UNITED NATIONS

ECONOMIC
AND
SOCIAL COUNCIL

LIMITED

ST/ECLA/CONF.7/L.1.34
27 December 1960

ORIGINAL: ENGLISH

LATIN AMERICAN ELECTRIC POWER SEMINAR

Held under the joint auspices of the Economic Commission for Latin America, the Bureau of Technical Assistance Operations and the Resources and Transport Economics Branch of the United Nations, with the collaboration of the Government of the United Mexican States

Mexico City, 31 July to 12 August 1961

# THE ECONOMIC CRITERIA TO BE APPLIED IN SELECTING INVESTMENTS

submitted by the

International Union of Producers and Distributors of Electric Power (UNIPEDE)

NOTE: This text is subject to editorial revision.

1. Discounting and the choice of interest rates

The future of an enterprise depends on its investment policy. The choice of investments is based on a comparison of sales prospects and the costs which a given investment decision will entail. Uncertainty as regards the future makes it necessary to limit the range of choice and to accept the fact that decisions lead to consequences that cannot be forecast beyond a certain date.

Discounting, which is a method of taking the time factor into account and arriving at the "present worth", provides an opportunity of making the values of such sales income and costs directly comparable by referring them to the same time base. Discounting helps to offset the effect that the distant future may produce on immediate decisions. Professor Schneider expresses the economic equivalence as follows:

$$1 \text{ franc now} = 1 \text{ franc one year later} \times (1 + i_1)$$

in which $i_1$ represents the rate of interest corresponding to the year 1.

This may be expressed in more general terms for n years and for the corresponding rates of interest x $i_1$, $i_2$ ... $i_n$ as follows:

$$1 \text{ franc n years later} = 1 \text{ franc now} \times \left[\left(\frac{1}{1+i_1}\right) \cdot \left(\frac{1}{1+i_2}\right) \cdots \left(\frac{1}{1+i_n}\right)\right]$$

Assuming that $i_1 = i_2 \ldots = i_n$, the expression may be written thus:

$$(1 + i)^{-n}$$

which is the value of 1 franc payable at the end of n years.

Several authors have raised the question of the choice of interest rate to be used in discounting. The role of interest is to express the scarcity of available capital. If the entire capital is negotiated on a free and competitive market, the equilibrium rate of the market should be used. Generally speaking, such a market does not exist, and each enterprise should therefore determine the rate it should use by studying the market from which it obtains its own capital.

/Mr. B.W.

Mr. B.W. van der Heuvel and Mr. G. Timmers have the following to say in this connexion: "If the possibility of attracting funds at a relatively favourable rate of interest is to be considered as an acquired and inherent property of the undertaking or of the particular branch of industry, the capital costs should be calculated at the rate which applies to this industry."

This may be compared with Professor Guidotti's pronouncement on the capital costs of new installations: "If an enterprise, thanks to the credit which it obtains on the market, can take advantage of a capital cost lower than that of the market, it can take this into account when calculating its costs." But, in the case of an enterprise which has to bear capital costs higher than the usual market rates, Professor Guidotti thinks that it is not advisable to apply such a rate of interest when making general calculations. For the latter, the usual capital cost of the market should be chosen.

## 2. Methods

The problem of choosing investments is usually highly complicated. There are two ways of dealing with it.

(a) It is possible to decide upon a production prospect P and to seek the best technical solution S (P). If this operation is repeated for each production prospect, the problem is reduced to a comparison of the various S (P).

(b) It is also possible, firstly, to decide upon a technical solution S and then to ascertain which production prospect P (S) gives S its maximum value, and then to compared the various P (S).

Possibility (a) is chosen in the very general case where possible production prospects are very few in number. Such is the case of electricity production in industrialized countries, where demand trends can be forecast fairly accurately. The problem then consists in ascertaining which of the equipment programmes that will lead to the fulfilment of production prospect P will ensure the maximum profit (or the minimum cost, if the enterprise has no influence on the

/sales price)

sales price), a programme[1] being defined as the aggregate of power units to be build during the period under review on specific dates.

It is possible to prescribe a general method for solving the problem, namely the combination method. A selection is made from all the feasible programmes of all projects that can be carried out by combining, to the maximum extent possible, compatible projects[2] scheduled for implementation on a given date. It is then possible: (a) to choose from the list the programmes which will enable the desired production prospect to be fulfilled; (b) to calculate the discounted profit that each will yield; and (c) to determine which will yield maximum profit.

This method is of very general application but, unfortunately, it can seldom be used in practice as the number of projects is usually large and it is thus impossible to draw up a complete list of all the conceivable programmes. Hence other methods, more practical and easier to apply, must be used. These may be divided into two main categories: (a) overall methods, whereby a programme is considered as a whole and individual projects take second place; (b) marginal methods, whereby each project is studied with a view to establishing criteria for the direct selection of projects which will constitute the optimum programme.

(a) Overall methods

Feasible programmes may be represented by the values of a certain number of parameters $X_1$ $X_2$ ... $X_n$, considered as the components of a vector X. Among those which will satisfy the specific production objectives, the one which yields the maximum discounted profit BX must be determined. This is a programming problem in which B (X) is the objective function. The situation in which X corresponds to a feasible programme that can be carried out and adapted to demand

1/ A programme means a group of projects and a project, in this context, any power plant or unit or equivalent, the construction of which is technically feasible.

2/ Projects are compatible when they can be incorporated in the same programme.

/may be

may be expressed algebraically by an aggregate of constraint superimposed on the X's. In practice, as small a number x of parameters as possible should be used. For this purpose, the various projects are regrouped into categories of power plants or units, the quantity of such plants or units in each category being taken as a parameter.

At present there is virtually no systematic method for solving this kind of problem in cases where constraint and the objective function are not expressed linearly as a function of x. This partly explains the essential role of linear programming. Eléctricité de France uses a linear programme of large dimensions (about 220 constraint and 250 unknown quantities) which enables it to investigate the various possibilities of the method.

Linear programming offers two particular advantages. Firstly, certain quantities, called "dual variables", which may be given an economic interpretation, may be calculated. Since their association with the constraint indicates whether it will be possible to fulfil a given production prospect, they represent the marginal costs of production. Secondly, it is easy to determine by means of the parametric method how the optimum solution varies when certain elements of the problem are modified and, more specifically, how the optimum programme varies if the production prospect is modified.

Overall methods do not generally provide a complete solution to the investment problem but rather an optimum programme, simply defined by the various constituent power plants or units.

There remains the problem of preparing the programme in terms of its various component projects. This problem can be tackled by using the so-called "marginal methods".

(b) Marginal methods

To each project p an individual criterion of value (or profitability) is applied, which makes it possible to determine whether p should be included in the optimum programme. The purpose of these marginal methods is to select the best projects.

/The relevant

The relevant calculations are based on the discounting principle. The methods used are that of the value in capital and that of the internal rate of interest or rate of profitability.

(i) Method of the value in capital

At a given time, e.g. when the power plant or unit enters into operation, the discounted value of the difference between future sales income and costs is calculated.

The formula giving the value in capital K at the initial moment is as follows:

$$K = (E_1 - A_1) \cdot (1 + i_1)^{-1} + (E_2 - A_2) \cdot (1 + i_2)^{-2} + \ldots + (E_n - A_n) \cdot (1 + i_n)^{-n} - A_o$$

$$= \sum_{j = t_o}^{j = n} (Ej - Aj) \cdot (1 + i_j)^{-j} - A_o$$

in which:

$-A_o$ = investment expenditure

$-E_1, E_2 \ldots E_n$ = annual expenditure from the first to the nth year

$-A_1, A_2, \ldots A_2$ = annual sales income from the first to the nth year

$-i_1, i_2, \ldots i_n$ = interest rates corresponding to the years 1, 2 ... n.

A first criterion is represented by K.

Thus, criterion $K > 0$ means literally that the expected sales income enables the enterprise to cover both probable costs and interest calculated at a fixed rate, but it also leaves a surplus.

If $K = 0$, the investment will cover only the anticipated costs using the anticipated sales income at the chosen rate of interest.

If several investments satisfy the criterion $K > 0$, the economically most profitable is that in which, ceteris paribus, K is at a maximum.

A particular case may arise when different investment projects produce the same series of sales income. In this case only, it may be possible not to include the sales income in the calculation, if it is known that K is positive for at least one of them[3/].

---

3/ It would also be possible to do so when K is negative, if, for any reason, the investment were unavoidable.

/It is

It is then sufficient to compare the values of the discounted costs.

$$C: \sum_{j = t_o}^{j = n} A_j(1 + i_j) - 1$$

K = maximum expressed here as C = minimum

(ii) Method of the rate of profitability

Whereas the previous method gives a result in terms of currency units or currency units per unit of invested capital, the method of the internal rate of interest gives a result in terms of a rate of interest.

It is necessary to ascertain at what rate of interest r the value of K is cancelled out. This rate of interest r is called the "internal interest" or "rate of profitability" of the investment.

The internal interest is a mean characteristic of the investment. It should be distinguished from the marginal interest (marginal profitability) which is the rate r' at which the balance K of a marginal alteration of the investment is cancelled out. The comparison of r' with the rate of interest i shows whether the substitution is economically advantageous.

(iii) Various criteria may therefore be used and it is difficult to choose among them. From the strictly logical point of view, the problem is insoluble even if the overall methods are not applied. Two projects are seldom independent of each other 4/. This means that the value of a project can be judged only if the other projects, with which it will be associated in the selected programme, are already known.

The project p is marginal to a programme, the general outline of which has been defined, and two marginal variants are compared, one including p and the other not. The marginal methods can be used because of the large number of the groups of projects which can be considered independent as a first approximation, and, later, because of the fact

---

4/ Two projects are independent of each other if the profitability of either is not affected whether the other is carried out or not.

/that it

that it is often justifiable to assume in theory that the essential features of the optimum programme are known. When this is not the case, the overall method must be applied.

Hence, a theoretical solution may be found to the problem of selecting investments by combining, in a process of successive approximations, both the overall and the marginal methods. Each type of method provides the information necessary for applying the other, and the sum of information thus obtained can be used to define the optimum programme.

(c) Uncertainty

Investment calculations require adequate and reliable information on future events, especially on technical progress, price relationships, competitive conditions and legal structures. But knowledge of future economic and social developments is necessarily insufficient. Thus the absolute accuracy of the investment calculation processes stands in contrast to the inadequate knowledge of the quantities on which these calculations are based. A comparison between the theories of decision, in the case of subjective and objective uncertainty, and the knowledge acquired in practice shows that the information that can be derived from these theories is neither new nor revolutionary. The condition of subjective uncertainty exists when the enterprise knows approximately the probability distribution of the quantities in the calculation. Such an uncertainty leads to a subjective evaluation of the situation, and subjective judgements determine the choice of the relevant factors and, hence, the lines along which the search for additional information should be directed.

The preference function of the enterprise replaces the profit maximization function. The former is more comprehensive, as it includes, in addition to the profit expected from the investment, the value set by the enterprise on safety and other factors bearing on the enterprise's operation.

In the case of objective uncertainty, the enterprise does not know the probability distribution, and it may seem advantageous for ultra-conservative enterprises to choose the investment which maximizes

/the minimum

the minimum profit (minimax criterion). But this is only one of the many possible criteria (e.g. the minimum risk criterion, the pessimistic-optimistic criterion and the theory-of-games criterion).

In a case of uncertainty, it is possible to go beyond the confining limits of conventional investment calculations when weighing the decision to be taken. While the often preeminent importance of safety should be emphasized, consideration might also be given to the advantages of flexible investment plans, adaptable to unforeseen contingencies. In many respects the results obtained coincide closelv with the processes applied in practice. According to Dr. Schneider, however, the conventional processes should be used when the available information so warrants. Here, as well as in all cases where the safety of the enterprise is at stake, the maximization of investment profit should be tempered with the need for safety in so far as these two factors may conflict.