions: years of life gained from immunization program

Category	Mortality	Morbidity	Total	Gain from DPT only	Gain from BCG only
Benefits (years)	56,000	16,992,000	17,048,00	15,127,000	1,921,000
Costs (US$ millions)	n.a	n.a	125	111	61
Cost-effectiveness ratios	n.a	n.a	7.3	7.3	31.8

n.a Not applicable

Source: Levin (1983)

Table 12 shows the costs and benefits of three interventions with the benefits calculated in terms of health years of life gained, which are calculated as the sum of the difference between the expected duration of life with and without the intervention plus the expected number of years of morbidity avoided as a result of the intervention. The analyst calculates the years of life gained from reductions in mortality and morbidity by using the same epidemiological model previously applied to calculate deaths prevented by adding the computation of cases, information on the average duration of morbidity, and years of life lost based on a life table.

Comparing option with subjective outcomes

Sometimes no quantitative data exist that relate interventions to outcomes. Suppose that we want to assess two options to improve performance in mathematical and reading, but have no data on test scores. The evaluator could first ask experts to assess the probability that test scores in the two subjects will rise by a given amount, say by one grade level, under the interventions being considered, and then weighting these probabilities according to the benefit of improving test scores in the two subjects. To elaborate, suppose informed experts judge the probability of raising mathematics scores to be 0.5 with strategy A and 0.3 with strategy B. Experts also judge the probability of raising reading scores to be 0.5 with strategy A and 0.8 with strategy B. The information is insufficient to choose between the strategies, however, because neither dominates for both subjects.

The weighted cost-effectiveness approach overcomes this difficulty by asking policymakers or other relevant audiences to assign weights to the gain in test scores. Suppose they assign a weight of 9 on a scale from 0-10 to a gain of one grade level in mathematics and a weight of 6 to gain of one grade level in reading. The score for strategy A would then be 7.5 (0.5x6+0.5x9), and the score of strategy B would be 9.0 (0.3x6+0.8x9). If strategy A costs US$375 and strategy A costs US$375 and strategy B costs US$400, then the cost-effectiveness ratio would be US$50 for strategy A and US$44 for strategy B. In this case, B could be the preferred strategy, because it is the most cost effective and generates the highest benefits.

Some important caveats

When quantitative data on the relationship between project interventions and their outcomes are available, and when only a single dimension of outcomes matters, cost-effectiveness analysis offers a systematic tool for comparison. The method does not incorporate subjective judgments. When such judgments enter into measuring project outcomes, the method is called weighted cost effectiveness analysis. The main advantage of weighted cost-effectiveness analysis is that we use it to compare a wide range of project alternatives without requiring actual data.

The reliance on subjective data gives rise to important shortcomings in weighted cost-effectiveness analysis. These shortcomings related to two questions: Who should rank the benefits of the options being considered? How should the ranking of each person or group be combined to obtain an overall ranking?

Choosing the right respondents is critical. An obvious group to consult comprises people who will be affected by the interventions. However, other relevant groups include experts with specific knowledge about the interventions and government officials responsible for implementing the options and managing the public resources involved. Given that the choice of respondents is itself a subjective decision, different evaluators working on the same problem almost invariably arrive at different conclusion using weighted cost-effectiveness analysis. The method also does not produce consistent comparisons from project to project.

Analysts must be careful when consolidating individual rankings. Preference scales indicate ordinal, rather than cardinal, interpretations. One outcome may assign a score of eight as superior to one assigned a score of four, but this does not necessarily mean that the first outcome is twice as preferable. Another problem is that the same score may not mean the same thing to different individuals. Finally, there is the problem of combining the individual scores. Simple summation may be appealing, but as pointed out in a seminal paper on social choice, the procedure would not be appropriate if there were interactions among the individuals so that their scores should really be combined in some other way (Arrow 1963). Because of the problems associated with interpreting subjective weights in project evaluation, weighted cost-effectiveness analysis should be used with extreme caution, and the weights be made explicit.

4.5. **Sensitivity Analysis**

Sensitivity analysis is undertaken to help identify the key variables that can influence the project cost and benefit streams. It involves recalculating the project results for different values of major variables where they are varied one at a time. Combinations of changes in values can also be investigated. Sensitivity analysis involves four steps:

- selecting those variables to which the project decision may be sensitive;
- determining the extent to which the value of such variables may differ from the base case;
- Calculating the effect of different values on the project results by recalculating The project NPV and EIRR; and
- interpreting the results and designing mitigating actions.

Project statements are made up from underlying project data and assumptions. For example, vehicle operating cost savings are made up from traffic projections for different proportions of vehicle type, their division into without project and generated traffic, data on road quality and maintenance operations, and data on the vehicles and their operating costs. Sensitivity analysis of the project benefits for a road improvement project should be based on changes in such underlying variables rather than the aggregate benefit measure. Focusing on underlying rather than aggregate variables facilitates the design of actions to mitigate against uncertainty.

Some of the variables entering into the project cost and benefit streams will be predictable and small in value compared with total costs and benefits. It is not necessary to investigate the sensitivity of the project to such variables. Other variables may be larger and less predictable. Post evaluation studies and previous project experience may indicate both the type of variable that is uncertain and the likely extent of divergence from the base case value. There are some types of variable in every project that are likely to affect the project result and may be key variables for the project.

The quantities of inputs required to produce the expected quantity of outputs will be given in the corresponding technical feasibility study. However this is often subject to considerable uncertainty. Inadequate supplies or maintenance can change the ratio between inputs and outputs and reduce project outputs. In addition, the quantity of output produced for a given set of input supplies will depend upon the incentives created for producers. Changes in management, improved skills, and financial returns to the producer will all influence the output produced from the available inputs. Consideration should be given to both the technical and institutional characteristics of the project as a guide to sensitivity analysis.

Quantities of outputs and inputs can also be affected by changes in technical or market conditions. Quantities should be broken down into their underlying components for example, agricultural outputs into areas and yields, or vehicle cost savings by type of vehicle, or construction costs into unit costs and quantities and the sensitivity of the project to each of the components considered. Output quantities will also depend upon demand forecasts and market analyses. The underlying assumptions of these forecasts and analyses should be subject to sensitivity analysis.

Changes in the major values in the project statements the main outputs, inputs, and investment costs may occur because of changes in prices for any of these items. Changes can occur in the market prices or shadow prices used in calculating costs and benefits directly or used in the estimation of opportunity costs. Commodity prices for major outputs and inputs can fluctuate considerably from year to year. The influence of the average annual forecast prices on the project worth should be tested by varying the forecasts, which should take into account the effect of possible changes in the quality of outputs over time on prices. The prices of labor and nontraded goods can also be subject to change although these might not have the same degree of impact on the project worth.

10. The timing and coordination of project activities may differ from the base case. The timing of investment costs that occur early in the project life can affect the measure of project worth considerably. Alternative timings incorporating pessimistic assumptions

about construction delays should be assessed. Different investments components need to be coordinated, for example, dam completion and resettlement in irrigation projects. The possible costs of delay in one investment component on the others should be investigated through alternative timing assumptions.

Project results can be seriously affected by the extent to which the investment assets are utilized. Lower utilization rates than in the base case will be reflected in lower output levels and lower operational costs, but without any decline in investment costs. Utilization is commonly expressed as a percentage of feasible capacity use. The effects of a reduction in the rate of utilization should be investigated through adjustments to both benefit and cost streams, where possible distinguishing between fixed and variable costs.

Economic analyses of projects involve the estimation of opportunity costs for the outputs and inputs. In most calculations economic costs and benefits are calculated by using the ratio of the shadow price of a project item, or the resources that go into it, to its market price. The effect of the estimated ratios on the project worth should be investigated through sensitivity analysis. Except for the most labor-intensive projects, it is rare that a project result would be significantly affected by a variation of the shadow wage rate for surplus labor; and for most projects, variation in the shadow wage rate for scarce labor is also unlikely to be significant. More significant will be the value assumed for the shadow exchange rate (SER) and therefore the shadow exchange rate factor (SERF), or the standard conversion factor (SCF), whichever numeraire is being used in the economic analysis. Alternative estimates of the SERF will affect both benefits and costs in the sensitivity analysis. Most simple estimates of the SERF (SCF) take account only of the tax and subsidy system and not of other factors separating financial and economic prices, such as monopoly rents; it is pertinent to include in the sensitivity analysis a higher value for the SERF (lower value for the SCF).

REVIEW QUESTIONS ON CHAPTER 4

1. Take locally assembled tractors. You may be told that the market price of Birr 65,000 includes a 30 percent local component (in other words, 30 percent of the market price represents domestic value added) and that 70 percent of the market price represents the imported component, which includes a 15 percent tariff. Thus, the local component will amount to Birr 19,500 (65,000 x 0.3 = 19,500), and the imported component including the tariff will amount to Birr 45,500 (65,000 x 0.7 = 45,500). The domestic value added will most likely arise from sources such as wages paid domestic skilled labor and domestically manufactured items that use mainly domestic raw materials. If so, we probably can accept the market price as a good indicator-of the opportunity cost to the economy of these items.

a) Determine the economic value of the imported component of the tractor; if the OER is Birr 10:$1 and the foreign exchange premium is 20 percent.
b) Calculate the total economic value of the tractor.
c) Obtain the economic value of the domestic component of the tractor. using conversion factor

2. Assume In the financial accounts, the cif Price of combine harvester (traded item) US$45,000 was converted to its domestic currency equivalent at the official exchange rate of Birr lO = US$1,and the foreign exchange premium on the imported combine was 20 percent to which we would add, say, a 10 percent duty, birr 1,500 in domestic handling and marketing charges, and Birr 2,250 in internal transport costs to the project site. To simplify matters, assume that all costs of moving the combine to the project site reflect only nontraded

a) Calculate the economic value of the harvester at the farm using the UNIDO APPROACH
b) Calculate the economic value of the harvester at the farm using the domestic price system
c) Calculate SER and the conversion factor

3. A cotton plantation project hires a rural ***Par Skill*** labor with annual wage rate of Birr 12,000 permanently. However rural labor has three labor division times. Productivity time of 120days engaged in sowing and harvesting activity of commercials crop with daily reward of Birr 25 with conversion factor of 1.25. The remaining rural labor time is also classified as production for domestic consumption in 95 days at Birr 10 per day and **off farming activities** Birr 20 for the rest days of the year. The conversion factor for domestic consumption and off farming activity is 0.5 and 1 respectively. Based on this information

    a) Calculate the shadow wage rate of the labor.
    b) Find CFi and give the economical interpretation of your finding
    c) Why the conversion factor for commercial crop is higher than domestic consumption.

4. Compare and contrast United Nation Industrial Development Organization (UNIDO) Approach and Little and Milrres (LM) approaches in calculating economic costs and benefits of projects.

5. Why world prices will differ from the domestic prices used in the financial analysis of projects? Describe the adjustments made to remove the difference.

6. Briefly discuss the procedure for estimating the economic value of nontraded outputs and inputs
7. Briefly discuss the procedure for estimating the economic value of traded outputs and inputs
8. Discuss briefly the **project components** of a newly designed Textile Plant.
9. Distinguish between cost effectiveness and weighted cost effectiveness ratios

10. Identify any education or health problem in your community and develop alternative programs/projects that can reduce the extent of the problem using the cost effectiveness analysis and select the most cost effective program.

11. A public health department of regional state of Tigray is considering 5 alternative programs to encourage parents to have their pre school children vaccinated against a communicable disease. The following table shows the cost and number of vaccinations predicted for each program.

Program	Cost in Birr	Number of vaccinations
A	20,000.00	2000.00
B	44,000.00	4000.00
C	72,000.00	6000.00
D	112,000.00	8000.00
E	150,000.00	10,000.00

a) Ignoring issues of scale which program is most cost effective?

b) Assuming that the public health department wishes to vaccinate at least 5000.00 children, which program is most cost effective?

c) If the health department believes that each vaccination provides social benefits equal to $20, then which program should it adopt?

12. Two alternative mosquito control programs have been proposed to reduce the health risks of western zone diseases in a state over the next five years. The costs and effectiveness of each program in each of the next five years are provided in the following table.

Year	Alternative A		Alternative B	
	QALY's saved	**Incremental cost (millions)**	**QALY's saved**	**Incremental cost (millions)**
Year 1	1.0	3.8	0.5	1.0
Year 2	0.5	0.0	0.5	1.0
Year 3	0.3	0.0	0.5	1.0
Year 4	0.1	0.0	0.5	1.0

a) Calculate cost effectiveness (CE) ration for each program

b) Calculate CE ratios discounting cost but not effectiveness assuming a discount rate of 4%

c) Calculate CE ratios discounting both costs and effectiveness at 4%

d) Assume that the uncertainty range for each of the yearly effectiveness estimates is plus or 10%. Assuming uniform distributions of errors, produce Monte Carlo distributions of CE ratios for each program and compare them.

CHAPTER 5

5.1 INTRODUCTION

It will be recalled that a project is an assemblage of people, financial resources and material facilities mobilized and organized for the purpose of attaining a well defined objective

The implementation of a project requires from the person in charge the display of managerial capacities in the widest sense of the term, in order to forecast, organize, direct and control the various operation. More specifically, an efficient planning system is an indispensable tool for the management of the project.

Project management/implementation is the project cycle, specifically evolved to coordinate and control the numerous activities of a project having complex *interrelationships. The execution of a modern project, most of the times, is a race against time. The efficient utilization of resources and meeting the target dates had become highly complicated and involved and has necessitated the application of scientific techniques of planning, scheduling and control**.***

Once a project is selected, the focus shifts to its implementation. This involves the completion of numerous activities (project components) by employing various resources-men, materials, machine, money, and time-so that a project on paper is translated into concrete reality. .

The activities of a project have inter-relationships arising from physical, technical, and other considerations. For proper planning, scheduling, and control of the activities of a project, given their inter-relationships and constraints on the availability of resources, network techniques have been found quite useful.

Network Techniques for Project Management

There are two basic network techniques: PERT and CPM. PERT, a short form for Program Evaluation Review Technique, was Designed to handle risk and uncertainty, PERT is eminently suitable for research and development programmes, aerospace projects, and other projects involving new technology. In such projects the time required for completing various jobs or activities can be highly variable. Hence the orientation of PERT is 'probabilistic'.

CPM, a short form for *Critical Path Method*, is similar to PERT, is one of the several related techniques for doing project planning. CPM is for projects that are made up of a number of individual "activities" .If some of the activities require other activities to finish before they can start, and then the project becomes a complex web of activities. It was developed to solve scheduling problems in industrial settings. CPM, primarily concerned with the trade-off between cost and time. It has been applied mostly to projects that employ a fairly stable technology and are relatively risk free. Hence its orientation is deterministic.

Widely diverse projects are open to analysis by PERT and CPM. Here is an illustrative list.

- ✓ Research and development programme
- ✓ Construction of a plant
- ✓ Building a river valley project
- ✓ Overhaul of an organization
- ✓ Training of manpower
- ✓ Starting a new venture
- ✓ Adult literacy programme

The common characteristics of the above projects that make them amenable to analysis by PERT or CPM are:

1. The project can be broken down into a well-defined set of jobs or activities.
2. The activities must be performed in a certain sequence, which is technologically ordered.
3. Within a defined sequence, the activities may be started and stopped in an independent manner.

This chapter discusses the basics of PERT, CPM.. It is organized into five sections.

- ✓ Development of project network
- ✓ Time estimation
- ✓ Determination of critical path
- ✓ Scheduling when resources are limited
- ✓ PERT model

5.1 DEVELOPMENT OF PROJECT NETWORK

The first step in network analysis is to draw network diagram, or network, showing the work, which must be completed to achieve the project objectives, and the logical interdependencies between the work activities.

Basic to PERT as well as CPM is the network diagram. The network diagram, also referred to as the project graph, shows the activities and events of the project and their logical relationships. A simplified network diagram for a dinner project is shown in

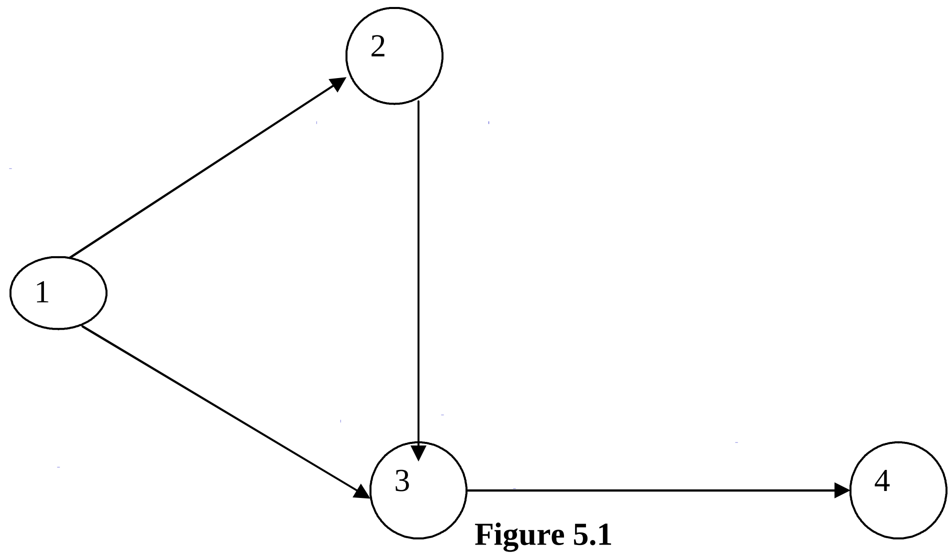


Figure 5.1

The network diagram is constructed in terms of activities and events. An activity is a specific task, job, or function to be performed in a project. For example, 'prepare dinner' (Figure 5.1) is an activity. An **activity** is represented by an arrow. The head of the arrow marks the completion of the activity and the tail of the arrow marks it’s beginning. (The length and 'compass' direction of the arrow have no significance).

An **event** is a specific point in time indicating the beginning or end of one or more activities. It represents a milestone and does not consume time or resources. For example, event 2 in Figure 5.1 marks completion of the activity 'send invitation.'

Since activities are the basic building blocks of a network diagram, it is necessary to figure out all the individual activities of the project. For this purpose, it is helpful to break the project in several steps. The number of steps, of course, would depend on the magnitude and complexity of the project. For industrial projects generally a two-step procedure would suffice. In the first step, the major parts of the project are identified and in the second step the activities of each major part are delineated. Activities should be so defined that they are distinct, reasonably homogeneous tasks for which time and resource requirement can be estimated.

Once the activities are enumerated it is necessary to define for each activity, the activities that precede it, the activities that follow it, and the activities that can take place along with. Given this information, the network diagram, showing the logical relationship between activities and events may be developed following either the forward method or the backward method.

The forward method begins with the initial event, marking the beginning of the project, and proceeds forward till the end event is reached. The backward method begins with the end event and works backwards till the beginning event is reached.

Rules for Network Construction

The rules to be observed in constructing the network diagram are discussed below:

1. Each activity must have a preceding and a succeeding event. An activity is numerically denoted by the pair of preceding and succeeding events. In the dinner project, for example, the activity 'send invitations' is designated as (1-2)
2. Each event should have a distinct number. The number given to an event can be chosen in any way, provided this condition is satisfied. In practice, however, normally events are so numbered that the number at the head of the arrow is greater than that at its tail.

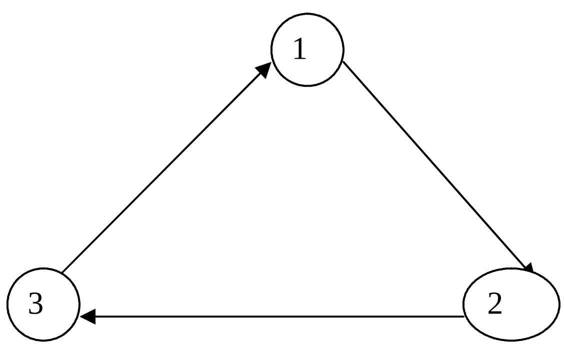
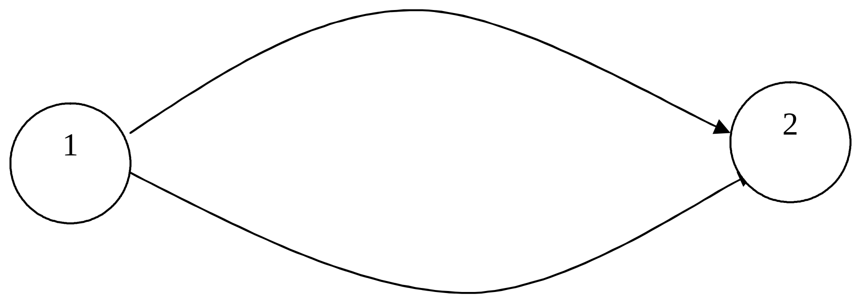


Figure 5.2

3. There should be no loops in the project network. A situation like the one shown in Figure 5.2 is unacceptable.
4. Not more than one activity can have the same preceding and succeeding event. This means that each activity is represented by a uniquely numbered arrow and a situation like the one shown in Figure 5.3 is not permissible.

Figure 5.3



To ensure that each activity is uniquely numbered it may be necessary sometimes to introduce dummy activities. **A dummy activity** is an imaginary activity which can be accomplished in zero time and which does not consume resources. It is represented by a dashed arrow. Figure 5.4 shows an alternative to Figure 5.3 with a dummy activity (3-2) introduced to conform to the rules of network construction.

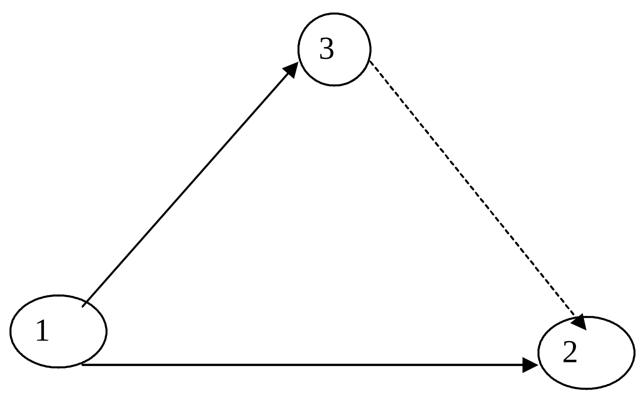


Figure 5.4

A dummy activity may also be used to represent a constraint necessary to show the proper relationship between activities. Figure 5.5 shows part of a network diagram having a dummy activity.

In Figure 5.5, X, represented as (7-6), is a dummy activity showing a certain logical relationship. According to this figure, activities *A* (4-6) and B (5-7) must be completed before activity C (6-8) can start.

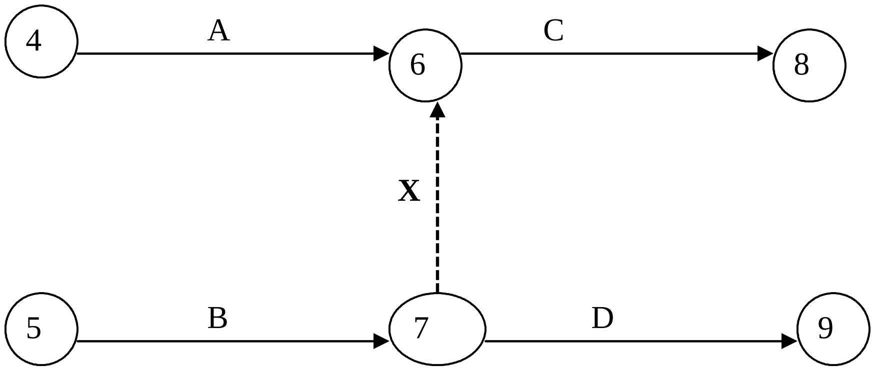


Figure 5.5

Illustration

A building project consists of the following activities:

A = Lay foundation	F = Plaster walls
B = Erect framework	G = Install siding
C = Install millwork	H = Decorate the interior
D = Install wiring	I = Finish the exterior
E = Install plumbing	

The interrelationship among these activities is as follows:

1. A should precede B.
2. B should precede C, D, E, F, and G.
3. C, D, E, and F should precede H.
4. G should precede I.

Given the above interrelationship the network diagram for the project is developed, in several steps, using the forward method, as shown in Figure 5.6.

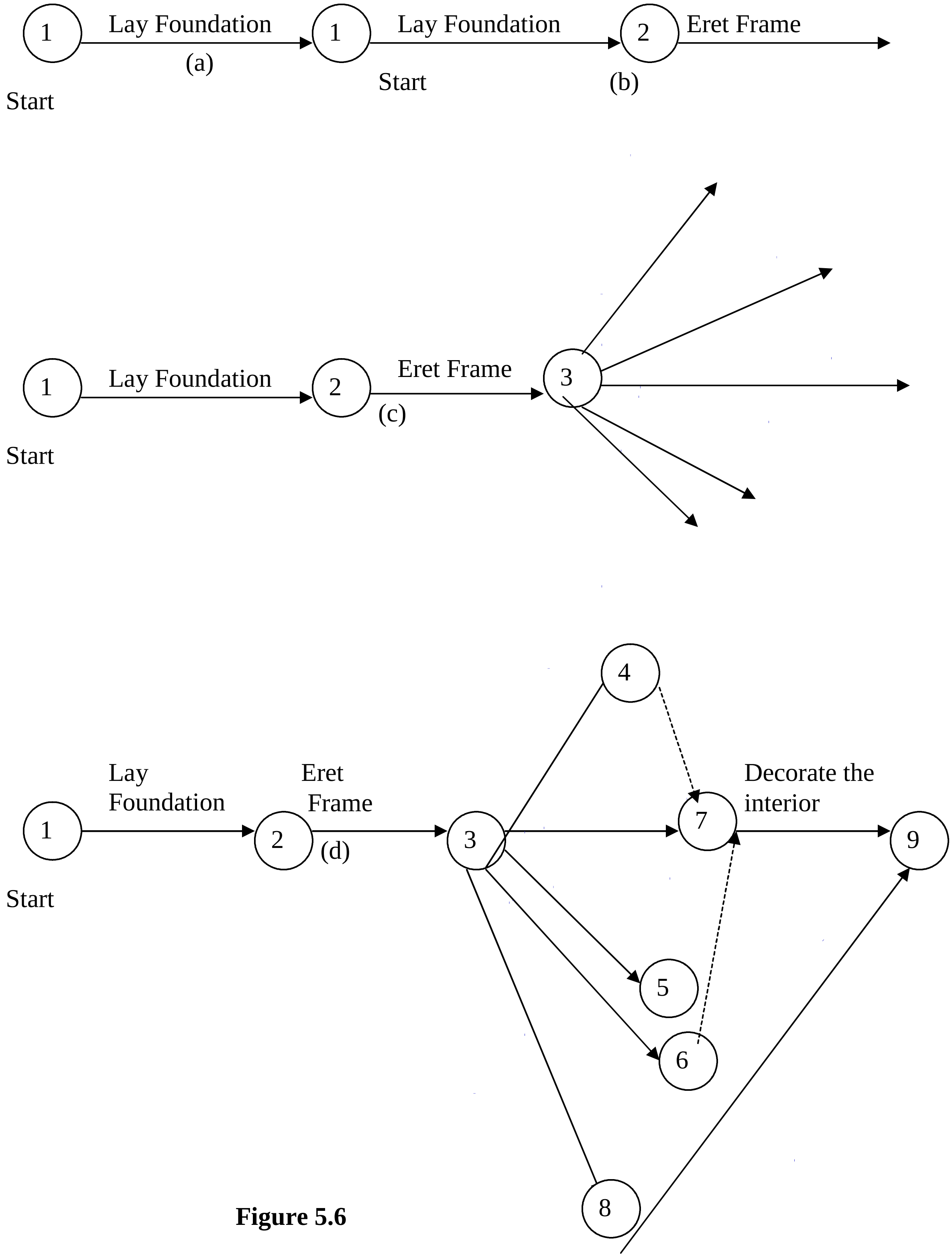

1
Lay Foundation
(a)
Start
1
Lay Foundation
Start
2
Eret Frame
(b)
1
Lay Foundation
Start
2
Eret Frame
(c)
3
1
Lay
Foundation
Start
2
Eret
Frame
(d)
3
4
7
Decorate the
interior
9
5
6
8

Figure 5.6

5.2 TIME ESTIMATION

Once the logic and detail of the network have been established, time estimates must be assigned to each activity. Generally, three time values are obtained for each activity:

1. Optimistic time *(t_o)*
2. Most likely time *(t_m)*
5. Pessimistic time *(t_p)*

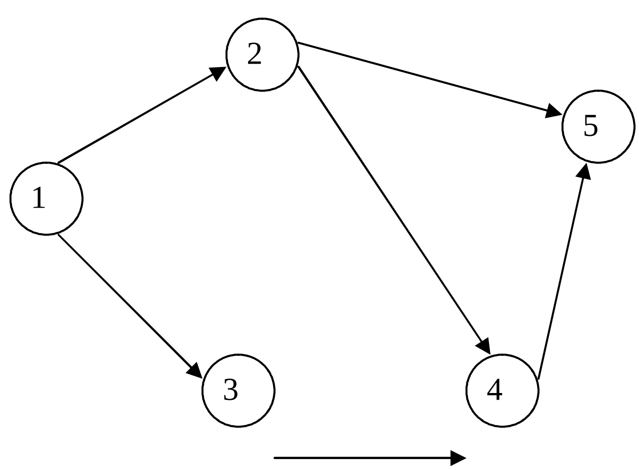
The optimistic time, t_o, is the time required if no hurdles or complications arise. The most likely time, t_m, is the time in which the activity is most likely to be completed. This estimate takes into consideration normal circumstances, making allowance for some unforeseen delays. The pessimistic time, t_p, is the time required if unusual complications and/ or unforeseen difficulties arise.

For discussing other aspects of PERT analysis a simple project shown in Figure 5.7 shall be used.

5.3 Obtaining Time Estimates

Time estimates should be obtained by the PERT planner from persons who are responsible for estimation. The following points should be borne in mind while obtaining time estimates.

Figure 5.7



1. Time estimates should be obtained by skipping around the network rather than by following a specific path. If estimates are obtained by following one path, there is a

tendency for the person providing the estimates to add them mentally and compare them with a previously conceived notion of the time of the total path.

2. The estimates of *to*, *tm*, and t_p should be defined independently of each other.
3. The time available for completing the project should not influence the estimates of *to*, *tm*, and t_p.
4. It should be made known that *to*, *tm*, and t_p are estimates and not schedule commitments.
5. The estimates of *to*, *tm*, and t_p should include allowances for occurrences which are generally considered as random variables (weather conditions, administrative delays, etc.) but not for occurrences that are normally not considered as random variables (flood, wars, etc.)

5.4 Average Time

Once the three time estimates for each activity are obtained, the expected value of activity durations is calculated. The expected value, t_e, is usually obtained by the formula:

te = (5.1)

te = weighted arithmetic average time

to = optimistic time

tm = most likely time

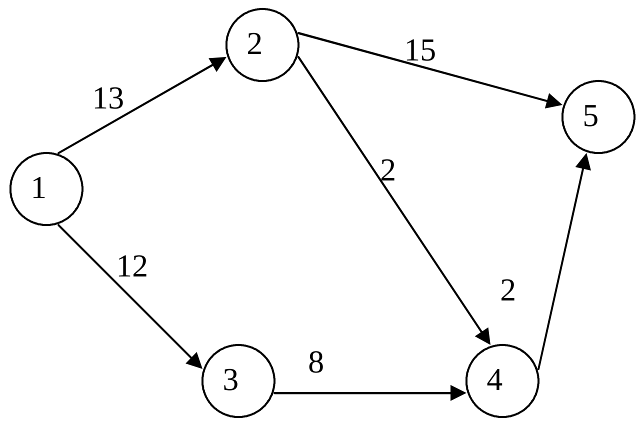
tp = pessimistic time

The time estimates for various activities in our illustrative project are shown below. Figure 5.8

Activity	Time estimate	Optimistic t_0	Most likely t_m	Pessimistic t_p	Average te=
Numerical description					
A 1 - 2		9	12	21	13
B 1 - 3		6	12	18	12
C 2 - 4		1	1.5	5	2
D 3 - 4		4	8.5	10	8
E 2 - 5		10	14	24	15
G 4 - 5		1	2	3	2

The network diagram with average time estimates is shown below.

Figure 5.9



1.5 DETERMINATION OF THE CRITICAL PATH

Once the network diagram with single time estimates has been developed, the following computational procedure may be employed for determining the critical path/s, event slacks, and activity floats.

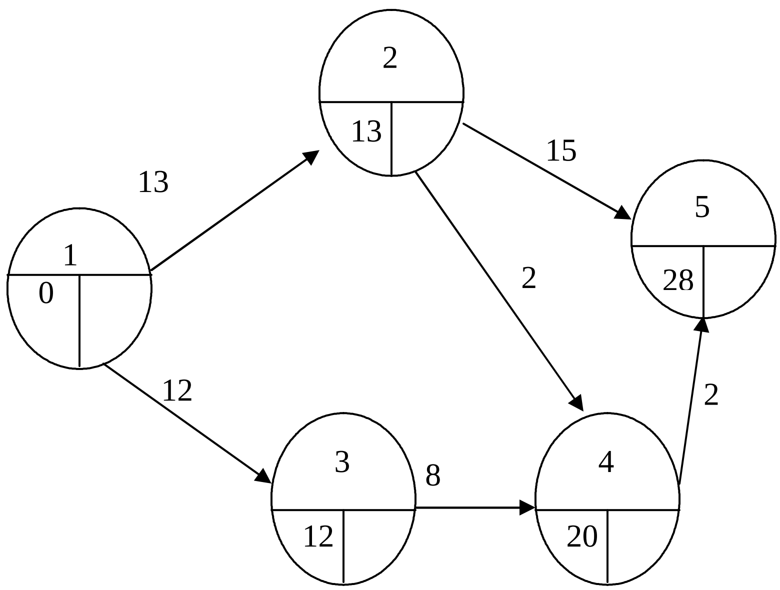
1. **Calculate the earliest occurrence time (EOT) for each event**.

An event occurs when all activities leading to the event have been completed. In the network diagram shown in Figure 5.9, for example, event 4 occurs when activities (2-4) and (3-4) are completed. Obviously activity (2-4) cannot begin unless event 2 occurs, which in turn requires the completion of activity (1-2). Likewise, activity (3-4) cannot begin unless event 3 occurs which in turn requires the completion of activity (1-3). Thus we find that event 4 occurs when activities (1-2), (2-4), (1-3), and (3-4) are completed. In other words, event 4 occurs when paths (1-2-4) and (1-3-4) are completed.

The *EOT* of an event refers to the time when the event can be completed at the earliest. Looking at event 4 we find that since the paths leading to it, viz., (1-2-4) and (1-3-4) take

15 weeks and 20 weeks, respectively, the *EOT* of event 4 is 20 weeks. In general terms, the *EOT* of an event is the duration of the longest path (from the beginning event whose *EOT* is set at 0) leading to that event. The *EOTs* of various events in our illustrative project are shown in Figure 5.10. It may be noted that in Figure 5.10 and subsequent figures a circle represents an event. The upper half of the circle denotes the event number, the left quarter in the lower half denotes the *EOT*, and the right quarter in the lower half denotes the latest occurrence time, a term described later.

Figure 5.10



The E*OT* of the end event obviously represents the minimum time required for completing the project. To obtain the *EOT* of various events we start from the beginning event and move forward towards the end event. This computational procedure is referred to as the forward pass. In this computation we assume that each activity starts immediately on the occurrence of the event preceding it. Hence the starting and finishing time for various activities obtained from this computation are the earliest starting time (EST) and the earliest finishing time (EFT).

The general formula for *EOT* is :

$$EOT\,(i) = \text{Max}\,[\,EOT\,(k) + d\,(k, i)\,] \qquad (5.2)$$

Where EOT *(i)* = earliest occurrence time of event *i*

EOT (k) = earliest occurrence time of event *k (k* precedes *a*nd there may be several *k's)*

d (k, i) = duration of activity *(k, i)*.The maximization shown is done considering all activities *(k, i)* leading to event node i.

The formulae for *EST* and *EFT* are:

$$EST\ (i, j) = EOT\ (i) \tag{5.3}$$

$$EFT\ (i, j) = EOT\ (i) + d\ (i, j) \tag{5.4}$$

EST (*i, j)* = earliest starting time for activity (*i, j*)

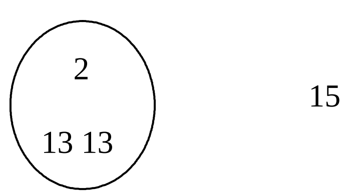
EOT (*i)* = earliest occurrence time of event (*i*)

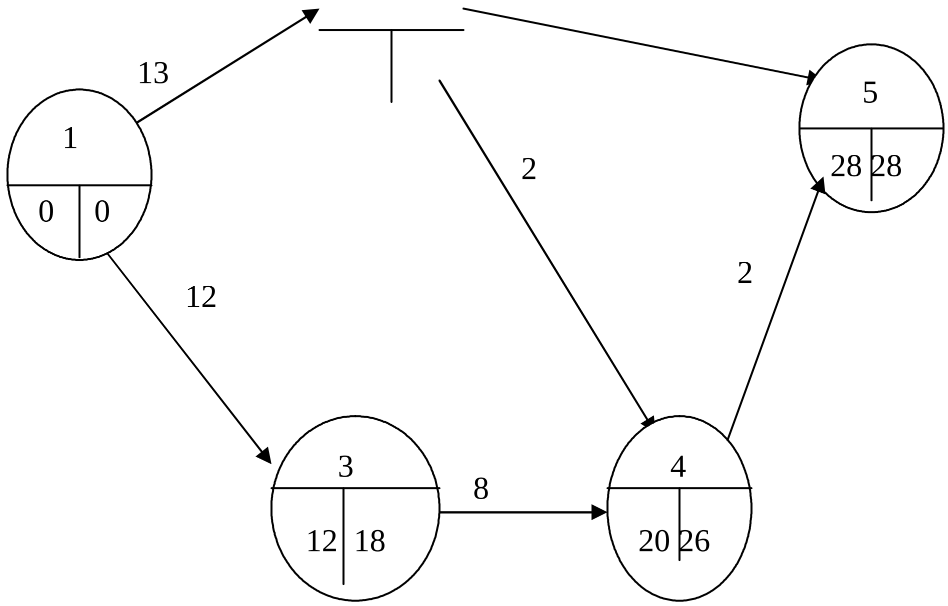
EFT (i, j) = earliest finishing time for activity (*i, j*)

d (*i, j)* = duration of activity (*i, j*)

2. Calculate the latest occurrence time (LOT) for each event.

The *LOT* for an event represents the latest allowable time by which the event can occur, given the time that is allowed for the completion of the project (occurrence of end event). Normally, the time allowed for the completion of the project is set equal to the *EOT* of the end event. (I**n other words, the project is supposed to be completed at the earliest possible time.)** This means that for the end event the *LOT* and *EOT* are set equal. The *LOT* for various events is obtained by working backward from the end event. This procedure is known as the backward pass. The *LOT* for event 4 in our illustrative project, for example, is equal to the *LOT* for event 5, the end event, minus the duration of the activity (4-5), which connects event 4 with 5. Since the *LOT* for event 5 is 28 weeks and the duration of activity (4-5) is 2 weeks the *LOT* for event 4 is 26 weeks (28-2). This represents the latest time by which event 4 should occur to enable the project to be completed in 28 weeks. Likewise, the *LOT* for other events can be calculated by moving backward. The *LOT* for various events is shown (in the right quarter of the lower half of event nodes) in Figure 5.11





The general formula for *LOT* is:

$$LOT (i) = \text{Min} [LOT (j) - d (i, j)] \qquad (5.5)$$

Where *LOT* (*i)* = latest occurrence time for *i*

LOT (j) = latest occurrence time for *j* (j follows *i* and there may be several *j'* s)

Projects 0

d (*i, j)* = duration of activity (*i, j*).The minimization shown here is done with respect to all activities (*i, j*) starting from i.

Given the *LOT* for various events we can calculate the latest finishing time *(LFT)* and latest starting time *(LST*) for various activities using the formulae:

$$LFT (i, j) = LOT (j) \qquad (5.6)$$

$$LST (i, j) = LFT (i, j) - d (i, j) \qquad (5.7)$$

where *LFT* (*i, j)* = latest finishing time for activity (*i, j*)

LOT (j) = latest occurrence time for event *j*

LST (*i, j)* = latest starting time for activity (*i, j*)

d (*i, j*) = duration of activity (*i,}*)

3.**Calculate the slack for each event.**

The slack for an event is the difference between its *LOT* and *EOT*. The slacks for various events of our illustrative project are shown in Figure 5.12.

Figure 5.12.
Event Stack

(in weeks)

Event	LOT	EOT	Slack = LOT - EOT
5	28	28	0
4	26	20	6
3	18	12	6
2	13	13	0
1	0	0	0

4. **Obtain the critical and slack paths**.

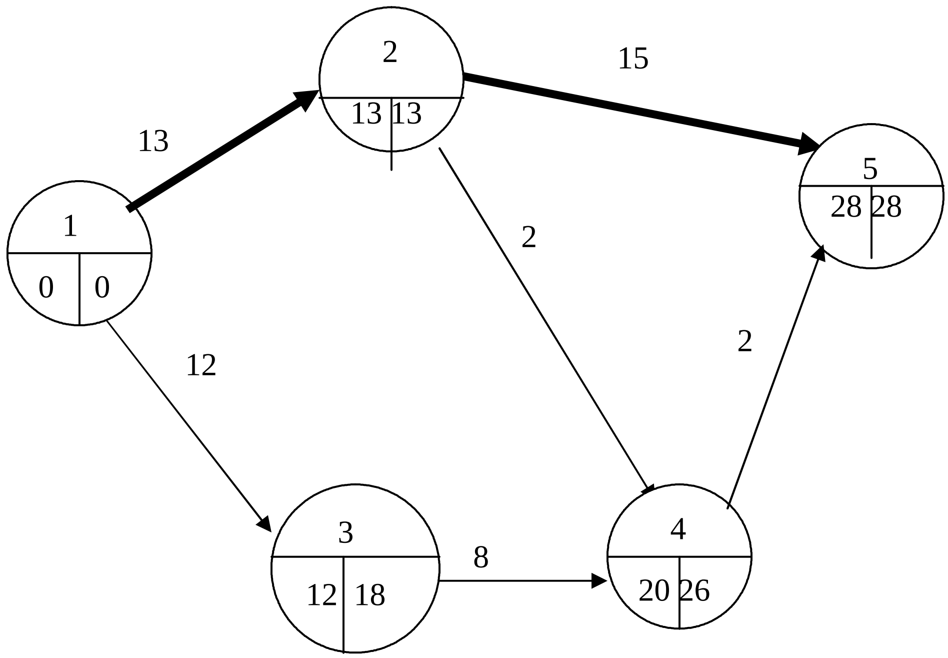
The critical path starts with the beginning event, terminates with the end event, and is marked by events, which have a zero slack. This is obviously the path on which there is no slack, no cushion. Other paths are slack paths with some cushion. The critical path for our illustrative project is (1-2-5). It is indicated by doubled arrows in Figure 5.13.

The critical path is the longest path from the beginning event to the end event. Since the end can be reached, i.e., project completed, only when this longest path is traversed, the minimum time required for completing the project is the duration on the critical path. The duration on the critical path of our project is 28 weeks; this is the minimum time required for completing the project. (It is already indicated by the *EOT* of event 5, the end event.)

5.Compute the activity floats.

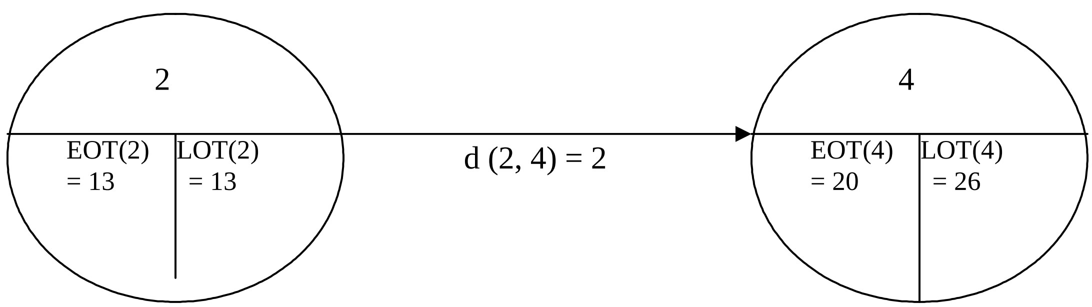
Given the estimates of activity time and event slacks, activity floats can be calculated. There are three measures of float: (i) total float; (ii) free float; and (iii) independent float. For illustrating these measures let us consider activity (2-4) of our illustrative project. Activity (2-4) is shown in Figure 5.14.

Figure 5.13



In Figure 5.14 *EOT*, *LOT*, and *d* represent respectively, earliest occurrence time latest occurrence time, and duration.

Figure 5.14



The *total float* of an activity is the extra time available to complete the activity if it is started as early as possible, without delaying the completion of the project. The total float for activity (2-4) is equal to:

Latest occurrence time for event 4	- Earliest occurrence time for event 2	- Duration of activity (2 - 4)
= 26 weeks	- 13 weeks	- 2 weeks
		= 11 weeks

The *total float* represents float under most favorable conditions. This is so because the activity can be started at the earliest (the *EOT* of the preceding event) and completed at the latest (the *LOT* of its succeeding event). Obviously, activities that do not have a float even under these conditions, the most favorable ones, are critical to the project and hence lie on the critical path.

The *free float* of an activity is the extra time available to complete the activity when the activity is started at the *LOT* of its preceding event and completed by the *EOT* of its succeeding event. The free float for activity (2 - 4) is:

Earliest occurrence time for event 4	- Latest occurrence time for event 2	- Duration of activity (2 - 4)
= 20 weeks	- 13 weeks	- 2 weeks
		= 5 weeks

The *independent float* of an activity is the extra time available to complete the activity when the activity is started at the *LOT* of its preceding event and completed by the *EOT* of its succeeding event. The independent float for activity (2 - 4) is:

Earliest occurrence time for event 4	- Latest occurrence time for event 2	- Duration of activity (2 - 4)
= 20 weeks	- 13 weeks	- 2 weeks
		= 5 weeks

The independent float represents the float under most adverse conditions. Hence when an activity has a positive independent float it means that the activity has cushion (equal to its independent float) irrespective of what happens elsewhere. (It may be noted that the independent float of an activity may be negative but the total float and free float cannot be negative.)

More generally, floats may be represented by the following equations:

$$TF(i, j) = LOT(j) - EOT(i\ J - d(i, j) \quad (5.8)$$

$$FF(i, j) = EOT(j) - EOT(i) - d(i, j) \quad (5.9)$$

$$IF(i, j) = EOT(j) - LOT(i) - d(i, j) \quad (5.10)$$

Where $TF(i, j)$ = total float of activity (i, j)

$LOT(j)$ = latest occurrence time for event j

$EOT(i)$ = earliest occurrence time of event i

$d(i, j)$ = duration of activity (i, j)

$FF(i, j)$ = free float of activity (i, j)

$EOT(j)$ = earliest occurrence time of event j

$IF(i, j)$ = independent float of activity (i, j)

$LOT(j)$ = latest occurrence time of event I

The floats for various activities of our illustrative project are shown in Figure 5.15.

5.6 SCHEDULING WHEN RESOURCES ARE LIMITED

From Figure 5.15, we find that critical activities (1-2) and (2-5) have no float associated with them. This mean that there is no flexibility whatsoever in scheduling these activities -the earliest starting time is the same as the latest starting time and the earliest finishing time is the same as the latest finishing time. For non-critical activities, however, some float is available and this provides flexibility in scheduling them. The choice available in this respect is bounded by two schedules: the early start schedule and the late start schedule.

Figure 5.15
Activity Floats

(in weeks)

Activity (i, *j)*	Duration	Earliest Start time (i, j)	Earliest Finish time (i, j)	Latest start time (i, j)	Latest Finish time (i, j)	Total float	Free float	Indep en-dent float
		= EST (i)	= EFT (j)	= LST (i)	= LFT (j)			
A (1-2)	13	0	13	0	13	0	0	0
B (1-3)	12	0	12	6	18	6	0	0
C (2-4)	2	13	15	24	26	11	5	5
D(3-4)	8	12	20	18	26	6	0	(6)
E (2-5)	15	13	28	13	28	0	0	O
F(4-5)	2	20	22	26	28	6	6	0

5.7 The Bounding Schedules: Early Start Schedule and Late Start Schedule

The early start schedule refers to the schedule in which all activities start as early as possible. In this schedule (i) all events occur at their earliest because all activities start at their-earliest starting time and finish at their earliest finishing time, (ii) there may be time lags between the completion of certain activities and the occurrence of events which these activities lead to; and (iii) all activities emanating from an event begin at the same time.

The early start schedule suggests a careful attitude towards the project and a desire to minimize the possibility of delay. It provides a greater measure of protection against uncertainties and adverse circumstances. Such a schedule, however, calls for an earlier application of resources.

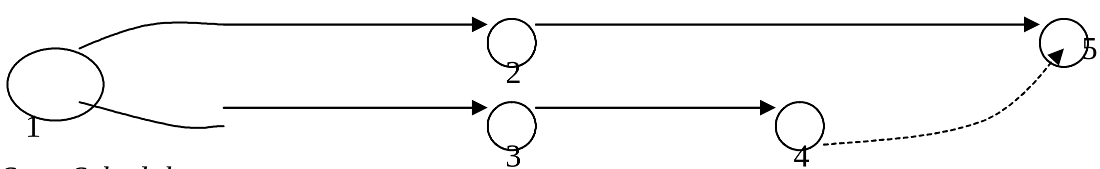
The late start schedule refers to the schedule arrived at when all activities are started as late as possible. In this schedule (i) all events occur at their latest because all activities start at their latest finishing time; (ii) some activities may start after a time lag subsequent to the occurrence of the preceding events; and (iii) all activities leading to an event are completed at the same time.

The late start schedule reflects a desire to commit resources late-as late as possible. However, such a schedule provides no elbowroom in the wake of adverse developments. Any unanticipated delay results in increased project duration.

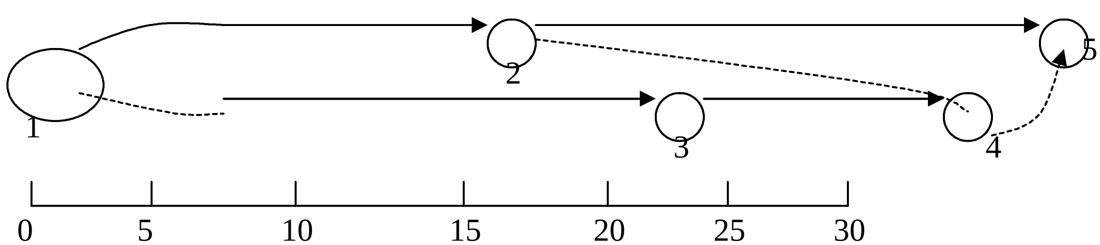
The early start schedule and the late start schedule for our illustrative project are shown in Figure 5.16. Here the project schedules are shown as graphs with a horizontal time scale.

Figure 5.16

Early Start Schedule



Late Start Schedule



PERT MODEL

So far the analysis was focused on the determination of the critical path, event slacks, and activity floats. For this purpose we used single time estimates of activity duration though initially three-time estimates were developed for each activity. Now we consider the variability of project duration.

Measures of Variability

Variability in PERT analysis is measured by variance or its square root, standard deviation. Variance of a set of numbers is the average squared difference of the numbers in the set from their arithmetic average. A simple example may be given to illustrate the calculation of variance. Let a series consist of numbers 4, 6, and 8. The average of this series is 6. The differences of various numbers in the series from this average are-2,0, and 2. Squaring them we get 4,0, and 4. Hence variance, the average of squared difference is 8/3, and standard deviation is

The steps involved in calculating the standard deviation of the duration of critical path are as follows:

1. Determine the standard deviation of the duration of each activity on the critical path.
2. Determine the standard deviation of the total duration of the critical path on the basis of information obtained in step 1.

For determining the standard deviation of the duration of an activity we require the entire probability distribution of activity distribution. We, however, have only three values from this distribution: *tp, tm, and to.* In PERT analysis, a simplification is used in calculating the standard deviation. It is estimated by the formula.

For determining the standard deviation of the duration of an activity we require the entire probability distribution of activity distribution. We, however, have only three values from this distribution: t_p, *tm, and to.* In PERT analysis, a simplification is used in calculating the standard deviation. It is estimated by the formula.

=

Where = standard deviation

t_p = pessimistic time

t_o = optimistic time

Variance is obtained by squaring

The standard deviation and variance of the activities on the critical path of our illustrative project are shown in Figure 5.17.

Assuming that the probability distribution of various activities on the critical path are independent, the variance of the critical path duration is obtained by adding variances of activities on the critical path.

Standard Deviation and Variance of Activity
Duration on Critical Path

Figure 5.17

Activity	tp	to		
(1-2)	21	9	2	4.00
(2-5)	24	10	2.33	5.44

Variance (Critical path duration) = Sum of variances of activity durations on the critical path

This means

$$\text{Standard deviation (Critical path duration)} = \left[\begin{array}{l}\text{Sum of variances of}\\ \text{activity durations o}\\ \text{The critical path}\end{array}\right]^{1/2}$$

The standard deviation of the critical path duration for our illustrative project is

$$\mathbf{(4 + 5.44)^{1/2} = 3.07}$$

Now we know that the mean, and standard deviation of the critical path duration for our project are 28 Weeks and 3.07 weeks, respectively.

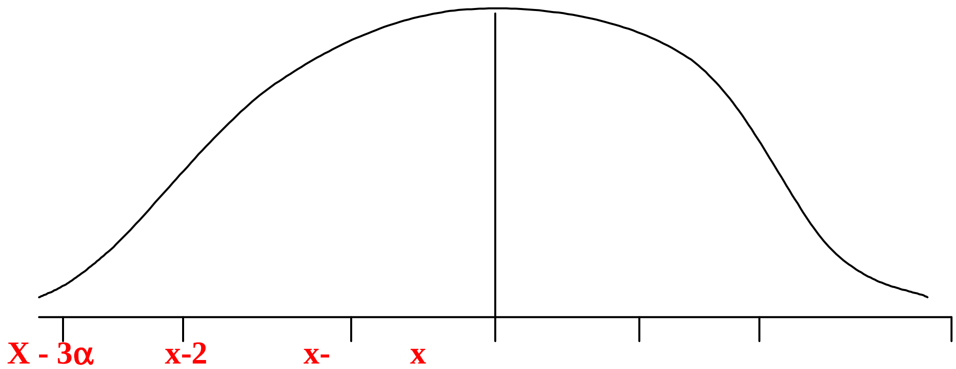
For real life projects, which have a large number of activities on the critical path we can reasonably assume that the critical path duration is approximately normally distributed with, mean and standard deviation obtained by the method described above.

A normal distribution looks like a bell-shaped curve as shown in Figure 5.18. It is symmetric and single peaked and is fully described by its mean and standard deviation. The probability of values lying within certain ranges is as follows:

Range	Probability

Mean One standard deviation	0.682
Mean Two standard deviations	0.954
Mean Three standard deviations	0.998

Figure 5.18



Probability of Completion by a Specified Date

Armed with information about mean *(T)* and standard deviation () for critical path duration, which is normally distributed, we can compute the probability of *com F* a specified date *(D)* as follows:

1. Find
2. Obtain cumulative probability up to Z^6 by looking at the probability distribution of the standard normal variant. This is shown in Figure 5.19.

Cumulative Probability up to Z for Standard Normal Distribution

Figure 5.19

Z	**Cumulative probability**

-3,0	0.001
-2.8	0.003
-2.6	0.005
-2.4	0.008
-2.2	0.014
-2,0	0.023
-1.8	0.036
-1.6	0.055
-1.4	0.081
-1.2	0.115
-1.0	0.159
-0.8	0.212
-0.6	0.274
-0.4	0.345
-0.2	0.421
0.0	0.500
0.2	0.579
0.4	0.655
0.6	0.726
0.8	0.788
1.0	0.841
1.2	0.885
1.4	0.919
1.6	0.945
1.8	0.964
2.0	0.977
2.2	0.986
2.4	0.992
2.6	0.995
2.8	0.997
3.0	0.999

The above procedure may be illustrated for our project, which has T = 28 and = 3.07. The probability of completing this project by certain specified dates is shown in Figure 5.20.

Probability of Completion by a Specified Date

Figure 5.20

Specified date (D)	Z	probability of completion by D

20	0.005
25	0.159
30	0.726

REVIEW QUESTIONS ON CHAPTER 5

1. What is the basic difference between PERT and CPM?
2. What steps are involved in PERT analysis?
3. Discuss the rules for network construction.
4. What considerations should be borne in mind in time estimation?
5. What is the procedure for determining the critical path?

6. What are *EOT* and *LOT?*
7. How would you calculate the variability of project duration and probability of completion at a specified time? Illustrate with an example.

PROBLEMS ON CHAPTER 5

1. Draw the network diagram for an industrial project with which you are familiar.
2. A project consists of the following activities represented in terms of preceding and succeeding events.

Activity	Mean time (weeks)
(1,2)	4
(1,3)	2
(1,4)	3
(2,4)	5
(3,4)	6
(4,5)	2
(5,7)	3
(2,5)	1
(4,7)	5

3.a project consists of 12 activities and their time estimates are shown below:

Activity	time (weeks)		
	t_o	t_m	t_p
(1 - 2) = A	4	6	10
(1 - 3)=B	3	7	12
(1 - 4)=C	5	6	9
(1 -7)=D	2	4	6
(2 - 4)=E	6	10	20

(2 - 6)=F	3	4	7
(2 - 7) =G	5	9	15
(3 - 4)= H	3	7	12
(4 - 5)=I	2	4	5
(5 - 6)=J	1	3	6
(3 - 7)=K	2	5	8
(6 -7)=L	1	2	6

(a) Draw the network diagram

(b) Determine the critical path

(c) Calculate event slacks and activity floats.

(d) Find the standard deviation of the critical path duration.

(e) Compute the probability of completing the project in 30 weeks.

CHAPTER 6

Monitoring and Evaluation

By the time you complete the module you should have the knowledge, skills, and attitudes to:

- Distinguish between monitoring and evaluation by giving examples of each.
- Describe the principles, characteristics, and objectives of M & E.
- Discuss why M & E is important for a project
- Discuss and demonstrate the use of information-gathering methods.
- Explain the role(s) that M & E can play
- Demonstrate how to plan and/or conduct an evaluation.

CHAPTER 6

Monitoring and Evaluation

6.1 I**NTRODUCTION**

6.1.1 What is Monitoring and Evaluation?

Throughout life we are monitored and evaluated: in school we receive grades, at work we are given performance appraisals, and we evaluate relationships and monitor our health.

Before we use the formal definitions of monitoring and evaluation, lets use commonsense definitions: Evaluation asks the question "Are we doing the right thing" or "Do we have the right plan?" and Monitoring checks to see if we are following our plan.

Monitoring and Evaluation is the systematic collection and analysis of information to enable managers and key stakeholders to make informed decisions, maintain existing practices, policies and principles and improve the performance of their projects.

Monitoring is the regular gathering analyzing and reporting of information that is needed for evaluation and/or effective project management. Monitoring is either ongoing or periodic observation of a project's implementation to ensure that inputs, activities, outputs, and external factors are proceeding according to plan. It focuses on regular collection of information to track the project. Monitoring provides information to alert the stakeholders as to whether or not results are being achieved. It also identifies challenges and successes and helps in identifying the source of an implementation problem.

Evaluation is a selective and periodic exercise that attempts to objectively assess the overall progress and worth of a project. It uses the information gathered through monitoring and other research activities and is carried out at particular points during the lifetime of a project.

Evaluation is different from monitoring. Monitoring checks whether the project is on track; evaluation questions whether the project is on the right track. Monitoring is concerned with the short-term performances of the project, and evaluation looks more at long-term effects of project goals. Frequently, evaluation is perceived as an activity, carried out by an expert or a group of experts, designed to assess the results of a particular project. This is a common misconception. It is vital that evaluation is carried out with the participation of all project stakeholders, including beneficiaries. The results of a periodic evaluation are fed into the project planning process as quickly as possible to enhance the project's effectiveness.

Monitoring is useful because it tends to highlight little problems before they become big ones. An evaluation is a systematic examination of a project to determine its efficiency, effectiveness, impact, sustainability, and the relevance of its objectives. The dictionary defines evaluation as a systematic investigation of the worth or merit of an activity. Traditionally, evaluation has been the last step in the project life cycle and in the project development process. However, it does not make sense to wait until the project is finished to ask the question "Did we do the right thing?" Indeed, you could evaluate the effectiveness at each stage of the project life cycle.

In a project the monitoring and evaluation group decides what to monitor. By collecting data regularly on activity inputs and outputs, processes, and results, the community can monitor the progress toward the group's goals and objectives (e.g., income generated by the sale of a cookbook, how many people sold how many books over what period of time). In managing a project indicators are indispensable management tools. They define the data needed to compare the actual verses the planned results.

M&E can be seen as a practical management tool for reviewing performance. M&E enables learning from experience, which can be used to improve the design and functioning of projects. Accountability and quality assurance are integral components of M&E, which help to ensure that project objectives are met, and key outputs and impacts are achieved.

6.1.2 Why Monitor and Evaluate?

M&E can help an organization to extract, from past and ongoing activities, relevant information that can be used as the basis for future planning. Without M&E how would it be possible to judge if a project was going in the right direction, whether progress and success was being achieved, and how future efforts might be improved?

A structured M&E approach makes information available to support the implementation of projects and activities and will enhance the sustainability. Used effectively M&E can help to strengthen project implementation and encourage useful partnerships with key stakeholders.

The main objectives of M&E are thus to:

- Ensure informed decision-making;
- Enhance organizational and development learning;
- Assist in policy development and improvement;
- Provide mechanisms for accountability;
- Promote partnerships with, and knowledge transfer to, key
- Stakeholders;
- Build capacity in M&E tools and techniques.

M&E is about feedback from implementation.
The ultimate **purpose** of M&E is change for the better.

6.1.3 **Different Kinds of M&E**

M&E can deal with many issues. It can be M&E of Projects. policy implementation, the performance of a unit in an organization, staff performance or, for example, deliveries from a subcontractor.

This (course) module deals with M&E related to a project. The concepts, tools, and procedures for project M&E, as presented in this module, also helps to understand other kinds of M&E.

6.1.4 Internal and External Project M&E

Internal Project M&E is built into the design of a project and is undertaken by the team that is responsible for management and implementation of the project.

This is done to ensure that the project meets deadlines, stays within the budget and achieves its objectives, activities, outputs and impacts!. A project that does not monitor its implementation is not a well-managed project.

Findings, recommendations etc of internal monitoring is usually captured in progress reports submitted by project management.

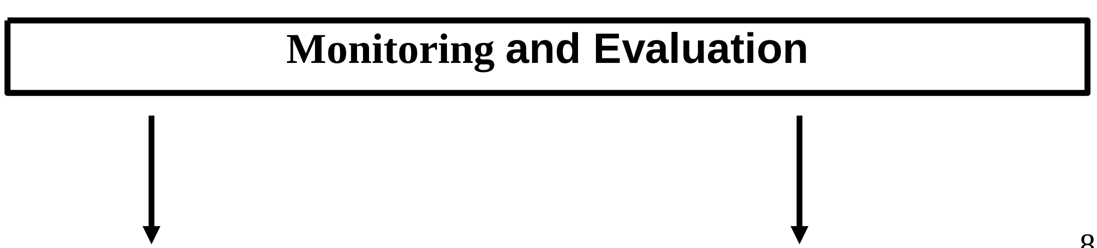
External Project M&E is carried out by an outside team, which is not directly responsible for the management or implementation of the project. External M&E should assess the effectiveness of the internal M&E put in place by the project management team. External monitoring can take place once the project has been completed, and/or during implementation of the project.

External M&E is often required by donor agencies or government organizations if, for example, they need to know how their funds are being spent or if their policies are being adhered to. All projects can benefit from external M&E.

Findings and recommendations of external monitoring are often documented in a review or evaluation report.

External M&E also monitors and evaluates **internal** M&E

Figure 6.1: Differences Between Internal and External M&E



Internal M&E		External M&E I
1. Integrated part of project design and management. 2. Undertaken by the project management team. 6. Findings, lessons learnt and recommendations documented in regular project progress/ activity reports.	⟷ Assessing & improving performance	1. Prescribed outside of project design and management. 1. Conducted by a team external to the project often carried out by consultants. 2. Findings, lessons learnt and recommendations documented in an

6.1.5 **Monitoring Levels**

Traditionally, M&E focused on assessing the inputs and activities of a project. Today the focus is increasingly on measuring the outputs and impacts of a project to achieve a broader development objective or goal.

Project inputs, activities and assumptions/risks are also important, however, as they all affect outputs. For example, if the budget (an input) is cut by 50%, this will obviously affect the outputs of the project and will need to be taken into account when conducting the M&E. The various monitoring levels in a project are:

Input Monitoring

Input monitoring is the monitoring of the resources that are put into the project - these include budget, staff, skills, etc. Information on this type of monitoring comes mainly from management reports, progress reports and accounting.

For example, ways of measuring this can be the number of days consultants are is employed, or the amount of funds spent on training and equipment.

Activity Monitoring

Activity monitoring monitors what happens during the implementation of the project and whether those activities which were planned, were carried out. This information is often taken from the progress report.

Output Monitoring

Output monitoring is a level between activity and impact monitoring. This type of monitoring assesses the result or output from project inputs and activities.

The measurements used for output monitoring will be those which show the immediate physical outputs and services from the project.

Impact Monitoring

Impact monitoring relates to the objectives of the project. The aim of impact monitoring is to analyze whether the broader development objectives of the project have been met.

Such monitoring should demonstrate changes that are fundamental and sustainable without continued project support.

6.1.6 **M&E and Stakeholder Participation**

The participatory approach to project management seeks to enable local communities living adjacent to projects and other local stakeholders to take part in decision-making and share the benefits of project activities. This participatory approach should also be applied to M&E. Participatory M&E can play an important role in ensuring that the participatory principles are put into practice by:

- Improving the effectiveness of project management and decision-making, as the parties who have been involved in M&E will be informed and aware of the results of the M&E procedure;
- Ensuring that accurate and reliable information is communicated to communities and stakeholders from the M&E process;
- Ensuring that stakeholders understand the reasons for failure in achieving project outputs and objectives and how and what to improve in the future;
- Providing mechanisms for transparency and accountability to stakeholders;
- Building community capacity in M&E tools and techniques.

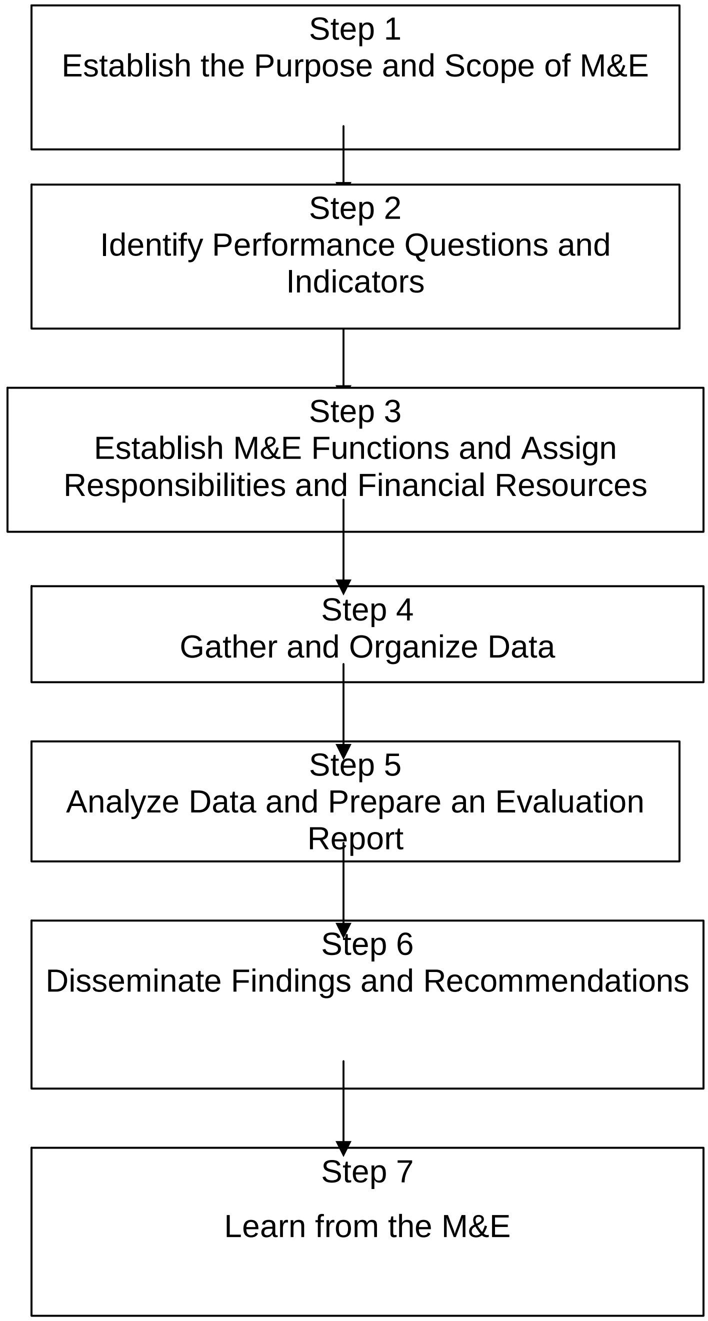
Recommendations from M&E are more likely to be accepted and taken forward by stakeholders, if they have had an active role in shaping them.

Activity: Think about a time when you were involved in an evaluation process. What kind of evaluation was it? What was the evaluation trying to find out? Was the evaluation participatory? Did the information gathered and reported get used?

6.2 **The Monitoring and Evaluation Procedure**

The M&E procedure below sets out the steps in planning and implementing external M&E. The M&E procedure must be customized to the specific needs of each project, taking into account the project objectives, inputs, outputs, activities, stakeholders and beneficiaries. The M&E steps will vary from situation to situation. Seven key steps are listed in Figure 6.2 and further explained in the rest of this chapter.

Figure 6.2: The M&E Procedure



6.2.1 **Step** 1: **Establish the Purpose and Scope of M&E**

Specifying the purpose and scope of the M&E helps to clarify what can be expected of the M&E procedure, how comprehensive it should be and what resources and time will be needed to implement it.

When formulating the purpose of M&E, relevant stakeholders including the project management team, should be consulted or at least made aware of and understand the purpose of the M&E.

Example **of an External M&E Purpose**

To verify that the development objective and outputs of the project have been achieved within the allocated budget.

The scope of the M&E may be determined by asking some of the following questions:

- What is the purpose of M&E?
- How much money is available for your M&E?
- What type of information is required by project management, donor agents or other stakeholders?
- What is the level of M&E expertise available?
- To what extent should local communities and other stakeholders, participate in the M&E procedure?

6.2.2 **Step** 2: **Identify Performance Questions and Indicators**

6.2.2.1 **Performance Questions**

A performance question is used to focus on whether a project is performing as planned and if not, why not. Performance questions will be guided by the broader development objective, the project objectives, the project outputs, as well as the M&E purpose. Once performance questions have been identified, it will be easier to decide what information is needed to evaluate the project. Table 1 gives examples of performance questions for the M&E of a particular project.

6.2.2.2. **Indicators**

Indicators should be guided by performance questions and linked to the purpose of the M&E. Indicators are basically measurements that can be used to assess the performance of the project.

While **performance questions** help to decide what should be monitored and evaluated, **indicators** provide the actual measurements for M&E and determine what data needs to be gathered.

The project itself may have indicators by which it monitors it's own progress - these may be used for external M&E, if relevant. Also the funding organization and other stakeholders can provide broader indicators that may be relevant to the external M&E of the project.

Indicators, and therefore the data needed to verify them, can be **qualitative or quantitative.** Quantitative data is factual while qualitative information is based on opinions and perceptions and thus may be subject to further interpretation. During M&E, one should aim to have both qualitative and quantitative indicators. Table 3 provides examples of quantitative and qualitative indicators.

Table 3: Examples of Quantitative and Qualitative Indicators

INDICATOR TYPES	EXAMPLES
Quantitative	. Fifty bundles of poles are harvested each month.

Indicators	. Five training courses were run during the project.
Qualitative Indicators	The pole harvesters regard the harvesting system as being sustainable Those who attended the training courses perceived the courses to be meeting the demands for skills in the area.

- *Relevant* - The indicators should be directly linked to the project 0bjectives/ outputs.
- *Technically feasible* - The indicators should be capable of being verified or measured and analyzed.
- *Reliable* - The indicators should be objective: i.e. conclusions based on them should be the same if different people assess them at different times.
- *Usable* - People carrying out the M&E should be able to understand and use the information provided by the indicators to evaluate the project.
- *Participatory* - Relevant stakeholders should be involved in the collection of information generated by the indicators, the analysis of the information and possible use of the information in the future.

6.2.3 Step 3: **Establish M&E Functions and Assign Responsibilities and Financial Resources**

Establishing M&E functions and responsibilities at the beginning of the procedure can help to avoid major communication issues, conflicts of interest, duplication of tasks and wasted efforts. Organizing responsibilities means deciding which stakeholders will be involved and clarifying and assigning roles to these stakeholders as well as to funding organization officials, project management and any partner organizations. Stakeholders may need to be trained in different aspects of the M&E procedure

M&E will require financial resources in accordance with the type of project(s) that is being evaluated as well as the M&E purpose, performance questions and indicators. Among the items that should be included in M&E costs are:

- Staff salaries;

- Fees and expenses for consultants;
- M&E training;
- Organizing M&E meetings and other participatory exercises.

Consultants can play an important role in enabling projects to fulfill its M&E responsibilities by providing specialist knowledge and expertise that may not be readily available in the organization.

6.2.**4 Step 4: Gather and Organize Data**

Data is the oxygen that gives life to M&E. However, selecting methods of data collection can be confusing, unless it is approached in a systematic fashion. Rarely is anyone method entirely suitable for a given situation. Instead, using multiple methods helps to validate M&E findings and provides a more balanced and holistic view of project progress and achievements.

The performance questions and indicators will provide guidance in deciding what data/information to gather and the methods to be used. Data can either be primary or secondary.

6.4.2.1 **Data Sources and Data Collection Methods**

Potential data sources and data collection methods are listed below:

- **Document Review:** Documents and reports provide a rich source of information for M&E.
- **.Interviews** : Interviews can provide a rich source of data, particularly in regard to qualitative and sensitive information that may not be readily available in official documents.
- ***Surveys and Questionnaires***: Surveys and questionnaires provide a way of obtaining information from a large number of people. Questions should be relevant and simple to answer.
- ***Field Visits and Transect Walks*** Visits to the site of a project can provide valuable information about the environment in which the project is taking place,

its impact on beneficiaries and the working methods that are being used. Transect walks are an effective participatory method to gather this information.

- ***Expert Opinion*** Obtaining the views of experts who are knowledgeable about particular aspects of the project's activities can in some instances provide valuable insights that may not be revealed by other methods of data collection.

6.2.4.3 Organizing and Storing Data

Data needs to be captured, organized and stored so that it can be readily used for the M&E purposes.. Proper capturing, organizing and storage is particularly important when information has been collected from different sources with different methods.

6.2.5 Step 5: **Analyze Data and Prepare an Evaluation Report**

The captured and organized data needs to be analyzed, and findings and recommendations summarized and compiled into a report.

In this regard, the performance questions and indicators can provide important assessment tools for the analysis. A final comparison with the outputs and impacts of the project should then be made. In this way performance, progress and achievements of the project can be assessed.

6.2.5.2 **Reporting**

Feedback and reporting are key to both internal and external M&E as, in this way, information can be meaningfully combined, explained, compared and presented. All reporting should thus be as accurate and relevant as possible. As mentioned earlier, external M&E will frequently use the internal project progress reports and other relevant information as part of the information gathered to externally monitor and evaluate the project. For external M&E the report is usually called an **evaluation or review** report.

6.2.6 **Step** 6: **Disseminate Findings and Recommendations**

The evaluation reports, or summaries of these reports, should be widely distributed and presented to decision-makers and key stakeholders including those who were consulted in the M&E process.

6.2.7 **Step** 7: **Learn from the M&E**

Knowledge gained through M&E lies at the core of DW AF's organizational learning process. M&E provides information and facts that, when analyzed, understood and accepted, become knowledge that can be used to improve Project management. Besides learning about the progress/achievements of the project outputs, etc, it is essential to learn from what works regarding partnership strategies, project design and implementation, and to feed this knowledge back into ongoing and future projects and policies. This information also provides a means to regulate the sustainable management of state projects by other agencies.

Project evaluations can help to bring development partners together, and when this occurs the learning from M&E goes beyond project to stakeholders involved in other development and natural resource management activities.

Review questions on chapter 6

1.CONDUCTING AN EVALUATION

Use the following case study:

As a Volunteer you are working with a group of craftspeople who produce baskets, linen, dresses and many other items. One of the challenges the craftspeople face is that the local and regional communities are unfamiliar with their work and their products. The group decides to hold a craft fair. The local government has given its blessing and is providing assistance, the local business merchants are participating, and even the schools are pitching in with volunteer assistance. There is an advertising plan, and all craftspeople are busy working on different committees. You are assigned to the monitoring and evaluation committee. Along with your group members, design a plan to monitor the fair's preparation and evaluate the fair once it is completed. In pairs, design a monitoring and evaluation plan for the craft fair. Use your imagination and the tools you have learned in this module. Once you have developed the plan, present it to the rest of the group and ask them to provide feedback. As you are developing your plan think through the following questions:

• Is the monitoring plan simple? Does it cover all aspects of the project?
• Does the evaluation plan ask key questions?
• Are there relevant indicators?
• Is it appropriately timed?
• Is the process participatory, does it engage people?

2 a) Start a computer learning center project
b) Establish a continuing education center. Project
c) Begin a community housing project.
d) Start a community beautification project
e) Conduct a consumer expenditure survey.

For the project ideas listed above develop two indicators for each. Try to develop both product and process indicators. When you've completed the task, share your indicators with your friends and discuss the following questions:

• Which product or process indicators were the easiest to write?
• Did you repeat an indicator in any of the projects?

- What information was missing?
- What process would you use to develop indicators in a participative way?
- How would you go about ensuring that the group was involved?
- What information-gathering methods might you use for the indicators you selected?