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Notes on the Development of the Criterion in a Mathematical Model Designed for Decision Making on the Selection of Investment Objectives in an Industrial Branch

An essential part in investment optimization is played by the development of the function-criterion: the finding out of an index for as accurate an estimation of investments as possible.

As the investment is an expenditure defrayed at the present time out of the net profit of past periods and with outcomes to be obtained in the future, the development of a limiting criterion in relation to time is not enough for estimating the investment. Here are two examples: the optimum utilization of a certain amount of the net profit resulting from past periods and designed for investments, or the full turning to account of the currently available material and human resources. The index used in characterizing the return on investments is to be highly synthetical and most generalized.

Western economists approach the subject of return on investments especially from the entrepreneurial viewpoint. As a result, there is a widespread idea among these economists according to which the fundamental criterion for grounding the estimation of an investment is to be considered the *profitability level*. Let I be the investment volume and P_n the net profit obtained through the operation of the objective during the year n, then the profitability level can be computed from the following equality:

$$\sum_{n=0}^{+\infty} \frac{P_n}{(1+p)^n} - I = 0 \qquad (1)$$

The actual significance assigned to p is: p is the profitability level for which there is no chance of loss included in the investment, nor is there any profit.

In case we assume the investment objective to last T years, the relation becomes:

$$\sum_{n=0}^{T} \frac{P_n}{(1+p)^n} - I = 0 \tag{2}$$

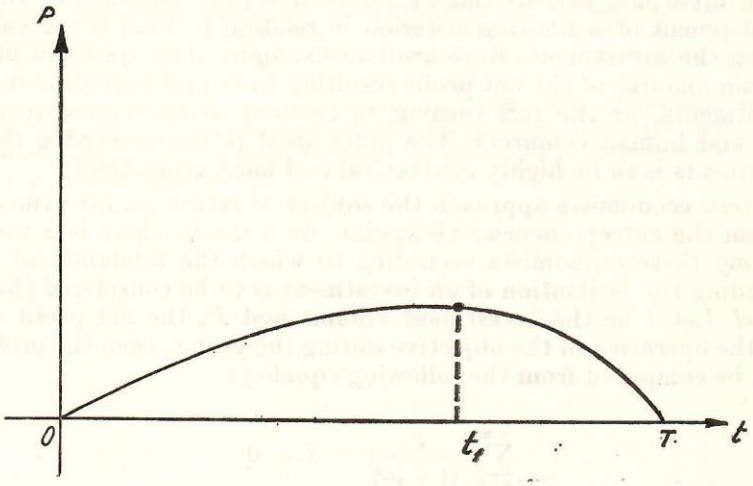
while in case of a permanent investment objective we have:

$$\int_0^T P(t)\ e^{-pt}\ dt - I = 0 \tag{3}$$

Obviously, the residual value after period T has elapsed is not taken into account. Function $P(t)$, representing the net profit to be obtained at time t, is shown in Fig. 1.

It is clar that within the interval $[0, t_1]$, the function is increasing ($P'(t) \geqslant \geqslant 0$), while within the interval $[t_1, T]$ the function is decreasing, ($P(t) \leqslant 0$). At $t = t_1$ we have a maximum.

As a definition, *the profitability level is a discount rate* peculiar to each investment alternative. Profitability as such allows only its own estimation. In order to select one out of the available alternatives, the profitability *levels* pertaining to each alternative are mutually compared and, on the other hand, they are also compared to the current discount rate. This discount rate can furthermore be considered as the bank interest rate. Considering the basic goal of any private entrepreneur — namely the achievement of the highest possible profit — the bank interest is the lower limit of the profitability level. The profitability *level* can never possibly be accepted at or under the interest rate, as by depositing the money in a bank, a higher or at least an equal profit



is obtained, with less risk, however, than if the same amount of money is invested in another business: industrial enterprise, trading, etc.

Consequently, the discount rate of investments made at various times also includes a "risk premium" whose value depends on the time they are tied up, besides the current bank interest. In the United States where the discount rate varies between 15 and 20 per cent, where the risk premium amounts to two thirds up to three quarters of these figures (i.e. 10—15 per cent). This rate is significantly affected by the geographic area, by the country or by the branch for which it is set up, as well as by the prevailling economic circumstances.

In our opinion, this position is caused by the way the concept "productive" is perceived: in the capitalist economy, any action yielding profit is productive. As a result, it makes no difference to the private entrepreneur how capital investment is made on condition it provides an "acceptable" profit rate.

It would be misleading to think that under socialism profitability is exempted of its role as an estimation criterion for the economic activity. The experience gained through the socialist construction and, above all, the experience gained during the socialist construction in the Socialist Republic of Romania, has shown that profitability of enterprises is further playing a significant part in the development of production activity. However, it has ceased to be a purpose "per se".

An essential feature of the socialist mode of production is described by the maximal economy of social work. There is a unanimous agreement in this sense among economists in socialist countries on the basic economic criterion for appreciating the production activity in general, and for investments in particular. This criterion is termed as *savings in social work consumption.*

How is it possible to retain this index within a formula so as to provide a strict substantiation for the mathematical relationship, as well as a precise economic interpretation of both the relationship as a whole and the elements used?

In the economic practice in the socialist countries, various efficiency indexes are used.

Thus, in the Polish People's Republic an index of return on capital investments is used, with the simplified formula:

$$E = \frac{\frac{1}{T} \times J + K}{P} \tag{4}$$

where

E = the index of economic return on investments;
T = the standardized time limit for investments recovery;
J = the investment volume;
K = current annual production costs;
P = the useful effect of investments.

The result of this ratio can be interpreted as a time for the recovery of *expenditures required for obtaining production* out of the useful effect of the investment. In the official Polish methodology, the useful effect of investments means the results obtained by utilizing the production funds, namely those results which serve well determined requirements of society. The useful effect of investments is then, above all, the volume of production or of services.

As can be seen, this formula succeeds to include within a single index both equivalent costs and the production volume achieved by the enterprise through a specific project alternative.

In the Hungarian People's Republic, two indexes referring to economic efficiency are used:

$$E_1 = \frac{M_1 - M_2}{B}, \tag{5}$$

$$E_2 = \frac{P - A}{B + M \times K_m}, \tag{6}$$

where:

E_1 and E_2 = investments' sparingness;
$M_1 - M_2$ = savings in the annual volume of wages and salaries accomplished through the investment;
B = investment volume;
P = annual increase of overall output;
A = the value of raw materials, other material resources and fuel used in obtaining the production increase;
M = the annual amount of wages and salaries associated to the production increase;
K_m = the specific investment used for freeing manpower.

Formula (5) shows the annual savings achieved from wages and salaries, related to one investment unit. By using formula (6) it is possible to find the value increase of the net annual output with respect to one investment value unit, in order to extend production and free manpower. In other words, in Hungary, the economic effect of investments in direct relation to savings obtained in wages and salaries is pursued. It is interesting to note that in the official methodology one does not speak about economic effectiveness' determination, but of investments' sparingness instead. This does not reflect a merely formal side of the question but its contents, as in Hungary effectiveness is considered as a synthetic concept. Thus, the ascertainment of investments' sparingness assumes the quantitative estimation of manpower costs used for the development of well determined capacities, set up in order to meet social requirements.

We consider that between the "sparingness" index, used in Hungarian methodology and the "efficiency" index used in the methodology common to other socialist countries, there is, however, a certain equivalence, particularly through the principle on wich their calculation is based: a comparison among results obtained through investments and the necessary expenditures for the attainment of those results.

In the economic practice of several socialist countries, such as the People's Republic of Bulgaria, the Czechoslovak Socialist Republic, the Socialist Republic of Romania and the U.S.S.R., in order to find the economic return on investments, the indexes "time limit for the investment recovery" and "the absolute economic efficiency coefficient" are more frequently used. In view of comparatively estimating two or more alternatives of an investment project, the formulas used for the equated costs are based on these two indexes. Equated costs are expressed as:

$$T_n \times C + I \tag{7}$$

or

$$E_n \times I + C \tag{8}$$

where:

T_n = the standardized time limit for the investment recovery;
E_n = the standardized absolute economic efficiency coefficient;
I = the investment value;
C = annual production costs.

Although the equated costs index is accepted in the official methodology, some economists show a critical attitude towards this index, particularly concerning the meaning associated to elements T_n and E_n and the incommensurability of C and I, especially in formula (8).

The recovery time limit is considered by these authors as an element inadequate for providing the relationship among annual production costs and the investment. Due to the different essence of C and I, some authors think that formula (7) is not adequate as against its contents, even if the formula in which this ratio is used, is structurally right.

Investments are made only once for the achievement of the established objective, while production costs are made gradually, during the entire lifetime of this objective. The other formula expressing the equivalent expenditures is additionally criticized on the ground of its being limiting, as it examines the problem only for a single year, while the investment exerts its effect over several years.

By more carefully analyzing the elements included in formula (8) and first of all the standardized absolute economic efficiency coefficient, it is possible, however, to emphasize some interesting aspects.

The absolute economic efficiency coefficient results from the ratio of accumulations (profits) achieved through investments and the value of those investments. In order to determine the best possible investment alternative out of a set of potential alternatives, we first apply this standardized coefficient to the investment value associated to each alternative. By taking into account how E_n is calculated, the product $E_n \times I$ stands for an accumulation, with regard to the economic content, since it is a value created in behalf of society, or more specifically, ,a standardized accumulation (profit) volume which has to be obtained as a result of that particular investment.

Indeed, we have:

$$E_n \times I = \frac{\text{standardized accumulations}}{\text{the standardized investment volume}} \times \text{investment volume} = \text{accumulation volume according to a standardized accumulation rate.}$$

Keeping in mind this assumption, what will the economic purport of the index known as "equivalent costs" be?

The sum $E_n \times I + C$ is the summation of a certain accumulation volume and the production costs required for producing it.

This sum can be interpreted as an *annual price* of the output achieved as a result of investment I. The alternative associated to the lowest "annual price" will obviously be considered as being more desirable since, according to this formula, it requires the lowest social work consumption.

Several economic problems interfere here, whose satisfactory solution is not possible through this index.

The first contradiction appears between the concept of savings on social work consumption and the "annual price" of production. A lower "annual price" indicates that the respective alternative requires less absolute effort as compared to another one. That, however, is all and there is nothing more to be inferred. This is certainly not enough for a criterion designed to help selecting one investment alternative instead of another one. The fact that an alternative having a lower „annual price" is selected does not imply that this alternative is also the most efficient one, as the actual savings achieved in social work consumption may be cancelled by the higher subsequent costs of maintenance, manufacturing, sales, etc.

Keeping in mind the decisive significance of current economic development for the future one, the savings achieved on social work consumption must, in our opinion, be viewed as they develop in the long run. In this sense, a more expensive investment with a higher efficiency, however, is more favourable than a cheaper, but less efficient one.

From this point of view, in our opinion, the above-mentioned index is not conducive to an information useful for decision making in the selection of an investment alternative.

A second important efficiency shown by the "equivalent expenditures" index is that it gathers by summation two elements whose achievement during the production activity leads to two exactly opposite trends. Thus, on the one hand we have production costs which are to be minimized, while on the other hand we have accumulations which must be maximized. As things are, the sum of these two elements gives rise to contradictory interpretations. Indeed, an alternative with higher production costs and lower accumulations can be judged as being more efficient than another one, because the sum costs + accumulations is lesser in the first than in the second alternative.

The selection of one investment alternative out of a set of potential alternatives can be made by comparing the accumulation whose achievement is predicted, with that corresponding to the standardized accumulation rate.

That is, the subtraction

$$A - E_n \times I \tag{9}$$

which must be a maximum. Here,

A = the total annual accumulation volume predicted to be achieved;
E_n = the standardized absolute economic efficiency coefficient;
I = the investment volume.

It is thus possible to rank the various alternatives according to the accumulation volume which can be achieved in excess of the standardized accumulation. At the same time, a decision on utilizing the investment volume at the national economy level is feasible, such that by achieving all investment objectives aimed at, the highest overall accumulation volume can be ensured.

By using this way of ranking the investments, the contradictions generated by formulas (7) and (8) are overcome. In our opinion, the use of formula (9) is all the more necessary as at present, within the entire economic efficiency problem, much attention is bestowed on indexes such as: profits, cash accumulation, profitability. Any economic activity and, above all, material production must be profitable, it must lead to the uninterrupted improvement of the ratio between achievements and social work consumption. The acquirement of increasing profits is considered as one of the basic elements of our country's manysided progress. Consequently, the part played by profitability in the economic activity is also changed; this is not a private issue to be dealt with by the various enterprises but a basic problem of the entire society.

Taking into account the peculiar aspect emphasized by expression (9), we think it would be advisable that accumulation be used as a criterion in the mathematical decision models regarding the selection of an investment alternative. By using either the total accumulation or the profit alone, we can in addition incorporate the savings in the social work consumption e. g. : cost savings.

It is advisable to set up the standardized economic efficiency coefficient for each separate branch, not for the national economy as a whole. Distinctions peculiar to each branch can thus be taken into account, as well as their specific economic conditions of production.

A sound basis is at the same time provided for a comparison of project alternatives. Within the national economy, the various production branches have a different economic efficiency. The computation of a single index for the entire national economy means a levelling of some actually rather dissimilar efficiency values. As a result, investments in branches characterized by a lower efficiency may be inconsistent with the standardized efficiency index and thus it is better not to make them, a fact which may have negative consequences on securing a proportional development of the entire national economy. These drawbacks are overcome by separately computing the standardized efficiency coefficient for each branch.

A special part is played by the time factor in estimating the economic return on investments. This factor affects the carrying out of expenditures — for investments and production — as well as the obtaining of incomes.

As a rule, the carrying out of expenditures is an intrinsic objective feature of the investment alternative agreed upon, of the adopted manufacturing technology, of the given budgeting conditions. By spreading out the investment expenditures in the construction or in the manufacturing stages over the whole year, funds are tied up during the operating stage. The periods during which funds remain tied up vary according to the time at which the expenditure is made. Thus, for an investment with a specified amount and duration, it is more favourable to plan the weight of expenditures towards the end of the period, as in this case there is a shorter time during which funds are tied up. Moreover, it is more favourable to place the weight of manufacturing

costs as near the time that the product is sold and its equivalent value is achieved as possible.

A planned economy creates a great many opportunities for steps to be taken in order to facilitate the economic return on investments increase. For this purpose, the socialist state avails itself of the economic plan, where the economic activity developed on a national economy scale is correlated. Moreover, it provides a high degree of stability for expenditure forecasts, as a result of the stability of prices within the price system utilized in the socialist economy.

The price fluctuation in the capitalist economy results in less knowledge of future expenditures, consequently the forecasts referring to them are uncertain.

The time factor also affects incomes, by the fact that the faster cash is collected, the faster will the funds used by the supplier in manufacturing the products sold be recycled in the economic circuit. At the national economy level this means that there exist additional opportunities to raise the national income.

It is highly important to know as precisely as possible the dates when funds become available for production, in order to be able to organize it in connection with the setting up of a sound working schedule, with decision making for a new investment, etc. Here again, the advantages of socialist economy are obvious, for a strict correlation of the income and expenditures can be achieved by means of the plan, so that the optimum utilization of the financial resources can be secured.

In order to find the economic return on investment, the expenditure has to be balanced against the income. Usually, their terms fall on different dates. In order to make them comparable it is necessary to discount them at a pre-established date which represents a reference basis. Most often one uses either the starting time of the investment or the implementation time of the objective which has been set up. Thus, the efficiency computation will include the effect of the invested good's duration as well. This is not a physical duration, but an economic variable which depends on the current and future economic circumstances. Among the factors which characterize these economic circumstances, we can mention: the technical progress, the development of the structure and volume of demand, price dynamics, etc. These factors change the place and role of the investment per branch and in the national economy, and implicitly, affect its economic efficiency.

The inclusion of the influence of the duration of the invested good in the efficiency computations is carried out by using the discount method. It is most advisable to use this method because it gives a highly accurate picture of the economic process under investigation and implicitly increasses the accuracy in efficiency estimation.

Here is an example: for the accomplishment of investment I there are two possible project alternatives:

— in alternative A, the investment value is 980 measuring units; the project secures the investment recovery in seven years and an annual net profit amounting to 60 measuring units;

— in alternative B, the investment value is 1000 measuring units; the project secures the investment recovery in four years and an annual net profit amounting to 100 measuring units.

The absolute efficiency coefficient is 0.429 in the first case, while in the second case it is only 0.4. Disregarding the effect of the time factor, the first investment looks more favourable, all the more as it also requires a lower initial financial effort.

With a discount rate of 5 per cent, the net profit for the first alternative would be 362 measuring units and 371 measuring units for the second. Consequently, there is also a change in the absolute efficiency coefficients, namely: 0.369 in the first alternative and 0.371 in the second.

We can see that the time factor has a decisive effect on the results. By taking it into account, the second alternative appears the more favourable of the two, since it enables the redemption of funds in a shorter period, making it possible to re-use them in the economic circuit.

Taking the time factor into account, we can correct formula (9) by using the discount method. In this sense, the following formula can be used:

$$\sum_{k=1}^{Tn} \frac{A_k - \frac{E_n \times I}{T_n}}{(1+R)^k} \tag{10}$$

where:

A_k = the accumulation volume during year k;
T_n = the standardized lifetime of the investment object;
R = the discount rate;
I = the investment volume.

From the above we can conclude that the value of the discount rate must be equal to the average annual planned rate of increase of the national income. It is desirable to formulate the function-criterion of the decision model, i.e. the selection of an investment, by assuming the utilization of the basic investment as well as by assuming the utilization of the total investment (the basic investment plus the secondary investments). On the use of the first or of the second assumption will depend the selection of one or of the other project alternative as the best. It is necessary that the results of both assumptions be known, in order to more accurately estimate the economic effort that society must make to develop the national economy.

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CONCERNANT L'ETABLISSEMENT D'UN CRITERE DANS UN MODELE MATHEMATIQUE DE DECISION SUR LE CHOIX DES OBJECTIFS D'INVESTISSEMENT DANS UNE BRANCHE INDUSTRIELLE

L'article concerne certains problèmes se rapportant aux critères d'efficacité des investissements. On apprécie que, pour établir correctement l'efficacité, il est nécessaire de tenir compte aussi de l'influence du facteur temps . C'est-à-dire, d'apporter au même moment les éléments valoriques avec lesquels on travaille. C'est pourquoi on fait une analyse critique des indicateurs d'efficacité utilisés à présent, avançant des arguments pro et contre. Aussi, on fait l'analyse critique des formules au moyen desquelles on exprime les dépenses équivalues . Dans la dernière partie de l'article on propose une formule de calcul de l'efficacité des investissements qui inclue en même temps l'élément qui introduit l'actuel.

ОБ УСТАНОВЛЕНИИ КРИТЕРИЯ В МАТЕМАТИЧЕСКОЙ МОДЕЛИ РЕШЕНИЯ О ВЫБОРЕ ОБЪЕКТОВ КАПИТАЛЬНЫХ ВЛОЖЕНИЙ В КАКОЙ-ЛИБО ОТРАСЛИ ПРОМЫШЛЕННОСТИ

В статье затрагиваются некоторые вопросы критериев эффективности капитальных вложений. Считается, что для правильного определения эффективности необходимо учитывать и влияние фактора времени в направлении приведения к одному и тому же моменту стоимостных элементов, которыми работают. В этом отношении производится критический анализ применяемых в настоящее время показателей эффективности и приводятся аргументы за и против. Критически рассматриваются также формулы, при помощи которых выражаются «приведенные расходы». В последней части статьи предлагается формула расчета эффективности капитальных вложений, в которую включен и элемент актуализации.