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EVALUATION OF PROJECTS IN CENTRALLY PLANNED ECONOMIES

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Introduction

The United Nations General Assembly in Resolution 1525 (XV) recommended that the Committee for Industrial Development should, inter alia:

....1.a) review the methods and techniques of programming general industrial development which have evolved from different countries and regions, and contribute to international cooperation in this field;

b) work out general conclusions on the basis of the experience of industrial development in all countries with a view to promoting the exchange of experience in the field of industrial development between countries of different regions and having differing economic systems;...

This is a preliminary draft of a study prepared by the Research and Evaluation Division for submission to the Committee for Industrial Development. It deals with the methods used and practical problems of industrial project evaluation in the Centrally Planned Economies (CPE).

The particular interest in reviewing the experience of the Centrally Planned Economies in the above-mentioned field stems from many reasons. In the first place, in spite of differences in institutional and political structure, the problems faced by the Centrally Planned Economies at the inception of their industrialization plans were in many respects similar to those currently faced by developing countries. In the second place, both types of countries, for different reasons, were unable to base their industrial development policies and methods upon this historical experience when experience of industry developed largely under the stimulus of the marked and developed Western countries price mechanism. In the third place, and for reasons which are related to the former considerations, the developing countries were faced with the extremely difficult and little explored problem of elaboration of "social" criteria of investment. In this respect, experience of the Centrally Planned Economies offers an interesting area of study.

It can be taken for granted that the use of adequate methods in project evaluation is of particular importance in the Centrally Planned Economies because of the centralized nature of the decisions on investment allocations. This is, however, a complex task and while a great deal of progress has been accomplished in the area of problems of evaluation there is still much to be done.

While the general criteria of investment allocation are clear enough the technique of formulation of adequate operational criteria and methods for use in evaluation of each particular investment project raises complex theoretical problems. A number of different criteria of project evaluation have been proposed, such as the "synthetic" index of economic effectiveness of investment, the marginal national income-investment ratio, the criterion of profitability and certain other techno-economical indices. It can be stated, however, that more and more economists in all these countries tend to favor the "synthetic" index of economic effectiveness of investment. This is also reflected in the new Official Instructions concerning evaluation of industrial investment projects. Bearing this in mind, attention is centered in the present study to the description and development of the "synthetic" index of economic effectiveness of investment.

In line with this present tendency in the Centrally Planned Economies toward the increasing use of synthetic index, there is a great deal of discussion under way in the economic literature of the Centrally Planned Economies concerning the interpretation of the theoretical basis of this index, namely the model of economic growth.

Different theoretical concepts are currently being widely tested in the practice of investment analysis. Two tendencies can be detected at the present time: one is to improve the methods of evaluation of individual investment projects by taking into account in the computation of "synthetic" index more and more economic factors; the second is to evaluate investment projects in the context of larger systems consisting of a number of such projects.1/

Owing to the above-mentioned tendency to use a uniform index in project evaluation attempts are being made now to extend the use of the "synthetic" index to international comparison of investment projects mong the Centrally Planned Economy countries; this aspect of investment efficiency analysis is, however, still at the beginnings. There are still considerable difficulties to overcome in such international comparisons; in particular, the problem of different economic structures and price levels.

1/ Some sophisticated mathematical models of investment efficiency analysis, including sectorial allocation, have been elaborated in the Centrally Planned Economies (especially in Poland, the Soviet Union, Hungary). So far, they could be hardly considered as operational devices.

It should be noted, that along with the problem of efficiency criteria parallel discussion is going on with regard to the price problem. The two problems are complementary and mutually supporting. The improvement of the analysis of investment efficiency criteria stimulates and advances that relating to the price structure and vice versa. It was not, however, possible to deal with this aspect of the analysis as well as with the role of the price structure in investment analysis in this paper.

Some examples have been presented in Appendix I in order to illustrate the scope and method of application of the "synthetic" index of economic effectiveness of investment in project evaluation. Appendix II gives the description of the modifications which the index of economic effectiveness of investment must undergo when an investment project is built up by stages.

2/ These examples are borrowed from the book, "Effectiveness of Investment, issued in Poland - 1961 - and in simplified form presented in Annex I.

I. Historical Outline

Over-All Patterns of Development and Investment Policy

At the inception of their industrialization plans the Centrally Planned Economies were at rather different stages of industrial development. In spite of marked differences in industrial development and in general economic conditions, they pursued during the last decade rather similar economic policies with regard to both the development patterns and the ways and methods of running the economy. This can be explained, to some extent, by certain common features of their economic situation, but also by the similarities in their political and institutional structure.

The social and economic reforms carried out in the Centrally Planned Economies at the early stages of their planned development made it possible for the central authorities to control income distribution and foreign trade and to control directly the allocation of capital investment; they also paved the way to the application of comprehensive planning. While, the institutional arrangements made it easier to launch and implement programmes of accelerated development, the economic problems faced by the governments were in many respects similar to those of the developing countries throughout the world.

A most salient feature of the economic situation of the Centrally Planned Economies, before they engaged in policies of accelerated industrialization, was the structural disequilibrium between the labour resources on one hand and the available capital on the other. It resulted in low level of utilization of manpower, low labour productivity, and consequently low living standards of the people. This was the most important basis for the policy of high capital investment which was carried on throughout the period of post-war economic development by all these countries.

Since in the Centrally Planned Economies the central authorities control income distribution through wages and prices and decide directly upon the bulk of total investment expenditure of the country—over 90% of the total in the European Centrally Planned Economies—the factors influencing the share of investment in national income are different than in the free enterprise economies. Generally speaking, the Centrally Planned Economies tend to determine the volume of capital investment at a high level. In development planning as well as in current economic policy all the factors which determine the upper limit of investment possibilities are taken into account and the investment volume is set at that level.

Technical absorbtive capacities constituted for a long time the largest bottleneck in expansion of capital investment and were, therefore, the most important factor in determining the upper limit of investment possibilities. The long-run solution of this problem consisted in developing capital goods industries, in practically all the countries. In order to increase investment capacities in the shorter run by way of foreign trade, import substitution was promoted wherever possible. Less emphasis was put on export expansion in earlier periods though this has changed in recent years.

While during the first development periods investment capacities were the most important factor determining the volume of capital investment, in the later periods considerations of consumption levels and income distribution have grown in importance. The propensity to save of the private sector does not play an important role in the Centrally Planned Economies. Nevertheless, social factors and particularly social attitudes towards current consumption levels and income distribution patterns played an increasingly important role in determining the upper limit of the share of investment in national income.

On the whole it can be stated that it is not the propensity to save and invest but the physical and economic limitations that influence the volume of investment in the Centrally Planned Economies. Therefore, the policy of high investment was pursued by way of bringing about structural transformations of the economy rather than by provision of incentives to save and to invest.

Creation of favorable structural conditions for a fast and steady growth through expansion of the countries" investment capacities determined the policy followed in allocation of investment. Thus, emphasis was put on:

a) preferential treatment of direct productive investment against unproductive investment,

b) fast expansion of domestic capital goods industries

as can be seen from these tables:

Table 1 Distribution of investment outlays (total=100)

Countries		Total investment outlays	Productive investments	of which Industrial sector	Agri- culture	Unpro- ductive Invest- ment	of whi resident construc
Bulgaria b/	1950-1955	100	79.0	52.4	10.2	21.0	3.7
	1956-1960	100	84.6	59.7	12.4	15.4	2.6
Czechoslovakia	1950-1955	100	63.7	41.7	10.8	36.3	11.5
	1956-1960	100	69.4	40.0	16.3	30.6	16.2
Poland	1950-1955	100	70.5	45.0	9.4	29.5	12.2
	1956-1960	100	68.9	41.5	11.6	31.1	18.7
Rumania	1950-1955	100	80.6	55.8	10.9	19.4	4.4
	1956-1960	100	80.3	51.1	17.6	19.7	6.1
Soviet Union	1951-1955	100	75.5 a/	46.5	17.7	24.5	14.1
	1956-1960	100	71.7 a/	42.0	18.3	28.3	11.6

Source: B. Zielinska, "Industrial Investments in Socialist Countries" in decennium 1950-1960 Gospodarka Planowa 3/1962.

Note: Productive investments cover investment outlays in industrial sector, agriculture, transportation and communications, trade, and material supply.

a/ estimates
b/ state investment outlays

Table 2 Distribution of investment outlays in selected industries, 1956-1960

	Investment outlays in heavy industry as rati to those in light and food industries	Investment outlays in metallurgy as ratio tc those in machine build ing industry	Investment outlays in chemical indus- try as ratio to those in metal work ing industry
Bulgaria	4.32	2.26	0.59
Hungary a/	6.83	1.63	1.24
Poland	4.56	0.89	0.87
Rumania	8.03	2.30	1.73
Soviet Union b/	8.37	0.62 c/	0.30

a/ 1957-1958
b/ 1952-1958
c/ only ferrous metallurgy

Capital intensity considerations were disregarded in the choice concerning structural transformations. On the other hand, the relative abundance of labour was taken into account in other fields, with an aim to maximizing output and particularly to increase output of capital goods (and exportable commodities).

Labour intensive techniques were used mostly in the following fields:

- in capital works,
- in the existing plants (by maximum utilization of existing capacities),
- to a lesser extent, in choice of techniques of the new plants.

Looking at the patterns of investment policy of the Centrally Planned Economies from the point of view of the relative scarcities of labour and capital, three main categories of problems may be distinguished:

1. Labour-intensive techniques were applied in all cases when they did not influence techniques in the longer run and did not affect the desired structural transformations of the economy. Labour-intensive techniques in construction works and multi-shift operation of plants are most typical of this category.

2. Much more caution was exercised as regards application of labour-intensive techniques in new plants, whenever the choice of equipment predetermined the level of technology for longer time periods.

In industries considered most important from the point of view of economic growth, the general tendency was to choose the most advanced techniques, while in industries of secondary importance more labour-intensive techniques prevailed. Even in the high priority industries, however, the policy of high capital intensity was not applied uniformly. In these industries high capital-labour ratios were generally applied in those productive processes where such ratios were more or less technologically fixed; that is, where the standards of quality and uniformity of products could not be maintained with any other combination of factors. In some countries, for instance, in such a high-priority industry as machine building in-factory transportation, handling of materials, quality control and several other ancillary operations were almost entirely manual.

The scarcity of skilled labour was another factor which, apart from technological requirements, prompted the use of capital-intensive methods in high priority sectors. Even where more labour-intensive methods could be applied, the maintenance of quality standards would have required a much greater supply of highly skilled workers than was available at the earlier stages of development.

3. In the case of certain major structural problems of investment allocation which played an important role in increasing a country's investment capacities in the long run, the question of capital intensity was disregarded.

2. Stages of Development and Investment Analysis

The methods of investment analysis in the Centrally Planned Economies were developed together with the evolution of their economic situation and in accordance with the development strategy followed during the various development periods. They were shaped by the pressing practical needs and had to respond to concrete and changing situations. It is only in more recent times that the economic theorists entered the field and attempted to develop more rigorous methods of investment analysis.

In the first post-war period all the Centrally Planned Economies undertook the reconstruction policy aiming at restoration of the pre-war industrial potential. In that period the field of economic choice in the investment policy was very narrowly restricted—mainly to the time schedule of reconstruction of the various plants. An over-all appraisal of investment capacities played a very important role. The concentration of the bulk of total investment expenditure in government's hands enabled the realization of the planned time-schedule. Overhead facilities—transport and electric power—were first on the priority list. Serious limitations in foreign trade made it necessary to proceed in the reconstruction of industry according to the needs of the technological interrelationships. Material balances were very helpful in this respect since they made possible the elaboration of internally consistent investment programmes, taking into account the existing capacities.

High effectiveness of investment in reconstruction, taking advantage of external economies, was one of the factors calling for rapid expansion of investment capacities. Therefore, emphasis on capital goods industries became apparent already in this development period. The ratio of investment to national income was growing appreciably, though by and large without negative impact on the living standards of the people.

By the beginning of the last decade most of the Centrally Planned Economies entered a new development period—the period of accelerated industrialization. This period was different in almost all respects from the first one. ~~The scope~~

There was a wide scope of economic choice for the shape of a new economic structure which aimed at creating favourable conditions for long-run economic development.

As intimated above the most serious problems appeared in economic choice concerning the volume of capital investment and the share of investment in national income. Appraisal of the institutionally acceptable saving ratio and of the countries investment capacities for many years ahead proved to be a most difficult problem which could not always be solved correctly. Realistic assessment of the cost of investment projects included into the programme was another difficult problem, since miscalculations in this area are likely to come up and in some cases did lead to serious consequences. Programming techniques by themselves are of little help in solving these two problems.

Full utilization of existing industrial capacity and a co-ordinated programme of new projects were two principles followed in investment programming.

In most of the Centrally Planned Economies the initial phase of accelerated industrialization was conceived as one which should establish the foundations for expansion of the capital goods industries and diversified industrial development. The main emphasis was therefore put on development of energy, raw materials and semi-products. Under this concept of development only general consideration was given to the place of a given country in world economy and the world trade. Further development made it necessary, however, particularly in the case of smaller countries to appraise investment projects also from the point of view of foreign trade.

This phase of accelerated industrialization was characterized by a fast increase in the investment income ratio. This rapid growth was made possible, first of all, by fuller utilization of the existing economic resources - labour resources and existing industrial capacities. 4/ The rise in the investment ratio was, however, brought to a halt after a few years. It encountered serious bottlenecks in investment capacities and, in some countries, social disturbances. Since also by about the same period - or a few years later - many of the new, big, industrial projects were completed, the countries entered a new development phase.

4/ By means of multiplying shifts, raising of labour intensity in ancillary

The new development period, accompanied by reappraisal of many concepts and strategies applied in the past, can be defined as one in which the Centrally Planned Economies achieved, by and large, the conditions for rapid long-run growth. Though for a few countries further acceleration may still be considered as desirable, most of them achieved a rate of growth based on a generally stabilized ratio of investment to national income.

The new period is marked by a transition emphasis - from a phase of highly dynamic structural changes accompanied by a drive for utilization of latent resources to that of more rational allocation of resources. The latter implies a greater emphasis on economic calculations in investment analysis.

Evaluation of investment projects

In the earlier periods, when the investment needs, namely the needs of increase of capacities in a given field, were ascertained investment solutions were sought by a comparative analysis of the various possible alternatives. The comparative analysis of investment projects was conducted using techno-economic coefficients. These covered detailed investment and current input data for each industry as regards raw materials, different types of labour force, power, fuel, etc. and specific technical parameters of performance. Particular attention was given to capital/output coefficients.

Since techno-economic coefficients have played an important role both in planning and project evaluation, they were very carefully assembled and evaluated by planning agencies and various projection organizations.5/ They were generally expressed in physical units, and are still very much used to evaluate economic advantages of different technologies, sizes of operation, etc., and for selecting the most appropriate engineering solutions.

In the course of time it became apparent that this method of evaluation was inadequate for the purpose of evaluating such problems as reconstruction of existing plants versus establishment of new plants or evaluating import substitution and export promotion projects.

5/ The experience of Czechoslovakia and of East Germany deserves special attention in this field.

The comparison of two or more alternatives is easiest, technically, in terms of techno-economic indices. In such cases, project maker is faced with homogeneous indices. But this method has its limitations in terms of evaluation of alternatives. In such cases, the project maker is faced with the evaluation of such alternatives as, for example, a lower output per worker rate and higher input of raw materials. 6/ In such cases the natural tendency was to use actual or devised prices as weights, investment alternatives being compared in terms of two indices: investment outlays and operating costs. It was soon realized, however, that these more generalized indices (i) depended heavily on the structure of prices, (ii) left open the problem of substitution between capital outlays and current operating expenses, and (iii) did not take into account the impact of the tie-up of investments during the construction period, technological progress, etc. Attempts to override these difficulties in comparing investment alternatives led to supplementing the method of techno-economic coefficients by an appraisal of investment projects, based on assessment of total outlays in value terms. This so-called "synthetic" coefficient applied for project evaluation takes usually the form of a relation between total investment and operating costs and output:

$$\frac{I/T \quad I + C}{P}$$

T = recoupment period (normative)
I = investment cost
C = operating cost (annual)
P = volume of output (annual)

The point of departure in forming a synthetic index is, as we will see later, a treatment of possible substitution between labour and capital.

The methods of dealing with the other factors mentioned above (e.g., tie-up of investments technical progress, time-pattern of production and current expenses) differ often from country to country.

This method of evaluation was initially applied for separate investment projects only, with an aim to finding the best techno-economic solution to a given investment target. The synthetic coefficients were also usefully compiled and compared for a number of projects within a given industrial sector (e.g., coal mining, power generation, etc.). An investment alternative

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6/ The output of steel per open-hearth worker in 1958 was 613 kg., in the German Democratic Republic and 544 Kg. in Poland, whereas the average daily steel output per square meter of open-hearth floor was 4.57 tons in the G.D.R. and 5.09 in Poland. Thus the indices adduced are contrais regarded as economically effective if its "synthetic" index is higher than that of any other alternative.

The research on and the methodology applied in the evaluation of the economic effectiveness of investment was based on the implied assumption of a "closed" economic system. This was due to the fact that (a) foreign trade in the USSR is relatively small although increasing in relevance from the point of view of investment choices; (b) the strategy of industrialization has been essentially autarchic in the initial periods and (c) the general independence of the domestic prices from world market prices because of the central control of prices and state monopoly of foreign trade.

Volume of exports and imports per capita[a]
(in rubles)

	1950	1960
Bulgaria	34	133
Hungary	62	177
Eastern Germany	43	227
Poland	49	85
Rumania	25	67
Czechoslovakia	104	250
USSR		47[b]

a/ Economic efficiency of foreign trade, B. Zotov, G. Shatalov, Ekonomiczeskaie gazete, 24/XI, 1962.

b/ The reply of the USSR to the United Nations Questionnaire on Industrial Planning and Development.

However, because of the rapid expansion of foreign trade, particularly in the smaller countries, it appeared necessary to introduce further refinements to those coefficients. The refined coefficients indicated first the import-content of exports or the optimal stage of processing of exports. Extensive research was also begun to bring in into the efficiency check the differences in the foreign exchange implications of the investment variants. Analysis of the import substitution and export promotion projects called for a certain reformulation of the above coefficient. A further refinement consisted in evaluating "systems" of projects. This brought about a greater degree of sophistication into the methods of investment evaluation.

Along with the improvement of the methodological tools of project analysis, there appeared other developments in the Centrally Planned Economies. More and more emphasis was put on medium and long-term planning as against short-term planning. Elaboration of long-range development plans - covering a planning period up to 1980 - in all the Centrally Planned Economies had important repercussions on investment analysis in the individual industrial sectors. The Centrally Planned Economies have also developed systems of spatial coordination and geographical planning. Thus, each investment project is being considered within a system of both sectoral and spatial connections. Last, but not least, is the development of a network of projections offices and industrial scientific institutes. The projection offices have developed in particular a great store of pre-investment data for various alternatives,

II Institutional Background

In the Centrally Planned Economies as has been stated the socialist form of ownership - state and cooperative ownership - is predominant, and due to this fact, planning covers the whole of the national economy. Such a plan of the national economy is a programme of action that coordinates i) information, ii) forecasts and iii) directives concerning output and capital formation for the plan period.7/ The objectives for the development of the country's economy are elaborated by the Planning Commission and quite often presented in several versions which are discussed by competent technical and political authorities.

The elaboration and discussion of the alternative versions make possible the adoption of the plan which best subserves the policy objectives of a government and is suitable to the specific conditions of a country. The targets in the plan provide the main skeleton of the plan which is subject to endorsement by the Parliaments, as in the case of medium-term plans, and is subject to approval by the Councils of Ministers in the case of perspective or annual plans.

Three basic types of plans are being elaborated - according to the time horizon covered:

1. <u>long-term expansion plans</u> for 15 or 20 years, sometimes called <u>Perspective Plans</u>. This sort of plan lays down the most general perspectives for the development of the national economy. Such plans - 20 years - are already elaborated or in the process of being drawn up.
2. <u>medium-term expansion plans</u>. The 5-7 year plans are a more concrete statement of the objectives of the Perspective Plan for a 5-7 year period of time. They are often considered as the main form of economic planning in the Centrally Planned Economies.
3. <u>short-term</u> - mainly annual - <u>working plans</u>. The annual plans specify economic tasks for a year's period of time in line with the provisions of the medium-term economic plan.

7/ In countries where private sector - e.g. agriculture in Poland - still plays some role, the plan also comprises means of planned regulation of this non-socialist sector.

All these types of plans are subdivided and coordinated for sectoral and geographical levels. Thus, plans are broken down and then coordinated according to the objective, time span and the structural - i.e. organizational - setup of the country as a whole. In the process of formulating a plan, particular attention is paid to one of the most important components of national economic plans viz. the investment plan. Its importance—which is proportional to the length of the time horizon of the plan—is owing to the fact that the Investment Plan is aimed at increasing productive capacities - a necessary condition of steady growth of an economy - ensuring necessary proportions among sectors, branches, and regions of the national economy in the process of its growth, and securing optimal progress of technology.

The Investment Plan comprises targets in regard to the commissioning of fixed assets, amount of gross capital investments which is in turn broken down into (a) construction and assembly work, (b) equipment and tools and (c) other capital work and expenditure, and lists of capital investment projects - these include general techno-economical description of projects.

The concrete volume and structure of gross capital investments in the industrial sector are determined - in practice - on the basis of the evaluation of investment possibilities - appropriate balances - according to the following criteria:

i. assumed increase of output in the course of a longer period of time - plans of outputs,

ii. analysis of the degree in which the existing output capacity has been made use of - output capacity balances,

iii. designing studies and cost estimates of individual productive projects - efficiency analysis.

Thus the aggregate of the social demand and the available production capacities to meet them are being taken as a point of departure. As needs always exceed in a growing economy available production capacities, the margin has to be covered by means of new investment.

In the industrial sector, the best suitable instruments for establishing investment requirements are the capacity balances. The investment requirements are inferred from the comparison of the output possible on the basis of the existing capacities - at the maximum degree of their utilization - with the planned targets.a/

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a/ The way on which industrial programme is formulated is not discussed here. Investments and increases in the production are planned at fixed - non-rising - prices.

Thus, volume of industrial investments depends mainly on established targets for industrial production. These, in turn, depend upon executed economic policy.

In the past, following principles might be observed as to the development of industrial sector:

1. An attempt to achieve such a volume and the structure of industrial production which would insure a steady and high rate of growth of the national economy.

2. To achieve the higher degree of self-sufficiency within the production of means of production. 9/

3. Accelerated development of backward regions consistent with rational use of country's natural resources.

4. Ensuring of national defense.

Once the given investment decision has been taken involving, for instance, the development of the cement industry, there remain two essential tasks of a planning-administrative nature: one is to choose the size of the capacity of cement factories and the number to be built; the other is to organize the actual work of construction.

The task of preparing blue prints, estimating costs, comparing between alternative projects and submitting possible variants to higher authority for decisions if necessary is undertaken by specialized "project-making (designing) organizations" which exist, e.g., in the Soviet Union at all-union, republican, Sovnarkhoz, and local levels, specializing in projects for particular types of construction. 10/ These organizations play an important role in the practical implementation of investment programmes. The problems of choice between investment alternatives to be discussed in the following chapter are weighed up in these offices and technical recommendations are made by them.

Besides the analysis of a particular investment project carried out by the project-making organization itself, such a project is analysed again by either a special commission or experts' group at the proper approving level

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9/ Recently this principle is being reformulated. Benefits from international division of labour within Centrally Planned Economies are underlined.

10/ In some other countries the project-making organizations are attached to the ministries, but usually located in the districts where the industries for which they prepare projects are concentrated.

enterprise, ministry or Council of Ministers. In the last case, the commission is usually attached to the State Planning Bureau.

The project also needs the approval of the Territorial Administrative Unit which is responsible for the development of the region within which this investment project is to be built. The Territorial Administrative Unit, of course, analyses investment projects from the standpoint of the optimal development of its region. Since the basis of such analysis is supposed to be a regional plan of social and economic development, this fact necessitates the elaboration of regional and city plans.

Financing of industrial investment projects is effected by means of budget endowments, bank credits, and internal resources of enterprises - proceed from profits and sinking allowances not transferred to the budget. The scope of investments financed from various sources is governed by rather detailed regulations. The general principle is that own means and bank credits serve to finance reproducing and modernizing investments undertaken on the basis of decentralized decisions.

The major part of investment in the state sector is financed by non-returnable budgetary grants. However, a sizeable and increasing share is financed from the enterprises' own resources, primarily from a portion of profits, and the amortization. With minor exceptions, these sums are transferred to specialized investment banks, which issue them when and if the expenditure is justified by the investment plan, or, in the case of extra-plan investment expenditures, when they fall under the regulations governing them.

The extent to which the planning process is centralized has varied considerably in the Centrally Planned Economies history. From this standpoint, investments in the state sector can be divided into several categories. There is, first of all, the distinction between "above-limit" and "below-limit" investments. Investment projects of a value exceeding a certain sum[11] must be approved by the centre, while those below these value limits do not require approval separately, but form part of aggregate sums allocated for investment purposes to the given sector.

11/This has varied between economic sectors and at different periods.

There is also a somewhat different distinction between centralized and decentralized investments, the latter being confusingly designated vnelimitnjie- "beyond limit".

Centralized investments are those covered by the central investment plan, and include "below-limit" investments if expenditure on them is provided for in the plan. Decentralized investments are financed from sources not covered by the plan at all, such as, for instance, the enterprise fund, projects of local industry or "mechanization" credits from the State Bank. The extent of decentralized investments was severely restricted at some time in the past. In recent years, however, their importance has again increased.

Of course, these "unplanned" investments are by no means uncontrolled12/ There are restrictions on the types of permitted investments; for example, in the Soviet Union a decree in 1958 forbade local investment in certain types of construction- offices, sport stadiums, etc.- without the special authorization of the republican government. Again the control over allocations of materials and equipment provides a further means of preventing diversion of resources into forms of investment not desired by the authorities.

An unavoidable condition for the most efficient use of a given investment fund is creating such a system of incentives that would stimulate to restrain investment propensity of all economic units - enterprises, etc. - to actual needs - planned expansion of production - to choose the best technological variants, and to shorten as much as possible the time of the construction and commissioning of industrial projects.

It is well-known that up to now the system of incentives in Centrally Planned Economies has produced the tendency of excessive investment demand. Under recent practice, an enterprise was stimulated to greater production by the enterprise fund. If an enterprise fulfilled its plan, its fund was increased e.g. from one to six per cent of the total profit. The profit on the mere fulfillment of the plan was minimal--it made itself felt only when

12/ The cost of investment projects is carefully controlled. Based on prices of materials, machinery and labour, on centrally-approved norms - e.g. of depth of foundations or thickness of walls- and when possible on approved architectural pattern, costs estimates-smety-are approved, and form the basis of the issues of money by investment banks.

the plan was exceeded. Only then could the director, who managed the fund, utilize the fund for greater investment or increasing the wages e.g. of the lowest paid workers. The central authorities increased the plan goal every year in the light of the past year. This means that the fund created by production, which exceeded the plan directive in the current year can be substantially reduced for the following year. Since this was the only fund available to stimulate the enterprise, the mechanism began to produce results completely contrary to expectations. The directors in order to maintain their funds made every effort to obtain from the higher authorities either a reduction in assigned plan fulfillment or additional investment funds. More or less the same motives prevailed at the higher levels. The current organizational changes in Centrally Planned Economies aim at substitution of the above-described mechanism by a more adequate one.

In order to choose the best technological variant of a given industrial project, it is necessary to have correctly devised criteria of economic effectiveness of investment and effective system of incentives to stimulate the elaboration by project-making organizations of more than one technological variant for a given industrial project. Permanent excess of demand for project-making organizations' work forces Centrally Planned Economies to look for such substituting solutions as comparison between variants at the very first stages of their elaboration and obtaining of more technological variants at least for some parts of a given project - partial alternatives. In addition to material incentives for project-making organizations to prepare more technological alternatives, there exist also systems of material incentives to encourage these organizations in preparing the most economical technological variants for a given project. The history of material incentives for shortening the construction period of a project would require a separate and lengthy chapter and is beyond the scope of this paper.

III. EVALUATION OF ALTERNATIVE SOLUTIONS

1. The scope and character of investment alternatives.

One of the most important requirements which has to be met in the course of an elaboration of a long-term expansion plan is the setting of, besides the rate of growth, the pattern of the consumption and investment. This requires the determination of a programme of production for the economy as a whole and for particular sectors (e.g. industrial,[13/] agriculture, transportation, construction, etc.), economic branches and commodities.

First draft of such a programme(s)[14/] of production serves, in turn, as the base and the point of departure to the elaboration of the first draft of investment programme, inter alia also for the industrial sector. Using capital-output ratios (for all branches of industrial sector) it is possible to get the first sketch of sectoral allocation of capital investment.[15/] If the programme of production for the industrial sector were to be regarded as definitely fixed, then the essential part of the programme of investment (i.e. sectoral allocation of investment) would be in principle determined. It follows that in such a situation planning authority would have free choice only in respect to:

i) building the new plants versus modernizing and expanding the existing plants in different branches of industrial sector;

ii) capital- or labour-intensity of particular investment projects;

iii) location of investment projects.

However, in the long-term especially perspective plan, a given set of production targets even on the level of individual goods represents, indeed, only the "general pattern of consumer and investment needs" which is planned to be achieved.

13/ In the Centrally Planned Economies, the concept of industry covers manufacturing as well as electric power generation and mineral industries. In the context of this paper the term industrial sector is used to cover these activities.

14/ The final programme of production is achieved in the course of successive iterations in the optimizing and balancing process. Due to this fact, the technological matrix of the national economy is adjusted through the substitution of more abundant for scarcer resources.

15/ "Capital-output coefficients are applied mainly in the course of the elaboration of first variants of long-term plans" - The Reply of the Polish government to the United Nation Questionnaire of Industrial Planning and Development. For details of the method of determining capital-output ratios see: "The method of determining capital-output ratios", V. Krasovski, V. Pomerancev, A. Tolkaczev, Planovoe Khoziastvo, 6/1962.

Taking into consideration feasibilities of satisfying the same kind of "consumer and investment needs" by different goods, and possibilities of expanding of foreign trade, there exists more alternative solutions to meet a given "planned structure of consumer and investment needs". The choice of one or another solution depends, first of all, upon investment analysis and economic calculations.

Investment analysis is carried on in the Centrally Planned Economies within the framework of plan elaboration,[16/] although not only within it. Studies are being carried out for various industrial branches for certain complex intersectoral problems, for regional systems, for separate new projects for the existing plants. etc. The work on these problems does not always coincide with the procedure of plan elaboration. Investment analysis is considered a task of the various planning agencies and of other bodies -projects-making bureaus, industrial scientific institutes, etc.- which should be performed on a continuing basis.

In the process of plan elaboration -of the 5 year plans and of the perspective plan- full account is taken of the various investment studies, and many new studies are being initiated. Particular attention is paid to projects to be included for the first years of the plan. Projects for further years may not always be studied in detail; work on them will continue during plan execution, and all necessary changes introduced into the plan.

It seems appropriate to present the scope and character of investment analysis not within the framework of plan elaboration but rather according to certain levels of investment analysis. The following main levels of investment analysis can be distinguished in the Centrally Planned Economies:

I. Programming of the industrial sector as a whole and as a part of the national economy. Most of the problems involved here belong to general planning rather than to investment analysis proper. There appear, however, certain intersectoral problems which are analysed with the help of methods appropriate for investment analysis.

II. Programming of an industry and analysis of larger industrial systems.

III. Evaluation of individual projects and of small groups of connected projects.

16/ The calculation of the effectiveness of capital investments is supposed to be an integral part of planning at all levels e.g. in the U.S.S.R. from the State Planning Committee to the economic councils and enterprises.

IV. Evaluation of partial engineering solutions.

Evaluation of real investment alternatives covers different problems at each level.

I. Although, in principle, the allocation of capital investments among industries in the industrial sector is not determined in the practice of the Centrally Planned Economies by quantitative analysis of economic effectiveness of investment.[17/] there are, however, important exceptions to the general principle of non-evaluation of economic effectiveness of investment of allocation of investments among different sectors and industries.

This evaluation is strongly recommended in selecting the branch of production to meet a definite requirement of the national economy when there are several branches producing similar or interchangeable goods. In these cases, effects of investing in different industries are easily comparable e.g., in physical units of substitutable goods or in foreign currency. Such substitutibility of effects, and in consequence, legitimate use of economic effectiveness of investment quantitative analysis in inter-industry studies, appears whenever:

a. industrial outputs are substitutable, i.e., may satisfy similar consumer or producer needs - e.g., oil vs. coal -;

b. projects aim at promoting exports or reducing imports, i.e. of earning foreign currency;

c. increase of output in producers' goods in some industries allows for economies in other industries, implementing successive stages of transformation of raw materials into final products;

d. projects aim at saving labour, raw materials, and energy.

17/ "The standard methodological rules proceed from the premise that the allocation of capital investments among branches of the national economy for the purpose of their balanced and proportional development, with the priority growth of the production of the means of production is decided on the basis of the balance sheet method of planning. At the same time, the choice of the most effective ways of solving the problems set should be made with due account for the economic effectiveness of the capital investments." Tipovaja metodika p. 10

Thus, it is evident that many important inter-industry issues can be quantitatively evaluated within the framework of the economic effectiveness of investment analysis.[18/]

II. In the stage of elaborating a "general" programme for an industry, efforts are concentrated on selection of the optimum combination of existing and anticipated new productive units. They are considered as one complex - an industry - in such a way that combined expenditure for combined industrial effects be at their minimum. Before final quantitative evaluation, different alternatives of development are carefully considered in a series of inter-related studies such as:

a. Detailed descriptions of all plants actually operating in this industry; determination of their actual capacities and outputs, labour productivities, technical and economic coefficients.

b. Alternative prospects of reaching optimum sizes of individual plants; enumeration of plants to be liquidated because of physical deterioration, of economic obsolescence; alternative combinations of productive units - existing and new plants - aiming at reading planned capacities in adequate time and with optimum economic effects.

c. Analysis of main raw materials and kind of energy used.

d. Analysis of regional aspects of different alternatives of development.

In all those studies quantitative methods of analysis are used along with qualitative considerations.

18/ There is also another important correction to the principle of non-evaluation, quantitatively, the economic effectiveness of allocation of investment resources among alternative industries.

This correction is the result of the analysis which takes place in the next stage; namely, "industry programming" i.e. when combining re-equipment or expansion of existing plants with construction of new plants is considered in such a way that an optimum organization and an optimum path of development of an industry could be ensured, meeting targets established in long-term plans. Very often conclusions reached in those extensive industrial studies are used for improving plans e.g., if investment - direct and indirect - required for development of an industry proves to be substantially under-estimated or over-estimated in the long-term plan - this conclusion is likely to result in target changes of the long-term plan. This evaluation of economic effectiveness of investment of internal distribution of industrial targets within a particular industry, as an indirect effect, necessitates change even in investment allocation between sectors and branches.

III. In elaborating a programme of an individual plant, evaluation embraces usually:

a. Choice of the optimum size, kind, assortment and quality of output with due attention paid to specialization, existing and anticipated co-operation of plants;

b. Choice of technology, of new materials, of fuel and power;

c. Choice of location - general and specific - and of the type of geographical co-operation. Very often evaluation is carried on jointly for two or more closely combined projects.

IV. When these solutions are sufficiently evaluated—in the stage of project engineering, the analysis concentrates on the choice of the following solutions suggested by project engineers:

a. Final choice of the level of technology and of the organization of the plant;

b. Choice of specific location and evaluation of its territorial consequences;

c. Choice of adequate construction and gestation periods, etc.

A special type of analysis constitutes "evaluation of economic effectiveness of developing and introducing new technology". This type of capital investment differs from typical industrial projects:

1. They are usually less capital intensive and consist mostly in re-equipment or smaller expansion of existing plants;

2. They are carried on, on a practically continuing basis, in all industrial plants;

3. Methods of evaluating and introducing those technical innovations must be very simple and applicable in several thousands of smaller and bigger plants.

Experience of the Centrally Planned Economies in investment analysis on various levels has demonstrated that the choice of the scope of analysis of particular problems is of great importance. Once the scope of analysis is chosen, the various alternative solutions are elaborated for it, and comparative analysis and evaluation undertaken. Attention is paid to select and appraise all real, relevant alternative solutions appearing in the analysed field.

Formulation of a scope for which alternative solutions are considered is a first important step in investment analysis. While in earlier periods investment analysis was most often limited to various alternative solutions of single projects, there is a strong tendency towards analysing larger systems. For example, the thermal power plants are analysed within a system embracing coal mines, transport facilities, transmission lines, etc. Projects using large quantities of energy (e.g. aluminium plants) are analysed together with power plants, etc. Whenever possible the impact of a plant on utilization of capacities in other fields (other industrial plants, transportation facilities) is considered. Foreign trade is introduced into the analysed systems whenever it is a real alternative in one respect or another.

While on the level on project analysis there is a tendency to embrace larger systems (groups of closely connected plants and various necessary facilities), this work is carried out on paralled with the work on higher levels embracing still larger sectoral or intersectoral systems. Here again, choice of the scope of analysis for which alternative soltuions are considered is of great importance. The systems formulated for analysis have to be manageable and cover all important problems of economic choice appearing in the economy and connected with the analysed field. The analysis of larger systems is carried on irrespectively of the organisational subdivision of the various projects and related fields.

2. Role of economic calculation

Evaluation of the above-mentioned alternative solutions is an important theoretical and practical problem in an economic system of socialization of practically all industrial capital. The state assumes in the Centrally Planned Economies both the right of and the responsibility for adequate allocation of investment resources directly or through its enterprises or semi-autonomous co-operatives. The rate of growth of the national economy and, consequently, improvement of standards of living depend to a large degree on the success of the most effective allocation of investment. This is also a difficult theoretical and practical problem. On the one,hand, "social" effectiveness of investment depends on numerous factors, not only economic, but also extra-economic (political, humanitarian, or military); not only quantifiable, but also difficult to quantify or simply unquantifiable, not only actual but also anticipated. Thus, elaboration of the most appropriate methods of project evaluation requires both extensive scientific research and long industrial experience.

On the other hand, in past practice, investment decisions had to be taken currently without delay, by planning agencies, government authorities and industrial organizations (especially at the 3rd and 4th level). Projects had to be elaborated, approved and implemented even without sufficiently satisfactory economic analysis. Lack of sufficient economic analysis was never considered as an argument for slowing down the rate of capital expansion. The role of both quantitative and qualitative considerations in the making of investment decisions had not been clearly defined.[19/] This created serious methodological disturbances and lengthy theoretical discussions.

At present, this aspect of the problem of economic effectiveness of investment appears to be settled in most Centrally Planned Economies. A need for quantitative criteria is generally recognized. Offical "Standard Methodologies" recommend use of definite quantitative criteria.

"A quantitative analysis is a fundamental tool of economic effectiveness of investment evaluation and a necessary evaluation for selecting investment decisions most advantageous for the national economy. It consists of an analysis of all quantifiable aspects of constructing and operating a plant-to-be, as well as of their appraisal from the angle of reducing to a minimum the total expenditure of social labour. Thus, quantitative analysis comprises both specific calculations and synthetic evaluation of all inputs and effects."[20/] Although quantitative analysis of the economic effectiveness of investment does not exclude nor replace qualitative considerations it is, however, an obligatory part of analysis even in the case when inquantifiable economic or extra-economic factors prevail in justification of investment necessity. In those cases, quantitative analysis is not an exclusive basis for investment decisions. Therefore, the project selector is now under obligation to check alternatives from the point of view of "comparative efficiency". It is this which is his principal guide, and <u>ceteris paribus</u> it is decisive.

19/ There were various reasons for this attitude. It rested largely on the view, dominant if not necessarily made explicit, that in a socialist society preferences in general, and time preferences in particular, are multi-angled; and that they do not lend themselves to useful quantification, let alone reduction to a common and simple basis of measurement.

20/ Polish Instruction.....<u>Instrukcja Ogolna</u> - (1960)

An attempt is made, from now on, to summarize Centrally Planned Economies' practical experience in the utilization of different quantitative expressions of economic effectiveness of investment. This attempt must be considered as preliminary, as both extensive practical experience 21/ and scientific research in this field is still continuing. 22/

It can be observed that in this research three leading methodological principles are widely accepted:

1. Criteria used for evaluation of economic effectiveness of investment of particular projects should comply with macro-economic criteria, especially with such principal criterion as maximization of national income in the longer run.

2. Criteria of economic effectiveness of investment for particular investment projects should be applied within certain restrictions imposed upon them and derived from the general economic plan or economic analysis carried out on higher levels.

3. Desirability and necessity of transition from simpler to more complicated 23/ models of economic growth of planned economy from which criteria of economic effectiveness of investment of industrial projects are derived.

In the light of the above principles, it is not surprising to find in the practice of project evaluation of Centrally Planned Economies:

1. employment of similar quantitative criteria on all levels of investment analysis;

2. attempts to rely mainly on a "synthetic"index which would uniquely determine the superiority of one alternative over another.

3. Basic form of synthetic formula

Since, as it has been said, the allocation of capital investment aims at maximization of national income of determined structure, -i.e. relative proportions of important commodities in the final output - the task of evaluation of economic effectiveness of investment is reduced, in principle, to choice by means of comparison of one out of various investment variants (solutions) bringing about equivalent effects from the point of the national economy.

21/ This practical experience is currently published in several engineering and economic periodicals.

22/ Most important scientific contributions are listed in selected Bibliography Appendix.

23/ i.e. taking into account more and more factors influencing rate and pattern of growth.

Bearing in mind such an assumption, the issue which must be regarded as an essential in the evaluation of economic effectiveness of investment is a choice of proper level of technique of a given investment project. Attempts to quantify the difference among alternative variants from that point of view have enabled laying down the basic and simplest form of synthetic index of economic effectiveness of investment.

The differences between two investment variants might be presented, in economic terms, in the form of rate of substitution between the additional investment outlays [24] and eventual decrease of production - operating - costs.[25] As the latter can be reduced to labour, this rate of substitution might be treated as the <u>individual marginal</u> rate of substitution between labour and

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24/ The term of "investment" consists of three elements in the Centrally Planned Economies:
- <u>direct investments</u>, i.e. outlays directly connected with completion of the particular project;
- <u>ancillary (associate) investments</u>, i.e. works that are not directly connected with the core of a project such as electric installations, railroad sidings which are normally planned and executed by organizations independent of the industrial ministry supervising the main undertaking.
- <u>indirect investments</u>, i.e. all those additional investment outlays that must be made to supply the requisite amount of inputs to a project plant once it will be working at capacity. Among the first-order linkages of this sort, may be cited the expense of expanding coal output to supply coal for new thermal plants - an important consideration in choosing between hydroelectric and thermal power - and the cost of adding capacity to the cement industry in order to furnish the concrete needed for building dam sites for hydroelectric projects. It is an important feature of calculations of economic effectiveness of investment in the Centrally Planned Economies that "ancillary" investments, irrespectively of the enterprises or other economic organizations which pay for them, are included into calculations. It is not a common rule, however, that "indirect" investments are included into calculations. In this respect the problem is partly solved by analyzing larger systems. Besides, only in cases when one alternative solution brings real savings of investment indirectly connected plants (or other facilities), savings are included into calculations in the form of "indirect" investment.

25/ Operating costs are to be considered and anticipated for the whole operation period. They usually include costs of maintenance and capital repairs but they do not include depreciation allowance.

investment.[26/]

This implies, of course, an assumption of a simple two-factor production function. It is rather a drastic abstraction from reality since in the Centrally Planned Economies, in rapid developing economies, certain raw materials and intermediate goods sometimes constitute acute bottlenecks which cannot be ignored when techniques are selected. This is a reason why Standard Methodologies also recommend other yardsticks in the choice-making process besides the use of a synthetic index. We refer here mainly to the use of indices in physical terms -techno-economical indices - such as input of fuel, power, and other materials per unit of output, output per unit of equipment, etc.

26/ Some authors, especially in the USSR, proposed also to take into consideration in the choice-making process something like the average rate of substitution.

Thus far, they say, designing and economic calculations have limited the estimate of recoupment in the different variants only to additional capital outlays. Yet, in many cases the magnitude of additional investments in one of the variants is insignificant as compared with the total volume of investments in all variants. The calculated magnitudes of recoupment of the additional investments are not characteristic of the total period required for the recoupment of all capital investments. There may be cases in which the additional investments are recouped in a short time, while the period for the recoupment of all outlays will be long even in the best variant. Thus, whereas the recoupment of partial investments in mechanization and automation in the iron and steel industry may take about a year or year and a half, the recoupment of all investments, according to data of the State Institute for Planning Metallurgical Enterprises, takes from ten to eleven years. That is why for planning puposes, it is the recoupment of all investments that acquires great importance and not recoupment of partial outlays. The period of recoupment of all investments is determined by calculation of expected saving as against the average cost of production in the given branch or as against the sales prices -if the latter conform to the average cost of production in the branch-. Yefimov, A. and Krasovskii, V. On Planned Indices of Economic Effectiveness of Capital Investments in the National Economy of the USSR.

In order to explain in what way capital-labour substitution forms the basis of synthetic index, it is convenient to assume two different variants of an investment project where: - production of each variant is the same in the sense used in the first paragraph;

- $I_1 < I_2$; I_1 and I_2 are investment outlays in the variants being compared;
- $C_1 > C_2$; C_1 and C_2 are the production - operating - cost of the annual output in these variants;
- T is the period of recoupment of the additional investment outlay or individual marginal rate of substitution between capital and labour;
- E a reciprocal of T is in the terminology used in Centrally Planned Economies, the coefficient of comparative effectiveness of capital investment.

Both T and E are determined by comparing the assumed variants - they might be: existing and newly planned plants, both planned variants, two types of new technology -.

$$\frac{I_2 - I_1}{C_1 - C_2} = T \text{ and } E = \frac{1}{T} = \frac{C_2 - C_1}{I_2 - I_1} \qquad (1)$$

If there were, for instance, another pair of investment variants and given a restricted amount of investment funds the period of recoupment may be used as an important criterion for selecting economically effective variants of investment.

Taking into consideration:

1) an almost infinite number of investment variants in the growing national economy;
2) that investment decisions have to be taken without delay, especially as was stated at the 3rd and 4th levels of investment analysis by thousands of state officials and project engineers, there is a necessity to estimate <u>ex ante</u> the social-marginal rate of substitution between labour and investment[27] which can be used as an

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27/ It assumes some uniquely determined, increasing function of average "capital-absorption" in the economy depending on the average productivity of labour in the new projects. For a given volume of investment resource set aside in the plan and a given labour force, a value of T corresponding to optimal levels of "capital-absorption" and labour productivity would maximize national income. It denotes a state of techniques corresponding to equilibrium in the labour market, with a given volume of investable capital and a postulated rate of increase of output.

important guiding criterion of choice of most effective alternatives of investment throughout the national economy.

It would mean that if

$$\frac{I_2 - I_1}{C_1 - C_2} < T \quad (2)$$

(where T is now the social-marginal rate ob substitution[28/] which can be used as a "normative")variant with characteristic I_2 and C_2 is the effective one.

28/ It seems that T computed in accordance with one of the methods proposed in the U. has a different nature. According to it, an approximation of T might be reached on the basis of either past or planned investment—saving in operating cost ratio, i.e.:

$$T = \frac{I}{(C_1 - C_2)P_2}$$

where: I = investment outlays in a given period (e.g. 5-year).
C_1 = unit operating costs (excluding depreciation allowances) in the first year of a period;
C_2 = unit operating costs (excluding depreciation allowances) in the final year of a period;
P_2 = output in the final year.

This proposal's authors hold the view that T computed in this way, both for the industrial sector as a whole and various industrial branches, gives valuable information about development trends of the economy and techniques and therefore should be an influential factor in determination of the investment policy.
A doubt has been raised, however, as to the sufficiency of T so computed as the investment criterion. This concept of T seems to bear close resemblance to what was earlier called average rate of substitution. In this place it should be mentioned that there does not seem to be an accord with regard to an interpretation of the recoupment period in various centrally planned countries.
Only poles rely explicitly on the interpretation of T with the help of relative scarcities of labour and capital.

The economic meaning of this (2) formula is clear. Additional investment outlay cannot be accepted, if it is not recouped by sufficient economies in operating costs, because in other sectors or branches of the economy the same investment outlay may bring about better economic results.[29]

In this sense the recoupment period (T) may well be interpreted as a kind of accounting price for capital.

Formula (2) can be expressed also as

$$\frac{I_2}{T} + C_2 \text{ or } I_2 + TC_2 < I_1 + TC_1 \quad \frac{I_1}{T} + C_1 \qquad (2a)$$

In general, among many alternatives this one—say i—is considered to be the most effective for which the expression

$\frac{I_i}{T} + C_i$ or $I_i + TC_i$ is the lowest one or is the minimum.

Bearing in mind that each variant of a given project brings about the same output, the planner and project-maker are supposed to minimize the expression

$$\frac{I \cdot \frac{1}{T} + C}{P} = \text{minimum} \qquad (3)$$

where P = annual production, i.e. if they consider several variants giving the same P, the best is the alternative for which the numerator is the lowest. In such a basic form the synthetic formula—index—is the simplest device used for comparing various investment alternatives, taking into account relative scarcities of labour and capital. The results of the present stage of discussion on this matter can be summarized as follows:

1. There does exist some social-marginal rate of substitution between labour and capital, i.e. $T > 0$.
2. There does exist an <u>optimal</u> social-marginal rate of substitution which

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29/ However, it must be stressed again here that a given investment project is not necessarily dropped as a result of economic effectiveness of investment evaluation if the urgency for the project was established and confirmed earlier by a balance sheet analysis.

equal to $0 < T < A$, where A=period of amortization.[30]

To achieve an exact quantitative estimation of the social MRS—marginal rate of substitution between labour and capital—or in other words the standard period of recoupment is obviously impossible due to the fact of the existence of an almost infinite number of investment variants during the planned period under consideration.

An approximation to the marginal rate of substitution (T) has been arrived at e.g. in Poland, by means of a survey which is said to indicate that in the majority of cases replacement of an obsolete by an up-to-date industrial plant —buildings included—would imply a substitution rate of about five. Rough corrections were made for a few other factors, such as the saving on raw materials and transport and on the cost of transfer and urbanization of rural manpower. Finally, a value of 6 was adopted for T. In countries where a uniform standard period of recoupment prevails, it has been established in limits of 5-6 years—e.g. Hungary 5, Poland 6. It has been realized very soon in these countries, however, that the common fact of limited substitution and mobility of production factors should be somehow taken into account, either by setting different normative periods of recoupment for each branch and economic region or in some other way.

In some Centrally Planned Economies—first of all in the Soviet Union—the differentiation of T for branches and economic regions is conceived as an important instrument to ensure preferences of planning authorities. Since T's level influences, undoubtedly, investment decisions left to lower echelons,

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30/ In this long discussion, two extreme positions have been refuted.

Those who postulated minimizing capital/output i.e. those who advocated the least capital intensity of the process of reaching the targets (T=0), laid themselves open to the charge that their criterion cuts across the path of technological progress and results in waste of labour force. Clearly this could not be accepted as a principle of economic policy.

On the other hand, those who advocated minimizing current costs/output (T=A) ignored an important question in running the developing economy—the shortage of capital and in a sense this means a waste of scarce investment funds. True, they could point out with prima facie good reasons that in the current costs/output "index" the dividend by definition takes care of capital outlay, since it includes depreciation allowances. However, depreciation allowance per unit of output amounts as a rule to very little, while in the planned economy, the absolute magnitudes of capital involved in this or that project are of paramount importance.

its differentiation is being used to bring these autonomous investment decisions in line with tasks formulated by central planning authorities. In general, according both to current practice and proposals raised, planning authorities in the Centrally Planned Economies can steer autonomous investment decisions <u>inter alia</u> by means of the two following methods:

(i) establishment of differentiated T's for branches and economic regions;

(ii) employment of differentiated coefficients in order to correct wages, prices, etc.[31/]

Although these methods by no means exclude each other, the first one is used most often in practice.

Among factors, which are taken into account differentiating T e.g. for branches, attention is most often called to the following:

1. Differences in pace of technical progress in various branches; branches with a higher rate have a shorter period of recoupment.
2. Differences in capital endowment; it is regarded that branches with high capital-labour ratio should have a longer period of recoupment.
3. Differences in capital longevity; it is said that plants with a longer period of operation should have longer periods of recoupment.
4. The importance of a particular branch for the overall economic development of a country; Longer periods of recoupment for those branches ensure preferences for extra progress of techniques.

These enumerated factors do not exhaust all that should be taken into consideration in differentiating T for particular branches. This problem is under current study.

Some countries which use, in principle, uniform T for the whole country allow its differentiating by means of quantifiable criteria. In Poland, for instance, introduction of the coefficient into the synthetic formula, taking into account the duration of the operation period, means, indeed, real differentiation of T. Preliminary computations proved that, for instance, in Poland where the uniform period of recoupment and the above-mentioned correcting coefficient are used, the obtained results do not differ substantially from those obtained in other countries where differentiated T is used. Actually,

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31/ The correction of the wage rate by means of an appropriate coefficient designed to reflect the availability of labour in a given economic region has been proposed in an instruction issued in Poland.

in most Centrally Planned Economies, normative periods of recoupment are 3-7 years i.e. coefficients of comparative effectiveness are established on the level of 0.15 - 0.3. Derived individual coefficients have to be better or at least equal to normative ones if the analysed variant is to be approved. An investment variant with "worse" coefficients--i.e. lower coefficients of comparative effectiveness or longer periods of recoupment--cannot be accepted unless in exceptional cases.

4. Development of synthetic index

Formula (3) represents the simplest, therefore basic, form of synthetic index of economic effectiveness of investment. As is well-known, investment variants differ not only in respect to substitution between labour and capital. So far the synthetic index has been gradually developed by taking into account differences among investment variants with regard to the problem of different patterns of gestation and fruition, i.e. i) extent of immobilization--tie-up or "freeze"--of investment during the construction; ii) the length of period of exploitation; and iii) time-shape of production costs during the period of exploitation.

It must be observed, however, that even this synthetic formula is a rather general one, which is changed or adopted to suit particular requirements of any system analysed. It cannot be applied indiscriminately and schematically for all cases.

Period of construction

In comparing investment variants, if they differ in the duration of construction, account is taken of the economic outcome of shortening or lengthening the period of building and commissioning.

Economic effectiveness of a particular investment variant depends heavily on its "construction period", i.e. on the scope of "immobilization" of the investment resources. It is obvious that longer construction periods imply simply longer periods of "immobilization"[32/] of investment resources employed in construction of a plant. This impact of duration of construction period upon economic effectiveness of investment of a given investment variant can be expressed in

32/ By the immobilization--freezing up-- period of particular parts of investment outlays during the period of construction is meant the period between the moment when such outlays are incurred and the moment when the object as a whole is put into operation.

synthetic index in different ways.

A. Mainly used in the Soviet Union

"Coefficient (I_{pr}), which takes into account the average effect that can be obtained in the given branch by the productive use of capital investments, is determined according to the compound interest formula:

$$I_{pr} = (1 + E)^t, \qquad (4)$$

where E is the normative coefficient of effectiveness in the given branch and

t is the period of time in years.

In cases in which the change in the period of construction is only a few years, coefficient I_{pr} can be determined according to the formula for simple interest:

$$I_{pr} = 1 + ET \text{[33]"} \qquad (4a)$$

B. Mainly in Hungary[34] and Poland[35]

The negative impact of the duration of construction period upon economic effectiveness of investment of a given investment variant is considered as proportional to the construction period itself and to the portion of investment realized in the period's successive years or months.

$$\sum_{t_o}^{t_b} I_t \, (t_b - t) \qquad (5)$$

33/ Tipovaje metodika. Recently V. Vybornov—"Ekonomiczeskaja ocenka faktora vremenii pri rekonstrukcji deistvujuszczich predprijatii", Voprosy Ekonomiki 8/1962—has exposed in detail a method very similar to that presented in B.

34/ "Vlianie srokov stroitelstva na effektirnost kapitalnych vlozenii", Mikosz Ajtai, Planovoe chosiastvo 10/1961. M. Ajtai expresses the cost of the "freeze" as an integral of a time function.

$$\int_{t_1}^{t_a} b\,dt$$

where t is the number of years, and b=f(t), the investment input. Then aiming at an operational approximation he deals with the problem substantially in the same way as Polish Methodology does.

35/ M. Kalecki, M. Rakowski "Uogolnienie Wzoru efektywnosci investycji," Gospodarka Planowa 11/1959.

where:

I_t = portion of investment realized in time "t" dating from the beginning of construction period.

t_b = construction—immobilization—period.

$I_t\ (t_b - t)$ = value of investment "immobilized" in time $(t_b - t)$.

This equation can be replaced by I n_z, where I = total investment. Then

$$I = \sum_{t=0}^{t_b} I_t \qquad (6)$$

The n_z is the average period of construction, i.e. of immobilization equal to:

$$\frac{\displaystyle\sum_{t=0}^{t_b} I_t (t_b - t)}{I} = n_z \qquad (7)$$

Now: $n_z = \frac{t_b}{2}$ when I is equally distributed in time.

$n_z > \frac{t_b}{2}$ when it is concentrated near the beginning of construction period.

$n_z < \frac{t_b}{2}$ when it is concentrated near its end.

What is the impact of immobilization on effectiveness of national economy? Assuming that an investment project is built instantly, it would produce, immediately, some new units of national income. It has been assumed that one unit of investment "produces" on the average q_n units of net national income. In such a case during the regular "construction period" additional national income produced by I would be $I \cdot q_z \cdot n_z$. Thus it may be considered that immobilization is responsible for a loss in national income equal to $I \cdot n_z \cdot q_z$ and that "real" investment costs of the project is equal not to I but

$$I\ (1 + q_z\, n_z) \qquad (8)$$

In such a case the basic formula (3) takes the form:

$$\frac{I \cdot \frac{1}{T}(1 + q_z\, n_z) + C}{P} \qquad (9)$$

There remains only the problem of calculation of "q_z", i.e. the value of net national income, "produced" every year by a unit of investment.36/

For the purpose of planning and control, the Centrally Planned Economies have elaborated the normative coefficients for the construction period which should be followed in investment planning for the various kinds of plants.

Operation period - an impact of technological progress

Variants of an investment project usually also differ from the point of length of productive operation. At the beginning of evaluation of economic effectiveness of investment in some Centrally Planned Economies, the period of operation in calculations was assumed equal to the physical life of the equipment. However, the necessity to take account of "moral" obsolescence of equipment caused by technical progress was more and more obvious.

Among quantitative attempts to deal explicitly with this question, two different methods can be distinguished:

36/ Whereas in Hungary q_z is assumed as equal to $E = \frac{1}{T}$ in Poland estimation of q_z is based on the following consideration:
If gross capital output ratio = m, then
national income "produced" each year by one unit of gross investment = $\frac{1}{T}$, and national income "produced" by one unit of net investment = $(\frac{1}{m} - v)$ where: v is a coefficient of replacement of fixed assets.

To increase the national income, however, it is necessary not only to invest but also to employ additional labour force. When the balance of labour force is in equilibrium, there is a need in some additional investment in order to "free" required labour force.

Therefore, an increase in national income equal to "d" can be obtained if:
(i) some direct investment equal to $m \cdot d$,
(ii) some additional investment equal to $(r \cdot d)$ in order to "free" the required force,
where: term "r" denotes real wage ratio
is employed.

Additional investment $r \cdot d$ requested in maximum acceptable recoupment period T would be $r \cdot d \cdot T$ and an increase of the gross national income to the amount of "d" units requires "additional" investment equal to $m \cdot d + T \cdot r \cdot d$. Under these assumptions, gross national income per year, produced by one unit of investment, is equal to $\frac{d}{m \cdot d + T \cdot r \cdot d} = \frac{1}{m + T \cdot r}$

Thus, assuming full employment it follows that:
- one unit of gross investment "produces" $\frac{1}{m + Tr}$ of units of national income,
- one unit of net investment "produces" $\frac{1}{m + T \cdot r} - v$ of units of net national income and that is q_z.

For Polish conditions, the following values were accepted for calculating q_z
$m = 2,5$; $T = 6$; $r = 0,5$; $v = 0,03$—depreciation amounts to 5% but it has been assumed to be 3% taking into account high rates of economic expansion.
Thus $q_z = \frac{1}{2,5 + 6 \cdot 0,5} - 0,03 = 0,15$.

A. In some Soviet industries the method of "discounting" outputs and operating cost is used. For instance, Standard Methodology for determining Economic effectiveness of Power Plants[37] recommends the following method:

"Par. 13. When capacity varies in function of time...variants may differ in the volume and timing of investment and operating costs in successive operation units. For making them comparable, investment and operating costs should be converted using:

(a) compound interest formula

(b) economic effectiveness of investment standard coefficient = 12.5% as the discount factor

(c) developed capacity period."

B. According to Polish Standard Methodology formula (3) and (9) were derived under the assumption of a period of operation equal to an average--so-called standard--period of operation within an industrial sector.

In the case when the anticipated operational period of the investment variant under consideration differs from the standard operational period n_s --in Poland n_s = about 20 years--it becomes necessary to make an appropriate correction with regard to both output and operating costs adopted in the synthetic index of effectiveness (9). This correction has been based on the reasoning according to which particular investment projects are treated as components of the investment process in the economy as a whole.

For this purpose, a conventional model of economic growth, pretty close to the real conditions, has been constructed; in this model:

(i) investment increases annually at a constant rate a percent;

(ii) operating costs increase annually at a constant rate c percent;

where: $c < a$ that is due to technical progress;

(iii) all newly built objects have the same period of duration of n years.

Under these assumptions, the value of Z_n—corrective coefficient for output[38/] and Y_n—corrective coefficient for operating costs[39/] as a function of n is

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38/ It has been assumed that every year some investments of average durability n years are carried on. These investments grow each year at the rate of a perce. Thus, if current investments are I, investments of the previous year are $\frac{I}{(1 + a)}$ and of year (n - 2) are accordingly $\frac{I}{(1 + a)^{n-1}}$

The value of fixed assets operating in year "n" equals the sums of investment completed during last years, i.e. equals:

$$M_n = \sum_{k=1}^{n} I \cdot \frac{1}{/1+a/^{k-1}} = I \frac{\left[1-/\frac{1}{1+a}/^n\right]/1+a/}{a}$$

If the capital output ratio is "m" output of existing fixed assets equals

$$F_n = \frac{M_n}{m} = I \cdot \frac{\left[1-/\frac{1}{1+a}/^n\right]/1+a/}{a \cdot m}$$

Output of an identical investment flow, but with standard period of operation n_s equals:

$$F_{n_s} = \frac{M_{n_s}}{m} = I \cdot \frac{\left[1-/\frac{1}{1+a}/^{n_s}\right]/1+a/}{a \cdot m}$$

Thus, output of the same investment flow changes in responses to change in operation period. Advantages of constructing plants with longer periods of operation than n_s is expressed by equation:

$$\frac{F_n}{F_{n_s}} = \frac{1-/\frac{1}{1+a}/^n}{1-/\frac{1}{1+a}/^{n_s}} = Z_n$$

Coefficient Z_n allows for replacing output of an investment alternative characterized by "n" years operating period by an "equivalent" output of a proje of "n" period.

39/ A longer period of exploitation corresponds to not only greater outputs' flow but also greater costs' flow. Identical equations for costs' equivalent by analogy with previous reasoning can be obtained:

$$Y_n = \frac{C_n}{C_{n_s}} = \frac{1-/\frac{1}{1+c}/^n}{1-/\frac{1}{1+c}/^{n_s}}$$

The only difference is in the value of "c" = discount rate for operating costs. Whereas outputs' flow increases at the annual rate of "a", costs increase, in comparison with previous years not by "a" %, but by a smaller rate "c"%, as a result of the successive reduction of operating costs per output unit in the more modern, latter built plants. In Poland "c" was assumed equal to 3% in comparison with an = 7%.

the following (in %):

n	5	10	15	20	25	30	35	40	45	50	∞
Z_n	38.7	66.3	86.0	100	110.0	117.1	122.2	125.8	128.4	130.2	135
Y_n	30.8	57.0	80.2	100	117.1	131.8	144.5	155.4	164.9	173.1	225

Note: It follows e.g. objects of a 20 years period of operation can be repla by objects of a 40 years period of operation, if, and only if, m--capit output ratio--increases no more than 25.8%

Thus, the Polish formula of effectiveness which brings values of P and C, referring to period n, to the standard period, assumes the following form:

$$\frac{I\,\frac{1}{T}\,/1+q_z n_z/ + C \cdot Y_n}{P \cdot Z_n} = \text{minimum} \qquad (10)$$

It is of essential importance for the understanding of the role of correc tive coefficients Z_n and Y_n to establish how the synthetic index of effectiven E changes as a result of their introduction for different operational periods, assuming all other parameters T, I, n_z, C and P are constant; in other words, how the index E = f(n) changes. It might be easily illustrated. For that purpose, it is convenient to present the formula (10) in the form of investment and cost component:

$$\frac{\frac{1}{T}\,I(1 + q_z n_z)}{PZ_n} + \frac{C}{P} \cdot \frac{Y_n}{Z_n} \qquad (10a)$$

The table below presents the values of the synthetic index assuming num values for the following parameters: T = 6 years; I = 200; n_z = 2 years; C = 1 P = 1.

	Operational period n								
	5	10	15	18	20	25	30	35	40
(1) $\frac{\frac{1}{T}\,I(1+q_z n_z)}{P\,Z_n}$	113,5	66,2	51,1	46,2	44,0	40,0	37,6	36,0	34,[illegible]
(2) $\frac{C}{P} \cdot \frac{Y_n}{Z_n}$	79,4	86,3	93,2	97,3	100,0	106,3	112,6	118,3	12[illegible],5
E = (1) + (2)	192,9	152,5	144,3	143,5	144,0	146,3	150,2	154,3	158,4

It follows:

(i) index of effectiveness is at minimum for the period of operation n=18 years, though the physical life of a given investment variant is equal to 25 years.

(ii) index of effectiveness is a function of n, i.e. $E = f(n)$[40]

For the sake of simplification of the calculation, the synthetic formula (10) is used in the practice in the form of a formula whose numerator is multiplied by coefficient b, that is, in the form:

$$E = \frac{(\frac{1}{T} J + C)b}{P} \qquad (11)$$

where: $J = I(1+q_z n_z)$ and the value for b[41] furnishes a special table.

For practical application synthetic formula (11) is recommended in the form:

$$E = \frac{= \frac{1}{T} J + C)b + S}{P} \qquad (12)$$

where operating costs appear in two positions (C and S), C means operating costs, without depreciation allowances, value of raw materials, other materials--and repairs[42]--are included in the amount of effectiveness as S which is the product of their own indices of effectiveness multiplied by the quantity used in production in a given object.

40/ It may be observed that out of the Polish formula there follows an optimal operation period which is a function--given the parameters--of relation between investment and operating costs: $\frac{I \cdot (1+q_z n_z)}{C}$. It is well acknowledged that the optimal operation period should depend on the rate of technical progress in each industry. The analysis of technical progress has not been sufficiently advanced yet to allow for formulation of different normative "c" 's--the rate of technical progress in the Polish formula is defined by coefficient "c". It is allowed, however, in practice to change the calculation on account of the rate of technical progress which is distinctly different from the general--normative--one.

41/ Coefficients b are chosen so that the value of the index in the simplified formula (11) is equal to the value of the index in the developed formula, i.e. $\frac{(\frac{1}{T} J+C)b}{P} = \frac{\frac{1}{T} J+CY_n}{PZ_n}$. This equation is fulfilled if: $b = \frac{\frac{1}{T} \cdot \frac{J}{C} + Y_n}{(\frac{1}{T} \cdot \frac{J}{C} + 1)Z_n}$

Thus, the value of "b" is definite for a given ratio $\frac{J}{C}$ and for given n. It must be observed that the coefficient "b" means actually diversification of the recoupment period (T) in connexion with the operating period. It has been found in Poland, that the recoupment period so corrected for various industrial sectors--according to their average operating period--is not so much different than in other countries which use different recoupment periods for various sectors.

42/ With regard to repairs, it is assumed that they play the same economic role in the calculation as raw materials because the technique of carrying out repairs is not determined by the amount of the investment outlays of a given object, but by the very nature of this work in which technological progress takes place

This method of presentation of raw materials in the account permits one to bring up the advantages of the variant characterized by a smaller use of raw materials and other materials.

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So far it has been assumed in developing synthetic formula of economic effectiveness of investment that output and operating costs remain annually constant during the whole operation period. A method has been developed which allows taking into account various time patterns of output and operating costs during the operation period.

The way of reasoning is similar to the case of generalization of formula for objects with different operational periods.[43/]

5. Evaluation of Import Substituting and Export Promoting Projects

As already indicated, the Centrally Planned Economies and particularly the smaller countries--Hungary, Czechoslovakia, East Germany, Poland etc.--pay a growing attention to the foreign trade. This is apparent in all fields of the economic policy--in development planning, in the policy of pricing, in investment evaluation, etc.

At the inception of the first industrialization plans and during their execution, the rentability in foreign trade was not considered a very important argument for investment allocation in the Centrally Planned Economies. On the contrary, it was considered that following the comparative advantage argument would petrify the old, backward economic structure of a country. The efforts were directed towards creating a new economic structure favorable for a fast and steady development, based on a diversified industrial basis. Achieving this principal aim, i.e. having developed new capacities in fuels, basic semi-products for capital goods industry and for chemical industry, the Centrally Planned Economies were changing their attitude towards foreign trade. This was reflected in price reforms, bringing the internal price relations closer to world prices relations in development planning, and also in methods and criteria applied for investment allocation.

See Annex III.

The formulae developed for evaluation of investment projects serving for comparative analysis of the various technical solutions of given investment targets, were being adopted for comparative analysis of the various projects bringing export promotion and import substitution.

It is explicitly expressed in Polish literature and official instructions that the synthetic formula elaborated for investment projects evaluation can be applied in evaluation of investment projects connected with the foreign trade - substituting imports and promoting exports. Thus, the investment evaluation which was initially confined within a narrow field of alternative solutions of a given investment target, is widening its field of application.

In the Polish formula certain modifications are being introduced when it is to be applied for evaluation of projects connected with the foreign trade. The formula applied for that purpose has usually the following form:

$$E_{D_n} = \frac{\left(\frac{1}{T} J + C \right) b + S'}{D_n} \qquad (13)$$

In this formula D_n = net annual exchange revenue; it is calculated by subtracting the foreign inputs (precisely speaking the value of imported and exportable commodities) from the gross exchange revenue. Therefore, also S' stands for raw materials which are not subtracted from gross exchange revenue only.

For smaller projects, carried on by enterprises (decentralized investment) a following, simplified formula is used:

$$\frac{q\,I + C_d}{P - S_d}$$

where: q = coefficient of efficiency (q = 0,2),

C_d = annual operating costs without depreciation allowances, reduced by foreign inputs,

P = annual value of output, calculated on the basis of foreign markets prices, converted into domestic currency at a special exchange ratio,

S_d = value of imported and exportable commodities which were subtracted from operating costs.

The project can be acceptable whenever the value of the above fraction is smaller than one. In guiding the evaluation of the small investment projects, q and the exchange ratio are used as instruments of the investment policy.

In Hungary, where foreign trade is of great importance, even the "basic" formula _/ of economic effectiveness of investment differs substantially from the type of "basic" or "comparative" coefficients used in other centrally planned economies. Special attention is paid to correct expression of both inputs and outputs of new projects in "social" accounting prices, based upon actual purchasing power of Hungarian currency and world market prices of commodities. The economic effectiveness of an investment is expressed in its "internationally comparable" values in the following formulae:

(i) on the level of a plant:

$$gü = \frac{T - A_i - A_b - L}{M + B_h + F_h} \qquad (14)$$

(ii) on the level of the economy as a whole:

$$gn = \frac{T}{M + A_i + A_b + L + F_h} \qquad (15)$$

Letters used in formulae denote:

T = value of output expressed in forints. It is obtained by multiplying the world market prices of the products by the respective quantities produced. In calculating forint equivalents of an - old - ruble or dollar exchange, rates of 3.00 and 45.00, respectively, are to be applied,

A_i = value of used imported materials in forints, calculated at the same rates of exchange;

A_b - value of domestic raw materials;

L = allowance for depreciation;

M = total calculated sum of wage costs on plant level including taxes on and social security contributions after wages, bonuses, etc.

B_h and F_h = amounts of national income not realized because of the "immobilization effect of investment. B_h denotes investment and immobilization effect of the fixed, and F_h of the circulating, capital.

_/ The description is based on a draft of instruction prepared in August 1959.

Thus, coefficient gü expresses value added (depreciation excluded) per one unit of wage costs combined with "immobilization" effect of investment. Coefficient gn, used for calculating effectiveness on the level of the economy as a whole, expresses gross value of output per one unit of appropriately calculated, full social operating cost.

The economic effectiveness of investment formulae applied for evaluation of investment projects connected with foreign trade allow for a comparative analysis of the various projects. The comparative analysis has its great merits. It is being carried within the industrial sectors and for inter-sectoral comparisons. Apart from its merits in project evaluation, it also helps in understanding where and why the economic efficiency varies from international conditions.

It is considered particularly instructive to perform the comparative analysis along the chains of the technological process within an industrial sector - it is called the effectivity analysis of the subsequent phases of production. This type of analysis is particularly recommended, e.g., for the steel industry and for the chemical industry.

It is also acknowledged that the comparative analysis is not sufficient for project evaluation. While, when correctly performed, it can show which alternative is better and which is worse, it does not say whether "worse" means "still good", whether "better" means "sufficiently good". This problem is not being determined by the formulae. It is rather exceptional that a final criterion is established by the authorities. This is the case, as shown above, for the small investment projects in Poland. As a rule, the final choice is being taken by the authorities, which taking into account the general economic situation and the development policy, put certain limits to the values of economic effectiveness of investment coefficients.

6. Analysis of investment in larger systems

Inadequacy of investment efficiency analysis confined to individual projects is commonly recognized in the Centrally Planned Economies. It has brought about attempts to scrutinize investment in larger systems. On the other hand, the predominancy of state ownership facilitates an investment analysis of large programmes consisting of sets of projects or even branches. Completely satisfactory analysis methods of investment in larger industrial systems have not been worked out yet. They are still in a preliminary phase of elaboration and experimentation. Particular attention among them calls some simple methods applied to analysis of:

(i) large multi-purpose projects;

(ii) systems of closely connected projects.

An analysis of multi-purpose projects is most often conducted in this way: a given multi-purpose investment project is broken down into component parts which are, in turn, compared with their feasible alternatives. Such an "analytical division" of a given multi-purpose investment is most often done by clear-cut specification of final effects of this investment and the repartition of both investment outlays and operating costs in accordance with those final effects.

Some difficulties arise, especially with regard to outlays' repartition of such a project which render services to different final effects. In some cases both investment outlays and operating costs of such a services-rendering project (a part of multi-purpose investment project) are apportioned among final effects using its services according to amount of services.[45/]

This multi-purpose investment project is "analytically" broken down into parts, which are compared with their alternatives. An alternative might be, for instance, a completely independent project. The ability to formulate all real alternative solutions is one of the most important skills in investment analysis.

In some other cases, other methods of efficiency analysis of multi-purpose investment projects are employed. For instance, in the evaluation of large water investment for irrigation, energy, flood control, transportation, etc., the following method has been used.

45/ G. Matlin "Krupnyie problemy ekonomiczeskoj effektyvnosti kapitalnych vlozenii e elektrifikacju" Voprosy Ekonomiki 1961

Outlays referring to each component part of this multi-purpose investment (e.g. irrigation) have been assumed as equal to outlays on an individual (e.g. irrigation) project with the same capacity. Then, so-compiled outlays of all parts have been summed up and compared with real outlays on a given multi-purpose investment project.

The above-mentioned method does not exclude, however, the necessity of elaboration and comparative analysis of different variants of multi-purpose projects with respect to localization, technical solutions etc. Multi-purpose investment projects differ from systems of connected projects. While in the first case, investment is usually carried on by one economic organization in the second case, series of projects are initiated by different organizations. According to research experience, substantial benefits can be obtained by analyzing systems of projects, which are very closely connected.

Two specific categories of closely connected investment systems may be distinguished:

(i) different projects, quite often, are so connected from different branches that a solution of one out of them exerts an influence on solutions of others with respect to localization, size, etc.

(ii) a given system of connected projects exerts influences on a whole economy which may be satisfactorily detected by means of ordinary calculations of costs based on existing prices (e.g. improvement of the transport system).

These systems of closely connected projects most often appear in an analysis of mining and manufacturing projects.

Such a system can consist of, for instance:

Alternative energy systems:

1. Coal mine combined with thermal power station and transmission lines;
2. Brown coal mine with thermal power station and transmission lines;
3. Water power station with transmission lines.

Alternatives of sulphur acid manufacturing system:

1. Elemental sulphur mine with sulphur acid manufacturing plant;
2. Anhidrite mine with sulphur acid manufacturing plant.

The first question which arises in the process of analysis of systems of connected projects is the determination of a scope of an analyzed system and formulation of all its real alternatives. Bringing out as many real alternatives as possible is one of the main conditions in discovering an optimal solution.

In simple cases, quantitative analysis with regard to systems of connected projects might be conducted by means of the same synthetic index as employed for evaluation of individual projects.

In more complicated cases, the formula used has to be adjusted to the nature of an analysed problem. Polish instruction recommends the following formula applicable to connected projects' systems:

$$E_{kom} = \sum_{i} E_i \; a_i$$

E_{kom} = effectivity index of a system of connected plants,

E_i = effectivity index of the i-th plant (calculated according to the explained synthetic formula); in it S_i (raw materials) covers only those raw materials, semi-products, etc. which are purchased from outside the system;

a_i = the coefficient denoting the use of the product (service) of the i-th plant per unit of the final product of the system; thus this coefficient shows how many units of the product of the i-th plant are necessary to obtain a unit of the final product of the analysed system. Hence, coefficient a_i for the plant which is the last link of the system is equal to 1.

7. Evaluation of investment in existing plants

In the Centrally Planned Economies, more attention is recently paid to comparative efficiency evaluation of investment in new vs. expansion of existing plants. Especially now after commissioning a series of basic projects in mining, electric energy, metallurgy, chemistry, etc. it is often possible to increase production efficiently by means of expansion and modernization of existing plants. From the viewpoint of potential demand and smooth and assured flow of inputs, the purposefulness and concepts of modernization to be undertaken are analyzed by taking into account perspective development of whole branches.

Some pertinent methods employed in Poland are presented below, for in this country they have been described in official instructions in more detail. Though slightly different methods are used in other countries, the general approach does not differ substantially from that presented below.

as regards evaluation of investment in existing plants, in principle, the same evaluation methods as applied in the case of comparisons of new projects is recommended. It is assumed, as a general rule, that in such analysis calculation covers:

(i) only those investment outlays which are to be incurred in an existing project, but it does not take into account those outlays which were incurred in the past and are expressed in the value of the existing assets;

(ii) operating costs and output after investment was made.

With due attention to the above general rule, comparative analysis of different kinds of investment in existing plants such as modernization, expansion, renovation, etc. among themselves and against the new project are examined. In particular, thorough efficiency analysis of expansion and modernization is carried on in the case when an alternative of a new project is feasible.

It is recommended, moreover, to keep analyzing incessantly all feasible additional investments in existing plants. As a comparative basis, in such an analysis, an alternative of increase of output is used by means of building a new plant. Quite often generalized characteristics of modern projects might be used as such a basis.

In evaluation of investment in an existing plant, it is recommended to explore:

(i) purposefulness of liquidation or extending its operating period by means of major repairs, involving replacement of important parts,

(ii) effectiveness of different modernization solutions.

Liquidation of the old plant is justified when its modernization alternatives as well as major repairs effectiveness is lower than effectiveness of building a new plant. Such an outcome of calculation, though essential for undertaking decision of liquidation, must be supplemented by analysis of other factors too.

A comparison of various modernization variants is conducted by means of a general formula of economic effectiveness of investment. It has been already stated that an approval of modernization variant should be proved against the new project.

It is neither possible, nor adequate in all cases to compare investment in existing plants with investment in a new project. For instance, in efficiency analysis of investment bringing about so-called saving effects in some raw material input coefficients, different methods of evaluation are employed.

8. Casus of Yugoslavia

The economic system of Yugoslavia is substantially less centralized than that of other socialist countries. More emphasis is laid on market mechanism and economic autonomy of state enterprises.

While general principles of the evaluation of economic effectiveness of investment remain mostly similar, quantitative indices used in Yugoslavia differ substantially from those discussed in the preceding sections.

For illustration of those methods an attempt is made to describe methods used in the Yugoslav State Investment Bank when making proposals for obtaining loans.[46/]

The plans (Federal, republican and local) set the global proportions of resources to be engaged for certain purposes (sectoral allocation) and the banks organize competitive biddings for the financing of projects within the limits of these propositions. Prospective investors send in their investment programmes comprising detailed technical and economic documentation in respect to investment costs and expected effects. The bank submits these investment programmes to a detailed scrutiny along general lines prescribed in the Decree of Investments. In this law certain criteria are mentioned, such as: the rate of interest, the level of self-participation in investment outlays, the repayment term for the loan, the term within which the construction is completed, the most attractive profitability index, investment cost per unit of output and foreign exchange of the given investment.

All these criteria, however, are mentioned exempli gratia and no order of priority is specified.

For the organization of a new competitive bidding the Board of Directors of the Bank establishes a definite order of priorities, using both criteria mentioned above and some additional ones. Thus, for example, in the decision on the organization of the competitive bidding for projects of expansion and modernization of existing sugar refineries and the building of new ones, it is provided that prospective investors fulfilling the following conditions will be given priority:

46/ Filip Vasic, The Yugoslav system of investment financing and the application of criteria in the selection of investment projects. The Engineering Economist, October-November 1960.

1. The most favourable conditions for the supply of needed raw materials, and as a consequence, the lowest cost per unit of sugar output.
2. The largest volume of total production of sugar in relation to the amount of invested resources.
3. The largest self-participation in investment outlays over and above the prescribed percentage.
4. The shortest period, from the moment of the granting of the investment loan, within which the normal run of the new capacities could be started.
5. The shortest term of loan repayment.

Annex I

Examples of Investment Analysis[1]

1. The economic effectiveness of sulphuric acid manufacture from various raw materials

The economic effectiveness of sulphuric acid manufacture depends to a high degree on the choice of raw material used for its production. Sulphuric acid can be produced from various raw materials. The use of a given raw material determines the employment of a specific technological method of production; self-evidently, technological methods differ themselves in regard to techno-economic indices.

Poland is richly endowed in two kinds of sulphuric raw materials: elemental sulphur and gypsum.

In the development plan sulphuric acid manufacture is based on elemental sulphur. Some experts, however, insist on basing sulphuric acid production also on gypsum.

Generally, gypsum as a raw material is cheaper[2] but its transformation costs - into sulphuric acid - are higher than elemental sulphur.

In view of the special role played by raw materials, the following calculatic takes into account their use. It concerns three essential raw materials: elemental sulphur, gypsum, and technological coal.

For the sake of simplicity it has been assumed that the period of exploitation of analyzed investments equals 20 years.

1/ Examples are taken from "Etektywnosc Investycj" edited by M. Rakowski Warsaw, 1961 Panistrowe Wydawnictwa Gospodarcze, and are presented in simplified form.

2/ In order to produce 1 ton of acid sulphur - 0,340 tons of elemental sulphur = 465 zl or 2,3 tons of gypsum = 57 zl - is needed. The latter raw material is 8 times cheaper.

Table (1)

A. Effectiveness of sulphuric acid manufacture from elemental sulphur

The following table presents data used in calculation and coefficients of economic effectiveness computed on their basis

Type of Investment	Investment annual output ratio (zloty/1 ton)	Annual operating cost (zloty/1 ton)	Period of immobilization of investments (in years)	Period of exploitation (in years)	Coefficient of effectiveness of investments (zloty/1 ton)	Input for 1 ton of sulphur a (m.t.)
xtraction and refinement of elemental sulphur	3160	682	2	20	1367	0.340
cid sulphur manuacture	600	104+0.34° 1367 = 569	1	20	684	x

In annual operating cost of acid sulphur manufacture, input value of elemental sulphur was separated and was computed as a product of input times coefficient of effectiveness of extraction and refinement of elemental sulphur.

Table (2)

B. Effectiveness of sulphuric acid manufacture from gypsum

In this technological process it is received simultaneously with acid sulphur and also cement in relation 1:1. Thus data concern both manufacturing 1 ton of acid sulphur and 1 ton of cement. For the sake of comparability from the total coefficient of effectiveness is subtracted the coefficient of effectiveness of cement manufacture.

Type of Investment	Investment annual output ratio (Zl/ton)	Annual operating cost (Zl/ton)	Period of immobilization (in years)	Period of exploitation (in years)	Coefficient of effectiveness of investment (Zl/ton)	Input/1 ton of acid sulphur and cement	Input/1 ton of cement
Extraction of gypsum	30.8	19	1	20	24.9	2.3	x
Extraction of coal	x	x	x	x	350	0.660	0.335
Acid sulphur and cement manufacture	3900	540+2.3°24.9+ +0.66°350= =828	1.5	20	1624	x	x
Cement manufacture	1100	183+0.335°350= =300	2	20	538	x	x

Table (2) points out that the coefficient of effectiveness of acid sulphur from gypsum is equal to (1624 - 538) = 1086 zl/ton. Since the same coefficient of effectiveness of acid sulphur from gypsum is equal (1624 - 538) = 1086 zl/ton. Since the same coefficient for acid sulphur from elemental sulphur has been 684 zl/ton, production of the latter one is evidently more effective.

*

* *

Economic effectiveness of both the above-mentioned methods of acid sulphur manufacture can be also analysed and compared from the standpoint of balance of international trade. While elemental sulphur is exportable and gypsum is not, planning authorities face a possibility of producing acid sulphur gypsum and of exporting "released" elemental sulphur (implied unelastic supply of the latter).

Analysis is carried on by means of comparison of two equivalent productive sets producing acid sulphur and cement.

The first set consists of plant manufacturing and sulphur from elemental sulphur and cement factory.

The second comprises a plant jointly producing acid sulphur and cement from gypsum and gypsum mines. Table 3 presents relevant coefficients for both sets; in it the value of input of raw materials was separated and expressed in dollars.

1. Investment outlays consist of investment outlays on gypsum mining; however, they don't comprise investment outlays on elemental sulphur and coal mining. Increment of the latter is considered due to the change in international trade; in this case, as a result of decrement of exports and not due to investment.
2. Transformation costs do not comprise inputs of exportable raw materials i.e. elemental sulphur and coal. The world market price for coal has been assumed 9 dollars/1 ton and respectively for elemental sulphur 30 or 25 dollars/1 ton.
3. The difference between Set I and II expresses the effectiveness of choosing solution (set) II. It enables additional exports of elemental sulphur which means the "gain" of 7.2 dollars on each ton of acid sulphur. However, the "gain" of one dollar is conditioned by both additional investment outlay to the amount 315 zl. and additional operating costs to the amount 41 zl.

Table (3)

	Investment outlays (in zl.)	Transforma-tion costs (in zl.)	Raw material input		
			Kind and quantity (in tons)	in dollars assuming price of 1 ton of elemental sulphur	
				30 dollars	25 dollars
Set I					
Acid Sulphur	600	104	elemental sulphur 0.34	10.2	8.5
Cement	1100	187	coal 0.33	3.0	3.0
Total	1700	291	x	13.2	11.5
Set II					
Acid sulphur and cement	3900	540	coal 0.66	6.0	6.0
Gypsum mine	71	44	x	x	x
Total	3971	584	x	6.0	6.0
Difference II - I	+2.271	+293	x	-7.2	-5.5
Price "of one dollar" assuming the price of elemental sulphur					
30 dollars	315	41	x	x	x
25 dollars	413	53	x	x	x

Synthetic index of effectiveness of the "gain" of one dollar, given immobilisation period of investment 1,5 year, would be

$$(315:6) \cdot (140.5 \cdot 135) = 105 \text{ zl.}$$

It is under the assumption: 1 ton of elemental sulphur = 30 dollars. In the case of 25 dollars/1 ton, the price of one dollar would be 137 zl. Bearing in mind the marginal exchange ratio has been equal to 78 zl. for 1 dollar, the alternative II is pretty ineffective.

Therefore, acid sulphur manufacture from gypsum is ineffective, both from the point of view of internal structure of costs and prices and from the standpoint of maintaining equilibrium in international trade balance.

2. <u>The effectiveness of employment of new technological process in the steel-making industry.</u>

The main general tendency in recent years in steel production is a growing use of oxygen in varying degrees in all steel-making processes.

Special attention is paid, in particular, to:

- the use of oxygen in martin furnaces and
- introduction of oxygen convertors.

While oxygen convertors seem to be the most economical from the point of view of capital investment and operational expenses, it should be emphasized that the choice of process depends on the real state of existing steel mills.

The economic effectiveness of the following alternative solutions will be analyzed:

1) The construction of new oxygen convertor steel mills with capacity:
   a) 3 million - 3 million 200 thousand tons per year (big)
   b) 600 thousand tons per year (small)
2) The construction of a modern martin steel mill with capacity of 2 million 100 thousand tons per year; the use of oxygen raises its capacity to 2 million 500 thousand tons per year.
3) Replacing the old steel mill by a new oxygen convertor steel mill with a capacity of three times higher <u>versus</u> a modernization of the old by means of the use of oxygen.
4) Sustaining in order the old steel mill with capacity of 180 thousand tons per year <u>versus</u> the construction of additional martin furnaces in a modern steel mill located nearby. Data for analyzed solutions are presented in the table below and will be used in calculations.

Table (4)

1	2	3	4	5	6	7	8	9	10	11
	Unit	Oxygen convertor steel mill		Modern martin steel mill		Old steel mill ("Kosciuszko")		Steel mill ("Nowotka")		
									new	
		big	small	without oxygen	with oxygen	without oxygen	with oxygen	existent	variant I	variant II
Annual capacity	thousand tons	3000	600	2100	2500	200	240	180	420	600
Total investment outlays	million zl.	1680	390	2240	2420	-	50	-	400	540
Investment-output (steel) ratio	zl/1 ton	560	650	1070	968	-	-	-	950	900
Operating costs (excluding fuel and depreciation allowances) per 1 ton of steel	zl.	130	155	180	145	410	280	400	300	280
Investment outlays on fuel required per 1 ton of steel	zl.	80	80	320	300	520	400	800	400	400
Operating cost of fuel required per 1 ton of steel	zl.	16	16	64	60	104	80	160	80	80
Period of inmobilization of investment outlays on steel mill	year	2	1.5	2	0.5	-	0.5	-	1.5	1.5
Period of inmobilization of investment outlays on fuel	year	3	3	3	3	3	3	3	3	3

Note: 1. Operating costs of fuel comprise operating costs of both gas and oxygen.
2. Investment outlays on fuel comprise investment outlays both on coal mining and transformation of coal into gas.

A. The effectiveness of the construction of an oxygen convertor steel mill with capacity of 3 million tons per year.

This steel mill is treated on a comparable basis. Its effectiveness is calculated according to the formula:

$$E = \frac{\frac{1}{T} I(1 + q_z n_z) + C_p Y_{n_{opt}}}{P \cdot Z_{n_{opt}}}$$

The optimal period of the mill's operation is equal to:

$$n_{opt} = f \frac{I (1 + q_z n_z)}{C} = f \frac{560 \cdot (1 + 0.15 \cdot 2)}{130}$$

correcting coefficients are equal to:

$$Y_{25} = 1.17$$

$$Z_{25} = 1.10$$

Thus, the synthetic index of effectiveness:

$$E_{conv.} = \frac{\frac{1}{6} \cdot 560 \cdot (1 + 0.15 \cdot 2) + 130 \cdot 1.17}{1 \cdot 1.10} = \frac{121 + 152}{1.10} = 248 \text{ zl/ton}$$

B. The effectiveness of the construction of a modern martin steel mill with a capacity of 2 million 100 thousand tons

The differences as to fuel input values between oxygen convertor and martin processes must be taken into account in this case according to the rules of both calculations and comparison of investment variants' effectiveness.

Each fuel input value is conceived as a synthetic index of such an amount of fuel which is required per 1 ton of steel in accordance with a given technological process.

$$E_{pal} = \frac{\frac{1}{T} I_{pal} (1 + q_z n_{z_{pal}}) + C_1 Y_{pal}}{Z_{pal}}$$

where: E_{pal} = synthetic index of effectiveness for a given fuel.

In the case of martin furnace:

$$E_{pal_{mart}} = \frac{\frac{1}{6} \cdot 320 (1 + 0.15 \cdot 3) + 64 Y_{opt}}{Z_{opt}}$$

where: $n_{opt} = f \dfrac{320 \cdot (1 + 0.15 \cdot 3)}{64} = f\,(7.25) = 27$ years; therefore

$$Y_{27} = 1.23 \quad Z_{27} = 1.13$$

Finally

$$E_{pal_{mart}} = \frac{\frac{1}{6} \cdot 320 \cdot 1.45 + 64 \cdot 1.23}{1.13} = \frac{77 + 79}{1.13} = 138 \text{ zl/tons of steel}$$

Per analogram E_{pal} of oxygen convertor steel mill is smaller than E_{pal} of martin in proportion 16 : 64 i.e. 4 times:

$$E_{pal_{conv}} = 138 \cdot \frac{16}{64} = 35 \text{ zl /1 ton of steel}$$

In order to compare the effectiveness of both steel mills analyzed so far, it is necessary to add to martin's transformation costs (C_{mart}) the difference between fuel input values $\Delta C_s = 138 - 35 = 103$ zl/ton.

Thus the effectiveness of martin steel mill is equal to:

$$E_{mart} = \frac{\frac{1}{T} I\,(1 + q_s n_s) + (C_{mart} + \Delta C_s)\,Y_{opt}}{Z_{opt}}$$

It is obtained using the data of column 5 of the preceding table:

$$n_{opt} = f \frac{1070 \cdot (1 + 015 \cdot 2)}{180 + 103} = f \frac{1391}{283} = f\,(4.9) = 24 \text{ years}$$

$$Y_{24} = 1.14; \quad Z_{24} = 1.08$$

Finally:

$$E_{mart} = \frac{\frac{1}{6} \cdot 1070 \cdot (1 + 0.15 \cdot 2) + (180 + 103) \cdot 1.14}{1.08} \quad \frac{232 + 323}{1.08} = 514 \text{ zl/ton}$$

A comparison E_{mart} with E_{conv} points out evidently that the synthetic index of effectiveness of a martin steel mill is more than twice as ineffective as that of the oxygen convertor. Therefore, in metallurgical enterprises with integrated steelworks, oxygen convertors are mainly being constructed.

Bearing in mind such a great difference in the effectiveness between both steel mills a question can be raised as to whether or not to destroy the existing martin furnaces and to replace them by oxygen convertors.

An answer "yes" is obtained if the following inequality is satisfied:

$$C_{st}\,\frac{Y_1}{Z_1} > E_{n_{opt}}$$

where: C_{st} = annual operating cost, unit in martin steel mill

$E_{n_{opt}}$ = index of effectiveness of oxygen convertor steel mill assuming optimal n;

Y_1 and Z_1 = correcting coefficients under the assumption of 1 year of operation of martin furnaces.

In this case $(180 + 103) \cdot \frac{0.0651}{0.0882} = (180 + 103) \cdot 0.74 = 209\ 248.$

It means that replacing the existing martin steel mill by the new oxygen convertor steel mill is not efficient.

A further efficient period of the operation of martin furnaces is computed according to the formula:

$$E_{n_{opt}} \left(\frac{1 + c}{1 + a}\right)^t = C_{st}\,\frac{Y_1}{Z_1}$$

where: c = annual rate of decrease

a = annual rate of growth of the accumulation

Thus

$$248 \cdot \left(\frac{1.03}{1.07}\right)^t = 209 \text{ and } t = 5 \text{ years;}$$

C. <u>The effectiveness of modernization of a martin steel mill</u>

Since the replacement of existing martin furnaces by oxygen convertors turned out to be inefficient, another alternative solution is now briefly discerned, viz. a modernization of these martin furnaces by use of enriched air (oxygen). Column 6 in the table presents indices of the modernized martin steel mill.

Operating costs of medernized martin furnaces are equal to:

$$145 \text{ zl.} + \Delta E_{pal_{mod}} \qquad \text{where: } \Delta E_{pal_{mod}} = 138 \cdot \frac{60}{64} = 130 \text{ zl/ton}$$

The difference with regard to ΔE_{pal} between modernized martin furnaces and oxygen convertors is equal to: $130 - 35 = 95$ zl/ton. Hence, operating costs of modernized martin furnaces $C_{mod} = 145 + 95 = 240$ zl/ton.

And equality determining an efficient period of operation of the mill after modernization presents itself as:

$$C_{med} \frac{Y_1}{Z_1} = E_{n_{opt}} \left(\frac{1 + c^t}{1 + a} \right)$$

Inserting relevant data:

$$240 \cdot 0.74 = 248 \left(\frac{1.03^t}{1.07} \right)$$

is obtained and hence $t_{med} = 9$ years.

Calculations based on the formula of effectiveness of modernization prove that modernization is economically efficient.

D. <u>Replacement of the old martin furnaces by oxygen convertors.</u>

The old martin steel mill with annual capacity of 200 thousand tons is to be replaced by a new oxygen convertor steel mill with annual capacity of 600 thousand tons.

The index of effectiveness for an oxygen convertor steel mill with smaller convertors than in the previous case:

$$E = \frac{\frac{1}{6} \cdot 650 \cdot (1 + 0.15 \cdot 1.5) + 155 \; Y_n}{1 \; Z_n}$$

Since:

$$n_{opt} = f \; \frac{650 \cdot (1 + 0.15 \cdot 1.5)}{155} = f \; (5.1) = 24 \text{ years}$$

Hence:

$$E = \frac{\frac{1}{6} \cdot 650 \cdot (1 + 0.15 \cdot 1.5) + 155 \cdot 1.14}{1.08} = 283 \text{ zl/ton}$$

(This index is a little bit worse than the index of the previous oxygen convertor steel mill. It is caused by the smaller size of the convertors).

Operating costs of to-be-replaced martin furnaces (410 zl/ton) must be enlarged by the difference in indices of effectiveness of fuel input values.

$$\Delta E_{pal} = 227 - 35 = 192 \text{ zl/ton}$$

Thus:

$$C_{mart} = 410 + 192 = 602 \text{ zl/ton}$$

Since the condition of efficiency of replacing martin furnaces by oxygen convertors is expressed by the already used formula:

$$C_{st} \frac{Y_1}{Z_1} > E_{n_{opt}} ;$$

it appears that this condition is fulfilled.

$$602 \cdot 0.74 = 446 > 283 \quad zl/ton$$

E. <u>Modernization of the old martin steel mill</u>

Due to modernization (see column 6 in table) total operating costs will decrease.

$$C_p = 280 \quad zl/ton \quad \text{(operating cost excluding fuel input)}$$

and

$$\Delta E_{pal} = 35 \cdot \frac{80}{16} = 140 \quad zl/ton \text{ (fuel input value);}$$

Together then

$$C_p + \Delta E_{pal} = 24\ 280 + 140 = \quad zl/ton;$$

Since

$$\left(C_p + \Delta E_{pal}\right) \frac{Y_1}{Z_1} = 420 \cdot 0.74 = 311 \text{ zl} \quad \text{is}$$

bigger than 283 zl (index of new oxygen convertor mill), this modernization is inefficient (compare results of section C which pointed out the efficiency of that modernization) .

Concluding comment:

In situations where existing steel mills are at different levels of techniques, it seems to be indispensable to conduct individual calculations to decide where and what kind of investment is efficient.

3. <u>Choice of efficient wall materials in construction</u>

A considerable range of substitution exists between wall materials in construction. The analysis below confines itself to the comparison of efficiency of three types of walls built from:

1) regular bricks with both sides of plaster

2) cinder blocks with both sides of plaster

3) gypsum slocks combined with granulated cinder.

All these types possess similar isolation qualities and widths (38 cm). However, the second and third types can be used merely either as a curtain wall or interior partition. In the following computations, "direct" investment outlays on a given wall component and "indirect" investment outlays e.g. in the case of cement investment outlays on fuel and electric power to the amount necessary for this cement production have been taken into account.

Since operating costs comprise depreciation allowances (reckoned from "direct" and "indirect" investment outlays), the following modified formula of synthetic index is used in order to exclude these depreciation allowances:

$$E = \frac{\left(\frac{1}{T}\ I + I_p\right) \cdot \left(1 + q_z\ n_z\right) + \left(C - \frac{I + I_p}{20}\right) Y_n}{PZ_n}$$

where: C = annual operating costs, including depreciation allowances (period of amortization = 20 years).

A. <u>Indirect investments (I_p) per 1m^3 of cinder blocks</u>

$$I_{p\ \text{cinder blocks}} = I_{p\ \text{coal}} + I_{p\ \text{cinder}} + I_{p\ \text{cement}}$$

$I_{p\ \text{coal}}$ = (40 kg of coal + 14 kwh · 0.5 kg of coal) · 0,6zl. = 28,20 zl.

$I_{p\ \text{cinder}}$ = 1.05 m^3 · 35 zl. = 36.75 zl.

$I_{p\ \text{cement}}$ = 230 kg. · 0.863 zl. = 198.00 zl.

Therefore $I_{p\ \text{cinder blocks}}$ = 28.20 + 36.75 + 198.00 = 263 zl/m^3

Indirect investment outlays computed analogously for other wall materials:

	Brick	Lime	Cement	Cinder blocks	Gypsum
I_p	0.22 zl/unit	0.155 zl/kg	0.204 zl/kg	263 zl/m^3	0.052 zl/kg

B. <u>Average period of immobilization of investment outlays on cement</u>

Data for cement:

Year of construction	1	2 2	3	4	5
i_t (year investment outlay mil.zl.	100	200	300	350	150
t_b- t in years	4.5	3.5	2.5	1.5	0.5
$i_t(t_b-t)$	450	700	500	525	75

It follows that: I (total "direct" investment outlays) = 1000

$$\sum_{t=0}^{t_b} i_t\,(t_b - t) = 2{,}250;$$

and

$$n_z = \frac{\sum_{t=0}^{t_b} i_t\,(t_b - t)}{I} = 2.25 \text{ years}$$

n_z for all wall materials:

Bricks	Lime	Cement	Cinder blocks	Gypsum
1.2	1.53	2.25	1.1	1.37

Other data, viz. "direct" investment-output ratio (I) and total operating costs (C_{st}) are as follows:

	Brick	Lime	Cement	Cinder blocks	Gypsum
I (in zl)	1.40/unit	0.544/kg	0.863/kg	178/m^3	0.350/kg
C_{st} (in zl)	0.69/unit	0.18/kg	0.266/kg	157.7/m^3	0.112/kg

Coefficients Z_n and Y_n are computed under the assumption:

- period of exploitation for cinder blocks 15 years
- period of exploitation for other materials 30 years

C. <u>Economic effectiveness of use of bricks</u>

$$E_{brick} = \frac{\frac{1}{6} \cdot (1.40 + 0.22) \cdot (1 + 0.15 \cdot 1.2) + \left(0.69 - \frac{1.40+0.22}{20}\right) \cdot 1.32}{1.17} = 0 \text{ zl/unit}$$

In exactly the same way E's for all other wall materials have been reached:

	Brick	Lime	Cement	Cinder blocks
E	0.957 zl/unit	0.290 zl/kg	0.444 zl/kg	226.1 zl/m^3

	Gypsum	Granulated cinder	Sand
E	0.171 zl/kg	32.31 zl/m^3	21.57 zl/ton

The synthetic index of effectiveness (E) for each kind of wall is equal to the sum of products of coefficients (E_i) for each material and their input coefficients (a_{ij}). To this sum of products $\left(\sum E_i\, a_{ij}\right)$ are added the outlays on labour and equipment.

Table (5)

Synthetic indices of economic effectiveness for three analyzed kinds of walls

		Measure of units	Brick wall	Cinder block wall	Gypsum block wall
rick	a	zl/unit	0.957	-	-
	b	unit	144.80		
	c	zl	138.57		
ime	a	zl/kg	0.290	0.290	0.290
	b	kg	25.93	9.23	4.1
	c	zl	7.52	2.68	1.19
ment	a	zl/kg	0.444	0.444	
	b	kg	4.74	10.64	-
	c	zl	2.10	4.72	
nd	a	zl/ton	21.57	21.57	21.57
	b	ton	0.179	0.104	0.05
	c	zl	3.86	2.24	1.08
nder ocks	a	zl/m^3		226.10	
	b	m^3	-	0.275	-
	c	zl		62.18	
nder	a	zl/m^3			32.31
	b	m^3	-	-	0.186
	c	zl			6.01
bour		zl/m^2	36.90	32.18	43.37
uipment		zl/m^2	6.97	5.55	14.00
sting mould		zl/m^2	-	-	0.23
1 m^2 of wall		zl/m^2	195.92	109.55	102.83

te: a= E of a given material (i)
b= input of a given material (i) for 1 m^2 of wall
c= value input of a given material for 1 m^2 of wall

The above type of calculations has played an important role in determining the development programmes of wall materials. For instance, in the Five Year Plan 1961-65 output of bricks was planned to reach 130 (1960=100), whereas output of gypsum for construction pruposes, 230.

4. An analysis of the economic effectiveness of the modernization of a spinning mill

This example is to some textent typical for an analysis of the economic effectiveness of a modernization.

I. Description of a spinning mill to be modernized before modernization:

- 104.4 thousand of spindles
- annual output = 9.8 thousand tons of yarn;
- unit operating cost = 32.520 zl/ton of which:
  material input is 25.800 zl/ton,
  labour input is 6.720 zl/ton.

In order to maintain the same output level it is unavoidable:

- to expand 63.4 million zl. on "essential" repair outlays in the first year of which:
  50.1 million zl. is expended on equipment and
  13.3 " " " " " buildings
- to conduct "essential" repairs with regard to:
  equipment every five years,
  buildings every ten years.

II. Description of the modernization.

By means of 160 million zl. of investment outlays it is possible:

- to replace 70 per cent of existing spindles
- to install new spindles to the total amount of 110.9 thousand
- to renovate ventilation system and buildings.

All that brings:

- output increment of 2,260 tons/per year
- decrease of operating cost unit to the level of 31,600 zl/ton (material input 25,750 zl. labour input 5,850 zl.)

Estimated future outlays on "essential" or major repairs after:

5 years - 12.6 million zl.
10 " - 33.1 " "
15 " - 35.7 " "
20 " - 55.0 " "

The "immobilization" of investment outlays brought about by this modernizatior is estimated under the following assumptions: _

1) Total investment outlays of 160 million of zl. are being expended:

   in the first year 93.9 million zl.

   in the second " 40.6 " "

   in the third " 25.5 " "

2) Output effects of modernization in per cent of total increase of output due to modernization amounts to:

   0 per cent in the first year

   5 " " in the second year

   65 " " in the third year

   These effects represent re-mobilization of investment outlays.

Table - 6 -

Immobilization of investment outlays

Year	Investment outlays in million zl.	Immobilization	Re-mobilization	Immobilization after takin into account re-mobilization
		in million of zloto-year		
1	93.9	93.9:2=46.95	-	46.95
2	40.6	93.9+40.6:2=114.20	8.0	106.20
3	25.5	93.9+40.6+25.5:2= 147.25	8.0+96.0=104	43.25
Total	160.0	308.40	112.0	196.40

Thus n_z = 196.4:160.0=1.228 year = 1.2

III. As an alternative solution against modernization, the construction of a new spinning mill with 50 thousand spindles:

Investment outlays 200 million zl.

Immobilization n_z = 1.85 year

Year output = 5,280 tons of yarn

Operating costs = 31.000 zl/1 ton of which:

material input = 25.500 zl and

labour input = 5.500 zl

In order to compute the synthetic index of effectiveness for a new spinning mill, it is necessary to know its optimal period of exploitation (n).

In the first stage of computation of that optimal period, the outlays on essential repairs were not taken into account because:

1) those outlays depend on the length of period of exploitation
2) the influence was negligible on the establishment of the optimal period of exploitation

Thus, optimal $n(n_{opt})$ is computed as a function of investment outlays (including immobilization) and transformation costs (labour input) ratio.

$$n_{opt} = f\,\frac{200.10^6 \cdot (1+0.15\cdot 1.85)}{5500 \cdot 5280} = f\,(8.8) = 31 \text{ years}$$

Assumptions in respect to essential repairs in the new spinning mill:

after	10	years	8.5	million	zl.
"	15	"	10.5	"	"
"	20	"	19.1	"	"
"	25	"	20.8	"	"
"	30	"	40.3	"	"

Since inclusion of major repairs into operating costs shortens n_{opt}, essential repairs after 30 years have not been taken into account.

Therefore:

$$\sum R = 8.5 + 10.5 + 19.1 + 20.8 = 58.9 \text{ million zl. i.e.}$$

about 2 million zl. per year (30 years of exploitation)

where: R = essential repairs

Adding the amount of annual major repairs to transformation costs n_{opt} is equal to

$$\frac{200\cdot 10^6 \cdot (1 + 0.15 \cdot 1.85)}{5500 \cdot 5280 + 2\cdot 10^6} = f\,(8.2) = 30 \text{ years}$$

Then the synthetic index of effectiveness for a new spinning mill

$$E_b = \frac{\frac{1}{6} \cdot 200\cdot 10^6 \cdot (1 + 0.15 \cdot 1.85) + (5500 \cdot 5280 + 2\cdot 10^6) Y_{30}}{5280\, Z_{30}}$$

$$= \frac{\frac{1}{6} \cdot 265.5 \cdot 10^6 + 31 \cdot 10^6 \cdot 1.3179}{5280 \cdot 1.1712} = 13491 \text{ zl/ton}$$

The question now arises: bearing in mind operating cost levels, has the old spinning mill the right to "live" longer at all?

The answer is yes, if

$$E_{st} \qquad E_b$$

where: E_{st} = synthetic index of old spinning mill

E_b = " " " new " "

Since E_b = 13491 zl/ton and

$E_{st} = 0.74\ C_{st} = 0.74 \cdot (6720 + 25800 - 25500)$[47/] = 5195 zl/ton

the further existence of the old spinning mill is proved.

And now the synthetic index of an old spinning mill is computed assuming that major repairs are performed. The period of exploitation was established for

old spinning mill = 15 years

modernized spinning mill = 20 years

with the help of a special formula for estimating the effectiveness of essential repair outlays. The effectiveness of investment outlays on the modernization is computed according to the following formula:

$$E_m = \frac{\frac{1}{6}\ I_m\left[(1 + 0.15 \cdot 1.2) - R_o\ (1 + 0.15 \cdot 0.25)\right] + \Delta C_m}{P_m}$$

where: I_m = investment outlays on modernization;

R_o = value of the first essential repair, which is avoided due to modernization of the old spinning mill;

$\Delta C_m = C_m\ Y_m - C_{st}\ Y_{st}$

$\Delta P_m = P_m\ Z_m - P_{st}\ Y_{st}$

n_m = 20 years; n_{st} = 15 years; (therefore: $Y_m = 1.0$; $Y_{st} = 0.8022$

$Z_m = 1.0$; $Z_{st} = 0.8597$)

The subscript: m means modernized spinning mill;

st means old spinning mill.

Transformation costs (C_m, C_{st}) include essential repairs

47/ The difference with respect to material input between the old and new spinning mills was taken into account.

Outlays on essential repairs (in million zl.):

	Spinning mill	
	old	modernized
After 5 years	50.1	12.6
" 10 "	63.4	22.1
" 15 "	-	35.7
Total	113.5	81.9

It follows that the average annual outlays on essential repairs would be:

1) in old spinning mill $113.5 : 15 = 7.6$ million zl.
2) in modernized spinning mill $81.4 : 20 = 4.1$ " "

and

$$(I_m - R_o) = 160 \cdot (1 + 0.15 \cdot 1.2) - 63.4 \cdot (1 + 0.15 \cdot 0.25) = 123 \text{ million zl}$$

$$C_m = (73.6 \cdot 10^6 + 4.1 \cdot 10^6) \cdot 1 - (68.8 \cdot 10^6 + 7.6 \cdot 10^6) \cdot 0.8022 \quad "$$

$$= 77.7 \cdot 10^6 - 61.3 \cdot 10^6 = 16.4 \text{ million zl.}$$

$$P_m = 12060 \cdot 1 - 9800 \cdot 0.8597 = 12060 - 8425 = 3635 \text{ ton}$$

Thus

$$E_m = \frac{\frac{1}{6} \cdot 123 \cdot 10^6 + 16.4 \cdot 10^6}{} = \frac{36.9 \cdot 10^6}{3635} = 10151 \text{ zl/ton}$$

A comparison E_m with E_b shows that E_m E_b (10151 1349) proving the efficiency of analyzed modernization.

5. Optimal duration of the sugar production season

The duration of a production season influences the final amount of output obtained from an agricultural raw material. There is at stake quantitative and qualitative losses of raw material. The duration can be shortened and output increased by means of installation of additional capacities. It means, however, additional investment outlays.

It is possible to estimate, based on the behaviour of the main techno-economic parameters, levels of operating costs, investment outlays and finally synthetic indices as a function of the length of duration of a production season.

The table below presents relevant data under the assumptions that:

- planned sugar beet crop is 11 million tons,
- the shortening of the interval of the production duration is equal to 100 - 50 days.

Table (7)

Duration of production season (in days) n	Volume of sugar beet actually processed (million tons) B_p	Capacity required (1000 t/24 hours) Z	Fixed productive assets (billion zl) M	Sugar output (thousand tons) P	Operating costs (billion zl) C
100	10.65	106.5	11.18	1473	8.87
98	10.66	108.8	11.42	1483	8.88
95	10.67	112.3	11.79	1498	8.88
93	10.67	114.8	12.05	1508	8.89
91	10.68	117.4	12.32	1518	8.90
90	10.68	118.7	12.46	1523	8.90
89	10.69	120.0	12.60	1527	8.90
87	10.69	122.9	12.91	1535	8.91
85	10.70	125.9	13.22	1542	8.92
83	10.71	129.0	13.54	1550	8.93
880	10.72	133.9	14.06	1561	8.94
75	10.73	143.1	15.02	1577	8.96
70	10.75	153.5	16.12	1592	8.98
65	10.76	165.6	17.39	1604	9.03
60	10.78	179.7	18.86	1615	9.07
50	10.81	216.2	22.70	1633	9.17

Note: 1. B_p is computed taking into account losses in the storage of 11 million tons of sugar beets
2. $Z = B_p : n$
3. $M = Z^p \cdot C$ where C = marginal investment-capacity ratio
4. C does not include operating costs of by-products
5. P depends on n

Synthetic indices of effectiveness for each interval (e.g. 100-98 days) have been computed assuming the period of immobilization $n_2 = 2$ years.

Table 8

Interval in days	M = I million zl.	C million zl.	P thousand tons	$E = \dfrac{\frac{1}{6} I(1 - i_z n_z) + C}{P}$ thousan zl/tons
100-98	236.3	5.1	9.9	[illegible].69
98-95	371.7	6.9	15.0	5.83
95-93	258.3	5.4	9.9	6.20
93-91	273.0	6.0	9.9	6.59
91-90	140.7	3.0	5.0	6.70
90-89	136.5	3.7	3.9	8.76
89-87	304.5	6.9	7.6	9.59
87-85	311.8	8.1	7.6	9.95
85-83	326.6	7.7	7.6	10.33
83-80	519.7	12.5	11.4	10.97
80-75	959.7	26.0	15.4	15.19
75-70	1,097.3	30.3	15.3	17.52
70-65	1,257.3	34.1	12.3	25.10
65-60	1,475.3	40.8	11.0	32.76
60-50	3,839.8	103.3	18.0	51.96

The table shows the increase of marginal capital-output ratio and synthetic indices of effectiveness (E).

In order to determine an optimal shortening of the production season, the obtained indices of effectiveness (E) are compared with the indices of alternative solutions (E_A). The purchase of an additional amount of sugar beet instead of "saving" by means of shortening the duration of production season has been assumed in these alternative solutions.

Table 9 presents:

- indices of alternative solutions (E_A)
- comparison of E_A and E with respect to the analogous n and P

Table 9

Interval in days	P (from table 2) thousand tons	B_P thousand tons	Z_A thousand tons per 24 hours	I million zl.	C_A million zl.	$E_A = \frac{\frac{1}{6} I_A (1+q_s n_s) + C_A}{P}$	E (from table 2)
100-98	9.9	71.6	0.72	75.6	53.5	7.06	5.69
98-95	15.0	107.8	1.10	115.5	80.5	7.03	5.83
95-93	9.9	70.5	0.74	77.7	52.7	7.02	6.20
93-91	9.9	70.1	0.75	78.8	52.3	7.01	6.59
91-90	5.0	35.2	0.39	41.0	26.2	7.02	6.70
90-89	3.9	27.4	0.30	31.5	20.4	6.97	8.76
89-87	7.6	53.2	0.60	63.0	39.7	7.03	9.59
87-85	7.6	53.0	0.61	64.1	39.6	7.04	9.96
85-83	7.6	52.7	0.62	65.1	39.5	7.05	10.33
83-80	11.4	78.8	0.95	95.8	58.8	7.05	10.97
80-75	15.4	105.7	1.32	138.6	78.9	7.07	15.19
75-70	15.3	104.1	1.39	146.0	77.9	7.16	17.52
70-65	12.3	83.0	1.19	125.0	62.3	7.27	25.10
65-60	11.0	73.8	1.14	119.7	55.4	7.39	32.76
60-50	18.0	120.1	2.00	210.0	90.5	7.56	51.96

Note: 1. $B_P = \frac{P \cdot 100}{W}$, where: W = percentage of sugar obtained from 1 unit of sugar beet

2. $Z_A = B_P : n$

3. C_A does not include operating cost of by-products.

determined at the point where E is bigger than E_A.

It means that in the analyzed case, the optimal duration is equal to 90 days. This case is complicated then by changing the assumptions with regard to:

- prices of the additional purchase of sugar beets
- building capacity versus modernizing old.

The realization of investment projects by stages[1/]

In the case when an investment project is built by stages, the index of effectiveness undergoes appropriate modification.

Generally speaking, the realization of a project by stages consists in the postponement in time of a part of the outlays for a given investment project without any harm to the realization of the production or service tasks for which the given investment project has been undertaken.

The realization of investment projects by stages brings some advantages which can be quantitatively expressed. These advantages, as compared with an investment project built at a time, are as follows:

a) a better utilization of investment outlays - as a result of a better adjustment in time of the capacity of an object to its increasing production.

b) the shortening of the construction period of particular stages due to the smaller scale of the construction,

c) a reduction of operational costs due to the application of more up-to-date technological solutions in the objects put into operation at the later stages and a decrease of overhead costs as a result of a better utilization of the production capacity,

d) an additional increase in production resulting from the fact that the operational period of the investment projects realized by stages does not end in most cases at the same time as that of the investment projects built at a time.

On the other hand, the disadvantage of the realization of investment projects by stages - as compared with the investment projects built at a time

1/ Instrukcja Ogolna....(Polish Instruction) 1962.

- is generally occurring relative increase in individual outlays.

For this reason the investment projects built by stages are not always more effective than those built at a time, and the choice between them must be based on the economic analysis.

On the basis of a schedule of commissioning capacities, it is possible to work out an appropriate schedule of investment outlays in which the moments of the realization of particular stages are distant from the first stage by periods of time $t_2, t_3, \ldots\ldots t_k$.

The objects built at the later stages - as compared with the object built at the first stage - will be characterized by the change of all their economic parameters. The index of effectiveness of the first stage is E_1, and the index of effectiveness of the second stage = E_2, and generally, the index of effectiveness of the j-th stage is E_j. Since the objects of the next stages (after the first stage) will be realized at the moments of time $t_2, t_3 \ldots\ldots t_k$, it can be assumed that the indices of effectiveness will be decreasing in inverse proportion to the increase of the social productivity of labour, that is, in proprotion:

$$\left/\frac{1 + c}{1 + a}\right/^{t_j}.$$

where: a = annual rate of investment growth;
c = annual rate of operating costs increase;
and $a \gg e$.

At the same time, since the social costs of production of the next stages (expressed by the indices of effectiveness $E_j . \left/\frac{1 + c}{1 + a}\right/^{t_j}$ are shifted by the period of time t_j as compared with the first stage, their role in the account is determined by means of coefficient $\left/\frac{1}{1 + e}\right/^{t_j}$ bringing the costs of the j-th period to the conditions of the first stage. In this connection, the index of effectiveness of a subsequent stage taking into consideration the economic progress during the period t_1 and the discount of costs at the initial moment is:

$$E_j \cdot \left(\frac{1 + c}{1 + a}\right)^{t_j} \cdot \left(\frac{1}{1 + c}\right)^{t_j} = E_j\left(\frac{1}{1 + a}\right)^{t_j}$$

As regards the output of a subsequent stage beginning at the moment t_j - counting from the first stage - in the account of effectiveness of an investment project realized by stages, it is presented, as the magnitude:
$P_jZ_j \cdot \left(\frac{1}{1 + a}\right)^{t_j}$, and for the investment as a whole, as:

$$\sum P_jZ_j \cdot \left(\frac{1}{1 + a}\right)^{t_j}$$

where:

$\left(\frac{1}{1 + a}\right)^{t_j}$ - is the coefficient bringing the output of the j-th stage to the conditions of the first stage,

P_j - the magnitude of output of the subsequent stage,

Z_j - coefficient correcting the output for the economically justified period of durability of the subsequent stage.

The numerator of the index of effectiveness of an investment project realized by stages respectively takes into account the weight of the output of each stage P_jZ_j, and amounts to:

$$\sum E_j \left(\frac{1}{1 + a}\right)^{t_j} \cdot P_jZ_j.$$

On the basis of the above definitions of the index of effectivenss of successive stages and the corresponding output-brought into conditions which are comparable with the first stage - it is possible to define the index of effectiveness of multi-stage investment as the quotient of the above values of the numerator and the denominator of this index. Hence, the general formula of effectiveness of such an investment is as follows:

$$E_e = \frac{\sum_{j=1}^{k} E_j \left(\frac{1}{1+a}\right)^{t_j} \cdot P_j Z_j}{\sum_{j=1}^{k} P_j - Z_j \cdot \left(\frac{1}{1+a}\right)^{t_j}}$$

By denoting $\left(\frac{1}{1+a}\right)^{t_j}$ by symbol g_j and the ratio $\frac{Z_j}{Z_1}$ by symbol z_j, the formula for an investment project realized by stages in the form as given in the Instruction (point 24, formula 3) is obtained:

$$E_e = \frac{\sum_{j=1}^{k} E_j P_j z_j g_j}{\sum_{j=1}^{k} P_j z_j g_j}$$

(for the first stage $t_j = 0$ and $g_j = 1$).

In the application of these formulae there may be two main cases:

a) when particular stages are independent of each other and can exist independently,

b) when the existence of subsequent stages is dependent on the first stage and their lives end the moment the first stage is liquidated.

ad a. - in view of the economic independence of particular stages it is possible to calculate the index of effectiveness E_k for each of them for the optimum operational period, that is for n_{opt},

ad b. - because of the interdependence of the durability of particular stages, the adoption of n_{opt} for the first stage means that the objects of subsequent stages will not, in principle, last for their respective optimum periods. Under such assumptions their durability is rigid and it is $n_1 - t_k$ ($n_1 = n_{opt}$ of the first stage).

In view of the difficulties of the deduction of a ready formula for this complex set it seems purposeful to calculate the overall index of effectiveness E_e for different n of the first stage and to choose such n for which E_e is the lowest.

Thus the profit from an investment realized by stages as compared with an investment built at a time finds its expression in the account in the reduction of the index of effectiveness in which both investment outlays and costs are discounted by means of a discount rate (0.07), whereas in an investment realized at a stretch the investment outlays are not at all discounted, and the operational costs are discounted at a rate of 0.03.

This method of calculation takes into account the economic benefits resulting from the increase in the productivity of social labour in the periods between the realization of the investment objects of particular stages.

In the case when the duration of the first stage does not limit the duration of the subsequent stages there is an additional benefit resulting from the increase in production in the investment project realized by stages as compared with the investment project built at a stretch.

Annex III[1]

The transformation of variable magnitudes of output and operating costs into constant magnitudes

The method of reasoning is similar as in the case of generalization of formula E for objects with different operational periods. The production in the given year is the sum of the production of particular objects put into operation in the given year, in the preceding year, etc., till the year n-1.

If the production of objects with a given curve of the increase of production in particular years of the operational period is denoted by $P_1, P_2 \ldots P_n$, the production of the objects which were put into operation in the given year will correspond to point P_1 on the curve of the increase of production (because of objects put into operation in the preceding year will correspond to point P_2 (because they are in the second year of operation), etc.

Considering that the older (by one year) objects are fewer, we shall find from the proportion $\frac{1}{1+a}$ (due to the increase of investments by a = 7% a year) that the annual production of all operating objects, for a given investment stream and for given capital intensities, will be proportional to:

$$\sum_{i=1}^{n} P_i \left/\frac{1}{1+a}\right/^{i-1}$$

If the production of objects did not change in time (if it was stable throughout the operational period and amounted to P_{st}), then the above sum would be proportional to the expression:

$$\sum_{i=1}^{n} P_{st} \left/\frac{1}{1+a}\right/^{i-1}$$

If the equation:

$$\sum_{i=1}^{n} P_i \left/\frac{1}{1+a}\right/^{i-1} = \sum_{i=1}^{n} P_{st} \left/\frac{1}{1+a}\right/^{i-1}$$

1/ Instrukcja Ogolna...(Polish Instruction) 1962.

is fulfilled, then the given investment stream yields the same production (the sum of the production of all objects operating in the given year) as the investment stream with stable production of all its objects. The value P_{st} calculated from this equation, can be considered as the equivalent of the values $P_1, P_2 \dots P_n$ from the curve of production during the operational period of the objects.

Transforming the equation, we shall obtain:

$$P_{st} \cdot \frac{/1 + a/^{n} - 1}{/1 + a/^{n-1} \cdot a} = \sum_{i=1}^{n} P_i \frac{1}{/1 + a/^{i-1}}$$

$$P_{st} = \frac{/1 + a/^{n-1} \cdot a}{/1 + a/^{n} - 1} \quad \sum_{i=1}^{n} P_i \quad \frac{1}{/1 + a/^{i-1}}$$

where:

$$\frac{/1 + a/^{n-1} \cdot a}{/1 + a/^{n} - 1} = r_p$$ - this is the so-called transforming coefficient for production. Its value for different n, for $a = 0.07$, is given in a special table.

The reasoning is analogical in the case of operating costs:

$$\sum_{i=1}^{n} K_i \; /\frac{1}{1 + c}/^{i-1} \qquad \sum_{i=1}^{n} K_{st} \; /\frac{1}{1 + c}/^{i-1}$$

with the only difference that, instead of coefficient a, coefficient c is used, analogically as in the case of consideration of the influence of different operational periods upon the cost element in the formula of effectiveness.

From this equation we obtain the equivalent value of K_{st}:

$$K_{st} = \frac{/1+c/^{n-1} \cdot c}{/1+c/^{n} - 1} \quad \sum_{i=1}^{n} K_i \cdot \frac{1}{/1 + c/^{i-1}}$$

where:

$$\frac{/1+c/^{n-1} \cdot c}{/1+c/^{n} - 1} = r_k$$ - this is the so-called transforming coefficient for costs.

The value of this coefficient for different n, for the rate of growth of overall costs c = 3%, is given in a special table.

In order to illustrate the method of equalization of the curves of production and costs as well as for a better explanation of the economic consequences of different distribution of these curves in time we shall give an example for the calculation of the equivalent for variable production and costs in three cases:

1) for production P = 100 units per each 30 years of life of an object,
2) for production P_1 = 80 units per each of the first 15 years, and for P_2 = 120 units per each of the last 15 years (the overall arithmetical average per 30 years will be 100 units a year),
3) for production P_1 = 120 units per each of the first 15 years and P_2 = 80 units per each of the last 15 years (here also the arithmetic average for the whole period is 100 units a year).

In the **first** case, according to the formula given above,

$$P_{st} = \frac{1,07^{29} \cdot 0,07}{1,07^{30} - 1} \cdot 100 \; \frac{1,07^{30} - 1}{1,07^{29} \cdot 0,07} = 100 \text{ units.}$$

which is obvious because a discount equivalent of a constant value is equal to this constant value.

In the **second** case - for production P_1 = 80 units a year, during the first 15 years we shall have

$$P_{st_1} = \frac{1,07^{29} \cdot 0.07}{1,07^{30} - 1} \cdot \sum_{i=1}^{i=15} 80 \cdot /\frac{1}{1,07}/^{i-1} =$$

$$\frac{1,07^{29} \cdot 0,07}{1,07^{30} - 1} \cdot 80 \cdot \frac{1,07^{15} - 1}{1,07^{14} \cdot 0.07}$$

The value of both fractions can be found in a special table for the expression:

$$r_p = \frac{/1 + a/^{n-1} \cdot a}{/1 + a/^{n} - 1}$$

for n = 30 and n = 15; for n = 30 expression r_p = 0,0753, and for n = 15 expression r_p = 0,1026.

From this it follows that:

$$P_{st_1} = 0{,}0753 \cdot 80 \frac{1}{0{,}1026} = 80 \cdot \frac{0{,}0753}{0{,}1026}$$

and analogically:

$$P_{st_2} = \frac{1{,}07^{29} \cdot 0{,}07}{1{,}07^{30} - 1} \cdot \sum_{i=16}^{i=30} 120 \cdot /\frac{1}{1{,}07}/^{i-1} =$$

$$= 0{,}753 \cdot \frac{1}{1{,}07^{15}} \cdot \sum_{i=1}^{i=15} 120 \cdot /\frac{1}{1{,}07}/^{i-1} =$$

$$= 0{,}0753 \cdot 0{,}3623 \cdot 120 \cdot \frac{1}{0{,}1026}$$

Together:

$$P_{st} = P_{st_1} + P_{st_2} = \frac{0{,}0753}{0{,}1026} \cdot /80 + 0{,}3623 \cdot 120/ = 90.7 \text{ units.}$$

Thus, for the initial production which is smaller than the general average, the average discount equivalent will also be lower than the average value P = 100 units.

In the third case the situation will be the reverse. Reasoning analogically as before, we shall obtain:

$$P_{st} = P_{st_1} + P_{st_2} = \frac{0{,}0753}{0{,}1026} \cdot /120 + 0{,}3623 \cdot 80/ = 109{,}8 \text{ units.}$$

Thus, the larger initial production gives discount equivalent which is larger than the arithmetical average P = 100 units.

The above example illustrates production benefits from such distribution of production when it is relatively larger at the initial stage of the operation period.

Variable costs can be transformed into a constant magnitude in a similar way. The method is analogical as in the case of production, with the only difference that the discount coefficient c is 3% instead of 7%. Assuming analogical values $K_1 = 80$ units during each of the first 15 years and $K_2 = 120$ units during each of the subsequent 15 years, and making analogical calculations, we shall obtain:

$$K_{st} = \frac{r_{k_{30}}}{r_{k_{15}}} \cdot /80 + \frac{1}{1{,}03^{15}} \cdot 120/$$

where the value $r_{k30} = 0{,}0496$; $r_{k15} = 0{,}0815$ and $1 : 1{,}03^{15} = 0{,}6427$ are found in a special table. Thus, $K_{st} = /0{,}0496 : 0{,}0815/ \cdot /80 + 0{,}6427 \cdot 120/ = 95{,}5$ units.

If we assume that during the first 15 years $K_1 = 120$ units and during the next 15 years $K_2 = 80$ units, we shall obtain $K_{st} = /0{,}0496 : 0{,}0815/ \cdot /120 + 0{,}6427 \cdot 80/ = 104{,}2$ units.

Thus, as in the previous case, lower initial costs ultimately give a lower equivalent than the arithmetical average, and higher initial operating costs - a respectively higher equivalent, however, to a smaller extent than in the case of production.

One more conclusion concerning individual operating costs can be drawn from the above. Production and costs in the above examples are chosen in such a way that the index of individual costs K : P for each year is equal to 1. This index continues to be equal to 1 for the stable production throughout the operational period. However, for increasing production and costs it amounts, in our example to $K : P = 95{,}5 : 90{,}7 = 1{,}05$, that is, it is higher than 1, whereas for decreasing production and costs $K : P = 104{,}2 : 109{,}3 = 0{,}95$, that is, it is lower than 1. This shows that the same costs are a greater burden for the economy if they are concentrated at the end of the operational period than in the case when they are concentrated in the beginning of this period.